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James Merryweather

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THE BRITISH PTERIDOLOGICIAL SOCIETY

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THE BRITISH PTERIDOLOGICAL SOCIETY was founded in 1891 and today continues as a focus for fern enthusiasts. It provides a wide range of information about ferns through the medium of its publications and available literature. It also organises formal talks, informal discussions, field meetings, garden visits, plant exchanges, a spore exchange scheme and fern book sales. The Society has a wide membership which includes gardeners, nurserymen and botanists, both amateur and professional. The Society's journals, the *Fern Gazette, Pteridologist* and *Bulletin* are published annually. The *Fern Gazette* publishes matter chiefly of specialist interest on international pteridology, *Pteridologist,* topics of more general appeal and the *Bulletin,* Society business and meetings reports.

Membership is open to all interested in ferns and fern-allies. **SUBSCRIPTION RATES** (due on the 1st January each year) are Full Personal Members £15; Personal Members not receiving the *Fern Gazette* £12; Student Members £9; Subscribing Institutions £25. Family Membership in any category is an additional £2. Applications for membership should be sent to the Membership Secretary (address above) from whom further details can be obtained. (Remittances made in currencies other than sterling are £5 extra to cover bank conversion charges). Airmail postage for all journals is an extra £4, or for those not receiving the *Fern Gazette,* £2.50. **Standing order** forms are available from the Membership Secretary.

[Front cover: *Dryopteris affinis* morph. *affinis*] *original Vignettes by Michael Hill*

Back numbers of the *Fern Gazette, Pteridologist* and *Bulletin* are available for purchase from P.J. Acock, 13 Star Lane, St. Mary Cray, Kent BR5 3LJ, from whom further details can be obtained.

EDITORIAL

This year *Pteridologist* is dominated by the papers presented at the symposium on fern hardiness held at Kyre Park in January, 1996. It really gives a kick start to a full investigation of hardiness which should enlighten botanist and gardener alike. Graham Ackers introduces the idea of a hardiness census in his list beginning on page 55. Please join in and record your own observations, past and future, and we will improve our understanding of which ferns survive under which conditions in the UK, and how they do it. Gradually, many new species will be found to thrive in our chilliest frost pockets, and some of those considered too tender to introduce to the U.K. may be found to be perfectly happy here (see page 73).

I'm going to dish out an award this year - *The Editor's Choice '97* - to the article which has given me most pleasure whilst editing. It was close, and the choice difficult. The finalists are both Scots, from east and west of the Great Falkirk Divide. What I personally enjoy reading in *Pteridologist* are articles which mix interesting narrative with the pteridology, so I was attracted to Alastair Wardlaw's on tree-ferns and Heather McHaffie's about mountain lady ferns. The latter has that little extra, botanical history, so Heather wins an unforgettable visit to the Bouckley garden, which includes the now legendary treat: home-made bread and butter, best cheddar and Jack's famous raw shallots, very (!) tasty descendants of those he got from an "old boy" back in 1946.

As you know, we recently lost our old friend Jimmy Dyce. As we took tea and cakes after a memorable memorial service in which we celebrated the diverse aspects of his long life, a plan began to emerge: we would dedicate the next edition of *Pteridologist* to his memory. May I ask you to submit proposals for articles which have a bearing on Jimmy's interests: polystichums, fern distribution recording, fern varieties, BPS excursions, fern books etc. (whisky?) immediately spring to mind. Please write to me outlining your article by 1st August, 1997. I will consult with a special editorial panel who will then issue commissions for articles which should be sent to me by Christmas, 1997. Several years' experience has made me resolve that if articles do not make the deadline for copy, they've had it, and that is my strict policy from now on. If articles don't arrive on time, *Pteridologist* will, I'm afraid, be thinner.

Congratulations to our last president Jack Bouckley on his *Harlow Carr Medal Citation* by the Northern Horticultural Society. He has joined the few honorary members of the NHS in recognition of his "....outstanding and distinctive service....". He was "....particularly commended for his promotion of the study and conservation of ferns".

JAMES MERRYWEATHER

CORRECTION

A piece of text, originally in John Mitchell's article *Setting up a monitoring system for* Woodsia *in the west of Scotland* (*Pteridologist* 2, 6 (1995) 285-287), appears to have been lost during the rather complicated, two-centre, editing of the proceedings of the 1994 Edinburgh meeting. In consequence Ben Lui became described as "a rather nondescript hill", a most undignified label, as several correspondents have pointed out to the innocent author.

The last paragraph on page 286 should have read: *Not all the* W. alpina *sites in the western highlands are as impressive as Ben Lui. One exceptionally large, yet little known colony in the west of Scotland occurs on a rather nondescript hill, which is probably why it was overlooked by the Victorian fern collectors.*

FERN HARDINESS SYMPOSIUM

At Kyre Park - 20th to 21st January, 1996

INTRODUCTION - THE HARDINESS WORLD

Graham Ackers

The intention of this talk is to set the scene for the weekend by introducing the sessions, reviewing briefly some hardiness topics, posing some questions, and suggesting some ideas for future research (*N.B.* the latter now includes additional ideas which emerged during the Symposium).

The Collins English Dictionary (1979 edition) gives as its definition of **Hardiness:** "The condition or quality of being hardy, robust, or bold". This is not particularly helpful, being somewhat tautological. More helpful is its definition of **Hardy:** "Able to live out of doors throughout the winter". Is this disarming simplicity valid, or is there more to the attribute of being hardy than the definition suggests?

Much of my own knowledge of fern hardiness comes from Rush, 1984. This would certainly be the last book to leave my collection in the event of any financial (or other unforeseen) crisis! A more structured approach to the hardiness literature is presented in Alastair Wardlaw's paper, *Survey of the Scientific Literature on the Frost Hardiness of Ferns* (page 74). The rest of what we know is probably locked away in the heads of growers, some of which we wish to unlock this weekend by means of the Open Forum.

The most casual of observations will indicate to an experienced grower whether a fern is healthy or not. What most of us do not know is what happens within a plant to cause an adverse reaction to hostile environmental conditions. Jennifer Ide's papers provide many of the answers (pages 59 & 62).

Plants growing in cliff or wall habitats (e.g. *Notholaena marantae*, *Cosentinia vellaea*, *Adiantum reniforme*) have adapted to temporary water shortages by remaining viable, but outwardly appearing shrivelled, soon to recover when appropriate water levels recur. However, it is ironical that such seemingly adaptable plants in the wild can be amongst the most difficult to cultivate - why should this be?

Frequently, it will be difficult to know whether a plant is failing owing to an inherent lack of hardiness, or adverse growing conditions. I have cultivated two specimens of *Dryopteris oligodonta* (a Canary Islands endemic) for several years - one in a sheltered location outside, the other in a cool greenhouse. The former has survived, but is always cut to the ground in winter, and never puts up more than one small frond in summer. The latter, however, is a picture of opulence, and gives me far more pleasure than its struggling garden grown companion. Last summer, I reversed the growing conditions of the two plants, so it will be interesting to see whether or not the fully grown pot specimen thrives out of doors. As plants at their limits of hardiness will tolerate much less variation in their environmental conditions, I fear for the survival of my Canary Islands fern following this harsh 1995/6 winter. (*N.B.* September, 1996 - it did not survive!)

Weeds are plants that grow profusely, both in the wild and in cultivation. Examples of weedy ferns are - *Pteris vittata* in the tropics and sub-tropics, *Dryopteris filix-mas* and bracken (*Pteridium aquilinum*) in Europe, and *Thelypteris noveboracensis* in Eastern North America. By definition, weeds are vigorous and tolerant growers, so what could we learn that might be helpful in a hardiness context from closely studying such species?

Another phenomenon worthy of study could be that of evergreen-ness. Evergreen plants are able to continue to use water in winter in oceanic climates, but in other situations evergreen-ness is a device to withstand drought. These two capabilities appear contradictory, so perhaps evergreen-ness is a multi-faceted characteristic? The evergreen *Polystichum lonchitis* thrives in the Alps, snow covered in winter, so why is it evergreen? Evergreen plants suffer if the ground freezes, because they cannot then obtain water. Presumably, snow cover in the Alps prevents the roots of *P. lonchitis* from actually freezing?

Deciduousness, on the other hand, is a hardiness device in continental (and alpine) climates, but can be a problem in oceanic climates, where pathogens may get to work in higher winter rainfall during dormancy.

It is useful to consider the value of hardiness zones as a concept. They were invented by Alfred Rehder in his 1927 book *Manual for Cultivated Trees and Shrubs*. This system was then used by Donald Wyman from 1938 onwards in various editions of his *Gardening Encyclopedia*, in later editions of which, Wyman adapted the system to his own. This was effectively taken over by the US Department of Agriculture in 1960, in which system 11 US zones are recognised. Several other countries now have hardiness zone maps, including Britain and Europe - e.g. in Gerd Krussmans *Manual of Broad Leaved Trees and Shrubs*, and in the *European Garden Flora* (where Heinze and Schreiber's system is used). As was pointed out during the Symposium, the *Gardening Which* hardiness zone map is probably the most useful for the British Isles.

All these systems are based on isotherms of minimum winter temperatures, thus being meteorological patterns and not directly hardiness zones. Providing one accepts this limitation, they can be of value - for example the fact that *Dryopteris wallichiana* is rated Zone 6, and *D. sieboldii* Zone 8 is useful, if only in relative terms. It is significant that the American Fern Society publishes the hardiness zones for the plants offered in their spore exchange list.

Although hardiness zones might be helpful as broad brush indicators, more important perhaps are the influences of local climates, and micro-climates. The stand of *Matteuccia struthiopteris* in my garden grows in a frost pocket. Their deciduousness protects them in winter, but they can succumb to late frosts, which are a problem in our oceanic climate. Alastair Wardlaw's paper *Experimental Enclosures for Fern Protection* (page 69) recognises the importance of micro-climates by describing their artificial creation in his own garden. Bob Brown's talk (not reproduced here) *Hardiness from a Horticulturist* related his experiences as a nurseryman with his non ferny herbaceous plants.

The final section of this paper relates to research ideas that could be taken forward collectively by the BPS. Appended to my original talk are thoughts that evolved during the Symposium. I consider it very important that the Society should contribute some original research and knowledge to the hardiness literature as it relates to ferns. For this to happen, the ideas below that are considered to be appropriate and viable would require incorporation into a co-ordinated programme. The research programme(s) would require careful design, with one or more leaders being identified.

For ease of reference, the ideas are numbered.

1. Hardiness Census. A form of census amongst growers was performed by Richard Rush as one of the inputs to his 1984 book. A further census should now be undertaken, casting the net as widely as possible - e.g. to include BPS members, institutions/gardens, NCCPG collection holders, etc. Contact with member growers occurs through the Spore Exchange Scheme, which could be one potential vehicle for conducting a census. The purpose of the census would be to determine what grows where, and under what conditions.

2. Fern Hardiness Trials. This would involve designing and conducting some form of BPS-wide trial(s). Such a trial could produce much more focused data than a census (which would only collect information on what people happened to be growing). Mike Pollock's talk (not reproduced here) *Experiences from RHS Trials* presented the rationale and operation of RHS trials (although none have been conducted with ferns).

3. Collect Information on Wild Habitats. From my own observations in the Acadia National Park in Maine, *Osmunda claytoniana* grows in noticeably dryer conditions than either *O. cinnamomea*, or *O. regalis*. A knowledge of the wild habitat preferences of cultivated, or potentially cultivable ferns would provide a valuable database of information. Sources could include literature, correspondents abroad, and members' visits to foreign parts.

4. Increase the Foreign Hardy Ferns in Cultivation. I vividly recall John Burrows recommending Southern African fern species that might lend themselves to European cultivation in his presentation at the BPS organised International Symposium on the Cultivation and Propagation of Pteridophytes (Burrows, 1992). His favourite was *Polystichum alticola*. The more ferns we have in cultivation, the more data will be available to help us understand the hardiness parameters. Apart from the higher, cooler areas of S. Africa, many other potential locations exist from which ferns might prove hardy - e.g. the Andes, Himalayas, Japan, Mexico, New Guinea, and Taiwan. Again, sources could be botanical gardens, contacts abroad, and members' visits. Such initiatives could come within the remit of the BPS sub-group on Foreign Hardy Ferns, run by Matt Busby, who presents some of his experiences in his paper *Foreign Ferns - Hardy or Not?* (page 57).

5. Fern Species as Hardiness Indicators. In a way, this proposal of Alastair Wardlaw's is rather the reverse of determining what grows where. The idea is to use a fern species to denote a particular hardiness regime (rather as plant communities are named with reference to a couple of the dominant species occurring in the community). For example, *Dicksonia antarctica* would be an ideal candidate to denote extreme oceanic/lusitanean conditions in Britain. Martin Rickard presents more information on the hardiness of tree ferns in his paper *Hardiness in Tree Ferns* (page 67). In this context, I would also recommend his excellent article in January's edition of *The Garden* (Rickard, 1996).

6. Fern Cultivation Distribution Atlas. In 1978, in conjunction with the BSBI, the BPS produced the *Atlas of Ferns of the British Isles*. An idea of Alastair Wardlaw's is that this concept could be extended to cover ferns under cultivation. The production of such an atlas could be borne in mind when conducting the census (see 1. above).

7. Experiment on the Control of Winter Hardening. Jennifer Ide points out that significant plant growth, and the ability to commence hardening, are mutually incompatible. Experiments could be conducted on the use of growth retardant hormones in the Autumn to encourage the onset of winter hardening. Spring might be included also, potentially to minimise the adverse effects of late frosts.

8. Temperature Survey. In order to obtain more accurate hardiness information than is available elsewhere, members could be asked to record the maximum and minimum temperatures in their gardens throughout the year (but particularly in winter).

9. Insulating Materials. In the context of providing winter insulation, as described in the papers by Alastair Wardlaw and Martin Rickard, a survey could be conducted into the relative and actual effectiveness of those available - e.g. straw, bracken, bubble wrap, rock wool, etc.

10. BPS Special Publication. Some of these results could be published in a BPS special publication, in perhaps 2 or 3 years time. Such a publication, which would complement but not replace Richard Rush's book, could bring together all current BPS knowledge on Hardiness, including an expansion of the information that is presented in the papers that follow.

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FOREIGN FERNS - HARDY OR NOT?

A. R. Busby

This is a title that I would not have chosen and is a question to which I do not have an answer. It is, however, a question I pose to myself quite frequently. Although my interest in foreign hardy ferns began when I started fern growing in the late 1960s, it was Richard Rush's book published in 1984 that really awakened my interest, and we owe Richard a debt of gratitude for his foresight and hard work in putting into print his experience in this field.

The interest in growing foreign hardy ferns has really only taken off in the last 15 years or so and only a limited number of foreign species were available commercially. The scope of available species and the interest in growing them in British collections has expanded considerably in recent times.

I would suggest that foreign ferns from temperate regions fall into three categories:

1. Those with an established record of being fully hardy, eg. *Adiantum venustum, Dryopteris wallichiana* and *Polystichum munitum.*

2. Those that are hardy in all but the worst of winters or are hardy if some protection is given, e.g. *Athyrium nipponicum* 'Pictum'.

3. Those that are not fully hardy, and those which have just been introduced and are not fully tried. More about those later.

Along with other BPS members, I have been fortunate in having the opportunity to receive material from that indefatigable fern hunter, Christopher Fraser-Jenkins, from time to time, and we owe him a great deal for having given us the chance to try something different; things that, if it were not for him, we would not have had the opportunity to grow. I must also mention and thank Martin Rickard and many other members who have been most generous to me over the years.

My own broad approach to new, unknown items is to keep them on the dry side, because they have a better chance of overwintering than those kept constantly wet. To achieve this, in 1986 I invested in a poly-tunnel so that new items would have a dry environment during the winter months. With propagation, it also provides spare material so that subsequent generations can be used experimentally in the garden while the parent plant remains relatively safe in the tunnel.

This raises another point. Ferns that are not reliably hardy should not be pot grown without adequate protection. Freezing of the rootball can kill the hardiest of plants and is a test that few hardy ferns should be subjected to. Hence the use of a poly-tunnel. Ferns whose hardiness is suspect can be planted in the ground which provides the roots with the protection of a large volume of soil.

The Royal fern, *Osmunda regalis* is the hardiest of ferns. I have grown it in 10 and 12 inch pots for many years. During the winter, the rootball becomes frozen solid, but I have yet to lose one. However, raising sporelings of these plants and overwintering them in small pots without protection, I regularly lose 25 - 30% due to freezing of the rootball. This suggests to me that young hardy ferns in small pots are vulnerable if not protected. If this is true of our hardiest of ferns, then there is all the more reason to be cautious with foreign treasures, especially if they have no hardiness track record in the British climate.

So, what is hardy? Should we distinguish between cold hardy and merely cold tolerant? There are so many variables that might affect a fern's ability to withstand our cold winter months such as heavy sticky clays as opposed to light sandy soils, or the higher average temperatures found in inner cities compared with those of the open countryside. These variables are considered by Rush in his book.

Research mentioned yesterday looked at the frost susceptibility of fronds of certain fern species. I am not sure that this is valid. It does not bother me if a species of fern loses its fronds in the winter: there are many deciduous ferns in temperate latitudes. What I want to know is whether the fern's rootstock is frost hardy and, to my mind, that is far more important.

In my tunnel I have a plant of *Adiantum hispidulum* which has come through the last five winters with ease. Although as a pot plant, it maintains its fronds throughout the winter, in my unheated tunnel it behaves as a deciduous fern. Its fronds take on a pinky-brown colour and maintain their shape as if dried, producing a new flush of fronds in late spring. How many other indoor ferns are capable of developing a seasonal cycle of growth? Additionally, the background of any one particular species must be considered, in other words the plant's native latitude and altitude. Surely, these must be the first criteria to consider, but I rarely know much about the kind of place a new acquisition comes from.

This leads us to our Spore Exchange Scheme. There are numerous species on offer that are likely to prove hardy or near hardy, but we do not get much feedback from members on their failures or successes. Margaret Nimmo-Smith records all information provided by the donors about where their spores were collected, which may include the altitude at which it was collected. The recently formed Foreign Hardy Fern Group hopes to address the problem of species suitability to the British climate by encouraging members to report their experiences. In this way, we will be able to add valuable information on the cultivation of foreign ferns in British collections.

So, to return to Richard Rush's book. Essentially he was inviting us to try this or try that, but we have moved on since the book was published in 1984. Many of the species he suggested might be hardy have proved to be so, and his book is not exhaustive. There must still be hundreds of species that are worth trying.

I urge you to experiment and report your experiences in our Society journals. Hopefully members of the Foreign Hardy Fern Group will lead the way and disseminate the information to members. Only in this way shall we be able to increase our knowledge of which foreign ferns are hardy and enable us to expand the range of interesting ferns in our collections.

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LOW TEMPERATURE SENSITIVITY IN PLANTS

Jennifer M. Ide

Botanists use the term "hardening" for the natural adaptive responses of plants which enable them to survive periodic or permanent change to stress-inducing environmental conditions. For example, hardening can occur to drought, heat, high or low light intensities. The gardener in temperate regions, on the other hand, is using it in a very restricted sense, referring to two particular adaptive responses by plants: that which he induces in seedlings and sporelings before planting them out in the garden by exposing them to increasingly drier conditions, and probably higher or even lower light intensities depending on the conditions under which the plants were grown; and that which occurs in plants in the garden each year at the end of autumn and through the winter, enabling plants to resist chilling and even frost damage by low temperatures. Both are natural processes and do not occur only when they are induced by horticulturalists. In the wild, for example, as seedlings and sporelings mature and increase in height they move into the more hostile environment of a less humid and more windy atmosphere, lower temperatures and frequently higher light intensities than they experienced immediately above ground level. It is about the second of these responses that this and the following article are concerned. This article describes low temperature sensitivity and the effects of low temperature on plants, whilst the following article sets out to explain what we know about adaptations of plants to low temperature, in particular, hardening.

There is a vast research literature on hardening but most of it deals with the response of different plants, mainly temperate ones of economic importance, to low temperature and freezing. Literature on what is happening in the plant when hardening occurs is far more meagre and I was unable to find a complete account which could be considered to be a consensus of our present state of knowledge of the process. Certainly no one appears to have used pteridophytes in attempts to elucidate what is happening although they have been used in experimental assessments of hardiness (see article by Wardlaw, page 76). In this, and the following article, I have attempted to synthesise the literature on the subject, which often varies in the detail and is even conflicting at times, and trust that my interpretation does not contain too many unacceptable compromises or inaccuracies. A knowledge of the injurious effects of low temperature on plant tissue, the conditions which induce hardening and of what is occurring when hardening takes place, is of considerable value to the fern cultivator, even though based on observations made on non-pteridophytes, and so I make no apologies for two articles without any direct foundations in pteridological research.

Temperature Sensitivity

Within the normal distribution range of a species, the ability to accommodate small and transient fluctuations in environmental conditions which occur throughout the day, such as temperature, light intensity, humidity and water availability, are normal. However, enzymes, which control physiological processes, and the organelles within cells in which these processes take place, function within a given range of each of these factors, the range being genetically controlled and geared to the normal geographical range of the species. For example, the temperature range for tropical plants is typically 10°C to 30°C, whereas in temperate species the same enzymes will function between 0°C and 25°C. In other words, the enzymes are temperature adapted. Outside these ranges the enzymes and organelles either function more slowly (usually the case at temperatures below the normal range) or they are progressively destroyed (usually the case at high temperatures). To tolerate levels in one or more environmental factors outside the range for which they are adapted, plants must become further adapted or they will perish. As far as the low temperatures of temperate winters are concerned, plants of tropical origin cannot adapt even to several degrees above freezing and suffer chilling injury and perish, whereas many native temperate species can adapt. Those temperate plants that cannot adapt avoid low temperatures by disappearing below ground or persist as dormant seeds or spores for the winter period.

