PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 11(2): 252–261
https://doi.org/10.14719/pst.3052

HORIZON
e-Publishing Group
HePG

REVIEW ARTICLE

Diversity and Chorotype Analysis of the Pteridophytes of Zimbabwe

Alfred Maroyi

Department of Botany, University of Fort Hare, Alice 5700, South Africa

Email: amaroyi@ufh.ac.za

OPEN ACCESS

ARTICLE HISTORY

Received: 29 October 2023
Accepted: 17 January 2024

Available online
Version 1.0 : 16 February 2024
Version 2.0 : 01 April 2024

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

Reprints & permissions information is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

Publisher's Note: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS,UGC Care etc. See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE

Maroyi A. Diversity and Chorotype Analysis of the Pteridophytes of Zimbabwe. Plant Science Today. 2024; 11(2): 252–261. https://doi.org/10.14719/pst.3052

Abstract

In the current investigation, an attempt has been made to document the floristic diversity and chorotype analysis of Pteridophytes growing in Zimbabwe. Previously published literature and online sources were consulted to confirm the nomenclature, precise locations, chorotype, stages of invasion, and conservation status of the Pteridophytes in Zimbabwe. The updated list of Pteridophyte taxa confirms that there are 297 taxa belonging to 83 genera and 19 families. The largest family is Aspleniaceae, with 78 taxa (26.26%), followed by Polypodiaceae and Pteridaceace with 67 taxa (22.56%) and 54 taxa (18.18%), respectively. The largest genus is *Asplenium* L., with 46 taxa (15.49%), followed by *Hemionitis* L. with 22 taxa (7.41%), *Ophioglossum* L. (16 taxa, 5.39%), *Thelypteris* Schmidel (14 taxa, 4.71%), and *Elaphoglossum* Schott ex J.Sm. (12 taxa, 4.04%). A total of 20 taxa (6.73%) are threatened with extinction, emphasizing the need for detailed knowledge of the nomenclature, conservation status, and distribution of Pteridophytes taxa in Zimbabwe. Research focusing on the diversity, ecology, and conservation status of Pteridophytes is imperative for biodiversity conservation, as they are an important component of natural ecosystems adapted to different habitats. Therefore, future studies on Pteridophytes in Zimbabwe should explore how the lack of floristic data on the plant group can hinder ecological research.

Keywords

Chorotype, Diversity, Pteridophytes, Threatened taxa, Zimbabwe

Introduction

Pteridophytes are spore-bearing vascular plants that do not produce flowers or seeds. They generate a large number of spores, which are dispersed over long distances, enabling them to colonize new habitats and establish a wide geographical range (1). The spores are light and small, typically measuring less than 0.1 mm in both the equatorial and polar axis, making them capable of dispersal by wind over thousands of kilometers (2, 3). These spores are also able to survive in soil for several years, forming spore banks, and can germinate after disturbances, becoming primary colonizers in disturbed habitats and barren land (1). Research suggests that Pteridophytes originated in ancient tropical habitats (4-6) and have a longer evolutionary history compared to most other vascular plants (5). They were the first land plants to have well-developed vascular tissue, which allowed them to grow taller and give rise to the first trees (7). Pteridophytes can be divided into two distinct evolutionary lineages: Lycophytes and Ferns, with an estimated 11,916 species in 337 genera and 51 families (8). Pteridophytes are typically found in cool, shady, and humid environments, such as the understory of

rainforests. Additionally, they can be found in dry environments like rocky habitats, and scoured riverbanks, and they can grow as epiphytes on tree trunks and in forest canopies (9, 10). Research has shown that Pteridophytes prefer wet, humid environments and shaded habitats because water is needed for sperm transport in gametophytes to facilitate sexual reproduction. They are unable to control water loss, and their leaves are not well-adapted to changing environmental conditions (10-12). Some Pteridophytes, like resurrection ferns, can survive long periods of drought by curling their fronds and appearing desiccated and dead. They can revive and unfold when moisture becomes available again (7, 13). Pteridophytes have a cosmopolitan distribution but are less common in arid zones like deserts. They are most abundant in moist tropics, where they often grow epiphytically (14). Additionally, Pteridophytes have developed a photochemical defense that is resistant to pathogens, predation, and fungal attack (15). However, some Pteridophytes can disrupt the natural balance in ecosystems and have negative impacts on human and animal health, food production, and the management of aquatic and land systems (15, 16). Due to their widespread distribution, ability to occupy various habitats, and sensitivity to environmental changes, Pteridophytes can serve as good indicators of habitats. They can be an effective tool for monitoring biodiversity, especially in the current context of the global biodiversity crisis caused by habitat transformation and loss (17). Given the current environmental challenges associated with increasing deforestation in Zimbabwe (18-21), there is a need to know more about local biodiversity, including Pteridophytes, to make informed environmental management decisions. However, very little research has been done on Pteridophytes in Zimbabwe, with only two scientific reports published over 40 years ago providing taxonomical, nomenclatural, and ecological information about Pteridophytes growing in the country (22, 23). Most research focused has focused on regional floristic studies in southern Africa, particularly South Africa (7, 24-33). Therefore, this study aims to document the diversity and analyze the chorotype of the Pteridophytes in Zimbabwe.

Materials and Methods

To compile the present checklist, we used a combination of multiple resources. The herbarium specimens of Pteridophytes kept in the National Herbarium of Zimbabwe, Harare (SRGH) (34) were utilized for this study. The species names were updated to recently accepted names according to the Pteridophyte Phylogeny Group 2016 classification (8), Plants of the World Online website (35), and Flora of Zimbabwe (www.florazimbabwe.co.zw). The families, genera, and species are listed in alphabetical order (Table 1). Each taxon was assessed to determine its chorotype in the country. For exotic species, the stages of invasion (cultivated, casual, naturalized, and invasive) were determined following the protocol proposed by Richardson et al. (36) and Richardson and Pyšek (37). This was achieved by using literature references, online resources, and information on herbarium specimen labels. The distributional data of all the taxa were compiled from herbarium specimens. The distribution of each taxon in Zimbabwe is indicated by letters representing the floristic divisions used in the Flora Zambesiaca: northern region (N), western region (W), central region (C), eastern region (E), and southern region (S) (38). To assess the extinction risk of the Pteridophytes in Zimbabwe, the IUCN Red List of Threatened Species (https://newredlist.iucnredlist.org/) was used to determine the conservation status of each taxon.

