Observations

As stated earlier the present investigations on East Himalayan Pteroids include in all 67 taxa belonging to five genera, namely Pteris, Conioagramma, Cheilanthes, Onychium and Adiantum (see App. I). Because of the diversity in the nature of the problems in different genera and also because of the convenience in discussing the species-complexes discovered for each genus, the observations are dealt with separately for each genus. In each of the genera, the cytological observations are listed first, which data are followed by cytotaxonomical observations and a discussion on species-complexes. A general discussion follows at the end.
PTERIS Linnaeus

Introduction

*Pteris* is an old and well recognised genus comprising of nearly 280 (Copeland, 1947) or 270 (Ching, 1940) or even 250 (Holtum, 1954) species, chiefly represented in nearly all the tropical and subtropical countries but also reaching New Zealand, Tasmania, S. Africa and north to Japan and the United States (cf. Copeland, 1947). *Pteris* as defined by Ching (1940) and Holtum (1947, 1954) is a group of species with utmost cytological uniformity, based on 29* (cf. Verma, 1959, Chiarugi, 1960 and T. Walker, 1962) and broad homogeneity in gametophytic generation (cf. Bower, 1923; Momose, 1948a,b; Verma-unpub.). However, in the concept of Copeland (1947) it even includes diverse elements like *Anisosorus* (n=49-50; Manton, 1958), *Lanchitida* (n=38; Manton, 1958) and *Idiopteris* (n=27; T. Walker, 1957) which cytology has now shown to be different and deserving

*The dibasic nature of the genus was indicated by Brownlie (1961) from reports of x=30 in two N. Zealand species, *P. macilenta* A. Rich. (n=60) and *P. comans* Forst. f. (n=30); but T. Walker (1962) recently records (also from N. Zealand) 2n=58 in *P. comans*, 2n=116 in *P. macilenta* and n=58 in *P. macilenta var. mendula* (Cot.) Cheesem. Evidently Brownlie's material requires re-investigation and the genus presently remains monobasic.*
of generic recognition.

*Pteris* as circumscribed by Ching (1940) and Holttum (1947, 1954) still includes three distinct groups based on venation pattern, namely *Eupteris* (free veined), *Camptteria* (costal aerole) and *Litobrochla* (reticulate or anastomising). The last two groups have received in the past a generic status (*Camptteria* Presl and *Litobrochla* Presl) whence *Pteris* included only the *Eupteris* element. Modern taxonomists (including the experimental taxonomists like T. Walker, 1962) do not consider the vein character alone to be sufficient to warrant camptertoid or litobrochoid derivatives a generic or even subgeneric status. Christensen's (1932) remarks "that the usual division of this genus into three subgenera: *Eupteris*, *Camptteria* and *Litobrochla*, characterised by venation only seems to me un-natural" are very pertinent.

However, a genus of such a large size and wide distribution is expected to include species-complexes of variable magnitudes and groups of inter-related species. This is well corroborated by the results of T. Walker (1958, 1960, 1962) on the genus *Pteris* and the species-complex of *P. quadriaurita* in particular. The latter 'species' has been a real problem in the Himalayas too and a large array of forms had been grouped under *P. quadriaurita*.

Although no subgroups in the genus are perhaps justifiable taxonomically, yet for the sake of convenience only in bringing out the magnitude of various species-complexes, the
entire E. Himalayan collection is split up arbitrarily into four sections (cf. Table I), namely Vittata, Cretica, Quadriaurita and Campteria.

The cytological observations are dealt with collectively, while the cytotaxonomic remarks on the taxa and a discussion on the species-complexes are considered for each section separately.

**CYTOLOGICAL OBSERVATIONS**

The entire element of *Pteris* presently investigated, primarily from E. Himalayas, comprises of 28 taxa, some distinct and confirmed species while others evaluated presently cytotaxonomically. Out of these two belong to Sect. Vittata, six to Sect. Cretica, seventeen to Sect. Quadriaurita and three to Sect. Campteria. Besides these, in the Sect. Cretica have also been included three non-Himalayan members, namely *P. multifida* Poir., *P. cratica* var. albolineata Hk. and *P. cratica* var. cristata (Hort.), because of their evolutionary significance.

The chromosome determinations for the taxa investigated are summarized in Table II, which also includes the earlier reports (if any) on these very taxa. The most striking feature revealed by this table is a very large number of taxa belonging to Sect. Quadriaurita which have been entered within commas (' '). These are the provisional names of the segregates in the Himalayan *P. quadriaurita* complex for which older names cannot be applied with authenticity. Taxonomic difficulty has been immense here, and provisional names have been used on the
Table I

Grouping of Darjeeling and Sikkim Himalayan *Pteris*

<table>
<thead>
<tr>
<th>Veins free</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple pinnate, pinnae all simple, not lobed or pinnatifid. Spores reticulate</td>
<td>Vittata</td>
</tr>
<tr>
<td>Simple pinnate with lower pinnae usually bifid or more but never deeply pinnatifid. Spores warted or tuberculate</td>
<td>Cretica</td>
</tr>
<tr>
<td>Pinnae deeply pinnatifid (bipinnatifid), lower pinnae usually bearing a secondary pinna basiscopically. Spores deep to light brown, generally smooth or rarely warted</td>
<td>Quadriaurita</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Veins forming costal aerolae</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinnae deeply pinnatifid, lower pinna once forked. Spores light to dark-brown, smooth</td>
<td>Campeteria</td>
</tr>
</tbody>
</table>
suggestion of Dr. Holttum. Other species have been fully verified taxonomically.

The cytology of the Himalayan forms very well confirms the base number 29. Out of 28 taxa from Himalayas, 9 are polyploids (6 triploid apogamous and 3 tetraploid sexual). Among the 19 diploids 5 are diploid apogamous. In all 11 taxa are apogamous and 17 sexual, which signifies the prevelance of apogamy in the genus and explains to some extent the causal mechanism of species complexity here. Unfortunately no sterile hybrid is discovered presently. It should be noted that the only three sexual tetraploids, i.e. _P. vittata_, _P. ensiformis_ and _P. semiminnata_ have been reported elsewhere too with a similar cytological status.

A perusal of Table II further reveals that before the publication of chromosome numbers in Himalayan ferns (cf. Verma in Mehra, 1961b), only 5 taxa were cytologically known out of the 31 included here (taxa marked + in the table) and none from the Himalayas. Even presently (cf. Fabbri, 1963) data exist only for 13 taxa from elsewhere. In nearly 9 cases the observations are similar to Himalayan members and in the rest four cases the present E. Himalayan report from Darjeeling and Sikkim regions make such species as species-complex, namely _P. pellucida_ Pr. (2x E. Himalayas, 4x Java), _P. Maurita_ L. (3x apog. E. Himalayas, 2x elsewhere), _P. nemoralis_ Willd. (3x apog. E. Himalayas, 2x Ceylon), and _P. aspericaulis_ Wall. (2x apog. E. Himalayas, 3x apog. Assam).
Besides the huge *P. quadriaurita* complex, comprising of sexual as well as apogamous forms (especially taxa numbers 12 - 22 in Table II), the present cytological data have revealed species complexity in two cases within the Himalayas (Table III). However, among the presently included species, excluding *P. quadriaurita* s.l., 6 are shown to be species-complex, the E. Himalayan cytotypes (present report) are marked * and outside ones are indicated with the sign * in Table IV.

**CYTOTOXONOMIC DATA AND DISCUSSION ON SPECIES-COMPLEXES**

**Sect. Vittata**:

The section includes a single well known species, *Pteris vittata* L., which occurs throughout the Himalayas, usually below 1,300 m. and more commonly at lower elevations along the dry slopes on gravelly soil, extending down to N. Indian plains where it is a favourite garden fern. In the literature on Indian ferns (cf. Clarke, 1880; Beddome, 1863, 1883) the species has been taken to be synonymous with *P. longifolia* L. and has commonly been known by this name. The latter is a Tropical American fern and specifically distinct from the Himalayan *P. vittata* (cf. Hieronymus, 1914a; Morton, 1957).

A comparative study of *P. vittata* from Amritsar, Dehra Dun, Meerut, Darjeeling, Sikkim and Mt. Abu shows that it responds favourably to different habitats or environments. In shady and humid situations the fronds become as large as 1 - 1.5 m. whereas the average length in open and xerophytic localities ranges
Table III
Species-complex in Himalayas
(excl. *P. quadriserrata* element)

<table>
<thead>
<tr>
<th>Species</th>
<th>Cytotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>P. vittata</em></td>
<td>2x (W. Himalayas), 4x (common)</td>
</tr>
<tr>
<td>2. <em>P. hispida</em></td>
<td>2x apog. (Assam), 3x apog. (common)</td>
</tr>
</tbody>
</table>

3. (*P. quadriserrata*-complex, especially taxa Nos. 12 - 22 in Table II).
### Table IV

**Total number of species-complex excluding \( P. \) quadriaurita element**

<table>
<thead>
<tr>
<th>Species</th>
<th>Cytotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( P. ) vittata</td>
<td>( 2x^* ) ( 4x^{**} ) ( 6x^* )</td>
</tr>
<tr>
<td>2. ( P. ) eratica</td>
<td>( 2xa^* ) ( 3xa^{**} ) ( 4xa^* ) (( 2x^* ) ( P. ) eratica aff.))</td>
</tr>
<tr>
<td>3. ( P. ) mollucida</td>
<td>( 2x^* ) ( 4x^* )</td>
</tr>
<tr>
<td>4. ( P. ) ensiformis</td>
<td>( 4x^{**} ) ( 5x^* ) (hybrid)</td>
</tr>
<tr>
<td>5. ( P. ) haurita</td>
<td>( 2xa^{<strong>} ) ( 3xa^{</strong>} )</td>
</tr>
<tr>
<td>6. ( P. ) nemoralis</td>
<td>( 2xa^* ) ( 3xa^+ )</td>
</tr>
</tbody>
</table>

\* Reports from Himalayas  
\* Reports from elsewhere

Compiled from present data, T. Walker (1962)  
between 25 – 50 cm. (Fig. 1). Sometimes even the general aspect of pinnae is altogether changed, especially at the base which may be truncate, cordate, or slightly auricled either basiscopically or acroskopically or on both sides (Figs. 2, 3).

Till recently *P. vittata* was known as a tetraploid throughout the N. Indian range (cf. Mehra and Verma, 1960) and elsewhere too (Ceylon, Ghana, Br. Cameroons, Nepal, Zululand, New Guinea and Philippines, cf. T. Walker, 1962). Extensive populations from E. Himalayas including all types of variants have also turned out to be tetraploid (n = 58, Fig. 4). However, a few specimens were collected near Bhujiya Ghat (near Naini Tal, W. Himalayas) which differed from the tetraploid in texture, width of pinnae and indusia. Cytological examination of such specimens (Fig. 5) yielded a diploid (n = 29, Figs. 6a, b) in W. Himalayas. Very recently Abraham, Ninan and Mathew (1962) report a hexaploid (n = 87) from S. India. *P. vittata* is, therefore, a species-complex comprising of three cytotypes—diploid, tetraploid and hexaploid. Out of these, tetraploid is the most widespread, while diploid is discovered from N. India and hexaploid is known from S. India. The writer as yet has no access to specimens of the hexaploid. Hence cytotaxonomic evaluation is attempted here for the two Himalayan cytotypes.
Discussion:

Pteris vittata complex

Pteris vittata occurs in its W. Himalayan range in two cytotypes, a diploid and a tetraploid. Both are sexual and in the absence of triploids are reproductively isolated. Apparently, both appear morphologically similar and conform to P. vittata, but when compared critically (Table V) differences are noticed as regards width of pinnae, angle of vein to mid costa, nature of spores and its dimensions, and stomatal size. The vein character is at least macroscopic. Collectively these taxonomic characters coupled with chromosome number suggest for each cytotype a distinct specific status. It is not certain as to which cytotaxon exactly is represented by the Linnaean type. Because of apparent wide distribution of the tetraploids (cf. Manton and Sledge, 1954; Manton, 1959; Mehra and Verma, 1960 and T. Walker, 1962), there is every likelihood of the holoype being a tetraploid. Should the spore and stomatal dimensions as well as the other characters (cf. Table V) prove to be in agreement with this suggestion, then the diploid taxon may require a distinct specific status.
Sect. Cretica:

Five species, namely *P. cretica* L., *P. pallucida* Pr., *P. stenophylla* Wall., *P. ensiformis* Burm. and *P. sectyline* Hk., have been gathered from the Himalayas, Darjeeling and Sikkim.
The species is amongst the earliest known apogamaous species-complex comprising of diploid, triploid and tetraploid cytotypes (all apogamous, cf. Table II). In addition T. Walker (l.c.) also reports a diploid sexual (P. craticea aff.) from Ternate. However, throughout the Himalayas, only the diploid apomict is discovered so far (‘n’ = 58; Figs. 28, 29) but it is polymorphic.

