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Review Paper

FLORISTIC DIVERSITY AND CHOROTYPE ANALYSIS OF THE PTERIDOPHYTES OF PAKISTAN

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ABSTRACT

In the current investigation an attempt has been made to document the floristic diversity, chorotype analysis and occurrence of the Pteridophytes of Pakistan. Previously published literature was consulted in order to confirm the nomenclature, precise locations and other attributes of this unique group of plants. Many field trips were undertaken in various districts of Khyber Pakhtunkhwa and specimens of various herbaria were studied in Pakistan and from other countries. Our updated list of taxa confirms that there are 168 taxa belong to 45 genera and 19 families. Pteridaceace and Dryopteridaceae are found to be largest families with 35 taxa each (41.67%), followed by Aspleniaceae with 28 taxa (16.67%) and Athyriaceae with 24 taxa (14.28%). *Asplenium* is the largest genus with 28 taxa (16.67%), followed by *Dryopteris* with 17 taxa (10.12%) and *Polystichum* with 15 taxa (8.93%). Phytogeographically the Sino-Himalayan elements is the major component of the diversity of the pteridophye flora with 94 taxa (55.95%), 18 taxa (10.71%) are cosmopolitan and European elements have 13 taxa (7.74%). We found that 43 taxa (25.6%) are extremely rare, 39 taxa (23.21%) are infrequent and 37 taxa (22.02%) are common.

Key words: Diversity, Flora, Habitat, Nomenclature, Pakistan, Pteridophytes.

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INTRODUCTION

Pakistan is situated between 23°–37°N and 61°–81° E with a total land area of 804,152 square kilometers. There is great diversity with respect to elevation from sea level to 8611 meters at K2, the second highest peak on earth, and the temperature varies from well below zero in the high glaciers and mountains to 52°C at Sibi, Sindh and Jacobabad, Balochistan. The mean annual precipitation ranges from 50 millimeters at Nok Kundi in Baluchistan to 2032 millimeters in the monsoonal uplands of Azad Jammu and Kashmir. The great variation in topographic, physiographic, edaphic, climatic and elevation has resulted in great diversity amongst plant communities (Ali, 1978). Conditions support the richest pteridophytes diversity in Azad Jammu and Kashmir, followed by Khyber Pakhtunkhwa and Punjab province (Gul *et al.* 2016a, b). Pakistan is still without a cryptogamic Flora although collectors have been at work for more than thirteen decades, yet some districts newly merged in Khyber Pakhtunkhwa formerly known as tribal areas of Pakistan, Gilgit-Baltistan, Sindh and Baluchistan Province are still little known. Stewart (1972) listed one hundred and thirty-three Pteridophyte species from Pakistan but many of the names he used are no longer correct according to modern nomenclature. Nakaike and Malik (1992, 1993) documented eighty-seven taxa from various localities of Pakistan but now some of their species-names are synonyms. Fraser-Jenkins (1992, 1993, 2008a, 2009, 2014; Fraser-Jenkins *et al.* 2016, 2018, 2019, 2020a, b) documented the Pteridophytes of the far western Himalayan regions and reported hundreds of species from various countries including a comprehensive specimen-based inventory of the Pteridophytes of Pakistan. But there is a lacuna regarding a comprehensive pteridophyte Flora of Pakistan. So, there is a need to arrange pteridophytes of Pakistan according to a modern system of classification, notably (PPG - I, 2016) which we follow. Pteridophytes are largely dominated by Spermatophytes but still constitute an important and prominent part of present-day vegetation of the world. Although they belong to a primitive group of spore-bearing vascular plants they constitute a considerable percentage of the flora of tropical and sub-tropical areas (Tryon and Tryon, 1982) and the species we see today are often highly evolved through rapid modern radiation and reticulate evolution. Pteridophytes establish new populations in different areas of the world because they exhibit little endemism (Fraser-Jenkins, 2008b). Mostly Pteridophytes are herbaceous in nature and favor moist and shady habitats with a long evolutionary history (Kramer and Green, 1990). According to PPG-I (2016)

