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MAMMOTH CLOVER RUST¹

W. H. DAVIS

Before the work of Liro, there was thought to be but one clover rust. He proved the rust on white clover to be autœcious and it was classified as *Uromyces trifolii-repentis* (Cast) Liro. It has been shown that the rust on red clover is also autœcious, having all four stages on red clover, and it is generally classified as *Uromyces trifolii* (Hedw. f.) Liro. The rust on alsike clover is autœcious, having all the stages, and was classified as *Uromyces hybridi*, Davis, in Vol. XXIV, Iowa Academy of Science, 1917.

The disposition of the rust on mammoth clover is not clear. Morphological examinations of the spores have caused taxonomists to assign this rust to the species on red clover or *U. trifolii* (Hedw. f.) Liro, but no inoculations have been made to prove this supposition. The teliospores and urediniospores of the rusts on the red and mammoth clovers are similar in size and in number of germ pores together with other structures. An æcial stage has not been reported on mammoth clover; it is taken for granted that only the uredinial and telial stages of red clover rust are found on the mammoth by using the mammoth as another host. Thus three important questions arise:

1. Is the rust on mammoth clover the same as that found on red clover?
2. Is an æcial stage found on mammoth clover?
3. Is this an autœcious or heterœcious rust?

With these questions in mind, the solution of this problem was started in the fall of 1918. Herbarium specimens of rusted clover plants of different species were collected. The winter being very open, plants could be dug from out of doors and repotted at various times. The plants were placed in the greenhouse and the rust harbored all winter.

The æcial stage, æciospores and pycnia.—Plants of mammoth clover were repotted from out of doors on December 9, 1918.

¹The usage of the common and species names are as follows: White clover, *Trifolium repentis* L.; Red Clover, *Trifolium pratense* L.; Alsike, *Trifolium hybridum* L.; Mammoth—a species of red clover, generally classified as *Trifolium medium* L. Leaflets hairy, entire, spotless, notched at tip. Stipules mostly smooth. Stems larger and taller than red clover.

Several blades and petioles bearing æcia and pycnia, on two different plants, were discovered on January 13, 1919. A red clover plant brought in on the same date (December 9, 1918) bore æcia on January 15, 1919. These materials were used for inoculations,

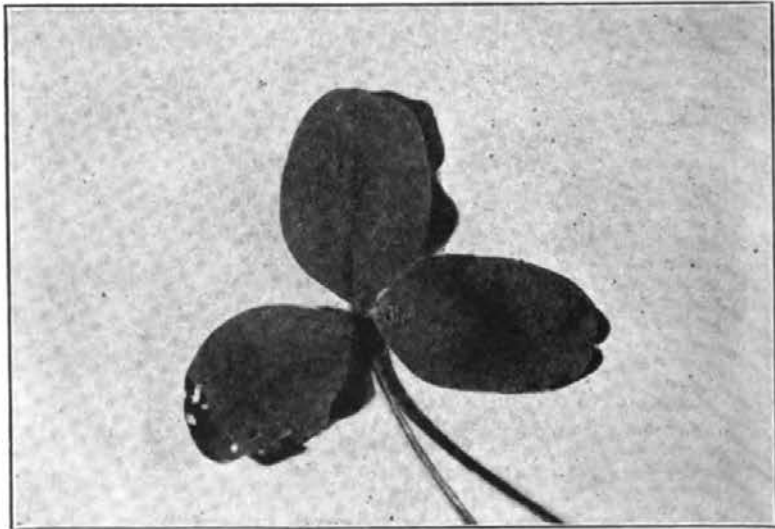


FIG. 84.—Æcia on a leaflet of a transplanted plant. (*T. medium* L.)



FIG. 85.—Æcia magnified about one hundred and seventy-five times, showing the nature of the peridial cells (recurving). (*T. medium* L.)

spore examinations and germinations, for imbedding and other work. Aeciospores allowed to fall in a drop of tap water on a glass slide, germinated 98 per cent in 24 hours. Some germ tubes were 0.7 mm. long. Measurements of aeciospores mounted in water were as follows: 16-26x16-28 microns. Standard 20x24 (thirty

PERIDIAL CELLS
MAMMOTH CLOVER
RUST - CAM. LUC. DR.
W.H.D.

