KANSAS USTILAGINEÆ

A Study of the Kansas Smuts especially with regard to Germination

J.R.S. Nelson
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Contents

Introduction
Life history of the order in general
Generalisation
Infection of the host plant
Vegetation
Formation of teleutospores
The Kauri species
Number and kind
Distribution
Explanation of objects and methods
Object of studies
Material used
Culture media
Apparatus
Drawings
Nomenclature

I. Ustilago
2. U. Ischaemi, Fuck.
5. U. laevis, (K行程) Magnus
7. U. nerva, (Jeuwwy) K. + S. 12
8. U. friilei, (Pers.) Jeuww. 12
9. U. aristidae, Reck. 12
11. U. vilari, Wint. 13
12. U. rabinovitschiana, Kühn. 14
13. U. rupiniana, Kühn. 14
14. U. neglecta, Neipel. 15
15. U. miles, zeai (DC.) Magn. 16
16. U. cesalii, Forch. & lebed. 16
17. U. minutulosa, (Nees) Jul. 18
18. U. androsovicus, K. + S. 18
19. U. bouleleca, K. + S. 19
20. U. punctatula, Tryon & Earle. 20
21. U. filamentula, K. + S. 20
22. U. minor, K. + S. 22

II. Tillelia.
23. T. foelana, (B. + C.) Schodt. 23
24. T. friilea, (Bjerk.) Wint. 24
25. T. Buchleheana, K. + S. 24
26. T. rotundata, Ell. + Ed. 25

III. Entlytoma
27. E. Compositarum, Farlow 25
28. E. Menisperm, Farl. + Trel. 24
29. E. Physalis, (Kalchbr + Coste) Wint. 26
II. Dracaena.
30. D. Aliumula (Naeq.) Comm. 24

T. Sisymbrium.
31. S. albus Pfeif. 27
32. S. cucullatum, Schlecht. 27

IV. Urocyclis.
33. U. Anemoneis, Pers., Schmidl. 27

Bibliography. 29
Explanation of Plateus. 30
Platus.
Kansas Ustilagineae.

The Ustilagines are among the most important fungi to man, economically. Millions of dollars are lost annually on account of their ravages among the cultivated crops. The study of their life history has been of great material value to agriculture in providing means of invention.

To science this group is also of interest from its peculiar position in the system of fungi, and because of the lack of knowledge relating to it and the difficulty of studying it, especially certain parts of the life history. Although several prominent botanists have put the better part of their efforts into the study of this order, the facts offer a vast store of knowledge yet unexplored.
About twenty genera of the Helicogonaceae have been distinguished. Magnes having recently added one and Breseld two. These are separated principally on the manner of production, aggregation, and germination of the spores.

Briefly the life history is as follows. The spores germinate in water or other liquids, producing a tube which is an elongation of the inner wall of the spore which, increasing in size by taking up water, breaks through the outer wall, or perhaps sometimes passes through a "pore pore" in this wall. This tube is called the prorogonium, is usually limited in length, and with a supply of nutrient material in the water, or to some extent in water along leads off conidia at the end or sides. These conidia may go on budding off.
Other conidia indefinitely in the manner of yeast. Feces of the conidia and unions of different cells in various ways are found in many of the species.

When the supply of moisture is limited the promycelium or conidia that have been produced grow out into long "gamet tubes" usually septate and the protoplasm following the end. Often long chains of conidia are produced in the air.

These gamet tubes penetrate the young tissues of the host plant usually in the early part of its life. The mycelium develops from this and grows throughout the host, finally producing its spores in the tissues of the host plant, usually in the ovaries or some part of the inflorescence.

The Vittilaginaceae in Kansas are represented by the
Grum Metilago, Tillita, Entilona, Nodicoriom, Urocyli of Doltsanria.
The above genera are arranged in order of their number of representing species in the State. For the greater number of our thirty three species belong to the genus Ustilago.

Scarcey enough data have been collected to show much regarding the distribution in the State. I have given the localities known except where the species is a very common one. Almost no work has been done on the fungi of the state, or any other fungi for that matter except by the botanists of this College and Mr. Elane Bartholome of Roots Co. Almost all the species we have are from Riley and Roots Counties. I have endeavored to obtain some information from other institutions of the state but they give little or no attention to this phase.
A few words on explanation of the methods of research, etc., in these studies will be necessary. The study has been primarily on the germination. The list has also been arranged to show what species are known to occur in the state and something of their distribution. Other observations of more or less indirect and importance have been included, especially the effect of the fungus on the host plants.

