

LISTS AND KEYS OF THE CEDAR RUSTS OF THE WORLD ¹

FRANK D. KERN

Emeritus Professor of Botany, The Pennsylvania State University

These lists and keys have been prepared in connection with a monographic study of the cedar rusts (genus *Gymnosporangium*) of the world. It is the author's belief that such a presentation will be found to have value in the hands of other workers.

Gymnosporangium was described by Hedwig. f. in de Candolle (Lamarek & Candolle; Flore Francais 3rd Ed. tome 2, pp. 216 and 217). One species is autoecious (*G. bermudianum*) on *Juniperus*, two species have uredial stages (*G. nootkatense* in the United States and *G. gaeumanni* in Switzerland). With these exceptions the species are heteroecious and demicyclic. Most of the species where the life cycles are known have their aecial stages (form-genus *Roestelia*) on the members of the Rosaceae tribe Pomeae or family Malaceae (depending upon the classification used). Exceptions are *G. ellisii* on the bayberry family, *G. speciosum* on the saxifrage family, and *G. exterum* and *G. vauquelinae* on the rose family. A few are known only in the telial stage and several are known only in the aecial (roestelial) stage.

The species possess such variable characters that a generic description is difficult.

The aecia are chiefly roestelioid, i.e., with elongated peridia, cylindrical or cornute, dehiscent by apical or lateral rupture; the aeciospore wall is usually colored, with numerous scattered pores. The telia may be variously shaped, applanate or pulvinate, laterally compressed or wedge-shaped, or terete, sometimes irregular, and usually expand when moistened due to the gelatinization of the long pedicels. In most species there can be distinguished darker, thick-walled teliospores and lighter, thin-walled teliospores.

It is believed that the lists and keys are self-explanatory. The drawings and photographs are included not so much to present the characters of certain species but rather to illustrate the meaning of some of the descriptive terms. It seems needless to point out that this sort of effort has its limitations, however. It must be acknowledged that the keys are not strictly dichotomous and that final separations may be difficult or confusing. In any event a contribution is being offered toward the identities, relations, and ranges of the various species.

In the check lists citations are included for the 55 valid species in *Gymnosporangium*, and the 11 names of the form species known in the aecial stage only. A bibliography of publications on the genus *Gymnosporangium* is very long. These selected references are presented as an aid to those interested in the taxonomy of the genus:

¹ Contribution No. 288 of the Department of Botany and Plant Pathology, The Pennsylvania State University.

- Arthur, J. C. 1934. Manual of the rusts in United States and Canada. 1-438.
- Bernaux, Paul. 1956. Contribution a l'étude de la biologie des *Gymnosporangium*. Ann. Epiphyt. 7: 1-210.
- Crowell, Ivan H. 1940. The geographical distribution of the genus *Gymnosporangium*. Canad. Jour. Res. C. 18: 469-488.
- Cummins, G. B. & Ling, L. 1950. An index of the plant rusts recorded for continental China and Manchuria. Pl. Dis. Reporter Suppl. 196: 520-556.
- Cummins, G. B. & Stevenson, J. A. 1956. A check list of North American rust fungi (Uredinales). Pl. Dis. Reporter Suppl. 240: 109-193.
- Eriksson, J. 1918. Die Schwedischen Gymnosporangien ihr Wirtswechsel und ihre Spezialisierung. K. Svens. Vet-Acad. Handl. 59: 1-82.
- Fischer, Ed. 1891. Ueber *Gymnosporangium sabinæ* (Dick.) und *Gymnosporangium confusum* Plowright. Zeitschr. Pflanzenkr. 1: 193-208, 260-283.
- . 1895. Die Zugehörigkeit von *Aecidium penicillatum*. Hedwigia 34: 1-6.
- Grasso, V. 1956. I *Gymnosporangium* di alcuni boschi della Toscana e le loro forme piceo-ecidiche. Ann. Accad. Ital. Sci. Foresta 5: 21-89.
- Hiratsuka, N. 1936, 1937. *Gymnosporangium* of Japan. I. Bot. Mag. Tokyo 50: 481-488. II. 549-555. III. 593-599. IV. 661-668. V. 51: 1-8.
- Jørstad, I. 1942. Some cyprian Uredinales. Nytt Mag. Naturvid. B. 83: 191-229.
- Hylander, N., Jørstad, I. & Nannfeldt, J. A. 1953. Enumeratio uredinearum Scandinavicarum. Opera Bot. 1: 1-102.
- Kern, Frank D. 1910. The morphology of the peridial cells in the Roesteliae. Bot. Gaz. 49: 445-452.
- . 1911. A biologic and taxonomic study of the genus *Gymnosporangium*. Bull. N. Y. Bot. Gard. 7: 391-483.
- . 1960 [1962]. Changing concepts in the genus *Gymnosporangium*. Mycologia 52: 837-844.
- Prince, Alton E. 1946. The biology of *Gymnosporangium nidus-avis* Thaxter. Farlowia 2: 475-525.
- Tanaka, T. 1922. New Japanese fungi. Notes and translations—XII. Mycologia 14: 282-295.

CHECK LIST OF THE SPECIES OF GYMNOSPORANGIUM

(* The twelve species preceded by an asterisk known in telial stage only.)

- amelanchieris* Ed. Fisch. ex Kern. Bull. N. Y. Bot. Gard. 7: 443. 1911.
- asiaticum* Miyabe ex Yamada. Shokubutsu Byorigaku (Plant Pathology) Tokyo Hakubunkwan, M. 37, 9: 304-306. 1904.
- **atlanticum* Guyot & Malencon. Trav. Inst. Scient. Cherifien Ser. Bot. 11: 15. 1957.
- bermudianum* Earle in Seymour & Earle. Economic Fungi No. 249. 1893.
- betheli* Kern. Bull. Torrey Club 34: 459. 1907.
- biseptatum* Ell. Bull. Torrey Club 5: 46. 1874.
- clavariiforme* (Pers.) DC. Fl. Fr. 2: 217. 1805.
- clavipes* (Cke. & Pk.) Cke. & Pk. in Pk. Ann. Rep. N. Y. St. Mus. 25: 89. 1873.
- confusum* Plowr. Brit. Ured. and Ustil. p. 232. 1889.
- corniculans* Kern in Arth. Mycologia 2: 236. 1910.
- **corniforme* Sawada ex Hiratsuka f. Bot. Mag. Tokyo 50: 554. 1936.
- cornutum* Arth. ex Kern. Bull. N. Y. Bot. Gard. 7: 444. 1911.
- cunninghamianum* Barcl. Sci. Mem. Med. Off. India 5: 78. 1890.
- cupressi* Long & Goodding in Long. Bot. Gaz. 72: 39. 1921.
- davisii* Kern. Bull. Torrey Club 35: 507. 1908.
- **effusum* Kern. Bull. N. Y. Bot. Gard. 7: 459. 1911.
- ellisii* (Berk.) Ell. N. Am. Fungi No. 271. 1877.
- exiguum* Kern. Bull. Torrey Club 35: 508. 1908.
- exterum* Arth. & Kern in Arth. Mycologia 1: 254. 1909.
- floriforme* Thaxt. in Kern. Bull. Torrey Club 35: 503. 1908.

