Cytology of Thirty Species of Ferns from the Palni Hills (South India)

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During the past three decades cytological investigations of the Indian Pteridophytes have been progressing steadily as evidenced by the fact that out of about 600 species of ferns known from the Indian region, over 500 species have been investigated. In the light of Holttum's rearrangement of genera of ferns (Willis, ed. 7, 1966) and his new system of the Thelypteroid genera of the Old World (1971), the total number of genera indigenous to S. India has been estimated to be ninety-four (personal communication from Dr. F. M. Jarrett) of which 64 have been cytologically examined earlier (Abraham and Ninan 1954, 1958, 1965; Abraham, Ninan and Matthew 1962; Ninan 1956 a, b, c, d, 1958 a, b, c, Bir 1965; Kuriachan 1968, 1976 1978, 1979, 1981; Kuriachan and Ninan, 1973, 1974, 1976; Bhavanandan 1968, 1981).

The Palni Hills in the District of Madurai, in the State of Tamil Nadu, an eastward offshoot of the Western Ghats of India, are situated between 10°10'N and 77° 25'E and encompass an area of 2068 sq. km. A neutral saddle divides these hills into two geographically distinct zones, the Upper and the Lower Palnis. The Upper Palnis form a plateau of 385 sq. km., of an average altitude of 2200 m, an undulating plateau interspersed with sholas and occasional peaks rising to a maximum of 2554 m at Vandaravu at the Western border of Tamil Nadu and Kerala.

The well-known town of Kodaikanal with an area of 16.8 sq. km. stands at the southern summit of the Upper Palnis which descends into a precipitious slope; on the east it slopes down abruptly into the Lower Palnis and on the west is the high plateau leading to the body of the Western Ghats. As an offshoot of the Western Ghats and as one of highest mountains of S. India, the Palnis receive heavy monsoonal rains both from the South West and North East and these rains distributed more or less uniformly during the year keep the vegetation nearly always fresh.

The present cytological work deals with the chromosome numbers of thirty species belonging to Ophioglossaceae (five species), Pteridaceae (one species), Adiantaceae (four species), Dennstaedtiaceae (one species), Thelypteridaceae (eight species), Athyriaceae (six species), Aspidiaceae (four species), and Lomariopsidaceae (one species). The vouchers for these species have been deposited in the Central Herbarium, Department of Botany, University of Kerala and Rapinat Herbarium, Tiruchirapalli, Tamil Nadu.

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Materials and methods

Field work in the Palnis during 1969-74 has revealed one hundred and fifty taxa of ferns belonging to sixty four genera. Nearly all these taxa were sent to Kew for determination by Dr. F. M. Jarrett and Prof. R. E. Holttum. The former had determined the majority of the species while the latter dealt with the whole of Thelypteridaceae. The author spent June-September, 1973 in Kew, examining all the South Indian materials belonging to the genera *Ophioglossum*, *Pteris*, *Vittaria*, *Dicranopteris*, *Diplazium*, *Polystichum*, *Leptochilus* and a few other genera.

As part of the ecological work most of the Palni ferns were transplanted in the green house of the Department of Botany at Trivandrum with a view to observing their growth-habit under changed conditions. Materials for meiotic squashes were mostly collected from these transplants. Developing sporangia were fixed usually between 9.00 and 10.30 a.m. A fixation period of three days was found to give best results and this has been followed throughout the present work. Exceptionally *Ophioglossum* and *Botrychium* yielded satisfactory results even after five months of fixation whereas *Sphaerostephanos arbuscula* gave a fairly good count after a fixation period of ten minutes. *Hypodematium crenatum* and *Christella dentata* were found to be difficult cytological materials while *Diplazium*, *Adiantum* and *Pteris* were found to be particularly easy to work with.

Throughout the work, Carnoy's fluid (absolute alcohol and glacial acetic acid in the ratio of 3: 1) was used as fixative and sporangia were squashed in acetocarmine. Slides were photographed in fresh acetocarmine and made permanent following Mc Clintock's (1929) method. Photographic illustrations and comments are provided only for select species of ferns.

Observations

Chromosome numbers of the Palni ferns studied presently are given in Table 1 together with data on locality, altitude and number of voucher specimens. Previous reports of chromosome numbers of the Palni ferns are provided in Table 2.