The degree of low temperature resistance shown by the tissues of different species is broadly related to the temperature regime in their natural range. Tolerance to low temperatures and frost is genetically determined and varies not only among species, but also among varieties and ecotypes. Most people are familiar with the notion of different species and even varieties having different tolerances to low temperature and frost, but may be less familiar with the concept of ecotype variance. The current interest in the cultivation of tree ferns has revealed a possible example of this: plants of *Dicksonia antarctica* grown at high altitudes in Tasmania are said to be more tolerant of lower temperatures than specimens grown at lower altitudes.

Tolerance of low temperature also varies in the course of development of an individual plant. Seeds and spores are generally the most resistant stages. Actively growing seedlings, sprouting shoots, tree saplings and young ferns are all extremely sensitive to low temperatures but, as mentioned previously, if stimulated by their environment and they possess the genetic ability to do so, become more tolerant of very different conditions as they mature.

Finally, all organs of the same plant are not necessarily equally resistant to low temperature at the same time. Leaves and roots are more sensitive to the same degree of frost than stems. Young leaves are less resistant than older ones and the leaf apex is often the only part of this organ to be injured. In ferns, the leaves are often less tolerant than rhizomes: note the death of leaves in many of our species as winter approaches or during it.

The Effects Of Chilling And Ice Formation On Sensitive Tissues

The physiological effects of low temperature are complex, and still rather poorly understood.

Chilling injury

Observations, such as the leakage of cell compounds, e.g. anthocyanins, tannins, in several studies have led to the suggestion that chilling injury at temperatures above 0°C in tropical plants results from physical and chemical changes in the cell membranes. Chilling is thought to bring about a phase change (liquid to solid) in the membrane lipids, which are important to the structure of the cell membranes, thus destroying the membrane permeability and resulting in cell disruption. Enzymatic lysis[1] at low temperatures may also cause inactivation of membrane-bound enzymes of the cell, especially those of the mitochondria, the organelles concerned with respiration.

In general, temperate plants are not susceptible to chilling injury at temperatures above 0°C and tend to show signs of damage only after ice has formed within their tissues. When hardened some cold tolerant species can be chilled to -38°C without damage.

Extracellular freezing

As the temperature falls the cell contents change from a "liquid" to a "solid" form: a process known as vitrification. The water *within* the cell is thought to supercool, i.e. it remains labile below freezing point and is in an amorphous state with no crystals present.

[1] disintegration of compounds by the activity of enzymes.

However, at approximately 0°C, or a few tenths of a degree below, the water in the intercellular spaces begins to freeze. The effect is to lower the vapour pressure in the intercellular (between cells) spaces below that within the cells and consequently water is withdrawn from the cell into these spaces, where it also freezes. As long as the periods of intercellular freezing are not prolonged and the rate of thawing is not too rapid, the formation of extracellular ice may not cause significant tissue damage in hardened plants.

However, if extracellular ice persists and cooling is slow enough (approximately 1°C per hour) the above processes result in a number of deleterious effects in the tissues. All the freezable water in the cell will be removed before the critical temperature is reached at which the supercooled water begins to crystallise out. Generally speaking, within sensitive cells ice begins to form at -1°C to -5°C, whereas it usually forms in supercooled cells between -13°C and -30°C depending on the species. It can be even lower; in alfalfa roots, for example, in laboratory tests ice did not begin to form until -45°C! The result of the removal of water is severe dehydration of the cell contents, which shrinks the entire cell, including the cell wall, and causes loose tissue. The cell contents are also disrupted, even the strands of cytoplasm breaking.

As well as causing mechanical damage to plant tissues, irreversible chemical changes occur within the protoplasm[2]: proteins, including enzymes, are denatured and, with various other components, are precipitated. Compartmented substances such as hydrolytic enzymes are released into the cytoplasm. The buffer system becomes unable to control pH, and there may be a tendency for macromolecules to condense when forced together by the dehydration of the cytoplasm. In many species, these effects inevitably lead to death of the tissues.

Mechanical damage from intercellular ice crystals occurs if the intercellular spaces are oo small to accommodate all the ice formed and cells are crushed, ruptured, or separated by splitting of their walls along the middle lamella. This is more likely to happen in young organs where the intercellular spaces are smaller than they are in mature tissues.

Rapid thawing may also cause death by crushing if the ice crystals thaw more quickly than the water can be reabsorbed into the cells and/or by further disruption of cell metabolism and water relations.

Intracellular (within cells) freezing: If cooling is rapid (rates of several degrees per hour) not all the water is removed from the cell and it will crystallise within it because the critical temperature is reached before all the water has been removed. The intracellular ice crystals cause mechanical damage, but the removal of water as ice crystals also causes a dehydration which, below a certain critical temperature or after a prolonged period, as with slow cooling, allows irreversible chemical changes (precipitation) within the protoplasm. (This accounts for the wilting so commonly observed, and for the injected areas which show up over a leaf blade when the intercellular ice first melts.)

As freezing occurs there is an instantaneous denaturation of cell protein because the ice crystals forming between the proteins exert a shearing action which causes the molecules to unfold, and new, deforming, disulphide intermolecular bonds to form. Rapid killing on freezing may result from this denaturation of the proteins of the plasma membranes, but slower metabolic injury may result from the denaturation of enzyme proteins.

Levitt, 1962-68, theorised that the mechanism of frost resistance is due to chemical and physical hindrance to the formation the disulphide bonds during freezing which, in turn, decreases the opportunity for protein denaturation. The formation of these

[2] cell contents (membranes, cytoplasm and organelles) excluding the cell wall.

intermolecular bonds may be prevented by one or more means: by the protection of the vulnerable parts of the molecule by substances present in the tissues; by synthesised substances formed during hardening; or by changes in the proteins themselves. Experimental and field observations tend to support this hypothesis.

Due to the resistant nature of their cytoplasm, hardened plants of many species can survive prolonged periods of very low temperature and high levels of cell desiccation. However, it appears that the cells of even the most resistant plants cannot tolerate intracellular freezing caused by very rapid cooling. Rapid cooling is nearly always fatal. Possibly mere deformation of the shrinking cell may be lethal.

When the ice crystals melt rapidly again the effect is lethal probably due to the cell walls expanding more rapidly than the protoplasts can swell and thus possibly tearing the two apart.

REFERENCES: *see page 66.*

ADAPTIVE RESISTANCE TO LOW TEMPERATURE INJURY IN PLANTS

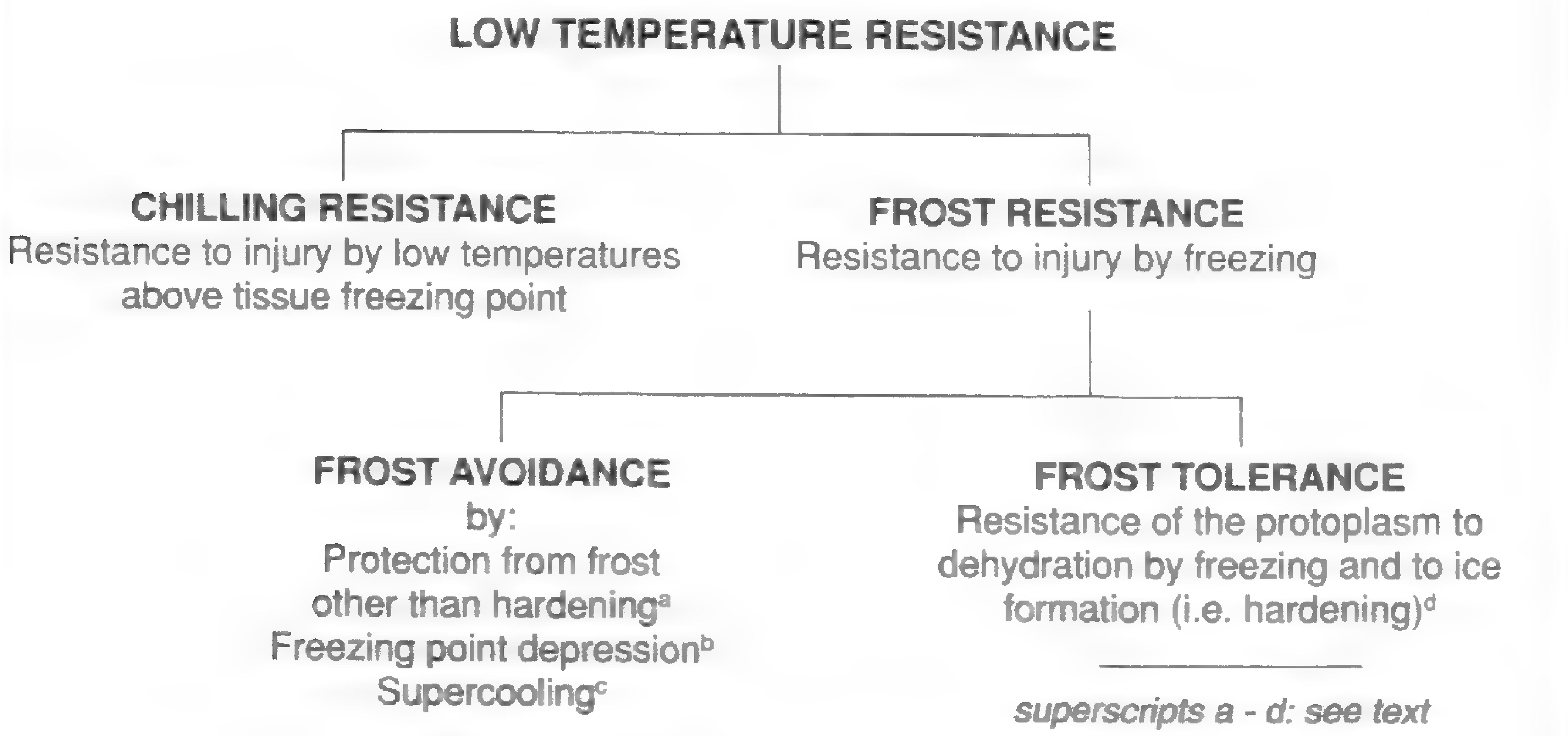
Jennifer M. Ide

Introduction

The previous article dealt with the sensitivity of plants to low temperatures and the effects of chilling and ice formation on sensitive tissues. In this article, I have tried to synthesise into a coherent account the scattered information available on the hardening process, the adaptive response of temperate region plants to low temperatures.

There are only a few mechanisms by which plants are able to protect tissues from low temperature injury, and they are not always effective! See summary in Figure 1.

Figure 1. The Components of Low Temperature Resistance
Based on Levitt, 1958 in Larcher, 1980



Examples of other adaptations found in temperate plants (Figure 1[a]) include:

- low cardinal temperatures (the minimum, optimum and maximum temperatures which control the functioning of physiological processes).
- prostrate and rosette forms
- insulation of vulnerable tissues
- surprisingly, the photoperiodically induced leaf drop in deciduous tree and shrub species and the evergreen habit in other woody species
- winter dormancy.

However, despite the possession of one or several of these adaptations, including dormancy (a widely adopted method of avoiding severe conditions in winter), survival of perennial plant tissues depends ultimately upon the ability of the cells to avoid injury by acquiring tolerance to low temperature chilling and considerable ice formation in their tissues, that is by hardening (Figure 1[d]).

As far as the hardening process itself is concerned, we are far from knowing, and even farther from understanding, all that is involved. It is not known how plants sense low temperature, nor is the pathway by which the signal is transduced understood, and the important consequential changes in cell function have been only loosely identified.

Stages In The Hardening Process

As noted earlier, there is a distinction between injury to protoplasm by the drop in temperature as such and injury by the process of freezing. As autumn draws in, growth ceases and only then can the plant enter a state of readiness for hardening; the hardening process then advances in phases, with each stage preparing the way for the next. In general, as the winter climate becomes more severe, the possession of more of these phases becomes necessary for plant survival.

In a theory developed by Tumanov and his co-workers (1967), the process is induced in herbaceous and woody species by exposure for several days or weeks to temperatures just above zero. In this pre-hardening stage, sugar and other protective substances (such as organic acids, amino acids, proteins) are accumulated in the protoplasm. The amount of water in the cells falls and the central vacuole divides into a number of smaller vacuoles. This, the first line of defence, is simply the depression of the freezing point of the water in the vacuole and cytoplasm due to the increased soluble solute content of the cell sap (Figure 1[b]). Thus, even before hardening, the tissues of most temperate plants can be cooled to a few degrees below zero (typically -1° to -5°C) before ice forms. This increased concentration gives complete protection from frost damage in warm areas with a low incidence of frost, such as Mediterranean regions, and to mild, short frosts in temperate regions. It is a form of chilling resistance only and cannot provide tolerance to extremely cold temperatures which will cause ice crystals to form. It may be, however, that this accumulation of solutes, possibly resulting from the suppression of photosynthesis by low temperatures, plays a more important role in protecting cytoplasmic macromolecules and membranes from the effects of the severe desiccation that can occur with freezing.

At this point the protoplasm is prepared for the second phase, which occurs when the temperature falls regularly to below -3°C and -5°C. This second line of defence will protect critically important tissues (dormant buds and xylem ray parenchyma cells) from freezing at temperatures down to about -40°C, and can come into operation only after growth has ceased and dormancy has been established. The plant tissues are "hardened" by exposure for several days to temperatures below +5°C, during which time the structure of the cell membranes and enzymes are reorganised in such a way that the cells can withstand the removal of water by ice formation. This protection is induced, therefore, by the falling temperatures of autumn. Autumn's shortening day length is also known to be essential in the preparation for the severe conditions of winter. Tissues conditioned in this way tend to behave as if they contained ultra-pure water, lacking any nucleating sites where ice formation can begin; thus they can undergo deep supercooling down to about -38°C (the spontaneous nucleating temperature of water) before ice forms. Although the reasons for this deep supercooling are not clear, the effect has been observed in the twigs of several tree species in which intracellular freezing occurs at -38° to -47°C. However, in other cases, supercooling gives protection only to -20° to -30°C.

Supercooling (Figure 1^{c}) is a temporary delay of ice formation in cells, promoted by either an accumulation in the protoplasm of protective substances (such as hydrophillic polymers) that hamper ice crystallisation or by dehydration of the cellular contents by extracellular freezing at the critical temperature. It was noted earlier that after hardy plants have developed their maximum resistance to cold they can withstand extremely low temperatures without injury, provided rapid freezing is delayed until all readily freezable intercellular water is removed to sites of extracellular ice formation. This may be the function of supercooling: to delay rapid freezing until all the freezable water has been removed from the cell.

Only after the second phase has been accomplished can plants enter, without danger, the third and final stage of hardening, required only in the most severe climates. During prolonged freezing with temperatures no higher than -5° to -15°C, the protoplasm achieves maximum frost tolerance. The critical temperature varies from species to species. Birch seedlings in readiness for hardening, which before the process was begun would have frozen to death at -15° to -20°C, at the end of the first phase can already endure -35°C. When they are completely hardened they can survive temperatures as low as -195°C (the temperature of liquid nitrogen), without impairing subsequent growth (Larcher, 1980). Cold thus forces hardening to proceed.

Once the most severe cold spell is over, the protoplasm returns to the first stage of hardening, but the tolerance can be returned to its highest level by renewed cold periods - as long as the plants remain dormant. In these cases it may be that intracellular ice formation is prevented because all of the freezable water in the cell has been withdrawn into the apoplast whilst supercooled, leaving thin layers of tightly bound, unfreezable water molecules round macro-molecules (proteins, lipids, etc.) and cell inclusions. This means that when the critical temperature for water nucleation (ice crystal formation) occurs all the water is outside the cells in the intercellular spaces, so that when it freezes it cannot damage the cell contents.

This is a rather simple account of frost resistance as a series of lines of defence and it needs qualifying on several counts.

1. Cooling must occur relatively slowly. Rapid cooling rates (several degrees per hour) tend to cause intracellular freezing and cell death even in hardened plants. This occurs, presumably, because the cell membranes are not sufficiently permeable to allow the water to leave the cell quickly enough for intercellular ice formation. Thus, even in the Alps, the rapid changes of temperature and the frequent cycles of freezing and thawing characteristic of spring, will lead to tissue damage, even in highly resistant species such as *Pinus cembra* (Tranquillini, 1964).

2. The tissues of a given species are not uniformly resistant to frost injury. Below-ground organs, which are normally insulated from the extremes of temperature experienced by aerial parts, are much more susceptible than stems and leaves (cf. some fern leaves and their rhizomes).

3. Cells of immature leaves, in contrast to cells of mature leaves, freeze rapidly and almost all are killed before freezing is complete.

4. The speed of water loss when cells are plasmolysed[3] increases with age as well as hardening. Extracellular formation of ice is induced by rapid water loss and depends on the permeability of the plasma membrane structure, the permeability of the cell wall and imbibitional forces of the protoplast. Plasma membranes of young protoplasts are highly impermeable and will not replace water lost from cell walls to sites of ice formation.

5. The rate of freezing influences the size and structure of ice crystals and may, thereby, determine the injury to cellular membranes and cytoplasmic inclusions.

6. Likewise, the structure of extracellular crystals is important: masses of small, imperfect crystals cause little damage, but masses of perfect crystals, enlarged by water vapour that diffused from protoplasts at low temperatures, are particularly destructive.

Dehardening

During the course of winter, the level of resistance in plants is adjusted to changes in the weather. Towards the end of winter, above-freezing temperatures cause the plants rapidly to lose their tolerance; but even in midwinter considerable resistance can be lost after a few days at +10° to +20°C. Maintenance of the hardened condition, therefore, appears to depend on the same environmental conditions that inhibit growth, induce dormancy, and develop cold resistance. The degree to which tolerance of freezing (i.e. the level of hardening) can be influenced by cold and heat is genetically controlled and characteristic of individual plant types, but the actual resistance level of a plant at any point in time depends on the degree of exposure to cold.

With the onset of warm weather, long photoperiods (long days), and growth in the spring, loss of hardiness is rapid. During the spring period of rapid growth, plants are exceptionally susceptible to frost injury. Kepper (1964), who worked with polypodiaceous fern species, found that the sporophytes of evergreen and deciduous fern species were most sensitive to cold injury in the spring and that cold resistance did not set in until the fronds were fully grown.

Environmental And Internal Factors And Cold Hardening

Unfortunately there is insufficient space to do more than to note that a number of both internal and environmental factors influence the hardening process.

Availability of sufficient inorganic nutrients, good moisture availability during the growing season and during the early stages of hardening, light intensity and spectrum especially immediately before dormancy, a specific photoperiod (usually a short one), and, as already seen, low temperature, all appear to be necessary to ensure the development of a tolerance to low temperatures. Perhaps the most important of these are a decrease of temperature below a critical level and the shortening of photoperiod below a critical length.

Several hormones (plant growth regulators), a phytochrome system, physical changes in the protoplasm and the accumulation of substances such as carbohydrates, especially sugars, and lipids and lipo-proteins appear to be involved. Changes in the nucleus, the amino acid and protein content, level of mRNA, and increases in enzyme activity have been observed. But the observations concerning most of these are conflicting and certainly their significance is far from being understood. Of course, it must be realised that unless a plant is genetically primed for hardening, even with all other factors being optimal, it will not do so!

A Miscellany Of Thoughts For Plant Hunters And Propagators!

1. On the ability to harden

Plants from warm climates introduced to a cold environment may be susceptible to cold injury for several reasons:

[3] Plasmolysis is the shrinkage of cell contents away from the cell walls as the volume of the the cytoplasm decreases when the water is withdrawn from the cell.

- because they fail to develop sufficient cold hardiness;
- they do not harden rapidly enough for protection from early cold weather;
- they deharden too rapidly, which makes them vulnerable to freezing temperatures in the late winter;
- ....or a combination of the above causes.
- they have an inherent ability to develop high resistance to cold but lack the correct biological timing in new climates (Weiser 1968).

Some plants can be induced to harden in controlled environments but not in natural environments and *vice versa*. Some hardly harden at all.

2. On the role of environmental and biological factors

- Development of cold hardiness is inversely proportional to growth rate (Levitt 1966).
- Environmental factors that depress growth, such as low temperatures, insufficient moisture, short photoperiods in plants that accumulate starch, and low nitrogen levels, enhance the cold tolerance of most plants.
- Absence of a rest period, e.g. under long day conditions (16-plus hours of day light), prevents slowly lowered temperatures from inducing cold hardiness.
- Not only different species, variations, ecotypes and age groups, but even the different individuals of a population may vary with respect to the nature and degree of low temperature resistance that they develop.

Final Comment

We still have a long way to go to obtain not only a full understanding of the process of hardening, but also of its genetic control and of those factors, both environmental and biological, that induce and influence the development of hardiness. Even assessing the hardiness of plants under controlled conditions is not easy nor are the results always convincingly reliable!

The seasonal change that makes many plants of temperate climates resistant to cold injury during dormancy (and susceptible to cold injury during growth) is a fascinating yet still obscure facet of a plant's relationship to its environment, as is the fact that many tropical plants have a latent ability to harden but have no requirement to do so.

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HARDINESS IN TREE-FERNS

Martin Rickard

Tree-ferns make such wonderful garden plants that any increase in our knowledge of the hardiness of each species is potentially of great value. Quite a few species have been considered suitable for cultivation in gardens in Britain, and with a mixture of recorded fact and a lot of guesswork, I have put the tree-ferns most commonly grown in what I think is their increasing order of hardiness (with acknowledgement to Alastair Wardlaw who first suggested to me the idea of ranking species in order of hardiness).

Cyathea leichhardtiana. Australian species with a rather slender trunk, perhaps 5-8 cm in diameter, hence cold penetrates quickly. Although native to Victoria, its natural distribution shows a preference for warmer areas and it is unlikely to do well out-of-doors or in a cold greenhouse in Britain.