In the limited time that has been put on the subject, scarcely a beginning could be made, and the principal thing learned in the spring's studies is that there remains a great amount of work yet to be done before the subject I have taken up can be called anything like complete.

The advantages offered by the excellent collections of U.S.
against in the College herbarium, and the other library, abounding in works on plants are almost as good as I could wish for.

The material used for germination I have collected mostly about Manhattan during the last two years.

The germination cultures have for the most part been made in hanging drop culture. A drop of the culture medium is put on the lower side of a cover glass sealed with vaccine to the stop of a chamber formed by gluing a glass ring to an ordinary microscope slide. This miniature damp chamber allows the necessary air for germination, prevents evaporation, and at the same time the culture may easily be observed with the microscope. The cultures were kept in a large moist chamber to keep a more equal temperature and supply of moisture.
The temperature of the room has not varied much from 70 \degree F.

Cultures of most of the smuts have been made both in water and in the modified Cohn solution used by Fellman and Twingle for the same purpose. Usually each culture of corn smut were made with the others in order to detect anything wrong in them. The corn smut being common and its germination well known it was well adapted to be used as a standard.

The most of the drawings have been made with a magnification of 1000 diameters given by a 2 mm oil immersion objective and a ocular with a Zeiss microscope, tube length 14, and an Abbe camera lucida. The drawings have been rather carefully made and are not intended simply to illustrate the written work, but to be equally prominent with it. Indeed they may show mor
than I have attempted to write. The nomenclature and synonymy I have not worked out to any great extent, and the list is not arranged exactly according to any system. The names used are mostly those used by Besconds in his Syllogum Fungorum, and the arrangement is much the same, with the newer species added at the end.

I have not considered it necessary to give descriptions of the species or to give armamentation studies of other investigations when I have not repeated them myself.
Ustilaginae

I. Ustilago


Common on species of cultivated Sorghum; on Kaffir corn, Manhatten (Keliman); on broom corn, Philipsburg; also reported from other places on the latter.

The spores germinate in water in a few hours, produce proplasmidia 20-35 μ long and about 1 μ wide. In many cases where the water supply was not so abundant, long germ tubes narrower than the proplasmidium were produced, 500 or more μ long, the protoplasm following the end and the remainder of the tube divided by septa into cells about three diameters long. Skeletal joints occur in abundance and a few bow joints. Conidia few.

On modified Corn Solution
Each germinated spore is soon surrounded by a mass of extensively branched promycelia bearing many conidia. No germinations or fusions until the solution becomes exhausted, then long threads grow out from the promycelia, and from the conidia.


In the deformed inflorescence of Andropogon furcatus. The stems are shortened and the smutted flowers enclosed in the upper leaf sheath.

I have not tried germinating the spore as all my material is several years old. The specimen are from Mr. Bartholomew, of Rooks Co. He says the smut is undoubtedly phenorical. Figures of the germination are given in Fries, Untersuchung, T. p. 96. t. 11. fig. 1-2.

argentine IV, n. 45 (Plate I, fig. 10-13)
Forming large hard masses in the inflorescence of Polygonum Pennsylvanicum, Pity and Republic counties.
The germination in water begins after a day or two and proceeds slowly. The promycelgia are frequently branched and irregular. Conidia few.

Common on Oats.
The germination of this species and the other small grain smuts (U. larvis, U. Hordci, U. xuida, and U. Tritici) have been quite fully studied and described by HELLERMAN and SWING at the second Annual Report of the Kansas Experiment Station.

Also on oats but not so...
Common as the above.

   On Barley, Manhattan.

   On Barley, Coatsidge.

   On wheat, common all over the state.

   XII. p. 315. (Plate I. fig. 1-35.)
   On Aristida (pennisetum?). Hodg.
   man and Ellis Counties. The spike
   fills the ovaries, and the awns are
   much shorter than usual, som-
   times almost absent.
   Germination in water begins almost immediately. After
   four hours, 10-12 μ was produced.
   This grows rapidly for 8 or 10 hours.
until 30-40 μ long, then a conidium is formed at the end. Three or four septa appear in the mycelium, and a part of the protoplasm in each cell thus formed passes into a conidium at its upper end, leaving a vacuole at the end next the spore. The conidia soon become detached.

In modified Cohn solution the germination is very similar, but slower and more vigorous.


On Ergotritis major, Riley

comly.