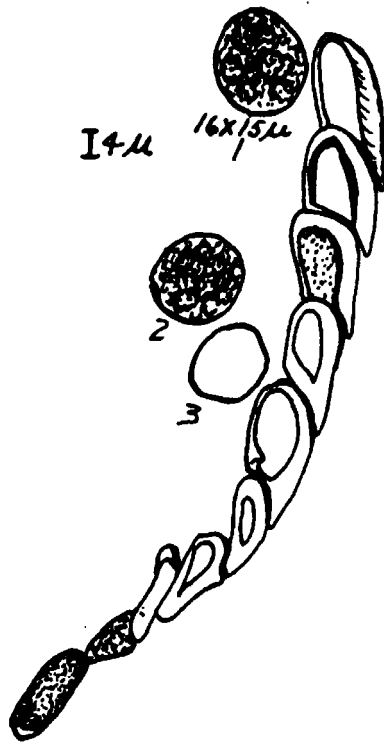


FIG. 86.—Peridial cells drawn from a prepared slide. Outer walls averaged 4 microns, inner walls, 2 microns. The upper cell was the only one on which striations were observed on the outer wall.

measured). This would tend to show the aeciospores of red clover rust are larger than those on mammoth clover. These spores are shown in figures 84 and 85, also in figures 86 and 87.

Urediniospores.—Urediniospores collected October 10, 1918, germinated by February 13, 1919, about 75 per cent. Those on the stems seemed to retain their vitality longer than those on the leaves. On February 20, 1919, but two of the spores on the leaves germi-

nated. One specimen showed the life of urediniospores on leaves in a dry, warm living room to be 55 days. A rusted mammoth clover plant retained the uredinial stage in the greenhouse all winter until April 2 when it was entirely dead, probably due to the rust as others not rusted were in a healthy condition.

Urediniospores mounted in lacto-phenol and examined after standing one week showed plainly 5 and 6 germ pores scattered.

*AECIOSPORES FROM AECIA ON
MAMMOTH CLOVER
CAMERARUCIDA 1-16-19 HY*

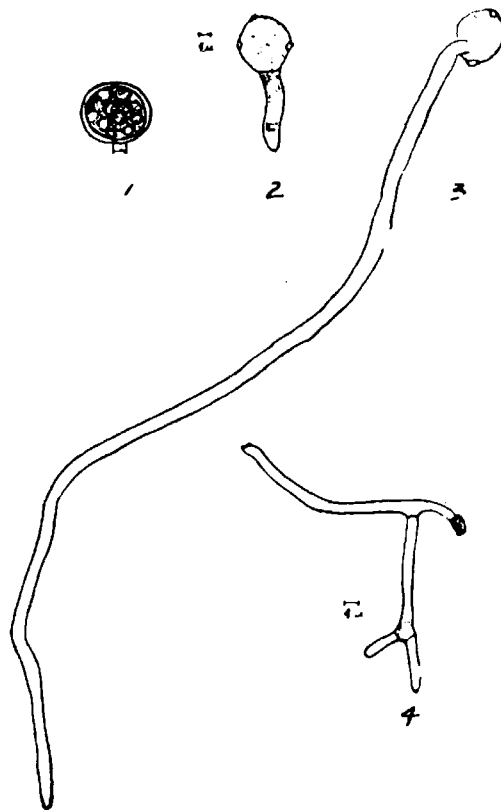


FIG. 87.—These germ tubes averaged 4 microns in diameter. Taken from a transplanted plant, December 12, 1918. Drawn after standing twenty-four hours in water. Number 4 shows a germ tube branching.

The number of germ pores varied from 5 to 7, thus following the rust on red clover in this respect. The spores are ecinulated and fifty projections were counted on one side of one spore. The spores are shown in figure 88.

The measurements of the spores varied slightly from the urediniospores on red clover but the variation is no more than could be expected between the measurements of any two spore samples.

Taxonomists, in general, regard the measurements as about the same.