Results and Discussion

Families and genera

The list of Pteridophyte taxa growing in Zimbabwe is presented in Table 1. A total of 297 species and infraspecific taxa of Pteridophytes are listed. These Pteridophytes are distributed among 19 families and 83 genera. The Zimbabwean flora contributes a substantial component to the global Pteridophyte diversity, as the current study revealed that at least 19 families (37.25%) of Pteridophyte families in the world are found in Zimbabwe (8, 39). The majority of the Pteridophytes (280 taxa, 94.28%) come from 11 families (Table 2). The families with the highest number of taxa are Aspleniaceae with 78 taxa (26.26%), followed by Polypodiaceae and Pteridaceace with 67 taxa (22.56%) and 54 taxa (18.18%), respectively (Fig. 1). Similarly, the families with the highest number of genera in the descending order of importance are Dennstaedtiaceae, Aspleniaceae, Pteridaceace and Polypodiaceae (Fig. 1). The rest of the families are represented by one to five taxa each (Table 1). The genera with the highest number of taxa are *Asplenium* L. with 46 taxa followed by *Hemionitis* L. with 22 taxa, *Ophioglossum* L. with 16 taxa, *Thelypteris* Schmidel (14 taxa), *Elaphoglossum* Schott ex J.Sm. with 12 taxa, and the rest of the genera are represented by one to nine taxa each (Table 1). In southern Africa, the major families characterized by at least five genera include Dennstaedtiaceae, Dryopteridaceae, Hymenophyllaceae, Polypodiaceae, Thelypteridaceae, and Woodsiaceae (7).

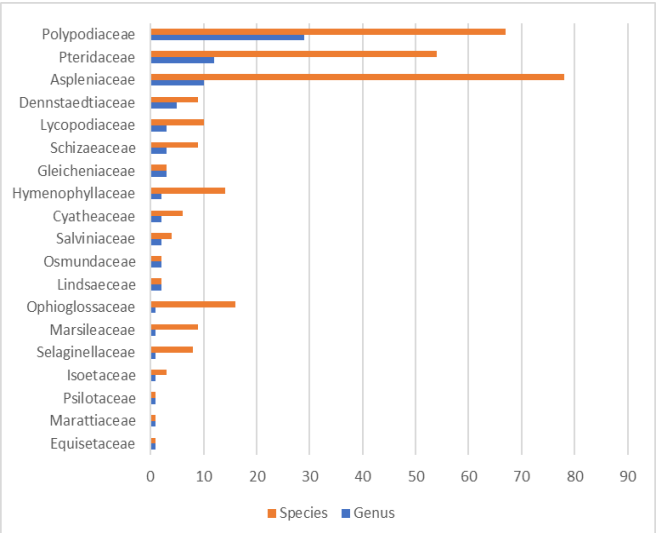

Fig. 1. Family-genus-species composition of Pteridophytes in Zimbabwe.

Table 1. List of Pteridophyte taxa growing in Zimbabwe

Family and taxa	†Distribution	Chorotype analysis
Aspleniaceae		
Asplenium aethiopicum (Burm.f.) Bech. subsp. *aethiopicum*	E	Epiphyte, lithophyte, and terrestrial
A. aethiopicum (Burm.f.) Bech. subsp. *dodecaploideum* A.F.Braithw.	E	Epiphyte, lithophyte, and terrestrial
A. aethiopicum (Burm.f.) Bech. subsp. *filare* (Forssk.) A.F.Braithw.	E	Epiphyte, lithophyte, and terrestrial
A. aethiopicum (Burm.f.) Bech. subsp. *tripinnatum* (Baker) A.F.Braithw.	E	Epiphyte, lithophyte, and terrestrial
A. anisophyllum Kunze	E	Epiphyte, lithophyte, and terrestrial
A. blastophorum Hieron.	E	Epiphyte, lithophyte, and terrestrial
A. boltonii Hook. ex Brause & Hieron.	ES	Epiphyte, lithophyte, and terrestrial
#*A. buettneri* Hieron.	E	Epiphyte, lithophyte, and terrestrial
A. capense (Kunze) Bir, Fraser-Jenk. & Lovis	E	Lithophyte and terrestrial
A. ceii Pic.Serm.	E	Epiphyte, lithophyte, and terrestrial
#*A. christii* Hieron.	ES	Terrestrial
A. cordatum (Thunb.) Sw.	NWCES	Lithophyte and terrestrial
A. dregeanum Kunze	E	Epiphyte and lithophyte
A. erectum Willd.	ES	Epiphyte and terrestrial
A. flexuosum Schrad.	E	Lithophyte and terrestrial
A. formosum Willd.	E	Epiphyte and lithophyte
A. friesiorum C.Chr.	E	Lithophyte and terrestrial
A. gemmiferum Schrad.	E	Epiphyte, lithophyte, and terrestrial
A. holstii Hieron.	E	Epiphyte and lithophyte
A. hypomelas Kuhn	ES	Epiphyte
A. inaequilaterale Willd.	NES	Lithophyte and terrestrial
A. laciniatum D.Don subsp. *laciniatum*	ES	Epiphyte and lithophyte
A. linckii Kuhn	E	Epiphyte, lithophyte, and terrestrial
A. lividum Mett.	E	Epiphyte and lithophyte
A. lobatum Pappe & Raws. var. *lobatum*	ES	Lithophyte and terrestrial
A. lobatum Pappe & Raws. var. *pseudo-abyssinicum* Schelpe & N.C.Anthony	E	Lithophyte and terrestrial
A. lunulatum Sw.	S	Lithophyte and terrestrial
A. mannii Hook.	E	Epiphyte
A. monanthes L.	WE	Terrestrial
#*A. mossambicense* Schelpe	E	Lithophyte
#*A. pellucidum* Lam. subsp. *pseudohorridum* (Hieron.) Schelpe	E	Epiphyte and lithophyte
A. phillipsianum (Kümmerie) Bir, Fraser-Jenk. & Lovis	S	Lithophyte
A. preussii Hieron. ex Brause	E	Lithophyte
A. protensum Schrad.	E	Epiphyte, lithophyte, and terrestrial
A. pumilum Sw.	NE	Lithophyte and terrestrial
A. rutifolium (P.J.Bergius) Kunze	ES	Epiphyte and lithophyte
A. sandersonii Hook.	E	Epiphyte
A. schelpei A.F.Braithw.	E	Lithophyte and terrestrial
**A. scolopendrium* L.	C	Terrestrial
#*A. sebungweense* J.E.Burrows	N	Lithophyte and terrestrial
A. simii A.F.Braithw.& Schelpe	E	Epiphyte and lithophyte
A. stuhlmannii Hieron.	NWCES	Lithophyte
A. sulcatum Lam.	E	Epiphyte and lithophyte
A. theciferum (Kunth) Mett.	ES	Epiphyte
A. trichomanes L. subsp. *quadrivalens* D.E.Mey.	E	Epiphyte
A. uhligii Hieron.	E	Epiphyte and lithophyte
Athyrium newtonii Baker	E	Lithophyte and terrestrial
A. schimperi Moug. & Feé	CE	Terrestrial
Blechnum attenuatum (Sw.) Mett.	CES	Epiphyte, lithophyte and terrestrial
B. australe L. subsp. *australe*	E	Lithophyte and terrestrial
B. bakeri C.Chr.	E	Terrestrial
B. capense Burm.f.	E	Terrestrial
B. inflexum (Kunze) Kuhn	E	Terrestrial
B. punctulatum Sw. var. *punctulatum*	NS	Lithophyte and terrestrial
B. tabulare (Thunb.) Kuhn	NES	Terrestrial
Christella buchananii (Schelpe) J.P.Roux	E	Terrestrial
Deparia boryana (Willd.) M.Kato	E	Terrestrial
D. zanzibarica (Baker) Christenh.	E	Terrestrial
**Diplazium esculentum* (Retz.) Sw.	C	Terrestrial
D. nemorale (Baker) Schelpe	E	Terrestrial
Hymenasplenium obscurum (Blume) Tagawa	E	Lithophyte and terrestrial

