Cold Requirements of Several Ferns in Southeastern Michigan

ROYCE H. HILL*,[1]

Dormancy mechanisms constitute a major adaptation of plants in the colder temperate zones. Dormant organs are especially resistant to winter cold, and it is known that an annual cold period is not only tolerated but is actually required for the resumption of growth in some temperate zone species. A cold requirement for completion of the annual cycle of growth and development in flowering plants native to the temperate zones is well known (Salisbury & Ross, 1969). However, little or no information is available on the role of low winter temperatures in the life cycle of temperate zone ferns.

Preliminary experiments suggested that six local fern species differed widely in their dependence on a cold treatment for renewed growth. Three species (*Osmunda claytoniana* L., *Athyrium filix-femina* (L.) Roth, and *Matteuccia struthiopteris* (L.) Todaro) required at least 30 days of outdoors cold treatment, during November-February, to produce appreciable bud-break indoors. The other species (*Cystopteris fragilis* (L.) Bernh., *Adiantum pedatum* L. and *Thelypteris palustris* Schott) broke bud after a cold period of only 12 days.

PROCEDURE

Plants of seven species of ferns were collected from their natural habitats during September 23-30, 1970. Fronds of these were cut back to ground level and the rhizomes, including buds, were potted in a soil mixture containing equal parts of sand, loam, and leaf mold. The plants were divided into six groups of ten plants each. The untreated group was placed in the greenhouse immediately after collection. The 12-week cold treatment group was placed in a cold room (a refrigerated storage room kept at 5°C and darkness) immediately after collection for 12 weeks.

The other four groups were placed in a holding room at 15°C and 8-hour photoperiod for varying periods of time before being placed in the cold room, resulting in different periods of cold treatment. For example, the 8-week treatment group was placed in the holding room for four weeks and then the cold room for eight weeks. With this experimental design, it was possible to remove all groups receiving cold treatment to the greenhouse at the same time. None of the rhizomes broke bud in the holding room, and the cool temperature (15°C) probably was not sufficiently low to satisfy cold requirements of the plants; generally, temperatures effective in breaking dormancy in buds are those below 10°C (Salisbury & Ross, 1969).

The groups receiving cold treatment were brought into the greenhouse on December 28. Greenhouse temperatures were 20-30°C during the day and 15-25°C at night. Photoperiods were effectively 24 hours, as incandescent lights illuminated the plants continuously.

*Science Department, Huron High School, Ann Arbor, MI 48105.

