ACTA SOCIETATIS
BOTANICORUM POLONIAE
Vol. XLVI, nr 4
1977

Periderm in *Ophioglossaceae*

[1] SHARDA KHANDELWAL AND [2]H. K. GOSWAMI

[1]Suraj Villa, Naya Bazar, Gwalior; [2]School of Biological Sciences, Bhopal University, Bhopal

(Received: July 9, 1977)

Abstract

This paper describes the occurrence of periderm in three genera, *Botrychium* Swartz., *Helminthostachys* Kaulfuss, and *Ophioglossum* Linn. under field conditions. Not all plants of an area belonging to the same or different species possess it. Based on population survey it is suggested that production of functional cork cambium (phellogen), a feature unlike *Fillicenae* may be an inherited trait.

INTRODUCTION

During recent years the periderm has acclaimed wide evolutionary significance on account of its being present in progymnosperms (Scheckler and Banks, 1972). Periderm is a characteristic of stems, branches and roots of gymnosperms and most dicotyledonous plants. Among *Pteridophytes* it is observed in woody lycopods, sphenopsids and *Botrychium* (Bower, 1926; Eames, 1936; Sporne, 1970; Bierhorst, 1971) but is absent in *Fillicales*. None of the previous workers have authentically reported periderm in root of *Botrychium* and in rhizomes of *Helminthostachys* and *Ophioglossum* although Boodle in 1899 (See Smith, 1955) had described small amount of secondary thickening in the stem of *O. vulgatum* L. and Maheshwari and Singh (1934) mentioned it in *O. costatum* L. Referring to probable function, Cambell (1911) mentioned "periderm in the rhizome of *Ophioglossaceae* is probably always associated with leaf bases and has the function of protecting the scar after a leaf has died".

But there has been, infact, no demonstration of functional cork-cabium in *Ophioglossaceae*. As mentioned by Fahn (1967) periderm

accompanies the development of secondary vascular tissue, which was not described by earlier workers. Present paper demonstrates different states of activity of cambium and definite presence of periderm in some roots and rhizome of certain plants of *Botrychium*, *Helminthostachys* and *Ophioglossum* under natural conditions.

MATERIALS AND METHODS

Extensive collections of *Ophioglossum* plants have been made during 1966—1974 from more than a dozen localities in Central India and as many as eight species are being studied. *Botrychium* was collected from Nainital and Ranikhet during September 1970 and 1973 and *Helminthostachys* plants were obtained from the departmental museum.

Materials were either fixed in F.A.A., acetic-alcohol (1:1) or in 70% alcohol. Small transverse pieces of roots and rhizome were dehydrated and prepared as paraffin blocks (56°C melting point). Hand cut sections of fresh materials were also prepared and stained with Sudan IV from numerous plants of each species. This enabled us to find out that the periderm was sporadic in plants of the same species.

