

Original Research Article

Revised Classification of Pteridophytes of Ethiopia and Eritrea

ABSTRACT

Aims: To conduct an in-depth inventory of the pteridophytes of Ethiopia and Eritrea, classifying them based on the Pteridophyte Phylogeny Group I (PPG I), in order to conform to the new trends in pteridophyte classification.

Study design: The desktop research approach

Place and Duration of Study: Samples for this study were collected from different areas in Ethiopia and Eritrea. These are neighbouring countries situated in northeast Africa, in the area known as 'The Horn of Africa'. Collections were made between August 2021 and March 2023.

Methodology: The desktop research approach was applied in this study. Secondary data on species of pteridophytes of Ethiopia and Eritrea that was obtained through a compilation published in 2009 by groups of researchers from the National Herbarium of the University of Addis Ababa and Uppsala University of Sweden through the Department of Systematic Biology. It was published in the Volume I of the '*Flora of Ethiopia and Eritrea*'. It comprised of 36 families, 78 genera and 192 species of pteridophytes. The classification of these species mainly followed the concept of Pichi Sermolli.

Results: This study has therefore produced a comprehensive checklist of documented species of pteridophytes in Ethiopia and Eritrea. It is comprised of 192 species, 76 genera and 27 families.

Conclusion: This study has revised the classification of pteridophytes of Ethiopia and Eritrea to conform to the PPG I classification approach. This resulted in 27 families, 76 genera and 192 species, with changes recorded at all levels of classification except the number of species. This outcome is therefore suggested to be applied in the herbaria and adopted by researchers of pteridophytes in Ethiopia and Eritrea, for ease of communication internationally.

Comment [A1]: The authors have indicated that field collections were conducted, yet the methodology section lacks comprehensive details on the process. It is essential to provide specifics about the field collection, including the exact locations, dates, and methods used for collecting specimens. Additionally, the methodology should specify that the collected specimens were identified and deposited in the [Herbarium Name, Institution, Location] for future reference and verification.

Comment [A2]: This section needs clarity

Keywords: *Pteridophytes, fern, checklist, Aspleniaceae, Ethiopia, Eritrea*

1. INTRODUCTION

Pteridophytes are known to be the most diverse group of vascular plants in the world and are the oldest lineage of vascular plants worldwide and the second-most specious after angiosperms [1]. Recently, pteridophytes have attracted a lot of attention. It has been discovered that they were the first plants to emerge after the K-pg asteroid event which smashed into the planet [2]. The same researchers discovered that, though dinosaurs were lost, forests were leveled and four out of five species of plants went extinct in areas close to the impact site, the first life to recolonize these areas was the pteridophytes. Pteridophytes are often found where volcanic eruptions have occurred. According to [3], they recover much more quickly than other organisms following exposure. It has also been found that the genomes of fe

Comment [A3]: The introduction is unnecessarily long and irrelevant, which may discourage readers from continuing with the article.

relatively large, comparable to that of the largest genome, *Paris japonica* [4], [5]. The importance of these plants to humanity therefore has to be investigated. Species of pteridophytes across the world are estimated to be about 11,916 [6]. Africa and Madagascar have an estimated 1,441 species [7]. For most pteridophytes, their simple structure, small forms, rhizome structures, spore producing ability and minute ecological requirements makes them great competitors and give them the ability to form dense colonies. As a result, they serve important functions in ecosystem processes such as being primary producers and ecological successors [8]. Pteridophytes are also said to serve as good bioindicators of climate change [9]. They also provide habitat and shade for smaller organisms, as well as preventing soil erosion [8]. Some genera of pteridophytes including *Asplenium*, *Microsorium*, and *Marattia* are used as ornamentals [9]. Pteridophytes also contain large amounts of secondary plant metabolites such as alkaloids [10], flavonoids [11], polyphenols [12], terpenoids [13], and steroids [14]. As a result, they act as source of fodder for cattle [15], and food for smaller animal such as caterpillars and insects. Some Pteridophytes are also used as food sources in sub-Saharan Africa, such as *Pteridium aquilinum* (L.) Kuhn in Angola, Cameroon, Nigeria and South Africa [16], *Ophioglossum reticulatum* L. in South Africa, Swaziland and Zanzibar, *Ceratopteris thalictroides* (L.) Brongn. in Madagascar and Swaziland, *Nephrolepis biserrata* Sw. in DRC and Nigeria [17],[18] and *Ophioglossum polyphyllum* A. Braun in Namibia and South Africa [19]. They are either eaten cooked as vegetables (66.7%) or raw as salad (12.5% each). Literature search revealed that some of the documented pteridophytes have high macro and micro nutrient content which are important for the maintenance of good health and prevention of diseases. Effective classification of these plants is therefore the basic requirement to further understanding of their other functions which is the focus of this study.

Ethiopia and Eritrea are both situated in the eastern part of Africa and are characterized by high temperatures and severe dry season. Though these two countries have been reported to be highly impoverished in terms of flora [8], a detailed inventory of pteridophytes will establish the state of preservation of what is available. The assemblages of species of pteridophytes of Ethiopia and Eritrea have been compiled through the National Herbarium of Addis Ababa and The Department of Systematic Biology, Uppsala University Sweden in 2009 by a group of researchers from these two institutions [21]. It was published in the Volume I of the Flora of Ethiopia and Eritrea. It contained 36 families, 78 genera and 192 species of pteridophytes, which mainly followed the concept of Pichi Sermolli [22].

The PPG I [6] established a new approach for the classification of pteridophytes called a Community-based approach'. This classification is a comprehensive classification for lycophytes and ferns, from class level down to the genus level. This approach used monophyly as the primary criterion for the recognition of taxa based on morphological and molecular data.