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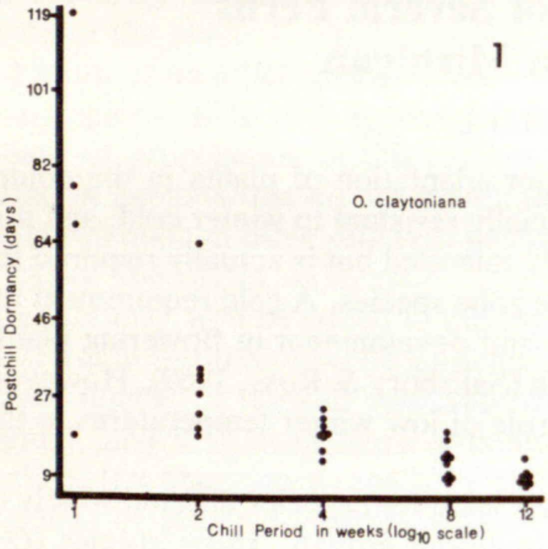
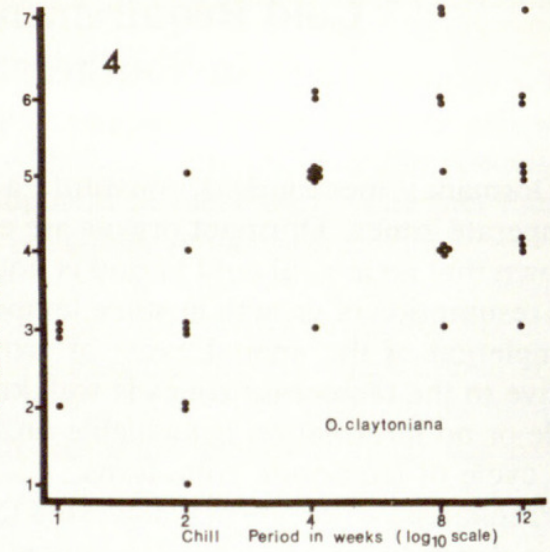
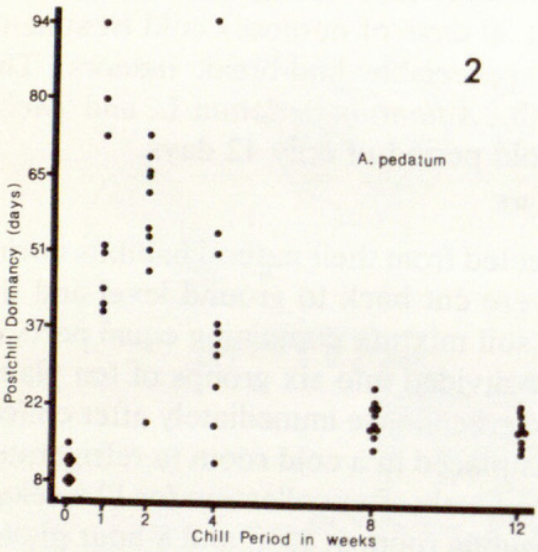
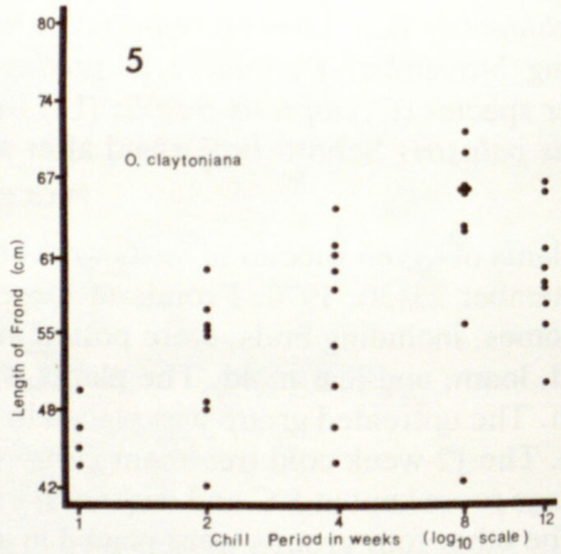
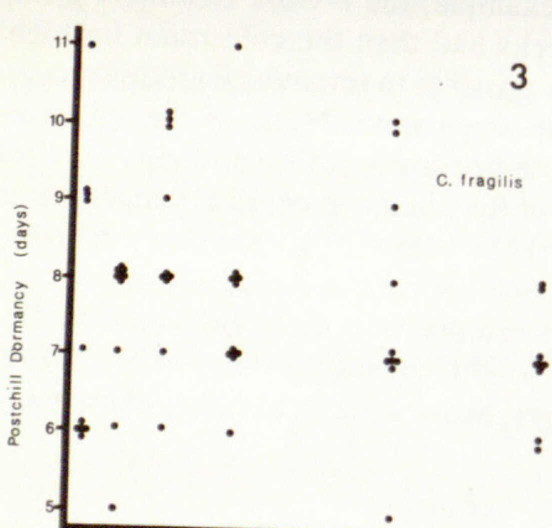
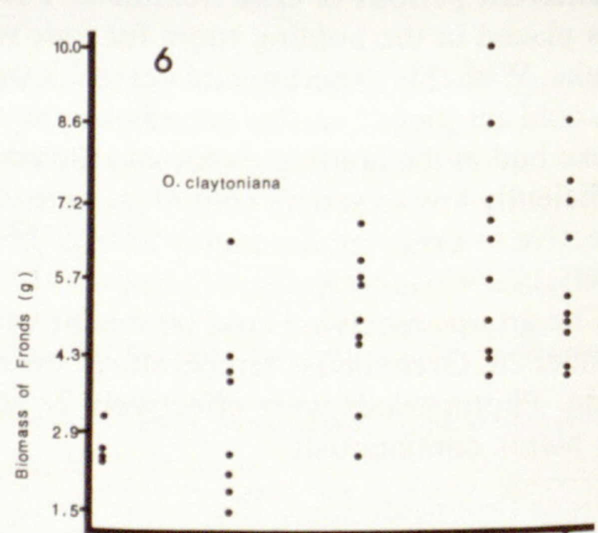