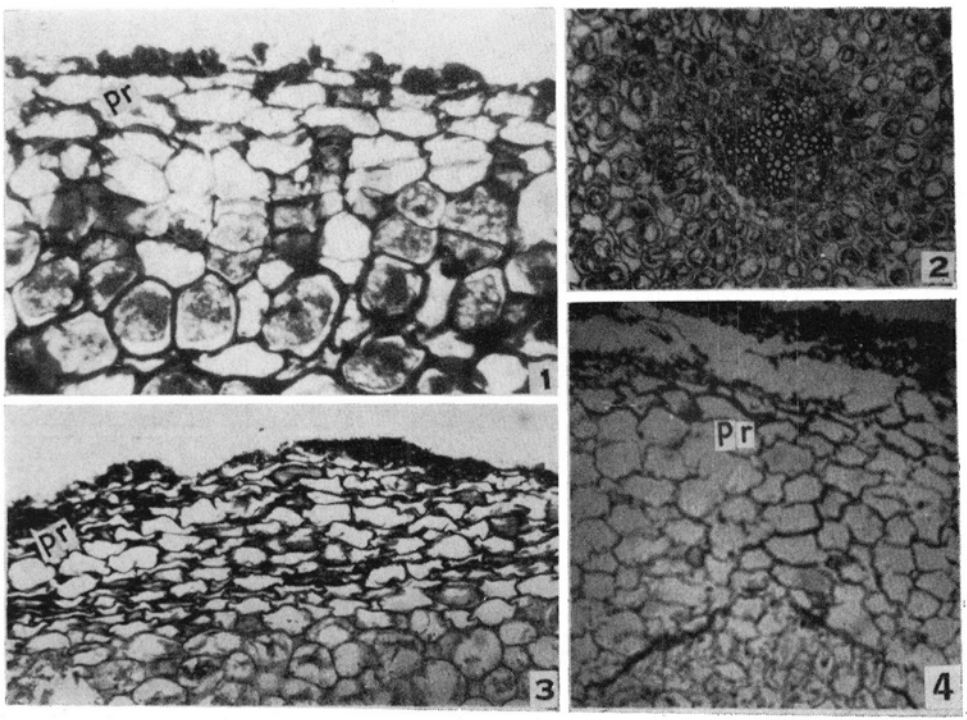
OBSERVATIONS

Roots

Ophioglossaceous roots are succulent, sparsely branched, and devoid of hairs. They are micorhizal and probably the fungus provides most of their absorbing surface.

Roots in cross section show massive cortex which is delimited from the central stele by an endodermis possessing characteristic thickening on the radial walls. Although the stele is of typical constitution, it shows many variables in species of three genera. In *Helminthostachys zeylanica* Hook the stele is reported to be hexarch or heptarch but we also record tetrarch condition; in *B. virginianum* Linn. and *B. ternatum* Thumb it is tetrarch or triarch. However, in most species of *Botrychium* and *Ophioglossum* the stele in either monarch or diarch.

Secondary thickening in the roots of this group is completely unknown except that experimentally induced by Peterson (1971) in *O. petiolatum* Hook. He observed a periderm like tissue in excised roots by the effect of benzyladenine and 2,4-dichlorophenoxyacetic acid. Incidentally we have observed secondary thickening in the extrastelar region in roots of *B. ternatum* (Figs 1 & 2) under field conditions. Periderm is formed by the activity of phellogen (cork-cabium) which originates in outer cortex and produces phellum (cork) externally and

