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UNITED STATES DEPARTMENT OF AGRICULTURE

Birdsfoot Trefoil and Big Trefoil[1]

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CONTENTS

INTRODUCTION

For a hundred years or more birdsfoot trefoil (*Lotus corniculatus* L.) and big trefoil (*Lotus uliginosus* Schkuhr) have been used in small plantings in the British Isles and in the countries of continental Europe. They have recognized forage value and are grown in France, Italy, Denmark, Germany, and elsewhere. In the more southern countries they have been used for both forage and seed, whereas in the north they are used principally for pasturage, but nowhere have they gained major importance. In Australia and New Zealand birdsfoot trefoil and big trefoil have been grown and have proved well adapted in limited regions. According to Levy (*2*) [2] it has been within the last quarter of a century that these perennials have been grown commercially in these countries. Birdsfoot trefoil is most extensively used, although big trefoil is recommended for certain situations. Both of these plants are native to the Mediterranean region and northward to the Scandinavian Peninsula.

In the past few years birdsfoot trefoil (*Lotus corniculatus*) has attracted attention in two widely separated sections of the United States. Just how and when it was introduced and became established in these areas is not known. In eastern New York and in western

[1] Cooperative investigations of the Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, and the Oregon Agricultural Experiment Station.

[2] Italic numbers in parentheses refer to Literature Cited, p. 13.

Oregon, where it first became naturalized, it has spread until now it is found over a comparatively large area. Floras of the eastern United States first listed *L. corniculatus* about 1900 (*1*). In the northwestern United States, it is first mentioned by Nelson (*6*) in 1917 as occurring in ballast near Portland. Specimens in herbaria show that plants were collected in New Jersey as early as 1876; in North Carolina and New York in 1885; and in Alabama in 1888.

The limited experience with both birdsfoot trefoil and big trefoil in the United States follows the pattern of the experience in Europe, Australia, and New Zealand, indicating that these plants are adapted to at least limited sections and can be used for forage and pasturage.

FIGURE 1.—A pure stand of birdsfoot trefoil just past full bloom. Note the similarity to a thick stand of alfalfa.

GENERAL DESCRIPTION

Birdsfoot trefoil is a long-lived herbaceous perennial with a well-developed branching taplike root with few to many stems developing from each crown. The plants for the most part are erect or ascending and attain a height of from 12 to 30 inches. The stems are comparatively slender, branch to some extent, and are moderately leafy. Each leaf has three leaflets, borne at the end of a short petiole, and has a cloverlike appearance. Usually the leaflets are obovate but vary widely with varieties and are sometimes almost linear.

Big trefoil has the general characteristics of birdsfoot trefoil but differs in having more flowers in each raceme and in having spreading rhizomes that are lacking in birdsfoot trefoil. Both big trefoil and birdsfoot trefoil have the general appearance of fine-stemmed alfalfa (fig. 1).

CLIMATIC REQUIREMENTS

From the information available it is concluded that birdsfoot trefoil is best adapted to a temperate climate and will do much better in the northern than in the southern half of the United States. Big trefoil, from very limited observations, may not be quite so winter hardy as birdsfoot trefoil, but plantings have survived and made good growth as far north as Massachusetts. The following is quoted from the Massachusetts Agricultural Experiment Station's Eighth Annual Report (*4, p. 174*).

> Sulla (*Hedysarum coronaria*) and *Lotus villosus*[3] have for several years shown a healthy and vigorous growth on our grounds; they stand our average winter very well. Both deserve a serious trial for stocking pastures with a nutritious growth. They shade the ground more efficiently in such localities than any of our coarser clover varieties. Some subsequent statements of their composition illustrate their high feeding value.

The most northern State reporting the growing of *L. corniculatus* is Maine (*3, p. 167*). The following is quoted from that station's annual report of 1889:

> Birdsfoot Clover.— * * * Our plants were 14 inches high. They had a tap root, sending up numerous branches with bright yellow flowers.

From 1905 to 1908 the Department, in cooperation with the Washington (State) Agricultural Experiment Station at Pullman, Wash., grew *L. corniculatus* and *L. uliginosus* in general trial plantings. Both grew well, the former attaining stem lengths up to 30 and the latter up to 22 inches, and although a dense, vigorous growth was made, they were considered inferior to alfalfa.

