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Cytology of Ferns and Other Pteridophytes of Western India*

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The paper gives an account of the cytological observations on the chromosomes in 51 species of ferns and other pteridophytes of Western India. Polyploidy was noticed in the genera *Lygodium, Pteris, Cheilanthes, Adiantum, Dryopteris, Cyclosorus, Blechnum, Asplenium* and *Microsorium.* The haploid chromosome numbers for *Diplazium maximum* n=(*ca.* 114), *Blechnum volubilis* (62), *Lastereopsis parishii* (41), *Tectaria barberi* (40), *Ampelopteris prolifera* (41), and *Asplenium laciniatum* (*ca.* 108) have been reported for the first time.
Chromosome numbers in the other five species differ from those reported in earlier records. *Ophioglossum reticulatum* seems to be a cytotaxonomic species complex and needs further investigation.

Key Words: Cytology, Ferns, Chromosome numbers

Introduction

Several contributions to the cytology of pteridophytes have been made by many authors. Manton and her associates (1950, 1954) worked on the ferns of Britain, Ceylon and Malaya. Fairly large amount of work has been done in our country particularly on ferns of Northern India by Mehra and his associates (1944, 1957, 1959, 1960 and 1961) and on ferns of Southern India by Abraham et al. (1962) etc. Compared to this the ferns in Western India have received little attention. However, cytology of some of them was worked out by Mahabale and his associates (1972). Hence this investigation was undertaken to get consolidated information on their chromosome numbers and to verify the earlier findings adding new ones wherever possible.

Material and Methods

Material of wild ferns was collected from Mahabaleshwar, Lonavla and Khandala which are the main centres of ferns and other pteridophytes. Material was fixed in acetic-alcohol (1:3) and Carnoy's fluid (3:1:1).

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Slides were made permanent using a modified MaClintock's method (1929).

Herbarium sheets of voucher specimens have been deposited in the Agharkar Herbarium of the Maharashtra Association for the Cultivation of Science—Research Institute, Pune (India). In listing genera of ferns Copelands (1947) classification was followed.

Observations

FAMILY PSILOTACEAE

1. *Psilotum nudum* Linn. (figure 53)

The preparations showed 2n = 212 mitotic chromosomes. This number agrees with the earlier report of mitotic chromosomes of *P. nudum* by Manton (1950), Ninan (1956) etc.

FAMILY EQUISITACEAE

2. *Equisetum debile* Roxb. (figure 51)

Cytological preparations showed that it has n = 108 chromosomes in the spore mother cells at the first meiotic metaphase. The same number of chromosomes have been reported for this species by Ninan (1955) and Mehra and Bir (1959).

3. *Equisetum diffusum* D. Don (figure 52)

It also has n = 108 chromosomes in the spore mother cells at the first meiotic metaphase.

FAMILY SCHIZAEACEAE

The family Schizaeaceae (Copeland 1947) consist of four living genera, *Schizaea* (with 30 species), *Lygodium* (40 species), *Anemia* (about 90 species) and Mohria (3 species). Of these *Lygodium* grows wild in the Western Ghats.

4. *Lygodium flexuosum* (L.) Sw. (figure 1)

This is a scrambler fern. It showed 60 bivalents based on x = 30 in the spore mother cells at the first meiotic metaphase. Manton and Sledge (1954) noticed n = 30 chromosomes in *L. scandens*, and n = 58 in *L. japonicum* from Ceylon. Abraham et al. (1962) have reported n = 60 chromosomes in *L. flexuosum* from South India. This genus thus shows two base numbers x = 29 and x = 30.

5. *Anemia rotundifolia* Schard. (figure 2)

This genus consists of about 90 species, nearly all in the Tropical America and a few in Africa and Madagaskar. Cytological studies on this species showed n = 38 chromosomes in the spore mother cell.

FAMILY PTERIDACEAE

The Pteridaceae of Copeland (1947) is a large complex family consisting of typically terrestrial ferns comprising 63 genera and 1150 species. Of these 10 genera and 17 species are indigenous in the area under study and some are cultivated species. They were investigated.

6. *Microlepia* Presl. (figure 4)

This is chiefly a tropical genus consisting of 45 species. *Microlepia spelunce* (L.) Moore showed n = 43 chromosomes in spore mother cells at a first meiotic metaphase. Previous records of chromosome number in this genus are n = 43 in *M. polyphylla* and n = 86 in *M. spelunce* (Manton & Sledge 1954). Manton (1954) has also recorded n = 84–87 in Malayan species and n = 129 in Tropical African material of *M. spelunce*. Abraham et al. (1962) have reported n = 88 chromosomes for this species from South India. It is a tetraploid form.

7. *Schizoloma ensifolium* (Sw.)J.sm. (figure 5)

Cytological preparations of this species showed that there are n = *ca.* 87 bivalents in the spore mother cells at first meiotic metaphase. Manton and Sledge (1954) have recorded n = 88 chromosomes in Ceylon material of the same species. Abraham et al. (1962) have reported n = *ca.* 87 in *S. ensifolium.* Our number agrees with that of Abraham (1962).

8. *Pteridium aquilinum* (L.) Kuhn. (figure 3)

This is supposed to be a single variable species. It is distributed throughout the temperate and tropical regions. Wild plants of this species clearly showed n = 52 chromosomes in the spore mother cells at first meiotic metaphase. The haploid number n=52 has also been reported in this species by Britton (1953), Manton and Sledge (1954) and Abraham et al. (1962).

Genus **Pteris** L.: This is a fairly large genus of about 250 species distributed in tropical and subtropical regions (Holttum 1954). Abraham et al. (1962) have pointed out that there is remarkable constancy in the basic chromosome number among the various species of *Pteris* studied. It is suspected that there might be a few species complexes with more than one distinct cytological type within each.

9. *Pteris biaurita* L. (figure 6)

Cytological examination of the plants of this species showed n = 29 chromosomes in spore mother cells at first meiotic metaphase. Abraham et al. (1962) have reported n = 58 and 2n = 58. This species is, therefore, reported as apogamous diploid, its base number being n = 29. Manton and Sledge (1954) have found that Ceylon material of this species is also apogamous diploid. Triploid apogamous form of this species has been recently reported from North India by Ghatak (1961).

10. *Pteris quadriaurita* Retz. (figure 7)

It also showed n=29 chromosomes in the spore mother cells at first meiotic metaphase. Manton and Sledge (1954) have reported the same number in Ceylon material while Abraham et al. (1962) reported a tetraploid form of this species from South India with n=58.

11. *Pteris ensiformis* Burm. (figures 9 & 61)

Cytological investigations showed n = 58 chromosomes. Manton and Sledge (1954) and Abraham et al. (1962) have also reported n=58 chromosomes for Ceylon and South Indian material of it.