In the classical works on Indian ferns (cf. Clarke, 1880; Beddome, 1892; Hope, 1901), the description of the species is not critical and as such none of the available Himalayan forms could be assigned the specific name craticea with authenticity. Dr. R.E. Holttum supplied a photograph of the Type in the Linnean Herbarium (Fig. 17) along with a complete description made by him.

After comparing with the Type, it is found that there is lot of variation in the species as regards the nature of the
terminal pinna, number of lateral pairs of pinnae, breadth of pinnae, texture, and colour of the stipe. The entire collection is sorted out into four groups, and named after the place of collection:

i) Mussoorie, Naini Tal, Lachen (N. Sikkim)

ii) Darjeeling

iii) Dharamsala

iv) Lachen near Chuntang (P.U. Coll. no. 1127).

There is some uniformity in the specimens from Mussoorie (Figs. 18, 21), Naini Tal (Fig. 19) and N. Sikkim (Fig. 20) which incidentally come closer to the Type. These are characterized by a generally bifid lowest pair. Scales are generally lanceolate, brown, smooth and attached by a broad base (Fig. 22). Rarely a marginal cell may produce a 2-3-celled glandular projection in Mussoorie material (Fig. 23).

Sterile pinnae are somewhat broader than the fertile ones, veins possess dilated ends and are often continuous with the cartilaginous brown margin. Fertile pinnae are linear, broad or narrow, long drawn out (subcaudate) into an infertile regularly spinulose-serrated apex (Figs. 24a, b), the sharp teeth being directed forward and outward in line with the veins.

Darjeeling populations (Fig. 25) concern only a few plants gathered in Senchal forests. Here the stipe is usually brown rather than straw coloured. Lamina consists of usually five alternate to sub-opposite pairs. Two or more lower pairs may be bifid.
Dharamsala specimens (Figs. 26a, b) have the uppermost lateral pinnae decurrent below the shortly stalked terminal one to a short distance. The stipe is straw coloured and the fertile pinnae are linear and fertile nearly to the tip.

The fourth kind concerns another N. Sikkim population (P.U. Coll. no. 1127) that occurs plentiful below Lachen (2,600 m.) and is a distinct variant from the Type. The fertile fronds have narrower pinnae (Fig. 27). Stipe is blackish purple below, brownish straminous above (occasionally brown), 50-60 cm. long. Lamina 20-25 cm., consists of usually 3 subopposite lateral pairs, in which the upper one is invariably decurrent on the rachis along with the terminal one and commonly to nearly 2/3 of the distance to the next 'node' below. Pinnae are green, thinly herbaceous, narrow-linear, sessile (or shortly stalked), usually 14 cm. long, 4-6 cm. broad and lowermost bifid. Margin wherever barren is closely and regularly spinulose-serrate. Quite often the fertile fronds comprise only of two lateral pairs, of which the upper one is decurrent almost to the 'node' below and lower bifid. Rarely there is only one lateral pair which is bifid.

**Taxonomic conclusions:**

The first three categories are more or less like the typical P. oretica with minor variations at Dharamsala and Darjeeling, but the diagnosis for the fourth category (P.U. Coll. no. 1127) from Lachen closely accounts for the related
Chinese species, *P. plumbea* Christ. The narrow linear pinnae, brown colour of the stipe, herbaceous texture and above all consistent decurrent nature of the upper pair are the chief characters that relate this taxon to *P. plumbea*. The fewer number of lateral pairs along with the occurrence sometimes of subdigitate type of fronds make it distinct from true *P. plumbea*. I have not seen any authentic specimen of *P. plumbea* but if the Lachen no. 1127 is not truly *P. plumbea*, it is not strictly *P. aratica* either.

Cytologically *P. plumbea* Christ var. *sintensa* Massam is known to be diploid sexual from Formosa (cf. T. Walker, 1962) and hence is unlike the present taxon. This Lachen taxon appears to be an extreme variant of the polymorphic and diploid apomict *P. aratica*, where variations at the diploid level represent at best distinct 'clones'. Morphologically distinct populations infact represent isolated population systems and each can perhaps be denoted by the term *binom* instead of species as suggested by Camp (1951). Presently, therefore, to maintain distinct identity of a true breeding population with characteristic morphology, I name the Lachen collection no. 1127 (Fig. 27) as *forma sikkimensis*. It may be stated that Scamman (1961) reported *P. aratica* L. from Costa Rica, the figure of which very closely resembles the *forma sikkimensis*. 
The taxonomic nomenclature of cultivated variety *Pteris eratica var. cristata* (Hort.) and *P. eratica* (from Argentina) seems to be somewhat controversial. Mr. F. Ballard (Kew) identified it as *P. eratica*—a cristate form, whereas in *The Book of Choice Ferns* (Vol. 7: 297, Asmund, 1915), it is described and illustrated as a variety of *P. serrulata*. The same attitude is apparent in *Index-Londinensis* (cf. Stapf, 1931). The latter is an illegitimate and older name for *P. multifida* Poir. (cf. Morton, 1957). The taxon is characterized by the decurrent nature of the uppermost two or three lateral pairs of pinnae forming a broad winged rachis which may often be fertile. Pinnae are partially fertile and the barren portions are sharply spinulose-serrate (saw edged) and the apices of the pinnae in mature fronds open out into variously branched tassels.

Another sample under the name of *P. eratica* was received from Buenos Aires (Argentina) where it occurs spontaneously. The particular specimen investigated (Figs. 31a, b) is gathered in the garden (not cultivated) at Olivos by Dr. J.S. Lichtenstein. It resembles the var. *cristata* in the winged rachis (often fertile), at least the upper half, decurrent and broader leathery pinnae, fertile in middle or throughout and somewhat saw edged cartilaginous margin. But it differs from var. *cristata* in the absence of terminal tassels and often trifid lower pinnae.
- 22 -

Decurrent nature of pinnae is characteristic of P. cristata forma sikkimensis but the winged rachis becoming fertile is characteristic of P. multifida (Fig. 39). It is not surprising, therefore, that var. cristata has been referred often in literature as a variety of P. serrulata (= P. multifida). But for tassels, the Argentina specimen is broadly very near var. 'cristata'.

Cytology:

Pteris cristata var. cristata cultivated at Meerut (India) is tetraploid apogamous and so is P. cristata from Buenos Aires (Argentina). Eight-celled sporangia are the commonest, and at metaphase, unequivocal counts of 'n' = 416 are made in each case (Figs. 32, var. cristata; 33, cristata from Argentina). Presently, 16-celled sporangia have only been analysed in var. cristata where they occur in a far greater frequency than any of the apogamous types investigated by the author. At metaphase I, 10 spore-mother-cells are analysed which are summarized in Table VI.

The associations are mostly bivalents and univalents though a few trivalents are also present (cf. Figs. 34, 35, 36). The average associations are 35.5_I, 36.2_II and 2.7_III. Quadrivalents and higher valency are completely lacking. The bivalents and trivalents arrange themselves on the metaphase spindle whereas the univalents usually remain scattered (Fig. 37). Some of the univalents may even divide at the
<table>
<thead>
<tr>
<th>Cells of G. aurea</th>
<th>Cells of G. aurea</th>
<th>Cells of G. aurea</th>
<th>Cells of G. aurea</th>
<th>Cells of G. aurea</th>
<th>Cells of G. aurea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>4</td>
<td>3</td>
<td>2</td>
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</tbody>
</table>

| 1                |
|------------------|------------------|------------------|------------------|------------------|------------------|
| No. of associations in 10 cells | 10 cells | 10 cells | 10 cells | 10 cells | 10 cells |
| 1                |

Table VI

- 22a -
first division. Most of the univalents remain outside the
telophase I nuclei while some of them may be included.
Tetrads also possess varying number of scattered univalents
(Fig. 38) and such spores are evidently abortive.

Pteris cretica var. albolimbata Hk.

As the name suggests, the pinnae have a broad white
strip along the mid vein throughout their entire length. The
fronds are dimorphic to a far greater degree (Figs. 40a, b)
than in P. cretica. Lamina of both sterile and fertile fronds
is comprised of widely spreading 1-2 sub-opposite lateral
pairs of pinnae and a simple (sometimes bifid or once lobed)
terminal leaflet. The sterile fronds possess a thickly
chartaceous to somewhat coriaceous texture; pinnae margin is
never spinulose-serrate but with distantly situated minute
acute dentations (teeth), slightly sharp, directed forward
and outward, 0.5 mm. long, 1-4 mm. apart and abruptly narrowed
(Fig. 41; compare with Fig. 24). The barren apex in the
fertile pinnae is minutely to broadly crenate-serrate but not
sharp (Figs. 42a, b).

Cytology:

Exceptionally clear spore-mother-cells from an 8-
celled sporangium of both cultivated material from Meerut and
wild Japanese samples have revealed 'n' = 87 (Fig. 43). In
archesporial mitosis, at several occasions 87 chromosomes are
lire plants were uprooted and replanted twice a year for three consecutive years. This proved to be a happy experience and 16-celled sporangia appeared in great numbers. An analysis of ten cells, two of which are illustrated in figures 45 and 46, is summarized in Table VII. The average associations are $27.8_1 + 21.8_{II} + 5.2_{III}$ (2n = 87). Quadrivalents are altogether absent.

Most of the univalents lag at anaphase I and ultimately the tetrads show a varying number of chromosomes distributed in each tetrad outside the nuclei (Fig. 47). These mature into abortive spores and are of little significance.

**Pteris pellucida** Presl

In general aspect *P. pellucida* (Fig. 48) is certainly distinct from *P. cretica* and the Himalayan collections made chiefly from Badamtam in Darjeeling district, exactly resemble Beddome's (1863) figure: F.S.I. t. 38.

*P. pellucida* from Malaya is stated to have pinnae finely toothed towards the apex (cf. Holtum, 1954) but the Himalayan samples are undulate or somewhat crenulate at the
<table>
<thead>
<tr>
<th>17</th>
<th>15</th>
<th>13</th>
<th>11</th>
<th>9</th>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

**Table XII**

Chromosomes analyzed in 15-97% of the cells of Arabidopsis thaliana.

<table>
<thead>
<tr>
<th>Cells</th>
<th>Associations</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
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<tr>
<td>II</td>
<td>15</td>
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<tr>
<td>III</td>
<td>13</td>
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<tr>
<td>IV</td>
<td>11</td>
</tr>
<tr>
<td>V</td>
<td>9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number in cells</th>
<th>Total number of chromosomes involved into associations and interaction 27°.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>5</td>
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<td>4</td>
<td>6.5</td>
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<td>3</td>
<td>6.5</td>
</tr>
<tr>
<td>2</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Mean per cell 2.17

Total number of chromosomes involved into associations 65.2.
infertile margin.

Eastern Himalayan populations of *P. bellucida* are diploid sexual with \( n = 29 \) (Fig. 49), yielding 64 seemingly viable tetrahedral spores in a sporangium. With the recent report of a tetraploid from Java (cf. T. Walker, 1962), it becomes a species-complex and the two cytotypes need to be examined taxonomically in view of the morphological differences between the Himalayan and Malayan populations.

*Pteris stenophylla* Wall.

In the literature on Indian ferns, the species (Fig. 50) has been described as a variety of *P. bellucida* from which it differs considerably. Rhizome is usually small compact bearing a tuft of leaves. Stipes straw-coloured, naked, 4-10 cm. long; scales on rhizome and stipe base similar, brown, lanceolate, entire with slightly thick walls in the middle (Fig. 51). Lamina consists either of a single broadly linear pinna or two or three sub-digitate pinnae in which character it finds resemblance to *P. dactyline* Hk. Pinnae are never fertile to the tip and the barren margin (Fig. 52) is slightly undulate and entire.

The plants collected at Mussoorie are already reported to be diploid sexual with \( n = 29 \) (cf. Mehra and Verma, 1960). Darjeeling Himalayan population collected near Badamtam is also diploid.
This is an extremely graceful fern of lower altitudes in the Himalayas often associated with *P. cretica* but treated always as a separate species. Complete description of the species is available in Beddome (1883), Clarke (1880) and Holttum (1954). However, certain peculiarities in it deserve special mention. Scales are linear-lanceolate, bright orange yellow pigmented except the one-celled thick clear margin, attached by a broad base, and marginal cells produced into 2-3-celled glandular hairs, more often limited to the lower region in larger scales (Fig. 53). The lowest pinnae are often 3-fid and the lowermost pinnule in a fertile pinna have often serrated rounded barren apex (Fig. 54). Veins diverge at an angle of 40 - 50° (70 - 80° in *P. cretica*) to the mid costa. Spores are unlike *P. cretica*, being blackish-brown, with a prominent equatorial collar and exine richly tuberculate.