worldwide there are about 12,000 taxa belong to c. 337 genera, c. 51 families, 14 orders and two classes of Pteridophytes. Habitat diversity, precipitation, moisture and rainfall have a high influence on species-richness with altitudinal gradients for all kinds of plants (Murad *et al.* 2000). The richest diversity of Pteridophytes is found in tropical and moist temperate regions followed by subtropical regions. Pteridophytes are mostly found in cool, moist and shady habitats such as damp rocks, walls, crevices of rocks, tree trunks, ponds, forest floor and margins, along perennial streams and in deep ravines and grasslands, mostly becoming evident in leaf during the monsoon season, when luxurious growth occurs (Khullar, 1994, 2000). One hundred and thirty-three taxa had previously been reported from Pakistan (Stewart, 1972), 189 species and subspecies and 14 hybrids were reported by Fraser-Jenkins (1992) from Pakistan along with Jammu & Kashmir, 87 taxa were reported from various areas of Pakistan by Nakaike and Malik (1992, 1993); 26 taxa from Dir Upper, Khyber Pakhtunkhwa, Pakistan (Saleem *et al.* 2000). Murtaza *et al.* (2004, 2006) conducted anatomical and morpho-palynological studies of five species collected from Aalra and Neelum valley, Muzaffarabad, Azad Jammu and Kashmir, Pakistan; Haq (2007) misidentified *Lygodium hazaricum* Haq for a common *Lygodium japonicum* (Thunb.) Sw. from Nandiar valley district Battagram, Pakistan; Murtaza *et al.* (2008) misidentified *Schizea dichotoma* (L.) J. Sm. For a common *Asplenium septentrionale* (L.) Hoffm. subsp. *septentrionale* from Neelum valley, Azad Jammu and Kashmir, Pakistan. Iltaf *et al.* (2012) documented 36 taxa from Punjab province, Pakistan, though few were mistaken; Fraser-Jenkins (2014) documented a definitive list of 157 taxa of Pakistan, excluding hybrids, without providing locality-information, but based entirely on herbarium-specimens seen and reidentified and on his own extensive collections (all of which have kindly been made available to us as lists); Gul *et al.* (2016a) documented 133 taxa from Mansehra district, including cultivated taxa and repeated synonyms of few taxa with some misidentifications; Zayauddin (2016) reported *Salvinia molesta* from Gharo Thatta, Sindh, Pakistan. Fraser-Jenkins *et al.* (2016, 2018, 2019 and 2020a, b) documented the pteridophytes of India in detail with their distribution, including Pakistan. Bibi *et al.* (2021) documented 41 taxa from district Torghar, Pakistan; Irfan *et al.* (2021a, b) documented the genus *Adiantum* and *Selaginella* from Pakistan. Here an attempt has been made to investigate the floristic diversity, chorotype analysis and occurrence of the pteridophytes of Pakistan briefly.

MATERIALS AND METHODS

In the current study an estimation of floristic diversity and chorotype analysis of Pteridophytes of Pakistan was conducted according to Fraser-Jenkins (2014). Plant-specimens collected by many Botanists from Azad Jammu and Kashmir, Gilgit-Baltistan and the districts of Abbotabad, Buner, Dir lower, Dir upper, Kohistan, Malakand, Mansehra, Shangla, Swabi, Swat, Torghar and Murree hills of district Rawalpindi were identified in various Herbaria of Pakistan, along with MO in USA and virtually in UK and other herbaria in USA were consulted, namely BM, HUP, K, ICP, ISL, KUH, MO, MUZU, NY, PUB, PFI, PMNH and RAW. All the collections with authentic information have been documented by us and C.R. Fraser-Jenkins, who has verified and listed all material and provided lists to us. The different parameters, correct name, family, locality, altitude, habitat, distribution, collector's name, year, voucher specimen-number and herbarium acronym were documented. Based on all these findings a comprehensive checklist was prepared and plants were classified according to the nomenclature of PPG-I (2016). Previous literature of Duthie (1898); Hope (1896); Stewart (1944, 1945, 1957, 1967, 1972, 1982); Nakaike and Malik (1992, 1993); Fraser-Jenkins (1992, 1993, 1997, 2008a, b, 2009, 2014); Khullar (1994, 2000) and Fraser-Jenkins *et al.* (2016, 2018, 2019, 2020a, b) were consulted for authentic identification of species. The occurrence of taxa was calculated according to Gul *et al*. (2017) with given formula: A species was considered as abundant if it was recorded from five or more than five localities, if recorded from four localities it was designated as common, if recorded from three localities designated as infrequent, if recorded from two localities designated as rare, and if reported from only single locality it was designated as extremely rare. The generic Index was calculated by the given formula: Generic Index = B/A; Where: B = total number of recorded taxa; A = total number of recorded genera.

RESULTS

Frequency of families and Genera: In current investigation a total of 168 taxa of Pteridophytes belong to 45 genera distributed in 19 families were reported from Pakistan, in agreement with Fraser-Jenkins (2014) and Fraser-Jenkins *et al.* (2016, 2018, 2019, 2020a, b). Pteridaceace and Dryopteridaceae are found to be largest families with 35 taxa each (41.67%), Aspleniaceae is the second largest family with 28 taxa (16.67%), followed by Athyriaceae with 24 taxa (14.28%), Thelypteridaceae with 7 taxa (4.17%), Selaginellaceae with 6 taxa (3.57%), Ophioglossaceae and Polypodiaceae with 5 taxa each (5.95%), Equisetaceae and Salvinaceae with 4 taxa each (4.76%), Dennstaedtiaceae and Woodsiaceae with 3 taxa each (3.57%), Osmundaceae and Hypodematiaceae with 2 taxa each (2.38%), followed by Blechnaceae, Marsileaceae, Lycopodiaceae, Lygodiaceae and Psilotaceae each having 1 species (2.98%) (Table 1).