Cyathea medullaris. New Zealand species of great beauty, trunk reasonably stout (20cm+), but has not established well even in south west Ireland. Recently planted at Portmeirion in North Wales where it has survived one winter. Worth trying over winter with protection.

Cyathea cunninghamii. Another slender trunked species (5-8cm) from Australia. Naturally occurs in humid river valleys. Range includes Tasmania, therefore must be fairly cold tolerant. Worth trying out-of-doors in a shelter?

Cyathea princeps. Mexico. Survived in a shelter for two winters but eventually died. Trunk 8-10 cm and very scaley. Best in cold greenhouse?

Cyathea dealbata. New Zealand. Surviving after many years in central Cornwall at Chyverton, with straw over crown in winter. Could do well in a suitable shelter. Wonderful plants of this species can be seen in south west Ireland. Trunk 20-30 cm when mature.

Cyathea spinulosa. Nepal. Slender-trunked (8-10 cm) but recorded above the Katmandu valley into temperate areas. Probably best suited to the cold greenhouse, but may survive in a shelter.

Cyathea smithii. New Zealand. Naturally occurs further from the equator than any other species of tree-fern, trunk stout (30 cm+) but I have no experience of this out-of-doors in the UK. Worth trying.

Cyathea cooperi. Australia. From further north in Australia than *C. leichhardtiana* but surprisingly has survived 5 winters in my shelter in Herefordshire. Trunk not very stout (8-12 cm). Not normally considered a candidate for hardiness testing.

Cyathea dregei. South Africa. Not, so far as I know, in cultivation in Britain, but it comes from exposed areas of the high veldt where frosts must surely be common. It is stout trunked (20-30 cm). If material becomes available it is certainly worth trying. I have heard from Australia that it is not an easy species to grow.

Cyathea tomentosissima. Papua New Guinea. Naturally survives frosts in its alpine grassland natural habitat (trunk perhaps 10-20 cm), but exposure would only be for a few hours. It could be interesting to try this out-of-doors along with several other high altitude New Guinean species.

Cyathea australis. Australia. Native to southern Australia including Tasmania, recorded up to 1,250 metres in Victoria. On paper the hardiest of all tree-ferns but I lost my plant after 1 winter, even in a shelter. Worth trying again. Trunk 20 cm+ in diameter.

Cibotium menziesii. Hawaii. A young plant has survived in my shelter for 5 years. Growth is slow but might be quicker if given more moisture. Trunk potentially stout, perhaps 30 cm.

Lophosoria quadripinnata. Central and South America, including quite well south in Chile. An odd-ball: rarely produces a trunk but might in an ideal site. Perhaps best in a cold greenhouse, although it seems very cold tolerant.

Cyathea* x *marcescens. Australia. A hybrid between *C. australis* and *C. cunninghamii*. Occurs very rarely, but is in cultivation in Australia where it is considered the hardiest cyathea. If ever available it would be worth trying here. Occurs naturally in Tasmania.

Dicksonia squarrosa. New Zealand. Never seems to do well out-of-doors; perhaps needs plenty of humidity? New Zealanders consider it very hardy. Worth trying in a shelter. Trunks slim (5-10 cm). Very attractive species with a tendency to produce branching trunks.

Dicksonia lanata. New Zealand. Never trunks in Britain but can produce an attractive bushy effect. Thrives unprotected at Inverewe in Scotland. Worth trying elsewhere in sheltered sites. Perhaps shelter is not necessary?

Dicksonia fibrosa. New Zealand. A small version of *D. antarctica*, but it seems to increase trunk height just as quickly, or even quicker in my experience. Seems as hardy as *D. antarctica*. Ideal for cold conservatories as it does not produce such long fronds. Survived 6 winters so far in my shelter. Trunk 10-20 cm.

Dicksonia antarctica. Australia including Tasmania - from where trunks are now being imported. In Victoria recorded from altitudes of 1,000 m plus (*C. australis* 1,250 m). Seems to be the hardiest species, with many very encouraging reports of winter survival unprotected, even in central England. This winter (1995-6) has so far been harder than in recent years, so survival records this spring will be interesting. Trunk usually 20-30(40) cm. (The similar South American species does not appear to have been tested but could prove of comparable hardiness).

Methods of protection are unlimited, but I suggest three options for *D. antarctica*:

1. For Tasmanian imports, which are possibly hardier than the original imports from southern Australia in the last century, minimum protection seems to work. I've used polythene plant trays tied around the trunk up to the crown with straw padding, and a straw cap to crown. For two winters this has worked well and is a low labour option. Of similar labour input are bubble wrap and fleece shelters. I have no experience of either, but they should both be adequate. All these systems result in the plants being defoliated except in the very mildest winters. I have heard of nursery stock being left in containers (30-40 litres) unprotected each winter. I await with interest the survival rate this year after a harder winter than of late.

2. Tree-ferns are expensive and the risks involved with option 1. can be reduced by using straw bales built around the shelter. This seems to work well, and I have had no losses to date.

3. Where several plants are grown collectively, and especially where additional species are involved, I favour protection as in option 1. with a straw bale wall built around the group. The whole is roofed with a polythene sheet (supported by wooden spars). It is a shelter like this which has successfully overwintered *Cyathea cooperi, Dicksonia fibrosa, Cibotium menziesii, Lophosoria quadripinnata* as well as *Dicksonia antarctica, Cyathea princeps* and *C. australis* for 2 and 1 winters respectively.

Finally a word of caution, I have been recording minimum temperatures in my garden since 1985-86. We have had a series of mild winters, so our experiences recently may be unduly optimistic. Unprotected winter minimums here in Hereford and Worcestershire are given overleaf, along with number of frosts.

Year	Winter minimum	Frosts	Remarks
1981-2	*-31.0°C*		*not my garden but only 1.5 miles away.*
1985-86	-12.0°C	73	
1986-87	-15.0°C	59	*D. antarctica* thrived in option 3.
1987-88	-8.0°C	46	
1988-89	-7.0°C	5	*C. australis, C. princeps* survived.
1989-90	-7.0°C	32	*C. australis* died.
1990-91	-9.7°C	68	*C. princeps* died.
1991-92	-9.5°C	50	
1992-93	-8.2°C	59	First Tasmanian *D. antarctica* introduced.
1993-94	-9.0°C	54	Tasmanian *D. antarctica....*
1994-95	-9.2°C	40	....became widespread.
1995-96	-8.8°C	42	*(so far - 5.2.96)*

From this series we can see that the Tasmanian imports were perhaps introduced at a climatically opportune time. I await with great interest news of experiments by members with *Dicksonia antarctica* and as many other species as possible over the years to come. There is much to be discovered on the whole subject of how best to grow tree-ferns in Britain, now is the best time to do it with several species becoming available. The challenge is there for the BPS to meet!

Footnote: *Anyone interested in tree-ferns is reminded that there is a Tree-fern Special Interest Group operating within the Society. For further information please send an A5 stamped, addressed envelope to: MARTIN RICKARD, Kyre Park, Kyre, Tenbury Wells, Worcs. WR15 8RP. Tel. 01885 410282.*

EXPERIMENTAL ENCLOSURES FOR FERN PROTECTION

Alastair C. Wardlaw

In trying to arrange suitable habitats for as wide a range of ferns as possible in my garden just north of Glasgow, I have been much influenced by this quotation from Reginald Kaye (1968):

There is no doubt that one of the chief enemies of ferns is the drying and mutilating effect of strong winds, yet where there are well established shelter belts of trees planted, it is surprising how many reputedly difficult plants will survive.

....where some shelter from punishing winds already exists, I would like to encourage a little pioneering spirit in trying out some of the exotic ferns.

With these thoughts in mind, I shall now describe some of the experimental enclosures and anti-wind devices I have made, and have had in use now for several years. My garden is not large enough to have a shelter belt of trees around it.

Humid rock cleft for filmy ferns

One of my ambitions is to have a representative specimen of every species of fern in the British flora, growing in the garden. Whereas many species require little more than shade, moisture and appropriate soil, the filmy ferns need a special niche. Figure 1A shows a shady cleft on a slope between two sandstone rocks which receives seepage from a fern bed at higher level through a drainage channel which was included when the area was

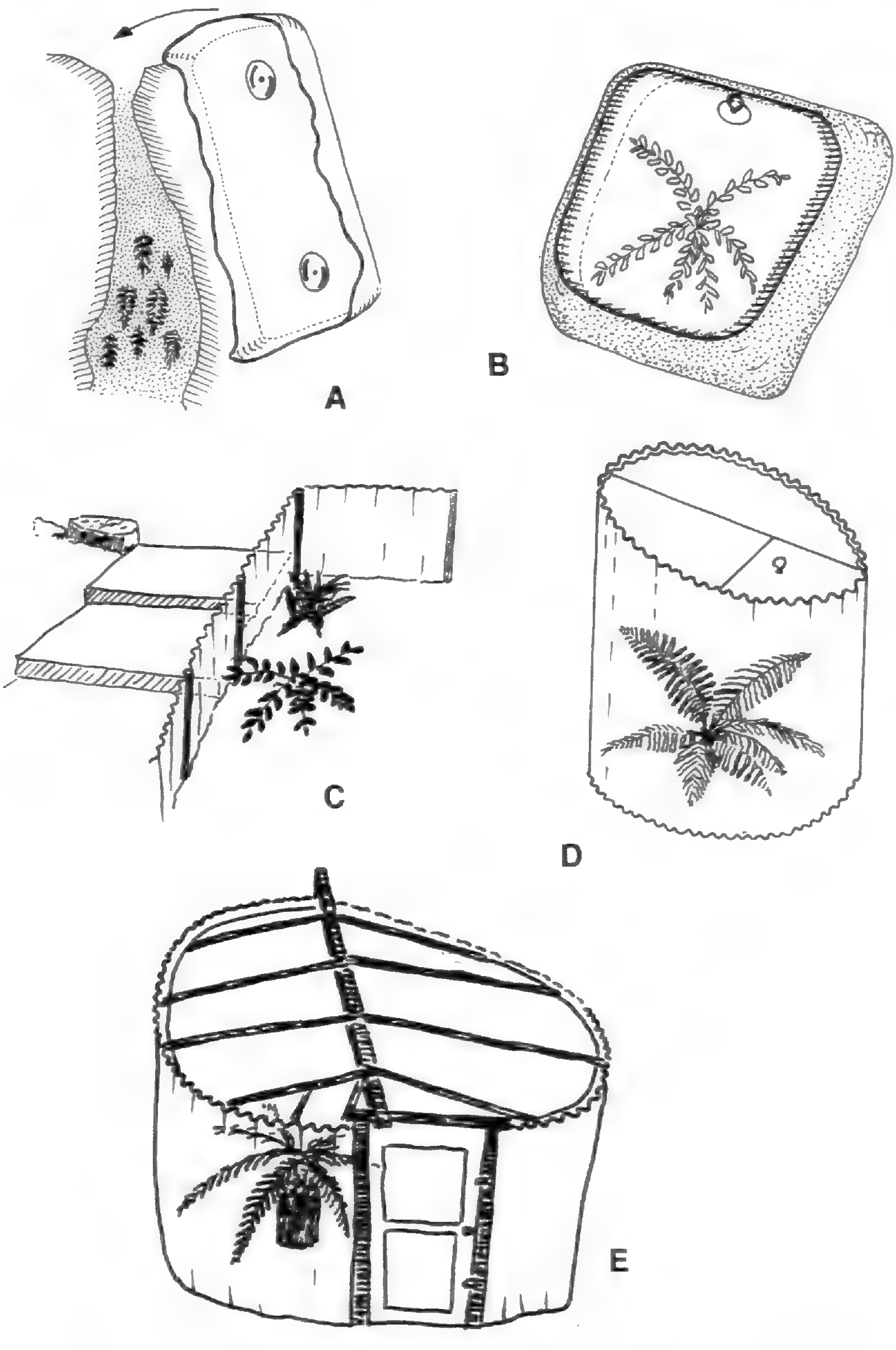

Figure 1 Sketches, to different scales, of the various experimental enclosures for ferns, as described in the text.

A Humid rock cleft for *Hymenophyllum tunbrigense*, with the cut-to-fit seed tray lid about to be replaced; **B** Sea-cave equivalent for *Asplenium marinum*; **C** Tranparent wall, about 40 cm high, which protects the ferns on the right from the prevailing south-westerly wind that comes from the left; **D** Protective PVC cylinder with perspex lid for the over-wintering of small tree ferns; **E** Walk-in PVC enclosure for a trunked specimen of *D. antarctica*.

being landscaped. To maintain high humidity, there is a transparent plastic seedbox lid whose edge has been cut with a soldering iron to fit the contours of the two rocks on either side of the cleft. The drawing shows the irregularly-cut lid about to be replaced over a mat of *Hymenophyllum tunbrigense*. Nearby is a similar niche with *H. wilsonii*.

Sea-cave equivalent for *Asplenium marinum*

A different setup is required for *Asplenium marinum* which needs the functional equivalent of a sea-cave. The requirements were assumed to be shade, percolating ground water, high humidity and protection from frost. The enclosure (Figure 1B) is a thick-walled concrete collar, tapering towards the top, of deliberately slightly irregular shape, and with a perspex lid to let in light. The structure is located on a shady slope that receives seepage from a drainage system above. In the coldest months it is given extra protection with a layer of bubblewrap.

Figure 2 presents weekly minimum and maximum temperature records for 1995, in the sea-cave and on a nearby shade thermometer hanging on a tree. The figure shows that the sea-cave experienced a kind of oceanic climate, in that the cave minimum tended always to be higher than the shade minimum and the cave maximum less than the shade maximum. In average winters when the shade minimum did not go below -5°C, the interior of the sea-cave did not fall below 0°C. Even during the exceptional cold spell in December 1995 when the shade temperature went down to -14°C, the interior of the "cave" did not go below -5°C. However this did damage the fronds of *A. marinum*, and the spring of 1996 is awaited to see if the plant itself has survived. [It did not]

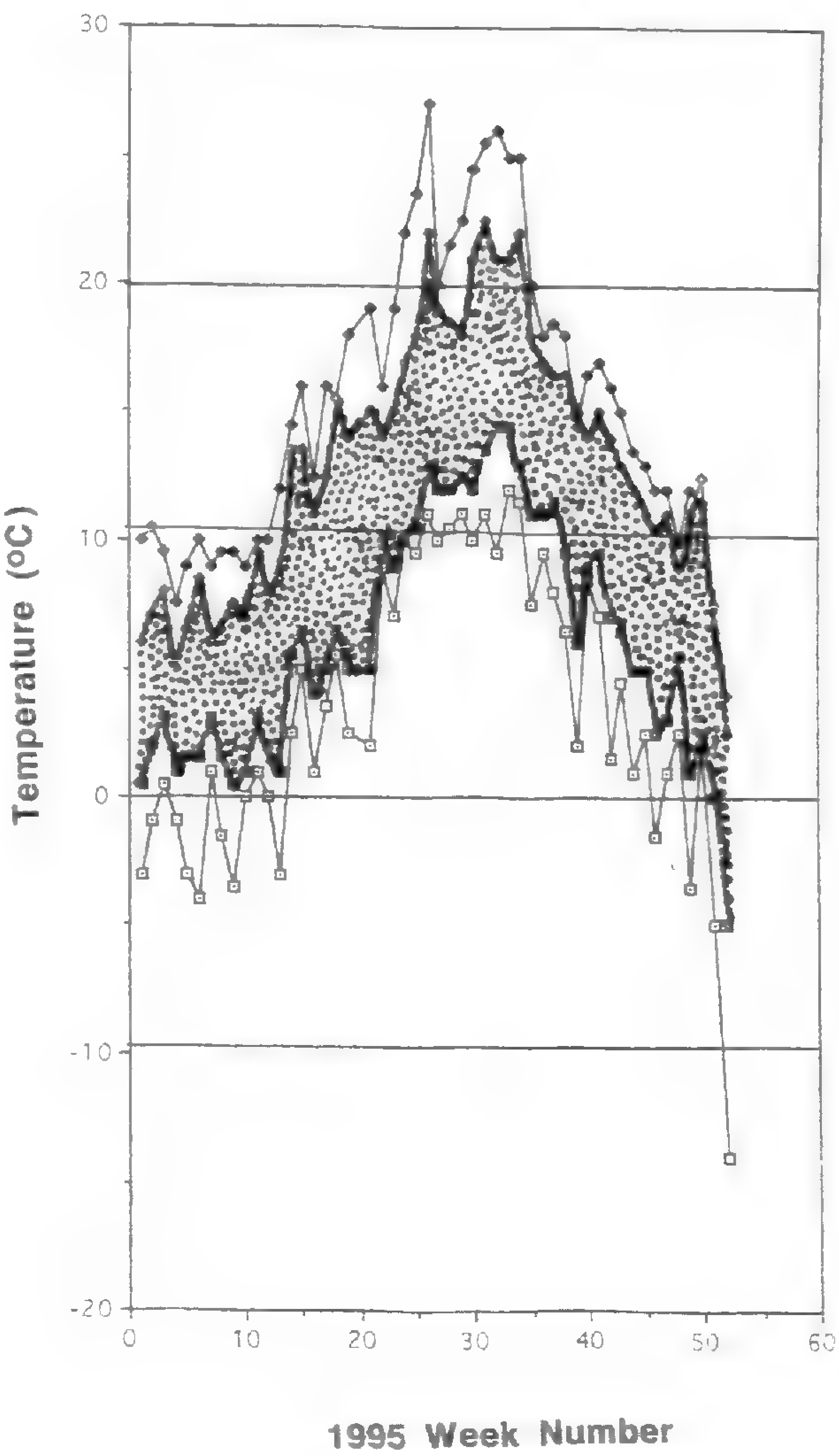

Figure 2 Weekly minimum and maximum temperatures in the shades and within the "sea cave" during 1995. The heavy lines enclosing the central dotted area are the "sea cave" minima and maxim, and the two outer lines are the corresponding shade temperatures.

Wayside-bank-in-Guernsey equivalent for *Anogramma leptophylla*

A similar concrete enclosure (not illustrated) was devised for *Anogramma leptophylla*, except that there is a bigger window on the top and down one side for admitting plenty of light, and the enclosure is located at the base of a seepage slope where it gets full sunlight for part of the day. The perspex window is removed altogether in the summer months to prevent scorching. This enclosure protects the plants from freezing in the cold months, while allowing a temperature much higher than the shade maximum on sunny days in the spring and autumn. This is hoped to imitate the conditions on a wayside bank in the Channel Isles where the species has its northern limit. The *A. leptophylla* fronds remained green after the exceptional (-13.5°C) frost in December 1995, even though the temperature within the enclosure went down to -5°C. Young sporophytes were appearing by mid-summer 1996.

Transparent Walls

There are some ideal fern-growing places in the garden, from the standpoints of soil, shade and moisture, but they tend to be battered periodically by strong winds. To avoid further cutting down the light, in an already shady place, with a stone or wooden wall, I have experimented with sheets of corrugated PVC of the type that is used for carport roofs. This can be cut and wired together in sections to fit the ground down a slope, and thus provide excellent and unobtrusive wind protection (Figure 1C), in this case for *Cyrtomium fortunei* and *Cystopteris dickieana.*

Elsewhere in the garden I have a much higher transparent wall (not shown) along part of the north boundary which gives useful protection to ferns and other shade plants from punishing north winds. This wall is about 1.8 metres high and 7 metres long and is supported partly by stakes and partly by being wired to a metal, hoop-topped fence.

Transparent walled enclosures for tree-ferns

Cylindrical enclosures of PVC with sloping perspex lids (Figure 1D) have been made to provide winter protection to small specimens of three species of tree-fern. The enclosures are about 0.8-1.0 metre diameter and similar in average height. These enclosures protect the ferns from wind, rain and drying during the winter months but not from freezing. Table 1. summarizes some of the temperature records for the winters of 1993-4 and 1994-5. It is apparent that the three species of tree-fern experienced minimum temperatures down to -3.5 to -5°C, much the same as the nearby shade temperatures. The other statistics, on first and last freezing temperatures and number of weeks with a weekly minimum below 0°C, were similar for the fern enclosures and the shade location. All three survived these exposures and stayed wintergreen. They were, however, killed after the December 1996 exposure down to -12°C within the enclosure.

Although the minimum temperatures in the fern enclosures were similar to the shade temperatures, the maximum temperatures soon started to diverge upwards as the season advanced. Therefore, around the beginning of April, the lids were removed in the daytime to prevent overheating, and soon afterwards were left off permanently. In late May the enclosures themselves were removed to leave the tree-ferns to grow unprotected during the summer and autumn months.

The PVC sheeting lends itself to the construction of much larger, walk-in enclosures (Figure 1E). This one, for a trunked specimen of *D. antarctica*, has walls 2 metres high, and interior headroom about 40 cm above that. It has a door and is about 3 x 4 metres inside. The ground plan is of an irregular elliptical shape, designed to fit neatly into an irregularly-shaped patch of shady ground that is hemmed in by a cedar tree, a path junction, a magnolia bush and a compost heap. The enclosure has a transparent-panelled door. The roof of bubblewrap is supported on sloping wooden spars and can be rolled back in the warmer months. The construction is based on tent and sail technology and uses no nails and very few screws.