- *formosanum* Hiratsuka f. & Hashioka. Bot. Mag. Tokyo **49**: 21. 1935.
fraternum Kern. Bull. N. Y. Bot. Gard. **7**: 439. 1911.
fuscum DC. Fl. Fr. **2**: 217. 1805.
fusisporum Ed. Fisch. Mitt. Naturforsch. Ges. Bern **1917**: 73. 1918.
gaeumanni* H. Zogg. Ber. Schweiz. Bot. Ges. **59: 426. 1949.
globosum Farl. The Gymnosporangia or Cedar Apples of the U. S. p. 34. 1880.
gracile Pat. Bull. Soc. Mycol. Fr. **18**: 46. 1902.
harknessianum Kern ex Arth. N. Am. Flora **7**: 737. 1926.
hemisphericum K. Hara. Dainippon Sanrin Kwaiho (Jour. Forest. Soc. Japan) **419**: 16-18. 1917.
hyalinum Kern ex Cummins. Mycologia **48**: 603. 1956.
inconspicuum Kern. Bull. Torrey Club **34**: 461. 1907.
japonicum Sydow. Hedwigia Beibl. **38**: 141. 1899.
juniperi-virginianae Schw. Shr. Nat. Ges. Leipzig **1**: 74. 1822.
kernianum Bethel. Mycologia **3**: 157. 1911.
libocedri (P. Henn.) Kern. Bull. Torrey Club **35**: 509. 1908.
meridissimum* Crowell. Canad. Jour. Res. C. **18: 11-12. 1940.
minus* Crowell. Canad. Jour. Res. C. **18: 10. 1940.
miyabei Yamada & Miyake. Shok. Zass. (Bot. Mag.) Tokyo **22**: 23. 1908.
multiporum* Kern. Mycologia **1: 210. 1909.
nelsoni Arth. Bull. Torrey Club **28**: 665. 1901.
nidus-avis Thaxt. Conn. Agr. Exp. Sta. Bull. **107**: 3. 1891.
nipponicum Yamada in Hiratsuka f. Mem. Tottori Agr. Coll. **3**: 143. 1935.
nootkatense Arth. Am. Jour. Bot. **3**: 44. 1916.
padmarenses* Balfour-Brown. Bull. Brit. Mus. (Nat. Hist.) Bot. **1: 205. 1955.
paraphysatum* Viennot-Bourgin. Revue de Mycol. **25: 304. 1960.
shiraianum K. Hara. Byochu-gai Zasshi (Jour. Pl. Prot.) **62**: 684. 1919.
speciosum Pk. Bot. Gaz. **4**: 217. 1879.
**taianum* sp. nov. (see below).
torminali-juniperinum Ed. Fisch. Zeitschr. Bot. **2**: 759. 1910.
trachysorum Kern in Arth. Mycologia **2**: 237-238. 1910.
tremelloides Hartig. Lehrb. Kaumkrankh. p. 55. 1882.
tsingchensis* Wei. Bot. Bull. Acad. Sinica **1: 210. 1947.
turkestanicum Tranz. Consp. Ured. U. S. S. R. p. 77. 1939.
vauquelinae Long & Goodding. Mycologia **31**: 671. 1939.
yamadae Miyabe ex Yamada in Omori. G. Shokubutzu Byorigaku (Plant Pathology) Tokyo Hakubunkwan, M. 37, p. 306-308. 1904.

Gymnosporangium taianum Kern, sp. nov.

Teliis caulicoli, in ramulis viridibus ligneisque evolutis, matrice leviter tumescenti, ordinatis in ligneis, solitariis in viridibus; hemisphaericis, 1.5-3 mm diam., vel oblongis et linguiformibus, 2-3 mm altis, fusco-brunneis ("carob brown"); teliosporis medio 1-septatis, ellipsoideis vel oblongo-ellipsoideis, $24-30 \times 53-67 \mu$, episporio $2-3 \mu$, cinnamomeo-brunneo, vel late ellipsoideis, $29-36 \times 57-63 \mu$, episporio $3-4 \mu$, castaneo-brunneo; poris 4-6 vel pluribus in quaque cellula, in uno zono transverso prope a septo, aut in duobus zonis, ad apicem et ad basim uno vel duobus tantum; pedicello elongato.

Type. On *Cupressus duclouxiana*, Yunnan, Kunming, China, *F. L. Tai et al.* 8097 (Herbarium, Plant Pathology, National Tsing Hua University, Kunming).

Tai (Farlowia **3**: 107. 1947) described this species in English. He knew that it did not agree with *Gymnosporangium cunninghamianum* but nevertheless referred it to that species. It is herein described as a new species. Tai cites three numbers, 8097, 8162, 8197. I designate 8097 as the type. Tai illustrated two teliospores (Farlowia **3**: 137, fig. 8, 1947).

KNOWN IN AECIAL STAGE ONLY

- distortum* (*Gymnosporangium*) Arth. & Cumm. Mycologia **25**: 400. 1933.
fenzelianum (*Gymnosporangium*) Tai & Cheo, Bull. Chinese Bot. Soc. **3**: 60. 1937.
guatemalianum (*Gymnosporangium*) Crowell, Canad. Jour. Res. C. **18**: 11. 1940.
leve (*Gymnosporangium*) Crowell, Jour. Arnold Arb. **17**: 50. 1936.
magnum (*Gymnosporangium*) Crowell, Jour. Arnold Arb. **17**: 50. 1936.
malyi (*Gymnosporangium*) Picbauer, Glasnika Zemaljskeg. Muz. Bozni Hercegorini **41**: 32. 1929.
nanwutianum (*Gymnosporangium*) Tai & Cheo, Bull. Chinese Bot. Soc. **3**: 60. 1937.
patulum (*Aecidium*) Sydow, Ann. Mycol. **5**: 506. 1907.
pourthiaee (*Aecidium*) Sydow, Mem. Herb. Boiss. **4**: 3. 1900.
sikangense (*Gymnosporangium*) Petrak, Acta Horti Gothob. **17**: 120. 1947.
wenshanense (*Gymnosporangium*) Tai, Farlowia **3**: 108. 1947.

DISPOSITION OF NON-VALID NAMES IN THE GENUS GYMNOSPORANGIUM

(A partial list only)

Synonyms	Accepted names
<i>aurantiacum</i> Chev.	<i>cornutum</i>
<i>aurantiacum</i> Sydow	<i>libocedri</i>
<i>blasdaleanum</i> Kern	<i>libocedri</i>
<i>botryapites</i> Kern	<i>biseptatum</i>
<i>chinense</i> Long.	<i>asiaticum</i>
<i>durum</i> Kern	<i>nelsoni</i>
<i>germinale</i> Kern	<i>clavipes</i>
<i>gracilens</i> Kern & Bethel	<i>speciosum</i>
<i>haraeanum</i> Sydow	<i>asiaticum</i>
<i>idetae</i> Yamada	<i>amelanchieris</i>
<i>juniperi</i> Link	<i>cornutum</i>
<i>juniperinum</i> Mart.	<i>tremelloides</i>
<i>juvenescens</i> Kern	<i>nidus-avis</i>
<i>koreanse</i> Jacks.	<i>asiaticum</i>
<i>macropus</i> Link	<i>juniperi-virginianae</i>
<i>mespili</i> Kern	<i>confusum</i>
<i>myricatum</i> Fromme	<i>ellisii</i>
<i>orientale</i> Sydow	<i>clavariiforme</i>
<i>oxycedri</i> Bres.	<i>confusum</i>
<i>penicillatum</i> Liro	<i>tremelloides</i>
<i>photinae</i> Kern	<i>japonicum</i>
<i>sabinae</i> Wint.	<i>fuscum</i>
<i>solenoides</i> Kern	<i>miyabei</i>

*Synonyms**Accepted names*

sorbi Kern
spiniiferum Sydow
tauricum Erikss.
transformans Kern
tubulatum Kern
yamadai Miyabe

nootkatense
asiaticum
confusum
fraternum
betheli
yamadae

GEOGRAPHICAL DISTRIBUTION BY CONTINENTS

NORTH AMERICA

asiaticum (introduced)
bermudianum
betheli
biseptatum
clavariiforme
clavipes
corniculans
cornutum
cupressi
davisii
effusum
ellisii
exiguum
exterum
floriforme
fraternum
fuscum (introduced)
globosum
gracile

harknessianum
hyalinum
inconspicuum
japonicum (introduced)
juniperi-virginianae
kernianum
libocedri
meridissimum
multiporum
nelsoni
nidus-avis
nootkatense
speciosum
tremelloides
trachysorum
vauqueliniae

Known in aecial stage only
guatemalianum

EUROPE

amelanchieris
clavariiforme
confusum
cornutum
fuscum
fusisporum
gaeumanni

gracile
minus
torminali-juniperinum
tremelloides

Known in aecial stage only
malyi

ASIA

amelanchieris
asiaticum
clavariiforme
confusum
corniforme
cornutum
cunninghamianum
formosanum

fuscum
hemisphericum
japonicum
miyabei
nipponicum
padmarensense
paraphysatum

ASIA (continued)

<i>shiraianum</i>	<i>fenzelianum</i>
<i>taianum</i>	<i>leve</i>
<i>tsingchensis</i>	<i>magnum</i>
<i>turkestanicum</i>	<i>nanwutianum</i>
<i>yamadae</i>	<i>patulum</i>
	<i>pourthiaeae</i>
Known in aecial stage only	<i>sikangense</i>
<i>distortum</i>	<i>wenshanense</i>

AFRICA

<i>atlanticum</i>	<i>cornutum</i> ?
<i>clavariiforme</i>	<i>fuscum</i>
<i>confusum</i>	<i>gracile</i>