Attempts at germination unsuccessful.


On Aporotoclav vaginiflora.

Cultures of spore failed to germinate.
12. U. RabinhorRiana, Kühn, Hedwigia, 1874, p. 41. (Plate IV, fig. 79.)

Common in the inflorescence of Panicum tenuiflorum. Every head on the smutted plants is usually smutted, a good evidence of early infection. The smut dwarf the host plant and causes it to branch more than normally. Growth vigorous and irregular in modified Cohn's solution. No conidia. No germination in water.

This species has been confused in Kansas with U. Creatii. The spores are larger, thicker walled, and older brown, and much more pulverulent in the mass of spores.


On Sorghum sp. Manhattan.
On Zea Mayz, Riley, Morris, Saline, Gray, and Jewell Counties. Rather common.
I have already described
The general appearance and the effect on the host plant in a note in the Botanical Gazette, October, 1875.

Germination after 24 hours in water. The promycelium is medium sized, grows little and bears few conidia.

In modified Colon solution germination takes place after two or three days. The promycelium is almost as wide as the spore at the base, and bears large yeast-like colonies of conidia. The conidia are short and oval.

The spore is aggregated in masses and this species seems to be a good Asterotheca, but until further study of the development I have left it here.

No. 1200.

On Astaria glauca. Manhattan. The snail does not affect the outward appearance of the
Host plant except to slightly enlarge the grains. Attempted germination unsuccessful.


Germination in water begins in 18-24 hours. The promycelium is thin or four-celled and often bears numerous conidia, usually live to four. The conidia are fusiform and usually easily detached. The whole promycelium is often detached a short distance from the spore in a few hours after production. Air conidia are abundant in dryer cultures.


On the greatly enlarged ovaries of the whole inflorescence of **Cus**-
Chama Tribuloides, all over the state, (Plate III. fig. 11-13); Paniceum capillare, Manhattan, (Plate I, fig. 14-17); P. prolif-erum, Manhattan, (Plate III. fig. 8-10, Plate IV. fig. 3-8); Andropogon scoparius, Mana-hattan, (Plate I, fig. 6-8).

The stems of the host plant are shortened and the enlarged ovaries project or are enclosed by the upper leaf. If the plant is not badly affected, the glumes and other floral organs grow out into long leaf-like bodies sometimes two or three inches long.

The germination in water is difficult. On lin or Fifteen cultures in water only a few sprout germinated. The germination in Modified Corn Solution takes place in one or two days, almost always sooner than it does in water.

The promycelium is usually a sinuose and often branching tube of no very great length. Sometimes it is short and may then
produce a few conidia, which are short and oblong. Germ tubes are frequent and some fusions between adjoining cells take place.

It is very probable that further study may make two or even three species out of this, but for the present I have placed them together. The germination of the spores from different host plants is different, but enough cultures have not yet been made to establish any thing as constant.

   Veronica, R. Repeated attempts at germinition unsuccessful.

   Common in Andropogon furcales, from several places in
The rust causes the host plant to flower several weeks earlier than it normally does, and the affected plants are about half as high as the healthy ones.

No germination in water.

In modified Cohen solution, the spores germinate after two or three days, but produce only an undivided and unbranched tube, and of moderate length. No conidia.

Two years ago some germinated well in normal solution and produced abundant short thick conidia.

19. U. Bouteloua, Kell. and Swing. from N.Y.

1889. p. 12. (not figured.)

In ovaries of Bouteloua

Algastrachya, Brooks and Riley County.

Germinates in water in about 12 hours. A short promycelium is produced in a few hours, and
soon bears a small conidium on the end and then a few lateral ones. The conidia are short and sometimes stalked. It may be that several conidia are produced in turn from the same point on the promycelium, as numerous conidia were floating in the water near budding promycelium.


Attempted germination was unsuccessful.

21. U. filamentos. U.S. (Plate I, fig. 1, 2, 4-6, Plate IV, fig. 1, Plate VI, fig. 1-4)

On Butelona racemosa and Agyrostachya, Riley and Whitehead Auct.

Producing roundish protruding swellings ½-2 mm wide and 1-12 mm long on the leaves and sometimes some of the host plant. Spores irregular.
by angled, sub-globose, dark yellowish brown, rather opaque, black in mass, minutely echinulate. Contents granular, 13 x 16 µ in diameter.