Table 1. Present work on chromosome numbers of the Palni ferns

Species	Locality and altitude	Voucher	n Number	Ploidy
OPHIOGLOSSACEAE				
<i>Botrychium daucifolium</i> Wall. ex Hook. & Grev.	Shembaganur 1800 m	1918	90	Tetrapl.
<i>B. lanuginosum</i> Wall.	Bear Shola 2300 m	756	90	"
<i>Ophioglossum nudicaule</i> L.	Perumalmalai 1600 m	1660	240	"
<i>O. petiolatum</i> Hook.	Tiger shola 1700 m	1970	c. 470	Octopl.
<i>O. vulgatum</i> L.	Berijam 2360 m	715	c. 243	c. Tetrapl.

Table 1. (Contd)

Species	Locality and altitude	Voucher	n Number	Ploidy
ADIANTACEAE				
<i>Adiantum zollingeri</i> Matt. ex Kuhn	Top Station 1500 m	1542	29	Dipl.
<i>A. capillus-veneris</i> L.	Top Station 1500 m	1086	30	"
<i>A. incisum</i> Presl	Palamalai 1200 m	854	30	"
<i>A. raddianum</i> Presl	Shembaganur 1800 m	1303	114	Octopl.
DENNSTAEDTIACEAE				
<i>Microlepia majuscula</i> (Lowe) Moore	Vallakavi 1200 m	649	86	Tetrapl.
<i>Amphineuron terminans</i> (Hook.) Holtt.	Manalur 1100 m	1357	72	"
<i>Christella dentata</i> (Forsk.) Holtt.	Pambar 2100 m	1177	72	"
<i>C. papilio</i> (Hope) Holtt.	Vellakavi 1200 m	645	36	Dipl.
<i>Macrothelypteris ornata</i> (Wall. ex Bedd.) Ching	Vellakavi 1200 m	654	62	Tetrapl.
<i>Thelypteris confluens</i> (Thunb.) Morton	Berijam Lake 2300 m	1326a	35	Dipl.
<i>Sphaerostephanos arbuscula</i> (Willd.) Holtt.	Perumalmalai 1200 m	669	36	"
<i>S. unitsu</i> (L.) Holtt.	Perumalmalai 1600 m	461	36	"
<i>Cyclosorus interruptus</i> (Willd.) H. Ito	Berijam Lake 2300 m	1309	36	"
ATHYRIACEAE				
<i>Diplazium polypodioides</i> B1.	Dolmen circle 1400 m	917	41	"
<i>D. esculentum</i> (Retz.) Sw	Manalur 1200 m	1360	41	"
<i>D. travancoricum</i> Bedd.	Blackburn 1900 m	1557	205	Pentapl.
<i>D. sp. (a)</i>	Shembaganur 1700 m	1310	123	Tripl.
<i>D. sp. (b)</i>	Vellakavi 1200 m	1727	82	Tetrapl.
<i>D. sp. (c)</i>	Manalur 1100 m	1355	41	Dipl.
ASPIDIACEAE				
<i>Tectaria polymorpha</i> (Wall. ex Hook.) Copel.	Vellakavi 1200 m	658	80	Tetrapl.
<i>Dryopteris sparsa</i> (Ham) O. Ktze	Perumal 1100 m	717	80	Tetrapl.
<i>Hypodematium crenatum</i> (Forsk.) Kuhn	Pannaikadu 1400 m	1113	82	Tetrapl.
<i>Polystichum setiferum</i> (Forsk.) Moore ex Woyner	Fairy Falls 2300 m	1287	82	Tetrapl.
LOMARIOPSIDACEAE				
<i>Egenolfia appendiculata</i> (Willd.) J. Sm.	Perumal 1600 m	513	41	Dipl.