Asplenium is the largest genus with 28 taxa (16.67%), *Dryopteris* is the second largest genus with 17 taxa (10.12%), *Polystichum* is the third largest genus with 15 taxa (8.93%), followed by *Athyrium* with 8 taxa (4.76%), *Pteris* with 7 taxa (4.17%), *Aleuritopteris*, *Cystopteris* and *Selaginella* each with 6 taxa (10.71%), *Adiantum* and *Deparia* each with 5 taxa (5.95%), *Diplazium*, *Equisetum*, *Lepisorus* and *Oeosporangium* each with 4 taxa (9.52%), *Cyrtomium*, *Coniogramme*, *Onychium*, *Woodsia* and *Ophioglossum* each with 3 taxa (8.93%), *Osmunda, Azolla*, *Salvinia*, *Cryptogramma*, *Notholeana*, *Hypodematium*, *Pteridium* and *Pseudophegopteris* each with 2 taxa (9.52%), followed by *Huperzia, Psilotum, Lygodium, Marsilea, Botrychium, Botrypus, Pellaea, Anogramma, Actiniopteris, Dennstaetdtia, Gymnocarpium, Ampelopteris, Christella, Glaphyropteridopsis, Phegopteris, Pronephrium, Woodwardia* and *Pyrrosia* with 1 species each (10.72%) (Table 1). The overall generic index value is 3.73 and all the invalid taxa documented previously by some authors have been excluded in the current study, while *Adiantum trapeziforme* L., *Pteris multifida* Poir, *Nephrolepis cordifolia* (L.) C.Presl and *N. exaltata* (L.) Schott are the cultivated species in Pakistan.

Concerning habitat 120 taxa (71.42%) are terrestrial growing in mountains under moist temperate forests, near streams in moist and shady places, 38 taxa (22.62%) are lithophytic, found on rocks and in rock-crevices, 5 taxa (2.98%) are aquatic, found in ponds, streams, lakes and 5 taxa (2.98%) are epiphytic, found on tree trunks. Concerning elevation 43 taxa (25.6%) are predominant from 1001–1500 m, followed by 42 taxa (25%) are found from 1501–2000 m, 31 taxa (18.45%) from 2001–2500 m, 21 taxa (12.5%) from 500–1000 m, 13 taxa (7.74%) from 2501–3000 m, 8 taxa (4.76%) from 1–500 m, 5 taxa (2.98%) from 3001–3500 m, 3 taxa (1.78%) from 3501–4000 m while the remaining 2 taxa (1.19%) are found above 4000 m. Concerning areas of distribution the maximum diversity was recorded in Azad Jammu and Kashmir with 110 taxa, Mansehra district has second-most diversity with 84 taxa, district Abbottabad have third-most diversity with 80 taxa, followed by district Swat with about 60 taxa, Gilgit-Baltistan and Murree hills of Rawalpindi district each with about 50 taxa, Dir lower, Dir upper and Shangla districts each with about 45 taxa, Chitral and Torghar districts each with 41 taxa, Buner and Swabi districts each with about 35 taxa, Kurram and Khyber districts each with 25 taxa, Islamabad with 10 taxa, Lahore district with 7 taxa, Jehlum, Mardan, Nowshehra, Peshawar, North Waziristan and Quetta districts each with 5 taxa, followed by Attock, D. I. Khan, Kohat, Karachi, Larkhana, Tharparkar and Sarghoda districts each with 2 taxa, of the total reported taxa.

Chorotype analysis: The chorotype analysis of all species was assessed by Fraser-Jenkins (2014), with which we are in broad agreement, but have made some individual re-assessments of certain species. The results showed that 129 taxa (76.79%) were uni-regional, 10 taxa (5.95%) were bi-regional, 18 taxa (10.71%) were cosmopolitan and 11 taxa (6.55%) were hybrid and without any phytogeographical elements. Most diversity was found in Sino–Himalayan elements with 94 taxa (55.95%), due to favorable climatic factors, heavy rainfall precipitation, humidity, soil-moisture, elevation, suitable habitat, favorable soil type and forest cover. Another factor is that Stewart (1957, 1967, 1972); Sheikh (1962); Nakaike and Malik (1992, 1993); Gul *et al.* (2016 a, b, 2017) explored the areas of Azad Jammu and Kashmir, Gilgit-Baltistan, Abbottabad, Mansehra, Chitral, Swat and Murree hills. The second largest diversity was found in European elements with 13 taxa (7.74%), followed by S.E. Asian elements with 9 taxa (5.36%), 4 taxa (2.38%) with Afro-Arabian elements, 3 taxa (1.79%) were endemic to W. Himalaya, 2 taxa each (2.38%) were adventive American and Circumboreal, 1 taxa each (1.19%) is Amphiatlantic and Neoendemic to W. Himalaya. Amongst bi-regional 2 taxa (1.19%) were shared by Sino-Himalayan and S.E. Asian elements, 1 taxa each (4.76%) were shared by Afro-Arabian and European, Circumboreal and European, Circumboreal and Sino-Himalayan, European and N. American, European and Sino-Himalayan, S.E. Asian and African, E. Asian and African, Sino-Himalayan and W. Asian elements, while 18 taxa (10.71%) were cosmopolitan and 11 taxa (6.55%) were hybrid and without any phytogeographical elements (Table 1).