12. *Pteris vittata* L.(=*P. longifolia*)(figure 11)

Cytological examination showed n=58 bivalents in spore mother cell. Manton and Sledge (1954) have reported the same number for this species from Ceylon. It is a tetraploid form. Abraham et al. (1962) have reported n=87 bivalents in spore mother cells which is hexaploid. They state that the presence of n=58 and n=87 chromosomes in *P. vittata* would suggest that this might also be a species complex like *P. ensiformis* and *P. quadriaurita.* This seems to be true. Table 1 clearly shows that the base number in *Pteris* is n=29. It is retained in all the species of *Pteris* so far investigated. Abraham et al. (1962) found more than one cytological type within each species of *P. quadriaurita, P. ensiformis* and *P. vittata.* They suggest that there may be a species complex which needs further study. Mehra (1961) has reported apogamy in *P. quadriaurita* (diploids and triploids) *P. cretica, P. aspericaulis* and *P. blumeana* are all diploids and *P. pellucens, P. biaurita, P. dactylina* and *P. nemoralis* are triploids.

Table 1 *Present and previous reports of chromosomes of ferns of Western India*

Family' Genus & Species	Present report of chromosome		Previous reports of chromosome
	n	2n	
I Schizaceae			
1. *Lygodium flexuosum*	60		n=60 (Abraham et al. 1962)
2. *Anemia rotundifolia*	38	—	n=38 (Abraham et al. 1962)
II Pteridaceae			
3. *Microlepia speluncе*	43	—	n=86 (Manton & Sledge 1954) n=88 (Abraham et al. 1962)
4. *Schizoloma ensifolium*	*ca.*87	—	n=87 (Abraham et al. 1962) n=88 (Manton & Sledge 1954) Sledge 1954)
5. *Pteridium aquilinum*	52	—	n=52 (Britton 1953, Manton &
6. *Pteris biaurita*	29	—	n=2n=58 (Abraham et al. 1962) n=87 (Ghatak 1961)
7 *Pteris quadriaurita*	29	—	n=29 (Manton & Sledge 1954) n=58 (Abraham et al. 1962)
8. *P. ensiformis*	58	—	n=58 (Manton & Sledge 1954)
9. *P. vittata* Linn.	58	—	n=58 (Manton & Sledge 1954) n=87 (Abraham et al. 1962)
10. *Actiniopteris radiata*	58	—	n=87 (Abraham et al. 1962) n=2n=87 (Mehra & Verma 1960)
11. *Cheilanthes farinosa*	58	—	n=30, 58 (Manton & Sledge 1954) n=58 (Abraham et al. 1962)
12. *C. albomarginata*	58	—	—
13. *Pityrogramma calomelance*	116	—	n=116 (Abraham et al. 1962)
14. *Adiantum philippense*	30	—	n=2n=90 (Manton & Sledge 1954, Britton 1953) 2n=90 (Roy & Sinha 1961)
15. *A. caudatum*	90	—	n=30 and n=2n=90 (Abraham et al. 1962) 2n=60 (Roy & Sinha 1957)
16. *A. trapeziforme*	30	30	2n=60 (Roy & Sinha 1961)
17. *A. capillus-veneris*	30	—	n=30 (Manton 1950, Britton 1953)

Family Genus & Species	Present report of chromosome n	2n	Previous reports chromosome
18. *A. peruvianum*	30	—	2n=60 (Roy & Sinha 1961)
III Davaliaceae			
19. *Nephrolepis cordifolia*	41	—	n=41 (Abraham et al. 1962)
20. *N. exaltata*	41	—	n=41 (Abraham et al. 1962)
21. *Leucostegia immersa*	41	—	n=41 (Mehra & Khanna 1959)
IV Aspidiaceae			
22. *Dryopteris sparsa*	82	—	n=82 (Mehra & Loyal 1965)
23. *D. serato-dentata*	41	—	n=41 (Mehra & Loyal 1965)
24. *D. felix-mass*	41	—	n=41 (Manton 1950)
25. *Lastreopsis parishii*	41	—	—
26. *Tictaria macrodonta*	40	—	n=40 (Abraham et al. 1962, Manton & Sledge 1954)
27. *Tectaria barberi*	40	—	–
28. *Cyclosorus parasiticus*	72	—	n=72 (Abraham et al. 1962, Panigrahi & Manton 1958)
29. *Athyrium hohenackerianum*	40	—	–
30. *A. filix-foemina*	40	—	n=40 (Manton 1950)
31. *Diplazium esculentum*	41	—	n=41 (Abraham et al. 1962)
32. *D. maximum*	*ca.*114	—	–
33. *Amplelopteris prolifera*	41	—	–
V Blechnaceae			
34. *Blechnum orientale*	33	—	n=33 (Abraham et al. 1962) n=34 (Ghatak 1961)
35. *B. volubilis*	62	—	–
VI Aspleniaceae			
36. *Asplenium laciniatum*	*ca.*108	—	–

Family Genus & Species	Present report of chromosome		Previous reports of chromosome
	n	2n	
VII Polypodiaceae			
37. *Microsorium punctatum*	36	—	n=36 (Abraham et al. 1962)
38. *M. membranaceum*	72	—	n=36 (Manton & Sledge 1954)
39. *Lepisorus thunbergianus*	36	—	n=36 (Manton & Sledge 1954)
40. *Phymatodes scolopendria*	--	36	n=36 (Abraham et al. 1962)
41. *Drynaria quercifolia*	37	—	n=37 (Abraham et al. 1962, Manton 1954)
VIII Ophioglossaceae			
42. *Ophioglossum costatum*	120	—	n=120 (Mahabale & Nair 1972) n=120 (Ninan 1956a)
43. *O. nudicaule*	120	—	n=120 (Mahabale & Nair 1972) n=120 (Ninan 1958)
44. *O. gramineum*	120	—	n=120 (Mahabale & Nair 1972) n=120 (Ninan 1958)
45. *Ophioglossum petiolatum*	120	—	n=120 (Mahabale & Nair 1972)
46. *O. polyaphyllum*	210	—	n=120 (Ninan 1958)
	215	—	n=116–117 (Verma 1956) n=210–215 (Mahabale & Nair 1972)
47. *O. reticulatum*	120	—	n=120 (Mahabale & Nair 1972) n=120 (Ninan 1958)
48. *O. reticulatum*	*ca.*510 515	—	n=ca. 630 (Abraham et al. 1962) n=ca. 1100 (Kurita & Nishida 1965)
IX Osmundaceae			
49. *Osmunda regalis*	22	—	n=22 (Manton 1950)
X Equisitaceae			
50. *Equisetum debile*	108	—	n=108 (Ninan 1955, Mehra & Bir 1959)
51. *E. diffusum*	108	—	n=108 (Mehra & Bir 1959)
XI Psilotaceae			
52. *Psilotum nudum*	—	210–212	2n=210–212 (Ninan 1956b)

13. *Actiniopteris radiata* (Swartz) Link. (*A. dichotoma* Forsk.) (figures 7 & 59)

According to Clarke (1880) and Copeland (1947), this species is of dry regions. It showed n = 58 chromosomes in the spore mother cells at the first meiotic metaphase. Mehra and Verma (1960) found that in the material from the foothills of W. Himalayas n = 2n = 87 and 58 chromosomes which are triploid and diploid apogamous forms.