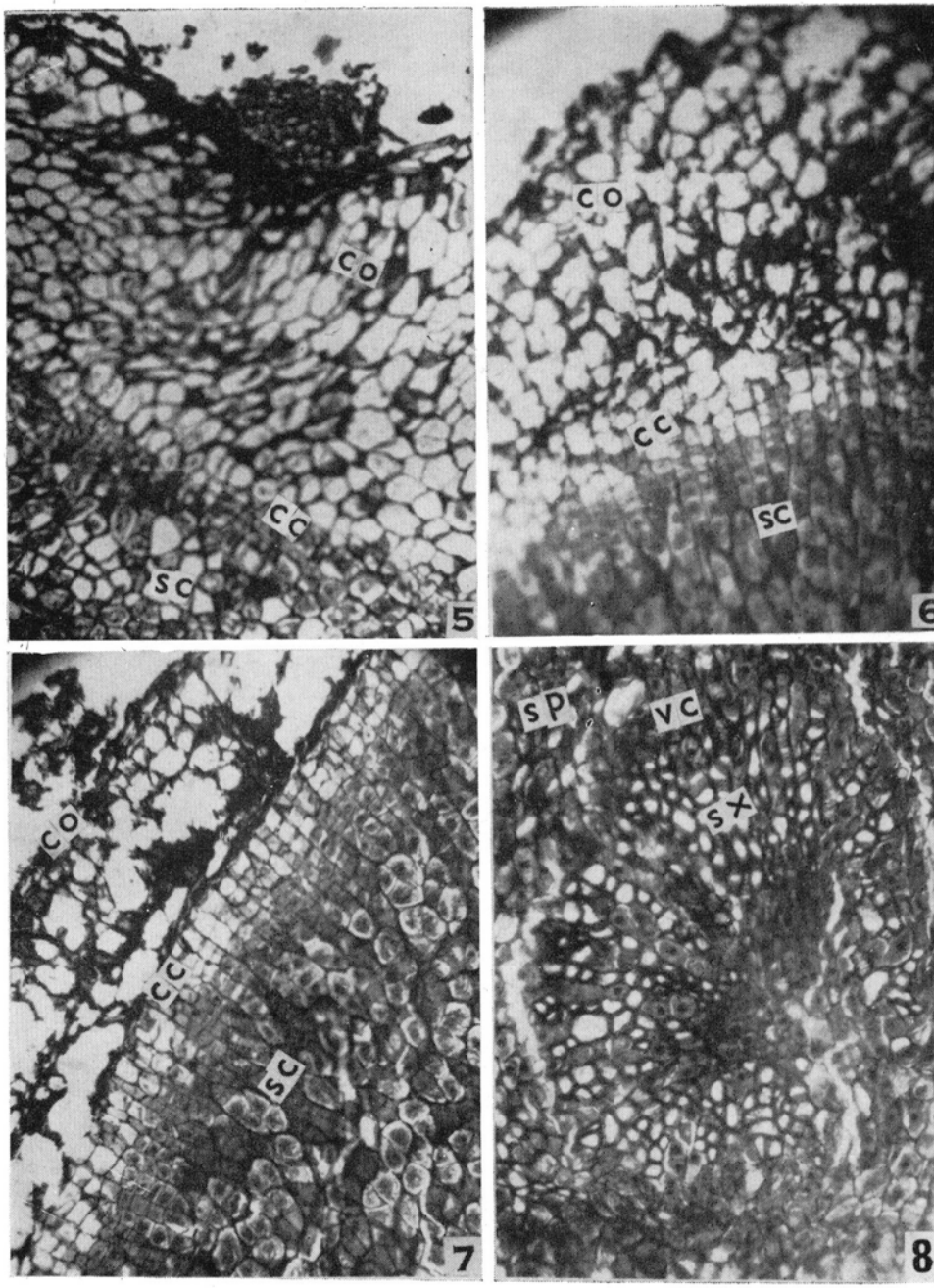


Transverse sections of root and rhizome

1. T. S. of root of *Botrychium ternatum* showing periderm, ×45
2. T. S. of the same root of *B. ternatum* showing tetrarch xylem without secondary vascular tissue ×30
3. T. S. of rhizome of *Helminthostachys zeylanica* showing periderm, ×25
4. T. S. of rhizome of *Ophioglosum costatum* showing periderm, ×25

Abbreviations used

Pr = Periderm; CO = Cork; Cc = Cork cabium; sc = secondary cortex; sx = secondary xylen; sp = secondary phloem; vc = vascular cabium. T.S = transverse section



Transverse sections of rhizome

5. T. S. of rhizome of *B. ternatum* showing periderm in early stage, ×25
6. T. S. of rhizome of *B. ternatum* showing periderm in mid stage, ×25
7. T. S. of rhizome of *B. ternatum* showing periderm in late stage, ×25
8. T. S. of rhizome of *B. ternatum* with secondary vascular tissue, ×25

phelloderm (secondary cortex) internally. The chemical diagnosis by staining with Sudan IV further confirmed that the tissue in question is periderm (Periderm consists of suberized cells which stain red with Sudan IV).

Rhizome

Ophioglossaceous stems are subterranean, but they are vertical in *Botrychium* and horizontal in *Helminthostachys* and *Ophioglossum*. These are soft, fleshy and micorhizal and like other parts of the plants, devoid of sclerenchyma. In cross sections, all ophioglossaceous stems have a definite stele in the basal region of axis delimited by a rudimentary endodermis. The stele is an ectopholic siphonostele surrounding prominent leaf gaps (B o w e r, 1926). In many species of *Ophioglossum* the gaps are very extensive and overlapping thus resulting in a distinct dictyostele or rudimentary type of dictyostele. Primary xylem maturation in mesarch in *Helminthostachys* and endarch in other genera.

The genus *Botrychium* is known to possess secondary vascular tissues and periderm. We now observe secondary thickening in the stelar and extrastelar regions in *B. ternatum* (Figs. 5—8) and also encounter periderm in the rhizomes of *H. zeylanica* (Fig. 3), *O. costatum* (Fig. 4), *O. vulgatum, O. petiolatum, O. nudicaule* Linn., *O. polyphyllum* A. Braun apud Seubert., *O. gramineum* Willd. and *O. lusitanicum* Linn. This must be indicated that not all plants are characterized (Table 1) in showing periderm although, each species produces certain plants with periderm. This also explains why earlier workers missed this tissue and assigned it to be typical mainly of *Botrychium*.