#*H. unilaterale* (Lam.) Hayata	E	Lithophyte and terrestrial
Stenochlaena tenuifolia (Desv.) T.Moore	E	Terrestrial
Thelypteris bergiana (Schltdl.) Ching	WE	Terrestrial
T. chaseana Schelpe	NCE	Terrestrial
T. confluens (Thunb.) C.V.Morton	NWCES	Terrestrial
T. dentata (Forssk.) E.P.St.John	NWCES	Terrestrial
T. friesii (Brause) Schelpe	CE	Terrestrial
T. gueintziana (Mett.) Schelpe	NWCES	Lithophyte and terrestrial
T. hispidula (Decne.) C.F.Reed	E	Terrestrial
T. interrupta (Willd.) H.Itô	NWE	Terrestrial
T. madagascariensis (Fée) Schelpe	E	Terrestrial
T. microbasis (Baker) Tardieu	N	Terrestrial
T. oppositiformis (C.Chr.) Ching	E	Terrestrial
T. pozoi (Lag.) C.V.Morton	E	Lithophyte and terrestrial
T. prolifera (Retz.) C.F.Reed	NWES	Terrestrial
T. pulchra (Bory ex Willd.) Schelpe	CES	Terrestrial
Woodsia burgessiana Gerr. ex Hook. & Baker	E	Lithophyte and terrestrial
Cyatheaceae		
#*Alsophila dregei* (Kunze) R.M.Tryon	NWCES	Terrestrial
#*A. humilis* (Hieron.) Pic.Serm.	E	Terrestrial
#*A. manniana* (Hook.) R.M.Tryon	E	Terrestrial
#*A. mossambicensis* (Baker) R.M.Tryon	E	Terrestrial
#*A. thomsonii* (Baker) R.M.Tryon	ES	Terrestrial
Gymnosphaera capensis (L.f.) S.Y.Dong	E	Terrestrial
Dennstaedtiaceae		
Blotiella glabra (Bory) R.M.Tryon	E	Terrestrial
B. natalensis (Hook.) R.M.Tryon	ES	Terrestrial
Histiopteris incisa (Thunb.) J.Sm.	E	Terrestrial
Hypolepis sparsisora (Schrad.) Kuhn	E	Terrestrial
Microlepia speluncae (L.) T.Moore	NWCES	Terrestrial
**M. strigosa* (Thunb. ex Murray) C.Presl	E	Terrestrial
Pteridium aquilinum (L.) Kuhn subsp. *aquilinum*	NWCES	Terrestrial
P. aquilinum (L.) Kuhn subsp. *capense* (Thunb.) C.Chr.	NWCS	Terrestrial
P. aquilinum (L.) Kuhn subsp. *centrali-africanum* Hieron.	NWCS	Terrestrial
Equisetaceae		
Equisetum ramosissimum Desf. subsp. *ramosissimum*	NWCES	Lithophyte and terrestrial
Gleicheniaceae		
Dicranopteris linearis (Burm.f.) Underw. var. *linearis*	NES	Lithophyte and terrestrial
Gleichenia polypodioides (L.) Sm.	NES	Lithophyte and terrestrial
Sticherus umbraculifer (Kunze) Ching	E	Lithophyte and terrestrial
Hymenophyllaceae		
Hymenophyllum capense Schrad.	E	Epiphyte and lithophyte
H. capillare Desv.	E	Epiphyte and lithophyte
H. hirsutum (L.) C.Presl	E	Epiphyte and lithophyte
H. kuhnii C.Chr.	E	Epiphyte and lithophyte
H. mossambicense (Schelpe) R.R.Schippers	E	Lithophyte
H. sibthorpioides (Bory ex Willd.) Mett. ex Kuhn	E	Epiphyte and lithophyte
H. splendidum Bosch	E	Epiphyte and lithophyte
H. tunbrigense (L.) Sm.	E	Epiphyte, lithophyte, and terrestrial
Trichomanes erosum Willd.	E	Epiphyte and lithophyte
T. frappieri Cordem.	E	Lithophyte
T. inopinatum (Pic.Serm.) J.E.Burrows	E	Epiphyte and lithophyte
T. melanotrichum Schltdl.	E	Epiphyte and lithophyte
T. diaphanum Kunth	E	Epiphyte and lithophyte
T. rigidum Sw.	E	Lithophyte and terrestrial
Isoetaceae		
Isoetes aequinoctialis Welw. ex A.Braun	N	Terrestrial
I. alstonii C.F.Reed & Verdc.	WS	Terrestrial
I. schweinfurthii A.Braun ex Baker	NWES	Terrestrial
Lindsaeaceae		
Lindsaea ensifolia Sw. subsp. *ensifolia*	E	Terrestrial
Osmolindsaea odorata (Roxb.) Lehtonen & Christenh.	E	Terrestrial
Lycopodiaceae		
Huperzia dacrydioides (Baker) Pic.Serm.	E	Epiphyte and lithophyte