1
O. claytoniana
Postchill Dormancy (days)
119
101
82
64
46
27
9
1
2
4
8
12
Chill Period in weeks (log10 scale)


4
O. claytoniana
Number of Fronds
7
6
5
4
3
2
1
1
2
4
8
12
Chill Period in weeks (log10 scale)


2
A. pedatum
Postchill Dormancy (days)
94
80
65
51
37
22
8
0
1
2
4
8
12
Chill Period in weeks


5
O. claytoniana
Length of Frond (cm)
80
74
67
61
55
48
42
1
2
4
8
12
Chill Period in weeks (log10 scale)


3
C. fragilis
Postchill Dormancy (days)
11
10
9
8
7
6
5
0
1
2
4
8
12
Chill Period in weeks


6
O. claytoniana
Biomass of Fronds (g)
10.0
8.6
7.2
5.7
4.3
2.9
1.5
1
2
4
8
12
Chill Period in weeks (log10 scale)

The date of bud-break was recorded for each plant, and growth measurements were taken 60 days later. These measurements included the number of fronds per plant, length of the longest frond per plant, and oven-dry weight (biomass) of the fronds per plant. Percentage-soriation (the percentage of fronds that were fertile for each group) was recorded for each treatment.

RESULTS AND DISCUSSION

Since the untreated group of each species was taken directly from the field to the greenhouse, it was possible to determine whether the plants were dormant at the time of collection in late September. Untreated plants of all species except *Osmunda claytoniana* L. broke bud at high percentages shortly after being brought into the greenhouse.

The percentage of bud-break in *Osmunda claytoniana* increased with increasing cold period, from 40% after one week of cold treatment to 100% after 8-12 weeks of cold. Postchill dormancy, the time lag between the events of removing the plant into the greenhouse from the cold room and the indoor bud-break of the plant, decreased markedly with increasing length of cold treatment periods. Duration of postchill dormancy decreased from as long as 120 days after one week of cold treatment to about 10 days after 12 weeks of cold treatment (*Fig. 1*). In total time before bud-break (cold treatment period plus postchill dormancy period in the greenhouse), plants treated for only one week required 127 days to break dormancy, whereas those treated with a cold period of 12 weeks required 94 days to break dormancy. Thus, longer cold treatments up to 12 weeks decreased the overall length of time until bud-break by about 33 days.

The combined requirements of a cold treatment and a variable postchill dormancy period for bud-break seem to be of adaptive value to this species. Fall-hardened plants would be unable to break bud during unseasonably warm autumn weather. Plants that received only a short cold period by this time either would not break bud or would require a period of postchill dormancy much longer than normally occurs in autumn. Unseasonably warm weather in February or early March would usually be shorter in duration and probably would not provide sufficient hours of temperatures suitable for postchill dormancy and bud-break.

It was impossible to determine the role of photoperiod in controlling bud-break in these experiments, as the plants were placed under 24-hour photoperiods in the greenhouse. In the case of *Osmunda claytoniana,* however, an additional experiment indicated that light has no effect on breaking dormancy. Extra plants of this species were removed from the cold room after four weeks of cold treatment (and darkness), and then were placed in darkness in the greenhouse. All of these plants broke bud. This observation suggests that the breaking of dormancy ultimately is under the influence of temperature.

FIGS. 1-3. The effect of length of cold treatment (chill period) on length of postchill dormancy. The F-value for each regression was significant at P = <.01 for FIGS. 1 and 2. FIG 1. *Osmunda claytoniana*. FIG. 2. *Adiantum pedatum*. FIG. 3. *Cystopteris fragilis*. FIGS. 4-6. The effect of length of cold treatment (chill period) on growth of *Osmunda claytoniana*. The F-value for each regression was significant at P = <.01. FIG. 4. Number of fronds per plant. FIG. 5. Frond length per plant. FIG. 6. Frond biomass.

Kriebel and Wang (1962) found similar cold requirements for Sugar Maple trees native to Michigan. The trees were left outdoors in an Ohio garden and then were brought indoors at intervals during the fall and winter months. The minimum duration of cold treatment promoting bud-break was nine weeks, and long periods of cold treatment resulted in shorter postchill dormancy periods.

