



BOR-20184964

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PHONE: (970) 494-7518	PRINTED:	2009-12-09 16:39:08
FAX:	REQUEST NO.:	BOR-20184964
E-MAIL:	SENT VIA:	World Wide Web
	PATRON TYPE:	USDA

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BOR Regular

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TITLE: CMI DESCR PATHOG FUNGI BACT COMMONW MYCOL INST  
VOLUME/ISSUE/PAGES: 58 (580) 2 p.  
DATE: 1978  
AUTHOR OF ARTICLE: Mordue, J.E.M.  
TITLE OF ARTICLE: CRONARTIUM FLACCIDUM.  
OTHER NUMBERS/LETTERS: CAIN789143726  
CALL NUMBER: 462.7 C73

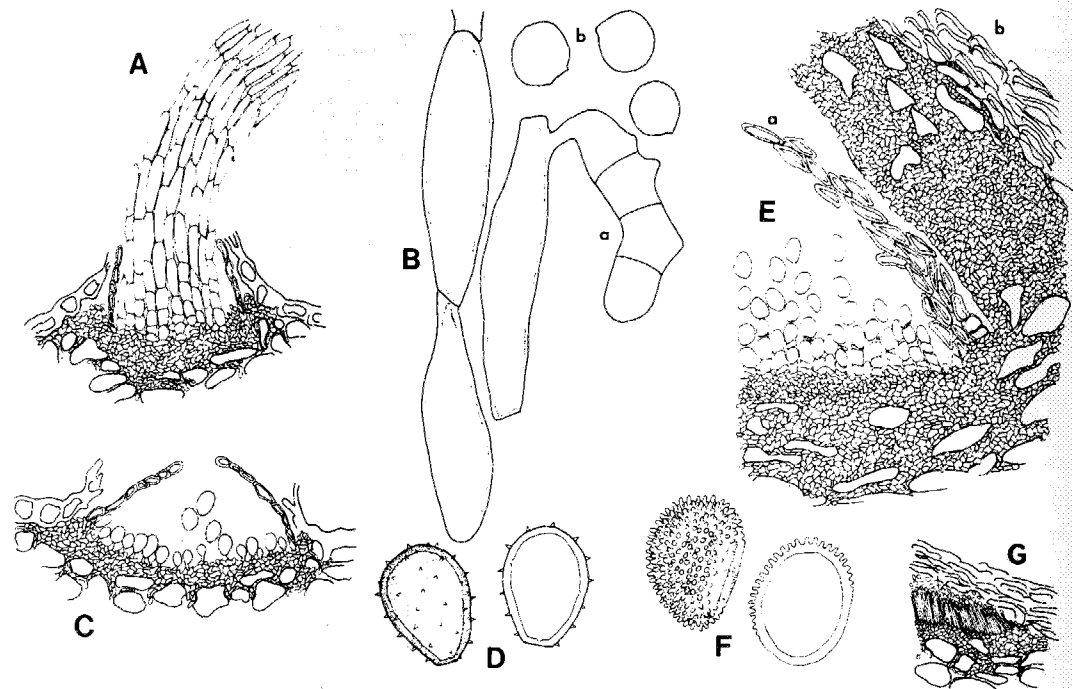
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A, V.S. telium,  $\times 145$ ; B, teliospores, (a) basidium, (b) basidiospores,  $\times 700$ ; C, V.S. uredinium,  $\times 145$ ; D, urediniospores,  $\times 700$ ; E, V.S. margin of aecium, (a) peridium, (b) host periderm,  $\times 145$ ; F, aeciospores,  $\times 700$ ; G, V.S. margin of pycnium,  $\times 145$ .

***Cronartium flaccidum* (Alb. & Schw.) Wint. *Hedwigia* 19: 55, 1880.**

*Sphaeria flaccida* Alb. & Schw., *Conspectus Fungorum*: 31, 1805.

*Cronartium asclepiadeum* (Willd.) Fr., 1815.

*Cronartium paeoniae* Cast., 1845.

*Cronartium nemesia* Vestergr., 1896.

*Cronartium pedicularis* (Dietr.) Lindr., 1900.

*Cronartium pini* (Willd.) Jörst., 1925.

*Peridermium cornui* Rostr. ex Kleb., 1890.

