beneath, glabrate above, rounded at each end; peduncles 4–7 cm. long; racemes 1–3-flowered, very short; bracts lanceolate, 1–2 mm. long; pedicels 2–4 mm. long, hirsutulous; calyx black-hairy, the tube 3–4 mm. long, the teeth 2 mm. long; corolla violet-blue, but changing to white or ochroleucous at the base and often fading to white throughout in drying, about 15 mm. long; banner broadly obovate, the wings and keel-petals a little shorter than the banner; pod borne on a straight gynophore 5–7 mm. long, the pod itself strongly falcate, 5–8 mm. wide and about 3 cm. long in a straight line from end to end, minutely black-hirsutulous to glabrous at maturity, splitting lengthwise on both sutures; seeds obliquely round-reniform, about 3 mm. long.

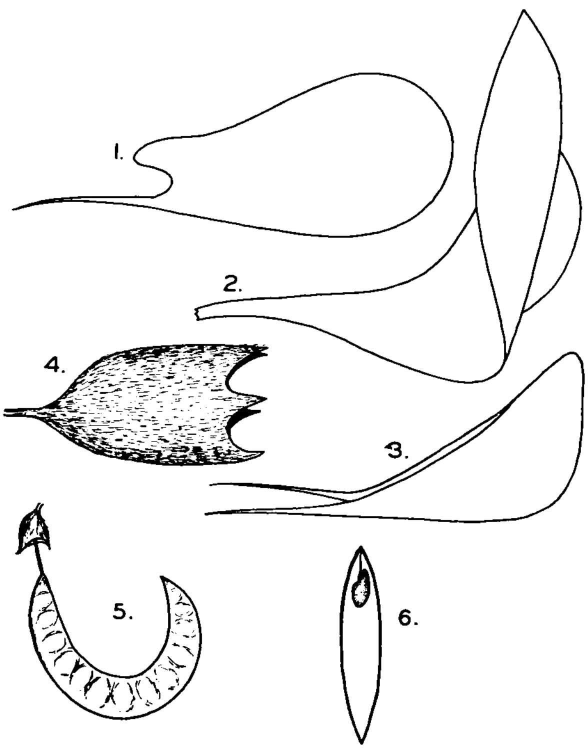

Fig. 1–6. *Astragalus falciferus* Hultén.—Fig. 1. Wing petal ×4.—Fig. 2. Banner ×4.—Fig. 3. Keel petals ×4.—Fig. 4. Calyx ×4.—Fig. 5. Fruit with gynophore ×0.8.—Fig. 6. Cross section of fruit ×4.

Type.—Collected between Lake Kluane and Don Jek River, Yukon Territory, August 11–27, 1920, *August Muller*, in herbarium of the Acad. Nat. Sci. Phila.

Cited specimens.—Along the Toklat River, Mt. McKinley Nat. Park, Alaska, June 25, 1939, *A. Nelson 3539;* Upper Igloo Creek, Mile 39, Mt. McKinley Nat. Park, Alaska, June 25, 1939, *A. Nelson 3561;* gravel bars on Toklat River, Mt. McKinley Nat. Park, Alaska, August 28, 1939, *A. Nelson 4247;* gravelly river bed, Toklat River, Mt. McKinley Nat. Park, Alaska, July 16, 1939, *Warren 2168;* and gravelly river bed, Toklat River, Mt. McKinley Nat. Park, Alaska, June 25, 1939, *Warren 2223.*

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A NOTE ON THE ORIGIN OF THE LATERAL ROOTLETS OF EICHHORNIA CRASSIPES (MART.) SOLMS [1]

Chester A. Arnold

A very unusual feature of the root of *Eichhornia crassipes* (the water hyacinth) is the place of origin of the lateral rootlets. The primordia of the lateral rootlets of this plant do not arise from mature and completely differentiated tissue, as in most plants, but appear in the growing portion very near the promeristem in tissues which have not undergone elongation, and in which only the earliest differentiation of the histogens has taken place. It is evident from a perusal of the literature that this rather unusual manner of origin has not escaped notice entirely, but it has never been stressed or fully figured. The probable reason for the neglect of this particular feature in discussions of root development in *E. crassipes* is that most studies have been made from transverse sections in which certain structural features are less prominent than in longitudinal cuts. Several authors have studied the promeristem of the root of *E. crassipes* in longitudinal section but their attention has been directed mostly to the early differentiation of the histogens. The only author to figure a sufficient length of root to show the sequence of lateral root development is Olive (1894), who gave a brief account of *Eichhornia* in a preliminary paper on the histology of the Pontederiaceae.