Genus **Cheilanthes** Swartz.: This genus consists of 180 species distributed in all warm temperate countries (Copeland 1947).

14. *Cheilanthes farinosa* (Forsk.) Kaulf. (figure 10)

Cytological examination of material showed n = 58 bivalents in spore mother cells at first meiotic metaphase. Abraham et al. (1962) have reported n = 58 chromosomes in the same species from South India. Manton and Sledge (1954) have reported n = 30 (diploid) and n=58 (tetraploid) chromosomes in Ceylon material. They have also reported (1954) triploid apogamous forms of this species with n = *ca.* 87 chromosomes.

15. *Cheilanthes albomarginata* Clarke (figure 12)

It showed n=58 chromosomes in spore mother cells. It will be seen from table 1, that the present number is a new report of chromosome number for this species.

Genus **Pityrogramma** Link.: This genus consists of about 40 species mostly distributed in America. Two species of this genus are commonly cultivated in the Botanical Gardens in Poona.

16. *Pityrogramma calomelanos* (L.) Link. (*Gymnogramme calomelanos*) (figure 13)

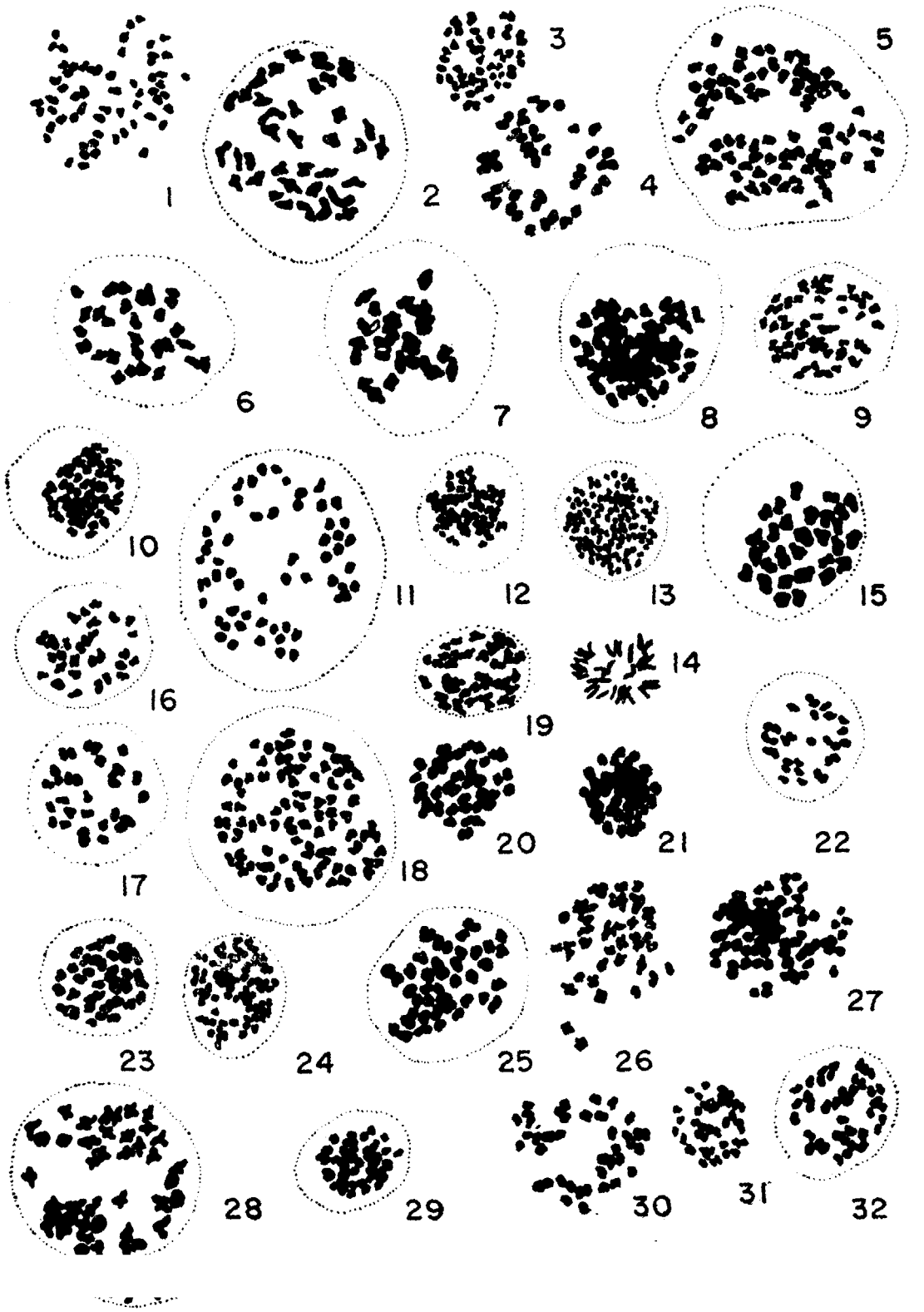
This silver fern showed n = *ca.* 116 chromosomes in spore mother cells. Abraham et al. (1962) found n = 116 chromosomes in *P. calomelanos* and *P. chrysophylla* which, is however, a multiple of 29. This would show that there are two base numbers, viz., n = 29 and n = 30 in the genus. It resembles in this respect *Lygodium* and *Cheilanthus.*

Genus **Adiantum** Linn.: This genus consists of nearly 200 species distributed in all the warmer parts of the earth. Some species are indigenous to this region.

17. *Adiantum philipense* Linn. (figure 15)

Cytological examination showed that this species is a diploid with n = 30 chromosomes. Manton and Sledge (1954), Britton (1953) reported triploid apogamous forms of this species, from Ceylon and South Africa with n = 2n = 90 chromosomes. Roy and Sinha (1961) also reported triploid form of this species with 2n=90 chromosomes and irregular meiosis.