At the Arlington Experiment Farm, Arlington, Va., plantings of *L. corniculatus* in 1909 and later years have made good growth and have attained stem lengths up to 30 inches. *L. uliginosus* at this station has not made as large a growth as *L. corniculatus* but has been quite vigorous. Seed of *L. corniculatus* sent by the Department to the Illinois Agricultural Experiment Station was planted at a substation in the southern part of the State and was grown from 1927 through 1929. This planting made good growth and appeared reasonably well adapted to southern Illinois conditions.

In cooperation with the North Carolina State Agricultural Experiment Station, plantings of *L. corniculatus* were maintained at Statesville, N. C., from 1931 to 1935. The plants attained a height of 18 inches and were reasonably vigorous. Other States in which successful experimental plantings or naturalized growths have been observed are California, Oregon, Michigan, and New York.

SOIL AND MOISTURE REQUIREMENTS

Birdsfoot trefoil is not exacting as to soil requirements and does well under a variety of soil conditions. It makes good growth on sandy and light gravelly soils as well as on heavier clay loam and has been observed growing in soils with moderate amounts of alkali. In the Catskill section of eastern New York it is growing on poor

[3] Three different plants have received the name *Lotus villosus*, namely, *L. villosus* Forsk., *L. villosus* Schur. (now referred to the synonymy of *L. corniculatus* var. *hirsutus* Koch), and *L. villosus* Thuill. (now treated varietally as *L. uliginosus* var. *villosus* (Thuill.) Lamotte). As no authority is given for the name in the publication cited, it is not possible to know definitely which plant was meant, but inasmuch as *L. uliginosus* var. *villosus* is the one most commonly handled commercially it seems likely that this is the plant referred to.

gravelly loam soils of recognized low-productive capacity for local standard crops. In the Pacific Northwest it is growing in similar situations but also is found growing luxuriantly on the more fertile lowlands of the coastal area. It is not particularly drought resistant but will stand average drought conditions and is equal to most other crops in this respect. Some writers, however, have claimed for it unusual drought resistance.

In soil requirements the plants are very similar, but their moisture demands differ. Big trefoil is suited to situations of greater moisture than birdsfoot trefoil, in fact in places it will grow under quite swampy conditions. Smith (*9*) refers to this species under the name Swamp Horn clover, as follows:

> It is a native of northern Europe, where it is esteemed for swampy meadow lands. It is now cultivated in Wisconsin and Minnesota on sour, peaty, or muck soils.

Recent reports [4] from these two States indicate that big trefoil no longer occurs in Minnesota but that it persists in Wisconsin.

VALUE FOR FORAGE

No feeding experiments have been conducted to determine the relative value of birdsfoot trefoil or big trefoil for forage, but the general experience of growers shows that they are entirely satisfactory for this purpose. Both species have been used in European countries, and general reports from Australia and New Zealand indicate that they are highly regarded for use in pasture mixtures. In eastern New York and in western Oregon farmers have pastured birdsfoot trefoil and recognize its high feeding value. It also makes hay of good quality. It is the practice of a number of farmers to grow birdsfoot trefoil as a mixture with grass, and it is in such a combination that it is most commonly fed. It is well adapted for use in this way and such a mixture is considered very valuable.

In addition to making good hay and pasturage the season of growth of birdsfoot trefoil and also big trefoil is such that good pasturage is available in the latter half of summer when pasturage is usually short. This feature is one of the strong assets of the crop and makes it especially valuable for use in pastures.

CHEMICAL ANALYSIS

The several published analyses of birdsfoot trefoil agree closely with reference to the constituents that can be compared. Following is an analysis of birdsfoot trefoil hay that was produced in the Rogue River Valley, Oregon, in 1940, and is considered average for plants in bloom:[5]

Constituent:	*Percent*
Protein	14. 24
Fat	2. 90
Fiber	29. 60
Calcium	1. 10
Phosphorus	. 28

[4] Correspondence on file in the Division of Forage Crops and Diseases.
[5] Analysis by J. R. Haag of the Oregon Agricultural Experiment Station.