Teliospores.—Teliospores from a collection of November 14, 1918, were set to germinate on January 2, 1919, and had germinated

GERMINATING UREDINIOSPORES
 RUST ON MAMMOTH CLOVER
 12-10-18.
 CAMBRALUCIDA.
~~ED~~

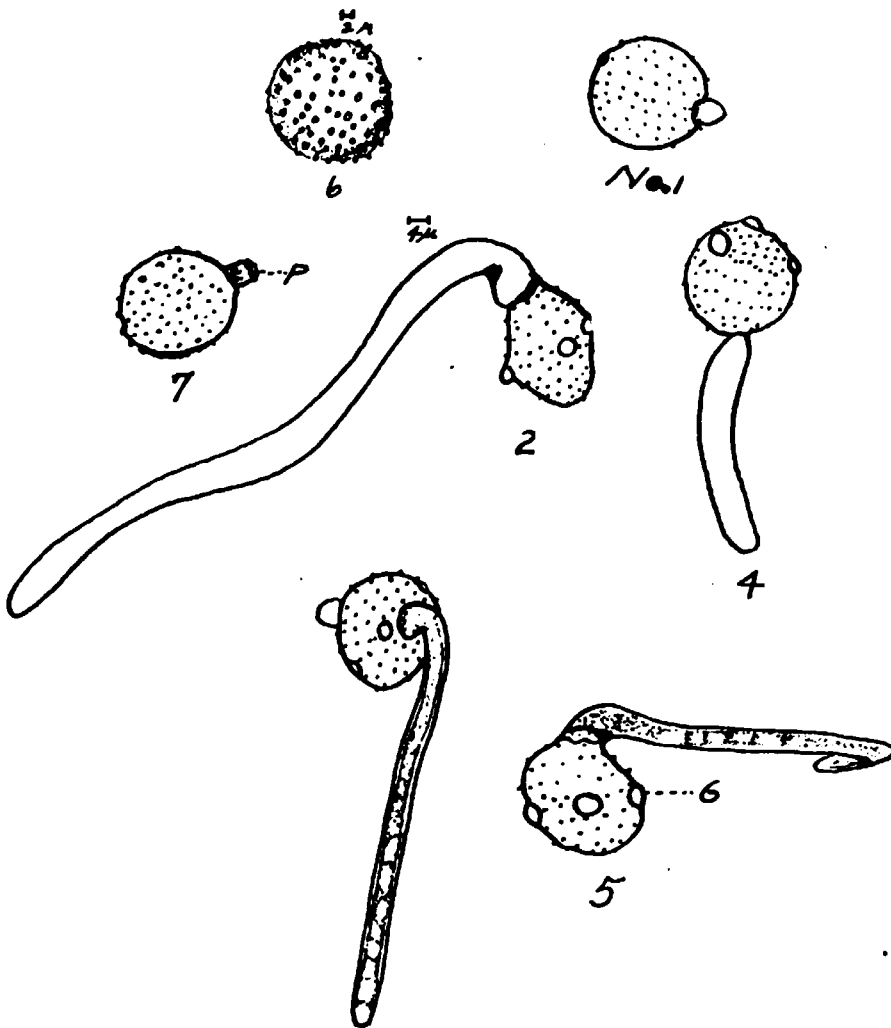


FIG. 88.—These spores averaged 22 by 24 microns. Drawn after being twenty-four hours in tap water. P=Pedicle. Number 5 shows uredinia at the time of opening (magnified).

40 per cent on January 12. Germinating teliospores are shown in figure 90, numbers 4 and 5.

Teliospores mounted in water and measured gave the following: 16-20x22-32 microns. Standard 18x24 (thirty-five measured). The teliospores on red clover measured 12-18x18-25 microns, on white clover 17-19x22-26 (thirty measured in each case). Thus it would appear that the teliospores on mammoth clover are larger but this fact is not of much importance since taxonomists differ so much in reporting spore measurements for these rusts. The following