In anatomy too, it differs from *P. cretica*. The latter is dictyostellic with a binary leaf-trace and the meristeles lie in a thick-walled brown ground tissue (Fig. 55). *P. ensiformis* possesses a unitary leaf-trace, and the meristeles lie in a thin-walled ground tissue with collenchymatous thickenings (Fig. 56). There is also no well developed hypodermis which is present in *P. cretica*. In this feature *P. ensiformis* also differs from *P. dactylina, P. stenophylla*.
and *P. multicauda* which have unitary leaf-trace.

All the Darjeeling Himalayan populations, chiefly the ones collected mostly on pony path from Badamtam to Teesta, are tetraploid sexual showing $n = 58$ (Fig. 57) with regular production of 64 tetrahedral spores per sporangium. So far known, in wild populations (cf. T. Walker, 1962) the species is throughout tetraploid. However, Abraham, Ninan and Mathew (1962) have reported a pentaploid from Trivundrum Public Gardens (S. India).

*Pteris dactyloidea* Hk.

It is one of the graceful species in *Pteris*, characterized by linear pinnae with their barren margins serrate and the pinnae digitate on a long stipe (Figs. 58, 59). In addition, the scales both at rhizome apex and stipe base are small, deep brown, linear-lanceolate with a broad base and a glandular tip (Fig. 60). The species usually occurs between 1,700 - 2,700 m. altitude and was collected several times on way to Lachen from Chungthang in N. Sikkim. Majority of the specimens have five pinnae though occasionally three may occur. The five pinnae are built essentially on the same plan as *P. craticea* except that the petiole of the central pinna is either totally suppressed or arrested from lengthening out and the only lateral pair is bifid. The entire system appears digitate. This condition is occasionally noticed in *P. craticea* var. *rhizophylla* and *P. craticea* forma *sikkimensis*. 
P. dactylica is a native of Sikkim, Yunnan and Khasia (Assam). It is faithfully described and figured in Beddome F.B.I. t. 23 (1883) and Ching, Icones Filicum Sinicarum, Fasicle II (1934A). Beddome (1883) and Clarke (1880) refer P. dactylica with pinnae 7-1 (usually five). The increased number of pinnae appears pertinent for P. eretica and the reduced number, to even one, finds parallel to P. stenophylla.

North Sikkim populations are triploid apogamous with 'n' = 87 (Fig. 61). Almost all the sporangia observed yield 32 spores and evidently 16-celled sporangia, if at all present, are extremely rare to have been detected in a few field fixations.

DISCUSSION (SPECIES-COMPLEXES)

Among the species of the Sect. Cretica no species-complex in the strict sense is discovered in the Himalayas. However, the present report of a diploid P. bellucida from E. Himalayas contrasts with the tetraploids known from Java (cf. T. Walker, 1962) and thus create a species-complex which requires further taxonomic analysis.

P. cretica is known to be a species-complex with 2x, 3x and 4x apogamous cytotypes, although in the Himalayas only the diploid cytotype is discovered so far. The species is polymorphic and the comparison with the Linnaean Type has yielded a distinct Lachen population (no. 1127) to be
designated as *P. cratica* forma sikkimensis. Furthermore, from a comparison of the spore dimensions, the Linnaean Type has been found to be diploid apogamous and it is this cytotype which shows a wide distributional range (cf. Table II).

The present work, however, includes the species-complex of *P. cratica* in a broad sense, and out of the three taxa constituting it, namely *P. cratica* (diploid), *P. cratica* var. albolineata (triploid) and *P. cratica* var. cristata (tetraploid), only the first one is Himalayan. Cytotaxonomic as well as cytogenetic discussion especially of the tetraploid var. *cristata* and triploid var. *albineata* is attempted here on indirect evidences from morphology and cytology.

Diploid (*P. cratica*):

All the morphovariants in the Himalayas are diploid apogamous and unfortunately chromosomal associations in 16-celled sporangial spore-mother-cells has not been possible presently. Manton (1950), however, did analyse such cells and found at metaphase I a large number of paired chromosomes, few trivalents, some probable quadrivalents and a certain number of univalents. On the strength of the evidence, she discussed two possibilities as to its origin: 1) a hybrid between two related species with a somewhat complete homology between chromosomes, 2) a formerly sexual species could have given rise to an apogamous form and in the absence of sexual behaviour and consequent natural selection, trans-
locations and effects of chromosomal changes may have accumulated.

Although the weight of chromosomal evidence suggested the second possibility, it was rejected by her since for most of the other apogamous ferns the second possibility was excluded and also a sexual form with similar morphology was not known to exist (cf. Manton, l.c.). Perhaps it is pertinent that Manton (1958) was still anxious to locate a possible sexual or ancestral type for *P. cretica* and now a diploid sexual is reported under *P. cretica* aff. from Ternate by T. Walker (1962). Evidently, the matter requires further investigations on ample material especially in regard to the analysis of 16-celled sporangia.

**Triploid (var. albolineata):**

This variety is very much distinct from *P. cretica* in respect of its characteristic dimorphic nature, thickly coriaceous (leathery) texture, sterile margin being cartilaginous and remotely crenate-serrate, teeth being very small with broad base, and veins being rather indistinct and submerged falling short of the margin. Fewer lateral pairs of pinnas in var. *albolineata* recall the situation in *P. cretica* from *aikkimensis*.

The cytological and morphological distinctness coupled with its wild occurrence in Japan are enough in my opinion to give this taxon a distinct specific status and it should better
be designated as *P. albolinnesa* (Hk.) Verma (stat. nov.).

**Cytogenetics:**

Sixteen-celled sporangia in apogamous ferns are of paramount importance for obvious reasons. Manton's (1950) analysis of such sporangia does not mention any exact figures but only reveals 'fewer unpaired chromosomes and more multivalents involving larger number of chromosomes'. A perusal of Table VII clearly shows that instead of fewer unpaired chromosomes and more multivalents, on an average more univalents than bivalents are noticed presently. The mean frequency of associations is 27.31+21.311 and 5.21111. Quadri- valents do not occur at all. These figures though not strictly but apparently suggest x pairs + x univalents condition. This becomes more clear if it is stated that nearly 50.3 chromosomes are involved in associations and 27.3 remain unpaired.

Taken as such the present condition of nearly x pairs + x univalents is regarded so far to result when a diploid hybrid or an apomict (AB constitution) or an allotetraploid (AABB) is back crossed to one of its parents (cf. Manton, 1953; Mehra, 1961a). The cytological and morphological implications in the present triploid var. *albolinnesa* are discussed below.

*P. cretica* (some of its *binom*) can hardly be doubted as one of the parents in var. *albolinnesa*. Manton (1950)
considers \textit{P. eratica} to be 'a hybrid between closely related species with much though not complete homology between the chromosomes of the two gametic sets', while Mehra (1961a) on the strength of Manton's (1. c.) statement, has symbolised \textit{P. eratica} as AA' (diploid apomict).

The present analysis of the triploid in a way suggests x pairs + x univalents at meiosis and if the diploid apomict \textit{P. eratica} is decidedly AA' in constitution, it appears to me that the univalents in the triploid var. \textit{albineata} mostly belong to the third parent, which being of \textit{eratica} alliance may contain a few homologous elements. Most of the pairs belong to the diploid apomict \textit{P. eratica}. Accordingly var. \textit{albineata} becomes AA'B in constitution, and as such represents either a modified condition of AAB or a new fourth type of triploid in the list of Mehra (1961a) since its origin is different. These types of triploid apomicts are conceivable. Furthermore, this conclusion is not much different from that of Manton (1950) "a hybrid between apogamous \textit{P. eratica} and some related sexual species".

\textbf{Putative parentage:}

\textit{P. eratica} is diploid apogamous. As to what might be the sexual parent involved, only an imaginative picture can be surmized on the assumption that most of the characters in a hybrid are intermediate between the two involved parents. Complete retention of such an expression of morphological
characters is possible in an apogamous fern, since this type of reproduction can be compared to clonal propagation of a highly specialized nature. From a survey of Table VIII, the sexual diploid parent should possess

1) dimorphic fronds with sterile pinnae much broader (and possibly fewer pairs),

2) nearly entire and somewhat cartilaginous sterile margin,

3) indistinct and submerged veins, falling short of margin,

4) thicker texture.

From the above diagnosis nearly five species, namely *Pteris esquiralli* Christ, *P. heteromorpha* Fée, *P. insignis* Mett., *P. pallucida* Pr. and *P. stenophylla* Wall. could share some of these characters and occur within the range of *P. cratica* and var. *albolineata*. So far, *P. pallucida* and *P. stenophylla* are cytologically investigated and are incidentally diploid sexual. However, the proper assessment of the problem awaits cytological knowledge about the rest of the species and actual synthesis of the triploid.

Tetraploid (var. *cristata*):

*P. cratica* var. *cristata* cultivated at Meerut is tetraploid apogamous. A large number of horticultural varieties in *P. cratica* are also known to be tetraploid apogamous, namely var. *dimetiti* (Manton, 1950; Schifferdecker, 1957).
var. major and var. childii (Manton, 1950) and var. owu randii (Vazart, 1956). Manton (l.c.) also found wild tropical material of *E. aratica* from Uganda to be tetraploid apogamous and T. Walker (1962) reports their wild occurrence in S. Rhodesia and Ascension Isl.

Tetraploid apogamous taxa can arise in nearly four ways: i) from crossing a diploid apogamous and a sexual tetraploid ii) from two sexual tetraploids iii) from a triploid apogamous and a sexual diploid iv) from a functional spore resulting from a four-celled sporangium of a diploid apogamous taxon.

Of all the previous workers Manton (1950) alone mentions in general about the 16-celled sporangia of the tetraploid apogamous forms investigated by her. She finds 'fewer unpaired chromosomes and more multivalents involving larger number of chromosomes'. On the strength of this data, Manton (1950) suggested the fourth possibility for all the tetraploid apomicts including *E. aratica* from Uganda, i.e. functional spore of a 4-celled sporangium in a diploid apogamous form and stated "since a mechanism for obtaining tetraploids from diploids is known to exist in the four-celled sporangia, there is no reason to regard the Uganda plant as anything other than a derivative by simple chromosome doubling from the simpler state (\(2n = 56\)) still retained in the European form of the species".

Genetically speaking, according to Manton (1950)
a spore resulting from a 4-celled sporangium of diploid apomict  
P. cretica would be of the constitution AAA'AA', if P. cretica  
is presumed as AA'. Obviously, on this presumption, in the  
16-celled sporangia of the present tetraploid apomict unpaired  
chromosomes are not expected to be in such large numbers as  
observed here. There are almost equal number of univalents  
and bivalents ( 35.5 I + 36.2 II + 2.7 III ) with negligible tri-  
valents ( cf. Table VI ). This clearly rules out the fourth  
possibility for the var. cristata.  

The possibility of two sexual tetraploids having been  
involved in the origin of this taxon seems to be remote parti-  
cularly when we have an apomict in P. cretica which is so  
similar to var. cristata in many respects.  

For the third possibility, the morphology does not  
lend support, i.e. the triploid var. albolineata to be one of  
the parents in the tetraploid var. cristata. Besides, the  
writer is not conversant with the morphology of the diploid  
sexual P. cretica aff. from Ternate and triploids from Turkey  
and Japan ( reported by T. Walker, 1962 ) and as such the third  
possibility cannot be thoroughly discussed.  

On purely morphological evidence, however, the first  
possibility, i.e. a diploid apomict x a tetraploid sexual  
apears sound. Morphologically speaking, the diploid apomict  
P. cretica should obviously be part parental to the tetraploid  
var. cristata. Furthermore, var. cristata has often been  
mistaken to be a variety of P. aerulata ( = P. multifida ),
which species incidentally is tetraploid sexual (cf. Mehra and Verma, 1960; T. Walker, 1962), and has long been in
cultivation together with P. arctica in various green houses.
A careful perusal of the comparison of P. arctica (Fig. 13),
var. aristata (Fig. 30) and P. multifida (Fig. 39) (cf.
Table IX) reveals that var. aristata retains somewhat inter-
mediate nature in morphology between multifida and arctica.
In the cartilaginous and sharply spinulose-serrate margin and
bifid lower pinnae, it resembles P. arctica. On the other
hand, the non-dilated vein endings, decurrent nature of pinnae
and winged rachis (often soriferous) are suggestive of
P. multifida. Spore diameter and stomatal dimensions as expected
show a pronounced increase in var. aristata over the type.
Consequences of such a comparison may be far reaching and
there is every likelihood that var. aristata in particular
may have arisen in cultivation as a cross between P. arctica
(some form) and P. multifida. Experimental investigations
are under way.