The Massachusetts Agricultural Experiment Station (*4, pp. 179–180*) on June 21, 1889, cut plants of *L. villosus* [6] in full bloom for analysis, which was reported as follows:

	Percent
Moisture	10. 68
Dry matter	89. 32

ANALYSIS OF DRY MATTER

Constituent:	Percent	Constituent—Continued.	Percent
Crude ash	8. 23	Magnesium oxide	. 336
Crude cellulose	24. 48	Ferric oxide	. 076
Crude fat	3. 00	Sodium oxide	. 365
Crude protein (nitrogenous matter)	13. 49	Potassium oxide	2. 064
Non-nitrogenous extract matter	50. 80	Phosphoric acid	. 688
Calcium oxide	1. 579	Nitrogen	1. 930
		Insoluble matter	. 888

It is evident from these analyses that both birdsfoot trefoil and big trefoil have a relatively high protein content and appear to be equal to clover and alfalfa in fat and minerals.

SEED SETTING

The general conclusion of investigators who have studied seed setting in *Lotus* species is that both birdsfoot trefoil and big trefoil are practically self-sterile. Silow (*8, pp. 239–240*) who has more recently given the subject consideration draws the following conclusion:

> *Lotus corniculatus* is practically self-sterile, but occasional plants set a few seeds after self-pollination. Plants of *L. major* Smith (=*L. uliginosus* Schk.) are, on the whole, incapable of spontaneous self-pollination; but after artificial self-pollination practically all plants are self-fertile, some to a very high degree. Thus these two perennial species are almost entirely dependent upon insect visitors for seed formation; * * * .

The fact that cross pollination is common in these species may account for the great diversity of forms that are readily apparent. Although birdsfoot trefoil and big trefoil are both open pollinated and crossing of varieties within each species has been shown to be beneficial to seed setting, it does not seem to have been demonstrated that the two species hybridize.

SEED CHARACTERISTICS

The seed of both birdsfoot trefoil and big trefoil are small. Birdsfoot trefoil will average about 375,000 seed per pound and is a little smaller than red clover seed. Big trefoil will average about 1 million seed per pound and is a little smaller than white clover seed. The color of the seed varies somewhat depending upon the stage of maturity and the age subsequent to harvesting. In general, birdsfoot trefoil seed is solid light to dark brown in color and big trefoil is a solid greenish yellow to yellowish green, becoming brownish with age. The weight of the seed in both species is about 60 pounds per bushel. Seed of both birdsfoot trefoil and big trefoil germinate readily except

[6] See footnote 3, p. 3.

for hard seed. The available information on hard seed is very limited. Germination tests of a number of commercial samples show as high as 56 percent of hard seed in birdsfoot trefoil, and it is evident that unless specifically scarified about half the seed or more will be hard. Under favorable storage conditions both birdsfoot trefoil and big trefoil retain their viability through a long term of years. Turner (*10*) reports big trefoil seed germinating 9.6 percent after a lapse of 81 years.

SOURCE OF SEED

Seed of birdsfoot trefoil has been harvested in limited quantity in eastern New York for the past few years, and a small acreage was harvested in 1940 in western Oregon and northwestern California. No seed of big trefoil has been harvested in the United States. In New Zealand, France, Italy, Hungary, Denmark, and Germany, and probably other European countries, one or both of these species have been grown in a limited way and seed harvested. Big trefoil seed has been produced in New Zealand, Germany, Italy, France, and probably other European countries.

INOCULATION

In districts where birdsfoot trefoil is occurring naturalized, the plants seem to be well inoculated. Experimental trials, however, have shown that the plants do not become inoculated under all conditions, and that artificial inoculation is frequently needed. It is recommended, therefore, that artificial inoculation be given to all new seedings.

FERTILIZER AND LIME NEEDS

The sections in the United States where birdsfoot trefoil has come into use are more or less deficient in lime, indicating that soils low in this compound can produce the crop satisfactorily. The experience in European countries bears out this conclusion and supports the belief that this crop may have a place in at least limited areas where the lime content of the soil is insufficient for most other legume crops. It should be pointed out, however, that although birdsfoot trefoil does well on soils deficient in lime it has been shown that under such conditions the use of this amendment often is beneficial. It has also been demonstrated that superphosphate and potash are beneficial. Robinson (*7, p. 277*) in the Empire Journal of Experimental Agriculture writes as follows:

> The success of the crop depends to a considerable extent upon the supplies of potash and phosphates in the soil. Given a sufficiency of these two plant-foods the crop is capable of yielding well for a long time, periods of 9–20 years being not uncommon.