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REFERENCE

Kaye, R. (1968). Hardy Ferns, p.158. Faber & Faber, London, pp. 203

Table 1

Weekly minimum temperature for the winters of 1993-4 and 1994-5. Records were kept of the shade temperature (at about 1.6 metres above the ground) and at about 20cm above ground within each of three PVC tree-fern enclosures as illustrated in Figure 1D

Winter	Shade				*D. squarrosa* enclosure			
	A	B	C	D	A	B	C	D
93-94	-5°C	9	20/11	26/2	-5°C	12	20/11	5/3
94-95	-5.5°C	11	26/11	1/4	-4.5°C	14	17/11	1/4

Winter	*D. antarctica* enclosure				*D. fibrosa* enclosure			
	A	B	C	D	A	B	C	D
93-94	-3.5°C	13	20/11	19/3	*Not then acquired*			
94-95	-3.5°C	4	17/12	1/4	-4°C	15	17/12	1/4

A: Lowest weekly minimum temperature
B: Number of weeks with weekly minimum below zero
C: Day/month date of first minimum below zero
D: Day/month date of last minimum below zero

HARDINESS OF *Adiantum cunninghamii*

A tatty plant of *Adiantum cunninghamii* which I planted out in the ground last summer, survived last winter unprotected and is now throwing up new fronds. Prior to this, I had no idea that the species could be hardy. It was raised from spores collected in a lowland area in the vicinity of Thames, North Island, New Zealand at around 37° south - a decidedly warm-temperature area where, for example, bedding begonias normally come through the winter. The coldest five nights this plant has experienced in my garden during the winter were:

Dec 26: -5.9°; Dec 29: -6.0°C; Jan 01: -7.4°; Jan 02: -7.9°C; Jan 03: -8.9°C

I have just transplanted the plant in question, to a nicer spot because I am so pleased with it. In a pot, this species sucks all the water out of its compost at a fearful rate; I lost most of the sporelings to drought before they even reached maturity. As this unexpected success shows, the flora of New Zealand is still very under-utilised in British gardens, and not everything from there is tender. I have a number of other N.Z. ferns probably new to cultivation in the U.K. coming on, I hope some will prove as hardy.

As an additional note, I have a *Cyathea dealbata* also unfurling new fronds having been in the ground all winter. It is my contention that ferns do not have to be fully hardy to be grown outside! A good thick covering of coarsely chopped bracken litter and sensible siting are all that it needs. *see p. 67*

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(E-mail: P.RICHARDSON@READING.AC.UK: *Pteridonet*, 20 March 1997)

SURVEY OF THE SCIENTIFIC LITERATURE ON FROST-HARDINESS OF FERNS

Alastair C. Wardlaw

Computer searching of the Science Citation Index

There is an abundance of literature in which various fern species are stated to be "frost-hardy" (e.g. Brownsey and Smith-Dodsworth, 1989; Cronin, 1989; Jones, 1987; Kelly, 1991; Rush, 1984). But few if any of these sources specify the exposure temperatures or durations, or the circumstances and reproducibility of the observations. In the present survey, the scientific literature was systematically searched via the Science Citation Index (SCI) for all articles dealing with frost-hardiness and freezing-resistance of ferns. It was thus hoped that more specific and exact information might be uncovered. Although the SCI does not include all the periodicals in the biological literature, it does allow rapid searching, back to 1981, of a large number of scientific journals and conference proceedings. However, among the journals *not* included in the Index are the three published by the British Pteridological Society, which indicates the limitations of the following database searches.

First, to gain some idea of the size of the whole literature on ferns in the database, the keywords Fern* and Pteridophyte* were entered into the computer so as to identify all the articles where these words occurred in the title, the abstract or the indexing keywords of the original papers. The use of the asterisk allowed the computer to respond to either Fern or Ferns and likewise with Pteridophyte in the singular or plural. In this way 2505 Fern, or Pteridophyte, references were registered as "hits" in the scientific literature back to 1981.

The computer was then asked to select from these 2505 references only those that contained the additional keywords Cold, Frost, Freez* or Hard*. The asterisked words allowed the computer to include Freeze, Freezing, Hardy or Hardiness. The subset of references so uncovered numbered two lots of 28 which contained many overlaps. These were scanned by title on the screen, from which 8 were selected for downloading by e-mail. Many of the unselected references had nothing to do with fern hardiness and, for example, contained papers about the hardiness of asparagus "fern" and the hardness of the fern-like pattern of zinc crystallization on galvanized steel.

Original papers on frost hardiness of ferns

This initial foray into the fern-hardiness literature did, nevertheless, reveal several highly relevant and useful papers, and copies of them were obtained from the British Library. These papers, in turn, in their bibliographies, referred to a few other fern-hardiness papers not uncovered in the original computer search. From these primary and secondary sources, a list of 13 fern-hardiness references was compiled (Appendix 1) which seems to be a reasonably complete listing of the scientific literature on this topic during the last 20 years.

This literature on fern-hardiness is only a minute part of the very large amount of published information on freezing resistance and frost-hardiness of other plants. The vast bulk of this literature deals with economically- or horticulturally-important plants such as cereals, vegetables, tea, coffee, ornamental shrubs and, particularly, trees. The most comprehensive modern source of information on frost hardiness of plants in general, including ferns, is probably the book by Sakai & Larcher (1987). This gives information on frost hardiness of around 900 plant species and has about 1000 references. Another excellent source is the 500 page book by Levitt (1980)

Summary of selected papers

A selection of the papers in Appendix 1 will now briefly be reviewed. Bannister (1984a), in Dunedin, New Zealand, investigated freezing resistance of local ferns by exposing samples of the fronds, in closed plastic bags, to a series of low temperatures in specially-programmed deep-freezes which had very accurate temperature control. The samples were then brought back to room temperature and observed for several weeks for frost damage, as compared with unexposed controls. He found that several native New Zealand fern species could survive temperatures of -4 to -6°C without damage, while only slightly lower temperatures caused 50% frond damage. The introduced species, *Dryopteris filix-mas*, was considerably more resistant. In a second paper, Bannister (1984b) investigated the frost-resistance of the fronds when tested at different times of year. With *D. filix-mas* and with the New Zealand species *Polystichum vestitum*, there was a clear increase of frost-hardiness during the winter months, whereas with two other native species, *Blechnum penna-marina* and *Phymatosorus diversifolius*, the seasonal hardening effect was much less. In a later paper on *B. penna-marina*, Bannister and Fagan (1989) reported frost resistance down to about -20° C in high-altitude provenances.

In another paper from New Zealand, Warrington and Stanley (1987) performed an extensive series of experiments with over 100 young potted plants of the tree fern *Dicksonia fibrosa*. In groups of 5, the plants were exposed to accurately regulated deep-freeze temperatures in specially designed chambers. The experiment was run at 4 seasons during the year to determine whether frost hardiness was induced during the winter months. After exposure, the ferns were returned to their outdoor site for observation. The summary of their results in Table 1 shows that *D. fibrosa* was appreciably more frost-hardy when tested in the winter than at other times and was not killed at that season until a temperature of -11°C was used. In a recent personal communication (1995), Dr Warrington informed me that so far as he was aware, these experiments are still the only ones in which the frost hardiness of a species of tree fern had been measured by direct experiment with plants put into deep-freezes. It may be noted that young tree ferns with fronds only 30 cm long and kept in pots may not have the same freezing resistance as mature plants rooted in the soil.

Table 1

Summary of Warrington and Stanley's (1987) experimental results on freezing resistance of *D. fibrosa* after preconditioning in different seasons

Season	Frost-hardiness temperature[1] (°C)	Lethal temperature[2] (°C)
Spring	-3	-9
Summer	-3	-7
Autumn	-5	-8
Winter	-8	-11

[1] The temperature which induced visually detectable damage on at least 50% of the plants in the sample.

[2] The temperature which caused death to at least 50% of the plants in the sample.

Sato and Sakai (1981) performed some interesting frost-hardiness experiments with several species of native Japanese ferns. Not only did they demonstrate seasonal induction of hardiness during the winter months, but surprisingly, found that the gametophytes were much more frost-resistant than the sporophytes. For example in winter experiments, gametophytes of *Polystichum braunii* withstood freezing to -40°C, whereas the sporophytes were killed by temperatures around -20°C. Similar results were obtained with several other species of Japanese fern, so the phenomenon seems to be quite general. These authors made the intriguing suggestion that persistence of these fern species in years of exceptional frosts may depend more on the hardiness of the gametophytes rather than that of the sporophytes.

The final paper for discussion here is by the same Japanese author Sakai (1970) which although it deals with willows, contains information which might well be applicable to ferns. The important message of this paper is that a plant species may not exhibit its full genetic capacity for frost resistance unless it has been grown for a considerable period in a low-temperature environment. Sakai took cuttings from a particular specimen tree of the willow *Salix babylonica* and sent the cuttings by airmail to be rooted in a series of locations from Hong Kong at latitude 23° N, to Sapporo at latitude 43° N. When the cuttings had all grown up into bushes, they in turn at different seasons of the year had cuttings taken from them. These were sent to a central laboratory for tests of freezing resistance. As summarized in Figure 1 (overleaf), the winter cuttings from the plants established in Hong Kong, where the mean January air temperature is 15°C, would only withstand -5°C, whereas bushes that had been grown in progressively northerly locations were increasingly frost-resistant. Thus the willow bush that had been adapted to Sapporo, with a mean January air temperature of -5.5°C, could withstand cooling to below -70°C. The viability of the cuttings after freezing exposures was demonstrated by their ability to develop buds and put out roots.

If a similar hardening phenomenon occurs with some ferns, it could mean that a fern species which demonstrates only modest frost resistance in its native habitat, may nevertheless have the genetic potential to withstand much more severe conditions if a proper period of cold-acclimitatization is applied. This provides hope for the survival in the UK of ferns whose present habitat is in much more temperate regions.

APPENDIX 1

List of journal and review articles on frost hardiness of ferns, 1964 - 1995

Bannister, P. (1984a). Winter frost resistance of leaves of some plants from the Three Kings Islands, grown outdoors in Dunedin, New Zealand. *New Zealand Journal of Botany* 22: 303-306.

Bannister, P. (1984b). The seasonal course of frost resistance in some New Zealand pteridophytes. *New Zealand Journal of Botany* 22: 557-563.

Bannister, P. and Fagan, B. (1989). The frost-resistance of fronds of *Blechnum penna-marina* in relation to season, altitude, and short-term hardening and dehardening. *New Zealand Journal of Botany* 27: 471-476.

Kappen, L. (1964). Untersuchungen über den Jahreslauf der Frost-, Hitze- und Austrocknungsresistenz von Sporophyten einheimischer Polypodiaceen (Filicinae). *Flora* (Jena) 155: 126-166.

Kappen, L. (1965). Untersuchungen über die Widerstandfähigkeit der Gametophyten einheimischer Polypodiaceen gegenüber Frost, Hitze und Trockenheit. *Flora* (Jena) 156: 101-116.

Kappen, L. (1966). Der Einfluss des Wassergehaltes auf die Widerstand-fähigkeit von Pflanzen gegenüber hohen und tiefen temperaturen, unter- sucht an Blättern einiger Farne und von *Ramonda myconi. Flora* (Jena) 156: 427-445.

	Mean January air temp (°C)	Maximum freezing resistance (°C)
Sapporo	-5.5	<-70
Shimizu	5.7	-30
Hachijo Is	10.2	-12
Kumamoto	4.6	-12
Hong Kong	15.4	-5

Figure 1

Summary of the experiments of Sakai (1970) on the effect of envionmental growth temperature on the freezing-hardiness of a single clone of the willow *Salix babylonica*, bushes of which were established at locations between Hong Kong and Sapporo.

Levitt, J. (1980). *Responses of plants to environmental stresses* vol. 1. *Chilling, freezing and high temperature stresses.* Academic Press, New York.

Sakai, A. and Larcher, W. (1987). Ferns, Section 7.3.2, pp. 206-209, In *Frost Survival of Plants. Responses and Adaptations to Freezing Stress.* Springer-Verlag, Berlin, Heidelberg, New York.

Sato, T. (1982). Phenology and wintering capacity of sporophytes and gametophytes of ferns native to northern Japan. *Oecologia* (Berlin) 55: 53-61.

Sato, T. (1983). Freezing resistance of warm temperate ferns as related to their alternation of generations. *Japanese Journal of Ecology* 33: 27-35.

Sato, T. and Sakai, A. (1980a). Freezing resistance of gametophytes of the temperate fern, *Polystichum retroso-paleaceum. Canadian Journal of Botany* 58: 1144-1148.

Sato, T. and Sakai, A. (1980b). Phenological study of the leaf of Pteridophyta in Hokkaido. *Japanese Journal of Ecology* 30: 369-375.

Sato, T. and Sakai, A. (1981). Cold tolerance of gametophytes and sporophytes of some cool temperate ferns native to Hokkaido. *Canadian Journal of Botany* 59: 604-608.

Warrington, I.J. and Stanley, C.J. (1987). Seasonal frost tolerance of some ornamental, indigenous New Zealand plant species in the genera *Astelia, Dicksonia, Leptospermum, Metrosideros, Phormium, Pittosporum,* and *Sophora. New Zealand Journal of Experimental Agriculture* 15: 357-365.

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Cronin, L. (1989). *Key Guide to Australian Palms, Ferns and Allies.* Reed, Chatsworth, New South Wales.

Jones, D.L. (1987). *Encyclopaedia of Ferns.Timber Press, Portland Oregon.*

Kelly, J. (1991). *Ferns in Your Garden. Souvenir Press Ltd, London.*

Rush, R. (1984). *A Guide to Hardy Ferns. British Pteridological Society, London.*

Sakai, A. (1970). Freezing resistance in willows from different climates. *Ecology* 51: 485-491.

END OF THE FERN HARDINESS SYMPOSIUM

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1. The green and graceful fern,
How beautiful it is.
There's not a leaf in all the land,
So wonderful, I wis.

2. Have ye e'er watched it budding,
With each stem and leaf wrapped small,
Curled up within each other
Like a round and hairy ball?

3 Have ye watched that ball unfolding
Each closely nestling curl
Its fair and feathery leaflets
Their spreading forms unfurl?

4. Oh, then most gracefully they wave
In the forest, like a sea,
And dear as they are beautiful
Are these fern leaves to me.

Twamley

Plate 1: *[illegible]*

Plate 2: *Deparia petersenii*

Photo: J. Vogel

Plate 3: *Christella dentata* (p.79)

Photo: A. Wardlaw

Plate 4: *Cyathea dealbata* in Pirongia Forest Park, North Is. New Zealand (p.92)

Photo: H. M. Hattie

Plate 5: ***Athyrium distentifolium*** with ***D. expansa*** (p 88)

Photo: H. M. Hattie

Plate 6: ***Athyrium flexile*** (p 88)

Plate 7: ***Dicksonia fibrosa*** in Memorial Park at Ohakune, North Is. New Zealand (p 94)

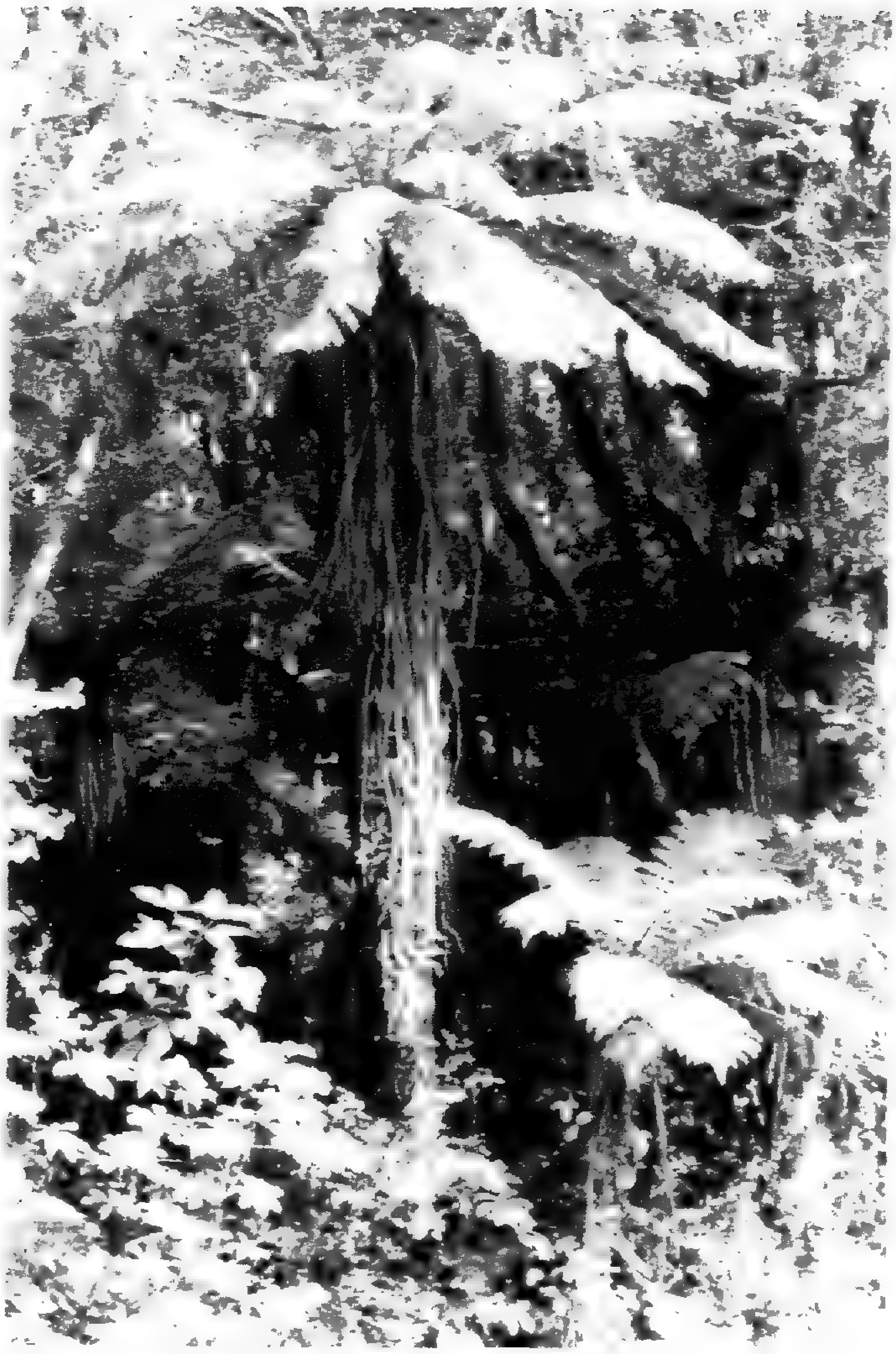
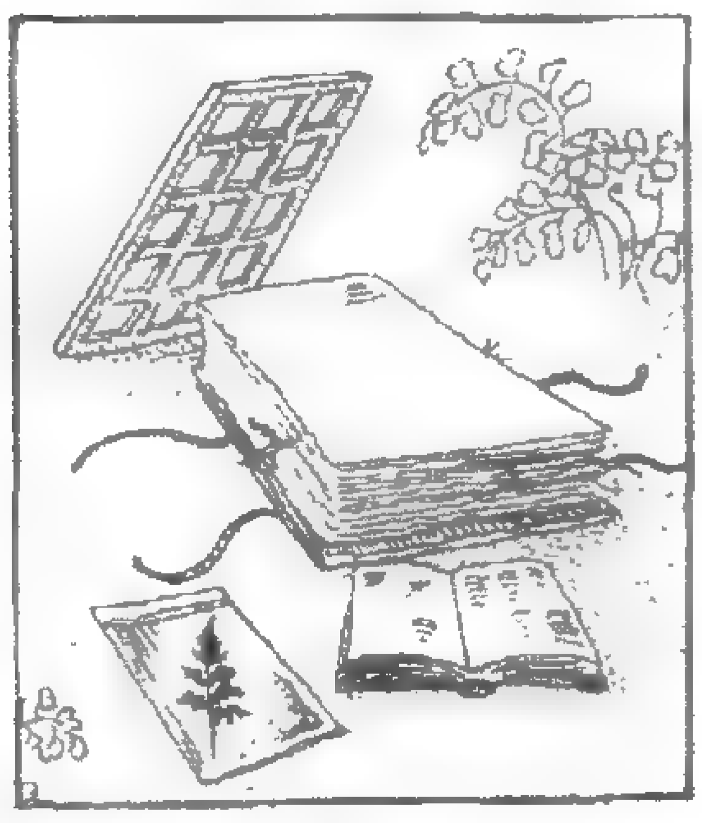


Plate 8: ***Cyathea smithii*** n[illegible] South Is. New Zeal[illegible]

Plate 9: ***Cyathea medullaris*** near Hokitika, S[illegible] Is. Ne[illegible] Z[illegible]



FIELD IDENTIFICATION OF THREE FERNS OCCURRING IN MACARONESIA

Graham Ackers

INTRODUCTION

The ferns *Stegnogramma pozoi*, *Christella dentata* and *Deparia petersenii* (plates 1-3) occur in the Macaronesian Islands, which include the Azores, Madeira, and the Canary Islands (also the Cape Verde Islands, not considered further here). Superficially, these three ferns look alike, and this resulted in field identification difficulties for several members of the BPS field trip to Madeira in 1995. These notes are intended to assist future visitors to the Macaronesian Islands to recognise the three species using field characteristics.

Two of the ferns (*Stegnogramma* and *Christella*) are 'thelypterids' (i.e. in the family Thelypteridacea), but *Dreparia* is similar. All three have small to medium sized pinnate-pinnatifid hairy fronds and a tendency to weediness. Another thelypterid, *Oreopteris limbosperma*, also occurs in the Azores and Madeira, but is relatively easy to distinguish as a distinct entity in the field. Those of us that are familiar with the British fern flora can easily distinguish the less hairy, brighter green frond, with the characteristic gradual size reduction of the lowest pinnae, and lemon scent.

These ferns have all been known under other names. The synonyms most commonly encountered in the literature are as follows:

TABLE 1

Current Name	Common Synonyms
Stegnogramma pozoi	*Thelypteris pozoi*
Christella dentata	*Thelypteris dentata* *Cyclosorus dentatus*
Deparia petersenii	*Diplazium lasiopteris* *Athyrium japonicum* *Lunathyrium petersenii* *Lunathyrium lasiopteris* *Lunathyrium japonicum*

Seven identification clues follow, the first three being the ones that I have found most useful in the field.