Comment on Pteris dactyline Hk.

P. dactyline is endemic to Sino-Himalayan region and
is triploid apogamous. Its putative parents, therefore, might
be expected to be present in the Sino-Himalayan range.

Pinnate arrangement in P. dactyline is basically of
arctica type, and in its range of number of pinnae and their
digitate nature, it resembles closely P. stenophylla and
P. cretica (especially forma sikkimensis). Incidentally, P. stenophylla is a diploid sexual while P. cretica a diploid apogamous. There seems to be no other species in the area worthy of consideration as a putative parent for P. dactylina. The morphological evidence and the altitudinal distribution are very much suggestive. Experimental studies are planned to see if P. dactylina is the outcome of hybridization between P. cretica (some form) and P. stenophylla.
Sect. **Quadriaurita**

The entire Himalayan element of *P. quadriaurita* seems to be less understood and all such forms that have their pinnae deeply pinnatifid with the lowest pinnae branched once or more times basiscopically have been grouped in *P. quadriaurita*. Majority of the Himalayan collections defy identification and no two persons appear to agree. It would only be sufficient to quote Dr. G. Taylor (Kew), who had the chance to examine some of my specimens with Mr. F. Ballard and remarked, "you will understand that the determinations of the members of *Pteria quadriaurita* 'complex' are only to be regarded as provisional". Dr. R.E. Holttum held a similar attitude and has advised me to denote my specimens as $P_1$, $P_2$, $P_3$ and so on for the present, while their exact identification and segregation of new species, if required, shall have to wait till collections in various herbaria are examined. This would also envisage
comparisons with the type specimens of various species. Prof. R.C. Ching and late Mr. A.H.G. Alston were equally inconclusive. The highly complex nature of the species is well supported by the interesting observations of T. Walker (1958, 1960), especially in three Ceylon species of the complex, namely *P. multiurita* Ag. (*n* = 29), *P. quadriurita* Retz. s.s. (*n* = 29) and *P. confusa* Walker ("n" = 38), which have yielded a bewildering variety of forms by inter-breeding and further the relationships of several entities are complicated by apogamy.

Although collections are made from Western as well as Eastern Himalayas, the present account refers only to the Darjeeling and Sikkim region in the Eastern range because of the extreme familiarity with this region gained during four successive visits from 1955 to 1958.

Needless to point out that the classical works on Indian ferns do not help and out of the 17 taxa (cf. Table II) in the Sect. *Quadriurita* (presently segregated), only three have been recognised specifically so far, namely *P. exelusa* Gaud., *P. longissas* Don and *P. semipliunata* L. However, even out of these the first two seem to be less understood at Kew because some of my specimens (unrelated) were compared with them.

The only real exhaustive work on the subject is by Hieronymus (1914b) who published a revision of the Old World's forms of *P. quadriurita* and described 31 species, all
falling under it in its widest sense. However, very lengthy description without a key and suitable diagrams in his treatise render it difficult to follow. About Hieronymus (l.c.) it would suffice to quote Christensen (1932) who expressed "several of the species described by Hieronymus (l.c.) are certainly distinct but it seems to me extremely difficult to identify specimens after his very detailed descriptions alone".

The later workers on Indian ferns (cf. Mehra, 1939; Stewart, 1942; Kachroo, 1953) have merely contended to refer perhaps all the forms of *P. quadriaurita* or their collections were not sufficient to warrant segregation into distinct species or varieties. Recently, only Alston and Bonner (1956) appear to have named the Nepal collection after Hieronymus (l.c.) but that even does not help much here. Hence, for the present, most of the taxonomic units in E. Himalayan element of *P. quadriaurita*, segregated on a complex of characters, are provided with provisional names (cf. Table II) so as to discuss their cytotaxonomic aspect. The task of their appropriate nomenclature is still in progress.

**Evaluation of taxonomical characters in *P. quadriaurita* complex**

As it would appear from Table II, most of the segregates have been given distinct provisional names while some of them have been identified specifically. The taxonomic
framework has been based on a critical examination of the entire collection. This revealed a good number of criteria upon which segregation into distinct taxonomic units could be based. The following characters are taken to be of taxonomic importance:

1. Habit and habitat
2. Scales, both rhizome and at stipe base
3. Nature of pinnae
4. Apex of pinnae, pinnules and fertile region
5. Costal and costular spines
6. Endings of lowest veins and vein ends
7. Colour and texture, if peculiar
8. Spores

As a consequence, Darjeeling and Sikkim populations (gathered so far) are split into sixteen (seventeen including distinct P. semipinnata L.) units which, however, include some very distinct species like P. subindivisa, P. subquinita, P. excelsa, P. rosoeurinacina and P. longipes but since even these at one or the other time have been confused with or merged with P. quadriaurita, their inclusion in the complex here seems justified.

Observations on the individual characters taken into consideration are stated in brief below, so as to stress their relative importance in the section Quadriaurita.
1. **Habit and habitat:**

Some of the members show marked ecological preferences and altitudinal distributional ranges. Thus the taxon *P. tongluense* (both forms) occur usually between 2,600 - 3,300 m. altitude, in open grasslands, in the form of small bushes, wherein the pinnæ are commonly directed upwards. In contrast, *P. excelsa* and *P. laxa* with lax and broader pinnæ are inhabitant of wet forest margins, occurring between 2,000 - 2,800 m. altitude. *P. blumeana* on the other hand prefers forest habitat whereas *P. subindivisa* and *P. roseolilacina* occupy drier and xeric situations at lower elevations (up to 300 m. alt.). *P. subquinata* is distinctive in its much smaller size and membranaceous pinnæ.

Rhizome posture contributes to some extent in certain cases but their aspect may differ with the habitat of a species. As a rule, *P. pseudohiaurita* is characterized by erect rhizomes which are most often emergent.

2. **Scales:**

Generally scales are present on the rhizome and extreme stipe base. In certain cases, these may extend up to a certain distance on the stipe and when intact, the species can easily be spotted out, like *P. aspericaulis* and *P. rigida*.

Scales for all the sixteen investigated taxa are shown in figure 63 (Figs. 63A-P) and it becomes evident that the shapes vary from broadly triangular-ovate to short
lanceolate to linear-lanceolate or even linear, often long and hair pointed. Majority of scales are bicolorous, with a central zone of elongated, brown pigmented cells and paler margin of variable width composed of somewhat quadrate cells (Fig. 64), or more transversely elongate cells (P. roseolilacina, Fig. 65). The margin may be smooth or shows peg-like projections, to a varying degree, formed by the outward elongation of the middle septa of two contiguous cells. In certain cases, the marginal cells may even be produced into elongated hair-like structures. In still others the brown pigment of the central zone is deep blackish-brown and appears sclerotic. Some of the species like P. subquinata (Fig. 63 M), P. excelsa (Fig. 63 L), P. longipes (Fig. 63 G) are distinct in possessing pale concolorous membranaceous scales, made up of only elongate cells. Such a magnitude of variation allows it to be a good diagnostic feature in matters of dispute. The validity of the statement is exemplified by the formulation of a key to the investigated species based on scales alone (Table X).

P. subquinata may be taken as an example. Hope (1901) considered it to be specifically distinct but Clarke (1880) treated it with P. quadrirurita, and so did Christensen (1906). The morphological distinctness is upheld by its concolorous entire scales as compared to bicolorous and 'somewhat lacerate' scales in rest of the 'quadriurita' complex.
Table X
Key to the Himalayan *quadriaurita* complex on scale character

**Concolorous**

<table>
<thead>
<tr>
<th>Description</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pale thin membranaceous (long)</td>
<td><em>P. excelsa</em></td>
</tr>
<tr>
<td>margin entire ..................................................................................</td>
<td></td>
</tr>
<tr>
<td>(linear-lanceolate)</td>
<td></td>
</tr>
<tr>
<td>marginal cells with glandular hairs</td>
<td></td>
</tr>
<tr>
<td>linear-lanceolate, long drawn out</td>
<td><em>P. mahrae</em></td>
</tr>
<tr>
<td>lanceolate-triangular-ovate, narrowed abruptly.</td>
<td><em>P. longipes</em></td>
</tr>
<tr>
<td>Deep brown, minute (upto 2 mm.) ................................................................</td>
<td></td>
</tr>
<tr>
<td><strong>Bicolorous</strong> (central zone of elongated cells, brown pigmented-sclerotic; pale margin of somewhat quadrate cells)</td>
<td></td>
</tr>
<tr>
<td>Broadly triangular-(ovate) lanceolate</td>
<td><em>P. 'blumeana'</em></td>
</tr>
<tr>
<td>small, mid zone sclerotic, broad pale margin with pegs and hairs</td>
<td></td>
</tr>
<tr>
<td>Linear-lanceolate (small upto 4 mm.)</td>
<td><em>P. 'tongulense'</em>*</td>
</tr>
<tr>
<td>mid zone deep brown to brown pigmented</td>
<td></td>
</tr>
<tr>
<td>marginal cells with pegs or hairs</td>
<td><em>P. 'tongulense'</em>*</td>
</tr>
<tr>
<td>or hairs</td>
<td></td>
</tr>
<tr>
<td>marginal cells without hairs</td>
<td><em>P. 'laxa'</em></td>
</tr>
<tr>
<td>Linear-lanceolate (long, from 4-6 mm.)</td>
<td><em>P. 'aspericusulis'</em></td>
</tr>
<tr>
<td>mid zone deep brown, occasionally sclerotic above, margin not broad, few hairs.</td>
<td></td>
</tr>
</tbody>
</table>
mid zone nearly black
(sclerotic), broad margin
with pegs or hairs............ P. 'sikkimensa'
P. 'himalavense'  
forma  A  
forma  B

Linear (elongate, more than 8 mm. long)

mid zone brown pigmented,
hair pointed, margin with
pegs ....................... P. subindivisa
mid zone brown pigmented-
sclerotic, few marginal
pegs ........................
P. 'pseudobuatirita'

Bicolorous (central zone of elongate cells,
pale margin of somewhat trans-
versely elongate cells)

Linear-lanceolate, narrowed to a hair
point, pale margin lacerate with
elongate hairs (also pegs)............ P. rosolilacina
3. **Nature of pinnae:**

Pinnae on the lamina may lie horizontally with respect to the rachis or slightly deflected upwards to even strongly directed upwards. In addition, the lowest pinnae may be once forked basiscopically or bear two or more secondary pinnae. The present study has yielded an interesting experience. Nearly all forms of *quadriaurita* complex with more than one basiscopic secondary pinnae on the basal pinna, proved to be triploid apogamous and each time the expectations were validated.

4. ** Apex of pinnae, pinnules and fertile region:**

Shape, size and apex of pinnules are of greater significance along with the fertile zone. A reference to Table XI reveals it to be another sound character. Pinnules may be regularly cut down almost to the rachis (costa) with the two sides of adjacent pinnules lying almost parallel so that the distance between the two lobes is narrow whereas in others the pinnules diverge from the sinus. Pinnule apex may be acute, obtuse, entire or serrated and the pinnules may be wholly or partially fertile.

5. **Costal and costular spines:**

At the junction of the costa and the rachis on the dorsal side, the edges of the groove are produced outwardly into distinct spines known as costal spines. These may be herbaceous, short, either adpressed and insignificant or little
Table XI
Pinnule apex and fertility zones in E. Himalayan quadriaurita complex

<table>
<thead>
<tr>
<th>Apex entire</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharply acute</td>
<td></td>
<td></td>
</tr>
<tr>
<td>almost wholly fertile, indusium broad ..</td>
<td>P. 'rigida'</td>
<td></td>
</tr>
<tr>
<td>wholly-partially fertile, indusium narrow</td>
<td>P. 'aspericulata'</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>P. 'subindivisa'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P. 'pseudochaurita'</td>
</tr>
<tr>
<td>Narrowed obtuse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>almost wholly fertile</td>
<td>P. 'kongulense'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>forma $\alpha$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>forma $\beta$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P. 'mehrae'</td>
<td></td>
</tr>
<tr>
<td>partially fertile, 1/5 region above and below infertile</td>
<td>P. 'laxa'</td>
<td></td>
</tr>
<tr>
<td>Obtuse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>smooth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>partially fertile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>broad infertile apical zone</td>
<td>P. 'himalayense'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>forma $\alpha$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>forma $\beta$</td>
<td></td>
</tr>
<tr>
<td>equally broad infertile apex</td>
<td>P. 'sikkimense'</td>
<td></td>
</tr>
<tr>
<td>acuminate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>partially fertile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>almost wholly fertile</td>
<td>P. 'subquinta'</td>
<td></td>
</tr>
<tr>
<td></td>
<td>P. 'blumeana'</td>
<td></td>
</tr>
<tr>
<td>Apex serrated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtuse, partially fertile</td>
<td>P. 'longisepa'</td>
<td></td>
</tr>
<tr>
<td>Acute, obtuse, partially fertile or from base to just behind apex</td>
<td>P. 'excelsa'</td>
<td></td>
</tr>
</tbody>
</table>
prominent and directed forward or these may be very sharp, large and stand almost at right angles to the laminar surface.

