Reports

Host Alternation of Spruce Broom Rust

Abstract. Repeated inoculations demonstrate that *Peridermium coloradense* A. & K. is the gametophytic stage of *Chrysomyxa arctostaphyli* Diet., previous reports notwithstanding. Thus *C. arctostaphyli* is eliminated as the only familiar exception to Transhel's law, which may apply universally to microcyclic rusts.

Peridermium coloradense on spruce (*Picea*) has long been considered conspecific with *Melampsorella caryophyllacearum* Schroet., which alternates between fir (*Abies*) and Caryophyllaceae. Evidence that these rusts are identical consists largely of the inoculation results of Weir and Hubert (*1, 2*), but these have never been fully confirmed. Pady and others have questioned conspecificity because of differences in morphology and distribution of the spruce and fir rusts (*3*). The most striking argument against synonymy of these names was that of Hunter (*4*), who compared pycnia of the two conifer rusts and concluded, regarding the spruce parasite, that "its type is that of a *Chrysomyxa.*"

Association of decay and mortality with rust witches' brooms in species of western American spruce has called the attention of U.S. Forest Service pathologists to *Peridermium coloradense.* Classification of the rust and determination of its telial hosts are natural first stages of investigation.

Accordingly, on 29 July 1960, aeciospores from a broom on *Picea engelmanni* (collected at Allenspark, Colorado, 28 July) were applied to both surfaces of moistened leaves of 16 caryophyllaceous and 7 ericaceous plants, as follows: ten *Stellaria media,* two *S. longipes,* two *Cerastium vulgatum,* two *Arenaria lateriflora,* two *Arctostaphylos uva-ursi,* one *Chimaphila umbellata,* three *Vaccinium scoparium,* and one *Kalmia polifolia.* An equal number of controls of each species was treated with water only. The potted plants were kept in a greenhouse inoculation chamber in Fort Collins, Colo., for 80 hr (at 100 percent relative humidity, 16° to 28°C), then on a greenhouse bench. After 15 days, the bearberry (*Arctostaphylos uva-ursi*) leaves developed abundant red spots; after 25 days, a careful check of all plants showed no disease symptoms in any except the bearberries, nor in any control plants. Microscopic examination showed that the red spots were the centers of dense rust mycelia.

The bearberries were wilding transplants. They had been in the greenhouse and rust free for 10 mo previous to the experiment; most of their leaves were greenhouse grown.

No sori developed on one infected plant kept in the greenhouse. The other inoculated bearberry was kept outdoors from 2 October until 7 November and then returned to the greenhouse; scores of recognizable telia were produced on it by 28 November (but none on an accompanying control plant). Basidia were not produced until the plant was exposed to 100 percent relative humidity (on 20 December 1960). The teliospores measured 8 to 17 by 16 to 47 μ and the basidiospores 8 to 9 by 9 to 10 μ; both were characteristic of *Chrysomyxa arctostaphyli* in shape, color, and wall thickness. Bearberry rust is not known within 20 miles of Fort Collins, and though it occurs in the mountains to the west, presumably its natural sporulation was completed weeks before inoculations were made; contamination thus seemed very unlikely. However, confirming experiments were undertaken. Aeciospores collected in South Dakota on *Picea glauca* were applied to another bearberry plant in the greenhouse; infection (judged by production of mycelium) was abundant, whereas the control was negative. Five series of inoculations were made from 2 August to 6 December 1960 on detached leaves floating on water in petri dishes. In the first series, aeciospores were applied to 41 leaves of *Chimaphila, Vaccinium, Pyrola,* and *Stellaria,* as well as to eight *Arctostaphylos* leaves; all 41 and their 32 control leaves remained healthy. Eight uninoculated bearberry leaves and four leaves to which aeciospores were applied on the upper epidermis showed no infection. All four bearberry leaves inoculated on the lower epidermis became heavily infected, as judged by production of mycelium. In the second experiment, *Peridermium coloradense* aeciopores from six different collections were used. Only two caused abundant infection (from Allenspark, Colo., and Deerfield, S.D.); concurrent tests on slides showed that only in these two was there measurable aeciospore germination. Of the four nonviable or slightly viable collections, only one gave rise to two red spots on a bearberry leaf, and no mycelium was observed in two hand sections from these spots. As in the first experiment with detached leaves, no infection occurred where spores were applied only to the upper epidermis—probably because no stomata occur there. Later inoculations on newly expanded bearberry leaves in petri dishes were designed to test light and temperature requirements for infection. All these experiments confirmed the spruce-bearberry alternation in that they gave rise to rust mycelium from broom rust aeciospores under some conditions, and all control leaves remained healthy.

These experiments demonstrate that *Peridermium coloradense* is the aecial stage of a rust which appears to be identical with *Chrysomyxa arctostaphyli.* In retrospect this finding is not surprising. *Peridermium coloradense* "cannot possibly be a *Melampsorella*" (*4*), and *Chrysomyxa arctostaphyli* without a spruce stage was abnormal among *Chrysomyxae.* The bearberry rust has about the same known range as spruce broom rust, from Alaska and Utah eastward almost to the Atlantic.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

Where one host is present without the other, as in Greenland, arctic Alaska, and the southern Appalachians, neither rust has been reported. A possible exception is the Kaibab Plateau of northwestern Arizona, where *Peridermium coloradense* is abundant on spruce but bearberry has not been reported. It will be interesting to see whether another *Arctostaphylos* species serves as host, or the broom rust is short-cycling on spruce, or bearberry is actually present. *Peridermium coloradense* has been reported southward to central Mexico (*5*), far beyond the range of bearberry, but probably this is erroneous because central Mexico is also far south of the spruce host's range. In Eurasia both hosts are present, but both rusts are absent, according to mycological works on that area.