H. gnidioides (L.f.) Trevis.	E	Epiphyte and lithophyte
H. ophioglossoides (Lam.) Rothm.	E	Epiphyte and lithophyte
H. phlegmaria (L.) Rothm.	E	Epiphyte and lithophyte
H. saururus (Lam.) Trevis.	E	Epiphyte and lithophyte
H. verticillata (L.f.) Trevis.	E	Epiphyte and lithophyte
Lycopodiella caroliniana (L.) Pic.Serm.	E	Terrestrial
L. cernua (L.) Pic.Serm.	NWCES	Terrestrial
L. sarcocaulos (A.Braun & Welw. ex Kuhn) Pic.Serm.	WES	Terrestrial
Lycopodium clavatum L.; Mitchell 348	E	Terrestrial
Marattiaceae		
Ptisana fraxinea (Sm.) Murdock var. *salicifolia* (Schrad.) Murdock	ES	Terrestrial
Marsileaceae		
Marsilea apposita Launert	NWC	Aquatic and terrestrial
M. coromandelina Willd.	S	Aquatic and terrestrial
M. distorta A.Braun	E	Aquatic and terrestrial
M. ephippiocarpa Alston	NWCES	Aquatic and terrestrial
M. farinosa Launert subsp. *farinosa*	WC	Aquatic and terrestrial
M. macrocarpa C.Presl	NWE	Aquatic and terrestrial
M. minuta L. var. *minuta*	N	Aquatic and terrestrial
M. nubica A.Braun var. *gymnocarpa* (Lepr. ex A.Braun) Launert	NW	Aquatic and terrestrial
M. owambo Doweld	W	Aquatic and terrestrial
Ophioglossaceae		
Ophioglossum caroticaule J.E.Burrows	N	Lithophyte and terrestrial
O. convexum J.E.Burrows	C	Terrestrial
O. costatum R.Br.	NWCES	Terrestrial
O. gomezianum Welw. ex A.Braun	NWCE	Terrestrial
O. gracillimum Welw. ex Hook. & Baker	N	Terrestrial
O. lancifolium C.Presl	WE	Terrestrial
O. latifolium (Prantl) J.E.Burrows	NC	Terrestrial
O. lusoafricanum Welw. ex Prantl	C	Terrestrial
O. polyphyllum A.Braun ex Seub. var. *polyphyllum*	NCES	Terrestrial
O. reticulatum L. subsp. *complicatum* (Miq.) J.E.Burrows	E	Terrestrial
O. reticulatum L. subsp. *reticulatum*	NWCES	Terrestrial
O. rubellum Welw. ex A.Braun	NE	Terrestrial
O. sandieae J.E.Burrows	N	Terrestrial
O. thomasii R.T.Clausen	W	Terrestrial
O. vulgatum L. subsp. *africanum* Pocock ex J.E.Burrows var. *africanum*	NCE	Terrestrial
O. vulgatum L. subsp. *africanum* Pocock ex J.E.Burrows var. *taylorianum* J.E.Burrows	NCE	Terrestrial
Osmundaceae		
Osmunda regalis L.	NWCES	Lithophyte and terrestrial
Todea barbara (L.) T.Moore	E	Lithophyte and terrestrial
Polypodiaceae		
Arachniodes webbiana (A.Braun) Schelpe subsp. *foliosa* (C.Chr.) Gibby	E	Lithophyte and terrestrial
Arthropteris monocarpa (Cordem.) C.Chr.	NCE	Terrestrial
A. orientalis (J.F.Gmel.) Posth. var. *orientalis*	NWCES	Lithophyte and terrestrial
#*Bolbitis gemmifera* (Hieron.) C.Chr.	E	Terrestrial
B. heudelotii (Bory ex Fée) Alston	NE	Terrestrial
**Campyloneurum cubense* Fée	C	Epiphyte and lithophyte
Ctenitis cirrhosa (Schumach.) Ching	E	Terrestrial
**Cyrtomium micropterum* (Kunze) Ching	C	Terrestrial
Davallia chaerophylloides (Poir.) Steud.	E	Epiphyte and lithophyte
**D. trichomanoides* Blume	C	Terrestrial
Didymochlaena truncatula (Sw.) J.Sm.	E	Terrestrial
Dryopteris antarctica (Baker) C.Chr.	E	Lithophyte and terrestrial
D. athamantica (Kunze) Kuntze	NCES	Terrestrial
D. kilemensis (Kuhn) Kuntze	E	Terrestrial
D. lewalleana Pic.Serm.	E	Terrestrial
D. manniana (Hook.) C.Chr.	E	Terrestrial
D. pentheri (Krasser) C.Chr.	NCES	Lithophyte and terrestrial
D. squamiseta (Hook.) Kuntze	E	Terrestrial
D. wallichiana (Spreng.) Hyl. subsp. *reichsteinii* Fraser-Jenk.	E	Terrestrial
Elaphoglossum acrostichoides (Hook.& Grev.) Schelpe	E	Epiphyte and lithophyte
E. aubertii (Desv.) T.Moore	E	Epiphyte and lithophyte

E. chevalieri Christ	E	Lithophyte
E. deckenii (Kuhn) C.Chr.	E	Epiphyte and lithophyte
E. hybridum (Bory) Brack.	E	Epiphyte and lithophyte
E. kuhnii Hieron.	CE	Epiphyte and lithophyte
E. lancifolium (Desv.) C.V.Morton	E	Epiphyte and lithophyte
E. lastii (Baker) C.Chr.	E	Epiphyte
E. macropodium (Fée) T.Moore	E	Epiphyte and lithophyte
E. marojejyense Tardieu	E	Lithophyte
E. spathulatum (Bory) T.Moore var. *spathulatum*	NE	Lithophyte
E. welwitschii (Baker) C.Chr.	C	Lithophyte
Grammitis cryptophlebia (Baker) Copel	E	Epiphyte
G. oosora (Baker) J.E.Burrows	E	Epiphyte and lithophyte
G. flabelliformis (Poir.) C.V.Morton	E	Epiphyte and lithophyte
G. pygmaea (Buchinger ex Mett.) Copel	E	Epiphyte
#*G. serrulata* (Sw.) Sw.	E	Epiphyte and lithophyte
**Lecanopteris scandens* (G.Forst.) Perrie & Brownsey	E	Lithophyte and terrestrial
Lepisorus excavatus (Bory ex Willd.) Ching	NE	Epiphyte and lithophyte
L. schraderi (Mett.) Ching	ES	Epiphyte and lithophyte
L. spicatus (L.f.) Li Wang	E	Epiphyte and lithophyte
#*Lomariopsis warneckei* (Hieron.) Alston	E	Lithophyte
Loxogramme abyssinica (Baker) M.G.Price	CES	Epiphyte and lithophyte
Megalastrum lanuginosum (Willd. ex Kaulf.) Holttum	E	Terrestrial
Microgramma mauritiana (Willd.) Tardieu	E	Epiphyte and lithophyte
Microsorum pappei (Mett. ex Kuhn) Tardieu	E	Epiphyte
M. punctatum (L.) Copel.	E	Epiphyte, lithophyte, and terrestrial
Nephrolepis biserrata (Sw.) Schott	E	Terrestrial
**N. cordifolia* (L.) C.Presl	NWCE	Terrestrial
**N. exaltata* (L.) Schott	CE	Terrestrial
N. undulata (Afzel. ex Sw.) J.Sm.	NWCE	Epiphyte and terrestrial
Oleandra distenta Kunze	NCE	Epiphyte and lithophyte
**Phlebodium aureum* (L.) J.Sm.	C	Epiphyte, lithophyte, and terrestrial
Phymatosorus scolopendria (Burm.f.) Pic.Serm.	E	Epiphyte, lithophyte, and terrestrial
#*Platycerium alcicorne* (P.Willemet) Desv.	E	Epiphyte
Pleopeltis macrocarpa (Bory ex Willd.) Kaulf. var. *macrocarpa*	NCES	Epiphyte and lithophyte
P. polypodioides (L.) E.G.Andrews & Windham subsp. *ecklonii* (Kunze) J.P.Roux	CES	Epiphyte and lithophyte
Pleopodium X simiana (Schelpe & N.C.Anthony) N.R.Crouch & Klopper subsp. *simiana*	CES	Epiphyte and lithophyte
Polystichum luctuosum (Kunze) T.Moore	E	Lithophyte and terrestrial
P. monticola N.C.Anthony & Schelpe	W	Lithophyte and terrestrial
P. sinense (H.Christ) H.Christ	E	Lithophyte and terrestrial
P. transvaalense N.C.Anthony	E	Lithophyte and terrestrial
P. zambesiacum Schelpe	E	Lithophyte and terrestrial
Pyrrosia lanceolata (L.) Farwell	E	Epiphyte and lithophyte
P. rhodesiana (C.Chr.) Schelpe	E	Epiphyte and lithophyte
P. schimperiana (Kuhn) Alston var. *schimperiana*	NCES	Epiphyte and lithophyte
Rumohra adiantiformis (G.Forst.) Ching	E	Epiphyte, lithophyte and terrestrial
Tectaria gemmifera (Feé) Alston	E	Terrestrial
Psilotaceae		
Psilotum nudum (L.) P.Beauv.	NWCES	Epiphyte and lithophyte
Pteridaceae		
#*Acrostichum aureum* L.	S	Terrestrial
Actiniopteris dimorpha Pic.Serm. subsp. *dimorpha*	NWCES	Lithophyte and terrestrial
A. pauciloba Pic.Serm.	N	Lithophyte and terrestrial
A. radiata (J.Konig ex Sw.) Link	NWES	Lithophyte and terrestrial
Adiantum capillus-veneris L.	NWCES	Lithophyte and terrestrial
**A. formosum* R.Br.	C	Terrestrial
A. hispidulum var. *hispidulum* Sw.	E	Terrestrial
A. incisum Forssk.	NWCES	Epiphyte, lithophyte, and terrestrial
A. mendoncae Alston	NES	Lithophyte and terrestrial
A. patens Willd. ssp. *oatesii* (Baker) Schelpe	W	Terrestrial
A. philippense L.	NWCE	Epiphyte, lithophyte, and terrestrial
A. poiretii J.E.Wikstr.	NWCES	Lithophyte and terrestrial
**A. raddianum* C.Presl	E	Terrestrial