GROWING IN MIXTURES

In many cases it is desirable to grow birdsfoot and big trefoil in mixtures rather than in pure stands. Most growers have followed this practice and except when seed is the main interest it is highly satisfactory. In pastures a mixture is to be preferred, and for hay

both good yields and satisfactory quality can be attained by the use of locally adapted combinations.

In New York timothy, orchard grass, red clover, alsike clover, and birdsfoot trefoil in mixtures have given good results. In western Oregon both big trefoil and birdsfoot trefoil have been satisfactorily grown in combination with bentgrass, red clover, timothy, and perennial ryegrass. In European countries mixtures of meadow fescue, *Bromus erectus* Huds., and birdsfoot trefoil have been grown successfully. Mixtures must be adapted to local conditions, and the best proportion of the different grasses and legumes will vary (fig. 2).

SEEDING

Experimental results and experience of growers have indicated that stands of both birdsfoot trefoil and big trefoil are sometimes difficult to obtain. More difficulty has been experienced with big trefoil than with birdsfoot trefoil but both need careful handling. A thorough preparation and firming of the seedbed seems to be essential. Shallow planting is also important. The seed should be covered as lightly as possible and still insure enough moisture for germination. Broadcast seeding and rolling to press the seed into the soil and firm the seedbed, so that moisture will be near the surface and in contact with the seed, is perhaps the safest method to follow.

In the northeastern United States seeding should be made from midsummer to early fall. Late-fall seedings may winter-kill. Spring seeding is less desirable, as the seedling plants of both birdsfoot trefoil and big trefoil grow very slowly and spring weeds offer too much competition. In the northwestern United States both east and west of the Cascade Mountains the best time for seeding is from April 1 to May 15, depending on latitude and seasonal conditions.

When seeding alone and a full stand is desired, birdsfoot trefoil should be seeded at from 8 to 12 pounds of good seed per acre and big trefoil 4 to 6 pounds per acre. In mixtures with grasses these figures can be greatly reduced. In New York some growers use but 1 pound of birdsfoot trefoil in a general mixture when the field is to be left down for a term of years. With time the stand of birdsfoot trefoil thickens and displaces some of the other plants in the mixture.

HARVESTING FOR FORAGE

Birdsfoot trefoil can be harvested and handled with ordinary farm machinery and is commonly cut with a mower and raked and handled as clover or alfalfa. Thin stands can be raked and handled quickly, but heavier stands require some time for proper drying.

In cooperative experimental plantings at the Michigan Agricultural Experiment Station, yields of hay were obtained amounting to 2 tons per acre for the first cutting and 1,500 pounds for the second. Lime, phosphate, and potash were applied to these plots and no doubt increased the yield, but on poor, badly eroded, nearby areas receiving only lime, good growth had been made. In cooperation with the Illinois Agricultural Experiment Station, plantings at one of the substations in southern Illinois yielded 3.81 tons dry weight per acre in 1929. These plantings were established in 1927.

FIGURE 2.—A good stand of birdsfoot trefoil in mixture with grasses.

European writers report yields comparable to those obtained in the United States at the stations reporting, and the experience of growers in this country justifies the statement that where birdsfoot trefoil does well, good yields can be expected and that two cuttings for hay can be made. Although nearly 4 tons of hay per acre can be obtained sometimes, it is probable that from 1 to 2 tons per acre is nearer the average.

HARVESTING FOR SEED

Birdsfoot trefoil and big trefoil are both difficult to harvest for seed. The seed ripens unevenly, and one plant will have both green