Untreated plants of the other fern species studied broke bud and periods of postchill dormancy were shorter in some of the species after receiving no cold

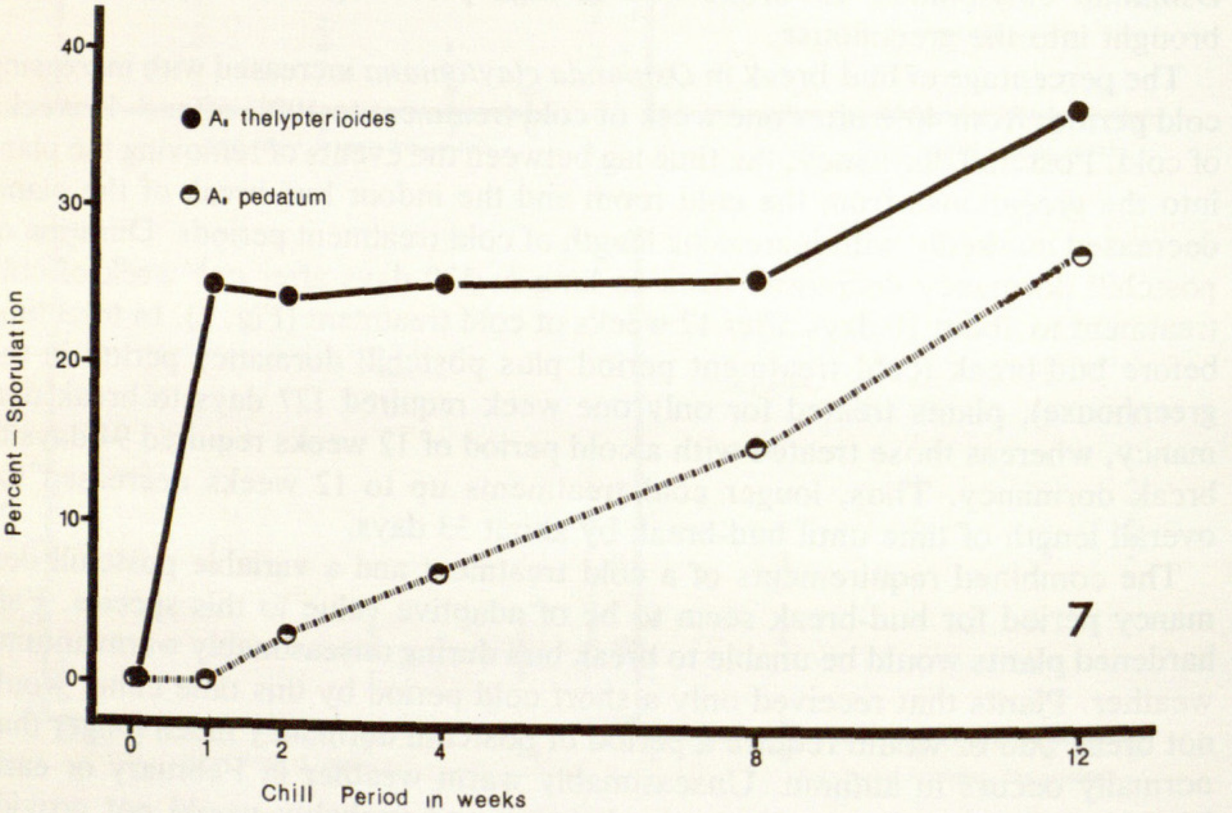


FIG. 7. The effect of length of cold treatment (chill period) on percentage-sporulation of *Adiantum pedatum* and *Athyrium thelypterioides*.

treatment than after receiving one week of treatment. This indicates that the plants were not dormant at the time of collection and that one week at 5°C was sufficient to induce dormancy. This was especially apparent for *Adiantum pedatum* (*Fig. 2*), which had a postchill dormancy of 7–15 days with no cold treatment and 40–94 days after one week of cold treatment. Among treated groups of this species, postchill dormancy periods decreased with increasing length of cold treatment in a manner similar to that observed in *Osmunda claytoniana*. Plants of *Adiantum pedatum* were not dormant by late September, but only one week of cold treatment at 5°C induced a condition of dormancy that was broken only after long periods of postchill dormancy or longer periods of cold treatment. It is apparent that the cool weather following the date of collection would have been sufficient to cause the plants to become dormant soon in their natural habitats. Dependence of bud-break and duration of postchill dormancy on the length of cold treatment in *Thelypteris palustris* was similar to that in *Adiantum pedatum,* although periods of postchill dormancy in the former never exceeded 26 days in any of the treatments.