Doubtless there remains much to be learnt about these ferns in Macaronesia, and BPS members visiting these beautiful islands are encouraged to record habitat and distributional observations to enhance the information given below.

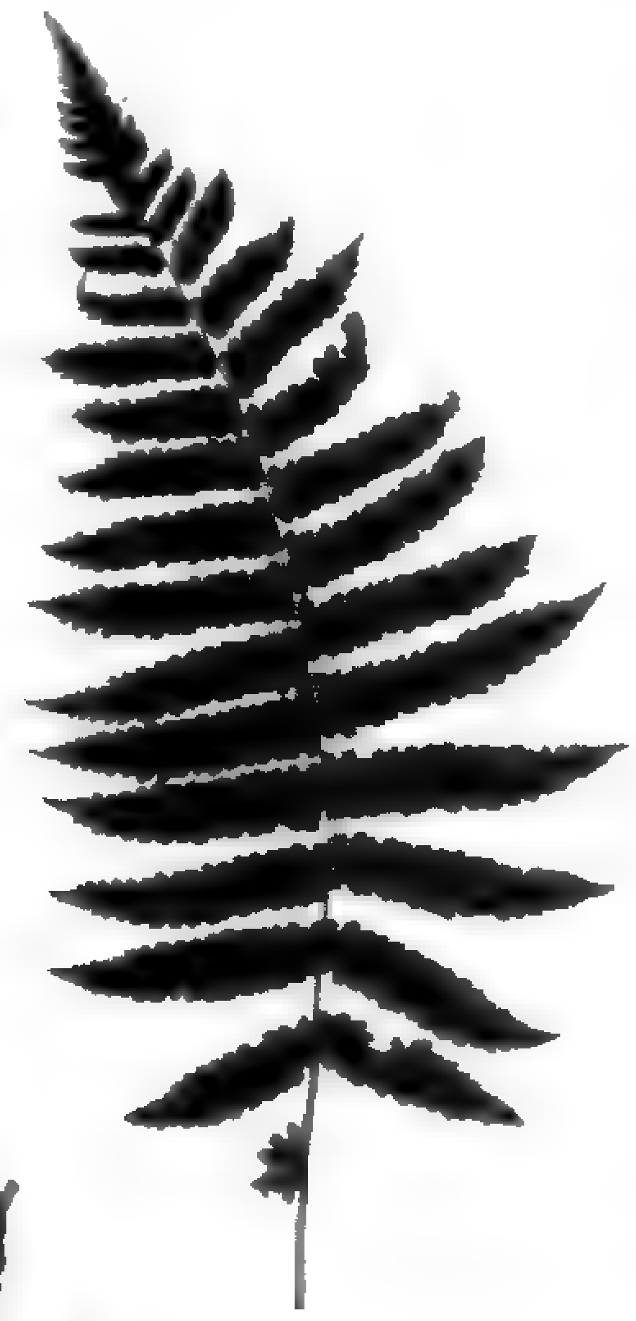
1. OVERALL FROND SHAPE

Fronds of *Deparia petersenii*, and large fronds of *Christella dentata* are reasonably distinctive. Smaller *Christella* fronds can be similar to fronds of *Stegnogramma*.

The frond measurements given below are typical ranges, not minima and maxima.

Stegnogramma fronds (p.80), which are 30 to 45 cm in length (blade 20 to 35 cm), are elliptic-lanceolate, the blade being broadest about one third to half way from its base.

small *Christella* ☞



Stegnogramma pozoi

The pinnae tend to be broad, and close together. They are lobed less than half way to the costa (pinna central vein).

Christella fronds (p.82) are 35 to 90 cm (blade 30 to 65 cm) in length, and are the most variable of the three species. Fronds are elliptic-lanceolate, with the blade being broadest about one third to half way from its base. The pinnae can be relatively **broad** and close together or **narrow** and well spaced (depending mainly on fertility and degree of shade). They are lobed less than half way to the costa. In **some** fronds, below the lowest pair of well formed pinnae, may occur a few markedly reduced pinnae, the lowest of which may be little more than lobes of lamina tissue. The gradation into these small pinnae is relatively sudden (unlike for example that of *Oreopteris limbosperma*, where the gradation is gradual). **Small** (< 45 cm) *Christella* fronds with broad pinnae can be confused with *Stegnogramma* fronds (top, right).

Deparia fronds (p.83) are 45 to 70 cm in length (blade 22 to 45 cm) and are almost **triangular** (strictly, ovate-deltate). The basal pair of pinnae, or the pair immediately above the basal pair, usually form the broadest part of the frond. The pinnae are well spaced and broad. The pinnae lobes are cut to **more** than half way to the costa.

2. ATTACHMENT OF PINNAE TO RACHIS

This character pertains to whether the pinnae are distinctly stalked or whether the lamina of the pinna is fused to some degree with the rachis (i.e. adnate). This character varies along the length of the frond of all three species.

All three species possess an elongated and narrow blade apex, where the pinnae coalesce.

In *Stegnogramma*, the lowest pair of pinnae (and occasionally the next pair) are stalked. From there, the base of the pinna becomes increasingly adnate, such that around the centre of the blade (the blade includes the apex in determining the centre), the join is distinctly adnate. I find this pinna character in the centre of the blade particularly useful in separating *Stegnogramma* from the other two species.

In *Christella*, **all** the main pinnae are stalked. The exceptions are the frond apex (noted above), and some of the reduced pinnae (if present) at the base of the blade (as noted in section 1 above). In specimens of *Christella* with broad pinnae, the adjacent lamina of some pinnae may be confluent with the rachis, but on close inspection will be seen **not** to be actually joined to it.

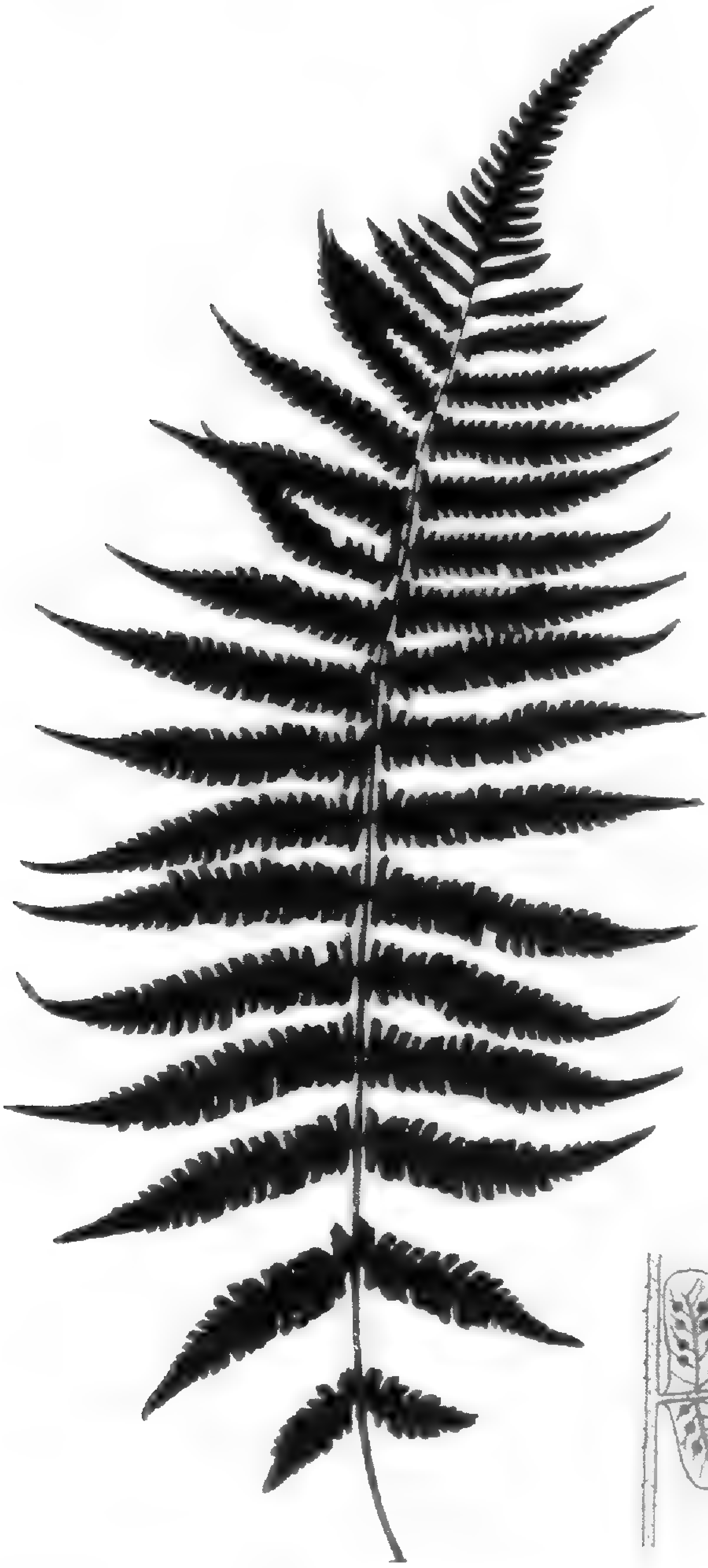
In *Deparia*, the pinnae are usually stalked to a point above the centre of the blade, when they start to become adnate. However, in **some** specimens, the pinnae stalks above the lowest pinnae pair may possess a small amount of lamina running along the stalk (I term this condition partially stalked). However, in no case does this approach the distinctly adnate condition around the centre of the blade that is so characteristic of *Stegnogramma*. These characters are summarised in Table 2.

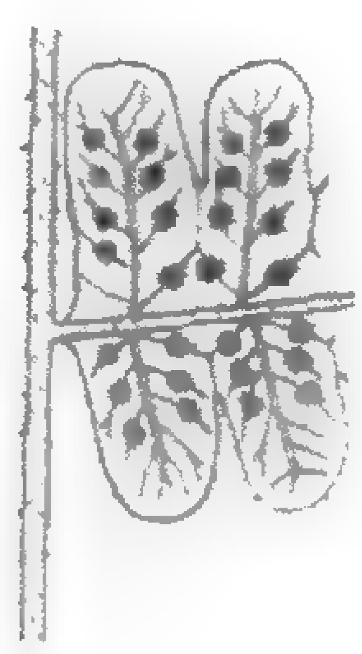
TABLE 2

	Stegnogramma pozoi	*Christella dentata*	*Deparia petersenii*
Blade apex	Pinnae coalesce	Pinnae coalesce	Pinnae coalesce
Pinnae immediately below blade apex	Pinnae not stalked	Pinnae stalked	Pinnae not stalked
Pinnae at the centre of blade	Pinnae not stalked	Pinnae stalked	Pinnae stalked or partially stalked
Lowest pair of well developed pinnae	Pinnae stalked	Pinnae stalked	Pinnae stalked
Reduced basal pinnae	Not present	If present, stalked or unstalked	Not present

TABLE 3

	Stegnogramma pozoi	*Christella dentata*	*Deparia petersenii*
Altitudinal distribution	250m to 1000m	Sea level to 500m	Sea level to 600m
Degree of shade and humidity	Prefers shade and high humidity, often with water seepage	Found in more open sites (sometimes in partial sun) with lower humidity, but with some preference for wet substrates	Prefers shade or part shade,high humidity, and a damp substrate
Habitat	Typically along levada walls (in Madeira), more rarely found in other habitats	Along grassy banks, lanesides and levadas	Along steep earth banks, grassy banks and lanesides
Habit	Fronds typically descending, occasionally ascending	Fronds typically ascending, rarely descending	Fronds either ascending or descending.





Christella dentata

3. SORI

Fertile fronds can be used to distinguish these species easily.

The sori of *Stegnogramma* occur along the pinna lobe veins and are linear but wide (approaching a narrow oval shape) when mature. No indusium is present, and the visible sporangia give a ragged aspect to the underside of the frond (the sori of the other two species look neater and tidier in comparison).

The sori of *Christella* are orbicular, with kidney shaped, hairy indusia. They occur along the pinna lobe length in two rows, which are equidistant between the margin of the pinna lobe and its central vein.

The sori of *Deparia* are linear (narrower than those of *Stegnogramma*), and lie along the pinna lobe veins. The indusium is attached along its length to the inner side of the vein, effectively forming a hinge, with sporangia being visible away from the hinge. (This reminds me of a pitta bread style kebab, with the sporangia as the filling!).

4. VENATION

The pattern of the veins can be investigated if all else fails! For example, it may not be possible to observe the characters described above if the specimen is infertile, and small and/or damaged. Providing it is certain that the specimen is referable to one of these three species, then venation will provide an unequivocal determination.

A good hand lens will be required for a clear view, and even then the clarity of the veins will vary between specimens.

Each pinna lobe possesses a central vein, from which side veins branch. The character to observe concerns the relationship of the **lowest** side vein with its opposite number from the adjacent pinna lobe, and the relationship of both these veins to the sinus (the gap between the adjacent pinna lobes).

In *Stegnogramma*, these two veins meet where they terminate at the base of the sinus.

In *Christella*, the two veins meet between the costa and the base of the sinus, and continue to the base of the sinus as a single vein.

In *Deparia*, the two veins neither meet, nor terminate at the base of the sinus. They terminate within the pinna lobe from which they originate, becoming indistinct towards the margin of the pinna lobe.

5. HAIRS

Whilst observing the venation, it will be difficult not to notice the hairs along the rachis and veins.

In *Stegnogramma* and *Christella*, these hairs are single-celled, translucent and needle-like. In addition, some brown pigmentation may be seen in some *Stegnogramma* hairs.

The hairs of *Deparia* are quite different, and hardly look like hairs at all. They are multi-celled, broad, brown where the cells join and translucent between joints. At low magnification (x10), they simply appear fat and curly, decidely odd in fact!

Deparia petersenii

6. HABIT AND HABITAT

Habitat preferences can provide valuable identification clues, a classic example being the curtains of *Stegnogramma pozoi* so typical of Madeiran levada walls (the other two ferns do not occur like this). The clues can perhaps best be obtained from the four variables of altitude, shade and humidity, habitat, and habit. These are summarised in Table 3 (page 81).

7. DISTRIBUTION

Worldwide, all three ferns have a wide distribution. *Stegnogramma* occurs in tropical and Southern Africa, Southern India, and in Europe is found rarely in Northern Spain and the Pyrenees. *Christella* is widespread in tropical and subtropical regions of the world, occurring for example in Africa, Malaysia, Asia, Philippines, New Guinea, Polynesia, Australia, New Zealand, and in Europe very locally in the Mediterranean region. *Deparia* occurs in India, China, Japan, Malaysia, New Guinea, Australia and New Zealand. In Macaronesia, it is not certain in some instances whether the ferns occur naturally or have been introduced.

A knowledge of the distribution of these ferns in Macaronesia can help confirm an identification. However, this information should not be relied upon too heavily, as existing occurrences could have been previously unrecorded, and the distributions of these ferns could be changing. For example, prior to 1995, *Deparia petersenii* was only known in Madeira from one specimen near Passo, São Vicente. However, the BPS trip in 1995 found several specimens adjacent to the road between Cruzinhas and Lombo de Cima. This suggests the possibility of this fern being on the brink of a wholesale colonisation of Madeira, as has happened in the Azores.

The distribution table that follows is based on Hansen and Sunding, 1993. Excluded from the table (Table 4, overleaf) are the Cape Verde Islands (where *Christella* occurs), and the Salvage Islands and the two outliers of Madeira - Porto Santo and the Desertas (from where none of these ferns has been recorded). Hansen and Sunding only provide presence-absence data, shown in the table as *Present* or blank. Where additional knowledge of abundancy exists, then *Present* is replaced with an abundancy judgement on the ACFOR scale: Abundant, Common, Frequent, Occasional or Rare.

TABLE 4

Archipelago	**Island**	*Stegnogramma pozoi*	*Christella dentata*	*Deparia petersenii*
Azores	Santa Maria		Present	Present
	São Miguel	Occasional	Occasional	Common
	Terceira	Present	Present	Present
	Graciosa		Present	
	São Jorge		Present	Present
	Pico	Rare	Occasional	Occasional
	Faial	Occasional	Occasional	Frequent
	Flores	Rare	Frequent	Frequent
	Corvo			Present
Madeira	Madeira	Abundant	Frequent	Rare
Canary Islands	Lanzarote			
	Fuerteventura			
	Gran Canaria		Rare	
	Tenerife		Rare	
	La Gomera		Occasional	
	El Hierro			
	La Palma		Occasional	

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ACKNOWLEDGEMENTS

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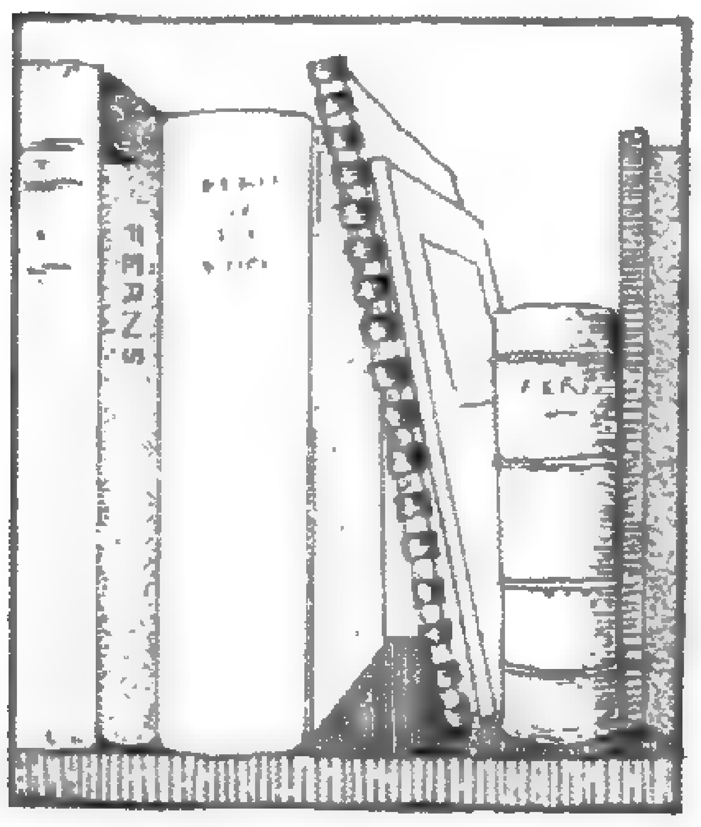


BOOK REVIEWS

WELSH FERNS, CLUBMOSSES, QUILLWORTS AND HORSETAILS. G. Hutchinson & B. A. Thomas eds. National Museums and Galleries of Wales, Cardiff, 1996. Price £11 (UK), £13 (Overseas) inc. p & p. 265 pp, 115 figures, numerous maps. ISBN 07200 04 35 7.

The long-awaited seventh edition of this handbook is a nicely produced A5 softback with an attractive cover, an attractive price, and several valuable new features. For those coming new to the book it should be made clear that, as in previous editions, all British species and hybrids are described and all species keyed, though the non-Welsh ones are treated less fully. Apart from general updating of taxonomy and nomenclature, the chief change from ed. 6 is in the treatment of distributions. Valuable maps showing the 10-km square distributions in four date classes in Wales are now included (though the maps oddly lack the Welsh border), as well as maps showing the European distribution. It is a pity that in spite of a detailed account of the vice-county system, occurrence in Welsh vice-counties is not given; this information is now available for all other vascular plants in *Flowering Plants of Wales*. *Welsh Ferns* was always an educational book as much as an identification guide, and this aspect has been enhanced by extension of the life-cycle diagrams, addition of diagrams of frond characters, and an enlarged glossary; much of the information on venation though has been cut, and the arrangement of most taxa alphabetically has improved ease of consultation at the expense of understanding. In the descriptions much helpful diagnostic detail has been added, and most of the information one requires to identify British species, subspecies and hybrids is more compactly available here than elsewhere. (There are infuriating gaps though, and spore details are still given in *Polystichum* for only one species.)

The chief weakness of the book is its illustrations. Most of the motley collection of largely non-comparable drawings and photos of previous editions is repeated, with the photos much worse reproduced. Three drawings each of an *Osmunda* and a *Hymenophyllum* sporangium are repeated, educational maybe but of no diagnostic interest, while there are none of *Polypodium* sporangia whose characters are all important and very difficult for beginners to understand from descriptions alone. Three pages of new drawings of alien species are very useful, as well as an excellent table of drawings of *Dryopteris* indusia in varying stages of maturation. A repeated drawing of a *D. filix-mas* pinna misleads by showing the margins of the segments entire, and does not relate to the drawing of *D. oreades*. In *D. affinis*, three subspecies *affinis*, *borreri* and *cambrensis* are recognised; it would have been helpful to have had the often recorded *paleaceo-lobata* mentioned in the synonymy. Connoisseurs of unusual and complicated indexes should enjoy the one in this book.

Welsh Ferns is strongly recommended to botanists at all levels throughout Britain and Ireland who want to learn about ferns as well as to identify them. But as I remarked in another review five years ago, we still lack a comprehensive book for identifying ferns; such a work needs to combine the taxonomic and educative coverage of *Welsh Ferns*, the clarity of illustration and diagnostic detail of Jermy & Camus, *The Illustrated Field Guide* (1991) which unfortunately skimps on hybrids, and the coverage of hybrids and the descriptive detail of Page, *The Ferns of Britain and Ireland* (1982) which is inadequately illustrated. Meanwhile one needs all three.