Occurrence of the taxa: Concerning occurrence of the taxa we found that 43 taxa (25.6%) are extremely rare, followed by 39 taxa (23.21%) are infrequent, 37 taxa (22.02%) are common, 25 taxa (14.88%) are abundant and 24 taxa (14.29%) are rare (Table 1). In view of the suitable climatic, topographical, physiographical, edaphic and elevation the interesting pteridophyte-rich localities are Balakot, Batgram, Sharan forest, Shogran, Kagan valley, Maahnoor valley, Naran valley, Siran valley, Dadar, Dhodial, Chatar plain, Sikyan, lake Saiful-muluk in Mansehra district, Jehlum valley, Leepa valley, Lolab valley, Naltar valley, Neelam valley in Azad Jammu and Kashmir, Kalam valley, Kabal valley, Madyan, Beshgram, Marghuzar, Malam Jaba, Miandam valley, Shawar valley and Utror valley in Swat, Murree hills of Rawalpindi district, Talash valley, Samarbagh, Laalqilla, Maidan valley, Shahi and Binshahi in Dir lower, Kumrat valley, Jelar valley in Dir Upper, Diamer, Hunza valley, Gojal, Ayenabad, Karimabad, Rupal valley, Rama valley, Kisheyanga valley and Skardu in Gilgit-Baltistan, Bara Gali, Nathiya Gali, Donga Gali, Ayubia National park, Meranjani, in Abbottabad district, Gadoon valley,

Beergali, Utla in Swabi district, Aplouri, Chakesar valley and Upper Shangla pass in Shangla district, Deewana baba, Karakar, Ilam mountain, Mahaban forest in Buner district, Bombrait valley, Kilash valley, Laspur valley, Lowari top, Mastuj in Chitral district and Urak valley in Balochistan. Amongst the extremely rare taxa in Pakistan are *Huperzia selago* subsp. *appressa*, *Selaginella reticulata*, *Psilotum nudum*, *Ophioglossum petiolatum*, *Pteris terminalis, Woodsia cycloloba, Deparia macdonellii, Diplazium longifolium, Dryopteris panda,* and *Pyrrosia porosa*. The majority of these are Sino-Himalayan species reaching the limit of their extension, due to the decreased rainfall from the Central and Eastern Himalaya to the Western hills has generally reduced pteridophyte diversity. Moisture, shade, forest cover and elevation from 250–3500 m promote the growth and diversity of Pteridophytes. Some of the extremely rare species occur above 3500 m and fern diversity decline rapidly, though such altitudes errand some lycophytes such as *Huperzia selago* subsp. *appressa*, *Selaginella aitchisonii* and *S. reticulata*.

Table 1. Floristic diversity and Chorotype analysis of the Pteridophytes of Pakistan.

Botanical Name	Family	Chorotype analysis	Occurrence in Pakistan
Huperzia selago (L.) Bernh. ex Schrank & Mart. subsp. *appressa* (Bach.Pyl. ex Desv.) D.Löve	Lycopodiaceae	Circumboreal and Sino-Himalayan	Extremely rare
Selaginella aitchisonii Hieron.	Selaginellaceae	Sino-Himalayan	Extremely rare
S. chrysocaulos (Hook. & Grev.) Spring	Selaginellaceae	Sino-Himalayan	Infrequent
S. jacquemontii Spring	Selaginellaceae	Sino-Himalayan	Abundant
S. reticulata (Hook. & Grev.) Spring	Selaginellaceae	Sino-Himalayan	Extremely rare
S. subdiaphana (Wall. ex Hook. & Grev.) Spring	Selaginellaceae	Sino-Himalayan	Rare
S. vaginata Spring	Selaginellaceae	Sino-Himalayan	Infrequent
Equisetum arvense L. subsp. *Arvense*	Equisetaceae	Circumboreal and European	Abundant
E. arvense L. subsp. *diffusum* (D.Don) Frser-Jenk.	Equisetaceae	Sino-Himalayan	Infrequent
E. palustre L.	Equisetaceae	European	Extremely rare
E. ramosissimum Desf.	Equisetaceae	Cosmopolitan	Abundant
Psilotum nudum (L.) P.Beauv.	Psilotaceae	Cosmopolitan	Extremely rare
Botrychium lunaria (L.) Sw.	Ophioglossaceae	Cosmopolitan	Infrequent
B. virginianus (L.) Michx.	Ophioglossaceae	Circumboreal	Extremely rare
Ophioglossum petiolatum Hook.	Ophioglossaceae	Sino-Himalayan	Extremely rare
O. polyphyllum A.Braun ex Seub.	Ophioglossaceae	Afro-Arabian and European	Extremely rare
O. reticulatum L.	Ophioglossaceae	Cosmopolitan	Extremely rare
Osmunda claytoniana L. subsp. *vestita* (Milde) Á.Löve & D.Löve	Osmundaceae	Sino-Himalayan	Common
O. japonica Thunb.	Osmundaceae	Sino-Himalayan and S.E. Asian	Infrequent
Lygodium japonicum (Thunb.) Sw.	Lygodiaceae	S.E. Asian	Infrequent
Azolla pinnata R.Br. subsp. *asiatica* R.M. K. Saunders & K.Fowler	Salviniaceae	S.E. Asian	Common
A. filiculoides Lam. subsp. *cristata* (Kaulf.) Fraser-Jenk.	Salviniaceae	Adventive American	Infrequent
Salvinia molesta D.S.Mitchell	Salviniaceae	Adventive American	Rare
S. natans (L.) All.	Salviniaceae	Cosmopolitan	Infrequent
Marsilea minuta L.	Marsileaceae	S.E. Asian and African	Abundant
Actiniopteris radiata (Sw.) Link	Pteridaceae	Afro-Arabian	Common
Adiantum capillus-veneris L.	Pteridaceae	Cosmopolitan	Abundant
A. incisum Forssk. subsp. *Incisum*	Pteridaceae	Afro-Arabian	Abundant
Adiantum pedatum L. subsp. *Pedatum*	Pteridaceae	Sino-Himalayan	Infrequent
A. tibeticum Ching	Pteridaceae	Sino-Himalayan	Common
A. venustum D. Don	Pteridaceae	Sino-Himalayan	Infrequent
Aleuropteris albomarginata (C.B.Clarke) Ching	Pteridaceae	Sino-Himalayan	Abundant
A. anceps (Blanf.) Panigrahi	Pteridaceae	Sino-Himalayan	Common