Anogramma leptophylla (L.) Link	NE	Terrestrial
Ceratopteris thalictroides (L.) Brongn.	NW	Aquatic
Cerosora argentea (Willd.) Hennequin & H.Schneid.	NCES	Lithophyte and terrestrial
Cheilanthes buchananii (Baker) Domin	NCES	Lithophyte and terrestrial
C. involuta (Sw.) Schelpe & N.C.Anthony var. *obscura* (N.C.Anthony) N.C.Anthony	NWCES	Lithophyte and terrestrial
#*Haplopteris elongata* (Sw.) E.H.Crane	E	Epiphyte
#*H. ensiformis* (Sw.) E.H.Crane	E	Epiphyte
H. guineensis (Desv.) E.H.Crane	E	Epiphyte and lithophyte
H. volkensii (Hieron.) E.H.Crane var. *volkensii*	E	Epiphyte and lithophyte
#*Hemionitis angulosa* (Bory ex Willd.) Christenh.	E	Terrestrial
H. bergiana (Schltdl.) Christenh.	E	Terrestrial
H. boivinii (Hook.) Christenh.	NWCES	Lithophyte and terrestrial
H. calomelanos (Sw.) Christenh.	NWCES	Lithophyte and terrestrial
H. concolor (Langsd. & Fisch.) Christenh.	NWCES	Lithophyte and terrestrial
H. doniana (J.Sm. ex Hook.) Christenh.	NES	Lithophyte and terrestrial
H. dura (Willd.) Christenh.	NWCES	Lithophyte and terrestrial
H. eckloniana (Kunze) Christenh.	CES	Lithophyte and terrestrial
H. farinosa (Forssk.) Christenh.	WCE	Epiphyte, lithophyte and terrestrial
H. hirta (Sw.) Christenh.	NWCES	Lithophyte and terrestrial
H. inaequalis (Kunze) Christenh.	NWCES	Lithophyte and terrestrial
H. leachii (Schelpe) Christenh.	WCES	Lithophyte and terrestrial
H. longipilosa (Bonap.) Christenh.	NC	Lithophyte and terrestrial
H. multifida (Sw.) Christenh.	NWCES	Lithophyte and terrestrial
H. pectiniformis (Baker) Christenh.	NCES	Lithophyte and terrestrial
H. pentagona (Schelpe & N.C.Anthony) Christenh.	N	Lithophyte and terrestrial
H. quadripinnata (Forssk.) Christenh.	NCE	Lithophyte and terrestrial
**H. rotundifolia* (G.Forst.) Christenh.	C	Lithophyte and terrestrial
H. schimperi (Kunze) Christenh.	NCE	Lithophyte and terrestrial
H. viridis (Forssk.) Christenh.	NWCES	Lithophyte and terrestrial
#*H. welwitschii* (Hook.) Christenh.	NC	Lithophyte and terrestrial
**Pityrogramma calomelanos* (L.) Link var. *aureoflava* (Hook.) Weath. ex L.H.Bailey	S	Lithophyte and terrestrial
Pteris buchananii Baker ex Sim	E	Terrestrial
P. catoptera Kunze	NE	Terrestrial
P. cretica L.	NWCES	Terrestrial
P. dentata Forssk.	E	Terrestrial
P. friesii Hieron.	NWCES	Terrestrial
P. linearis Poir.	C	Terrestrial
P. mildbraedii Hieron.	E	Terrestrial
P. muricella Fée	E	Terrestrial
P. vittata L.	NWCES	Lithophyte and terrestrial
Vittaria isoetifolia Bory	E	Epiphyte and lithophyte
Salviniaceae		
**Azolla filiculoides* Lam.	NCE	Aquatic
A. nilotica Decne. ex Mett.	NW	Aquatic
A. pinnata R.Br. subsp. *africana* (Desv.) R.M.K.Saunders & K.Fowler	NW	Aquatic
**Salvinia molesta* D.S.Mitch.	NWCE	Aquatic
Schizaeaceae		
Anemia angolensis Alston	N	Lithophyte and terrestrial
A. lepigera (Baker) Christenh.	WCES	Lithophyte and terrestrial
A. nudiuscula (J.P.Roux) Christenh.	NWES	Lithophyte and terrestrial
A. simii Tardieu	NCES	Lithophyte and terrestrial
A. vestita (Baker) Christenh.	ES	Lithophyte and terrestrial
Lygodium kerstenii Kuhn	ES	Terrestrial
L. microphyllum (Cav.) R.Br.	E	Terrestrial
Schizaea pectinata (L.) Sw.	E	Terrestrial
S. tenella Kaulf.	E	Terrestrial
Selaginellaceae		
Selaginella caffrorum (Milde) Hieron.	S	Lithophyte and terrestrial
S. dregei (C.Presl) Hieron.	NWCES	Lithophyte and terrestrial
S. goudotiana Spring var. *abyssinica* (Spring) Bizarri	NE	Lithophyte and terrestrial
S. imbricata (Forssk.) Spring ex Decne.	NWE	Lithophyte
S. kraussiana (Kunze) A.Braun	E	Terrestrial
S. mittenii Baker	NWCES	Lithophyte and terrestrial
S. nivea Alston ex Alston subsp. *nivea*	S	Terrestrial
#*S. perpusilla* Baker	S	Terrestrial