Figures 1–32 Camera lucida drawings of the chromosomes. *1, Lygodium flexuosum,* n=60(×590); *2, Anemia rotundifolia,* n=38(×810); *3, Pteridium aquilinum,* n=52(×590); *4, Microlepia speluncae,* n=43(×540); *5, Schizoloma ensifolium,* n=*ca.* 87(×630); *6, Pteris biaurita,* n=29(×630); *7, P. quadriaurita,* n=29(×630); *8, Actiniopteris radiata,* n=58(×590); *9, Pteris ensiformis,* n=58(×590); *10, Cheilanthes farinosa,* n=58(×593); *11, Pteris vittata,* n=58(×630); *12, Cheilanthes albomarginata,* n=58(×590); *13, Pityrogramma calomelanos,* n=116(×590); *14, Adiantum traperiforme,* 2n=30(×540); *15, A. philipense,* n=30(×630); *16, A. capillus-veneris,* n=30(×590); *17, A. traperiforme,* n=30(×590); *18, A. caudatum,* n=90(×630); *19, Leucostegia immersa,* n=41(×540); *20, Nephrolepis cordifolia,* n=41(×540); *21, N. exaltata,* n=41(×540); *22, Adiantum peruvianum,* n=30(×590); *23, Dryopteris serato-dentata,* n=41(×630); *24, D. sparsa,* n=82(×630); *25, Lastreopsis parishii,* n=41(×540); *26, Tectaria macrodonta,* n=40(×540); *27, Cyclosorus parasiticus,* n=72(×590); *28, Diplazium esculentum,* n=41(×540); *29, Dryopteris filixmas,* n=41(×540); *30, Athyrium filix-foemina,* n=40(×540); *31, A. hohenackerianum,* n=40(×540); *32, Tectaria barberi,* n=40(×540)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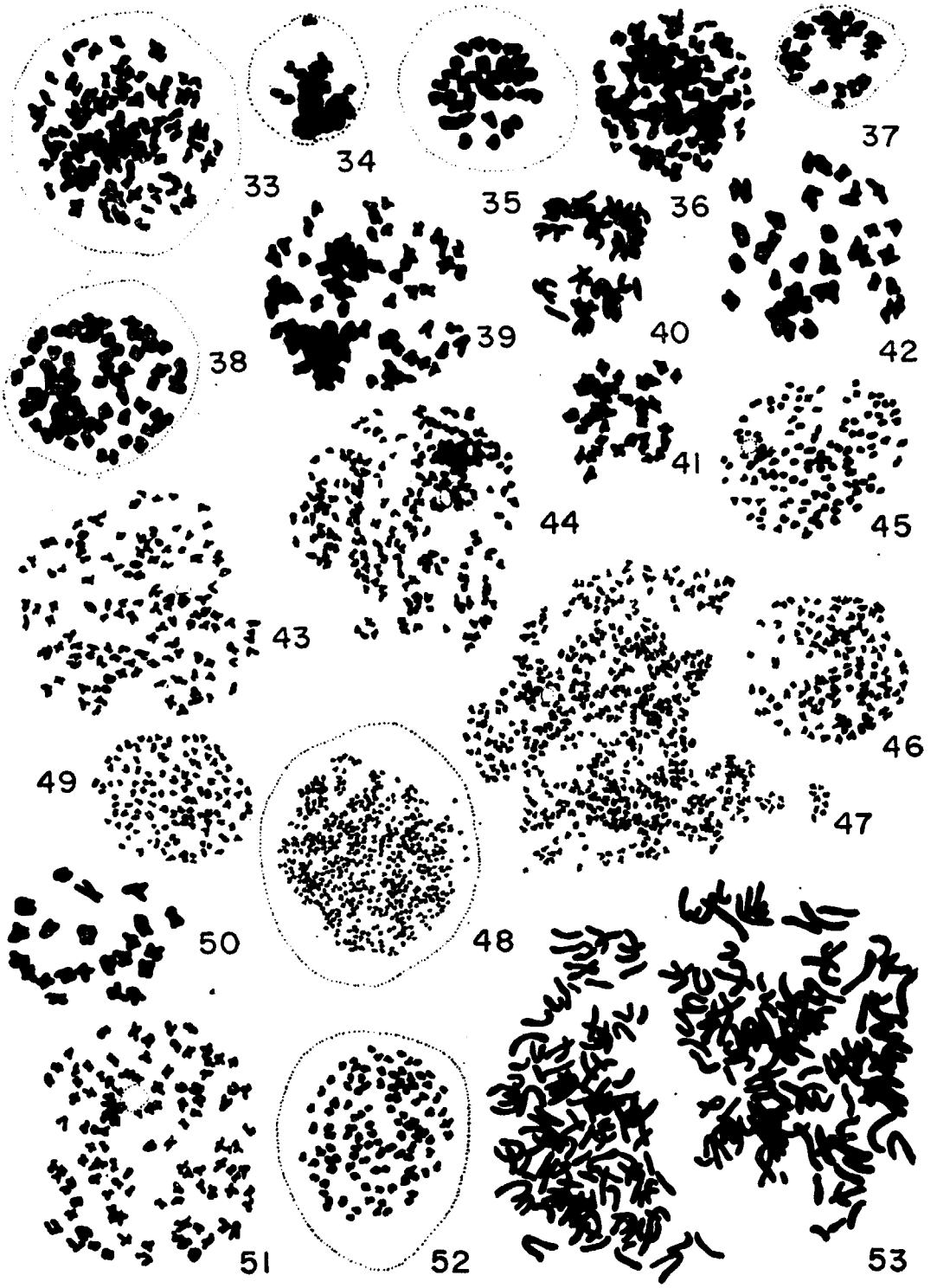
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18. *Adiantum caudatum* Linn. (figure 18)

It showed n = 90 chromosomes in the spore mother cells. Abraham et al. (1962) reported that this species from South India is a diploid (n = 30), and also a triploid apomict with n = 2n = 90 chromosomes. Roy and Sinha (1957) have reported diploid form of this species from Pachmarhi with 2n = 60 chromosomes.

19. *A. trapeziforme* Linn. (figures 14 & 17)

Material of this species showed n = 2n = 30 chromosomes. Roy and Sinha (1961) reported diploid plants with 2n = 60 chromosomes.

20. *A. capillus-veneris* Linn. (figure 16)

Cytological preparations showed n=30 chromosomes in spore mother cells. It is a diploid. Britton (1953) and Manton (1950) have reported n = 30, and 2n=60 chromosomes in this species.

21. *A. peruvianum* Linn. (figure 22)

Its material showed n = 30 chromosomes in spore mother cells at first meiotic metaphase. This is a diploid. Roy and Sinha (1961) reported 2n = 60 chromosomes from the root as expected.