ANALYTIC KEYS

Aecial Stage Exclusively Considered

1. Aecia cupulate, peridium short, lacerate or erose.
 2. Aeciospore-wall thicker above. (*Aecidium*) *patulum*.
 2. Aeciospore-wall evenly thick.
 3. Aeciospore-wall pale brown. *magnum*.
 3. Aeciospore-wall pale yellow.
 4. Wall thin (1-1.5 μ). *libocedri*.
 4. Wall thick (3-4 μ). *nootkatense*.
 3. Aeciospore-wall nearly colorless.
 5. Wall thin (1 μ). (*Aecidium*) *pourthiaeae*.
 5. Wall medium thick (2-3 μ).
 6. Wall strongly verrucose. *ellisii*.
 6. Wall minutely verrucose. *wenshanense*.
1. Aecia roestelioid.
 7. Peridium retaining tubular or cornute form, not much altered by dehiscence.
 8. Peridium finally dehiscient at apex, slightly or not lacerate.
 9. Peridial cells verrucose.
 10. Side-walls of peridial cells verrucose only on inner third.
 11. Aeciospore-wall pale yellow, 2-2.5 μ . *inconspicuum*.
 11. Aeciospore-wall cinnamon-brown, 1-1.5 μ . *miyabei*.
 10. Side-walls of peridial cells verrucose over entire surface.
 12. Aeciospore-wall finely verrucose, 2-2.5 μ . *harknessianum*.
 12. Aeciospore-wall rugose-verrucose, 2.5-3 μ . *malyi*.
 9. Peridial cells verruculose.
 13. Aeciospores 20-26 $\times$ 23-31 μ , wall 2-3 μ . *nipponicum*.
 13. Aeciospores 18-23 $\times$ 19-28 μ , wall 1.5-2 μ . *asiaticum*.
 9. Peridial cells closely papillose. *vauquelinae*.
 9. Peridial cells subspinulose. *japonicum*.
 9. Peridial cells spinulose.
 14. Peridial cells rather long (80-120 μ).
 15. Aeciospore-wall verruculose. *guatemalianum*.
 15. Aeciospore-wall smooth. *leve*.
 14. Peridial cells not so long (50-90 μ).
 16. Peridium hypophyllous, 1-3 mm high. *nanwutianum*.
 16. Peridium hypophyllous and fruticulous, 2-6 mm. *exiguum*.
 9. Peridial cells semi-rugose, with elongated papillae. *nelsoni*.
 9. Peridial cells rugose.
 17. Inner and side walls rather sparsely or coarsely rugose.
 18. Inner and side walls 7-9 μ thick, aeciospore-wall 1.5-2 μ . *amelanchieris*.

18. Inner and side walls 2–2.5 μ thick, aeciospore-wall 2–2.5 μ . *cornutum*.
17. Inner and side walls densely and rather finely rugose.
19. Aeciospore-wall dark cinnamon-brown, aeciospores 18–25 $\times$ 20–29 μ . *hemisphericum*.
19. Aeciospore-wall yellowish brown, aeciospores 18–23 $\times$ 23–38 μ . *fenzelianum*.
8. Peridium tardily or not at all dehiscent at apex, with slits along the sides.
20. Peridial cells tuberculate.
21. Papillae on side-walls short, aeciospore-wall 1.5–2.5 μ . *yamadae*.
21. Papillae on side-walls blunt, aeciospore-wall 2.5–3.5 μ . *kernianum*.
20. Peridial cells verrucose with roundish or oval papillae. *corniculans*.
20. Peridial cells verrucose-rugose with irregular papillae. *cupressi*.
20. Peridial cells rugose with closely set ridge-like papillae. *davisii*.
20. Peridial cells smooth. *biseptatum*.
7. Peridium more or less tubular, altered by becoming lacerate or fimbriate.
22. Peridium strongly revolute.
23. Peridial cells somewhat curved when wet, side-walls rugose nearly to outer side. *floriforme*.
23. Peridial cells strongly curved when wet, side-walls sparsely rugose on inner half. *juniperi-virginianae*.
22. Peridium spreading or more or less erect after dehiscence.
24. Peridial cells smooth. *hyalinum*.
24. Peridial cells sculptured.
25. Peridial cells subspinulose. *trachysorum*.
25. Peridial cells verrucose.
26. Peridial cells rhomboidal.
27. Aeciospore-wall chestnut-brown. *turkestanicum*.
27. Aeciospore-wall pale-yellow.
28. Aeciospores 21–24 $\times$ 24–29 μ . *speciosum*.
28. Aeciospores 21–32 $\times$ 24–39 μ . *clavipes*.
26. Peridial cells linear (150–300 μ), much curved or coiled when wet. *fraternum*.
26. Peridial cells oblong (80–130 μ), slightly curved when wet. *clavariiforme* or *gracile*.
25. Peridial cells rugose.
27. Peridium short (0.5 to 1 or 2 mm high).
28. Aeciospores small (17–22 $\times$ 19–26 μ).
29. Aeciospore-wall cinnamon-brown, 2.5–3.5 μ . *confusum*.
29. Aeciospore-wall very pale cinnamon-brown 2–2.5 μ . *exterum*.
28. Aeciospores medium-sized (18–27 $\times$ 19–35 μ).
30. Aeciospore-wall rugose (2–2.5 μ). *distortum*.
30. Aeciospore-wall verrucose.
31. Aeciospore-wall yellow-brown, 3–5 μ . *sikangense*.
31. Aeciospore-wall light chestnut-brown, 1.5–2 μ . *cunninghamianum*.
31. Aeciospore-wall dark chestnut-brown (2–2.5 μ). ** bermudianum*.
28. Aeciospores large (28–35 $\times$ 30–45 μ). *tremelloides*.
27. Peridium more or less elongated (1.5–4 mm high).
32. Aeciospores small (15–19 $\times$ 18–25 μ), wall 1.5–2 μ . *globosum*.
32. Aeciospores larger (15–26 $\times$ 18–32 μ), wall 2.5–3.5 μ . *nidus-avis*.
27. Peridium further elongated (2–5–6 mm or more).
33. Aeciospores large (18–24 $\times$ 19–35 μ). *fusisporum*.
33. Aeciospores small (16–18 $\times$ 18–23 μ). *shiraianum*.
33. Aeciospores medium-sized (18–24 $\times$ 19–30 μ).
34. Aeciospore-wall cinnamon-brown, 1.5–2.5 μ . *torminali-juniperinum*.
34. Aeciospore-wall chestnut-brown, 2.5–3 μ . *betheli*.
7. Peridium balanoid, rupturing along sides, apex remaining bluntly conical. *fuscum*.

Telial Stage Exclusively Considered

1. Telia foliicolous, or on green stems, with no or slight hypertrophy.
2. Telia causing fasciation of the branches (witches' brooms).
3. 'Witches' brooms globose, with scale-like leaves, sori bluntly conical. *kernianum*.

* This is the only known species which is autoecious; here the aecia are on *Juniperus*.