+ = Zimbabwe is divided into five floristic regions, i.e., N = northern, W = western, C = central, E = eastern and S = southern; # = Threatened and * = exotic species

Table 2. Proportion of Pteridophyte taxa within each family (record of families with more than 5 taxa)

Family	Number of taxa	%
Aspleniaceae	78	26.26
Polypodiaceae	67	22.56
Pteridaceae	54	18.18
Ophioglossaceae	16	5.39
Hymenophyllaceae	14	4.71
Lycopodiaceae	10	3.37
Dennstaedtiaceae	9	3.03
Marsileaceae	9	3.03
Schizaeaceae	9	3.03
Selaginellaceae	8	2.69
Cyatheaceae	6	2.02

Chorotype analysis

Out of the recorded 297 taxa, 16 species (5.39%) are exotic to Zimbabwe (Table 1). In terms of invasion status, 43.75% of the exotic species are cultivated as ornamental plants, 25.0% are naturalized, 18.75% are recorded as casuals, and 12.5% are invasive. The majority (43.75%) of the species belong to the Polypodiaceae family, while 25.0% belong to the Pteridaceae family, and the Aspleniaceae and Salviniaceae families contribute 12.5% each. These findings generally concur with observations made by Jones et al. (15) that Pteridophytes are widely cultivated as horticultural plants for their evergreen habit, foliage appearance, high environmental tolerance, and rapid growth rate. The majority of cultivated species that usually become naturalized or invasive are members of the Blechnaceae and Dennstaedtiaceae. Dryopteridaceae, Polypodiaceae, Pteridaceae, and Salviniaceae families (15). Research in Argentina showed that 6.79% of the Pteridophytes in this country are alien weeds, categorized as segetal, aquatic, ruderal, and/or toxic (40). In South Africa, 13 alien species (4.06% of the total Pteridophytes) were recorded as invasive in natural and semi-natural areas closer to water systems and indigenous forests (10). Previous research in Zimbabwe showed that species such as *Adiantum raddianum* C.Presl (family Pteridaceae), *Azolla filiculoides* Lam. (Salviniaceae), *Lecanopteris scandens* (G.Forst.) Perrie & Brownsey (Polypodiaceae), *Microlepia strigosa* (Thunb. ex Murray) C.Presl (Dennstaedtiaceae), and *Salvinia molesta* D.S.Mitch. (Salviniaceae) are naturalized as weeds in the country (41-43).

The floristic region with the highest number of Pteridophytes in Zimbabwe is the eastern region with 251 taxa (84.51%), followed by the northern region (98 taxa, 33.0%), the southern region (89 taxa, 29.97%), the central region (88 taxa, 29.63%), while western Zimbabwe (65 taxa, 21.89%) has the lowest number (Fig. 2). The relatively lower number of Pteridophytes in the western part of Zimbabwe is due to the harshness of the region's climate, as western Zimbabwe is hot and dry, characterized by low and erratic rainfall (41-43). The majority of Pteridophytes in Zimbabwe (213 taxa, 71.72%) are terrestrial, growing in moist conditions, near streams, and in shady places. Close to half of the Pteridophytes, 161 taxa (54.21%) are lithophytic, while about a third, 89 taxa (29.97%) are epiphytic, and 14 taxa (4.71%) are aquatic (Table 1). The majority (13 species) of the aquatic Pteridophytes belong to the Marsileaceae and Salviniaceae families. The species belonging to the Marsileaceae family are heterosporous aquatic or semi-aquatic plants, often growing as dense clumps on the shores of rivers, streams, or ponds and, in some cases, submerged in shallow water (7, 44-46). Similarly, species belonging to the Salviniaceae family are small and heterosporous free-floating aquatic plants lacking true roots (7, 47, 48). Besides that, there is one species belonging to the family Pteridaceae, *Ceratopteris thalictroides* (L.) Brongn. is a free-floating or rooted plant that has been recorded in the hot regions of the country in slow-flowing rivers and streams, backwaters of pools, and lakes (49). In southern Africa, *C. thalictroides* has also been recorded in Botswana, Eswatini, Namibia, and South Africa (7).

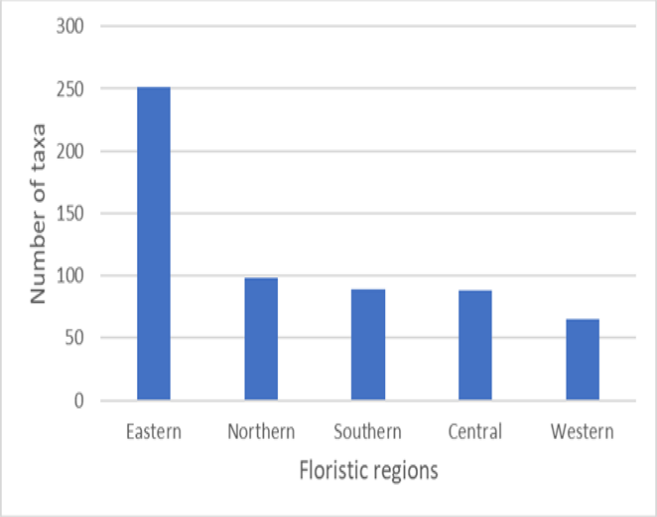

Fig. 2. The distribution of Pteridophytes in Zimbabwe.

A total of 20 Pteridophyte taxa (6.73%) are threatened with extinction in Zimbabwe (Fig. 3). *Platycerium alcicorne* (P.Willemet) Desv. is categorized as Extinct in Zimbabwe due to habitat fragmentation and loss, agricultural activities, and over-collection (50). *Acrostichum aureum* L. and *Alsophila thomsonii* (Baker) R.M.Tryon are categorized as Critically Endangered due to habitat fragmentation and loss and also a result of having a small population size that is restricted over a small geographical range. Four species, namely *Alsophila humilis* (Hieron.) Pic.Serm., *Haplopteris elongata* (Sw.) E.H.Crane, *H. ensiformis* (Sw.) E.H.Crane and *Hemionitis welwitschii* (Hook.) Christenh. are categorized as Endangered due to factors such as grazing, habitat fragmentation and loss, and over-collection. Seven species, namely *Asplenium buettneri* Hieron., *A. christii* Hieron., *A. mossambicense* Schelpe, *A. pellucidum* Lam. subsp. *pseudohorridum* (Hieron.) Schelpe, *Hemionitis angulosa* (Bory ex Willd.) Christenh., *Hymenasplenium unilaterale* (Lam.) Hayata, and *Selaginella perpusilla* Baker, are categorized as Vulnerable mainly because the taxa are rare with restricted geographical distribution and threatened by afforestation activities, grazing, habitat fragmentation, and loss. Six species, namely *Alsophila dregei* (Kunze) R.M.Tryon, *A. manniana* (Hook.) R.M.Tryon, *Asplenium sebungweense* J.E.Burrows, *Bolbitis gemmifera* (Hieron.) C.Chr., *Grammitis serrulata* (Sw.) Sw., and *Lomariopsis warneckei* (Hieron.) Alston, are categorized as

Near Threatened due to habitat fragmentation and loss resulting from mining activities and over-collection of the species (50). *Adiantum mendoncae* Alston (Pteridaceae) is categorized as rare and near-endemic, recorded in Eastern, Northern, and Southern Zimbabwe, Manica, Nampula, and Sofala provinces in Mozambique (51). *Asplenium sebungweense* is also another near-endemic species confined to Northern Zimbabwe and Zambia (26, 28, 29).