		and S.E. Asian	
A. bicolor (Roxb.) Fraser-Jenk.	Pteridaceae	S.E. Asian	Abundant
A. formosana (Hayata) Tagawa	Pteridaceae	Sino-Himalayan	Common
A. grisea (Blanf.) Panigrahi	Pteridaceae	Sino-Himalayan	Common
A. leptolepis (Fraser-Jenk.) Fraser-Jenk.	Pteridaceae	Sino-Himalayan	Infrequent
Anogramma leptophylla (L.) Link	Pteridaceae	Cosmopolitan	Extremely rare
Coniogramme affinis Hieron.	Pteridaceae	Sino-Himalayan	Infrequent
C. intermedia Hieron.	Pteridaceae	Sino-Himalayan	Common
C. serrulata (Blume) Fee	Pteridaceae	E. Asian and African	Infrequent
Cryptogramma brunoniana Wall. ex Hook. & Grev.	Pteridaceae	Sino-Himalayan	Infrequent
C. stelleri (S.G.Gmel.) Prantl	Pteridaceae	Sino-Himalayan	Infrequent
Notholaena himalaica Fraser-Jenk.	Pteridaceae	Sino-Himalayan	Extremely rare
N. lanuginosa (Desv.) Desv. ex Poir.	Pteridaceae	European	Rare
Oeosporangium nitidulum (Hook.) Fraser-Jenk.	Pteridaceae	Sino-Himalayan	Abundant
O. persicum (Bory) Vis.	Pteridaceae	European	Common
O. pteridioides (Reichard) Fraser-Jenk. & Pariyar subsp. *acrosticum* (Balb.) Fraser-Jenk. & Pariyar	Pteridaceae	European and N. African	Common
O. subvillosum (Hook.) Fraser-Jenk. & Pariyar	Pteridaceae	Sino-Himalayan	Infrequent
Onychium cryptogrammoides Christ	Pteridaceae	Sino-Himalayan	Abundant
O. lucidum (D.Don) Spreng.	Pteridaceae	Sino-Himalayan	Common
O. vermae Fraser-Jenk. & Khullar	Pteridaceae	Sino-Himalayan	Common
Pellaea calomelanos (Sw.) Link	Pteridaceae	Afro-Arabian	Extremely rare
Pteris aspericaulis Wall. ex J. Agardh	Pteridaceae	Sino-Himalayan	Common
P. cretica L. subsp. *Cretica*	Pteridaceae	European and Sino-Himalayan	Abundant
P. cretica L. subsp. *laeta* (Wall. ex Ettingsh.) C.Chr. & Tardieu	Pteridaceae	Sino-Himalayan and W. Asian	Abundant
P. terminalis Wall. ex J.Agardh	Pteridaceae	Sino-Himalayan	Extremely rare
P. vittata L. subsp. *Vittata*	Pteridaceae	Cosmopolitan	Common
P. vittata L. subsp. *emodi* Fraser Jenk.	Pteridaceae	Sino-Himalayan	Common
?? *P. vittata* L. subsp. *vermae* Fraser Jenk.	Pteridaceae	Sino-Himalayan	Rare
Dennstaedtia wilfordi (T. Moor) Christ.	Dennstaedtiaceae	Sino-Himalayan	Rare
Pteridium brownseyi Fraser-Jenk.	Dennstaedtiaceae	European	Infrequent
P. revolutum (Blume) Nakai	Dennstaedtiaceae	S.E. Asian	Common
Asplenium adiantum-nigrum L. subsp. *adiantum-nigrum*	Aspleniaceae	Cosmopolitan	Abundant
A. ceterach L. subsp. *Ceterach*	Aspleniaceae	European	Infrequent
A. daghestanicum Christ subsp. *aitchisonii* (Fraser-Jenk. & Reichst.) Fraser-Jenk.	Aspleniaceae	Sino-Himalayan	Extremely rare
A. daghestanicum Christ subsp. *hunzanum* (Reichst. & Fraser-Jenk.) Fraser-Jenk.	Aspleniaceae	Sino-Himalayan	Extremely rare
A. daghestanicum Christ subsp. *iskardense* (Reichst.) Fraser-Jenk.	Aspleniaceae	Sino-Himalayan	Extremely rare
A. dalhousiae Hook.	Aspleniaceae	Sino-Himalayan	Abundant
A. fontanum (L.) Bernh. subsp. *pseudofontanum* (Kossinsky) Reichst. & Schneller	Aspleniaceae	European	Common
A. khullarii Reichst. & Rasbach ex Fraser-Jenk.	Aspleniaceae	Sino-Himalayan	Extremely rare
A. laciniatum D.Don subsp. *kukkonenii* (Reichst. & Viane) Fraser-Jenk.	Aspleniaceae	Sino-Himalayan	Infrequent
A. laciniatum D.Don subsp. *Laciniatum*	Aspleniaceae	Sino-Himalayan	Common
A. laciniatum D.Don subsp. *tenuicaule* (Hayata) Fraser-Jenk.	Aspleniaceae	Sino-Himalayan	Infrequent
A. nesii Christ	Aspleniaceae	Sino-Himalayan	Rare
A. punjabense Bir, Fraser-Jenk. & Lovis	Aspleniaceae	W. Himalayan Neoendemic	Common
A. *ruta-muraria* L. subsp. *ruta-muraria*	Aspleniaceae	Amphiatlantic	Common
A. ruta-muraria L. subsp. *dolomiticum* Lovis & Reichst.	Aspleniaceae	European	Extremely rare
A. sarellii Hook. subsp. *pekinense* (Hance) Fraser-Jenk., Pangtey & Khullar	Aspleniaceae	Sino-Himalayan	Extremely rare
A. septentrionale (L.) Hoffm. subsp. *caucasicum* Fraser-Jenk. &	Aspleniaceae	European	Infrequent