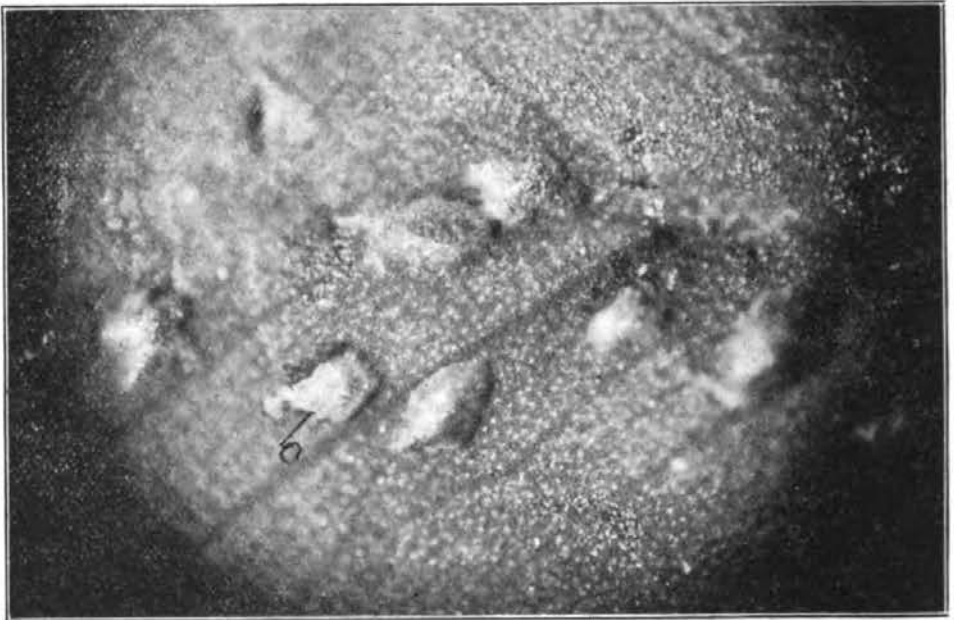


FIG. 89.—Uredinia opening.

table will show the measurements given to teliospores on different hosts by different authors. Germinating teliospores are shown in figure 90, numbers 4 and 5. D=A germinating sporidium.

Host	Arthur	Saccardo	Sydow	Howell	Davis
<i>T. repens</i>	13-19x20-29	15-22x20-35	16-25x18-30	15-20x20-28	17-19x22-26
<i>T. pratense</i>	16-20x20-27		16-25x18-30	16-20x27-35	12-18x18-25
<i>T. (medium)</i>	Do.		Do.	Do.	16-20x22-32

All measurements in Microns.

As the rust on *T. repens* L. is treated by most of these authors as that on *T. medium*, this would complicate matters still more. The teliospores conform to the shape, structure and color of the rusts on white and red clovers. There seems to be no safe basis on which to separate the species on examination of teliospores.

Peridial Cells.—Five different sections of leaves from two different plants of mammoth clover bearing æcia, were killed in Flem-

ming's and in Gilson's solution, imbedded, cut, stained and the peridial cells examined for morphological differences. The inner walls are minutely verrucose like the other clover rusts, striæ could be found on the outer walls. The inner walls of the peridial cells were so thin that difficulty was experienced in sectioning them.

TELIOSPORES OF MAMMOTH CLOVER RUST—W.H. DAVIS.