The roots of *E. crassipes* are small, only the largest and most rapidly growing ones exceeding a millimeter in diameter. In roots growing at an ordinary rate the lateral rootlets first appear through the epidermis at a distance less than a centimeter away from the cap, but in very rapidly growing ones the interval is much longer. No roots have been observed in which the rootlets have actually emerged within

[1] Received for publication May 13, 1940.

the long cap, although near the top of the cap small protruberances may be present on the root surface which are due to pressure of the developing rootlets within.

The early differentiation of the histogens is clearly revealed in longitudinal sections of the roots (fig. 1 and 2). The small meristem is situated in the usual place at the extreme tip immediately behind the cap, and the procambium extends directly backward from it as a gradually broadening core of cells which stain less deeply than those immediately bordering them (fig. 2). It is from some of these richly protoplasmic cells around the procambium that the rootlet primordia arise. This surrounding zone consists of two layers of cells, the innermost of which becomes distinct slightly before the outer. The outer layer is partially developed endodermis, and in transverse section it shows as a ring in which the cells are radially aligned with those of the cortex. These cells differ from the adjacent cortical cells only in their slightly greater radial diameters. The cells of the inner layer, which develop into the pericycle, alternate with those of the outer layer until the protruding lateral rootlets disturb the regularity of arrangement.

When this inner layer first becomes differentiated its cells are nearly cubical (as seen in longitudinal section), but farther back they broaden slightly so that the radial diameter slightly exceeds the vertical one. The cells of the outer layer are similarly shaped, and together the two cell layers (consisting of the immature pericycle and endodermis) contrast sharply with the adjacent cells on either side which remain more nearly cubical or become vertically elongated.

The first indication of lateral root development is a slight enlargement of two pericycle cells lying side by side—cells first observed and figured by Nägeli and Leitgeb (1868) during their classical studies of root development. Immediately following this stage, some of the cells of the outer layer (the endodermis) undergo radial division, and the resulting cells become the outer part of the rootlet primordium.

The distance from the promeristem at which the primordia arise depends upon the rapidity of lengthwise growth of the root. In the more slowly growing roots they form nearer the apex, but in rapidly growing ones they are farther away, the difference being due to variation in length of the growing regions. The position of the primordia with respect to tissue development is more constant in that they originate at the forward end of the region of elongation. In the longitudinal sections shown in figures 1 and 2, the earliest visible indications of lateral rootlets are located about .25 mm. from the promeristem. At this point the diameter of the tip (exclusive of the cap) is about one-half that of the mature root. The youngest primordia are very close together, but throughout the elongation region they become successively more distant, and in the mature part the rootlets are separated by a distance about equal to the diameter of the root (fig. 1). Secondary wall thickenings in the xylem first appear at the rear of the elongation region at a considerable distance above the place of origin of the rootlet primordia.

Although the lateral rootlets of *Eichhornia* may arise near the root-tip, in an unusual place, the condition apparently is not restricted to this genus. A

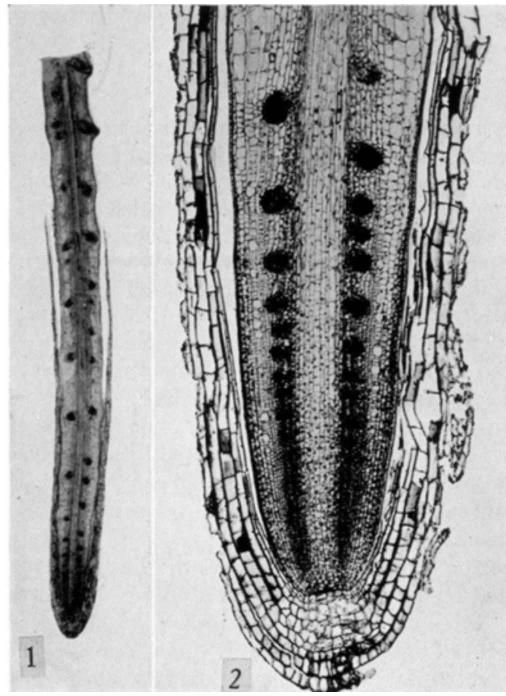

Fig. 1 (left). Longitudinal section of root of *E. crassipes* for a length of about 7.5 mm. from the tip. × about 12.

