

DIVERSITY AND DISTRIBUTION PATTERNS IN THE PTERIDOPHYTE FLORA OF PAKISTAN AND AZAD KASHMIR

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Abstract

Current investigation aims to analyze diversity and nature of distribution of the pteridophyte taxa of Pakistan based on published literature and current field studies by the authors. Many field visits were conducted in Hazara Division and some locations of Gilgit-Baltistan province from 2012 to 2014. An updated checklist suggests that there are 202 species and intra-specific taxa distributed in 62 genera and 19 families. Dryopteridaceae was the largest family with 47 taxa (23.5%), followed by Pteridaceae (41 taxa; 20.5%) and Woodsiaceae (21 taxa; 11.5%). *Dryopteris* Adonson was the largest genus with 23 species (11.38%), followed by *Asplenium* L. and *Polystichum* Roth with 18 species (8.90 %) each. Generic index was 3.27. Sino Japanese elements were dominant with 154 taxa (78.35%), followed by Irano Turanian and Saharo Sindian elements with 6 (3.09%) species. Seventy three taxa (36.5%) were extremely rare and 36 rare (18%). Potential areas were Kashmir (110 spp.; 56.70%), Mansehra District (84 spp., 43.29%) and Abbottabad District (80 spp.; 41.23%). *Neolepisorus fortunei* (T.Moore) Li Wang is reported for Pakistan. The genus *Neolepisorus* Ching is also a new record for Pakistan. Further field studies are imperative in order to draw a true picture of the pteridophyte diversity of Pakistan especially focusing North Balochistan, Kurram Agency, Dir Upper, Kohistan and Gilgit-Baltistan.

Key words: Azad Kashmir, Diversity, Distribution Patterns, Pakistan, Pteridophyte Flora.

Introduction

Pteridophytes, the seedless vascular plants, constitute the third largest group, represented by 12838 species distributed in 19 orders and 58 families (Hasselaar & Swale, 2001). Majority of the species are distributed in tropical and subtropical areas with limited distribution in temperate regions. These taxa had a very flourishing past in dominating the vegetation on the earth about 280-230 million years ago (Parajuli & Joshi, 2014). Majority of the plants are now replaced by the seed-bearing vascular plants in the extant flora. However, they still constitute a fairly prominent part of the present day vegetation of the world with lesser degree of speciation and endemism (Smith, 1972; Kato, 1993; Chandra, 2000).

To date, about 5521 vascular plant species have been reported from Pakistan, distributed under 1572 genera and 220 families. Of these, c. 400 species are endemic distributed in 169 genera and 45 families (Ali, 2008). Phytogeographically, four regions have been identified viz., Irano Turanian, Sino-Japanese, Saharo Sindian and Indian region. Among these regions, Irano Turanian and Sino-Japanese regions are floristically richer (Ali & Qaiser, 1986). Major proportion of previously known pteridophyte taxa of Pakistan are reported from Sino-Japanese region (Stewart, 1972; Nakaike & Malik, 1992; 1993).

Previously, few workers have contributed in the exploration of the fern flora of Pakistan. Among these, Stewart (1972) was the main and prominent contributor. He listed about 133 taxa from Pakistan and Kashmir based on his own collections and collections of other workers in his precious catalogue entitled "An Annotated Catalogue of The Vascular Plants of West Pakistan and Kashmir". Later on Nakaike and Malik (1992; 1993) provided a check list of pteridophytes particularly focusing the North-Western Himalayan region of Pakistan. These findings were published in the Cryptogamic Flora of Pakistan. They

reported 87 taxa under 18 families and 30 genera. Shah (2001) also prepared a check list of 57 taxa of the Ayoubia National Park, Abbottabad District. The ferns and allies of the Western Himalaya were documented by Fraser-Jenkins (1992). He reported 189 species for Pakistan. Later on, he further added 52 taxa (Fraser-Jenkins, 2014). However, in the later case, he could not provide the precise localities of the taxa. Therefore, many taxa reported without precise locality could not be included in this study. Currently Gul *et al.* (2016) provided a check list of 130 taxa for Mansehra District and distributed in 34 genera and 17 families. Most of the species are common in these checklists.

In the current study an attempt has been made to compile an updated checklist, phytogeographical position and distribution patterns of the pteridophyte taxa of Pakistan and Azad Kashmir using previously published literature and field based observations by the authors. Frequent field visits were carried out in the Hazara Division and also visited some localities of Gilgit-Baltistan province as well.