A. O. CHATER

THE FERNS OF TASMANIA by Michael Garrett. Tasmanian Forest Research Council, Inc.c/- GPO Box 207B, Hobart, Tasmania - 7000, 1996. Hard cover (signed by the author, but only 100 copies) and paperback. Price: apply to BPS Booksales. ix plus 217 pp, 7 figures, 150 colour plates and 101 distribution maps. ISBN 072463519X

Tasmania has 100 native and one introduced species of pteridophyte, and Mike Garrett describes them all. Each has a page to itself which carries concise text and a distibution map plus reference to colour plates which form the central section of the book, but I'm aghast. Few fern books attempt to present a colour photograph of every species, and certainly, some of the plates will be duff ones. Not the case here! *The Ferns of Tasmania* seems to illustrate all, or virtually all of the 101, and there's not a mediocre picture among them. All are informative and some are stunning and must look wonderful on the screen. *The Ferns of Tasmania* begins with an informative introduction to the fern flora followed by a good treatment of the general biology of pteridophytes for the beginner, a guide to growing, discussion of the diversity, distribution and history of Tasmania's ferns and their ecology. Appendices include summary tables of ecological features and distributions outside Tasmania, glossary, what looks to be an practical dichotomous key, plentiful references and a comprehensive index. I think I'll have to dig very deep to find the criticism the enthusiastic reviewer is expected to include.

This book has been very intelligently designed, making reference and cross-reference easy. Where there is nothing to say, there's no distracting waffle, and clear page space is left uncluttered, a familiar aspect of modern book design. However, there is so much white on many pages, I wonder if we could not have been treated to a bit more information, perhaps amplifying the morphological information one would otherwise pick up from the key. I am a little concerned about the key. I tried *Ophioglossum lusitanicum* as if a beginner, and went wrong in the first couplet (actually a triplet). Even so, the brief text contains loads of information about each fern, including interesting aspects of distribution and ecology and, despite being totally unfamiliar with this flora, I found myself informed and entertained; easily convinced to put Tasmania on my shopping list.

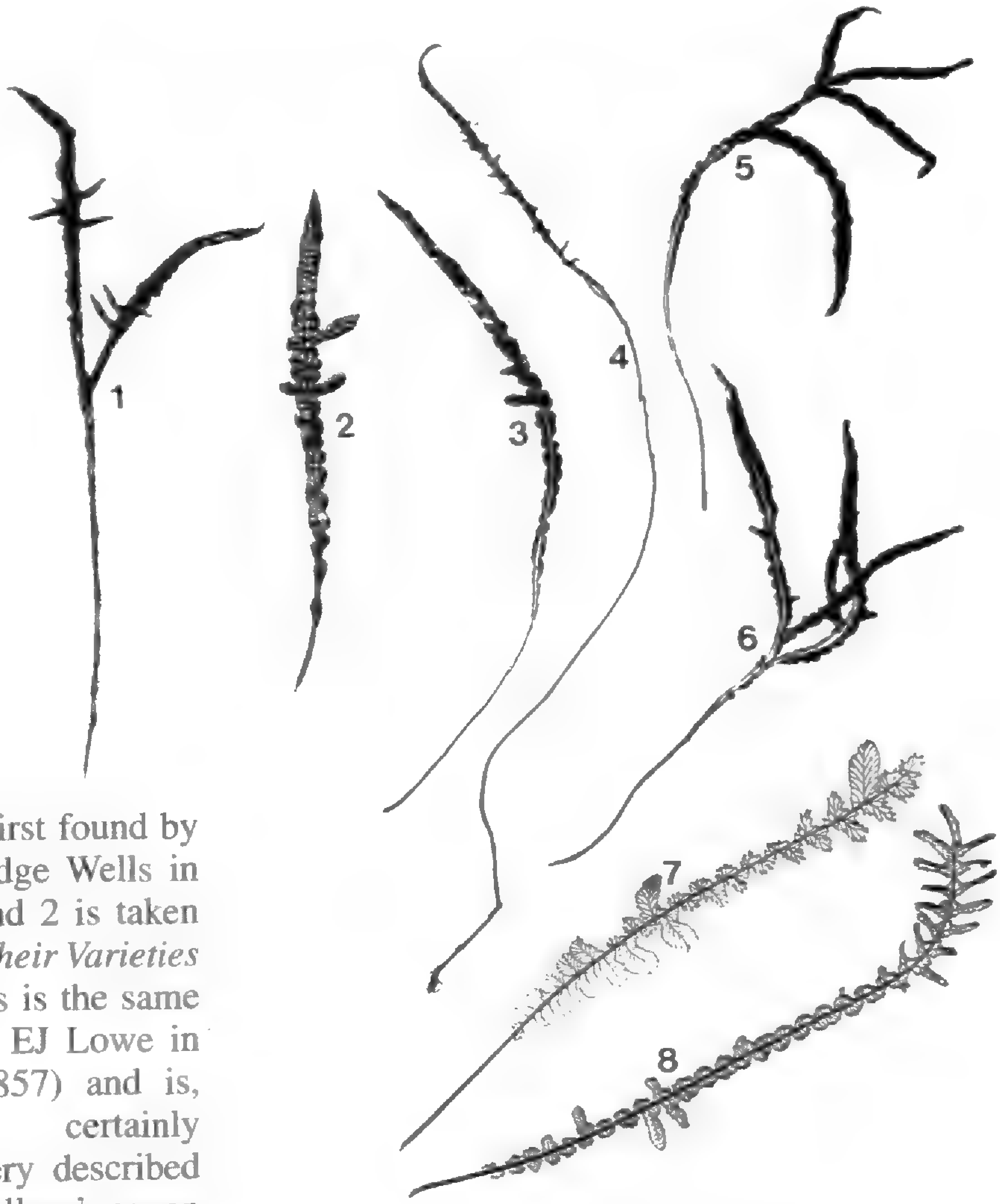
It seems that it will be difficult to order *The Ferns of Tasmania* in the UK; even Blackwell's couldn't help me. I hope that BPS booksales will be able to satisfy what ought to be a voracious market.

JAMES MERRYWEATHER

BLECHNUM SPICANT 'HETEROPHYLLUM' GROUP

Martin Rickard

It is a rare pleasure to be able to record the rediscovery of this fern, long thought to be extinct, both in cultivation and in the wild. It was found by Arthur Chater while botanising in eastern Merioneth in August, 1995. It is an extraordinary variety which caught him by surprise: *It gave me quite a turn when I first saw it - I thought it must be something new for Britain! If there hadn't been a lot of normal* Blechnum *nearby, I doubt whether I would have guessed what it was.* If it had that effect on a very experienced general botanist, imagine what a fern person might have felt!



One large clump was found in a rock crevice on a steep, rocky, SSE facing slope. All leaves were similar to the four numbered 3 to 6. About half of the fronds in the clump were dichotomously (or trichotomously) branched. Fertile fronds (4) had the sori all along the expanded part of the frond.

Blechnum spicant 'Heterophyllum' is an old cultivar. So far as I can discover, it was first found by Wollaston near Tunbridge Wells in 1853 (2,7 and 8). Frond 2 is taken from *Brtish Ferns and their Varieties* (Druery, 1910), but this is the same frond as illustrated by EJ Lowe in *Our Native Ferns* (1857) and is, therefore, almost certainly Wollaston's find. Druery described *B. spicant* 'Heterophyllum' as an irregular and curious form. Lowe does not describe a beauty: bearing two kinds of frond either separately or together; part normal, part altered in form, the segments becoming narrowed and inciso-dentate, or contracted in a semicircular form, occurring irregularly. The fertile fronds have the same characters. 7 and 8 are taken from *The Nature Printed British Ferns* (1859) by T Moore.

Also in the 1850s it was found at Todmorden by T Stansfield and Ilfracombe by Dadds. In 1866 the Reverend ZJ Edwards published in *Ferns of the Axe* (second edition, 1866) that it had been found at Axminster and Thorcombe. In 1876 Crouch found it in the Lake District. In *Flora of Todmorden* (1911) it was recorded for Mytholm Valley, Staups Clough and elsewhere. It was, therefore, perhaps tolerably common.

In *The Book of British Ferns* (1903), Druery illustrated the variety using a different frond (1). This frond is very similar to the series collected from Merioneth, and may represent an improved form of the original, but Druery fails to mention it in the text, still referring to it as *B. spicant* 'Heterophyllum'.

Really, all the evidence suggests that *B. spicant* 'Heterophyllum', as originally described, was no great beauty and would perhaps be ignored today. However, this new find, while still irregular and curious, seems to be more uniform than the old form, a very distinctive plant which should be well worth growing.

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GLEN PROSEN REVISITED*

Heather McHaffie

Photo: Heather McHaffie

Polypodium flexile Moore

One of the original Glen Prosen plants collected by James Backhouse in 1852.

On the 24th of July 1852 three botanists came over the hill from Corrie Fiadh at the head of Glen Clova. There was James Backhouse, well known for his nursery in York. He was accompanied by his son, also called James, and a friend, Thomas Westcombe. They had spent several days in the area looking at alpine plants. Of especial interest to them was a species of lady fern that had only recently been recognised in this country as distinct from *Athyrium filix-femina*. At that time it was called *Polypodium alpestre*, the alpine lady fern, now *Athyrium distentifolium* Tausch ex Opiz (Plate 5).

As they came round the slopes of Maire they came to a rocky outcrop above the Maire Burn. Here they found more *P. alpestre* looking superficially very similar to *Athyrium filix-femina*. But on examining the back of the frond the circular sori were clearly visible, demonstrating its classification as a polypody. These were very different from the j-shaped sori of *A. filix-femina* and almost entirely lacked indusia. As they looked closer it became apparent that there was also something else, a smaller, narrow-fronded form, quite unlike the usual *P. alpestre* which they had been collecting for several days (Plate 6). As James Backhouse (senior) later wrote: *A remarkable variety, with deflexed pinnae, was met with in one place in Glen Prosen.* (Backhouse, 1852).

They found the discovery of sufficient interest to merit the collection of a substantial number of robust, fertile fronds. These were taken back to York and were doubtless the subject of much scrutiny and discussion. Letters would have been written, and in May 1853 the Backhouses sent specimens of both types to Edward Newman who thus addressed the Phytologist Club:

> *The President observed that since he had the pleasure of inviting attention to the occurrence, in Scotland, of a fern previously unrecorded as British, several very ardent and most acute botanists had searched the districts indicated, and with complete success. The result, however, was the discovery of not a* single *species alone, but of two. Through the kindness of Mr Backhouse, he had had the opportunity of examining an extensive and very beautiful series of each of these; and although in this early stage of the inquiry he by no means wished to do more than indicate the obvious distinguishing characters, he considered it due to his friends to communicate to the public the results of their researches.*
>
> (Newman, 1853)

Newman decided at the same time that a more appropriate generic name for the two would be *Pseudathyrium*. Both *Pseudathyrium* and *Polypodium* were used throughout

* This article is the transcript of a talk given at the BPS autumn indoor meeting at the University of York on 12th October, 1996

the 19th century until eventually *Athyrium* became more generally used into the 20th century, and *alpestre* has been replaced by the current *distentifolium*. He provisionally called his new fern *Pseudathyrium flexile*, but as it has never been found anywhere else within the circumpolar range of *A. distentifolium*, it has retained the specific name. Its common name has recently been changed from the flexile lady fern to Newman's lady fern.

Newman gave *flexile* its name from the tendency of the stout stipe to bend sharply near the base so the fronds are held flat against the ground. He gave a detailed description of both *P. alpestre* and *P. flexile*. The blade of the smaller *flexile* is very narrow and the pinnules are less frilly. If the fronds are only partially fertile, then *flexile* is usually only fertile at the base, and *distentifolium* (or *alpestre*) is only fertile at the tip. This tendency to opposites is continued in the more congested nature of the deflexed lower pinnae of *flexile*, contrasted with widely spaced basal pinnae in *distentifolium*. Conversely, *flexile* has widely spaced terminal pinnae, while in *distentifolium* they are more crowded.

Newman was confident that the fern was sufficiently distinct and over-ruled any reservations by those who had originally found it: *Mr Westcombe and Mr Backhouse entirely abandon the idea of it being a form of* alpestre, *although there can be no doubt, we have seen that this idea did present itself to both of them at the moment of finding it, possibly because they were totally unprepared for the occurrence of a second new fern on ground for so many years trodden by our Scottish friends in their herborising excursions.* (Newman, 1854). In 1859 Thomas Moore expressed some reservations: *It is certainly a very distinct variety, and very constant, probably a variety rather than a species, this moreover being the view adopted by its discoverer Mr Backhouse, who writes: Dissimilar as it is from* P. alpestre, *I shall continue doubtful of its specific difference if it does not turn up in other places.* (Moore, 1859).

In due course other localities were reported. In 1867 it was first found at Ben Alder, which has the largest population of any known site. It has been recorded, sometimes as only a single plant, right across the Central Highlands. There are records from Knoydart, Ben Nevis, Glen Spean, Bridge of Orchy, Glen Lyon, Beinn Eibhinn and several places in the Cairngorms, Lochnagar and Caenlochan.

The locality at Glen Prosen was visited with diminishing frequency towards the end of the 19th century, especially once the Ben Alder site had been discovered. The last known herbarium specimen of *P. flexile* was collected in 1894 and after that there is no further mention of it in the area. Cowan (1915) reports a Scottish Alpine Botanical Club excursion to Glen Prosen in 1914 but only mentions *P. alpestre*. Perhaps the plants had been over-collected, or the sheep and deer ate them into oblivion. Keen botanists concentrated on the basic rocks in Glen Clova where there was ample scope for a day spent botanising.

On the 27th of June 1995 David Ellis and I came over the hill from Corrie Fee. There was no time to go wandering off to look for woodsias, no deviating from the path to have a quick search for *Lycopodium annotinum*. Watched by a suspicious pair of eagles we purposefully climbed up to the watershed. It was the beginning of a long, hot summer. We scrunched across the lichen on the tundra-like plateau and came down into the head of Glen Prosen. For months I had been looking at maps of the area. I had read and re-read the sparse clues offered by the herbarium sheets: *Micaceous rocks at the head of Glen Prosen . . . . above the Maire Burn.* From my reading and limited experience I had definite ideas about a suitable habitat for *A. distentifolium*, and hence also for *flexile*. I was looking for a north, north-east or north-west facing corrie above at least 600 or 700 m. Only a limited range of species can survive the extended snow-cover found in suitable places at this altitude and this gives the ferns a competitive advantage. Unfortunately, the map did not suggest anywhere very appropriate at all. The best I could find at more than 600 m was the South Craig with an aspect to the east-north-east.

As we approached the Craig, walking in above the Maire Burn, a brood of young ptarmigan flew away, and their mother stayed to distract us. It was the right sort of place for ptarmigan, with good big boulders. A lush carpet of *Vaccinium myrtillus* (blaeberry or bilberry) swept right round them and up to the foot of the craigs, leaving no spaces for any ferns on the ground. The ledges on the craigs were mostly too accessible to grazing sheep or deer. With difficulty, I scrambled up a rock face to reach the only visible clumps of fern. The first was *Athyrium filix-femina*, with bluey-green fronds, unlike the yellow-green of *A. distentifolium*. I had a slug's-eye view of the sparse, narrow, darker scales at the base of the *A. filix-femina* stipes. Infertile *A. distentifolium* can often be distinguished by the broad, paler scales. Also, *A. distentifolium* pinnules are more triangular than *A. filix-femina* which tends to have parallel-sided pinnules. On the next ledge there was lot of *Dryopteris oreades*. Finally I did encounter some *A. distentifolium*, so I worked methodically up and down across the parts that were most difficult to get to, but with no sign of the absent *flexile*.

Eventually I crashed back down at the appointed time to meet my companion. I was hot, scratched and despondent. All that remained was the weary trek up the hill, the trudge all the way across the top in the baking sun, and the steep descent on the other side. In a misguided attempt to cut the corner, I suggested that we should go straight up the hill so as to omit two sides of the triangle we had previously followed.

It was extremely warm. I trailed behind up an impossibly steep slope of *Nardus stricta* (mat grass). Had I felt more my usual didactic self I could have said that just such a vegetation was typical of late winter snow-lie. However, on pausing yet again to look at the view with unseeing eyes, I did notice some large rocks with ferns in the middle. The bright yellow-green suggested *A. distentifolium* and it seemed a good excuse for a rest to go and look closer. Some of the rocks were flat enough to sit on, and yes, it was *distentifolium*. The largest clumps growing in the middle of the rocks had been grazed but the arrangement of the slabs was such that there were good gaps underneath, so I peered in. And there, at last, was what I was looking for. The same narrow frond that I had seen at Ben Alder, the same fertility pattern and the same distinctive habit. It was indeed the fern that Newman had called *Pseudathyrium flexile*.

The herbarium specimens of the Glen Prosen plants tended to have wider spaced pinnae than many of those from elsewhere, and these did also. On a warm, sunny, south-facing slope expansion was probably more rapid than in other sites. A quick survey round the rocks revealed more plants. Some, at the end of June, were nearly ready to shed their spores, although that was an exceptional season. After much taking of photographs I went on up the slope with strangely renewed vigour and happily skipped off across the skyline. Although I have since seen the fern in several other locations, mostly in far greater abundance, there was a distinct satisfaction in having re-found the original type locality.

Just over a year later I surveyed the trays of ferns in the university greenhouse with rather less jubilation. During the unusually dry summer of 1995 I had collected a wide range of spores in near perfect conditions. I had carefully nurtured the gametophytes and watched their development. There were now hundreds of young plants from Ben Alder, Glen Prosen, Creag Meagaidh, Bridge of Orchy and Glen Coe. The *flexile* plants had grown very quickly and some had produced spores within nine months of sowing. *A. distentifolium*, true to my previous experience, was less precocious although vegetatively larger. But all was not well. How could I have been so careless? There are always a few spores of other species which creep in as rogue plants, but to have nearly half of some trays with two different types of ferns seemed to imply a disgraceful amount of contamination. Then a pattern began to emerge. On the whole, *flexile* spores produced *flexile* sporophytes. There were four *distentifolium* plants among 415 *flexiles*; very much the rogue-level one might expect. There were seven batches of *distentifolium* that were apparently pure although they were mostly rather small samples. But eleven sets of spores, collected in the field from apparently typical *distentifolium*, had produced anything from a quarter to one half *flexile* sporelings.

For some time I was puzzled by these ratios. Using Mendel's work to explain a possible one-gene mutation, the expectation would be one quarter pure *flexile*-type plants, one quarter pure *distentifolium*-type, and one half of the plants would look like *distentifolium* but have the potential to produce the *flexile* mutation. This would mean that three quarters of the sporophytes should look like *distentifolium*, but this was not the case. However, because these ferns were the result of mixed mating, albeit with spores from the same parent, there was the opportunity for either self or cross-fertilisation to occur and this could explain the ratios.

It is tempting to wonder about James Backhouse's experience in cultivating these ferns. The Backhouse Nursery had great expertise in growing a wide range of native and foreign species of ferns and Newman (1854) reported that both *flexile* and *alpestre* were growing freely in cultivation at York. If spores of *flexile* alone been propagated then they would have produced true progeny and its status would have been no further clarified. Only if spores from certain *A. distentifolium* populations like Glen Prosen were sown, would the two kinds of sporophytes have been produced. Even then, a mixed batch could have been the result of contamination, especially as they were probably collected into a vasculum where they would have been in close proximity. At that time, ideas on genetic variation had not been developed. In 1859 Moore referred to James Backhouse's misgivings about the status of *flexile* which Newman had so firmly proclaimed. Why, seven years after it was first found was there still some doubt over its identity? What, in the light of his extensive fern-growing experience did James Backhouse observe? He might not have had an explanation for the results, but what conclusions did he draw?

This article reports part of an investigation into the ecology of Scottish *Athyrium distentifolium* and *flexile*. Research into their relationship is continuing.

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TREE-FERNS IN SOUTH-EASTERN AUSTRALIA AND NEW ZEALAND*

A Tourist's View

Alastair C. Wardlaw

In February and March of 1996 I had a seven-week 'trip of a lifetime' in south-eastern Australia, Tasmania and New Zealand. I went with my wife, Jackie, and we were joined from Tasmania onwards by two Canadian friends, Tony and Shirley Bidwell, both botanists. For Jackie and me, the first stop was in Los Angeles, and then onwards to Sydney, Melbourne and the southern coast of Victoria. Thereafter we visited Tasmania for one week, and then spent four weeks touring the South and North Islands of New Zealand, eventually travelling homewards *via* Waikiki Beach in Hawaii. The trip was in the late summer and early autumn of the southern hemisphere, and thus a very good time for touring because schools had gone back after the summer recess, leaving holiday accommodation relatively easy to get. Also, most fern species had spores at that time.

I was the only seriously pteridological member of our party, although the others all had a keen eye for the diverse aspects of the natural world. Nevertheless, in a typical excursion into the bush, they would forge ahead along the trail while I stopped to identify and photograph the ferns. So I have a lot of pictures like Plate 4 with the beautiful *Cyathea dealbata*, the silver tree-fern of New Zealand, accompanied by the disappearing view of the other members of the party. That is why I have called this article "A tourist's view", because the tree-ferns I saw were mainly those we happened to pass on our tourist travels, and only occasionally because they were specially sought out. And although tree-ferns are the focus here, I was entranced by the numerous species of ground fern, most of which were new to me. For fern identification, I took Cronin (1) for the Australian species, and Brownsey & Smith-Dodsworth (2) for the New Zealand species.