Majority of the species of *Adiantum* have basic chromosome number n = 30 but exceptionally *Adiantum pedatum* has n = 29, as the base number (Briton 1953).

FAMILY DAVALLIACEAE

This is a small family consisting of twelve genera (Copeland 1947).

Genus **Nephrolepis** Schott.: This is a genus of about 30 species, a few being distributed in tropical regions.

22. *Nephrolepis cordifolia* (L.) Pr. (figure 20)

Chromosome number of this species was found to be n=41. It was very difficult to get clear preparations in this species as the chromosomes have a tendency to clump together. Abraham et al. (1962) have reported the same chromosome number for the material from Trivandrum (Kerala State).

23. *N. exaltata* (L.) Schott. (figure 21)

The chromosomes in the spore mother cells were found to be n = 41. Manton and Sledge (1954) have found *N. cordifolia* and *N. hirsuta* to be diploid with n=41 chromosomes.

24. *Leucostegia immersa* (Wall.) Presl. (figure 19)

It grows on hill slopes. It showed that it has n=41 bivalents in spore mother cells at the first meiotic metaphase. This agrees with the chromosome number earlier reported by Mehra and Khanna (1959) in the Mussoorie material.

FAMILY ASPIDIACEAE

This is the largest of Copeland's families consisting of 66 genera and near about 2950 species. Cytology of several genera of this

Figures 33–53 Camera lucida drawing of the chromosomes. *33, Diplazium maximum*, n=*ca.* 114(×980); *34, Ampelopteris prolifera*, n=41(×540); *35, Blechnum orientale*, n=33(×540); *36, Aspelnium laciniatum*, n=*ca.* 108(×540); *37, Lepisorus thunbergianus*, n=36(×540); *38, Blochnum volubilis*, n=62(×540); *39, Microsorium membranaceum*, n=72(×540); *40, Phymatodes scolopendira*, n=26(×540); *41, Microsorium punctatum*, n=36(×540); *42, Drynaria quercifolia*, n=37(×540); *43, Ophioglossum costatum*, n=120(×540); *44, O. polyphyllum*, n=210–215(×590); *45, Ophioglossum petiolatum*, n=120(×590); *46, O. nudicaule*, n=120(×630); *47, O. reticulatum*, n=*ca.* 510–515(×690); *48, O. reticulatum*, n=*ca.* 495(×540); *49, O. gramineum*, n=120(×540); *50, Osmunda regalis*, n=22(×540); *51, Equisetum debile*, n=108(×540); *52, E. diffusum*, n=108(×540); *53, Psilotum nudum*, 2n=210–212(×540)

family has been well worked out. In the present study the cytology of 7 genera and 12 species was worked out.

Genus **Dryopteris** Adanson: Copeland (1947) has reported 150 species naturally occurring all over the world.

25. *Dryopteris sparsa* (Don) O. Ktze. (figure 24)

It showed n=ca. 82 chromosomes in spore mother cells. This number agrees with the earlier report by Mehra and Loyal (1965).

26. *D. serato-dentata* (Bedd.) Hayata. (figure 23)

Cytological investigation showed n=41 bivalents in the spore mother cells. Mehra and Loyal (1965) also reported the same chromosome number for the material from Darjeeling.

In this genus apogamy has been reported in the British material of *D. remota, D. atrata, D. borreri* and in the Ceylon material of *D. paleacea* (Manton 1950, Manton & Sledge 1954). Mehra (1961), Mehra and Loyal (1965) found it in *D. odontoloms, D. seratodentata, D. fruticosa, D. atrata* and *D. sparsa.* It seems that apogamy is of frequent occurrence in this genus.

27. *D. filix-mass* (L.) Schott. (=*Lastrea filix-mass*) (figure 29)

It grows in moist shady places and it is quite common at Mahabaleshwar. It has n=41 chromosomes in the spore mother cells at the first meiotic metaphase. This agrees with the earlier report by Manton (1950). Panigrahi (1965) found n = 82 chromosomes in *D. villarsi.*

28. *Lastreopsis parishii* (Hook.) Ching. (figures 25 & 54)

Plants of this genus are found in lime-stones (Holttum 1954). It has a peculiar habit of shedding its fronds and resting in dry season. Cytological preparations showed that it has n=41 bivalents in the spore mother cells which is the first report of chromosome number in this species.

Genus **Tectaria** Cav.: The genus consists of about 200 species distributed in the tropical and subtropical regions of the world.

29. *Tectaria macrodonta* (Fee) C. Chr. (=*Aspidium cicutarium*) (figures 26 & 27).

Material of this species was collected from Khandala and Mahabaleshwar where it was growing on slopes in shady places and in the crevices of rocks. It showed n=40 chromosomes in the spore mother cells. Manton and Sledge (1954) and Abraham et al. (1962) have also reported the same number of chromosomes in the material of this species from Ceylon and South India respectively.

30. *T. barberi* (Hk.) Copel. (=*Polypodium barberi*) (figures 32 & 58)

It had n=40 chromosomes in the spore mother cells at the first meiotic metaphase. This is basic chromosome number for this genus.

Genus **Cyclosorus** Link.: The reare about 300 species in this genus distributed in both the tropical and subtropical regions.

31. *Cyclosorus parasiticus* (L.) Farwell (=*Nephrodium molle*) (figure 27)

Cytological examination showed n=72 bivalents in the spore mother cells. It is a tetraploid. Abraham et al. (1962) reported the same chromosome number in this species from South India. Panigrahi and Manton (1958) have reported n=72 chromosomes in this species. This genus seems to be very uniform cytologically having the same characteristic basic chromosome number n=36.

Genus **Athyrium** Roth.: This is a large genus consisting of about 600 species (Copeland 1947) having a very wide range of distribution all over the world.

32. *Athyrium hohenackerianum* Bedd. (fig. 31)

It showed n=40 bivalents in the spore mother cells at the first meiotic metaphase.

33. *A. filix-foemina* Roth. (figure 30)

It showed n=40 bivalents at the first meiotic metaphase. Manton (1950) has reported the same chromosome number in this species growing in Britain. There are two basic chromosome numbers in the genus *Athyrium*. n=40 and n=41. In the present study it gave exceptionally clear preparations of 40 chromosomes showing unequivocally that the basic number is 40 and not 41. Manton and Sledge (1954) also stressed this point as they also obtained exceptionally clear preparations showing 80 chromosomes, the base number being 40.

Genus **Diplazium** Swartz: This genus has been merged by Copeland (1947) with *Athyrium*, but the present study showed that it cannot be grouped with *Athyrium* on the ground that all the plants examined from Mahabaleshwar and Khandala differ from *Athyrium* regularly in having basic chromosome number n = 41.