Materials and Methods

Study area: Geographically, Pakistan has a unique position and is located between 23°-37° N and 61°-81° E, with an area of 804, 152 square kilometers. The altitude extends from sea level to 8, 611 m (K2, known as the second highest peak on Earth) and temperature ranges from well below zero in the high, glacier-clad mountains to 52°C (125°F) at Sibi in the plains. Mean annual precipitation ranges from c. 50 mm at Nok Kundi in Baluchistan to 2032 mm in the monsoonal uplands of Kashmir (Ali, 1978; Ali & Qaiser, 1986). This great variation in elevation, temperature, precipitation and other physical parameters resulted in diverse biotic communities (Ali, 1978). The unique combinations of various parameters coupled with climatic conditions support a rich fern flora of Pakistan.

Experimental Design: Several field trips were conducted in the Hazara Division especially potential sites (previously known and unexplored) of Mansehra District and few field trips in Hunza, Gilgit-Baltistan province. Plant sample of each taxon was collected and relevant information was noted properly. Collected material was pressed, poisoned and mounted on standard herbarium sheets. These plant specimens were further identified with the help of authentic literature especially Flora of Chana (Zhang *et al.*, 2013) Flora of North America (FNA, 1993). In addition to field studies, previously published literature was also thoroughly reviewed. Various parameters viz., main locality, sub locality, altitude, distribution, habitat type, collector's name

and year within study area (if available) were noted. Based on these findings, a comprehensive checklist was prepared.

To make base distribution concentration of the taxa, the study area under consideration was categorized into 11 main localities viz., Chitral District, Gilgit-Baltistan, Kohistan District, Mansehra District, Abbottabad District, Kashmir, Swat District, Dir (Upper & Lower Dir District), Kurram Agency, Punjab and Balochistan. In each main locality, each specific site from where the taxon collected or previously reported was considered as spot.

The following criterion was used to determine abundance:

Abundance	Condition
Very Common	If a taxon is distributed within 5 or more than 5 main localities in the study area or cultivated
Common	If a taxon is distributed within 3-4 main localities in the study area
Infrequent	If a taxon is distributed within 2 main localities in the study area
Rare	If a taxon is distributed within single main locality in the study area
Extremely Rare	If a taxon is distributed within single sub locality/single site of any single main locality in the study area

Generic Index was also calculated by the following formula:

$$\text{Generic Index} = A/B$$

Where:

A = Number of total known species;

B = Total known genera

Photographs were also taken during field visits especially focusing habitat, habit and reproductive parts. Current nomenclature was confirmed through the plant list (www.theplantlist.com). Finally, collected specimens were deposited in Hazara University Herbarium (HUP) for permanent records and future reference.

Results

Distribution and concentration: About 202 taxa are listed and distributed under 19 families and 62 genera. Dryopteridaceae is the largest family with 47 taxa (23.27%), followed by Pteridaceae and Woodsiaceae with 41 (20.5%) and 21 (10.5%) taxa respectively. The remaining families are represented by less than 20 species each. Genera-wise, *Dryopteris* was the largest genus having 23 taxa (11.38%). *Asplenium* and *Polystichum* come to next with 18 taxa (8.91%) in each genus. Less than 16 species were recorded for the remaining genera. Generic index was 3.47 (Tables 1-2). Locality-wise, maximum concentration was observed in Kashmir i.e. 119 taxa (54.45%), followed by Mansehra (84 taxa; 41.58%) and Abbottabad with 80 (39.6%) species. The remaining localities had less than 27 taxa each (Fig. 1). As for altitude is concerned, these taxa were distributed between 500m-6000m. Maximum number of the taxa (145 taxa; 71.78%) was recorded between 1100m-2599m. Above 3500m, number of taxa was declined abruptly and was favoring some Lycophytes like *Lycopodium selago* and *Selaginella sanguinolenta*. At 5000m only 2 species were recorded (Fig. 2).