The first tree-ferns were noted *en route* during the two-night break we had in Los Angeles after the 11-hour flight from Heathrow. We had booked in to an hotel in the Marina del Rey district which is near to the airport and the ocean. To my delight, there were numerous tree-ferns near the hotel, despite there being no native Californian species. However, *Cyathea cooperi*, a tree-fern from Australia, was widely planted outside hotels, office buildings and apartments in the local streets. Its slender trunk with characteristic stipe scars and large graceful fronds provided novel shapes to intermingle with the palms and other exotic vegetation. Apparently a local supplier is propagating *C. cooperi* on a large scale for the landscaping trade. I should like to have known if we were seeing the variety 'Brentwood' which is supposed to grow much faster than the wild type. I also noted *Dicksonia antarctica*, from Australia, and *D. squarrosa*, from New Zealand.

After nearly 15 hours non-stop and in darkness across the Pacific in a Boeing 747, we arrived in Sydney. Its stunning Opera House and harbour proclaim it to be one of the great cities of the World. It has a marvellous botanic garden with modern fernery and with *C. cooperi*, which we had just seen in Los Angeles, much in evidence. The photograph opposite shows this species in the old part of Sydney near the Harbour Bridge, with a backdrop of elegant 19th Century terrace houses and wrought-iron railings. We also found *Cyathea australis* quite commonly as a park specimen in Sydney, but its fronds tended to be more ragged than those of *C. cooperi.*

* This article is the transcript of a talk given at the BPS autumn indoor meeting at the University of York on 12th October,1996

Cyathea cooperi
near the harbour bridge, Sydney

From Sydney, an hour in the plane took us to Melbourne, a more staid and less extrovert city, but also with an excellent botanic garden and fern gully, this time with flying foxes chattering in the tree tops. Here we admired the very tall and slender *Cyathea brownii,* the Norfolk Island tree-fern. A highlight of our time in Melbourne was the visit to Neil Pike and his Ausfern Nurseries on the city outskirts. Neil's main business is with trunks of the soft tree-fern, *D. antarctica*, that are salvaged as a by-product of forestry operations. They are exported under licence to his Ausfern depot in Essex. The popularity of this species is due partly to its frost-hardiness and abundance in south-eastern Australia and Tasmania, but largely to its ability to withstand physical abuse. Thus whereas all other species of tree-fern, I was told, have to be dug out with a root ball if they are going to survive, *D. antarctica* can endure being chain-sawed off at the base of the trunk, shorn of its fronds and shipped as a blunt-ended stump, spending 2 or 3 months in a dark container at around 5°C. Then, on exposure to higher temperatures, and given some light and water, a flush of fronds sprouts from the top.

To emphasise that *D. antarctica* can grow while detached from the ground, Neil's nursery had numerous trunked specimens standing (wired to a support), but unrooted, on bare paving slabs. He even had a specimen hung horizontally at waist height on chains from the roof. Yet all had produced a good spread of fronds. Neil said that *D. antarctica* does not need to be rooted in the ground for survival, provided it gets frequent watering. He also stated that, from the standpoint of cultivation in U.K. gardens, the species of tree-fern fall into three categories: category one, *D. antarctica*, which he considers easily the best; category two, a few other species such as *Cyathea tomentosissima*, from the highlands of New Guinea, and *C. australis* from south-eastern Australia which might be worth trying; and category three, all the remaining species of tree-fern, including those from New Zealand.

From Melbourne, Jackie and I hired a car to drive 120 miles down the Great Ocean Road to the small seaside resort of Apollo Bay on the south coast of the State of Victoria. Apollo Bay describes itself as Paradise on Earth and I wouldn't dispute this. Here I had a most illuminating opportunity to compare the natural habitats of *D. antarctica* and *C. australis* within a few minutes walk of each other along the Barham River Road at the back of the town. Thus, while the dicksonia was confined to the dark understory beneath tall gum trees where photography required the use of flash, the cyathea was growing in the hedgerows. There it was fully exposed to sun and wind, and with British brambles twining up through its fronds. Both species of tree-fern are apparently frost-hardy to a similar degree; therefore *C. australis* might be a better prospect for British gardens than the more commonly offered *D. antarctica*, if trunked specimens could be provided at reasonable cost.

From Melbourne we flew over the Bass Straight and across Tasmania to the capital, Hobart, in the south of the island, where we met up with the Bidwells. Tasmania is about 200 miles across, both north-south and east-west, and the week we spent there was not nearly long enough to explore properly all the strange and beautiful sights, like the Cradle Mountain area. There is a good deal of roadless wilderness, as well as ranch lands, forests and vineyards. We found the Tasmanian wine very palatable. There is a lot of wild-animal life, judging from the amount of roadkill, and the Tasmanian Devil is apparently still quite abundant. Tasmania is the classic place for *D. antarctica*, which we saw widely planted in suburban gardens and along the roadside in forests. It was also being used as fencing material since the dead stumps are so cheap and durable. But truly luxuriant stands have to be sought in dark and damp forests and gullies.

One of the few people doing ecophysiological research on *D. antarctica* is Greg Unwin whom we visited at the Launceston campus of the University of Tasmania. He directed us to Notley Fern Gorge in the north of the island where we saw *D. antarctica* as the dominant plant. It occurred right at the bottom of the gorge, with dense overhead shading from the tall, broad-leaved trees. Many of the dicksonia trunks were themselves gardens of filmy ferns and other epiphytes. Greg had told us to look out for a demonstration specimen of *D. antarctica* which had had an 18-inch length removed from its trunk, leaving the rest of the plant wedged between tree branches and with its base completely detached from the ground. We duly found it and noted that it had a good head of fronds at the upper end. Presumably in a rainforest, the root mass that covers the trunk of the fern somehow gets enough moisture and nutrient for survival. This supports Neil Pike's view that *D. antarctica* does not have to be rooted in the soil in order to live. Greg Unwin suggested that the way *D. antarctica* fronds form a shuttlecock-like conical receptacle (below) may be important for collecting and directing leaf litter into the apical area from which the nutrients can be washed down the trunk.

D. antarctica was also abundant in Tasmania's Mount Field National Park (below) which has a wide range of habitats, from temperate rain forest up to arctic-alpine vegetation above the tree line. Sawn stumps of the dicksonia had been used by the hundred to make corduroy tracks through the forest, trunks that, if alive in Britain, would retail at over £100 each. I therefore couldn't help feeling that the forest track was paved with gold.

After Tasmania, we returned to Melbourne to change planes for the three and a half hour flight to Christchurch on the South Island of New Zealand. Eighty million years ago, Australia and New Zealand were part of the same land mass, but now they are separated by the 1,200 miles of the Tasman Sea. Although tree-ferns existed 80 million years ago, Australia and New Zealand today have only one species of tree-fern in common. This is *Cyathea cunninghamii*, which is not particularly abundant in either country. In Christchurch, the commonly planted tree-ferns in parks and gardens were *Dicksonia squarrosa*, the rough tree-fern, and *D. fibrosa*, known by the Maori name of wheki-ponga (Plate 7). Both species are native to New Zealand.

***Dicksonia antarctica*,**
at Mt. Field National Park,Tasmania

These two dicksonias were also seen further south, in suburban gardens in Dunedin, and in the wild in Bethune's Gully on the outskirts of that city. Additionally, this enchanting gully was home to the easily recognizable *C. dealbata*, with its silvery-undersided fronds (Plate 4), and *C. smithii*, (Maori 'katote') with its characteristic skirt of denuded stipes and rachises (Plate 8). Peter Bannister, Professor of Botany at the University of Otago in Dunedin and whom we had arranged to meet, said that Dunedin gardens rarely get frosts below -2°C and then next day they generally heat up with strong sunshine. He also told us that it was not easy to buy a tree-fern from any nursery in the Dunedin area since most people who wanted such a plant would simply take one from the bush.

From Dunedin, we drove north-west into the mountains, to the winter-sporting areas of Queenstown, Arrowtown and Wanaka. This region proved to be a treefern "desert". Even the gardens did not have tree-ferns, apparently because the climate is too cold and dry. At Arrowtown, for example, I was told by a local that the winter temperature goes down to -17°C, accompanied by up to five weeks of snow cover. The situation was very different after we had crossed the mountains at the Haast Pass and reached the wetter, and milder, western side of South Island. Here we came into a tree-fern paradise. The species were the same as those already mentioned but they were present in an abundance that filled every view. Plate 8 shows a stately specimen of *C. smithii* on the track to Roaring Billy Falls. This track provided my first encounter with the delightful *Trichomanes reniforme*, the kidney fern, scrambling over the ground and up tree trunks, like ivy in a British wood. Among the other notable ground ferns were Prince of Wales feathers, *Leptopteris superba*, the related *L. hymenophylloides* and *Sticherus cunninghamii*.

Our first stop on the west side of South Island was at the village of Fox Glacier which is provided with excellent hiking trails through the forest, and a superabundance of fern species. If I were allowed to go back to only one place in New Zealand for fern hunting, it would be here. There is rain forest, high mountains and the Fox Glacier itself with its end face of unstable ice only a short drive away. A nice feature of the woods, at least when we were there in mid-March, was that they were free of biting insects, unlike say the Canadian woods with their mosquitoes and black flies, and the Scottish woodlands with their midges. Nor are there snakes in New Zealand, unlike Tasmania where we saw and photographed one of the large poisonous species.

Another excellent feature of New Zealand is the ready availability of well-equipped, self-catering motels which allow for cheap touring. Our party of four never paid more than £60 total for a motel unit with two double bedrooms and fully-equipped kitchen and sitting room. These could be rented by the single night, or for several days, by phoning a day or two in advance. With the local supermarkets staying open till 8 or 9 p.m., catering was easy. We travelled with a box of non-perishable groceries, lived very well indeed and saved on the expense of restaurant meals. We also found we had brought far too much spare clothing since all the motels had coin laundry and drier facilities. As regards money, we charged up our credit card accounts before leaving UK and then used credit cards for cash over the counter at banks (no bother at all) and to pay for the motels and car hire. *Mastercard* and *Visa* were the most useful, *American Express* less so. We took no travellers cheques and did not miss them.

Further north, up the western side of South Island in the region of the jade centre, Hokitika, the majestic black tree-fern *Cyathea medullaris* came into prominence. Its shining thick black stipes and height above other foliage in the forest were very regal (Plate 9). We saw it for the rest of our travels in South Island through to the wine-producing district of Marlborough. On the North Island of New Zealand where we spent our last 12 days, the only additional species of tree-fern seen was *C. cunninghamii*. This last sentence does not do justice to all the other marvellous sights on North Island, such as the volcano, Mount Ruapehu, which erupted soon after our visit, the hot springs of Waimangu Thermal Valley, and Rangitoto Island in Auckland Bay. With the ground ferns, I was overwhelmed by the numerous species of *Asplenium*, *Blechnum*, *Grammitis* and *Hymenophyllum*, and all the new genera like *Anarthopteris*, *Ctenopteris*, *Diplazium*, *Gleichenia* and *Pneumatopteris*.

Although for me the tree-ferns were the greatest of visual treats, they do not seem to be particularly cherished by the ordinary New Zealanders. The All Blacks rugby team has *C. dealbata* as its emblem but I did not see many actual plants of silver tree-fern being kept as treasured specimens in parks or gardens. Most New Zealanders I spoke to referred to tree-ferns rather dismissively by the Maori name of "ponga". And one gets the impression that these elegant pteridophytes are regarded as little more than cheap fencing material. For example, in a large plant nursery near Wellington, the property was enclosed by a palisade of dead 8-foot *D. squarrosa* trunks touching one another, maybe 70 yards long. Yet inside the nursery, there was only one miserable specimen of a tree-fern for sale, a *D. fibrosa* with a trunk of about 18 inches.

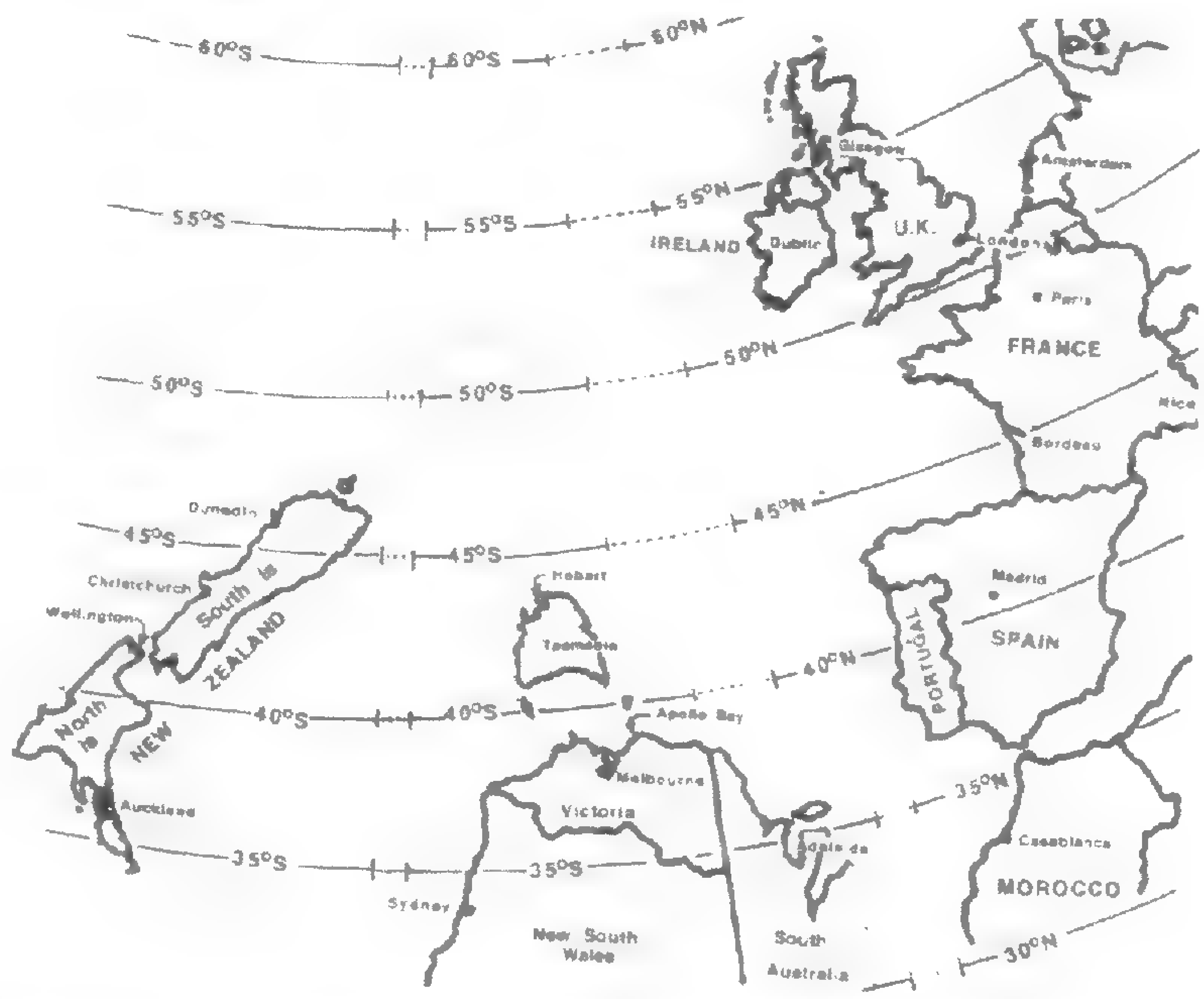

Fig. 1 Map of south-eastern Australia and New Zealand upside-down at latitudes equivalent to those in Western Europe and NorthAfrica

On returning home, I tried to put my impressions into a cartographical perspective by drawing maps of south-east Australia and New Zealand with their latitudes super-imposed upside-down on Western Europe and North Africa (Fig. 1). This emphasised that the places we had visited all lay in balmy latitudes roughly equivalent to between Casablanca and the Loire Valley. Thus the tree-ferns of the Antipodes grow much closer to the Equator than the places in the British Isles and Ireland where tree-ferns survive out of doors. Even 50° south, the southern latitudinal limit for *C. smithii*, the most southerly-growing of the New Zealand tree-ferns, is equivalent cartographically to the Scilly Isles at 50° north. In Scotland, *D. antarctica* flourishes on the Island of Arran in the Clyde Sea Area at 55° North. As a tree-fern enthusiast, I am hoping that *D. antarctica* and other tree-fern species can be persuaded to grow in my garden in Glasgow. But I shall have to provide some protection against the worst of our winter. *See article on page 69.*

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[clearly defined deadlines for 1998 are given in Editorial on page 53]

Brantwood House, the beautiful lakeside home of John Ruskin near Coniston, Cumbria, is staging an exhibition from Easter 1997 entitled *Ferns in the Fells*. The inspiration for this exhibition stems from the ways in which ferns have always played a part in the environment and in the interests of those who have shaped the Brantwood of today.

William J. Linton, who bought the house in 1853 when Brantwood was little more than a Lakeland cottage, was involved in the radical republican fringe of the Chartist movement. He used his ability as one of the foremost wood engravers of his time to produce various strongly political publications and, pursuing a fascination with botany, to write and illustrate *The Ferns of the English Lake Country*. This exquisite little book, published in Windermere in 1865, was one of the first Cumbrian fern floras and ran to two later editions. It is from this work that the inspiration for a new Linton Fern Garden at Brantwood was drawn.

In 1871, Linton sold Brantwood to the artist and crtitic John Ruskin who lived there until his death in 1900. Ruskin created a living workshop for his ideas, artistic, social and environmental within the steep and craggy landscape around his home. He gardened with the natural landscape and indigenous plants that throve on the acidic soils of his estate. Ferns of many kinds enjoyed the walls and fellsides around Brantwood; often in his writings and illustrations would Ruskin extol their beauty of form and effect.

After his death, Ruskin's gardens were allowed to return to nature until a major renovation of their structure and philosophy was begun in the 1980s.

At the beginning of a new era for Brantwood, the room where Linton produced his republican literature is being presented as a series of themed exhibitions exploring some of the many facets of Ruskin's interests and of life at Brantwood, giving his thoughts and ideas contemporary relevance. The first of these exhibitions will explore the history of our native ferns, from their primaeval beginnings through to the present day, and illustrate the part that they have played in the story of Brantwood and its creators.

Ferns In The Fells will present visitors with a fascinating insight into the historical, ecological, medicinal and decorative ways in which ferns have assisted and inspired mankind, using a variety of materials, living displays and fern memorabilia inspired by the Victorian passion for ferns. Further exploration of Lakeland ferns will be encouraged with a Fern Walk through grounds to the rapidly growing collection of over 160 Cumbrian fern species and their cultivars now displayed in the Linton fern garden. We hope that this exhibition will inspire both the existing fern addict and those who cannot tell bracken from *Blechnum* to look more closely at the world of ferns around them.

The exhibition will open daily from Easter, and will continue throughout the season. Tickets will be available from the main house and museum, where there will also be a wide selection of ferns and other plants for sale. An excellent restaurant, Craft Gallery and toilets are also available on site.

HELEN SURTEES

If any members have material or exhibits they would be prepared to have included in this unique exhibition, we would love to hear from you. Please contact Helen Surtees or Sally Beamish, head gardener, on 01939 441396.

ACQUIRING A TASTE FOR FERNS

Heather McHaffie

As I perched on a wobbly boulder near Bridge of Orchy and bit into my cheese roll, I noticed evidence of an earlier lunch at the same spot. The clump of *Dryopteris expansa* further up the scree had been neatly eaten. So had every other clump in immediate view. This prompted speculation on the relative palatability of the different ferns on offer. A cautious nibble at some *D. expansa* proved that it was not unpleasant. Some *D. affinis* ssp. *borreri* had suffered similarly and was found to be reasonably acceptable. Browsing farther afield, some still-expanding *D. oreades* had been sampled and I did likewise. It seems that all these *Dryopteris* are tolerable.

Moving on to *Athyrium,* I had already had difficulty in refinding two clumps of *A. filix-femina* as they had been so well munched, although I found them less appetising than *Dryopteris. A. distentifolium* I had long observed to have been popular with the deer. At Glen Prosen, the deer eat the largest, most conspicuous fronds, but I was puzzled as to how they got at ones on the ledges half under the rocks, until I came across startled mountain hares and interrupted their snack. It is relatively unusual to find caterpillars eating ferns, so I was especially interested to discover one eating *A. distentifolium.* I took it home and hopefully offered it *A. filix-femina*, but as larvae tend to keep to their first food plant this one was too discriminating and would not eat it. It settled down to cultivated *A. distentifolium* and interestingly accepted *A. flexile* too. Perhaps this would be a useful new technique, using trained caterpillars to differentiate between species. When it eventually pupated and emerged, it was a silver-Y moth (*Autographa gamma* L.). This is a well-known migrant that was particularly widespread in 1996 and the progeny can eat a variety of herbaceous plants. Personally, I still preferred the *D. expansa.*

Polystichum lonchitis is frequently seen eaten back and I found that it is not too unattractive while still young, though very tough when mature. Some ferns are rarely seen grazed at all. *Gymnocarpium dryopteris* and *Phegopteris connectilis* are in this category and certainly tasted very bitter. *Cryptogramma crispa* I have never seen grazed and in my estimation rates as the least palatable fern. Despite chewing only a small portion, and rapidly disposing of it, the taste remained for the rest of the afternoon. I agreed with the other herbivores that this one is best left alone.