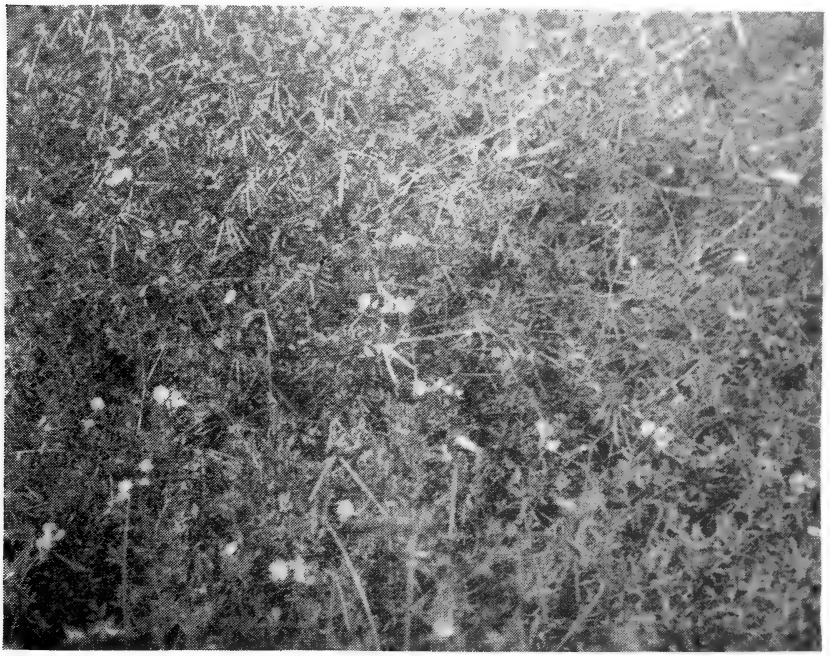

FIGURE 3.—Birdsfoot trefoil with well-developed seed pods and flowers on the same plants.

and ripe pods at the same time (fig. 3). When ripe, the pods open easily, and this results in considerable loss of seed. In order to get maximum seed yields, it is necessary to watch the plants closely and to harvest when the maximum of seed is sufficiently mature. This will be when the first pods are well browned and a goodly number have turned a dark-violet color. The plants will still be green. Cutting can be done with a reaper or a mower with or without swather attachments. The cut material should be windrowed, then put in shocks, and later stacked or threshed, depending on facilities available. The seed immediately after harvest should be watched closely to prevent damage, as the moisture from the immature seed may cause molding.

Seed yields vary, but 100 pounds of clean seed per acre is the usual quantity saved by the few growers who have harvested the crop in

the United States. Yields between 200 and 300 pounds per acre have been reported from France, but it is probable that these were maximum yields.

PASTURAGE

Birdsfoot trefoil and big trefoil serve well in pastures in sections to which they are adapted. The plants are palatable and nutritious and seem to be particularly well suited for growing with grasses. Being long-lived perennials when once established in pasture mixtures they endure for a term of years. In western Oregon big trefoil has been in experimental plots that have been grazed and cut for hay

FIGURE 4.—Dairy cows on birdsfoot trefoil and grass pasture.

for nearly 20 years, and the stand and growth are still good. In eastern New York farmers are grazing birdsfoot trefoil and report entirely satisfactory results. The plants stand trampling and grazing well and livestock have done well on birdsfoot trefoil pasture (fig. 4). No experimental data are available on the comparative value of birdsfoot trefoil for pasturage, but general information indicates that it is probably equal to alfalfa, clover, and other standard legumes.

European writers differ in some minor details regarding the value of birdsfoot trefoil for pasturage, but all agree that it is a valuable plant. Some of the features stressed by these writers are disease resistance, drought resistance, longevity, and the fact that it will grow under conditions where clover fails. It is also pointed out that birdsfoot trefoil furnishes succulent pasturage in mid to late summer at a time when most other plants are making little or no growth. This latter characteristic appeals strongly to those in the United

States who have used it for pasturage, and it is one of the qualities that adds greatly to its value.

ENEMIES

Several of the common insect pests of clover and alfalfa have been reported to occur on birdsfoot trefoil in Europe and Russia, although no serious injury by them has been mentioned. These insects also occur in the United States, but the only material injury by them reported in this country was a case reported by Monteith and Hollowell (*5*) in which nursery rows "were heavily infested with the potato leafhopper" and showed injury similar to that caused on alfalfa by this insect.

DESCRIPTION OF VARIETIES AND FORMS

A number of varieties and forms have been described under both *Lotus uliginosus* and *L. corniculatus*. *L. corniculatus* in particular is extremely variable and, even from seed used for commerical plantings, plants that differ widely are usually present. Under natural conditions regional strains have developed, and these constitute the many variants that have been given varietal and form designation. For the most part shape of leaflets and habit and size of the plants have been the basis of differentiation, but in some cases color and number of flowers have been recognized. The following descriptions and keys give the specific characters that separate species, varieties, and forms and indicate the range of variation that exists.