Pycnia and aecia caulicolous, on slightly to moderately swollen fusiform cankers. *Pycnia* spreading beneath the periderm, flat, about  $40-50\mu$  deep and  $0.5-3\text{mm}$  diam., at first yellowish, exuding pycniospores  $1-2\mu$  diam. in orange droplets, later darkening, gradually disrupted by enlarging aecia. *Aecia* peridermioid, about  $2-7\text{mm}$  diam., dehiscence circumscissile or irregular. *Peridium* several cells thick, the cells rhomboid ellipsoid, elongated, up to  $80\mu$  long by  $38\mu$  wide, the walls  $4-8\mu$  thick, strongly verrucose; rigid hair-like peridial filaments are frequently present. *Aeciospores* globose to ovoid-ellipsoid,  $21-36 \times 14-24\mu$  (mean  $26 \times 19\mu$ ) with hyaline walls  $2-4\mu$  thick; walls verrucose except for smooth area at base or side, the warts approx.  $1\mu$  diam. and  $1-2\mu$  high. *Uredinia* hypophyllous, in groups or scattered, bullate,  $0.1-0.3\text{mm}$  diam., peridiate, dehiscing by a central pore. *Urediniospores* broadly ellipsoid to obovoid,  $18-30 \times 11-20\mu$  (mean  $24 \times 15\mu$ ), wall hyaline,  $1.5-2.5\mu$  thick, echinulate with the spines  $2-4\mu$  apart and about  $1\mu$  high, though some spores show almost smooth areas; germ pores inconspicuous. *Telia* develop in the uredinia or separately, producing basally peridiate teliospore columns up to  $2\text{mm}$  long and  $0.1-0.2\text{mm}$  wide, pale orange to cinnamon brown, sometimes closely grouped on clearly defined spots, sometimes more scattered. *Teliospores* catenate, firmly adherent, fairly short ellipsoid at apex of telial columns, longer and more cylindrical below, ends rounded or truncate,  $20-64 \times 10-16\mu$  (commonly about  $55 \times 12\mu$ ), wall hyaline, yellowish to golden, about  $1\mu$  thick, often thickened at ends or corners (particularly at apex of spore) to  $2-3\mu$ , smooth. The teliospores germinate without dormancy and the upper part of the telial columns usually has a whitish powdery appearance due to the presence of basidia and basidiospores.

The only satisfactory distinction between aecia of this taxon and those of *Endocronartium pini* (Pers.) Y. Hiratsuka (= *Peridermium pini* (Pers.) Lév.) is mode of aeciospore germination. Germ tubes of *E. pini* are short, regularly septate and of determinate growth and are considered to represent basidia of an endocyclic rust, whereas those of *Peridermium cornui* are longer, of indeterminate growth and irregularly septate. For additional synonymy of aecial state see Hylander, Jörstad & Nannfeldt (1953) *Enumeratio Uredinearum Scandinavicarum, Opera bot. (Bot. Notiser Suppl.)* 1 (1), 102 pp.

**HOSTS:** *Pinus* spp. including *P. sylvestris*, *P. pinaster*, *P. pinea*, *P. halepensis*, *P. wallichiana* and most hard pines. Alternate hosts include species of *Asclepias*, *Impatiens*, *Loasa*, *Melampyrum*, *Nemesia*, *Paeonia*, *Pedicularis*, *Ruellia*, *Schizanthus*, *Tropaeolum*, *Verbena*, *Vincetoxicum*. *Vincetoxicum officinale* is an important alternate host in Europe.

**DISEASE:** Scotch pine blister rust, resin canker.

**GEOGRAPHICAL DISTRIBUTION:** Throughout Europe and Asia to the Far East, wherever susceptible hosts occur.

**PHYSIOLOGIC SPECIALIZATION:** Evidence of two races has been obtained in Italy (56, 4719, 5222).

**TRANSMISSION:** Pycniospores by insects attracted by sugary exudate; other spores are directly air-borne.

**NOTES:** Some early records of this rust as a pathogen are unreliable due to conflicting views on its nomenclature. The great majority of infection of pines by aeciospores is via foliage, although direct attack through stem wounds can take place (48, 961). A period of several years may elapse between infection and the appearance of the aecial state on an infected stem. Lesions are characterised by excessive resin exudation and cankers, with resin-soaking of the underlying wood. Girdling of stems, with death of the distal parts, results from cankers, largely due to reduction of sapwood transport of water and minerals by blockage of the xylem by resin (46, 3233; 50, 3218). *P. sylvestris* is relatively resistant when young but becomes susceptible at ages of 20-50 years (15, 619; 38, 632; 41, 417; 48, 961). There is no relation between pine vigour and susceptibility (15, 619; 54, 4663). Aeciospore germination occurs in water between 5° and 30°C with an optimum at 15°C; it is poor at 20-23°C and nil at 35°C (56, 4720).

In Poland industrial air pollution (mainly SO<sub>2</sub>) was toxic to the fungus at high concentrations but acted as a stimulant at lower concentrations (53, 1956).

The infective range between pines and alternate hosts appears to be limited and eradication of the latter is recommended as a control measure (15, 619; 54, 4202; 56, 1777).

There is evidence of useful heritable variation in susceptibility in *P. sylvestris* in Britain (48, 961). Where *Paeonia* spp. provide dangerous cultivated alternate hosts, selection for resistance could contribute to disease control (53, 3059).

Outbreaks of Scots pine blister rust are often associated with insect infestations (*Myelophilus piniperda*, *Bupalus piniarius*, *Pissodes notatus*) which aggravate the damage caused (15, 619; 50, 2008; 52, 2392). Egg laying of *P. notatus* is localised on pines attacked by *C. flaccidum* (52, 2392).

J. E. M. Mordue and I. A. S. Gibson

[Numbers in brackets, e.g. (55, 1234), refer to abstracts in the *Review of Plant Pathology*]

Issued by the Commonwealth Mycological Institute, Ferry Lane, Kew, Surrey, England,  
Printed in Great Britain by The Cambrian News (Aberystwyth) Ltd.

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