3. Witches' brooms brush-like, usually with juvenile leaves, sori hemispheric. *nidus-avis*.
2. Telia not causing fasciation.
4. Telia hemispheric.
5. Telia chiefly epiphyllous.
6. Teliospores 2-celled, rarely 3- or 1-celled. *shiraianum*.
6. Teliospores 2-celled.
7. Teliospores with hyaline papillae.
8. Teliospores 35–49 μ long, papillae noticeable. *torminali-juniperinum*.
8. Teliospores 40–55 μ long, papillae large. *davisii*.
7. Teliospores without hyaline papillae. *nipponicum*.
5. Telia arising between the scale-like leaves. *hemisphericum*.
4. Telia musciform. *multiporum*.
4. Telia pulvinate.
9. Telia sometimes causing corniform elongation of leaves. *corniforme*.
9. Telia without deformation of leaves or branches.
10. Teliospores 2–3 or 4-celled, uredinia with paraphysis-like structures. *paraphysatum*.
10. Teliospores 2–5-celled, uredinia unknown. *libocedri*.
10. Teliospores 2-celled.
11. Teliospores pastilliform, squarish or irregular. *formosanum*.
11. Teliospores ellipsoid.
12. Teliospores with wall thicker above. *fraternum*.
12. Teliospores with wall evenly thick.
13. Teliospores small (35–45 μ long). *asiaticum*.
13. Teliospores large (55–80 μ long). *inconspicuum*.
12. Teliospores with hyaline papillae over pores (sori also caulicolous). *cornutum*.
4. Telia tongue-shaped, or conical, teliospores 42–63 μ long. *exiguum*.
4. Telia wedge-shaped, teliospores 37–53 μ long. *betheli* (or *nelsoni*).
4. Telia truncate, teliospores 45–72 μ long. *harknessianum*.
4. Telia unknown; uredia present, teliospores intermixed, 2-celled.
14. Teliospores with papillae; urediospores with 6–8 pores. *gaeumanni*.
14. Teliospores without papillae, urediospores with 2 pores. *nootkatense*.
1. Telia caulicolous, on smaller branches, with little hypertrophy.
15. Teliospores with 1–2 pores in each cell, near the septum. *cunninghamianum*.
15. Teliospores with 4–6 pores, in one or two transverse zones. *taianum*.
1. Telia caulicolous, on witches' brooms.
16. Telia hemispheric, reddish brown.
17. Teliospore-wall cinnamon-brown, often slightly thicker above. *nidus-avis*.
17. Teliospore-wall hyaline to fulvous, uniform. *vauqueliniae*.
16. Telia cylindrical, orange-color.
18. Teliospores 2-celled. *gracile*.
18. Teliospores 2–5-celled. *ellisii*.
1. Telia caulicolous, on galls or gall-like excrecences.
19. Galls rotund, small, telia pulvinate.
20. Telia following aecia, cinnamon-brown, spores 34–50 μ long. *bermudianum*.
20. Telia without aecia, chestnut-brown, teliospores 48–60 μ long. *meridissimum*.
19. Galls subglobose or reniform (in some species telia may also occur on swellings of large branches or trunks).
21. Telia laterally compressed, scattered.
22. Telia irregularly tongue-shaped, often crenate. *cupressi*.
22. Telia wedge-shaped.
23. Teliospores with papillae over the pores. *yamadae*.
23. Teliospores without papillae. *globosum* (or *betheli*).
21. Telia irregularly compressed, often confluent. *nelsoni*.
21. Telia terete.
24. Telia somewhat conic, chestnut-brown.
25. Teliospores with slight hyaline thickenings over the pores. *corniculans*.
25. Teliospores with wall uniformly thick. *floriforme*.
24. Telia subcylindric.
26. Telia cylindric-acuminate, 10–20 mm long, golden-brown. *juniperi-virginianae*.
26. Telia mostly tapering, 6–10 mm long, chestnut-brown. *trachysorum*.

21. *Telia* pulvinate, crowded, often confluent. *turkestanicum*.
1. *Telia* cauliculous, on fusiform enlargements.
27. Enlargements slight, mostly on smaller branches.
28. *Telia* cylindrical, teliospores 2-celled. *padmarensense*.
28. *Telia* appanate, teliospores with pedicels terete.
29. Teliospores with hyaline papillae over the pores. *cornutum*.
29. Teliospores without hyaline papillae.
30. Teliospores with wall thicker above (3–5 μ). *hyalinum*.
30. Teliospores with wall uniform. *amelanchieris*.
28. *Telia* hemispheric, teliospores with pedicels carotiform. *clavipes*.
28. *Telia* conic, or laterally compressed. *confusum* or *fuscum*.
27. Enlargements irregularly fusiform, knot-like or gall-like on larger branches.
31. *Telia* appanate.
32. Teliospores 1–3-celled (40–80 μ long). *miyabei*.
32. Teliospores 2-celled (40–60 μ long). *tremelloides*.
31. *Telia* wedge-shaped (sori also on galls, and foliicolous). *betheli*.
27. Enlargements gradually fusiform, mostly on woody branches.
33. *Telia* hemispheric mostly small and definite.
34. Teliospores 2–4-celled. *biseptatum*.
34. Teliospores 2-celled.
35. Pores 2, near the septum, or three in upper cell, 1 apical. *nidus-avis*.
35. Pores usually 4 in a band near the septum, or with 1 or 2 additional in each cell. *atlanticum*.
33. *Telia* appanate, or pulvinate, usually large and indefinite.
36. Teliospores small, 32–42 μ long. *exterum*.
36. Teliospores large, 45–60 μ long. *minus*.
33. *Telia* terete, cylindric, or slightly compressed. *clavariiforme*.
33. *Telia* cristiform, irregularly crenate above. *speciosum*.
33. *Telia* conic, or laterally compressed.
37. Teliospores 1-celled. *tsingchensis*.
37. Teliospores 2-celled.
38. Teliospores ellipsoid, 42–51 μ long. *confusum* or *fuscum*.
38. Teliospores fusiform, falcate or sigmoid, 46–90 μ long. *fusisporum*.
33. *Telia* tongue-shaped, often crenate above. *cupressi*.
33. *Telia* wedge-shaped, often irregular and lacunose.
39. Teliospores medium-sized (42–55 μ long). *effusum*.
39. Teliospores rather large (44–67 μ long). *japonicum*.
1. *Telia* cauliculous, on larger branches, or main trunk, often with some hypertrophy.
40. *Telia* pulvinate. *meridissimum*.
40. *Telia* laterally compressed.
41. Teliospores 1-celled, telia dentiform. *tsingchensis*.
41. Teliospores 2-celled.
42. *Telia* tongue-shaped, crenate, 4–6 mm high. *cupressi*.
42. *Telia* wedge-shaped, 3–4 mm high. *betheli*.
42. *Telia* often irregular and lacunose, 7–10 mm high. *effusum*.
41. Teliospores 2–3-celled, telia cristiform. *speciosum*.

HOST KEYS

Hosts Harboring Aecial Phase

On *Amelanchier*

1. *Aecia* aecidioid. *libocedri*.
1. *Aecia* roestelioid.
2. Peridium retaining tubular form, not much altered by dehiscence.
3. Peridium dehiscent at apex, slightly or not lacerate.
4. Peridial cells verrucose.
5. Side walls of peridial cells verrucose on inner third. *inconspicuum*.
5. Side walls of peridial cells verrucose over entire surface. *harknessianum*.
4. Peridial cells rugose. *amelanchieris*.
4. Peridial cells semi-rugose, with elongated papillae. *nelsoni*.
4. Peridial cells spinulose. *guatemalianum*.

3. Peridium tardily or not at all dehiscent at apex.
6. Peridial cells verrucose with roundish or oval papillae. *corniculans.*
6. Peridial cells verrucose-rugose with irregular papillae. *cupressi.*
6. Peridial cells smooth. *biseptatum.*
2. Peridium more or less tubular, altered by becoming lacerate and spreading.
7. Peridial cells rugose. *nidus-avis.*
7. Peridial cells verrucose.
8. Aeciospore-wall pale yellow. *clavipes.*
8. Aeciospore-wall cinnamon-brown. *gracile* or *clavariiforme.*

On Aronia

1. Aecia roestelioid, peridium retaining tubular or cornute form. *davisii.*
1. Aecia roestelioid, peridium becoming lacerate and spreading.
2. Peridial cells rhomboidal (45–90 μ). *clavipes.*
2. Peridial cells oblong (80–130 μ), slightly curved when wet. *clavariiforme.*
2. Peridial cells linear (150–300 μ), curved or coiled when wet. *fraternum.*

On Chaenomeles

1. Aecia aecidioid. *libocedri.*
1. Aecia roestelioid.
2. Aeciospore-wall pale yellow, 21–32 $\times$ 24–39 μ . *clavipes.*
2. Aeciospore-wall cinnamon-brown, 18–26 $\times$ 21–30 μ .
3. Peridial cells rugose, with long ridges. *nidus-avis.*
3. Peridial cells verruculose, with long papillae. *asiaticum.*

On Comptonia (See Myrica)**On Cormus (See Sorbus or Malus)****On Cotoneaster**

1. Aecia roestelioid, peridium retaining tubular form, peridial cells spinulose, aeciospores verrucose. *nanwutianum.*
1. Aecia roestelioid, peridium becoming lacerate or fimbriate.
2. Peridial cells rugose, aeciospore-wall rugose. *distortum.*
2. Peridial cells rugose, aeciospore-wall verrucose.
3. Aeciospores 19–22 $\times$ 19–26 μ . *confusum.*
3. Aeciospores 18–24 $\times$ 19–35 μ . *fusisporum.*
2. Peridial cells papillose. *sikangense.*
2. Peridial cells verrucose.
3. Aeciospore-wall cinnamon-brown. *clavariiforme.*
3. Aeciospore-wall pale yellow. *clavipes.*