In some species the mid vein or costa may also bear prominent costular spines at the junction of veins to the costa while others totally lack them. Certain species like *P. roseo-lilacina* and *P. longipes* are marked by the presence of prominent costal and costular spines, almost perpendicular to the laminar surface. The presence or absence of these is a good taxonomic criterion, since in individuals of a taxon no variation is noticed.

6. **Endings of lowest veins and vein ends:**

   In most cases, the lowermost vein from the costae of adjacent pinnules end much above the sinus but only in a single case of *P. 'pseudohisaurita'* these end invariably just at the sinus. In no case these tend to meet below the sinus in a campteroiď fashion.

   Vein ends may yield another factor of taxonomic significance (cf. Table XII). These may either be simple, dilated slightly or sufficiently swollen. Veins may either fall short of the margin or be continuous with the margin, which may be thin or firm, herbaceous or somewhat cartilaginous.

7. **Colour and texture:**

   Texture of fronds is constant to a fair degree in individuals of the same species and differs markedly from others. Lemina may either be thin, light green and sub-membranaceous
Table XII

Vein ends in E. Himalayan *quadriaurita* complex

| Lowest vein ending above sinus | Veins fall short of margin (slightly) | P. 'tongluense' form  
|                               | ends not swollen                      | forma $\alpha$ 
|                               |                                           | P. 'laxa' 
|                               | ends little dilated                    | P. 'sikkimensa' 
| Veins fall short of margin(distinctly) | ends slightly dilated                  | P. 'himalayense' form  
|                               |                                           | forma $\beta$ 
|                               |                                           | P. longipes 
|                               | ends distinctly dilated                | P. *exselsa* 
|                               |                                           | P. *mahreae* 
| Veins almost continuous with margin | ends not swollen                      | P. subindivisa 
|                               |                                           | P. 'blumeana' 
|                               |                                           | P. 'rigida' 
|                               |                                           | P. subquinta 
|                               | ends slightly dilated                  | P. 'aspericaulis' 
|                               |                                           | P. rossolilacina 
| Lowest vein ending just at sinus ..  |                                           | P. 'pseudobiusaurita' |
to herbaceous, or thick, rather coriaceous and often dark-green. Extremely dry rigid texture is characteristic of P. 'rigida'. P. 'himalayense' is characterized by lemon-brownish-green tinge. Colour and texture, though fairly constant, can only be used with a certain reserve.

8. Spores:

Specifically, spores have a limited significance because of their general similarity. Spores in general are brown, tetrahedral without a perispore but with a thickened border of brown colour around the triangular base. This thickening is known as the equatorial collar and the degree of its thickening, varies to a certain extent in some cases while in others it may be narrow and indistinct. Apart from it, the size variation in different 'cytotypes' affords a positive morphological character to judge the cytological status of a taxon in herbarium material.

**CYTOAXONOMICAL OBSERVATIONS**

It has been indicated at many places that the Sect. *Quadriaurita* in E. Himalayas comprises of 17 taxa, most of which bear provisional names of the author. Out of these, *P. semipinnata* is very distinct and can easily be excluded from the complex. Out of the remaining 16, only 5 bear the authentic specific names but all falling in the *P. quadriaurita* complex in a broad sense. The taxonomy of all the taxa so far known is
is inadequate. Hence, in the observations to follow critical
taxonomic data is obtained for each taxon. Furthermore, in
order to bring out the various sub-complexes within the
'quadriaurita complex', the various related taxa have been
grouped together. As such 11 groups are maintained, out of
which 5 pertain to sub-complexes comprising of two or more
taxa.

1. *Pharia 'tongluense' ( sub-complex )

The species is easily spotted out in the field by
its small bushy or caespitose habit, with all the pinnæ directed
upwards, growing abundantly in open grassland at higher ele-
vations (2,600 - 3,300 m.). It is extremely common below
Tonglu Dak Bungalow (Darjeeling district) and frequent near
Tiger Hill and Jalapahar road at Darjeeling.

Two distinct forms are met with, one of them
(forma α) is distinctly herbaceous with dull green stipes,
soft green lamina with acute and diverging pinnules (Fig. 66);
while the second one (forma β) possesses notably a tough-
subcoriaceous texture with dark-brown to purple stipes (Fig. 67).

There is no record of such forms in literature and
most probably these were taken to be *P. quadriaurita* by Clarke
(1877). A brief taxonomic description for these taxa seems
necessary. Fronds nearly deltoid to subdeltoid, c.45 - 75 cm.,
stipes c. 30 cm., lamina 30 - 40 cm. with 4-8 opposite to sub-

date pairs, ending in a
long terminal pinna (10-15 x 3-4 cm.) in the dark stiped form and not much elongated in the dull green stiped form.

Basal pinnae bifid (Figs. 66, 67), pinnae not caudate, linear-lanceolate, cut down to costa into 25-30 pinnules, wide apart, narrowed upwards into acute-obtuse entire apex. Pinnules (Figs. 68, 69) almost fertile to apex (less so in dull green stiped form), middle ones 2 cm. x 4 mm., indusium broad, membranaceous, c. 1 mm. broad, somewhat pale-brownish in dark stiped form. Veins free, wide apart (1.5 - 2 mm.), semi-prominent-prominent, nearly all furcate at middle, lowermost veins end much above the sinus. Vein ends not swollen and reach the margin only at base. Costa grooved dorsally, prominent costal spines, 1 mm. long, green purple with a broad base (Fig. 70). Both surfaces bear 3-6-celled hairs in the region of costule, veins and laminar surface (Fig. 71). Spores tetrahedral, brown, smooth, wrinkled slightly close to the triradiate mark (Fig. 72), equatorial collar narrow.

**Cytology:**

Both forms in *P. tongulense* are diploid sexual with n = 29 (Figs. 73, 74) yielding 64 spores per sporangium. Sexual nature is ascertained as well from spore germinations.

The species has been investigated in successive visits to Darjeeling Himalayas and in the summer of 1957 individuals possessing dark stipes and yet herbaceous texture were found growing in an unusually shaded aspect on roadside to
Jalapahar. These plants yielded unexpected results. In many cases 29 bivalents, normal anaphase I (Fig. 75), anaphase II (Fig. 76) yielding absolutely normal tetrads result (Fig. 77). Generally at diakinesis some univalents (Figs. 78, 79) are observed, and an analysis of 10 such spore-mother-cells (Table XIII) shows that the average associations are $27_{I}I + 4I$. Univalents in general lag at anaphase I (Fig. 80) and appear as round 'micronuclei' in spore tetrads (Figs. 81a,b,c). Such spores are abortive.

2. Pteris 'laxa'

It belongs to P. 'tongluense' group in broad morphological pattern but differs in the character of scales, habit and habitat, larger segments, partial fertile region and general aspect (Figs. 82, 83). It is a fern of moist shaded habitat on forest margins usually between 2,100 - 2,900 m. altitude, and is plentiful in and around Darjeeling and Tonglu. It is marked by the very lax, broad and long submembranaceous, herbaceous, pleasing green pinnae and usually one to two pendant fronds attached to creeping or slightly ascending rhizome.

Both at Kew and Calcutta it has been identified as in P. excelsa Gaud., from which it differs considerably/matter of scales, size of fronds and pinnules, barren pinnule apex entire (serrate in P. excelsa), veins, indusia and general aspect. This perhaps implies that both P. excelsa (Fig. 117) and P. 'laxa' are less understood and probably the bundles at
Table XIII

Analysis of abnormal S.M.C. in dark stiped P. *tongluense*

<table>
<thead>
<tr>
<th>No. of cells</th>
<th>Associations</th>
<th>2n number</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>26</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>Mean associations</td>
<td>4</td>
<td>27</td>
</tr>
</tbody>
</table>
Fronds nearly 60 - 85 x 20 - 30 cm., lamina with 4 - 5 opposite to subopposite long spreading pairs of pinnae, lowest bifid, 22-26 x 5-6 cm., terminal pinna like the lateral ones. Scales in a packet at stipe base, linear-lanceolate, bicolorous, pale margin, brown in centre, margin with peg-like projections of contiguous cells but no marginal hairs (Fig. 64). Pinnae cut down to costa into 22-25 alternate pinnules, wide apart (2-5 mm.). Pinnules (Fig. 83) 2-2.3 cm. long, 5 mm. wide; with almost parallel sides narrowed above to a obtuse or narrowed apex. Both surfaces beset with 3-4-celled articulate hairs. Sinus deep, often meets costa; veins fall short of margin and ends not swollen, almost always forked above base, wide apart, prominent. Nearly 1/5 upper pinnule region infertile, barren margin entire, smooth and apex obtuse. Costal spines prominent, green, thin, herbaceous, hardly 1 mm. long from a broad base. No costular spines.

Cytologically it is diploid sexual throughout, showing n = 29 (Fig. 84). A sporangium yields 64 tetrahedral spores.

3. Platia 'blumeana' and P. 'sikkimensis' (sub-complex)

In general aspect (compare Figs. 85a,b; 86) both

* P. 'blumeana' resembles P. blumeana Ag. (cf. Eieronymus, 1914b) in many respects and is perhaps the same.
the taxa are similar, the only visual difference being the presence of 2-6 basiscopic secondary pinnae on the basal pinnae in *P. 'sikkimense'* and its larger size. Both may aptly be regarded as constituting the *blumeana* complex*, although both are apogamous and hence effective reproductive isolation occurs.

*P. 'blumeana'* is very variable and some of the forms appear to be close enough to the type of *P. quadriaurita* but differs in possessing few costular spines (none in *P. quadriaurita*, cf. Christensen, 1932), vein endings not swollen and continuous with the margin and pinnule apex entire, obtuse or acuminate (Fig. 87) (serrated in *P. quadriaurita*). *P. 'sikkimense'* in addition to its larger size and more than one basiscopic secondary pinnae, is distinctive in its perfectly entire obtuse pinnules and little dilated vein ends, reaching just near the margin (Fig. 88). Besides, the sinus is somewhat callous and often bears a spiny protuberance on the ventral side, just near the sinus. Scales, too, are equally peculiar being somewhat smaller and broadly triangular to ovate-lanceolate in *P. 'blumeana'* (Fig. 63 D), and linear-lanceolate in *P. 'sikkimense'* (Fig. 63 E). Both, of course, agree in general pattern possessing a central zone of elongated narrow cells and pale broad margin of somewhat quadrate cells, fringed and often produced into hairs. Pinnae in both the taxa end in a slightly caudate apex (Figs. 85a, b; 86) - a quadriaurita character.

*P. 'sikkimense'* has invariably partially fertile pinnules, while

* Personal communication with Dr. G. Taylor (Kew).
P. 'blumeana' as delimited here constitutes both partially and wholly fertile pinnules. Spores in both cases are remarkably alike; smooth tetrahedral with unequally broad equatorial collar (Figs. 89, 90).

In the sub-complex blumeana, P. 'sikkimensae' is important. This distinct taxon has been identified by Dr. S.K. Mukerji (Calcutta) as P. pallucens Ag. and by Mr. F. Ballard (Kew) as P. longipes Don (syn. P. pallucens Ag.). As would be evident later, P. longipes is a very characteristic species with usually tripartite fronds, serrated barren pinnule apex, and concolorous entire scales (Fig. 630 and see page 62). However, often the lower two divisions of the frond in P. longipes are not completely bipinnate and appear to bear a larger number of basiscopic secondary pinnae which presents casually a similar aspect as larger forms of P. 'sikkimensae'. This is perhaps the reason for incorrect identification of this taxon with P. longipes. I would agree with Clarke (1880) that fragments of P. longipes are frequently mistaken for P. quadriaurita and here it is the reverse. Evidently P. longipes is also poorly understood in various herbaria.