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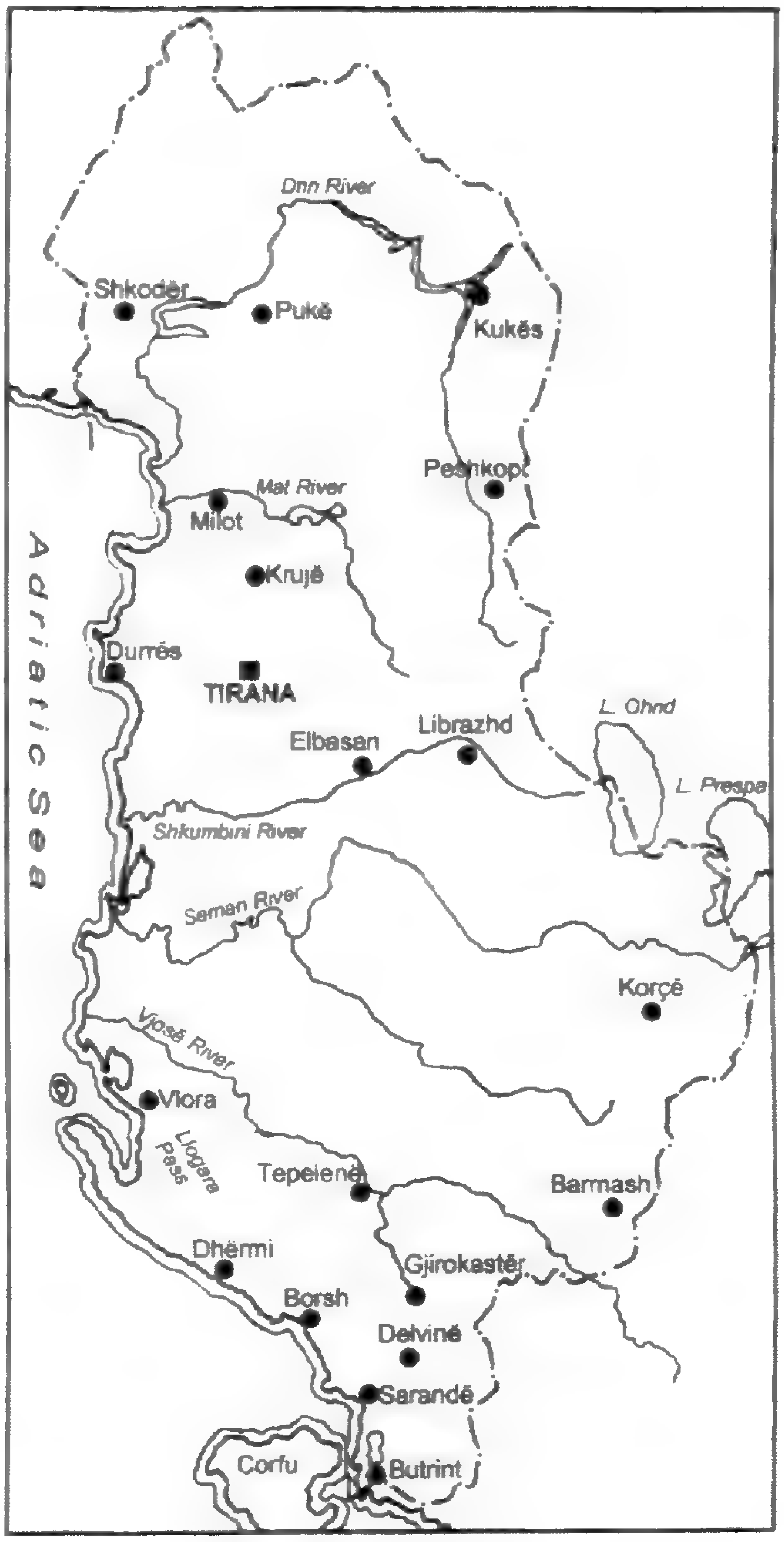
Nature made ferns for pure leaves,
to show what she could do in that line.

....a leaf like that of a fern, the proudest of
all plants in the structure of her foliage.

It was once believed that biting the first fern fronds seen in
spring would insure one against the toothache for a year.

SOME ALBANIAN FERNS

Peter Barnes



Slightly smaller than Belgium, Albania is a little known but fascinating country on the Balkan Peninsula, opposite the heel of Italy's boot. It is the most mountainous (and the poorest) country in Europe, with a consequent floristic diversity (over 3,200 species) that was well-described by Hoda (1993). In the *Flora e Shqipërisë* (*Flora of Albania*), only 9 fern-allies and 36 species of fern (including two species whose status is uncertain) are recorded - on the face of it, a meagre total, even by British standards. However, there are some interesting species there, some familiar from Western Europe, but others representing the Mediterranean element that is so conspicuous among the higher plants of Albania.

In the course of a two week visit to central and south Albania in April 1991 with a party of botanists and horticulturists, I was able to see 14 of the ferns (plus one possible hybrid) and 3 allies as well as a wide range of flowering plants. A subsequent week-long visit, in August of the same year, took me to the north of the country. Unfortunately this was a flying trip, in company with a party that was, apart from my wife, less keen to indulge the whims of a solitary botanist. Consequently, few ferns were seen in that region. However, there is little doubt that montane species would be well represented in the north, something I would love to have the opportunity to follow up!

In the meantime, the following notes may be of interest to others contemplating a visit to this beautiful country.

Selaginella denticulata

Various places along the road from the Llogara Pass to Dhërmi and Borsh; rock crevices near Lake of Butrint; shaded rock crevices, Delvinë. A small and completely prostrate species with short, stalkless strobili. It grows in damp rock crevices in several roadside locations, often quite exposed, and then strongly tinged with reddish-orange. This species is not recorded for Albania in *Flora Europaea* or either of the Albanian Floras, but it is in *Atlas Florae Europaeae*. *Selaginella helvetica* is also recorded from Albania, but was not seen.

Equisetum arvense

Uji i Ftohtë near Tepelenë, in woodland close to Vjosë river. This Uji i Ftohtë (there is another near Vlorë) is a beauty spot with a restaurant by the river. *Platanus orientalis* grows almost in the water. The area might repay further botanising.

Equisetum telmateia
Uji i Ftohtë near Tepelenë, in woodland near the Vjosë river.

Cheilanthes acrostica
Various places along the roadside between the Llogara Pass, Dhërmi and Borsh; Butrint. Growing in rock crevices in quite exposed sites.

Adiantum capillus-veneris
Shady wet cliff by road west of Librazhd; the uncommon *Pinguicula hirtiflora* also grows here. Peshkopi: rough, stony ground behind sanatorium, in shade of boulders, but the area appears to be fairly dry.

Pteridium aquilinum
Delvinë, amongst scrub vegetation; near Milot in open places; waste land by Mesi bridge near Shkodër; Pukë to Kukës road on roadside bank. Nowhere did I see the really extensive stands that are commonly met with in Britain.

Asplenium onopteris

Asplenium trichomanes
Butrint, on stony bank in deep shade; Delvinë, shady rock crevices; Uji i Ftohtë, near Tepelenë, on stone walls.

Asplenium adiantum-nigrum
Roadside banks between Vlorë and the Llogara Pass; Butrint, on shady banks; Delvinë, stony banks among scrub.

Asplenium onopteris
Butrint, shaded bank; Delvinë in shady places among scrub.

Asplenium ceterach
Castle walls, Shkodër, looking very wizened in August; Dajti mountain, east of Tiranë, in rock crevices; Iljaz, north of Dhërmi in roadside walls; Butrint, on walls; Muzinë pass (east of Delvinë) small plants in rock crevices; Uji i Ftohtë near Tepelenë, in walls.

Asplenium scolopendrium
Uji i Ftohtë near Tepelenë, among stones in damp woodland near river.

?***Asplenium x ticinense*** (*adiantum-nigrum* x *onopteris*)
Butrint (previous year's frond) shady bank. This is a distinctive-looking frond (see p. 102), but we all know how misleading that can be with the ferns. The name is suggested very tentatively.

Cystopteris fragilis
Barmash, among rocks in woodland margin. I was surprised not to see this much more often, given what a rocky country it is.

Polystichum setiferum
Delvinë, in shady places among scrub, plants growing to 60 cm; Syri i Kalter Blue Eye, a spectacular spring at Bistricë, south-east of Delvinë. A large specimen was growing in the bank immediately above the pool in which the spring wells up.

Dryopteris villarii (syn. *D. villarii* subsp. *pallida*)
Roadside banks between Vlorë and the Llogara Pass; Iljaz, north of Dhërmi; Uji i Ftohtë

near Tepelenë. An attractive fern, more divided and less rigid looking than our native *D. submontana* (syn. *D. villarii* subsp. *submontana*).

Polypodium australe

Iljaz, near Dhërmi, small plant, growing with *Asplenium ceterach* on wall; Butrint; Syri i Kalter, Bistricë, a fine specimen in a large tree of *Platanus orientalis*. The splits of the *Polypodium vulgare* complex are not recorded in the Albanian Floras and records of this species from Albania are deliberately omitted in *Atlas Florae Europaeae*.

Polypodium vulgare

Delvinë, on rocks among scrub, small, stunted specimens appeared to be this species.

Anogramma leptophylla

Vlorë, steep rocky bank on coast road south of town; Llogara/Dhërmi/Borsh road, descent from Llogara pass (between Vlorë and Dhërmi) to Ionian sea; Iljaz, rock crevices by road; Butrint, rock crevices. This fern, although evidently quite widespread, at least in the south-west, does not appear in the *Flora e Shqipërisë*, the *Flora Eskursioniste e Shqipërisë*, *Flora Europaea* or the *Atlas Florae Europaeae*. It was noted, with *Selaginella denticulata*, from Butrint by North.

Checklist of ferns and fern-allies of Albania

Huperzia selago	*Cheilanthes persica*	*Asplenium fissum*
Selaginella selaginoides	*Adiantum capillus-veneris*	*Asplenium ceterach*
Selaginella helvetica	*Cryptogramma crispa*	*Asplenium scolopendrium*
Selaginella denticulata	*Anogramma leptophylla*	*Athyrium filix-femina*
Equisetum hyemale	*Pteridium aquilinum*	*Cystopteris fragilis*
Equisetum ramosissimum	*Thelypteris palustris*	*Polystichum lonchitis*
Equisetum fluviatile	*Asplenium petrarchae*	*Polystichum aculeatum*
Equisetum palustre	*Asplenium trichomanes*	*Polystichum setiferum*
Equisetum arvense	*Asplenium csikii*	*Dryopteris filix-mas*
Equisetum telmateia	*Asplenium viride*	*Dryopteris villarii*
Ophioglossum vulgatum	*Asplenium adiatum-nigrum*	*Dryopteris carthusiana*
Botrychium lunaria	*Asplenium onopteris*	*Gymnocarpium dryopteris*
Botrychium matricariifolium	*Asplenium cuneifolium*	*Gymnocarpium robertianum*
Osmunda regalis	*Asplenium septentrionale*	*Polypodium australe*
Notholaena marantae	*Asplenium ruta-muraria*	*Polypodium vulgare*
Cheilanthes acrostica	*Asplenium lepidum*	*Marsilea quadrifolia*

Apart from adding a few dots to the distribution records in *Atlas Florae Europaeae* there are, perhaps, no real excitements here. Nevertheless, I found both visits rewarding in many ways and not just for the ferns. Albania is a country of great diversity and beauty and most visitors are quickly won over by the immense charm and kindness of its people, however poor they may be by the standards of Western Europe.

I visited the country at a political watershed, just after the first democratic elections, which returned what was to prove a short-lived socialist government. The first trip was during a sort of political hiatus, but society appeared to be functioning fairly smoothly. However, by August it was distressing to see how the industrial and agricultural infrastructure were disintegrating. Too much of the communist-inspired infrastructure had been scrapped, with nothing to take its place. The subsequent years have consequently been very turbulent, cumulating in the present alarming situation (March 1997): the ship is still wallowing rudderless in stormy seas as I noted in August 1991. I don't suppose that anyone can foretell what will happen there over the next few months and years but, should the opportunity arise, I should jump at the chance to pay another visit, to enjoy further the ferns and other plants and, above all, to renew the friendships that I made.

ACKNOWLEDGEMENTS
I am grateful to Petrit Hoda of the University of Tiranë for his invaluable guidance in the field; to Primrose Peacock for organising the first trip I went on; to the Royal Horticultural Society for financial support and to Chris Page at Edinburgh for his comments on some of the *Asplenium* specimens.

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Asplenium x ticinense

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CERTIFICATE OF MERIT

A. R. Busby

Since 1894 it has been within the power of the BPS Committee to award Certificates of Merit for new and outstanding fern cultivars. It has been many years since the Society has been asked to consider an award.

Members who visited the 1991 Centenary Fern Show at Pebworth, Warwickshire may recall the diminutive cultivar of *Asplenium scolopendrium* exhibited by Mr Alf Hoare. I was most struck by this delightful and novel form, and felt that it deserved to be more widely known. At a recent meeting of the Fern Nomenclature Sub-committee, I drew the attention of the meeting to this new cultivar, having ascertained from the raiser that he would be prepared to accept the BPS award. Alf Hoare wrote of how he came by this unique form:

> *It was about 1983 that I noticed some strange looking prothalli, in that they were very much wrinkled. They were growing with other ferns inside a large expanded polystyrene container, but unfortunately there was no label. The container was on the flat roof of my garage, kept closed with a sheet of glass placed upon it.*

Eventually I potted up eight young sporophytes but six did not survive the transition. The remaining two grew rather slowly until they were exhibited at the 1991 Centenary Fern Show. Not long afterwards they were put in Alpine Garden Society shows.

Subsequently one of the plants started to rot off and despite cutting away the affected part, it eventually died. The surviving plant continued to grow slowly, so much so that it seemed to have no will to live! Then, perhaps assisted by a clean-up of the fronds prior to showing, it started to make progress again. At the time of writing, it is growing quite well and I have vowed to cut off any rhizome that creeps over the side of the pot and give it to Martin Rickard for further propagation.

Alf suggested two or three names, and sub-committee chose 'Elf' .

Fern varieties to which certificates of merit have been awarded by the British Pteridological Society

Compiled by JW Dyce, *British Fern Gazette* 9(5) 1964.

Asplenium trichomanes 'Inciso-crispum Clement' (1921)

Asplenium scolopendrium 'Crispissimum' (1938); 'Crispum Angustifrons Sheldon' (1937); 'Crispum Cristatum John Cousins' (1927); 'Crispum Fimbriatum Muricatum Lowe' (1921); 'Crispum Fimbriatum Sagittatum Sheldon' (1930); 'Crispum Sagittatum' Sheldon' (1931); 'Crispum Speciosum Moly' (1921); 'Crispum Splendens Moly' (1927); **'Elf A Hoare' (1996)**; Lacerato-fimbriatum Sheldon' (1930); 'Laceratum Grande' (1931); 'Ramo-cristatum Cranfield' (1937); 'Sagittato-crispum Cristatum Perry' (1926).

Athyrium filix-femina 'Caput Medusae' (1938); 'Cruciato-cristatum Baccatum Kingsmill Moore' (1922); 'Plumoso-cristatum Lovelady' (1930); 'Plumosum Laxum Sheldon' (1931); 'Setigerum Percristatum Sheldon' (1929).

Blechnum spicant 'Bipinnatum Sheldon' 1931; 'Percristatum Rowlands' (1926); 'Ramo-cristatum Blow' (1927); 'Smithies Seedling' (1938); 'Tricapitatum' (1904).

Dryopteris dilatata 'Grandiceps Cranfield' (1938).

Dryopteris filix-mas 'Cristata-tenuis Parker' (1932); 'Grandiceps C Henwood' (1924).

Dryopteris oreades 'Crispa Cranfield' (1939).

Dryopteris affinis 'Fimbriato-cristata Angustata Cropper' (1922); 'Polydactyla Whiteside' (1929); 'Whitwell' (1922).

Polypodium vulgare agg. 'Bipinnatum FW Stansfield' (1926); 'Cambricum Henwood' (1922); 'Cristatum Henwood' (1922); 'Omnilacerum Oxford' (1921); 'Plumosum Whilharris' (1927); 'Pulcherrimum congestum Perry' (1928).

Polystichum aculeatum 'Cristatum Henwood' (1927); 'Divisilobum Cranfield' (1927); 'Folioso-incisum Sheldon' (1933); 'Gracillimum Attenuatum Druery' (1938); 'Gracillimum-critulatum Cranfield' (1937); 'Gracillimum-pulcherrimum Cranfield' (1937); 'Grandiceps Sheldon' (1937); 'Pulcherrimum Cranfield' (1927); Druery (1921; Kingsmill Moore (1934); 'Pulcherrimum Foliosum Edwards' (1922); 'Pulcherrimum Plumosum Green' (1921); 'Sinuosum Kingsmill Moore' (1931).

Polystichum setiferum 'Acutilobum Stansfield' (1927); 'Acutilobum Divisum FW Stansfield' (1930); 'Acutilobum Laxum Sheldon' (1934); 'Acutilobum Macrodon T Stansfield' (1930); 'Acutilobum Polydactylum Kingsmill Moore' (1930); 'Congestum Perserratum Perry' (1924); 'Decompositum Dissectum Perry' (1926); 'Divisilobum Bland' (1922); 'Divisilobum Discretum Clapham' (1937); 'Divisilobum Falcato-pinnulum' (1923); 'Divisilobum Falcatum' (1923); 'Divisilobum Foliosum Variegatum Harris' (1921); 'Divisilobum Pallens Sheldon' (1937); 'Divisilobum Perserratum Phillips' (1928); 'Divisilobum Plumosum Baldwinii' (1923); 'Divisilobum Plumosum Erectum H Stansfield' (1921); 'Divisilobum Venustum' (1923); 'Foliosum Moly' (1927); 'Foliosum Grande Walton' (1922); 'Inciso-setosum Sheldon' (1934); 'Lineare Caudatum T Stansfield' (1928); 'Lineare Cristatum Ed.' (1906); 'Multilobum Sheldon' (1934); 'Multilobum Rotundatum Benbow' (1927); 'Percristatum Cranfield' (1921); 'Percristatum Grande Cranfield' (1927); 'Perserratum Grandiceps Askew' (1931); 'Pluma-struthionis FW Stansfield' (1926); 'Plumosum Elegans Sheldon' (1937); 'Plumosum Rarefactum H Stansfield' (1921); 'Pulcherrimum Cranfield No.1' (1925), F W Stansfield (1922), H Stansfield No.4 (1925), No.5 (1938); 'Pulcherrimum Moly's Green' (1927); 'Pulcherrimum Variegatum' (1928); 'Rotundatum Phillips' (1927); 'Tripinnatum Meade' (1925); 'Tripinnatum Grande Kingsmill Moore' (1930).

Oreopteris limbosperma 'Formoso-cristata FW Stansfield' (1922); 'Grandiceps Smithies' (1903).

LETTERS

Fern Cultivar Names

The juxtaposition in *Pteridologist* 3,1 (1996) of Martin Rickard's piece under this title, and Clive Jermy's review of the new edition of the *International Code for the Nomenclature of Cultivated Plants* is, in some ways unfortunate, as the latter tends to undermine the first! This is the first edition of the *Code* to put the cultivar group concept on a formal basis. The official title is now **cultivar-group**, with a hyphen to make it clear that it is a formal category. In itself, this is a good thing, since the concept was left rather in the air in previous editions.

However, and to my mind rather disturbingly, a cultivar-group is now defined as "an assemblage of two or more similar, *named* cultivars within a genus..." [my italics]. In the 1980 *Code*, it was "an assemblage of similar cultivars".

The intentional addition of the word *named* thus appears to preclude the use of a cultivar-group as a convenient hold-all for *un-named* variants, as in Martin's example - and as advocated in my article *The horticultural nomenclature of ferns* (*Pteridologist* 1, 4 (1988) 192-195).

There is currently a debate in the pages of *Hortax News* (newsletter of the Horticultural Taxonomy Group) on just this aspect. The editor of the new *Code*, also of *Hortax News*, is Piers Trahane, who invites further views on the use and formation of cultivar-group epithets. I would hope that some BPS members may like to give their thoughts, as the practical application of cultivar-groups to the fern scene may have been overlooked. Piers can be contacted at: Hampreston Manor, Wimborne, Dorset BH21 7LX (E-mail: PIERS@INDHORT.DEMON.CO.UK).

***PETER BARNES**, Alltgoch, Llangeitho, Tregaron, Ceredigion SY25 6TT*

A fungus on ostrich fern

I am an insatiable amateur mycologist. There are already around 15,000 species of fungus known in Britain, but I would like to enlist the help of your readers in finding yet another.

The one I want is *Woldmaria filicina*, a curious species known in Europe only on dead stem bases of *Matteuccia struthioperis* (ostrich fern). What is almost certainly the same species occurs in North America on *Osmunda cinnamomea*, so it just might also occur on our own royal fern, *O. regalis*. *W. filicina* is widespread in northern Europe, including areas where ostrich ferns are not native, but has never been recorded in Britain. I feel it could well occur here, at least in Scotland, but it is inconspicuous, and won't be recorded here unless specifically searched for. Although it has been known for over a century, few people are aware of its existence, so not much can be read into its absence from British records.

What we are looking for is 1-2 cm long, yellow-brown, furry patches on old, blackened stem bases. Under a hand lens these are seen to be made up of dense aggregations of short macaroni tubes, each 2-3 mm long by 0.5 mm wide. The fertile surface is on the inside of these tubes.

Woldmaria, formerly *Solenia* (= a pipe), is possibly a relative of the large and well-known beef-steak fungus, *Fistulina hepatica* on oak trees, whose fruiting surface, under a lens, is also seen to be made up of discrete tubes. *Woldmaria* has a common close relative, *Henningsomyces candidus*, which forms similar white tubules on the rotting undersides of logs. The taxonomic position of all these fungi is obscure.

Most records have been made in summer and early autumn, but this may only reflect the popular fungus foraying season in inhospitable northern climes. A week of damp, frost-free weather at any time of year might well prove suitable. If you are lucky enough to find it (and there shouldn't be much doubt - no other fungus on ferns is remotely similar), please send me a voucher (2 or 3 stem bases) to go in the Kew herbarium with details of who, when and where (map ref. please), and anything known of the history of ostrich ferns at the site. The material would be equally acceptable truly fresh or thoroughly dried (over a radiator or in an airing cupboard).

***ALICK HENRICI**, 57 Clarendon Road, London W11 4JD*

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