Table 1. Family-wise number of taxa in Pakistan and Kashmir

Family	Genera (A)	Species (B)	% of taxa in total	Generic Index B/A
Aspleniaceae	2	20	10	3.27
Blechnaceae	1	2	1	
Dennstaedtiaceae	4	5	2.5	
Dryopteridaceae	6	47	23.5	
Equisitaceae	1	4	2	
Lomariopsidaceae	2	5	2.5	
Lycopodiaceae	1	1	0.5	
Lygodiaceae	1	2	1	
Marsiliaceae	1	2	1	
Ophioglossaceae	4	6	3	
Osmundaceae	1	3	1.5	
Psilotaceae	1	1	0.5	
Polypodiaceae	7	12	6	
Pteridaceae	12	41	20.5	
Salviniaceae	2	3	1.5	
Schizaeaceae	1	1	0.5	
Selaginellaceae	1	5	2.5	
Thalyppteridaceae	8	19	9.5	
Woodsiaceae	6	21	10.5	

Table 2. Ten Largest genera in the pteridophyte flora of Pakistan and Kashmir

Genus	No. Species	% in total
<i>Dryopteris</i>	23	11.38
<i>Asplenium</i>	18	8.90
<i>Polystichum</i>	18	8.90
<i>Chelidanthus</i>	13	6.44
<i>Athyrium</i>	11	5.45
<i>Thyelypteris</i>	09	4.45
<i>Adiantum</i>	07	3.47
<i>Pteris</i>	06	2.98
<i>Nephrodium</i>	05	2.48
<i>Selaginella</i>	05	2.48

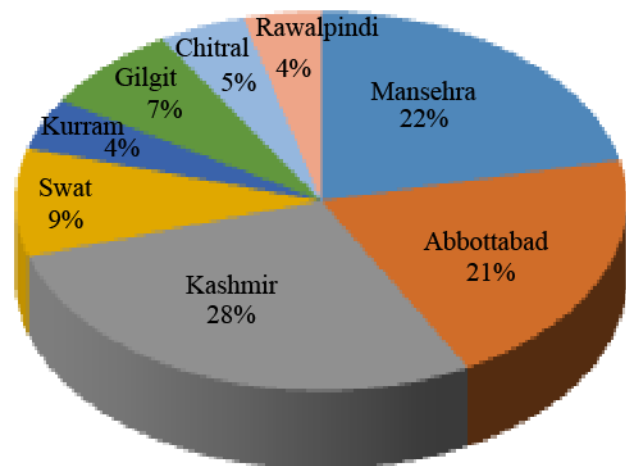


Fig. 1. Main locality-wise distribution of taxa in Pakistan and Azad Kashmir

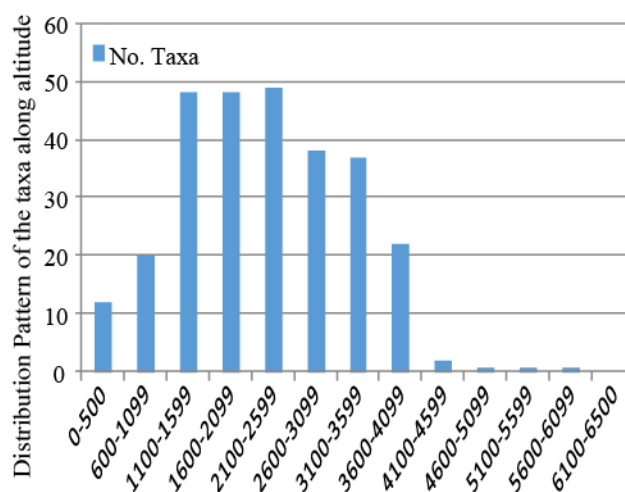


Fig. 2. Alleviation-wise distribution of the taxa in Pakistan and Azad Kashmir

Table 3. Distribution of the taxa in different phytogeographical regions of Pakistan

S.No	Region	No. of Species	%age in the total known taxa (194)
1	Sino Japanese	154	79.38
2	Irano Turanian	06	3.09
3	Saharo Sindian	04	2.06
4	Indian	0	0
5	Sino Japanese - Irano Turanian	19	9.79
6	Sino Japanese - Saharo Sindian	3	1.55
7	Species without locality information	04	2.06

Note: Among 202 known species, only 194 wild species were phytogeographically analyzed.

Phytogeographical analysis: Phytogeographical analysis is given in the Table 3. The Sino Japanese elements were dominant with 154 species (79.38%), followed by Irano Toranian having 7 (3.09%) species. Only 4 Saharo Sindian elements (2.06%) found to occur, while from Indian region even single taxa could not be reported yet. Among these taxa, uniregional elements were dominant with 164 taxa (84.53%), bioregional elements come to next with 22 taxa (11.34%). Among biregional elements, Sino-Japanese and Irano-Toranian shared 19 taxa, while the remaining 3 taxa were common between Sino Japanese and Saharo Sindian region. Among rare taxa, eight taxa have also least distribution worldwide and confined 2-4 countries only (Table 4). One hybrid viz., *Pseudophagopteria levingie* x *pyrrhorhachis* Nakai (Sharan Forest, Mansehra District) and two subspecies viz., *Asplenium daghestanicum* Christ subsp. *hunzanum* (Reichst. & Fraser-Jenk) Fraser-Jenk (For Hunza) and *Asplenium daghestanicum* Christ subsp. *skardense* (Reichst.) Fraser-Jenk (Skardu, Baltistan) for Pakistan (Fraser-Jenk, 1914).