Cytology:

P. 'blumeana' is diploid apogamous with 'n' = 58 (Fig. 91). Usually 32 tetrahedral spores result in a sporangium and the 16-celled sporangia seem to be rarer. No such spore-mother-cell is analysed at metaphase I but three cells at
anaphase I show a large number of lagging univalents (Figs. 92, 93); some of them may be divided, an assumption based on relative size alone. The number of lagging univalents (23-34) at anaphase I is perhaps sufficient to presume that at metaphase I pairs are few and that nearly 50 per cent chromosomes remain unpaired.

Morphological distinctness of *P. sikkimense* from *P. blumeana* is upheld by chromosome number. It is a triploid apogamous with 'n' = 87 (Fig. 94). Sixteen-celled sporangia are not observed, though their presence cannot be denied in view of the presence of a small percentage of shrivelled spores among very large number of well filled ones.

4. *Pteris himalayense* (sub-complex)

In it are included two forms, *A* and *B* (Figs. 95, 96), which share much with *P. blumeana* complex but differ in their basket-like habit, lemon green colour, upwardly deflected pinnae, relatively smaller pinnules, spores with regular equatorial collar (compare Figs. 89, 90 with 97a, b) and to some extent distinctive scales. Vein endings are equally distinctive, being slightly dilated and falling short of the margin, in which character it finds resemblance to *P. quadrisetosa* (s.s.). In matter of costal and costular spines, *P. himalayense* is near to *P. sikkimense* but in the former these are sharp and raised. Both the laminar surfaces are beset with articulate hairs.
The two forms in *P. himalayanae* are very close differing at best in size of pinnules (Figs. 98, 99); 8 mm. x 1 cm. x 2 - 2.5 cm. in forma $\alpha$ and 1.5 cm. x 4 mm. in forma $\beta$. The former has usually bifid lower pinnas but quite often two basiscopic secondary pinnas may be borne on the basal pinnas. Forma $\beta$, on the other hand, bears 2-4 secondary pinnas basiscopically (usually more than two).

Both forms are restricted to round about Lebong forests in Darjeeling. They often occur close by, usually in open cleared lands, presenting a basket-like bushy habit.

Cytologically forma $\alpha$ is diploid apogamous ('$n$' = 58, Fig. 100) while forma $\beta$ is triploid apogamous ('$n$' = 87, Fig. 101). This is an additional difference which is also manifested in the spore size. Sixteen-celled sporangia are not observed.

5. *Pteris aspericaulis*, *P. rigida* and *P. subindivisa* Clarke (sub-complex)

*P. aspericaulis* : It is nearly *P. aspericaulis* Wall. (Fig. 102). It is a rigidly coriaceous species, and often high red in the veins, young fronds being deep red. It is plentiful round about Darjeeling and N. Sikkim between 670 - 2,200 m. altitude, occurring most commonly on forest margins. The lower pinna is commonly bifid but large sampling often includes one pinna of the lowest pair simple and the other bifid, or at times both are simple whence it resembles super-
Pinnules in *P. subindivisa* Clarke (a low altitude fern). But it differs from the latter in its large size, number of lateral pairs of pinnae, pinnule size, scales (Fig. 63 H), and spores. Pinnules in *P. aspericaulis* (Fig. 103) are sharply acute, cut down to the costa and partially fertile to almost wholly fertile.

*P. aspericaulis* is diploid apogamous (n' = 58, Fig. 104) throughout Darjeeling and Sikkim Himalayas. Usually 32 tetrahedral spores result in a sporangium. Sixteen-celled sporangia are never observed. It should be noted that T. Walker (1962) reports *P. aspericaulis* Wall. from Assam as triploid apogamous.

*P. rigida*: The very name applied suggests its extremely rigid and tough texture. It is characterized by dark dull green fronds of ample size arranged in a basket fashion around almost an erect rhizome. Scales (Fig. 63 I) are long, linear-lanceolate extending to appreciable distance over the stipe, a character which separates it from every other Himalayan species investigated. Scales bicolorous, central brown pigmented region of nearly 11 cells (often sclerotic) and pale smooth (or with few peg-like projections) 1-3-celled margin. Pinnae (Fig. 105) are narrowly linear-lanceolate, deflected upwardly, basal ones bifid. Pinnules (Fig. 106) are small (1.3 cm. x 5 mm.) sharply acute and spiny at apex. When fertile, indusium almost reaches the costule from both sides (Fig. 107) in Darjeeling populations. The N. Sikkim
populations have usually narrower indusia (Fig. 106). Veins end above the sinus, with not much dilated ends but continuous with the margin. Spores are equally distinctive with narrow equibroad equatorial collar, dark brown (Fig. 108).

In some of the morphological features it matches broadly with P. 'aspericaulis', a factor important cytotoxonomically since all variable populations of P. 'rigida' are diploid sexual with n=29 (Fig. 109). Sporangia regularly yield 64 tetrahedral spores. The species has been gathered plentifully near Lebong Hospital (Darjeeling) and about Chunghang (N. Sikkim) on way to Lachen.

P. subindivisa Clarke: It is a low level fern, plentiful on wet rocks by the pony path along the rivers Teesta and Rangit, particularly between the 13th and 16th mile on way to Teesta from Badamtam. Clarke’s (1880) collection also came from this very locality but unfortunately he himself reduced it to a varietal rank in P. quadriaurita (cf. Beddome, 1883) and it was followed by Christensen (1906). In N. Sikkim it occurs at Dikchu, but not common. It usually bears 1-3 lateral pairs of pinnae, the terminal being the largest and the basal ones simple (Fig. 110). It has nearly the same coriaceous or rigidly herbaceous texture as P. 'aspericaulis' and is likewise red nerved, often wholly red when young. Pinnules (Fig. 111) are acute to a sharp point, veins distinct, swollen at the ends and are continuous with the margin. Scales linear,
long hair pointed with a broad somewhat curved base, and distinctive (Fig. 63 J). Central zone is brown, often sclerotic and pale margin is deeply lacerate due to numerous peg-like projections formed of two contiguous cells. Spores are perfectly smooth in comparison to somewhat warted in P. 'asperiiculis'.

All populations investigated are diploid sexual, showing n=29 (Fig. 112) at diakinesis. A sporangium yields 64 tetrahedral spores.

6. *Pteris 'pseudobiusurita'*

Specific name 'pseudobiusurita' has purposely been assigned to this well marked Sikkim and Darjeeling (rare) populations because Dr. S.K. Mukerji (Calcutta) thought it as *P. biaurita* L., perhaps because of the apparent resemblance to the open triangular costal aeroles, often observed in *P. biaurita* var. *nemoralis* (cf. Christensen, 1932). *P. biaurita* is characterized by narrow costal aeroles which extend from costule to costule, the arching veins being practically parallel to the costa. Kew was correct in keeping my specimens in *P. quadriaurita* complex.

Since it is distinct from *P. biaurita*, it requires some taxonomic description. Rhizome erect, generally emergent, with tuft of fronds in a rosette; pinnae directed upwards, caudate, basal ones bifid (Fig. 113). Scales up to 3 cm. on the stipe, bicolorous, middle zone deep blackish-brown,
pale margin frayed due to hair-like projections of some cells (Fig. 63 K). This is unlike *P. biaurita* in which the margin is usually one cell thick produced mostly into peg-like projections. Lowermost pinnae largest, lanceolate, nearly 20 x 2.5 - 3.5 cm., cut down to costa into 24 pairs of acute pinnules.

Veins simple or forked and invariably the lowermost pair of veins (basiscopic, if forked), one from the costa and the other from costa curve towards and end just at the sinus but never meet below it in a campteroid manner (Fig. 114).

Hundreds of individuals are analysed for vein character to utmost constancy and this alone can segregate it from rest of the Himalayan species. Pinnules about 2 cm. x 4-6 mm., fertile from sinus to almost the acute tip (Fig. 115). Veins fall short of the margin and ends not swollen. Two to five-celled articulate hairs present on both surfaces, in the region of costa and veins. Spores deep brown, tetrahedral, exine slightly warted or wrinkled (not smooth) - somewhat tuberculate in *P. biaurita*.

Morphology alone can safely segregate *P. pseudo-biaurita* from rest of the *quadriaurita* complex and *P. biaurita* (including *P. nemoralis* Willd.). In genetic constitution, it is a triploid apogamous showing 'n' = 87 (Fig. 116).

Eight-celled sporangia occur in abundance while the presence of spore-mother-cells equivalent of 16-celled sporangia can only be inferred from the admixture of abortive spores among large number of well filled ones.
The species in fact needs little introduction and can be separated with comparative ease by large tapering, falcate segments, serrated at their barren apex (Figs. 117, 118a,b). Clarke's (1880), Beddome's (1883) and Hope's (1901) account is excellent but in spite of it, it seems to be little understood, so much so that P. *laxa* was identified as *P. excelsa* Gaud. both at Kew and Calcutta. Hence a few taxonomic notes are required here.

Rhizome ascending, not much thick, beset with membranaceous lemon coloured linear (broad below) concolorous scales with entire margin (Fig. 63 L). Fronds usually 120-180 cm. or more with remotely arranged, deeply green glossy caudate pinnae, nearly 20-33 x 10-15 cm. Basal pinnae usually simple, rarely bifid. Pinnae deeply cut, pinnules acute, 5-10 x 1-1.5 cm., partially or wholly fertile; involucres broad, olive green or brown, barren apex serrate. Lower veins reach above the sinus, vein ends dilated and fall short of margin (Figs. 118a, b). Costal spines small and herbaceous, no costular spines. Undersurface beset with articulate hairs, upper naked.

It is a graceful fern that loves water and is plentiful in N. Sikkim, below Lachen (2600 m.). It is a diploid sexual (n=29, Figs. 119a, b) and there is a regular production of 64 tetrahedral spores in each sporangium.
8. *Pteris subquinita* Wall. ex Hope

This is the smallest and membranaceous species of *Pteris*, 20-25 cm. high and has been collected plentifully from shaded and well protected wet rocks near Chungthang (1,700 m.) in N. Sikkim. Rhizome is small compact; scales only on rhizome, lanceolate, small, composed of elongated cells, deep brown, margin entire (Fig. 63 M). Stipes tufted, straminous, thin, terete, 7-13 cm., lamina pleasing green, herbaceous-papyraceous, broadly triangular, 9-12 x 9 cm., usually consisting of one terminal (the largest and broadest) pinna and one lateral pair (frequently-rarely 2 or 3) which bears one secondary basiscopie pinna or quite often the basal pinna is simple and only the basiscopie pinnule is elongated (Fig. 120). Pinnae cut down to the costa into equally broad segments spreading at right angles from the costa, 6 x 2-3.5 cm. Pinnules partially fertile from above the sinus to much below the acuminate apex (Fig. 121). Veins distant, prominent on both surfaces with slightly dilated ends, slightly continuous with the margin. Indusium broad, brownish; costular spines absent and costal spines very small, herbaceous. Few long articulate hairs in the region of costa on the undersurface, elsewhere glabrous. Spores tetrahedral, smooth to slightly rough, brown, and a narrow indistinct equatorial collar.

* Nomenclature after Alston and Bonner (1956).
The above diagnosis separates _P. subquinata_ distinctly from the remainder of the taxa, particularly with respect to size, habit, texture, and above all scales. It is a common fern in Nepal, Sikkim and extends westward to Kumaon and N.W.F.P. (cf. Hope, 1901). It is one of the prettiest species and the bifid lower pinnae, as accurately stated by Hope (l.c.), forms an unequally armed St. Andrew's Cross.

It is a diploid sexual species with _n_ = 29 (Fig. 122) and with a normal output of 64 spores per sporangium.

9. _Pteris roseolilacina_ Hieron.

It has been identified by Mr. F. Ballard (Kew) who also stated it to be perhaps the same as _P. aspericaulis_ Wall. Of course this attitude is in accordance with Christensen (1931) who treated _P. roseolilacina_ as a variety of _P. aspericaulis_. I have not seen the type of _P. roseolilacina_ and I am not very sure about the nomenclature of this taxon but have tentatively retained it as _P. roseolilacina_ since Ballard could name it as such. It is, however, decidedly different from _P. 'aspericaulis', _at least the E. Himalayan element.

This is a new record for the Himalayas and is collected from Badamtam-Teesta pony path along the river Teesta in Darjeeling district. It is certainly not plentiful but its rough crisp fronds, red when young, with their basiscopic secondary pinnae forming an unequally armed cross with the basal pinnae (Fig. 123), hardly escape a fern collector. Taxonomic
notes are desirable here to stress its morphological distinctness from P. 'aspericaulis'.