Table 2. Previous works on chromosome numbers of the Palni ferns

Species	Locality	n	2n	Ploidy
ABRAHAM <i>et al.</i> (1962)				
<i>Botrychium lanuginosum</i> Wall.	Kodaikanal	—	180	Tetrapl.
<i>Marattia fraxinea</i> Smith	"	78	156	"
<i>Osmunda regalis</i> L. (<i>O. hugeliana</i> Presl)	"	22	44	Dipl.
<i>Sphenomeris chinensis</i> (L.) Maxon	"	c. 100	—	Tetrapl.
<i>Cheilanthes mysorensis</i> (Wall. ex Hook.)	"	30	50	Dipl.
NINAN (1956c)				
<i>Osmunda regalis</i> L. (<i>O. hugeliana</i> Presl)	"	22	44	"
KURIACHAN (1968)				
<i>Microlepia platyphylla</i> (D. Don) J. Sm.	Perumalmalai	43	86	"
<i>Asplenium erectum</i> Bory ex Willd.	Bear Shola	36	—	"
<i>A. formosum</i> Willd.	"	36	—	"
<i>A. indicum</i> Sledge	"	144	—	Octopl.
<i>A. normale</i> D. Don	Pillar rocks	36	—	Dipl.
<i>A. tenuifolium</i> D. Don	Kodaikanal	36	—	"
<i>A. unilaterale</i> Lam. var. <i>rivale</i> Bedd.	Pillar rocks	40	—	"
<i>A. unilaterale</i> Lam.	Kodaikanal	40 _{II} + 36 _I	116	Triploid hybrid
<i>Loxogramme involuta</i> (D. Don) Presl	Bear Shola	70	—	Tetrapl.
<i>Paraleptochilus decurrens</i> (Bl.) Copel	Kodaikanal	—	72	Dipl.
BHAVANANDAN (1968)				
<i>Thelypteris paludosa</i> (Bl.) K. Iwatsuki	"	62	124	Tetrapl.
(<i>Stegnogramma pozoi</i> (Lagasca) Ching)				
<i>Dryopteris boryana</i> (Willd.) C. Chr.	"	120	120	Tripl. apog.
(<i>Dryothyrium boryanum</i> (Willd.) Ching)				
<i>Dryopteris wallichiana</i> (Spreng.) Hyland.	"	123	123	"
<i>D. hirtipes</i> (BL.) Kuntze	"	82	—	Tetrapl.
<i>Cyclosorus unitus</i> (L.) Ching (<i>Sphaerostephanos unitus</i> (L.) Holtt.)	"	36	—	Dipl.
<i>Diplazium japonicum</i> (Thunb.) Bedd.	"	123	246	Hexapl.
(<i>Lunathyrium japonicum</i> (Thunb.) Kurata)				
<i>Polystichum auriculatum</i> (L.) Presl	"	41	—	Dipl.
BHAVANANDAN (1981)				
<i>Dryopteris atrata</i>	"	82	—	Tetrapl.
<i>Diplazium beddomei</i>	"	41	—	Dipl.
	"	41	—	"

Observations on select species

Botrychium daucifolium Wall. ex Hook. and Grev. Spore mother cells showed the presence of 90 bivalents (Fig. 1.). This is a tetraploid based on $n=45$. present in *B. lunaria* (Manton 1950) and is being reported for the first time from S. India. Manton and Sledge (1954) have reported the same number from Ceylon.

All photographs. $\times 725$. Figs. 1-9. 1, *Botrychium daucifolium* Wall. ex Hook. & Grev., $n=90$. 2, *Ophioglossum nudicaule* L., $n=240$. 3, *O. vulgatum* L., c. $n=243$. 4, *Pteris vittata* L., $n=58$. 5, *Adiantum zollingeri* Mett. ex Kuhn, $n=29$. 6, *A. raddianum* Presl, $n=114$. 7, *Microlepia majuscula* (Lowe) Moore, $n=86$. 8, *Christella papilio* (Hope) Holtt., $n=36$. 9, *C. dentata* (Forsk.) Holtt., $n=72$.

Ophioglossum vulgatum L. $n=243$ (Fig. 3). Several aneuploid numbers ranging from $n=150$ to $n=520$ have been reported previously for this species from the Himalayas by Verma (1956). The highest aneuploid number, $n=c. 570$ has been reported by Ninan (1958b) from materials collected from Munnar, Kerala.

Pteris vittata L. $n=58$, a tetraploid (Fig. 4). Mehra and Verma (1960), Verma

and Khuller (1956c) have found the same number on Himalayan materials whereas $n=87$ has been observed by Abraham *et al.* (1962) from materials collected from Madras gardens.

Adiantum zollingeri Mett. ex Khun. It is a diploid, showing 29 bivalents in spore mother cells (Fig. 5). This is the first report for this species. (*A. pedatum* L.

All photographs except no. 13 ($\times 450$) $\times 725$. Figs. 10–18. 10, *Thelypteris confluens* (Thunb.) Morton, $n=35$. 11, *Sphaerostephanos arbuscula* (Willd.) Holtt., $n=36$. 12, *Diplazium polypodioides* Bl. $n=41$. 13, *D. travancoricum* Bedd. $n=205$. 14, *D. esculentum* (Retz.) Sw $n=41$. 15, *Diplazium* sp. (a) $n=123$. 16, *Diplazium* sp. (b) $n=82$. 17, *Hypodematum crenatum* (Forsk.) Kuhn, $n=82$. 18, *Polystichum setiferum* (Forsk.) Moore ex Woyner, $n=82$.

from the Himalayas is the only other Indian species of this genus with $n=29$ as reported by Verma.