On Crataegus

1. Aecia aecidioid.
2. Aeciospore-wall uniformly thick.
3. Aeciospores small (12–20 $\times$ 14–23 μ). *libocedri.*
3. Aeciospores large (24–29 $\times$ 30–32 μ). *magnum.*
2. Aeciospore-wall thicker above (up to 9 μ). *patulum.*
1. Aecia roestelioid.
4. Peridium remaining more or less tubular, somewhat lacerate.
5. Peridial cells tuberculate. *kernianum.*
5. Peridial cells strongly spinulose. *exiguum.*
5. Peridial cells verrucose-rugose. *malyi.*
5. Peridial cells rugose. *globosum.*
4. Peridium losing tubular form, deeply lacerate.
6. Peridial cells sculptured.
7. Peridial cells verrucose.
8. Aeciospore-wall pale yellow. *clavipes.*
8. Aeciospore-wall cinnamon-brown. *clavariiforme* or *gracile.*
7. Peridial cells rugose.
9. Inner and side walls moderately rugose, rather thick (3–6 μ). *betheli.*
9. Inner and side walls strongly rugose, thick (5–7 μ). *confusum.*

7. Peridial cells subspinulose.
6. Peridial cells smooth.
4. Peridium strongly revolute.

trachysorum.
hyalinum.
floriforme.

On *Cydonia*

1. *Aecia aecidioid.* *libocedri.*
1. *Aecia roestelioid.*
 2. Peridium rupturing at apex and more or less along the sides.
 3. Peridial cells verruculose with long papillae. *asiaticum.*
 3. Peridial cells tuberculate with blunt papillae. *kernianum.*
 2. Peridium losing tubular form, becoming lacerate and spreading.
 4. Peridial cells verrucose.
 5. Aeciospore-wall pale yellow, coarsely verrucose. *clavipes.*
 5. Aeciospore-wall cinnamon-brown, moderately verrucose. *clavariiforme* or *gracile.*
 4. Peridial cells rugose, linear-rhomboid; aeciospores medium-sized ($18-28\ \mu$).
 6. Inner and side walls strongly rugose with ridges of varying length. *confusum.*
 6. Inner and side walls rugose with long narrow ridges interspersed with roundish papillae. *nidus-avis.*
 4. Peridial cells rugose, rhomboid; aeciospores large ($28-45\ \mu$). *tremelloides.*

On *Fendlera*

Aecia roestelioid, peridium tubular, peridial cells verrucose, aeciospores $21-24 \times 24-29\ \mu$. *speciosum.*

On *Gillenia*

Aecia roestelioid, peridium soon lacerate and spreading, peridial cells rugose, aeciospores $17-21 \times 21-26\ \mu$. *exterum.*

On *Heteromeles*

Aecia roestelioid, peridium not spreading much, peridial cells spinulose. *exiguum.*

On *Juniperus*

Aecia roestelioid, on galls, peridium lacerate, aeciospores $16-19 \times 19-29\ \mu$. *bermudianum.*

On *Macromeles* (See *Malus*)

On *Malus*

1. *Aecia aecidioid.*
 2. Aeciospores small ($18-20 \times 14-23\ \mu$). *libocedri.*
 2. Aeciospores large ($23-27 \times 27-39\ \mu$). *nootkatense.*
1. *Aecia roestelioid.*
 3. Peridium conical or subcylindrical, dehiscent only at apex 1-1.5 mm high. *hemisphericum.*
 3. Peridium cornute, retaining shape, 3-5 mm high. *cornutum.*
 3. Peridium tubular, spreading or more or less erect after rupturing.
 4. Peridial cells tuberculate. *yamadae.*
 4. Peridial cells verrucose.
 5. Aeciospores $21-32 \times 24-39\ \mu$, wall yellow. *clavipes.*
 5. Aeciospores 18-24 diam., wall cinnamon-brown. *miyabei.*
 4. Peridial cells spinulose. *leve.*
 4. Peridial cells rugose.
 6. Aeciospores small ($15-19 \times 18-25\ \mu$), wall thin ($1-2\ \mu$). *globosum.*
 6. Aeciospores medium ($18-23 \times 23-38\ \mu$), wall medium ($1.5-2.5\ \mu$). *fenzelianum.*
 6. Aeciospores large ($28-35 \times 30-45\ \mu$), wall thick ($3-5\ \mu$). *tremelloides.*
 3. Peridium strongly revolute after dehiscence. *juniperi-virginianae.*

On *Mespilus*

Aecia roestelioid, becoming lacerate, peridial cells rugose. *confusum.*

On *Micromeles* (See *Sorbus*)

On Myrica

Aecia aecidioid, peridial cells with thick outer wall, smooth, thinner inner wall, verrucose, spores $24-30 \times 27-34 \mu$. *ellisii*.

On Peraphyllum

1. Aecia roestelioid.
 2. Peridium rupturing at apex and along the sides, peridial cells semi-rugose. *nelsoni*.
 2. Peridium rupturing at apex, not lacerate along sides, peridial cells verrucose. *inconspicuum*.

On Philadelphus

Aecia roestelioid, peridium tubular, peridial cells verrucose. *speciosum*.

On Photinia (Pourthiaea)

1. Aecia roestelioid.
 2. Peridial cells subspinulose. *japonicum*.
 2. Peridial cells verruculose. *asiaticum*.
1. Aecia cupulate.
 3. Aeciospores medium-sized ($18-23 \times 23-30 \mu$), wall $2-3 \mu$. *wenshanense*.
 3. Aeciospores small ($17-19 \times 19-24 \mu$), wall 1μ (*Aecidium*). *pourthiaecae*.

On Pyrus

1. Aecia aecidioid.
 2. Aeciospores small ($18-20 \times 14-23 \mu$). *libocedri*.
 2. Aeciospores large ($23-27 \times 27-39 \mu$). *nootkatense*.
1. Aecia roestelioid.
 3. Peridium losing tubular form, becoming lacerate and spreading.
 4. Peridial cells rhomboid in side-view.
 5. Peridial cells rugose, aeciospores brown. *cunninghamianum*.
 5. Peridial cells verrucose, aeciospores yellow. *clavipes*.
 4. Peridial cells linear-rhomboid in side-view.
 6. Peridial cells verrucose. *clavariiforme*.
 6. Peridial cells rugose.
 7. Inner and side walls moderately rugose, medium $3-5 \mu$. *globosum*.
 7. Inner and side walls strongly rugose, thick, $5-7 \mu$. *confusum*.
 3. Peridium retaining tubular form, rupturing at apex.
 8. Peridium cylindrical, long ($3-6 \text{ mm}$). *asiaticum*.
 8. Peridium cylindrical, medium ($2-5 \text{ mm}$).
 9. Peridial cells tuberculate. *kernianum*.
 9. Peridial cells rugose or parallel-striated. *shiraianum*.
 3. Peridium balanoid, rupturing along sides, apex remaining bluntly conic. *fuscum*.

On Sorbus

1. Aecia aecidioid.
 2. Aeciospores small ($18-20 \times 14-23 \mu$). *libocedri*.
 2. Aeciospores large ($23-27 \times 27-39 \mu$). *nootkatense*.
1. Aecia roestelioid.
 3. Peridium retaining tubular form, dehiscence at apex.
 4. Peridial cells rugose. *cornutum*.
 4. Peridial cells verrucose. *miyabei*.
 4. Peridial cells verruculose. *nipponicum*.
 3. Peridium losing tubular form becoming lacerate or spreading.
 5. Peridial cells rugose.
 6. Peridia elongated ($1.5-4 \text{ mm}$ high).
 7. Aeciospores small ($15-19 \times 18-25 \mu$), wall $1.5-2 \mu$. *globosum*.
 7. Aeciospores medium-sized ($15-26 \times 18-32 \mu$), wall $2-3.5 \mu$. *nidus-avis*.
 6. Peridia elongated ($2-5$ or 6 mm or more).
 8. Aeciospores very large ($28-35 \times 30-45 \mu$), wall $3-5 \mu$. *tremelloides*.
 8. Aeciospores small ($18-24 \times 24-27 \mu$), wall $1.5-2.5 \mu$. *torminali-juniperinum*.
 5. Peridial cells verrucose. *turkestanicum*.

On Vauquelinia

vauqueliniae.