Rhizome small, compact, scaly. Scales small, broad at base narrowed upwards into a hair point (Fig. 63 N), deep black (sclerotic) in the central region, pale lacerate margin of usually elongate or transversely elongate cells (never quadrate as in rest of the 'quadriaurita' complex), commonly produced outwardly into elongate peg-like projections (Fig. 65), pale margin narrow, central cells generally elongate. Fronds dull green, purple red when young, thin and crisp, 22-50 cm., stipes straminous-greenish purple, terete. Lamina with usually 4-5 lateral pairs of pinnae with caudate apices, lowermost largest (9 x 1.5-2 cm.), bifid or occasionally with two basiscopic secondary pinnae. Pinnae cut down into nearly 25-30 small fine linear (1.6 cm. x 3 mm.) pinnules obtuse-acuminate (somewhat) apex (Fig. 124). Costal and costular spines numerous, long (up to 1.5 mm.), narrow and sharp, more elongate near the apex, often borne on the veins (Fig. 125). Spines directed perpendicular to surface. Veins close, distinct, half raised, end above sinus, little dilated, fall short of exact margin (or even continuous). Both surfaces beset with 3-5-celled articulate hairs. Pinnules partially fertile, indusium broad, brown. Spores (Fig. 126) deep brown, warty, tetrahedral with a distinct but narrow equatorial collar.

It is a diploid sexual with invariably 29 bivalents at diakinesis (Fig. 127) and 64 tetrahedral spores are formed.
in each sporangium. Recently T. Walker (1962) reports
2n = 58 for the species from Nepal.

10. *Pteris longipes* Don (sub-complex)

The Indian *P. longipes* Don belongs to section
Tripartitae wherein the lamina is divided into a central
portion and two basal opposite branches of about the same size.
Each division of the ternately divided frond resembles a frond
of *P. quadriaurita* in which the basal pair of pinnae are undivided.
Another prominent character is the costal spines which are
sharp and lie perpendicular to the costa. Circumscribed as
such there are two distinct forms in E. Himalayas. One of them
has horizontally placed basal branches; broader segments,
serrated at their barren apex (Figs. 128, 132). The second
type is characterized by ascending basal branches, smaller
segments with entire barren apex (Figs. 129, 133). However,
Clarke's (1880) and Beddome's (1883) description of
*P. longipes* and the figure referred to by them (Bedd., F.S.I.
t. 32, 1863) exactly tallies with the first type with serrated
segment apices. It is a common graceful fern in N. Sikkim at
about 1,300 - 1,700 m. and was gathered on several occasions
from Gangtok to Dikchu and further to Singhik, but is rare in
Darjeeling. The second type appears to be rarer in the area
since it could be collected only once in 1956 near Lebong
Hospital (Darjeeling) at about 1,650 m.

Apart from it, more important observations concern
the extent of pinnation of the two lateral divisions in
E. longipes. The smaller individuals (often sterile) have
generally the two lateral divisions less pinnate on acrosopic
side, and very often bears pinnae only on the basiscopic side*. This
condition presents a superficial resemblance to E. 'sikkim-
ensis' where the frond is equally large and the basal pinnae
are provided with 2–6 secondary pinnae basiscopically. This
is perhaps the reason why E. 'sikkimensis' (Fig. 86) was
identified as E. longipes (= E. ruelliana Ag.) both at Kew
and Indian Botanic Gardens, Calcutta. The two species are
widely different in scales, spores, costular spines, barren
pinnae apex and in general aspect. It also implies that both
at Kew and Calcutta, the bundles of E. longipes represent a
mixture of some species. Apart from morphology the two species,
E. longipes (n=29) and E. 'sikkimensis' (n' = 87), differ
markedly in cytology, a point which is significant in cytotax-
nomy.

Both E. longipes Don and its segregate are diploid
sexual with n = 29 (Figs. 130, 131a,b). The normal output
of spores is 64 per sporangium.

Since the two Himalayan types with the aspect of
E. longipes are diploid sexual, an intensive morphological

*Christensen and Holttum (1934) have referred such forms from
Borneo as E. longipes var. philippensis (Fée) G. Chr., which
I feel may be an extreme form of E. longipes occurring there.
comparison of the two is essential for taxonomic evaluation of
the form with entire segments, although the two characters,
stated earlier by themselves are perhaps sufficient to segre-
gate the two forms.

Close morphological comparison of the two forms
is attempted in Table XIV, which clearly indicates that apart
from the nature of basal branches and segment apices ( Figs.
132, 133 ), the two forms differ markedly in texture, colour,
size of pinnules, fertile region, veins, size of costal spines
and the presence or absence of costular spines ( Figs. 134,
135 ). These are enough to justify each a distinct specific
status.

There seems to be no other record from India of
a ternately divided species in free veined Pteris except
P. longipes Don ( syn. P. pallucena Ag., cf. Clarke, 1880 ).
It is learnt from Kew that the second form ( Figs. 129, 133 )
has not been described so far. Hence, the new Himalayan
segate deserves a specific name and P. mehrae is suggested,
the species being named after my revered teacher, Prof. P.N.
Mehra. A brief taxonomic description is given below:

Pteris mehrae  sp. nov.

Rhizome upright, fronds tripartite, firm membra-
naceous-thickish, 100 cm. long, stipe as long as lamina, seg-
ments narrow nearly 6 x 2 mm., costa mostly beset with brownish
articulate hairs ( up to 16-celled ), segments partially fertile,
barren apex slightly wavy to entire, indusium broad, thin
membranaceous but firm, costal spines prominent, 1.5 mm. long,
sharp and perpendicular to surface, costular spines absent,
spores brown, smooth with small equatorial collar ( Figs. 63 P,
129, 133, 135, 136 ).

11. *Pteris semipinnata* L.

This is the only species in the present study
which defies the general grouping adopted here. This well
known South East Asian ( incl. Japan ) species is characterized
by pinnae lobed only on the basiscopic side and a terminal
elongated pinnatifid apex ( Fig. 137 ). Clarke ( 1880 ) refer-
red about the Chinese and Japanese specimens in which the
pinnæe are pinnatifid more or less on the upper margin until
forms occurred so completely bipinnatifid that "it is difficult
to say what should be done with them". Occasionally the Malayan
specimens bear a lobe near the acrosopic base of the pinnae
and this feature is permanent in the closely allied Malayan
species *P. dalhousiae* Hk. Since intermediates between the two
species occur, Holtum ( 1954 ) suggested 'perhaps hybridiza-
tion occurs'.

From a morphological standpoint, the lobing of the
pinnæe ( partial pinnation ) alongwith an elongate pinnatifid-
sect terminal pinna is a *quadriaurita* group character ( in
*cretica* group lamina terminates in an elongate simple pinna
even if lateral pinnæe may bear lobes on both sides- *P. multifida*).
The general aspect of lobing is also different. The type of margin (Fig. 138) can closely compare with *P. ensiformis* (cretica alliance) but, in general, may also conform to *P. axysala* (quadriaurita group). Lanceolate bicolorous scales (Figs. 139a,b) with the central zone of elongated brown pigmented cells and the lemon yellow margin also of elongate cells merging into smooth quadrate cells is unlike *P. aratica* and also finds no parallel in *P. quadriaurita* (s. lat.). Spores possess a narrow equatorial collar and a finely granulated or (tuberculated) exine (Fig. 140), which to some extent compares with *P. aratica* alliance. Hence, *P. semipinnata* holds a peculiar position in *Pteris* as regards morphology and extent of pinnation.

The Himalayan populations gathered at Manjitar (200 m.) below Darjeeling are tetraploid (*n* = c.58, Fig. 141) with usual output of 64 spores in a sporangium. Recently T. Walker (1962) records the species also as tetraploid from Malaya, Hong Kong and Formosa. Perhaps it would not be too much to suggest experimental hybridization between some suitable forms in *P. quadriaurita* and *P. aratica* alliance which might elucidate *P. semipinnata* character as an allotetraploid between the two groups. The variation in the extent of pinnation of pinnae may be due to segregating populations.
DISCUSSION

1. *P. Himalayan element* and *Pteris quadriaurita* Retz. (s.s.)

The section *Quadriaurita* is one of the most difficult and centres round the *P. quadriaurita* complex, nearly all the forms being understood previously as forms of *P. quadriaurita*. The extensive collections and their intensive study of taxonomical characters have revealed 17 elements in the group (cf. Table II), and the preceding pages have been attributed to their cytological status and their morphological criteria. Since the name *quadriaurita* is associated with the complex, it is imperative to know what *P. quadriaurita* Retzius sensu strictus is. The type of *P. quadriaurita* is deposited in the herbarium at Lund in Sweden and was collected by König in Ceylon. There are no duplicates of this collection and hence a type sheet has not been available for study. All the same three excellent photographs (Fig. 62) representing the entire plant, the upper halves of the pinnae and the venation in the type specimen are kindly supplied by Dr. G. Taylor (Kew). From these photographs the following observations are made:

The type specimen bears the stamp of Herbarium Retzius Lund at the top right hand corner. There is no remark as to the name of the species by Retzius except at the bottom right corner, it is written Vertel. In addition, there are two labels, one of F. Ballard who determined it to be *P. quadriaurita*
Retz. on 24.10.1929 while the second bears 'Type of P. quadriaurita Retz. obs. vi. 1938 and determined on 19.8.1938'. There is no doubt that it represents the type of P. quadriaurita. The frond is an incomplete one and mainly shows the laminar portion. Lamina nearly 25 cm. x 12-17 cm., with six lateral opposite to sub-opposite pairs of pinnae and a terminal one of similar shape but larger than the ones immediately below. Basal pinna bifid, acroscopic pinna 10-12 x 2.5 cm. The next pinna also bifid. Pinnae deeply cut down nearly to costa into 12-16 pinnules, basiscopic ones slightly larger. Pinnae end in an elongate caudate apex, 2-3.5 cm. long. Pinnules equidistant from base to apex and the sides lie almost parallel, 1-1.5 cm. x 4 mm.; partially fertile, from just above the sinus to 1/3 distance down the apex; barren apex crenate-serrate with denticulations directed upwards; apex obtuse-acute. Indusium nearly 0.6 - 0.7 mm. broad. Veins free, forked once near the base; lowermost veins, one from the costa and the other from costule end much above the sinus; fall short of margin and dilated at ends.

When the type of P. quadriaurita (s.s.) is compared to the presently discovered E. Himalayan forms, it appears that the caudate apex of pinnae in P. quadriaurita (s.s.) is equally characteristic of P. 'blumesna', P. 'sikkimensa', P. 'asperigaulis', P. 'pseudohiaurita' and P. excelsa. The serrated barren apex and the swollen ends of the veins, falling short of margin, are shared only by P. excelsa and P. longipes.
The latter may be regarded as an extreme member of *P. quadriaurita* complex in which the primary stipe is tripartite. It would, therefore, seem that it is only *P. excelsa* that can be related somewhat by its positive characters to *P. quadriaurita* (s.s.), but it differs markedly in its extremely large size (150–180 cm., pinnae up to 30 cm.; pinnules 5–10 cm.), veins forked at or near the middle or 3–4 branched, broad indusium. Sikkim collections are truly *P. excelsa* and tally very closely with the descriptions of Beddome (1883), Clarke (1880) and Hieronymus (1914b). It can be safely concluded that at least in E. Himalayas, *P. quadriaurita* (s.s.) is not represented, provided the character of veins, barren apex are taken to be constant and significant. The description of Clarke (l.c.) and Beddome (l.c.) for *P. quadriaurita* is so general as to include all the diverse elements in it. It is anyhow pertinent to point out that out of all the Himalayan forms examined by Mr. F. Ballard (Kew), *P. 'blumeana'* is stated to be as good *P. quadriaurita* from a morphological standpoint. This form has an entire barren margin, vein ends not swollen and continuous with the margin. Above all, *P. 'blumeana'* is diploid apogamous while *P. quadriaurita* (s.s.) is a diploid sexual (cf. T. Walker, 1958), which also implies that true *P. quadriaurita* is not represented in E. Himalayas. T. Walker (1958) has perhaps correctly pointed out that the name *P. quadriaurita* in any sense should be restricted to Ceylon and South Indian populations.
2. Species-complexes

P. quadriaurita (s.l.) in E. Himalayas is a huge species-complex and even after the taxonomic segregation made here, some of the taxa do include cytological races, while some taxa appear to be interrelated. Yet another category of taxa concern the existence of distinct morphological types within a good species, i.e. P. longipes Don. Such groups of taxa have been stated earlier in the text to be sub-complexes. The various sub-complexes observed are as under:

i) P. 'longipes', sub-complex comprising of two forms (♂ and ♀), both diploid sexual.

ii) 'blumeana complex' comprised of P. 'blumeana' (2x apog.) and P. 'sikkimensis' (3x apog.).

iii) P. 'himalayense', sub-complex comprising of two forms, forma α (2x apog.) and forma β (3x apog.).

iv) P. 'rigida' (2x), P. 'aspericaulis' (2x apog.), and P. subindivisa (2x) sub-complex.

v) P. longipes, sub-complex comprising of two forms, P. longipes Don (s.s.) and P. mehrees Verma, sp. nov., both diploid sexual.