Abundance: Abundance of known taxa has been shown in the Table 5. Seventy three taxa (36.5%) were extremely rare, followed by infrequent and rare taxa with 54(27%) and 36(18%) taxa respectively. Only 14 taxa were found to be very common and were distributed in more than 5 main localities. For extremely rare and rare taxa, Mansehra district was the most significant locality having 40 taxa, followed by Kashmir and Abbottabad District with 28 and 16 species respectively (Fig. 3). Further, spot-wise, the most important among these spots was the Ayubia National Park (Abbottabad), where maximum rare species i.e. 10 species (29.41%) were recorded, followed by Sikyan (Mansehra District) with 4 species (8.82 %). Some other important spots were Shalizan (Kurram valley), Siran valley (Mansehra District) and Kashmir with 2 species (4.4%) each. Sikyan (Mansehra District) with a small area in comparison to other spots but having most important species. Among total known spots, 10 were existed in Mansehra District.

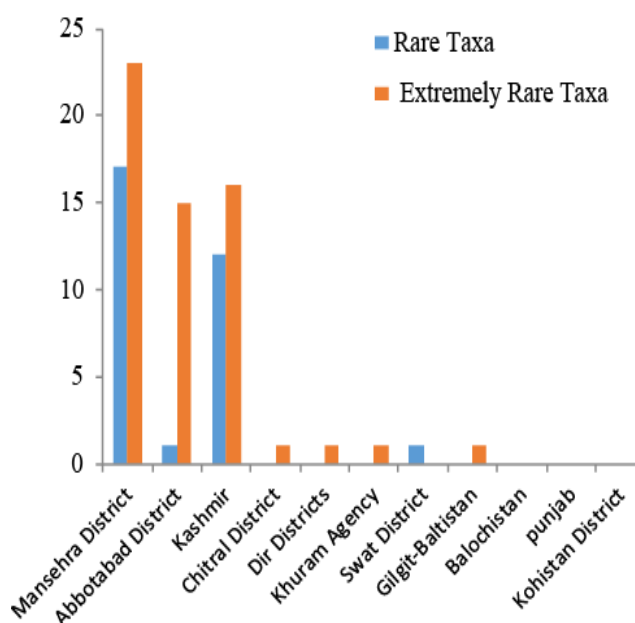


Fig. 3. Distribution of rare and extremely rare species in the study area

Table 4. Species and hybrids with least distribution in Pakistan and in the world.

S. No.	Species name	Local Distribution	Global Distribution
1	<i>Cheliantes bicolor</i> Fraser-Jenk.	Between Balakot and Mansehra	Pakistan, India and China
2	<i>Dryopteris redactopinnata</i> S. K. Basu & Panigrahi	Mansehra: Sharan Forest	Bhotan, India, Nepal, Pakistan, Kashmir
3	<i>Dryopteris yugongensis</i> Ching	Mansehra: Sharan Forest	Pakistan, India, China
4	<i>Dryopteris x macdonellii</i> Fraser- jenk.	Mansehra: Sikiyan near Nadi,	Pakistan and India
5	<i>Mildella nitidula</i> (Hook.) C.C. Hall. & Lellinger	Abbottabad: Ayubia National Park	Bhotan, India, Nepal, Pakistan, Kashmir, China
6	<i>Coniogramme affins</i> (C. Presl) Hieron	Abbottabad: Ayubia National Park	Pakistan, India and Nepal
7	<i>Deparia macdonellii</i> (Bedd.) M. Kato	Abbottabad: Sikiyan near nadi Mansehra	Pak and India
08	<i>Psuedophegopteris levingei</i> (C. B. Clarke) Ching	Abbottabad: Sharan Forest Mansehra	China Afghan, India, Pakistan, Kashmir
09	<i>Psuedophegopteris levingei x pyrhorhachis</i> Nakai	Abbottabad: Sharan Forest Mansehra	Pakistan (Endemic)