A. raddianum Presl. It is an octoploid, showing 114 bivalents in spore mother cells (Fig. 6). Abraham *et al.* (1962) have reported $n=57$ and $2n=114$ in a morphological variant of this species under the name *A. cuneatum* Langsd & Fish.

while Roy and Sinha (1961, 1962) have reported tetraploid *A. cuneatum* with $n=60$ and $2n=120$ from N. India.

Microlepia majuscula (Lowe) Moore. A tetraploid, showing $n=86$ (Fig. 7). This is the first report for this species. Abraham *et al.* (1962) have reported $n=88$ (aneuploid) in *M. speluncae* and Kuriachan (1968) $n=86$ in *M. platyphylla*.

Christella dentata (Forsk.) Holtt. The Palni material of this species has been determined by Prof. R. E. Holttum, but according to him, typical *dentata* (type from Arabia) does not occur in S. India. *C. dentata* from the Palnis, presently examined, has therefore to be understood in a wide sense.

Meiotic preparation showed this species to be a tetraploid with $n=72$ (Fig. 9). This is in conformity with the Madeira materials as shown by Manton (1950). Ghatak (1962) has also reported $n=72$ in S. Indian materials of this species. However, N. Indian plants of *C. dentata* are found to be diploids with $n=36$ (Loyal 1961, Ghatak 1961).

Thelypteris confluens (Thunb.) Morton. This is a diploid with $n=35$. This is the first report for this species (Fig. 10).

Diplazium travancoricum Bedd. It is a pentaploid with $n=205$ (Fig. 13) and is the first report for this species. Mature sporangia are frequently seen devoid of spores. Sporangia with 64 spores (indicative of sexual reproduction) have never been observed though some are observed to contain a few spores. Abraham *et al.* (1962) have reported $2n=205$ for *D. sylvaticum* from S. India. Manton and Sledge (1954) found the Ceylon materials of this species to be pentaploid apomict with $n=c. 200$. Though a mitotic count of *D. travancoricum* could not be obtained, yet it is suspected to be an apomict like *D. sylvaticum*.

Diplazium sp. (a). It is a triploid with $n=123$ (Fig. 15). This species is also probably apogamous since empty sporangia as well as those with varying numbers of spores have been frequently observed. Bir (1965) has reported $n=2n=123$ in *D. maximum* C. Chr. from Eastern Himalayas.

Diplazium sp. (b). It is a tetraploid with $n=82$ (Fig. 16). This is in conformity with the earlier report by Abraham *et al.* (1962) under the name *D. latifolium* D. Don.

Hypodematium crenatum (Forsk.) Kuhn. It is a tetraploid showing 82 bivalents in spore mother cells (Fig. 17). This is the first report from S. India. The sporangia from plants raised in the green house never attain the natural size. Besides, most of the sporangia produced under cultivation are devoid of spores. The spores from wild plants are mostly empty. Plants of the Western Himalayas are reported to be diploids with $n=41$ (Mehra and Loyal 1965).

Polystichum setiferum (Forsk.) Moore ex Woyner. It is a tetraploid with $n=82$ (Fig. 18) which is being reported from S. India for the first time. *P. aculeatum* var. *setose* with $n=41$ has been reported from the Himalays by Verma).

Comments

Species with more than one cytotype

Manton (1958), and Abraham *et al.* (1962) have demonstrated the existence of different cytotypes in the same species in their studies on the ferns of Ceylon, the

Himalayas and S. India respectively. Kuriachan (1968) and Bhavanandan (1968) have added more data from their studies on S. Indian ferns. Manton (loc. cit.) basing herself on the 12 recorded cases of species with more than one cytotype among Ceylon ferns, believes that the frequency of such species in the Island would be of the order of 50 per cent and Abraham *et al.* (1962) arrived at similar conclusion regarding the S. Indian ferns. Though within the present study of Palni ferns, no species with different cytotypes has been encountered, yet some of the species of this area have cytotypes which are different from those of the same species occurring elsewhere. Such species are enumerated in Table 3.