The last mentioned sub-complex need not be discussed again since it has been sufficiently detailed earlier (p. 62-65). The first four sub-complexes are discussed below:
i) P. 'kongulansa' sub-complex

Two forms, $\alpha$ and $\beta$ (Figs. 66, 67) have been maintained on morphology, both being diploid sexual. However, certain individuals morphologically closer to forma $\beta$ are discovered which show at meiosis $2n = 41$ as the mean chromosomal associations (cf. Table XIII). Often 29 bivalents with normal anaphase I and anaphase II are observed. The meiotic irregularity very likely reveals the hybrid nature of these individuals. Critical morphological comparison, could place them more or less intermediate between forma $\alpha$ and forma $\beta$. The normal production of spores speaks for sexual reproduction and if these are hybrids between forma $\alpha$ and forma $\beta$, the two putative parents are genetically close. Yet the two forms are very much distinct morphologically, possibly they have not yet achieved full genetic segregation.

ii) 'blumeana complex'

It is comprised of diploid apogamous P. 'blumeana' and triploid apogamous P. 'sikkimensa'.

P. 'blumeana' ('n'=58): Metaphase analysis of spore-mother-cells from a 16-celled sporangium is not known. Observations of nearly 23-34 lagging univalents at anaphase I is perhaps sufficient to indicate that nearly 50 per cent of chromosomes enter into associations while the rest remain as univalents. This would in all probability imply a hybrid
origin for this taxon but scanty data may at times be misleading. If it were to be of hybrid origin, the probable parents are hard to suggest because of its apparently wide distribution. Sexual diploids occur in Sikkim and Darjeeling (and as well as W. Himalayas) which together with true E. quadriaurita (Ceylon diploid) may unfold the issue.

P. 'sikkimense' ( 'n' = 87) It is distinct from P. longipes Don with which my specimens were identified by various persons and in fact is related to P. 'blumeana' in gross morphology (p. 50, 51). However, both maintain their distinctness in morphology as well as in chromosome number for P. 'sikkimense' is triploid apogamous and P. 'blumeana' diploid apogamous. Genomic constitution of the triploid is not known since 16-celled sporangia have not been analysed. But in the absence of tetraploids in the 'quadriaurita' complex in E. Himalayas, the triploids have evidently resulted from a cross between a sexual and an apogamous diploid, the latter contributing the apogamous behaviour. One of the parental possibilities seems P. 'blumeana' ( 'n' = 58), to which P. 'sikkimense' shows some good resemblance. It would, however, be idle to speculate at this stage about the sexual diploid for which a thorough search is required in Sikkim and elsewhere coupled with actual synthesis.

iii) P. 'himalayense' sub-complex

Close morphological resemblance of forms and
form $\beta$ in $P.$ 'himalayense' perhaps signifies the diploid apogamous taxon ($\text{forma } \alpha$) to be part parental to the triploid ($\text{forma } \beta$). Chromosome number coupled with spore size, pinnule size and number of basiscopic secondary pinnae are enough criteria to afford each form a distinct taxonomic entity. As to the possible sexual diploid involved in the triploid, a speculation is not worthwhile, since the triploid shows little deviation from the diploid apomict $P.$ 'himalayense'.

iv) $P.$ subdivisa, $P.$ 'rigida' and $P.$ 'aspericaulis' sub-complex

$P.$ subdivisa (diploid sexual) shares with $P.$ 'aspericaulis' (diploid apogamous) some morphological characters while the latter finds resemblance in others to $P.$ 'rigida' (diploid sexual). Hence the three taxa form a related group, though distinct by themselves, both in morphology and chromosome number. A comparative statement of characters in these three taxa is tabulated in Table XIVa. It reveals that $P.$ 'aspericaulis' represents an intermediate taxon between the two extremes, $P.$ 'rigida' and $P.$ subdivisa, especially in the number of lateral pairs, nature of basal pinnae, position and nature of scales, pinnule size. In rest of the characters $P.$ 'aspericaulis' either resembles $P.$ 'rigida' or $P.$ subdivisa. Such a state of affairs is expected in interspecific hybrids, and in apogamous ferns this condition is likely to multiply unaltered. $P.$ 'aspericaulis' is diploid apogamous and fills also the altitudinal distributional gap
between *P. subindivisa* (n=29, 300-500 m. alt.) and *P. 'rigida'* (n=29, 1650-1750 m. alt.). These considerations are suggestive of at least *P. subindivisa* being part parental to

*P. 'asperigaulis'* and Clarke's (1880) remarks, "that it* is

related to *P. asperigaulis* Wall. of which it may be an extreme

form", are very pertinent in this direction. *P. 'rigida'* is

somewhat variable in the Himalayas and some form of it most

likely serves as the other parent in *P. 'asperigaulis'*. Furthermore, T. Walker (1962) recently reports

triploid apogamous populations of *P. asperigaulis* Wall. from

Assam which thus extends the limits of the complex and requires

further search in the Himalayas.

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*P. subindivisa*
The group derives its name from the genus *Campteria* Presl characterized by a single series of costal aerolae formed by the basiscopic basal vein from one costule joining with the acroscopic basal vein of the costule next below, with several branch veins passing from the arc to points on the edge near the base of the sinus (Fig. 142). *Campteria*, thus delimited, should have been *G. biaurita* Hk. (syn. *G. wightiana* Presl). The modern taxonomists have not allowed it a generic recognition and have transferred all such species to *Pteria* on the plea that in some individuals of *G. biaurita* the veins of the contiguous segments often miss connections.
below the sinus.

According to Clarke (1880) and Beddome (1883, 1892) only two species, *Pteris biaurita* L. and *P. wallichiana* Ag., occur throughout the Himalayas, particularly Darjeeling and Sikkim.

*Pteris biaurita* L.

*P. biaurita* is met with at lower elevations rather frequently in S. Himalayas and has been sampled from various localities between 200-800 m. altitude in Darjeeling district and Sikkim. Morphologically two distinct forms have persistently been observed in the area investigated. One of the forms has blunt segments with broad sinus and equal width of segments, never fertile to apex and venation is strictly campteroid (Figs. 142, 143), the arching vein being nearly parallel (often slightly triangular) to the costa.

The second taxon in general frond form, number of lateral pairs of pinnæ, and texture resembles the previous one but the segments are quite often narrow, acute-acuminate (sometimes bluntly obtuse), far apart (sinus broad) and almost wholly fertile (Fig. 144). Veins in general are campteroid with triangular aerolæ and sometimes seem to miss connections below the sinus (Fig. 145). The two forms have never been observed to be attached to a single rhizome.

Gamble (cf. Hope, 1901) had also two similar collections from Sehim, below Darjeeling and his samples of the second type contained individuals that often missed the
connections of the contiguous veins below the sinus. He had referred such individuals to *Pteris nemoralis* Willd. Previously *P. nemoralis* was taken to be synonymous with *P. hiaurita* (cf. Christensen, 1906) but presently it is regarded as distinct from *P. hiaurita* as evident from Alston and Bonner's (1956) report of *P. nemoralis* Willd. from Nepal. Christensen (1934), however, considers *P. nemoralis* as a synonym under *P. linearis* Poir., perhaps on the suggestion of Ching (1933) who would prefer to name all the Asiatic ferns hitherto called *P. hiaurita* as *P. linearis* Poir. Since Alston and Bonner's treatment is recent, I would prefer to retain the name *P. nemoralis* for the second form.

It is pertinent in this context to refer here to the criteria suggested by Christensen (1932) to distinguish the two taxa, *P. hiaurita* and *P. nemoralis*. According to him the typical form of the species (*P. hiaurita*) is marked by narrow costal aeroles that extend from costule to costule, the arching vein being practically parallel to the costa. In *P. nemoralis* the aeroles are triangular, often not closed. Himalayan samples are in well conformity to it and the first form (Fig. 143) becomes *P. hiaurita* while the second form (Fig. 145) is *P. nemoralis*.

It should be added that the scales both at rhizome apex and stipe base in both the taxa are narrowly linear to linear-lanceolate (Figs. 146, 147, 148), 1.5 - 3 mm., dark brown with pale yellow 1-2-celled margin, the latter produced
frequently into uniseriate hairs with the terminal cell often glandular. Most of the contiguous cells on the margin show marginal 'peg-like' projections. Scale structure is quite distinct especially from *P. pseudobisurita* (Fig. 65 K), which taxon is generally confused with *P. bisurita*.

**Cytology:**

*P. bisurita*: All the Himalayan collections of *P. bisurita* centred around Badamtam, Teesta and Sikkim are triploid apogamous revealing 'n' = 87 (Fig. 155). Only 8-celled sporangia are observed. It should be indicated further that Mehra (1938b) was the first to report apogamy in *P. bisurita* by direct germination of spores, collected in Sikkim.

The species is already known to be a species-complex, being diploid apogamous in Ceylon, Jamaica, Philippines, Ghana, Burma, Assam, Java and Sumatra, and triploid apogamous in Ceylon and Nepal (cf. T. Walker, 1962). It is obvious that even within Ceylon and Himalayas (Nepal, Darjeeling and Assam) both the cytotypes occur.

*P. nemoralis* Willd. (syn. *P. linearis* Poir.): It is only sampled from Badamtam in Darjeeling and Gangtok in Sikkim. Both these collections are triploid apogamous showing 'n' = 87 (Fig. 156) in an 8-celled sporangium.

Eight-celled sporangia outnumber the 16-celled ones and the latter are perhaps rare. Only two such dividing
spore-mother-cells could be analysed. The bivalents more often form a central somewhat interconnected or clumped mass that renders exact counting difficult. Though no critical analysis was made, but it became apparent that at least $28_1$ (27-30) and $26_{II}$ (or more) are present (Fig. 157). This roughly suggests the condition of $x$ pairs + $x$ univalents since 29 is known to be the basic number. Again at telophase II or the tetrad stage nearly 23-25 (24?) univalents are observed (Fig. 158) as laggards. Almost all the univalents are of the same size and it is likely that the univalents lag completely at metaphase I and perhaps only few may be included in the telophase I nuclei. That these lagging univalents may also divide at metaphase II or (perhaps also at metaphase I) is evidenced by the presence of nearly 41 'chromosomes' in one tetrad possessing four nuclei (Fig. 159). On the basis of size alone, some of them appear convincingly as divided univalents.

*Pteris wallichiana Ag.*

It is the most graceful species in *Pteris* characterized by fronds subpedately divided into 7-5-3 (rarely 9) pinnae which stand out in one plane in the form of a semi-circle subtended by very long stout stipes with broad base. The fronds generally vary from 80 to 250 cm, where most of the length is contributed by the stipe (up to 180 cm.). Pinnae are pinnated, secondary pinnae (Fig. 150) being 10-15 cm. long, linear-lanceolate, deeply pinnatifid. Segments (Fig. 151)
linear-lanceolate, somewhat falcate, obtuse-acute, sterile ones (as well as sterile margin) serrulate, never wholly fertile. Veins truly camptocentric with arching vein nearly parallel to the costa. Scales (Fig. 152) membranaceous, broadly lanceolate, 3-6 mm. long, yellow-deep lemon coloured, composed of elongated cells and with smooth margin. Stipe and rachis covered with 3-6-celled or more articulated hairs, closely adpressed which fall off even at touch. Spores are nearly similar to P. biaurita (Fig. 153) but the equatorial collar is broad in P. wallichiana (Fig. 154).

Morphologically speaking, at least two well defined forms occur in Darjeeling, one with dark brown stipe and rachis with two green stripes running along the entire length, one on each side of the dorsal groove; while the other possesses a crisp texture and dull green stipes and rachises. The two types of fronds have never been found attached to a single rhizome. Pteris wallichiana is a fern of open situations and occurs plentiful between 1,800 - 3,000 m. altitude both in Darjeeling and Sikkim.

**Cytology:**

The two forms differentiated on the colour of the stipe, rachis and texture are cytologically similar. The material yields rather easily to squashing and 29 bivalents are counted at diakinesis (Fig. 160) in each of the numerous collections. A perfectly regular meiosis yields 64 spores.