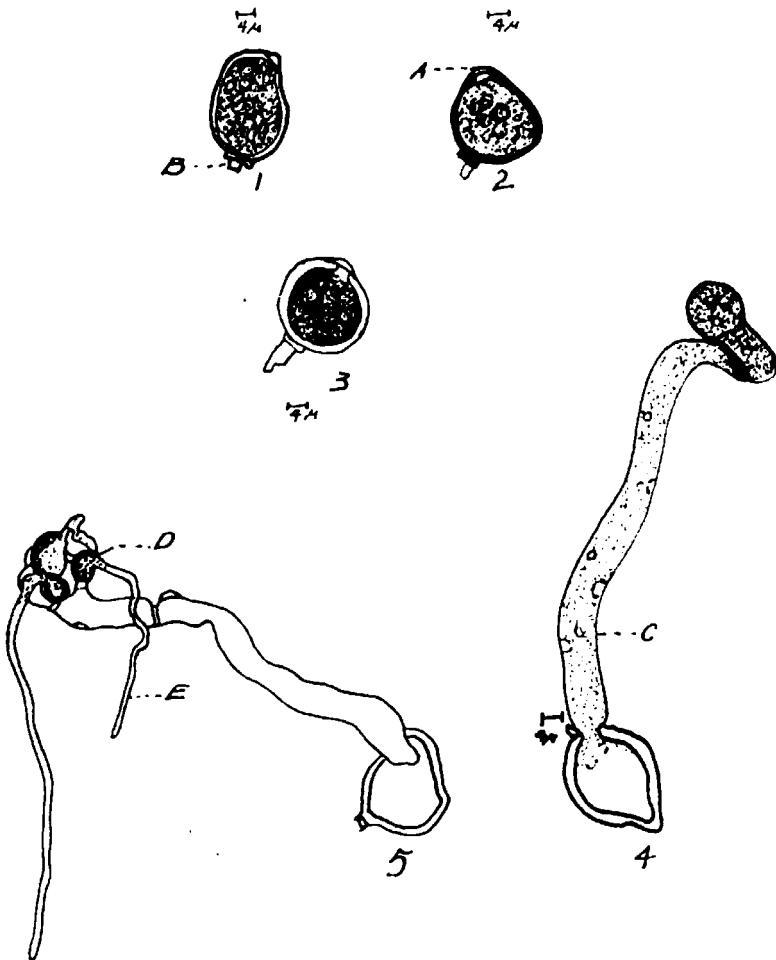


FIG. 90.—Numbers 4 and 5 are germinating teliospores which have stood in tap water for two weeks. In number 5 D=sporidium germinating.

Measurements of sections of the peridium showed the inner walls to average 2 microns thick and the outer walls, 4 microns thick. The inner walls of the peridial cells of red clover rust are 3 microns; outer, 6 microns. Of alsike, inner, 1 micron, outer, 3 microns. Thus it would seem that the peridial cell thicknesses conform closer to those of alsike clover than to red clover rust. The peridial cells are

Inoculations.—The following table will show some of the principal inoculations and spore sowings made together with the results.

TABLE OF INOCULATIONS ON CLOVERS.

NUMBER	SPORES USED	DATE OF SOWING	HOST	NUMBER LEAVES	DATE	RESULTS NUMBER INFECTED	REMARKS
1	II from White	10-28-15	Mammoth Red	10	11-14-15	0	
2	II from Red	10-28-15	White Mammoth Red	10	11-14-15	0	
4	I from White	11-15-15	White Mammoth Red	10	11-28-15	7	
5	I from White	11-15-15	White Mammoth	10		10	
41	II from Mammoth	12-16-18	Mammoth Med. Red	5		0	Same as Number 2
42	I from Mammoth	1-13-19	White Alsike	5	1-3-19	4	I Dead. Not rusted
43	I from Red	1-13-19	Mammoth Med. Red	5		4	3 highly; 1 clear
	I from Mammoth		Mammoth Red	5	2-3-19	0	One dead
	I from Mammoth		Mammoth Red	5	4 wks.	0	One dead
	I from Mammoth		Mammoth Red	3		1	4 leaves dead
	I from Mammoth		Mammoth Red	3		3	
	I from Mammoth		Mammoth Red	2		2	
	I from Mammoth		Mammoth Red	4		4	
	I from Mammoth		Mammoth Red	4		1	3 dead

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The rust on mammoth clover was transferred to red clover only and the rust on red clover transferred to mammoth through the aeciospores and urediniospores of each.

SYNONOMY.

(Referring to the rust on *T. pratense* L.).

1. *Uromyces trifolii* (Hedw. f.) Lev. Monographia Uredinarium 2:133.
2. *U. trifolii* (Hedw. f.) Lev. The British Rust Fungi. Grove, p. 92.
3. *U. fallens* (Desm.) Kern. Danish Fungi. Lind, p. 338.
4. *Nigredo fallens* (Desm.) Arth. N. Am. Flora 73:255 Arthur.

Note—Synonymy prepared by Dr. J. J. Davis, Wisconsin University.

Causal Organism.—The causal organism is probably *Uromyces trifolii* (Hedw. f.) Lev. and all stages are found on mammoth clover. There is not enough definite proof to establish a new species.

CONCLUSIONS.