Table 3. Palni species existing in different cytotypes elsewhere

Species	n Number	Ploidy	Source	References
<i>Adiantum raddianum</i> Presl	57	Tetrapl.	Kerala	Abraham <i>et al</i> (1962)
(<i>A. cuneatum</i> Langsd. & Fisch)	60	"	N. India	Roy & Sinha (1961)
	114	Octopl.	Palnis	<i>Present Study</i>
<i>Cyclosorus interruptus</i>	36	Dipl.	Kerala	Bhavanandan (1968)
(Willd.) Ching				
(<i>Amphineuron terminans</i>	72	Tetrapl.	"	"
(Hook.) Holtt.)	72	"	Palnis	<i>Present study</i>
<i>Macrothelypteris ornata</i>	31	Dipl.	N. India	Loyal (1961)
(Wall. ex Bedd.) Ching	62	Tetrapl.	Palnis	<i>Present study</i>
<i>Christella dentata</i>	36	Dipl.	N. India	Loyal (1961)
(Forsk.) Holtt.	72	Tetrapl.	Palnis	<i>Present study</i>
<i>Hypodematium crenatum</i>	41	Dipl.	N. India	Mehra & Loyal (1961)
(Forsk.) Kuhn	82	Tetrapl.	Palnis	<i>Present study</i>
<i>Polystichum setiferum</i> (Forsk.)	41	Dipl.	Europe	Manton (1950)
Moore ex Woyner	82	Tetrapl.	Palnis	<i>Present study</i>
<i>Diplazium esculentum</i>	c. 80	"	Ceylon	Manton & Sledge (1954)
(Retz.) Sw.	41	Dipl.	Palnis	<i>Present study</i>
<i>Asplenium unilaterale</i> Lam.	76	Tetrapl.	Kerala	Kuriachan (1968)
<i>A. unilaterale</i> Lam. var.	40	Dipl.	Palnis	"
<i>rivale</i> Bedd.				
<i>Lunathyrium japonicum</i>	123	Hexapl.	"	Bhavanandan (1968)
(Thunb.) Kurata	82	Tetrapl.	Malaya	Manton & Sledge (1954)

Polyploidy among Palni ferns

Manton and Sledge (1954) have found sixty per cent of Ceylon ferns to be polyploids and Abraham *et al.* (1962) have shown that 57 out of 108 S. Indian ferns they studied are polyploids. Compared to these data the incidence of polyploidy among the Himalayan ferns is low, being only about 30 per cent.

It can be seen from Table 1 and 2 that out of 53 species 30 are polyploids (60 per cent) and hence the frequency of polyploids in the Palnis agrees with that already reported by Abraham *et al.* (1962) for S. India and Manton and Sledge (1954) for Ceylon.

Of the 30 polyploids 21 are tetraploids, four triploids, one pentaploid, one hexaploid and three octoploids. Polyploidy in *Diplazium* appears to be rather frequent, but in S. India it has not reached beyond the pentaploid level, whereas in Jamaica,

as shown by Walker (1966), the majority of the species of this genus cytologically investigated (12 out of 20) are octoploids.

Apogamy

Abraham *et al.* (1962) have estimated that about 10 per cent of the S. Indian ferns are apogamous. The same has also been found to be the situation in Ceylon ferns (Manton and Sledge 1954). In both cases apogamy has been found mostly in Pteroid, Diplazoid and Athyroid ferns and particularly at the triploid level. Bhavanandan (1968) in his study of the Palni ferns, has found *Dryoathyrium boryanum* and *Dryopteris wellichiana* to be triploid apogamous, the former with $n=2n=120$ and the latter with $n=2n=123$. In the present study apogamy has been suspected in *Diplazium travancoricum* ($n=205$) and *Diplazium* sp. (a) ($n=123$) as in these two cases sporangia with 64 spores have not been observed.

Summary

1. Chromosome numbers for thirty species of ferns indigenous to the Palnis have been reported in the present study. All these numbers except those of *Botrychium lanuginosum* and *Sphaerostephanos unitus* are first reports from the Palnis.

2. The following species are studied cytologically for the first time from S. India: *Botrychium daucifolium*, *Macrothelypteris ornata*, *Christella papilio*, *Polystichum setiferum*, *Hypodematum crenatum*.

3. Chromosome numbers for the following species have been reported for the first time: *Adiantum zollingeri*, *Microlepis majuscula*, *Thelypteris confluens*, *Diplazium* sp. (a), *D. travancoricum*.

4. The present study taken together with the previous reports reveals the existence of new cytotypes in the following species: *Adiantum raddianum*, *Macrothelypteris ornata*, *Christella dentata*, *Cyclosorus interruptus*, *Diplazium esculentum*, *Polystichum setiferum*, *Hypodematum crenatum*.

5. Out of fifty three species of ferns known cytologically from the Palnis thirty are polyploids (60 per cent).

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