The bearberry *Chrysomyxa*, though called microcyclic (*2*), is on the "wrong" host to be so according to Transhel's law, which is (in part) that microcyclic rusts occur on the aecial hosts of related macrocyclic species (*6*). The aecial hosts of *Chrysomyxae* are *Picea* species, not Ericaceae. No evidence was ever presented that *Chrysomyxa arctostaphyli* is microcyclic; it was simply stated to be so. It provided the principal apparent exception to Transhel's generalization (*6*). Because the telia produced on bearberry from inoculation with *Peridermium coloradense* are identical with those of *Chrysomyxa arctostaphyli*, we can now assume that the latter is not a microcyclic species. Other possible exceptions are also species of *Chrysomyxa*, and are even less known than bearberry rust; quite likely they too are host-alternating. The "law" may apply to all microcyclic rusts.

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13 April 1961

Preference Factors in Experimental Alcoholism

Abstract. Normal rats which refused 5- and 20-percent alcohol in a previous study were restricted to 5-percent and 20-percent solutions in their home cages for either 30 or 120 days. Differential preferences for alcohol solutions of up to 8-percent were established as a function of length of time animals consumed alcohol but not as a function of the particular concentration consumed prior to testing.

One of the principal experimental procedures in physiological studies of alcohol consumption is the voluntary self-selection method. By daily increasing the percentage concentration of alcohol, Richter and Campbell (*1*) have shown that rats preferred alcohol over water in ranges of from 1.4 to 6.5 percent. Myers (*2*), however, found that rats which had never been exposed to alcohol refused a 5-percent solution and would not select this concentration in preference to water; this preference was reversed only when the rats were restricted to alcohol for at least 10 days. From this and other evidence (*3*), it seems that in Richter's experiments the gradual increases in concentration of alcohol modified the animals' preference threshold.

In order to clarify the role of the time and concentration factors in self-selection, 16 male, 300-day-old hooded rats of the Colgate strain were trained in boxes containing three levers (*4*) to obtain with each respective lever press a pellet of food, 0.03 ml of water, or 0.03 ml of 5-percent alcohol in one apparatus or 20-percent alcohol in the other (*5*). Each animal was deprived of food and alcohol for 24 hours, and during the 1-hour test session obtained its only food and fluid until the next day at the same time. In all cases the rats preferred water to both concentrations of alcohol throughout the 12 consecutive test sessions. Therefore, the rats were divided into four equal groups so that fluid intakes in their home cages were restricted to 5-percent alcohol for either 30 or 120 days, or 20-percent alcohol for 30 or 120 days. During this time they were maintained on their normal free-feeding laboratory food regimen. Retesting was then carried out, with half of the rats in each of the groups offered alcohol solutions which were increased from 5-percent, in 1-percent steps on sucessive daily test sessions, and the other half offered alcohol that was decreased from 15-percent concentrations in the same manner. As in previous research (*2*) the data showed that food responses (intake) were identical across all groups.

With respect to fluid preference as a function of the two alcohol concentrations in the home cages, there were no differences between the preference curves of rats that consumed 5-percent solutions and those that drank 20-percent solutions. The data from these two groups therefore were combined.

Figure 1 illustrates the preference functions based on the effects of increasing versus decreasing the order of alcohol concentrations offered during testing. Neither the 30- nor the 120-day group on the decreasing alcohol schedule manifested a clear-cut preference for alcohol until the concentration dropped to 4 percent (bottom graph). This is in sharp contrast to the preferences for higher alcohol concentrations by the groups offered alcohol increasing in concentration by 1 percent each day (top graph). Here it is postulated that the water preferred during the 9-day period in which the alcohol concentrations were high and in the aversive range reduced the acclimation to and counteracted the effects of the long-term drinking.

In Fig. 2 an over-all comparison of water and alcohol response functions, independent of the increasing or decreasing order, clearly shows that in the 30-day groups a shift in preference from alcohol to water occurs more

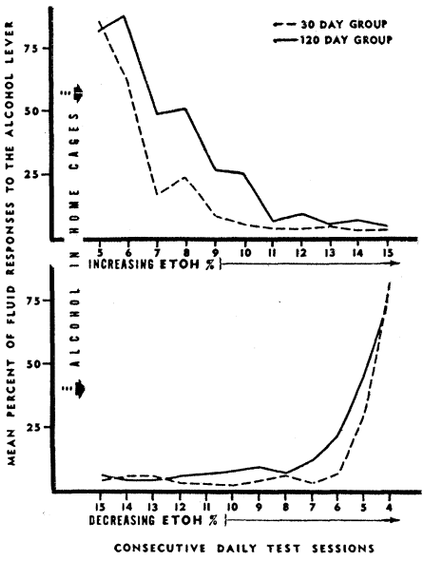

Fig. 1. Comparison of the two testing methods for offering alcohol solutions to both 30- and 120-day groups of rats. On successive days, the alcohol solution was increased by 1-percent steps (top) or decreased by 1-percent steps (bottom).