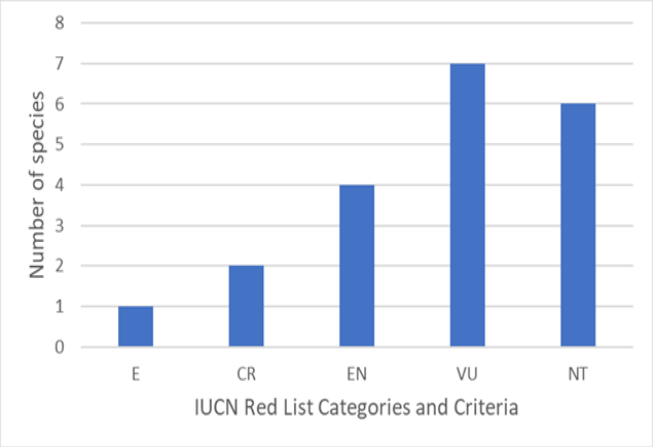

Fig. 3. Number of Zimbabwean Pteridophytes in the different IUCN Red List Categories of Threat.

Conclusion

The current study has provided a list of Pteridophytes growing in Zimbabwe. Further studies on this category of plants are needed, as 6.73% of the documented taxa are at risk of extinction due to anthropogenic causes such as habitat loss and fragmentation. Pteridophytes growing in Zimbabwe are also threatened by afforestation, agricultural and mining activities, grazing, and over-collection of the taxa. Therefore, gaining a better understanding of Pteridophyte biology, ecology, and conservation needs will contribute to the improved management of this plant group in the country.

Acknowledgements

I appreciate the University of Fort Hare, South Africa for funding this research.

Compliance with ethical standards

Conflict of interest: The author declares that there is no conflict of interest.

Ethical issues: Ethical standards were maintained in writing this article.

References

1. Thomas BA, Cleal CJ. Pteridophytes as primary colonisers after catastrophic events through geological time and in recent history. Palaeobiod Palaeoenviron. 2022;102:59-71. https://doi.org/10.1007/s12549-021-00492-1
2. Wolf PG, Schneider H, Ranker TA. Geographic distribution of homosporous ferns: Does dispersal obscure evidence of vicariance? J Biogeogr. 2001;28:263-70. https://doi.org/10.1046/j.1365-2699.2001.00531.x
3. Qian H, Zhang J, Jiang MC. Global patterns of fern species diversity: An evaluation of fern data in GBIF. Plant Divers. 2022;44:135-40. https://doi.org/10.1016/j.pld.2021.10.001.
4. Sharpe JM, Mehltreter K, Walker LR. Ecological importance of ferns. In: Mehltreter K, Walker LR, Sharpe JM(eds) Fern ecology. Cambridge University Press, Cambridge. 2010; pp. 1-21. https://doi.org/10.1017/cbO9780511844898.002
5. Akinsoji A, Agboola OO, Adeonipekun PA, Oyebanji OO, Adeniyi TA, Ajibode MO. Occurrence and distribution of Pteridophytes in parts of Lagos and Osun states. Ife J Sci. 2016;18(2):447-53.
6. Anderson OR. Ecophysiology and adaptability of terrestrial ferns: Perspectives in a changing global climate. In: Nowicki L, Kowalska A, editors., Ferns: Ecology, importance to humans and threats. Nova Scientific Publishers, New York. 2018;pp. 1-55.
7. Crouch NR, Klopper RR, Burrows JE, Burrows SM. Ferns of Southern Africa: A comprehensive guide. Struik Nature, Cape Town. 2011.
8. Pteridophyte Phylogeny Group (PPGI). A community-derived classification for extant lycophytes and ferns. J Syst Evol. 2016;54(6):563-603. https://doi. org/10.1111/jse.12229
9. Phoutthavong K, Nakamura A, Cheng X, Cao M. Differences in pteridophyte diversity between limestone forests and non-limestone forests in the monsoonal tropics of southwestern China. Plant Ecol. 2019;220:917-34. https://doi.org/10.1007/s11258-019-00963-8
10. Jones EJ, Kraaij T, Guerbois C, Moodley D. An assessment of the invasion status of terrestrial alien ferns (Polypodiophyta) in South Africa. S Afr J Bot. 2020;131:64-73. https://doi.org/10.1016/j.sajb.2020.02.008
11. Page CN. Ecological strategies in fern evolution: A neopteridological overview. Rev Palaeobot Palynol. 2002;119(1-2):1-33. https://doi.org/10.1016/S0034-6667(01)00127-0
12. Walker LR, Mehltreter K, Sharpe JM. Current and future directions in fern ecology. In: Mehltreter K, Walker LR, Sharpe JM (eds) Fern ecology. Cambridge University Press, Cambridge. 2010;pp. 360-78. https://doi:10.1017/CBO9780511844898.011
13. Jackson EF, Echlin HL, Jackson CR. Changes in the phyllosphere community of the resurrection fern, *Polypodium polypodioides*, associated with rainfall and wetting: Changes in the phyllosphere community of the resurrection fern. FEMS Microbiol Ecol. 2006;58(2):236-46. https://doi:10.1111/j.1574-6941.2006.00152.x
14. World Conservation Monitoring Centre (WCMC). Global biodiversity: Status of the earth's living resources. Chapman and Hall, London. 1992.
15. Jones EJ, Kraaij T, Fritz H, Moodley D. A global assessment of terrestrial alien ferns (Polypodiophyta): Species' traits as drivers of naturalization and invasion. Biol Invasions. 2019;21:861-73: https://doi.org/10.1007/s10530-018-1866-1
16. Robinson R, Sheffield E, Sharpe J. Problem ferns: Their impact and management. In: Mehltreter K, Walker LR, Sharpe JM, editors., Fern Ecology. Cambridge University Press, Cambridge. 2010;pp. 255-322. https://doi.org/10.1017/CBO9780511844898.009
17. Abotsi KE, Bose R, Adjossou K, Deblauwe V, Rouhan G, Segla KN *et al*. Ecological drivers of pteridophyte diversity and distribution in Togo (West Africa). Ecol Indicat. 2020;105. https://doi.org/10.1016/j.ecolind.2019.105741
18. Chipika JT, Kowero G. Deforestation of woodlands in communal areas of Zimbabwe: Is it due to agricultural policies? Agric Ecosyst Environ. 2000;79:175-85. https://doi.org/10.1016/S0167-8809(99)00156-5
19. Matsvange D, Sagonda R, Kaundikiza M. The role of communities in sustainable land and forest management: The case of Nyanga, Zvimba and Guruve districts of Zimbabwe.