The germination in water in favorable cases begins in about 12 hours. The usual manner is to form long septate tubes (about 300 µ long). The cells 2-3 µ x 4-10 µ) which grow rapidly in length for two or three days, these produce a few conidia and usually branch some. The branches near the edge have a tendency to grow backward in a peculiar manner.

In nutrient solutions more abundant conidia are produced. These vary from fusiform to almost spherical. Chains of air conidia were sometimes seen. These conidia vary in length like the others but are usually shorter. The conidia are at first smaller at the apex, they end off secondary conidia at the end grow longer and fuller.
and finally become septate, the whole chain of conidia forming a long irregular branch of short thick cells bearing small conidia at the nodes. (7f. 9, Plate 2). In old cultures some of these cells become enlarged and rounded as if they were attempting to form diphtelospores.

The smut has been found well developed the last of April and is probably parasitic in the underground parts of the host. Pastures have been found on the leaves just emerging from the ground. The affected plants readerily rott and up flower stems but when they do the smut may occur in some of the flowers or at the base of the spicatelets.

22. U. minor, U.S. (Plate I fig. 3 ii, fig. 2 ii, 6 ii). On leaves of Portulaca vinculata. Manhattan, 1875.

Much like the preceding, but spores much smaller (8-9 μ). Contents.
less homogenous, frutules on level plane fewer and larger.

On account of lack of fresh material none of the sports germinated in my cultures this spring. From the few that were germinated two years ago, the germination seems to be about the same as U. filicina.

I have examined a great number of the three species of Bouteloua growing together here, where B. oligocephala and racemosa were much swelled, and in almost every case bisexuality was four from single.

II. Jilelia.

Common on Wheat (Triticum spp).
A few spores of this and the next germinated in water after about a week. Conidia produce fasciculate on the end of the promycelium.
On Wheat (*Triticum sp.*) Rocks
and Gravel Counties.

In ovaries in the normally
staminate spikelets of *Buchloea decen-
ylobides*, Jewell Co. (Miss Dalie), Burns
and Ford Counties (Welleslen and
Swingle).

In the early part of last
year while making some gemina-
tion lists preliminary to infection
experiments with corn smut, a cul-
ture of *T. Buchananii* was made
on a glass slide in a moist cham-
ber, from material collected
in Jewell Co. The previous summer.
This year I have not succeeded
in getting the same material to
generate. Unfortunately no draw-
ings of the first were made and
only the following note, "After 9
days, germination good, some
show the characteristic conidia
of *Tilletia*."
26. T. rotundata, U.W. W.
    Collected this year in overflow of Panicum virgatum, Manhattan, and on herbarium specimens collected by Joseph Henry at Salina in 1886. Attempted germination unsuccessful.

III. Entigloma

Owing to lack of suitable fresh material no germination studies of this genus were made.

    On leaves of Ambrosia silvatica, Riley and Clay Counties; Bidens Elginiana, Elgin County, Ontario; Abrotsch Lameskii, Rook Co.; Senecio Balsamite, Riley.

    Common on leaves of Menispermum Canadense.
   Hedwigia, 1883, p. 130, and 1887, p. 8.
   On Solanum nigrum, Riley.
   Co.; Physalis pubescens, Riley Co.; P. longifolia, Rocks and Riley Counties.
   Probably on other Solanaceae in the state.

IV Dossansaeea.

I have not accurately identifying the material we have of this genus, and having no fresh specimens I have not attempted germination.

   Sec. II. Vol. XIV (1883) p. 286.
   On Alisma Plantago, Rocks and Saline Counties, and D. Sagittariae variabilis, Riley Co.
   The one on the last note may be D. Sagittariae. (1)

A Dossansaeea on Potamogaster is reported from Lawrence by Mr. W. G. Barber
of the Stata University, probably D. occulta.
V. Sorosporium


32. S. cuneatum Schu. 2nd Ed. W. Ulster Appx. Cat. Flora. N.Y. (Plate IV, fig. 5, 6). In enlarged slums and con-travel inflamecent of Solidago Missouriensis, Rodeo Es. and on old weathend specimen of Solidago of Manhattan. Germination in water begins in 12 days. More or less branch of tubes printed at the ends and replaﺦ, a few conidia and in dry cultures long chains of air conidia are produced.

VI. Urocystis

Ofl. 1877, p. 376.