Lovis			
A. septentrionale (L.) Hoffm. subsp. *septentrionale*	Aspleniaceae	Cosmopolitan	Common
A. trichomanes L. subsp. *humistratum* (Ching) Fraser-Jenk.	Aspleniaceae	Sino-Himalayan	Extremely rare
A. trichomanes L. subsp. *inexpectatum* Lovis	Aspleniaceae	European	Extremely rare
A. *trichomanes* L. subsp. *quadrivalens* (D.E.Meyer) Landolt	Aspleniaceae	Cosmopolitan	Abundant
A. trichomanes L. subsp. *Trichomanes*	Aspleniaceae	Cosmopolitan	Abundant
A. viride Huds.	Aspleniaceae	Cosmopolitan	Common
A. x *alternifolium* Wulfen Nothosubsp. *alternifolium* Fraser-Jenk.	Aspleniaceae	Hybrid taxa	Infrequent
A. x *chingii* Fraser-Jenk.	Aspleniaceae	Hybrid taxa	Extremely rare
A. laciniatum nothosubsp. x *hopei* (Viane & Reichst.) Fraser-Jenk.	Aspleniaceae	Hybrid taxa	Rare
A. septentrionale nothosubsp. x *rehmanii* Fraser-Jenk.	Aspleniaceae	Hybrid taxa	Extremely rare
A. trichomanes nothosubsp. x *lusaticum* (D.E. Meyer) Lawalree	Aspleniaceae	Hybrid taxa	Rare
Woodsia alpina (Bolton) S.F.Gray	Woodsiaceae	European	Extremely rare
?*W. cycloloba* Hand.-Mazz	Woodsiaceae	Sino-Himalayan	Extremely rare
W. glabella R.Br. ex Richardson	Woodsiaceae	European	Extremely rare
Woodwardia unigemmata (Makino) Nakai	Blechnaceae	Sino-Himalayan	Common
Athyrium atkinsonii Bedd.	Athyriaceae	Sino-Himalayan	Infrequent
A. attenuatum (C.B.Clarke) Tagawa	Athyriaceae	Sino-Himalayan	Common
A. mackinnoniorum (C.Hope) C.Chr.	Athyriaceae	W. Himalayan endemic	Common
A. rupicola (Edgew. ex C.Hope) C.Chr.	Athyriaceae	Sino-Himalayan	Infrequent
A. schimperi Moug. ex Fée subsp. *biserrulatum* (Christ) Fraser-Jenk.	Athyriaceae	Sino-Himalayan	Common
A. strigillosum (T.Moore ex E.J.Lowe) T.Moore ex Salomon	Athyriaceae	Sino-Himalayan	Infrequent
A. wallichianum Ching	Athyriaceae	Sino-Himalayan	Rare
A. mackinnoniorum x *strigillosum*	Athyriaceae	Hybrid taxa	Extremely rare
Cystopteris fragilis (L.) Bernh. subsp. *diaphana* (Bory) Litard.	Athyriaceae	Cosmopolitan	Rare
C. fragilis (L.) Bernh. subsp. *dickieana* (R.Sim) Hyl.	Athyriaceae	Cosmopolitan	Common
C. fragilis (L.) Bernh. subsp. *Fragilis*	Athyriaceae	Cosmopolitan	Common
C. montana (Lam.) Desv	Athyriaceae	Circumboreal	Rare
C. fragilis (L.) Bernh. subsp. *dickieana* (R.Sim) Hyl. x *C. fragilis* (L.) Bernh. subsp. *diaphana* (Bory) Litard.	Athyriaceae	Hybrid taxa	Rare
C. fragilis (L.) Bernh. nothosubsp. x *montserratii* (Prada & Salvo) Fraser-Jenk.	Athyriaceae	Hybrid taxa	Rare
Deparia allantodioides (Bedd.) M.Kato	Athyriaceae	Sino-Himalayan	Infrequent
D. japonica (Thunb.) M.Kato subsp. *Japonica*	Athyriaceae	Sino-Himalayan	Infrequent
D. japonica (Thunb.) M.Kato subsp. *petersenii* (Kunze) Fraser-Jenk.	Athyriaceae	S.E. Asian	Infrequent
D. macdonellii (Bedd.) M.Kato	Athyriaceae	W. Himalayan endemic	Extremely rare
D. subsimilis (Christ) Fraser Jenk.	Athyriaceae	Sino-Himalayan	Infrequent
Diplazium esculentum (Retz.) Sw	Athyriaceae	S.E. Asian	Rare
D. khullarii Fraser-Jenk.	Athyriaceae	Sino-Himalayan	Extremely rare
D. longifolium (D.Don) T.Moore	Athyriaceae	Sino-Himalayan	Extremely rare
D. maximum (D.Don) C.Chr.	Athyriaceae	Sino-Himalayan	Common
Gymnocarpium fedtschenkoanum Pojark.	Athyriaceae	Sino-Himalayan	Common
Ampelopteris prolifera (Retz.) Copel.	Thelypteridaceae	S.E. Asian	Infrequent
Christella dentata (Forssk.) Brownsey & Jermy	Thelypteridaceae	Cosmopolitan	Abundant
Glaphyropteridopsis erubescens (Wall. ex Hook.) Ching	Thelypteridaceae	Sino-Himalayan	Common
Phegopteris connectilis (Michx.) Watt	Thelypteridaceae	Cosmopolitan	Infrequent
Pronephrium penangianum (Hook.) Holttum	Thelypteridaceae	S. E. Asian	Infrequent
Pseudophegopteris levingei (C.B.Clarke) Ching	Thelypteridaceae	Sino-Himalayan	Infrequent
Pseudophegopteris microstegia (Hook.) Ching subsp. *laterepens* (E.W.Trotter) Fraser-Jenk.	Thelypteridaceae	Sino-Himalayan	Abundant
Hypodematium crenatum (Forssk.) Kuhn subsp. *Crenatum*	Hypodematiaceae	Afro-Arabian	Abundant
H. crenatum (Forssk.) Kuhn subsp. *loyalii* Fraser-Jenk. & Khullar	Hypodematiaceae	Sino-Himalayan	Common