The characteristics that distinguish *L. corniculatus* and *L. uliginosus* from all other *Lotus* species are as follows:

Styles not dentate; flowers yellow; calyx campanulate; teeth equal and equaling the tube; leaves not dotted or revolute; banner equaling the wings and keel; bracts three; stem of keel shorter than the keel.

The only characteristics definitely distinguishing the two species are the rhizomes and flowers. The definite features of these are as follows:

Flowers usually 8 to 12 (rarely 6 to 7); rhizomes spreading. *L. uliginosus* Schkuhr.

Flowers 5, sometimes 6, and rarely 7; rhizomes not spreading. *L. corniculatus* L.

L. uliginosus is only moderately variable and but two varieties have been described. The following key gives the characteristics separating these:

Plants smooth or nearly so ---------- var. *glabriusculus* Bab.
Plants hairy ---------- var. *villosus* (Thuill.) Lamotte.

L. corniculatus is extremely variable, and a large number of varieties have been described. Many of these were originally given specific rank. The following key indicates the wide range of variation and gives the principal characteristics distinguishing the different varieties and forms.

A. Leaflets obovate to oblong, large or small.
  B. Plants large, usually with 5 flowers, stems mostly smooth, leaflets midlarge.
    C. Stems smooth or slightly hairy.
      D. Leaflets smooth, or with few scattering hairs.
        Calyx teeth about as long as the calyx tube
          var. *arvensis* (Schkuhr) Ser.
        Stems ascending, long internodes.
          Leaflets very large.
            Flowers 1 cm. long, plants robust 3 to 5 dm. high
              f. *silvaticus* Baumg.
            Flowers over 1 cm. long, plants 3 to 4 dm. high
              f. *grandiflorus* Rouy.
          Leaflets medium or small.
            Leaflets medium ..... f. *genuinus* Posp.
              Flowers reddish yellow to red
                f. *rubriflorus* Lamotte.
              Flowers yellow with red keel
                f. *variegatus* A. and G.
            Leaflets small ..... f. *parvifolius* Peterm.
        Stems decumbent, short internodes ... f. *alpestris* Lamotte.
        Calyx teeth about one-third as long as the calyx tube
          var. *microdon* Peterm.
      D. Leaflets hairy or with long ciliate hairs.
        Plants ordinary type, but leaflets long ciliate
          var. *ciliatus* Koch.
        Leaflets small, thick stems, branches decumbent
          var. *crassifolius* (Pers.) Ser.
        Leaflets very small, 3 to 6 mm. long ... f. *parvifolius* Rouy.
    C. Stems densely hairy.
      Stems ascending, 2 to 4 flowers ..... var. *hirsutus* Koch.
        Plants very dense, medium-size leaflets
          f. *pilosissimus* (Schur) Rouy.
        Plants procumbent, small leaflets ..... f. *minor* Rouy.
      Stems decumbent ..... var. *delorti* (Timb.) Rouy.
        Stems much branched, medium size leaflets, flowers small, bright yellow ..... f. *symmetricus* (Jord.) Rouy.
        Stems moderately branched, leaflets very small
          f. *parvifolius* Rouy.
  B. Plants small with 1 to 3 flowers, stems more or less hairy, leaflets small
    var. *alpinus* Ser.

A. Leaflets lanceolate to linear, small.
  B. Calyx teeth much longer than the short calyx tube
    var. *preslii* (Ten.) A. and G.
    Plants medium large, entirely without hairs ... f. *glaber* (Rouy) A. and G.
    Plants small, quite hairy ..... f. *sibthorpii* (Rouy) A. and G.
  B. Calyx teeth shorter or little longer than the calyx tube.
    Plants medium or large.
      Plants rather long, hairy, 2 to 5 dm. high
        var. *major* (Scop.) Brand.
      Plants glabrous ..... var. *tenuifolius* L.
        Stems 0.6 to 1.5 dm. long, upright
          f. *sabulicola* (Rouy) A. and G.
        Stems 4 to 8 dm. long.
          Stems decumbent, branches elongated
            f. *longicaulis* (Martr.-Don) A. and G.
          Stems erect, flower racemes with very long peduncle
            f. *pedunculatus* (Cav.) Rouy.
            All parts fine, leaflets small ..... f. *parvifolius* Rouy.
            Leaflets rather thick or fleshy
              f. *crassifolius* (Lamotte) A. and G.
    Plants very small ..... var. *microphyllus* Hausskn.

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