34. *Diplazium esculentum* (Retz.) Sw. (figure 28)

It showed that in spore mother cells there are n=41 bivalents at the first meiotic metaphase. This number agrees with the number earlier reported by Abraham et al. (1962).

35. *Diplazium maximum* Don. (figures 33&65)

Cytological preparations of it showed n=ca. 114 chromosomes in the spore mother cells at the first meiotic metaphase. This is the first report of the chromosome for this species.

36. *Ampelopteris prolifera* (Retz.) Copel. (=*Gonipteris prolifera*) (figures 34 & 64)

This is distributed throughout the Indian region in the plains and hills. It showed n=41 chromosomes in the spore mother cells at the first meiotic metaphase. This is the first report of chromosomes for this species.

FAMILY BLECHNACEAE

Genus *Blechnum* Linn.: Cytology of two species has been worked out.

37. *Blechnum orientale* Linn. (figure 35)

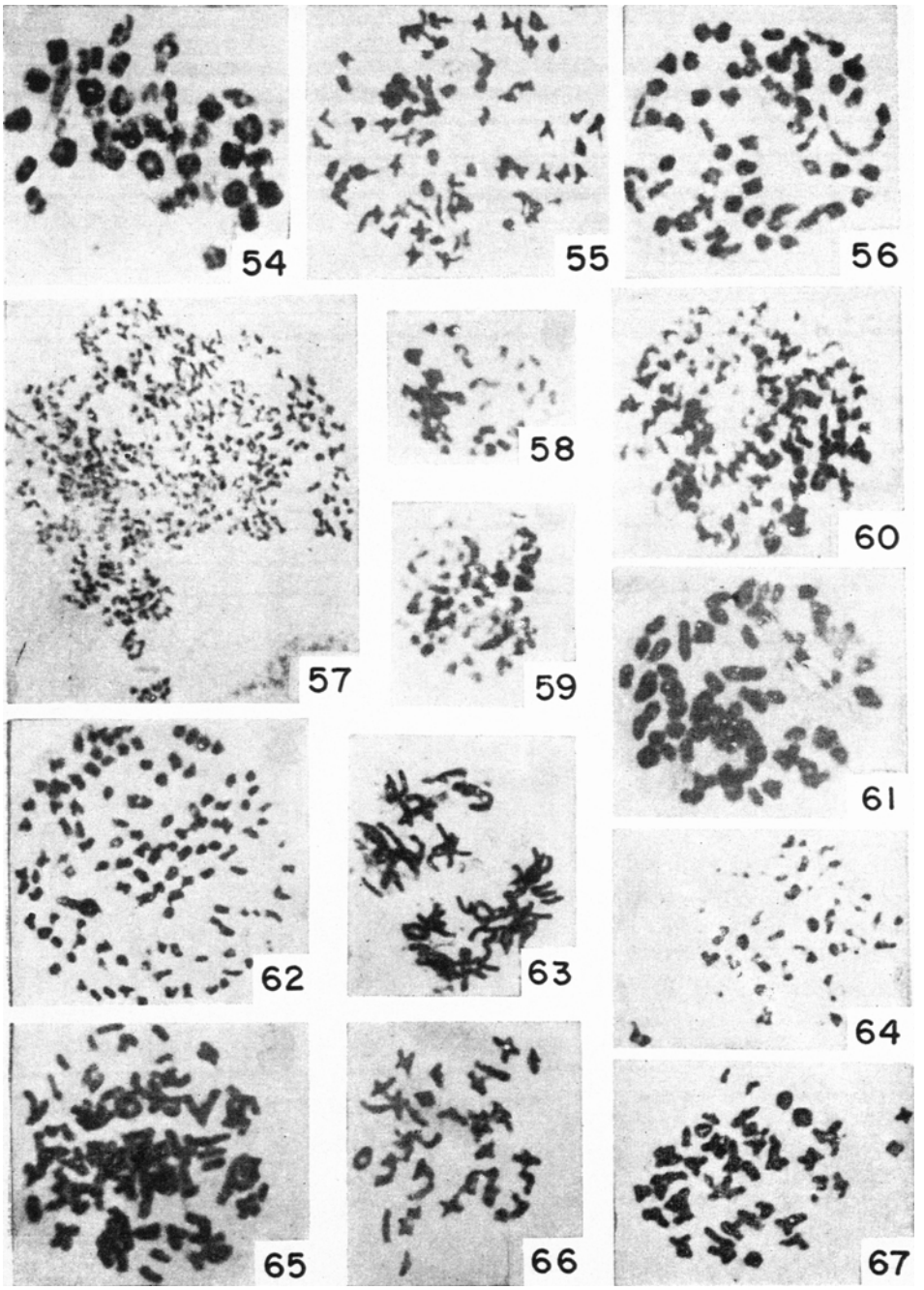
It showed n=33 chromosomes in the spore mother cells at the first meiotic metaphase. This number agrees with the earlier reports by Manton and Sledge (1954) and Abraham et al. (1962). Ghatak (1961) has reported n=34 chromosomes in North Indian material of this species.

38. *B. volubilis* Linn. (figures 38 & 56)

It gave exceptionally clear preparations showing n=62 chromosomes in the spore mother cells at first meiotic metaphase. This is the first report of chromosomes for this species. Manton and Sledge (1954) have reported 28, 31, 32 and 33 chromosomes for different species of this genus. Ghatak (1961) has reported n=34 chromosomes for *B. orientale*. The genus is thus remarkable for varied multi-basic chromosome numbers.

FAMILY ASPLENIACEAE

This family consists of a single large genus *Asplenium* and eight small genera. Genus *Asplenium* Linn.: This is one of the largest and most distinct genus of ferns consisting of 700 species (Copeland 1947). They are very widely distributed.



Figures 54-67 Photomicrographs of chromosomes. *54, Lastreopsis paris*, n = 41(×925); *55, Microsorium membranaceum*, n = 72(×460); *56, Blechnum volubilis*, n = 62(×1000); *57, Ophioglossum reticulatum*, n = *ca.* 515(×540); *58, Tectaria barberi*, n = 40(×460); *59, Actiniopteris radiata*, n = 58(×500); *60, Asplenium laciniatum*, n = *ca.* 108(×690); *61, Pteris ensiformis*, n = 58(×750); *62, Ophioglossum petiolatum*, n = 120(×500); *63, Phymatodes scolopendria*, 2n = 36(×460); *64, Ampelopteris prolifera*, n = 41(×925); *65, Diplazium maximum*, n = *ca.* 114(×500); *66, Microsorium punctatum*, n = 36×(690); *67, Tectaria macrodonta*, n = 40(×690)

39. *Asplenium laciniatum* Linn. (figures 36 and 60)

It showed n=ca. 108 chromosome in spore mother cells. This is the first report of chromosomes for this species. This number shows that it has basic number 36. It shows that some species of this genus exhibit pretty high chromosome numbers among the Leptosporangiate ferns namely n=144 and n=216. The genus has a large number of tetraploids, but on the contrary the diploids are very few. Different species of the genus also show constancy of basic chromosome number n=36. It would be interesting to resolve the species complex by further study of plants growing naturally at different places.