Cyrtomium anomophyllum (Zenker) Fraser-Jenk.	Dryopteridaceae	Sino-Himalayan	Rare
C. caryotideum (Wall. ex Hook. & Grev.) C.Presl	Dryopteridaceae	Sino-Himalayan	Infrequent
C. macrophyllum (Makino) Tagawa	Dryopteridaceae	Sino-Himalayan	Rare
Dryopteris barbigera (T.Moore ex Hook.) Kuntze	Dryopteridaceae	Sino-Himalayan	Common
D. blanfordii (C.Hope) C.Chr. subsp. *Blanfordii*	Dryopteridaceae	W. Himalayan endemic	Abundant
D. chrysocoma (Christ) C.Chr.	Dryopteridaceae	Sino-Himalayan	Rare
D. cochleata (D.Don) C.Chr.	Dryopteridaceae	S.E. Asian	Extremely rare
D. dickinsii (Franch. & Sav.) C.Chr.	Dryopteridaceae	Sino-Himalayan	Extremely rare
D. edwardsii Fraser-Jenk.	Dryopteridaceae	Sino-Himalayan	Extremely rare
D. filix-mas (L.) Schott subsp. *filix-mas*	Dryopteridaceae	European	Rare
D. komarovii Kossinsky	Dryopteridaceae	Sino-Himalayan	Common
D. nigropaleacea (Fraser-Jenk.) Fraser-Jenk.	Dryopteridaceae	Sino-Himalayan	Abundant
D. panda (C.B.Clarke) Christ	Dryopteridaceae	Sino-Himalayan	Extremely rare
D. ramosa (C.Hope) C.Chr.	Dryopteridaceae	Sino-Himalayan	Abundant
D. redactopinnata S.K.Basu & Panigrahi	Dryopteridaceae	Sino-Himalayan	Infrequent
D. serratodentata (Bedd.) Hayata	Dryopteridaceae	Sino-Himalayan	Extremely rare
D. stewartii Fraser-Jenk.	Dryopteridaceae	Sino-Himalayan	Abundant
D. xanthomelas (Christ) C.Chr.	Dryopteridaceae	Sino-Himalayan	Infrequent
D. zayuensis Ching & S.K.Wu	Dryopteridaceae	Sino-Himalayan	Extremely rare
Dryopteris x *macdonellii* Fraser-Jenk.	Dryopteridaceae	Hybrid taxa	Extremely rare
Polystichum bakerianum (Atkins. ex C.B.Clarke) Diels	Dryopteridaceae	Sino-Himalayan	Extremely rare
P. discretum (D.Don) J.Sm	Dryopteridaceae	Sino-Himalayan	Common
P. lachenense (Hook.) Bedd.	Dryopteridaceae	Sino-Himalayan	Extremely rare
P. lonchitis (L.) Roth	Dryopteridaceae	European	Common
P. luctuosum (Kunze) T.Moore	Dryopteridaceae	Sino-Himalayan	Infrequent
P. mehrae Fraser-Jenk. & Khullar	Dryopteridaceae	Sino-Himalayan	Rare
P. piceopaleaceum Tagawa	Dryopteridaceae	Sino-Himalayan	Infrequent
P. prescottianum (Wall. ex Mett.) T.Moore	Dryopteridaceae	Sino-Himalayan	Common
P. shensiense Christ	Dryopteridaceae	Sino-Himalayan	Rare
P. sinense (Christ) Christ	Dryopteridaceae	Sino-Himalayan	Extremely rare
P. squarrosum (D. Don) Fée	Dryopteridaceae	Sino-Himalayan	Abundant
P. thomsonii (Hook.f.) Bedd.	Dryopteridaceae	Sino-Himalayan	Infrequent
P. yunnanense Christ	Dryopteridaceae	Sino-Himalayan	Abundant
Polystichum x *inayatii* Fraser-Jenk.	Dryopteridaceae	Hybrid taxa	Extremely rare
Polystichum x *stewartii* Fraser-Jenk.	Dryopteridaceae	Hybrid taxa	Extremely rare
Lepisorus clathratus (C.B.Clarke) Ching	Polypodiaceae	Sino-Himalayan	Rare
Lepisorus nudus (Hook.) Ching	Polypodiaceae	Sino-Himalayan	Rare
L. scolopendrium (Ching) Mehra & Bir	Polypodiaceae	Sino-Himalayan	Rare
L. thunbergianus (Kaulf.) Ching	Polypodiaceae	Sino-Himalayan	Rare
Pyrrosia porosa (C.Presl) Hovenkamp	Polypodiaceae	Sino-Himalayan	Extremely rare