Hosts Harboring Telial Phase

On *Chamaecyparis*

1. *Telia* foliicolous, without hypertrophy, teliospores 2-celled.
 2. Teliospores with medium cinnamon-brown walls, thicker above, 3–5 μ . *fraternum.*
 2. Teliospores with thin, lemon-yellow walls, uniform, 1–1.5 μ . *nootkatense.*
1. *Telia* caulicolous, causing more or less hypertrophy.
 3. Enlargements of stems slight or gradually fusiform.
 4. *Telia* pulvinate, teliospores 2-celled. *hyalinum.*
 4. *Telia* hemispheric, teliospores 2–4-celled. *biseptatum.*
 4. *Telia* terete, slender, teliospores 2–5-celled. *ellisii.*
 3. Enlargements irregular, knotty, teliospores 1–3-celled. *miyabei.*
1. *Telia* often causing fasciation of the branches. *ellisii.*

On *Cupressus*

1. *Telia* caulicolous, on smaller branches only, with little hypertrophy.
 2. Teliospores with 1–2 pores in each cell, near the septum. *cunninghamianum.*
 2. Teliospores with 4–6 or more pores, in one transverse zone near the septum or in two zones, those near apex or base only two in number. *taianum.*
1. *Telia* caulicolous, on smaller branches, with fusiform swellings. *minus.*
1. *Telia* caulicolous, extending to larger branches and main trunk, with hypertrophy.
 3. Swellings fusiform to subglobose galls, telia becoming tongue-shaped and irregular, teliospores 2-celled, 16–27 $\times$ 30–60 μ . *cupressi.*
 3. Swellings at first rotund galls, later fusiform swellings, telia pulvinate, teliospores 2-celled, 24–28 $\times$ 48–60 μ . *meridissimum.*
 3. Swellings fusoid, on branches of various ages, telia laterally compressed, teliospores 1-celled, 24–31 $\times$ 34–59 μ . *tsingchensis.*

On *Juniperus* sect. *Oxycedrus*

1. *Telia* foliicolous, or on green stem, not causing hypertrophy of the stem.
 2. *Telia* hemispheric or depressed-globose.
 3. Teliospores with hyaline papillae over the pores.
 4. Teliospores 35–49 μ long, papillae noticeable. *torminali-juniperinum.*
 4. Teliospores 40–55 μ long, papillae large. *davisii.*
 3. Teliospores without hyaline papillae. *shiraianum.*
 2. *Telia* pulvinate or applanate.
 5. Teliospores with hyaline papillae. *cornutum.*
 5. Teliospores without hyaline papillae. *corniforme.*
1. *Telia* caulicolous, causing witches' brooms. *gracile.*
1. *Telia* on twigs or branches, causing more or less hypertrophy.
 6. *Telia* hemispheric, teliospores with carotiform pedicels. *clavipes.*
 6. *Telia* applanate or pulvinate, teliospores with terete pedicels.
 7. *Telia* on smaller branches with slight hypertrophy.
 8. Teliospores with hyaline papillae. *cornutum.*
 8. Teliospores without hyaline papillae. *amelanchieris.*
 7. *Telia* on larger branches with hemispheric or gall-like swellings. *tremelloides.*
 6. *Telia* terete. *clavariiforme.*
 6. *Telia* conic or laterally compressed, higher than wide. *confusum* or *fuscum.*
1. *Telia* unknown; uredia present, teliospores intermixed, teliospores 2-celled. *gaeumanni.*

On *Juniperus* sect. *Sabina*

1. *Telia* foliicolous, or on green stems, without hypertrophy.
 2. *Telia* causing fasciation of branches (witches' brooms).
 3. *Telia* hemispheric, teliospores medium-sized (37–52 μ long). *nidus-avis.*
 3. *Telia* bluntly conical, teliospores large (45–74 μ long). *kernianum.*
 2. *Telia* not causing fasciation of branches (or slight).
 4. *Telia* arising between the leaves. *inconspicuum.*
 5. Pedicels of teliospores carotiform.
 5. Pedicels of teliospores terete.
 6. Pores 2 in each cell near septum, or only one in upper cell.
 7. Teliospores subglobose (25–30 $\times$ 30–35 μ). *hemisphericum.*

7. Teliospores ellipsoid ($17-27 \times 37-65 \mu$). *betheli* (or *nelsoni*).
6. Pores 5-7 in each cell, scattered. *multiporum*.
4. Telia borne on the leaves.
8. Telia pulvinate, or hemispheric.
9. Teliospores ellipsoid ($15-27 \times 36-45 \mu$). *asiaticum* (or *nipponicum*).
9. Teliospores pastilliform ($20-39 \times 36-75 \mu$). *formosanum*.
8. Telia tongue-shaped or truncate.
10. Teliospores small ($18-23 \times 45-55 \mu$). *exiguum*.
10. Teliospores large ($16-22 \times 45-72 \mu$). *harknessianum*.
1. Telia cauliculous, often causing witches' broom effect.
11. Telia cylindrical, teliospores $47-86 \mu$ long. *gracile*.
11. Telia hemispheric, teliospores $37-52 \mu$ long. *nidus-avis*.
11. Telia hemispheric, teliospores $52-65 \mu$ long. *vauquelinae*.
1. Telia cauliculous, causing more or less hypertrophy.
12. Telia on galls or gall-like excrescences.
13. Galls irregular, often breaking forth in succession along fusiform swellings, sometimes isolated. *betheli*.
13. Galls globoid, subgloboid, or reniform.
14. Telia laterally compressed.
15. Telia wedge-shaped.
16. Teliospores with papillae over pores. *yamadae*.
16. Teliospores without papillae. *globosum*.
15. Telia irregularly compressed, often confluent. *nelsoni*.
14. Telia terete, somewhat conic, chestnut-brown.
17. Teliospores with hyaline thickening over pores. *corniculans*.
17. Teliospores without hyaline thickenings. *floriforme*.
14. Telia subcylindric.
18. Telia cylindric-acuminate 10-20 mm long, golden-brown. *juniperi-virginianae*.
18. Telia mostly tapering, 6-10 mm long, chestnut-brown. *trachysorum*.
14. Telia pulvinate.
19. Teliospores small ($18-25 \times 34-50 \mu$), following aecia. *bermudianum*.
19. Teliospores medium ($23-29 \times 45-58 \mu$), without aecia. *turkestanicum*.
12. Telia on fusiform swellings (sometimes on large branches or trunks).
20. Telia hemispheric, applanate, or pulvinate.
21. Pedicels of teliospores terete.
22. Pores 1, near the septum in lower cell, apical in upper cell. *exterum*.
22. Pores 2, near the septum, or 3 in upper cell with 1 apical. *nidus-avis*.
22. Pores 4 or more, near the septum, rarely or 1 or 2 additional above and below. *atlanticum*.
21. Pedicels of teliospores carotiform. *clavipes*.
20. Telia cristiform, or crenate. *speciosum*.
20. Telia wedge-shaped, often irregular and lacunose.
23. Teliospores medium-sized ($42-55 \mu$ long). *effusum* (or *betheli*).
23. Teliospores large ($57-66 \mu$ long). *japonicum*.
20. Telia conic or often laterally compressed, higher than wide.
24. Teliospores ellipsoid ($30-60 \mu$ long). *fuscum* (or *confusum*).
24. Teliospores fusiform, falcate, or sigmoid ($46-90 \mu$ long). *fusisporum*.
20. Telia cylindrical, teliospores very long (up to 200μ). *padmarensse*.

On *Libocedrus*

1. Telia foliicolous, pulvinate, teliospores 2-4-5-celled.
2. Uredial stage present, with numerous, conspicuous paraphysis-like structures. *paraphysatum*.
2. Uredial stage unknown. *libocedri*.

LEGENDS TO FIGURES

FIG. 1-4. *Gymnosporangium*, peridia of aecia showing variations in form and dehiscence (all somewhat enlarged). FIG. 1. Aecia cupulate, *G. libocedri* on *Crataegus*. FIG. 2. Aecia cornute, *G. cornutum* on *Sorbus*. FIG. 3. Aecia lacerate and spreading, *G. confusum* on *Crataegus*. FIG. 4. Aecia balanoid, *G. fuscum* on *Pyrus* (photo by V. Grasso).