High percentages of bud-break and short periods of postchill dormancy in all treatments typified the other four species studied. *Figure 3* shows that postchill dormancy periods never exceeded 11 days in any of the plants of *Cystopteris fragilis.* This indicates that these plants were never dormant, but had remained in a quiescent state during cold treatment. It is likely that these plants merely tolerate low temperatures during the winter months and begin bud-break shortly after the return of favorable temperatures for growth in the spring.

Length of cold treatment appeared to exert especially strong effects on the growth of *Osmunda claytoniana.* The number of fronds per plant increased with increasing length of cold treatment, up to eight weeks (*Fig. 4*). This relationship between frond production and cold treatment was not apparent in the other species studied. Cold-treated plants of *Athyrium thelypterioides* produced more fronds than untreated plants, but increasing the period of cold treatment failed to increase the frond number further.

Frond length and frond biomass also increased with length of cold treatment up to eight weeks in *Osmunda claytoniana* (*Figs. 5* and *6*). Frond length and biomass were higher in cold-treated plants of *Thelypteris palustris* than in untreated plants, but increasing the period of cold treatment did not promote greater frond length or biomass.

Dependence of soriation on cold treatment was found in only two species (*Fig. 7*). None of the fronds of untreated plants of *Athyrium thelypterioides* were fertile, but 25-40% of the fronds of cold-treated plants produced sori. Plants of *Adiantum pedatum* receiving no treatment or one week of cold treatment were infertile, but percent-sporulation increased markedly with further cold treatment.

CONCLUSIONS

It is concluded from these experiments that the species studied differ in their dependence on an annual cold treatment. *Osmunda claytoniana* has an obvious cold requirement for bud-break and vegetative growth and appears to enter dormancy earlier in the fall than the other species. This species may be better adapted to winter temperatures than the other species studied. Bud-break and some parameters of growth were influenced by duration of cold treatment in *Adiantum pedatum* and *Thelypteris palustris.*

At the other extreme, *Cystopteris fragilis, Onoclea sensibilis, Athyrium thelypterioides,* and *Athyrium pycnocarpon* do not appear to require cold treatment for renewed growth and do not seem to enter a true state of dormancy. Plants of all treatments of these species commenced growth soon after they were brought into the greenhouse. These species apparently remain in a quiescent condition during winter. Although it would be expected that plants of these species would suffer frost damage following occasional autumn warming trends, I have not observed this in the field. Apparently these plants tolerate frost (although I have observed frost damage of some of these species after late spring frosts of great severity) or are more dependent on seasonal photoperiods than on seasonal temperatures for timing of bud-break. Additional studies of some of these species are needed to determine the influence of photoperiod on the induction and breaking of dormancy.

LITERATURE CITED

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SALISBURY, F. B., and C. ROSS. 1969. Plant Physiology. Wadsworth Publishing Company, Belmont, California.

REVIEW

"A TAXONOMIC REVISION OF THE GENUS CNEMIDARIA (CYATHEACEAE)," by Robert G. Stolze. Fieldiana Botany **37:** 1-98. 1974.—The taxonomy of the American members of the family Cyatheaceae has been a source of frustration to botanists for over a hundred years. Only in the past few years has the group received the critical modern study it needed so badly. Tryon has provided us with an excellent treatment of the family in synoptical form. Revisionary work on the component genera has included papers by Gastony, Tryon, Riba, and Windisch. Stolze's revision of the natural group of species maintained as *Cnemidaria* by Tryon is another in this series of excellent systematic treatments. Pteridologists may now look forward to the day when the entire family will be represented in contemporary monographs of this same kind.

A close look at Stolze's revision reveals the quality of the work. The survey of preserved specimens from herbaria has been extensive. Stolze saw nearly 2000 specimens from at least 17 different herbaria, representing plants from the West Indies, Central America, and South America. Experience in the field has also played a major role in the project. Stolze has provided us with a useful guide to the collection of these giant ferns from his experience with sadly incomplete specimens in the herbaria, and happily complete plants in the field. There is a critical review of the morphology of plants in the genus, including work on the unusual anastomosing venation and porate spores. A section on evolution and geography develops the theme of geographic speciation typical of the American Cyatheaceae. The systematic treatment of the species attests to Stolze's careful attention to the elucidation of nomenclature, and the construction of manageable keys. Indices to Latin names and collections complete the study. The text is provided with illustrations in pen and ink by Richard Roesener. Stolze's definitive work on *Cnemidaria* is a useable one—as long as your material is complete!—*David S. Barrington, Pringle Herbarium, Department of Botany, University of Vermont, Burlington, VT 05401.*