Jàmbá J Disaster Risk Stud. 2016;8(3):a281. https://doi.org/10.4102/jamba.v8i3.281

20. Zvobgo L, Tsoka J. Deforestation rate and causes in Upper Manyame Sub-Catchment, Zimbabwe: Implications on achieving national climate change mitigation targets. Trees For People. 2021;5:100090. https://doi.org/10.1016/j.tfp.2021.100090
21. Mataruse PT, Nyikahadzoi K, Fallot A. Smallholder farmers' perceptions of the natural and anthropogenic drivers of deforestation and forest degradation: A case study of Murehwa, Zimbabwe. Transact Royal Soc S Afr. 2022. https://doi.org/10.1080/0035919X.2022.2152507
22. Schelpe EACLE. Pteridophyta. In: Exell AW, Launert E, editors., Flora Zambesiaca. Crown Agents for Overseas Governments and Administrations, London. 1970;pp. 1-254.
23. Burrows JE, Burrows SM. A checklist of the pteridophytes of Zimbabwe. S Afr J Bot. 1983;49:193-212.
24. Jacobsen WBG. The ferns and fern allies of Southern Africa. Butterworths, Pretoria. 1983.
25. Jacobsen WBG, Jacobsen NHG. Comparison of the pteridophyte floras of Southern and Eastern Africa, with special reference to high-altitude species. Bull du Jardin Bot Nat de Belg. 1989;59:261-317. https://doi.org/10.2307/3668347
26. Burrows JE. Southern African ferns and fern allies. Frandsen, Sandton. 1990.
27. Goldblatt P, Manning J. Cape plants: A conspectus of the Cape Flora of South Africa. Strelitzia 9. National Botanical Institute of South Africa, Pretoria. 2000.
28. Roux JP. Conspectus of Southern African Pteridophyta: An enumeration of the Pteridophyta of Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa (including the Marion Island group), Swaziland, Zambia and Zimbabwe. Southern African Botanical Diversity Network Report No. 13. National Botanical Institute, Pretoria. 2001.
29. Roux JP. Synopsis of the Lycopodiophyta and Pteridophyta of Africa, Madagascar and neighbouring islands. South African National Biodiversity Institute, Pretoria. 2009.
30. Manning J, Goldblatt P. Plants of the Greater Cape Floristic Region 1: The core Cape Flora. Strelitzia 29, South African National Biodiversity Institute, Pretoria. 2012.
31. Snijman DA. Plants of the Greater Cape Floristic Region 2: The extra Cape Flora. Strelitzia 30. South African National Biodiversity Institute, Pretoria. 2013.
32. Retief E, Meyer NL. Plants of the Free State: Inventory and identification guide. Strelitzia 38. South African National Biodiversity Institute, Pretoria. 2017.
33. Bredenkamp CL. A flora of the Eastern Cape province Volume 1. Strelitzia 41. South African National Biodiversity Institute, Pretoria. 2019.
34. Thiers B. Index herbariorum: A global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. 2023. Available from: http://sweetgum.nybg.org/ih/, accessed on 13 September 2023.
35. POWO. Plants of the World Online. 2024. Available from: http://www.plantsoftheworldonline.org/, accessed on 18 September 2023.
36. Richardson DM, Pyšek P, Rejmánek M, Barbour MG, Panetta FD, West CJ. Naturalization and invasion of alien plants: Concepts and definitions. Divers Distrib. 2000;6:93-107. https://doi.org/10.1046/j.1472-4642.2000.00083.x
37. Richardson DM, Pyšek P. Naturalization of introduced plants: Ecological drivers of biogeographical patterns. New Phytol. 2012;196:383-96. https://doi.org/10.1111/j.1469-8137.2012.04292.x
38. Pope GV, Pope DG. Collecting localities in the flora Zambesiaca area. Flora Zambesiaca Management Committee, Royal Botanic Gardens, Kew, Richmond. 1998.
39. Christenhusz MJM, Byng JW. The number of known plants species in the world and its annual increase. Phytotaxa. 2016;261(3):201-17. https://doi.org/10.11646/phytotaxa.261.3.1
40. Yañez A, Gutiérrez DG, Ponce MM. Weedy ferns (Polypodiopsida) in Argentina: diversity, distribution and impact on human activities and ecosystems. An Acad Bras Cienc. 2020;92(1):e20180983. https://doi.org/10.1590/0001-3765202020180983
41. Maroyi A. A preliminary checklist of naturalized and introduced plants in Zimbabwe. Kirkia. 2006;18:177-247.
42. Maroyi A. The casual, naturalised and invasive alien flora of Zimbabwe based on herbarium and literature records. Koedoe. 2012. https://doi.org/10.4102/koedoe.v54i1.1054.
43. Maroyi A. Data on introduced plants in Zimbabwe: Floristic changes and patterns of collection based on historical herbarium records. Data Brief. 2017;15:348-69. https://doi.org/10.1016/j.dib.2017.09.046
44. Pryer KM. Phylogeny of marsileaceous ferns and relationships of the fossil *Hydropteris pinnata* reconsidered. Int J Plant Sci. 1999;160(5):931-54. https://doi.org/10.1086/314177.
45. Xu Z, Deng M. Marsileaceae. In: Xu Z, Zhou G, editors., Identification and control of common weeds: Volume 2. Springer, Dordrecht. 2017;pp. 95-97. https://doi.org/10.1007/978-94-024-1157-7_16
46. Aros-Mualin D, Flexas J, Galbier F, Kessler M. Exploring the ecological relevance and variability of circadian regulation in Marsileaceae. Amer Fern J. 2022;112(4):303-19. https://doi.org/10.1640/0002-8444-112.4.303
47. Xu Z, Deng M. Salviniaceae. In: Xu Z, Zhou G, editors. Identification and control of common weeds: Volume 2. Springer, Dordrecht. 2017;pp. 99-103. https://doi.org/10.1007/978-94-024-1157-7_17
48. De Benedetti F, Zamaloa MC, Gandolfo MA, Cúneo NR. The South American and Antarctic peninsula fossil record of Salviniales (water ferns): Its implication for understanding their evolution and past distribution. Review Palaeobot Palynol. 2021;295:104521. https://doi.org/10.1016/j.revpalbo.2021.104521
49. Hyde MA, Wursten BT, Ballings P, Palgrave CM. Flora of Zimbabwe: Species information: *Ceratopteris thalictroides* (L.) Brongn. 2024. Available from: https://www.zimbabweflora.co.zw/speciesdata/species.php?species_id=148300, accessed on 6 September 2023
50. Mapaura A, Timberlake JR. Zimbabwe. In: Golding JS, editor. Southern Africa plant Red Data Lists. Southern African Botanical Diversity Network Report No. 14. SABONET, Pretoria. 2002; pp. 157-82.
51. Darbyshire I, Timberlake J, Osborne J, Rokni S, Matimele H, Langa C *et al*. The endemic plants of Mozambique: diversity and conservation status. Phyto Keys. 2019;136:45-96. https://doi.org/10.3897/phytokeys.136.39020