FIG. 5-16. *Gymnosporangium*. FIG. 5-8. Variations in peridial cells of aecia (after Kern). FIG. 5. Verrucose (in part), *G. inconspicuum*. FIG. 6. Rugose, *G. nidus-avis*. FIG. 7. Spinulose, *G. exiguum*. FIG. 8. Smooth, *G. hyalinum*. FIG. 9-16. Variations in form of teliospores and uredospores. FIG. 9. *G. gaeumanni*. a. Two uredospores with thin walls; one with thick wall, amphispore. b. Two teliospores (after Zogg). FIG. 10. *G. tsingchensis*, teliospore with one cell. FIG. 11. *G. bisepatum*, teliospore with several cells (after Kern). FIG. 12. *G. clavipes*, teliospore with carotiform pedicel (after Kern). FIG. 13. *G. ellisii*, teliospore with linear-fusiform shape, several cells (after Kern). FIG. 14. *G. davisii*, teliospore with hyaline papillae over the pores (after Kern). FIG. 15. *G. multiporum*, teliospore with several scattered pores (after Bethel). FIG. 16. *G. clavariiforme*, teliospores with lanceolate shape, two cells (after Kern).

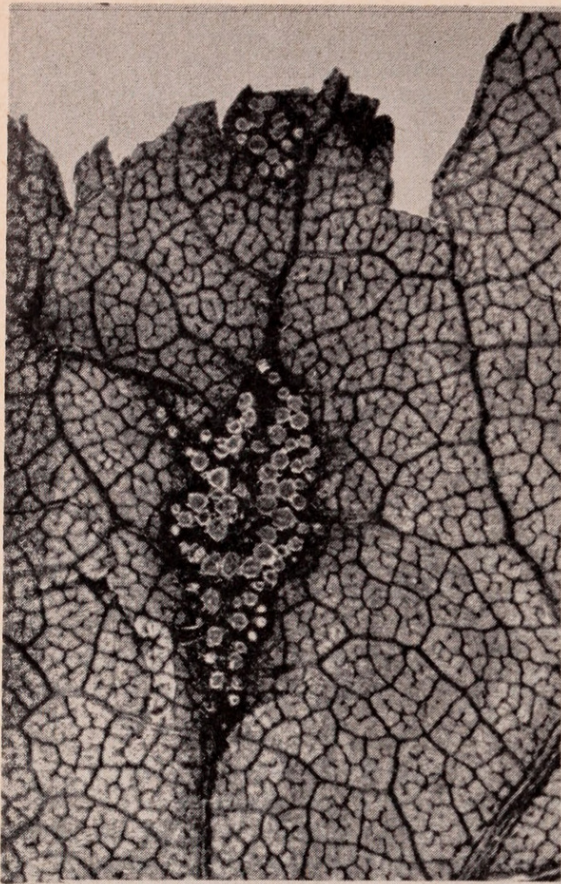
FIG. 17-24. *Gymnosporangium globosum*, aecial and telial stages. FIG. 17. Several groups of aecia with tubular peridia, becoming lacerate above, on leaf of *Crataegus*. FIG. 18. A peridium. FIG. 19. A straight, rugose peridial cell. FIG. 20. An aeciospore. FIG. 21. Photograph of a globose gall on *Juniperus*. FIG. 22. Sketch of gall showing scars of telia of previous season. FIG. 23. A wedge-shaped telium. FIG. 24. A teliospore.

FIG. 25-32. *Gymnosporangium juniperi-virginianae*, aecial and telial stages. FIG. 25. Annular group of aecia with fimbriate and revolute peridia on leaf of *Malus* (after Kern). FIG. 26. Single peridium from above. FIG. 27. Aeciospore showing several pores. FIG. 28. A curved rugose peridial cell. FIG. 29. Subglobose or reniform galls on *Juniperus* (after Kern). FIG. 30. Sketch of a gall showing collar-like swelling at base of each telium. FIG. 31. A cylindric-acuminate telium. FIG. 32. A teliospore.

FIG. 33-37. *Gymnosporangium*, showing varied distribution of sori—four telia, one aecium (after Kern). FIG. 33. Telia foliicolous, pulvinate, *G. libocedri*. FIG. 34. Telia foliicolous, hemispheric, *G. davisii*. FIG. 35. Telia on a gall, irregularly compressed, often confluent, *G. nelsoni*. FIG. 36. Aecia on a gall, cylindric, *G. bermudianum*. FIG. 37. Telia on gall-like excrescences, terete, somewhat conic, *G. corniculans*.

FIG. 38-41. *Gymnosporangium*, effects on hosts produced by the telial stages. FIG. 38. Telia causing fasciation of the branches, *G. kernianum* (after Kern). FIG. 39. Telia on fusiform enlargement, applanate, *G. exterum* (after Kern). FIG. 40. Telia on slight fusiform swellings, pulvinate, *G. cornutum* (after Oersted). FIG. 41. Telia on irregular enlargement, applanate, *G. tremelloides* (after Kern).

FIG. 42, 43. *Gymnosporangium clavariiforme*, telia on gradual fusiform enlargements, terete or slightly compressed. FIG. 42. Telia mature but dry. FIG. 43. Telia after swelling in moisture.