DISCUSSION

Previous study of Pteridophytes in Pakistan has been carried out by a few well-known researchers who documented them (chiefly by Stewart, 1957, 1967, 1972; Fraser-Jenkins, 1984, 1992, 1993, 2014; Nakaike and Malik, 1992, 1993). Apart from the wider work throughout Pakistan of mentioned authors, many workers often focused on Azad Jammu and Kashmir and various districts of Hazara and Malakand division viz. (Shah *et al.* 1985 a, b; Ullah *et al.* 2014; Rahman *et al.* 2015; Attaullah *et al.* 2017, 2020; Shah *et al.* 2018 a, b; Shah *et al.* 2019 a, b, c; Shah *et al.* 2020, 2021; Zaman *et al.* 2019; Hazrat *et al.* 2020; Irfan *et al.* 2021c) while some localities of Pakistan are still not explored. The maximum species distribution was found in the Himalayan range of Pakistan in Azad Jammu and Kashmir and Mansehra district due to favorable climatic, edaphic, physiographic, elevation, thick forest cover and suitable habitat. Fewer species occur in the Hindu-Kush and Karakorum ranges due to less rainfall, less moisture and less humidity prevailing there. Humidity, precipitation, forest cover and elevation particularly from 250–3500 m promote the growth and diversity of Pteridophytes. A generic index of 3.73 and a familial index of 8.84 resulted from the frequency of families, genera and species of pteridophytes in Pakistan. However as compared to the total area of Pakistan the number of taxa is small. As some localities of Pakistan are still insufficiently studied, especially Baluchistan, North-Western localities of Khyber Pakhtunkhwa, the low hills of the Punjab and some localities of Sindh, they should be explored in

future. Exploration should be conducted at the national level and it is possible that a number of some taxa could be added to the pteridophyte-flora of Pakistan and to Districts where they were not previously recorded. Potential extinction of taxa is a serious problem in different localities of Pakistan. Some interesting pteridophyte rich localities are very important such as Sharan forest, Kagan valley and lake Saiful-muluk in Mansehra district, Neelam valley in Azad Jammu and Kashmir, Kalam valley and Malam Jaba in Swat, Murree hills of Punjab, Shahi and Binshahi in Dir lower, Diamer, Hunza, Karimabad in Gilgit-Baltistan, Bara Gali, Nathiya Gali, Donga Gali, Meranjani in Abbottabad, Gadoon valley in Swabi, Upper Shangla pass in Shangla should be declared as protected areas in order to protect these important group of species.

Conclusion: The current study reports 168 taxa belong to 45 genera distributed amongst 19 families in Pakistan. This is in almost exact agreement with Fraser-Jenkins (2014) once hybrids reported elsewhere by Fraser-Jenkins, have been added to his checklist. The revision we have made concerns changing the taxonomic classification into the molecular-cladistic genera and families of PPG-I (2016) and adding the presence of the adventive species, *Salvinia molesta* in Pakistan following two reports of it by others. Pteridaceace and Dryopteridaceae each were found to be the largest families, followed by Aspleniaceae and Athyriaceae. *Asplenium* is the largest genus, followed by *Dryopteris* and *Polystichum*. Phytogeographically the Sino-Himalayan elements have the maximum diversity followed by European elements and S.E Asian elements. As some Northern areas and newly merged districts of Khyber Pakhtunkhwa formerly known as tribal areas, and the hills of Punjab, Sindh and Baluchistan province are still insufficiently explored, there is a considerable need to study them further, which could increase the number of reported species. Potential extinction of taxa is a serious problem in different localities of Pakistan, therefore conservatory measures from local communities and government should be properly practiced.

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