1. This rust on mammoth clover may be transferred to red clover.
2. The rust on red clover may be transferred to mammoth clover.
3. All stages of the clover rust may occur on mammoth clover.
4. The rust can not be transferred to alsike and to white clover.
5. There seem to be morphological differences between this rust and the rust on red clover.
 - (a) Sizes of the different spores.
 - (b) Thickness of peridial cells.

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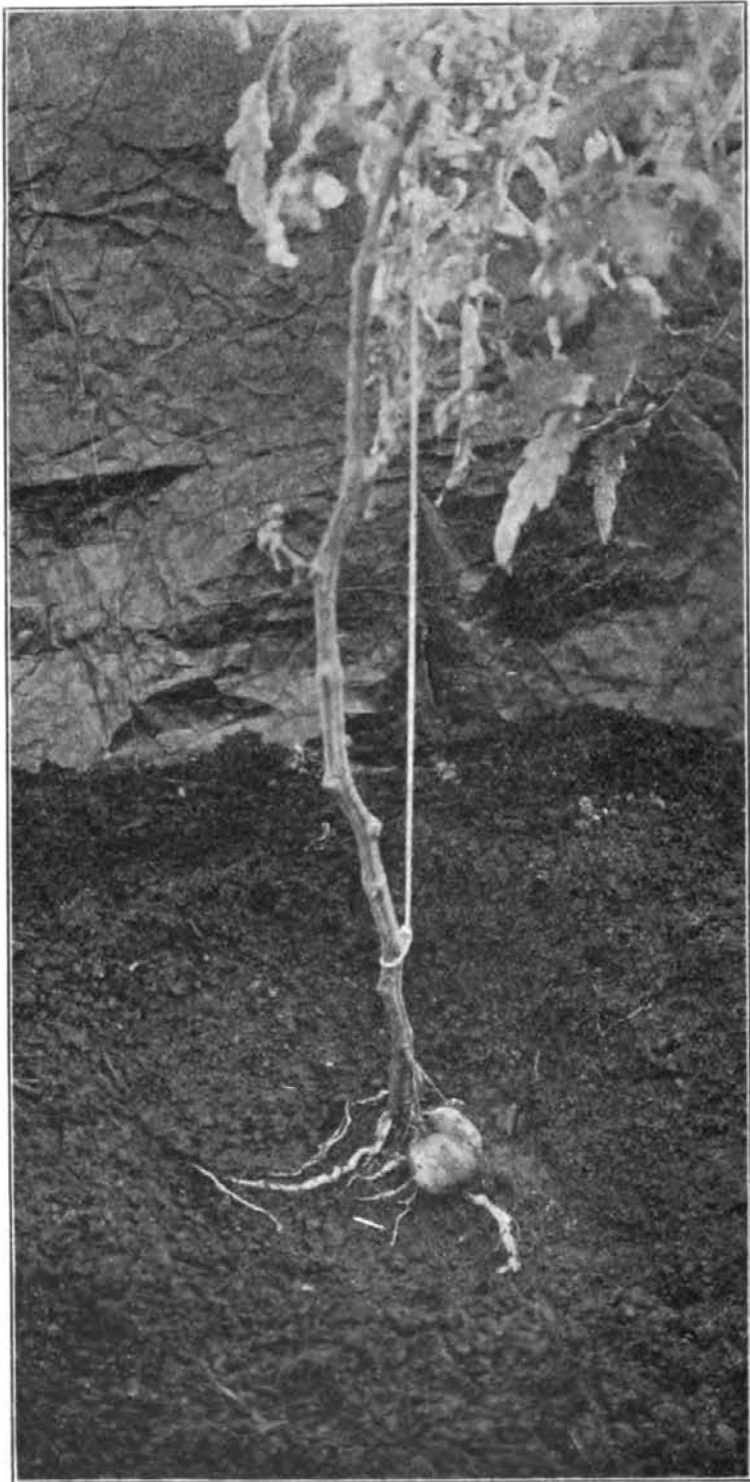


FIG. 91.—A subterranean tomato. This tomato was a Field's Red Head, grown in the greenhouse, started in the fall of 1918. On February 12, 1919, while Mr. Robert Billings was working the soil around the roots he called my attention to the formation of the under-ground tomato. The photograph was taken three weeks later.