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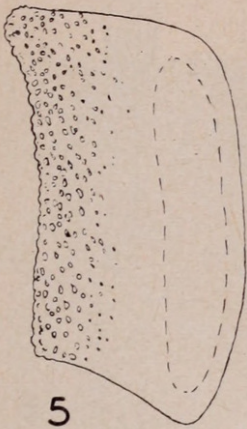
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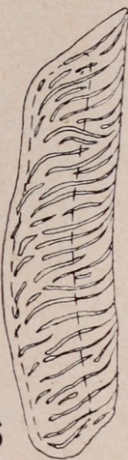
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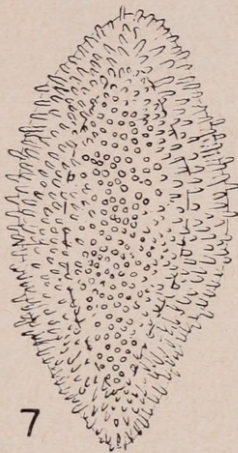
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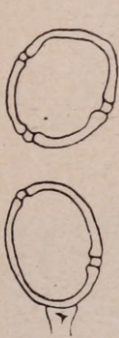
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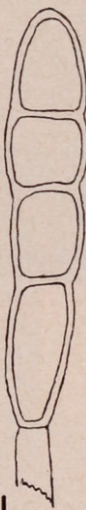
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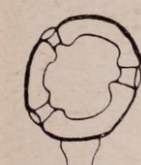
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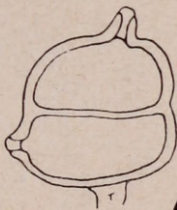
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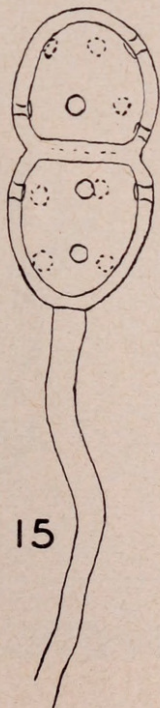
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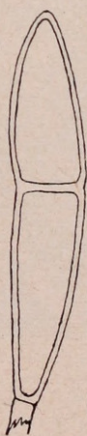
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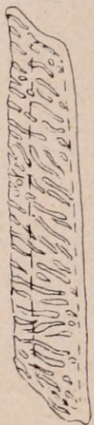
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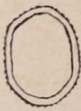
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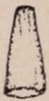
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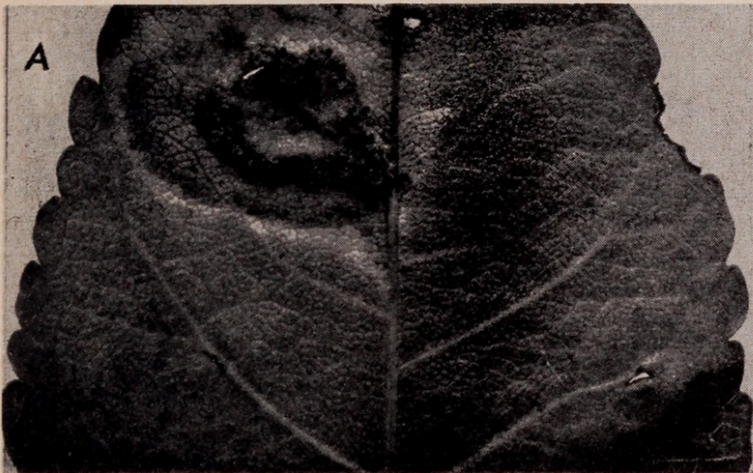
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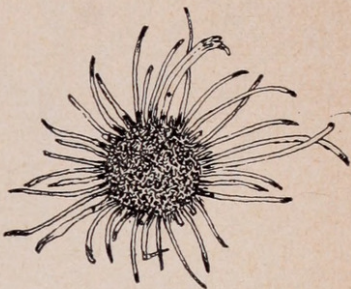
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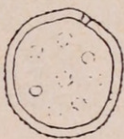
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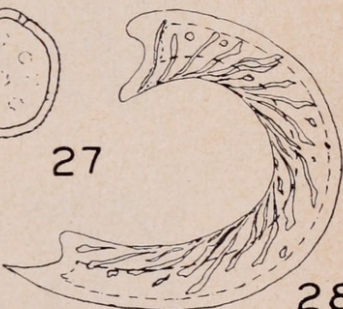
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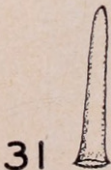
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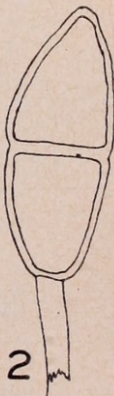
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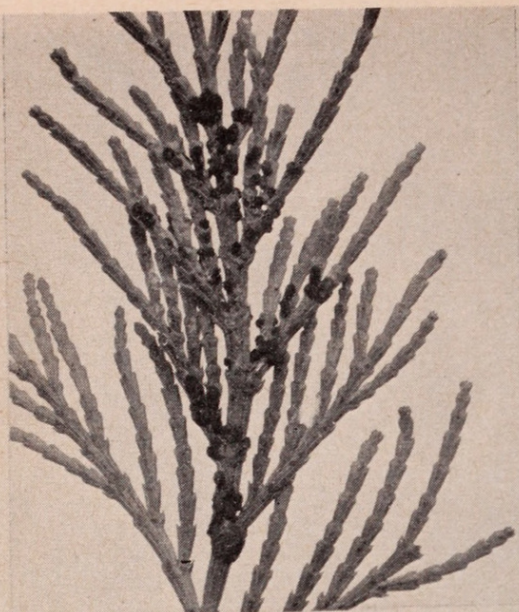
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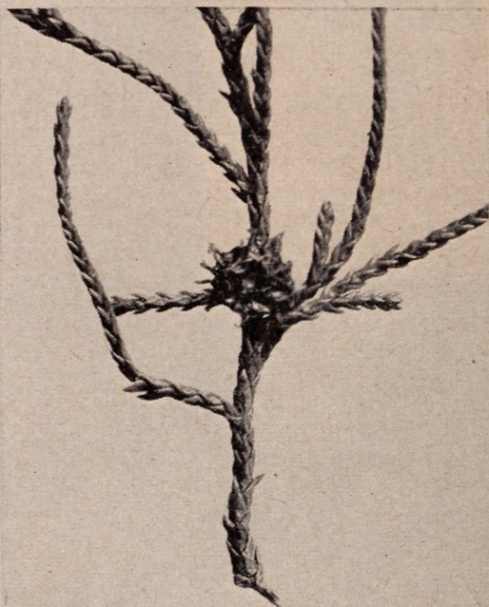
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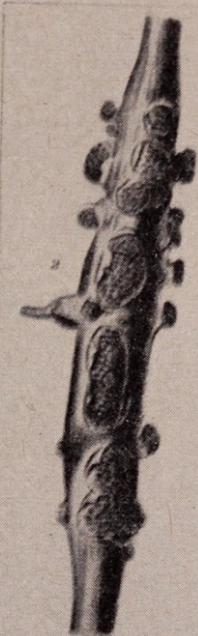
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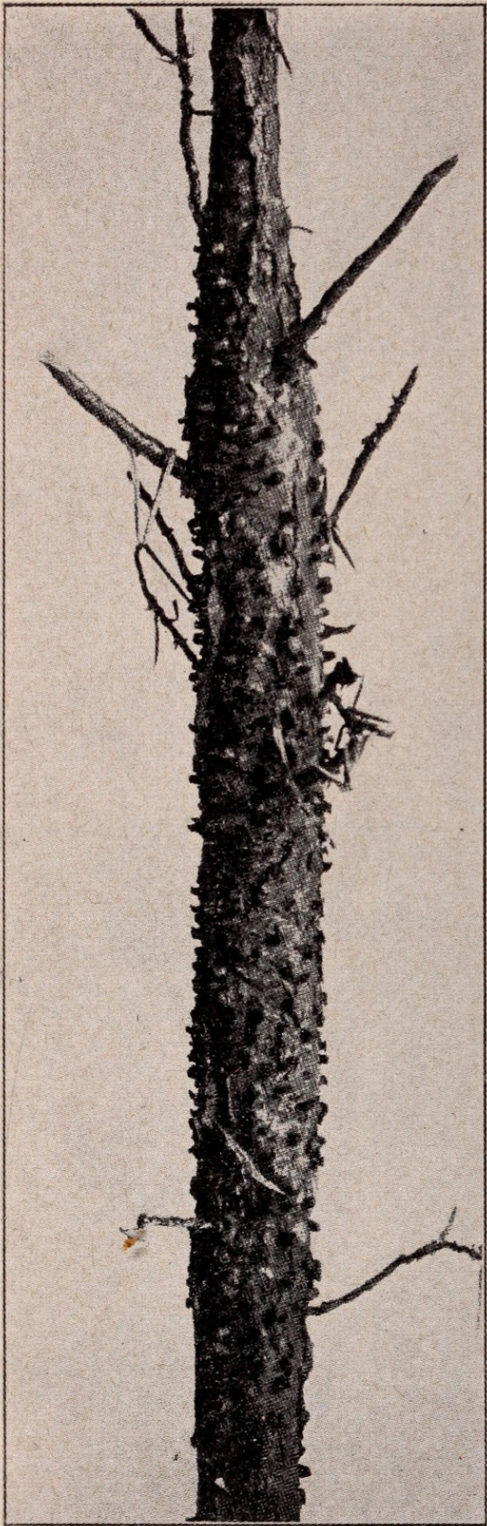
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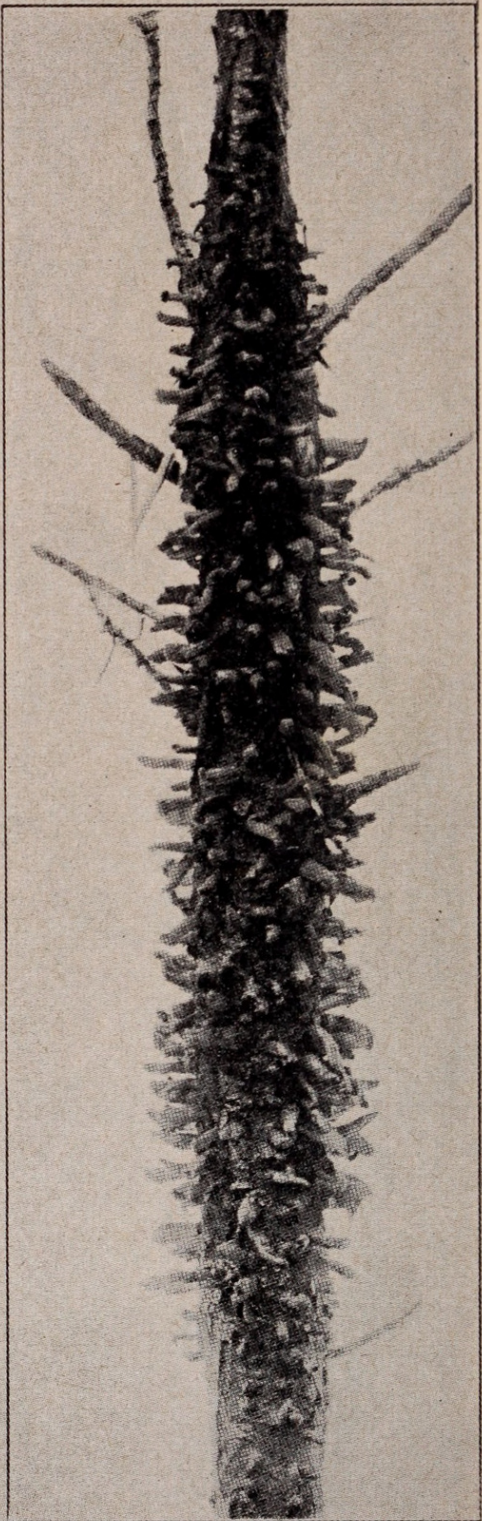
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