Fig. 2 (right). Elongating tip of the same root shown in figure 1. × about 80.

similar development may occur in other members of the Pontederiaceae. For example Van Tieghem and Douliot (1888) make the following statement: "The lateral rootlets of *Pontederia cordata* originate in the growing point, very near the tip of the axis, and then toward the base pass obliquely through the cortex." They evidently saw the same type of development as that just described for *Eichhornia.* Further investigations may show it in other monocotyledons.

SUMMARY

The lateral rootlets of *E. crassipes* make their first appearance in the immature pericycle only a short distance from the promeristem, and not, as in most plants, in mature or nearly mature tissue. They first show as a series of closely spaced cell enlargements which become more distantly spaced as the tissue matures and the root elongates.

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THE REGULARITY OF MEIOSIS IN MICROSPOROCYTES OF TRIFOLIUM REPENS [1]

Sanford S. Atwood and Helen D. Hill

In planning and pursuing a practical breeding program with any species it is useful to have some previous knowledge of the regularity with which the chromosomes pair and disjoin. Such observations are now available for relatively few species and should be especially interesting for white clover, since it is a tetraploid. The somatic number of 32 was reported for white clover by Karpechenko (1925) and Wexelsen (1928), while the reduced number of 16 was reported by Kawakami (1930) and Senn (1938).

Materials and methods.—The 11 plants used in this investigation came from 11 seed collections made by cooperating agronomists in Maryland, Michigan, New York, Oregon, West Virginia, and New Zealand. Ten of the plants were considered representative of certain of the types of white clover occurring naturally in pastures of the northeastern United States; the other was Ladino clover (L 14 (3) in tables). The plants were selected from a nursery of nearly 10,000 individuals as representing a wide diversity of morphological types in respect to such characters as spread, height, density, amount of flowering, and size of leaves and stolons. When slips from these plants flowered in the greenhouse during the spring of 1938, fixations for this study were made.

All fixations were with modifications of Navashin's fluid. In the eight modifications of "A" solution tried, the per cent of chromic acid varied from 0.7 to 1.5 and of glacial acetic acid from 7 to 15. Likewise, eight modifications of the "B" solution were used with per cent of commercial formalin varying from 20 to 80. Several combinations of these 16 modifications gave equally satisfactory fixations. Much more critical in determining quality of fixation was the pretreatment used. The best results were obtained by prefixing for about a minute in Carnoy's solution or a modification of it and then immediately sinking the buds in the fixing fluid by exhausting the air from the vial by means of a vacuum pump. After being in the fixative for about 24 hours, the buds were washed in several changes of 70 per cent alcohol. Following the usual dehydration, the heads were cleared in cedar oil and embedded in paraffin. Serial cross-sections of the entire heads were cut at thicknesses of 12 to 15 microns and were stained with Heidenhain's haematoxylin.

[1] Received for publication May 31, 1940.
Contribution of the U. S. Regional Pasture Research Laboratory, Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, in cooperation with the Northeastern States.

Table 1. *Number of microsporocytes showing regular or irregular chromosome pairing at diakinesis and heterotypic metaphase. (See text for description of irregularities.)*

	Regular pairing—16 bivalents					
		Heterotypic metaphase				
Plant number	Diakinesis	Polar view	Side view	Total	Irregular pairing	Total
2 (25)	1	36[a]	37[b]	74	One side view, IM: $15_{II} + 2_{I}$	75
8 (4)	1	27	16[a]	44		44
12 (7)	..	41	45	86	One polar view, IM, questionable	87
15 (31)	44	50	17	111		111
35 (19)	10	56[c]	..	66	Two polar views, IM, questionable	68
35 (38)	..	7	10	17		17
44 (23)	..	5	1	6		6
49 (52)	6	22	..	28		28
62 (111)	..	32	16	48		48
62 (177)	3	31	71	105	One side view, IM, questionable	106
L14 (3)	..	20	..	20		20
Total	65	327	213	605	Five (including 4 questionable)	610

[a] Includes one with precocious disjunction of one pair.
[b] Includes two with precocious disjunction of one pair and two with precocious disjunction of two pairs.
[c] Includes two with precocious disjunction of one pair.