On leaves of Aquavora Caroliniana. Roots Co. (Bartholomew)

No material for germination.
- Bibliography -

Arthur - List of Iowa Ustilaginaceae.
Webber - Rusts and Smuts of Nebraska.
Jellison - Fungi of Wisconsin.
Kellerman - Study of Farm Crops.
Kellerman and Swingle - Reports and Bulletins, Kansas Experiment Station.
Brefeld - Untersuchungen über die Brandpilze and other papers.
Fischer de Waldheim - Various papers on Ustilaginaceae.
Löhr - Papers on Smuts.
Winkler - Die Pilze.
Plowright - British Uredinae and Ustilaginae.
Saccardo - Sylloge Fungorum.
Just - Jahrbucher.
Magnus - Papers on Ustilaginaceae.

Various other journals, magazines, reports, and lesser papers.
Explanations of Plates.

Plate I. x 1000

Fig. 1-5, U. anietidae. 1. from edge of culture, Mod. Colus Sol. 2-5, in water.

Fig. 6-8, U. Cesalii on Andertegran spores in Mod. Colus Sol.

Fig. 9, Portion of old branch of U. filamenta from Bontelona oblique Tadaya in Mod. Colus Sol.

Fig. 10-13, U. anietidae americana in water.

Fig. 14, Spores in a mass of U. Cesalii on Parvum capillare germinating. The ends a and b curve downward toward the surface of the culture drop (water).

Fig. 16, Same culture, peculiar conidia.

Fig. 15 Same showing knee joints beginning to form between adjoining cells.

Fig. 17, Old promycelium with conidia, and germ tubes proceeding from knee joint at a and b. The former passing under a sperm mass at e.

Plate II.

Fig. 1-5, U. porphyri after 24 hours in water x 1200

Fig. 6-8, U. mays zea, germination after 24 hours
in water, from fresh material collected in August 10 days before germination.

Fig. 9, A portion of colony of budding conidia (U. maya gray) in Mod Color Sol. x 1200.

Fig. 10, Same species, old material after 48 hours in water, x 1200.

Fig. 11, 12, Dry plate cultures of same in moist chamber, x 370.

Fig. 13, air conidia from exhausted culture in maxium solution, x 2000.

Fig. 14-15, U. Reiliiana after 3 days in water, x 1200.

Plati III.

Fig. 1, 2, U. Cesalii on Cenchrus tribuloides, x 2000.

Fig. 3, Spores of U. Cesalii (2) in Andropogon, Sep.

Fig. 4, 5, Spores of U. Rabinhristiana on Pan-
icum sanguinale, x 2000.

Fig. 6, 7, Spores of U. Cesalii (3) on Panicum
proliferum, x 2000.

Fig. 8-10, U. Cesalii (3) on Panicum proliferum, germination in water, x 1000.

Fig. 11-13, Germination of U. Cesalii on Cen-
chnus tribuloides in mod. color sol.
after 3 days, x 1000.

Fig. 14-17, Germination of U. audiophonicus
after 3 days in Mod. Cohn Sol. x 1000.

Plate IV.

Fig. 1, Aporus of U. filamenta in Botryococcus
raceemosa, x 1000.

Fig. 2, Aporus of U. minor, x 1000.

Fig. 3, 4, Germination of U. cesatii (?) on Pann.
icum prolifera, after several
days in Mod. Cohn Sol., production of
gem tubers from the promycelium, x 1000.

Fig. 5, 6, Germination of Gastrosporum cuneatum
in water, x 1000.

Fig. 7-9, U. Rabinowskiana after 3 days
in Mod. Cohn Sol. Fig. 8, much
swollen promycelium from both end of
the spor, x 1000.

Plate V.

Fig. 1, U. filamenta afer 4 days in water
x about 800.

Fig. 2, Typical germination of U. filaments
in Mod. Cohn Sol., after 48 hrs. x 1200.

Fig. 3, Concomidio (U. minor) after
8 days in Mod. Cohn Sol., almost dry
at time of drawing. Spore and ends
of long filaments not shown. x 1200.
Fig. 4, 5. U. filiculenta beginning to germinate in water, after 15 hours, x about 1000.

Fig. 6. Germination of U. filiculenta in Mod. Colon Soil, after 4 6 hours. Not a very vigorous specimen, x 1200.

Plate VI. Natural size.

Fig. 1. U. filiculenta in inflorescence of Bouteloua racemosa.

Fig. 2, 3. Vertical appearance of U. filiculenta on B. racemosa.

Fig. 4. Same on B. oligostachya.

Fig. 5. Small portion of a plant of Bouteloua hirsuta with U. minor.