FAMILY POLYPODIACEAE

This family is a large one and consists of 65 genera and nearly 1040 species (Copeland, 1947). In the present study 4 genera and 5 species have been investigated.

Genus **Microsorium** Link.: There are about 40 species, all Asiatic. This genus is lumped with *Phymatodes* by Copeland (1947) but separated by Holttum (1947). They are not distinguishable cytolcgically.

40. *Microsorium punctatum* (L.) Copel. (=*Pleopeltis punctata*) (figures 41 & 66)

It showed that at first meiotic metaphase there are n=36 chromosomes in spore mother cells. It is a diploid. Abraham et al. (1962) have reported a tetraploid form of this species with n=72 chromosomes.

41. *M. membranaceum* (D. Don.) Ching (=*Pleopeltis membranacea* Don.) (figures 39 & 55)

It was growing epiphytically on the trunk of *Ficus racemosa* L. and also on walls of houses. Cytological investigations showed that there are n=72 chromosomes in the spore mother cells at first meiotic metaphase. It is a tetraploid form. Manton and Sledge (1954) have reported a diploid form of this species with n=36 chromosomes.

Genus **Lepisorus** J. Sm.: This genus consists of 25 species mainly growing in China and North India. Copeland (1947) unites this with the mainly tropical American genus *Pleopeltis*. But Christensen (Holttum 1947) keeps them separate.

42. *L. thumbergianus* (Kaulf) Ching (=*Pleopeltis linearis* Thunb.) (figure 37).

It showed n=36 chromosomes in the spore mother cells at first meiotic metaphase. Manton and Sledge (1954) have reported three base numbers in it, viz., n=35, 36 and 37 in the genus. It is not known at present whether 35, 36 or 37 is the characteristic base number of *Lepisorus*. Further studies on other species would determine it.

43. *Phymatodes scolopendria* (Burm.) Ching (=*Pleopeltis phymatodes* L.) (figures 40 & 63)

Cytological preparations showed 2n=36 meiotic chromosomes. It is a diploid apomict. This is the first report of mitotic chromosomes for this species. Genus *Drynaria* J. Sm.: It is an epiphytic species of the genus having about 6 species.

44. *Drynaria quercifolia* (L.) Sm. (figures 42)

Material of this species showed n=37 bivalents in the spore mother cells at the first meiotic metaphase. This number agrees with the earlier reports in *D. quercifolia* and *D. rigidula* from Malaya (Manton, 1954). Mahabale and Patankar (unpublished) had also found the same chromosome number, n=37 in this species.

FAMILY OPHIOGLOSSACEAE

This family of interesting Eusporangiate ferns shows peculiarities in morphology as

well as cytology. *Ophioglossum* has 30 cosmopolitan species. A good deal of work has been done on this family by many workers. Mahabale (1962) has given an account of the species occurring in India and Mahabale and Nair (1972) have described cytology of 6 species of the family Ophioglossaceae. Kurita and Nishida (1965) have also described the cytology in some species of Japanese *Ophioglossum*.

Genus **Ophioglossum** Linn.: In the present study cytology of six species of *Ophioglossum* has been investigated.

45. *O. costatum* R. Br. (=*O. fibrossum* Schum.) (figure 43)

Cytological preparations showed n=120 bivalents in spore mother cells at first meiotic division. The number agrees with the number reported earlier by Ninan (1956a) for plants from Palghat and by Mahabale and Nair (1972) for plants from Khandala.

46. *O. petiolatum* Hooker (=*O. pedunculosum* Prantl) (figures 45 & 62)

In these plants spore mother cells had n = 120 bivalents at first meiotic metaphase which agrees with the number reported by Mahabale and Nair (1972) for this species growing at Poona.

47. *O. nudicaule* Linn. f. (figure 46)

Plants of this species showed n=120 chromosomes in spore mother cells at the first meiotic metaphase. In the material from Palghat and Kumbhanad, Ninan (1958) reported n=240 chromosomes, but in *O. nudicaule* var. *typicum* and *O. nudicaule* var. *tenerum* Ninan (1958) had found n=120 bivalents in spore mother cells. The present number agrees with the number reported by Mahabale and Nair (1972) for the plants growing at Poona. From the above observations it seems that the two varieties of it growing at Bangalore and Poona show resemblance in their cytology as well as in morphology.

48. *O. gramineum* Willd. (figure 49)

These plants showed n=120 chromosomes in the spore mother cells at first meiotic metaphase. This number agrees with the earlier report by Ninan (1958) for the plants from South India and the plants from Poona by Mahabale and Nair (1972).

49. *O. polyphyllum* R. Br. (=*O. aitchisoni* d'Alm.) (figure 44)

They showed n=210–215 chromosomes at the first meiotic metaphase. This number does not agrees with the number n=116–117 reported by Verma (1956) or n=120 reported by Ninan (1958) even though Ninan's source of material was also Poona. It agrees with the report of Mahabale and Nair (1972) where they found n=210–215 chromosomes in this species.

50. *O. reticulatum* Linn. (figures 47, 48 & 57)

Plants of this species from Mahabaleshwar showed n=ca. 510–515 chromosomes in the spore mother cells at the first meiotic metaphase (figures 47 & 57). Cytological preparations of Poona material had n=ca. 495 chromosomes (figure 48). Abraham et al. (1954) and Ninan (1958) have reported n=564, 570 chromosomes in Trivandrum material, n=566 in Parambhikulam material, and n=631 chromosomes in the material from a place 200 miles North of Trivandrum City. Mahabale and Nair (1972) reported n=ca. 420 chromosomes in *O. reticulatum* growing at Poona. Apparently there is a good deal of variation in chromosome numbers in plants from different places.

The chromosome number in the *Ophioglossum* species varied n=120, 210–215, 495, 510. Mahabale and Nair (1972) state that "there might have been duplication on

account of which they are forming a polyploid series with basic chromosome number assumed to be 15 as all other numbers are multiples of 15". This gets full support from the observations made in the present study.

FAMILY OSMUNDACEAE

It is a natural family consisting of three genera (Copeland 1947). Only *Osmunda* occurs here.