DISCUSSION

Triloboxylon halli (Arnold) Scheckler and Banks is the oldest plant in which periderm has been found to be present. In younger plants from lower Upper Devonian strata, the periderm has been reported in *Trilogoxylon ashlandium, Tetraxylopteris schmidii* and *Proteokalon petryi* all belonging to *Aneurophytales* of progymnosperms. Periderm in *Botrychium* has often lead to speculate that *Ophioglossales* might have arisen from certain progymnosperms or from coenopterids (B i e r h o r s t, 1971). B a n k s (1968) however suggests that *Ophioglossales, Coenopteridales* and *Fillicales* might have originated separately from a still earlier group like *Rhyniopsida*.

Our observation of periderm in three genera, *Ophioglossum, Botrychium* and *Helminthostachys* suggests that the periderm production is

a typical feature inherent in *Ophioglossales*. Obviously, this group is anatomically different from *Filicales*, besides possessing many dubious relationships already known (See Bierhorst, 1971). With a view to find out the frequency of *Ophioglossum* plants possessing periderm a series of hand cut and microtomed sections were stained with Sudan IV. Our observations on 136 plants corresponding to seven species of *Ophioglossum* indicate (See Table 1) that all plants do not possess periderm.

Table 1

Periderm in different species of *Ophioglossum*

S. No.	Name of species	No. of plants examined.	Periderm in Rhizome	Frequency
1.	*O. costatum*	50	34	0.680
2.	*O. vulgatum*	35	20	0.570
3.	*O. polyphyllum*	30	30	1.000
4.	*O. nudicaule*	6	5	0.833
5.	*O. petiolatum*	5	3	0.600
6.	*O. gramineum*	5	4	0.800
7.	*O. lusitanicum*	5	3	0.600
	Total	136	99	.727

Recently the role of environmental factors (such as day-length period, mechanical injury etc.) has also been studied in periderm production in certain angiosperm genera (Waisel et al., 1967; Borger and Kozlowski, 1972 a, b, c). Borger and Kozlowski have also stressed on physiological control over the development of secondary xylem and periderm production.

The plants of *O. costatum*, *O. nudicaule*, *O. gramineum*, *O. petiolatum* and *O. lusitanicum* have been collected from open areas measuring 3—5 square feet mainly from isolated hill tops. We thus believe that presence or absence of periderm in *Ophioglossum* plants (Table 1) can not be accounted due to environmental influence but they indicate internal (and physiological) differences.

This is also true for rhizome of *Helminthostachys* and rhizome and roots of *Botrychium* and we opine that the trait of production of periderm exhibits genetic segregation. All three genera which are diploid exhibit variability in expression suggesting common genes among them. Mode of inheritance can be conclusively proved only by breeding experiments but it is possible to estimate the segregational ratios and suspect the mechanism involved in a diploid population. Here the ratio is not constant showing nearly 50%, 75% and 100% segregation, which suggests

that periderm production may be conditioned by dominant mode of inheritance. Their origin from such a gene pool where periderm production was an established trait therefore seems quite probable.

Acknowledgments

We are thankful to Dr. J. P. Kaushik, Department of Botany, Government Science College Gwalior for certain suggestions. Thanks are also due to Prof. M. S. Agarkar, Department of Botany Rewa for his help with plant collections.

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Address for correspondence:
Dr. H. K. Goswami, Ph. D.
L. I. G. A 322
E-7, Arera Colony
Bhopal; India

Periderma w rodzinie Ophioglossaceae

Streszczenie

W pracy wykazano, że w trzech rodzajach z rodziny *Ophioglossaceae: Botrychium* Swartz., *Helminthostachys* Kaulfuss, and *Ophioglossum* Linn. występuje periderma. Autor uważa, że zdolność do wytwarzania funkcjonalnego fellogenu jest cechą dziedziczną badanych roślin.