**Fig. 4.** *Neolepisorus fortunei*: A, Sporangia with single hair point; B, & C, close up view of Sori; D, Arrangement of sori; E, habit; F, sporangia

Table 5. Abundance of the taxa in Pakistan and Azad Kashmir

Abundance	No. of Taxa	% in the Total Taxa
Very Common	14	7
Common	23	11.5
Infrequent	54	27
Rare	36	18
Extremely Rare	73	36.5

New Generic Record

Neolepisorus fortunei (T. Moore) Li Wang is reported for the first time for Pakistan. The genus (i.e. *Neolepisorus* Ching) is a new record for Pakistan. The details of the species are as follows:

Neolepisorus fortunei (T. Moore) Li Wang, *Bot. J. Linn. Soc.* 162: 36. 2010; *Fl. China.* 2-3: 806. 2013. (Fig. 4)

Perennial herbs with long slender rhizome, 3.7 mm in diam. Scales pseudopeltate, appressed, triangular, 2.5-4 × 1.4-2 mm; margin slightly denticulate; apex acute, clathrate, cells longitudinally rectangular toward apex. Fronds homomorphic, slightly glaucous; stipe 0.5-20 cm, 1.5-3.8 mm in diam.; lamina simple, narrowly elliptic to linear, 18-23 × 1.7-2.2 cm, herbaceous; base narrowly decrescent, margin undulate especially towards the base; apex acute or acuminate; Veins distinct. Sori separate, yellow, in 1-row (slightly irregular) parallel to costa, orbicular, superficial; sporangia with paraphyses, simple uniseriate hairs with glandular apical cells

Specimen examined: Hunza District: Ghamesar, below Chaghurum Bati, c. 2600m, *Jan Alam & Naveed Alam* 8500 (HUP).

Habitat and abundance: Grows on shady stone wall's crevices along streams. Only few individuals were seen in the area. This seems to be a rare taxon.

Worldwide distribution and distinctiveness: About seven species have been reported for this genus distributed in NE India, China, Japan and Philippines. *Neolepisorus fortunei* (T. Moore) Li Wang is distinguished from the remaining taxa through its long slender rhizome, 1-row (irregular) orbicular superficial sori parallel to costa, and simple uniseriate hair like paraphyses with glandular apical cells (Zhang *et al.*, 2013).

Discussion

The pteridophyte group has been neglected in Pakistan as few workers have contributed to explore this plant group (Stewart, 1972; Nakaike & Malik, 1992, 1993; Shah, 2001). It is interesting to note that these workers mostly focused Kashmir and Hazara Division and the major portion of Pakistan is still unexplored. Himalayan range of Pakistan and Kashmir has maximum species diversity (i.e. c.70 %). Maximum concentration is probably due heavy

rain falls and availability of forest habitat. Few taxa have been reported for the Hindu-Kush and the Karakorum Range. The lesser rainfall from Eastern Himalayas to Western Himalayan hills is probably responsible for poor ferns diversity. As moisture, shade, forest cover and altitudinal medium range (i.e. from 500 m to 2800 m) promote growth and diversity of Pteridophytes (Bower, 1928; Kramer, 1990; Croft, 1999).

Generic index (3.27) shows remarkably high diversity for Pakistan and Azad Kashmir. However, keeping in view extensive and diverse area of the region, the current number of species seems to be less. As the most part of Pakistan is still unexplored i.e. whole of Baluchistan, Northern and North-Western areas of Khyber Pukhtunkhwa (Waziristan, Dir, Swat, Kalam, Chitral), Kashmir (Neelum Valley, Muzaffarabad), hilly areas of Punjab and Gilgit-Baltistan. Hence, a thorough exploration plan should be made at national level policies and there is possibility that many taxa could be added to the current list.

Species extinction phenomenon has become the most serious issue among the international communities. International Union for Conservation of Nature and Natural Resources (IUCN) has developed comprehensive criteria for evaluating the conservation status of a taxon (Anon., 2001). Unfortunately, in the case of Pakistan, even single pteridophyte species could not be evaluated according to these criteria. Therefore, the conservation status of the taxa should be evaluated at top priorities with special focus on rare taxa. Some spots are very important having many rare and extremely rare species in the study area: Sharan forest and Sikiyan, Mansehra District; Ayubia National Park, Abbottabad District. Hence, Sharan forest and Sikiyan should be declared protected area in order to protect these fragile taxa.

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