Genus *Osmunda* Linn.: This cosmopolitan genus has 14 species, the number of species depends chiefly on how many of these forms could be reduced to *Osmunda regalis* L. in an author's view (Copeland 1947).

51. *Osmunda regalis* Linn. (figure 50)

The material showed n=22 chromosomes in the spore mother cells at the first meiotic metaphase. This number agrees with the earlier report of Manton (1950). Manton (1950) had also observed n=22, 44 and 2n=44, 66 and 88 chromosomes in *O. regalis* growing in British Isles.

Discussion

The paper gives an account of the chromosome numbers in 51 species of the Pteriodphytes of Western India belonging to 29 genera and 11 families. Of these 9 families belong to ferns.

(i) *Basic chromosome numbers*

The basic chromosome numbers in ferns studied here fall between 29 and 41 and agree with the monoploid numbers of ferns previously reported from other places.

Among the Eusporangiate ferns, species of *Ophioglossums* form a distinct group by themselves as they have a very high chromosome number. No species of *Ophioglossum* has been found to have less than 120 haploid chromosomes. *Ophioglossum petiolatum* has the highest number of chromosomes (n=ca. 1100) in the plant kingdom (Kuriata & Nishida 1965). The earliest record of very high chromosome number in the genus *Ophioglossum*, more than 1000 in *O. reticulatum* is by Campbell (1911). Mahabale and Nair (1972) have worked out the chromosome numbers in different species of *Ophioglossum* occurring in this part of the country. They assumed that basic chromosome number in this genus is n=15. In the present study the chromosome numbers in *O. reticulatum* were found to be n=495 and 510–515. Obviously this species has population groups with different chromosome numbers at different places such as Pune (n=495) and at Mahabaleshwar (n=510–514).

In the Leptosporangiatae basic chromosome numbers are n=29 and 30. *Lygodium* has 30, *Pteris* 29, *Cheilanthes* 29, *Pityrogramme* 29 and *Adiantum* 30. The same haploid numbers have been reported for other genera like *Cryptogramma*, *Pellaea*, *Vittaria*, *Onuchium*, *Monogramme*, *Doryopteris*, *Hemionitis* and *Acrostichum* growing in different regions (Manton 1950 & 1954, Manton & Sledge 1954, Mehra & Verma 1957 and Abraham et al. 1962).

Another group of ferns has 36 or 37 as the haploid number. Basic chromosome number is n=36, characteristic of Aspleniaceae. The number 37 occurs frequently in the members of the family Polypodiaceae. In the genera *Cyclosorus*, *Asplenium*, *Microsorium* and *Phymatodes* haploid number of chromosome was 36. In the present study n=37 chromosomes were observed in *Drynaria*. Abraham et al. (1962) have reported this very number for the genera *Pseudodrynaria*, *Phlebodium*, and *Platycerium*.

The third group of genera has haploid number of chromosomes 40 and 41. This number is chiefly found in the family Aspidiaceae. Thus the genera *Tectaria* and *Athyrium* have haploid number 40 and

Diplazium, *Nephrolepis*, *Dryopteris* and *Leucostegia* have basic number 41. Genera belonging to the family Davalliaceae and Aspidiaceae such as *Davallia*, *Oleandra*, *Bolbitis*, *Rumohra* and *Cyrtomium* have 40 or 41. (Manton 1954, Abraham et al. 1962).

(ii) *Polyploidy*

Manton (1953) after studying fern flora of Ceylon came to the conclusion that "Polyploidy as such is not an adaptation to cold climate and cannot be correlated with the ice age". She also pointed out that evolution proceeds faster in the tropics than in the temperate latitudes. Mehra (1961) supported Manton's view after an extensive examination of ferns in the Eastern and Western Himalayas. Abraham et al. (1962) also supported Manton's view on the basis of study of the ferns of Southern India.

It is generally believed that the seed plants have high chromosome numbers and that they have been evolved from the lower ones through polyploidy. It seems that a similar tendency is operating in the other groups like Pteridophytes also. In the present investigation the lowest number is found in *Ophioglossum* (n=120). It was recorded in *O. graminium* and *O. petiolatum* and the highest number n=495 and 515 was reported in *O. reticulatum*. As suggested by Mahabale and Nair (1972), it is probable that both auto- and allopolyploidy or their combination might be working here in the evolution of this genus, or it might have worked at some stage or the other in its long history. There might have been duplications also on account of which a polyploid series has been evolved. Another example to the point is *Lygodium*. Manton and Sledge (1954) found that in *L. flexuosum* there are n=30 chromosomes and that it is a diploid fertile species. But in the present material n=60 chromosomes were observed, obviously it is a tetraploid form. Other tetraploids in the area are—*Pteris ensiformis* (n=58), *P. vittata* (n=58), *Cheilanthes farinosa* (n=58), *C. albomarginata* (n=58), *Dryopteris sparsa* (n=82), *Cyclosorus parasiticus* (n=72), *Blechnum volubilis* (n=62) and *Microsorium membranaceum* (n=72).

Abraham et al. (1962) studied 108 taxa of ferns from South India. They have reported 53.0% of polyploids. Mehra (1961) from his study of 251 taxa of ferns from the Eastern Himalayas and 67 taxa from the Western Himalayas obtained 36.2% and 23.8% of polyploids respectively. In the present study of 34 taxa 26.5% of polyploids were noticed. Apparently the rate of species evolution is rather slow here.

(iii) *Apogamous ferns*

Adiantum caudatum seems to be a triploid apomict with n=90 chromosomes. Manton and Sledge (1954) have reported this species as a triploid apomict with 2n=90 and n=90 chromosomes. In the present study somatic chromosome number (2n) could not be worked out because of the paucity of good material. The remaining 25 species are fertile diploids. There are 2n=36 chromosomes in *Phymatodes scolopendria* but Abraham et al. (1962) have reported n=36 chromosomes in it. It, therefore, seems to be diploid apomict.

(iv) *Record of new chromosome numbers*

Following are the first records or new records of the chromosome numbers brought out by the present study:

Species	*Chromosome number*
(1) *Lastreopsis parishii*	n=41
(2) *Microlepia spelunce*	n=43
(3) *Actiniopteris radiata*	n=58
(4) *Tectaria barberi*	n=40
(5) *Diplazium maximum*	n=ca. 114

(6) *Ampelopteris prolifera* n=41

(7) *Blechnum volubilis* n=62

(8) *Asplenium laciniatum* n=ca. 108

(9) *Microsorium membranaceum* n=72

(10) *Phymatodes scolopendria* 2n=36

(11) *Ophioglossum reticulatum* n=495 and n=510–515

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