Comment [A4]: Remove the extraneous introduction and focus on summarizing the previous research on Pteridophyte diversity specific to the study area.

Include a comprehensive review of the global advancements in Pteridophyte classification.

Explain the importance of this study and its significance for the scientific community.

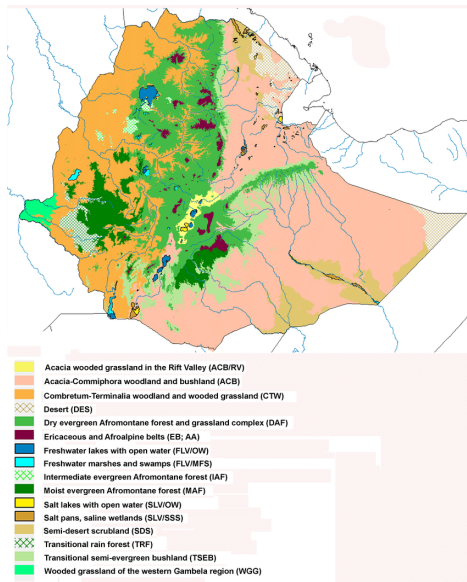
Comment [A5]:

1. It appears that the author did not consult any herbarium collections during the preparation of this manuscript.
2. Without consulting herbaria, how can the authors accurately determine the total number of pteridophyte species in the study area?
3. It is evident that the author has primarily relied on the "Flora of Ethiopia and Eritrea – Vol I" as the sole source for data collection.
4. Given that their source was published in 2009, what about other sources that have been published since then? There is a possibility of an increase in the number of species in the study area.
5. The author should review and reference all relevant literature up to the present date to provide an accurate count of the total number of species..

The aim of this study was to conduct an in-depth inventory of the pteridophytes of Ethiopia and Eritrea, classifying them based on the PPG I [6] in order to conform to the new trends in pteridophyte classification.

2. MATERIAL AND METHODS

Ethiopia is situated in northeast Africa, in the area known as 'The Horn of Africa'. It is bordered by Eritrea, Sudan, South Sudan, Kenya, Somalia, the self-proclaimed separatist territory of Somaliland and Djibouti. Encompassing an area of 1,104,300 km² and it is completely landlocked and located between approximately E 32°58'00" to E 48°00'00" and 30°25'00" N to 14°55'00" N. This country has a diverse climate and landscape, ranging from equatorial rain forest with high rainfall and humidity in the South and Southwest, to Afro-Alpine on summits of the Simien and Bale Mountains, to desert-like conditions in the north-east, east and South east lowlands. Overall, Ethiopia is considered largely arid, but exhibits a high variability of precipitation. Ethiopia is the second most populous country in Africa and has a population over 120.3 million people (2021). Ethiopia has the fifth highest biodiversity in Africa [23]. Consequently, these highlands have formed unique vegetation types (Figure 1).



Source: www.google.com

Figure 1: Vegetation map of Ethiopia

Eritrea on the other hand lies in the northeastern corner of the Horn of Africa, bordered by Ethiopia, Sudan and Djibouti with a coastal front along the Red Sea with a population of about 3.17 million people. Habitats and ecosystems found in

Comment [A6]: The study area map lacks GPS coordinates, a scale bar, and a direction arrow. To improve the map's utility, please include these essential elements.

Eritrea include Juniperus forests, riverine forests, coral reefs and traditional farming systems. A total of 700 plants have been recorded in Eritrea. Eritrea is also recognized as a centre of origin and centre of diversity for a number of crops, notably the cereals: sorghum, wheat and barley. Eritrea has suffered one of the most severe cases of environmental degradation following 30 years of armed struggle, persistent drought and environmental neglect. Having once had significant natural resources, fertile land, dense forests and high rates of wildlife, the country's environmental resources are now denuded with fragile and fragmented ecosystems (Figure 2).



Source: www.google.com

Figure 2: Vegetation map of Eritrea

Ethiopia and Eritrea are neighbouring countries. Initially they were one country following the Second World War, where Eritrea was federated with Ethiopia in 1952. Eritrea finally regained its independence from Ethiopia in 1991. These countries have a diverse climate and landscape, ranging from equatorial rain forest with high rainfall and humidity in the South and Southwest, to Afro-Alpine forests on summits of Mountains, to desert-like conditions in the north-east, east and South east lowlands. Overall, Ethiopia and Eritrea are considered largely arid, but exhibit a high variability of precipitation.

2.1 Data collection

The desktop research approach was applied in this study. Secondary data on species of Pteridophytes of Ethiopia and Eritrea that was obtained through a compilation of information on pteridophytes published in 2009 by groups of researchers from the National Herbarium of the University of Addis Ababa and Uppsala University of Sweden through the Department of Systematic Biology [21]. It was published in the Volume I of the Flora of Ethiopia and Eritrea. It comprised of 36 families, 78 genera and 192 species of pteridophytes. The classification of these species mainly followed the concept of Pichi Sermolli [22].

Comment [A7]: The study area map lacks GPS coordinates, a scale bar, and a direction arrow. To improve the map's utility, please include these essential elements.

Comment [A8]: Sentences are repeated in introduction as well as in methodology section. avoid repetitions.

2.2 Data analysis

Microsoft Excel 2010 was used for data treatment and preparation of the checklist. Diagnostic characters were determined for use in the classification. All species were then re-classified according to the PPG 1 [6] approach.

3. RESULTS AND DISCUSSION

The Pteridophyte Phylogeny Group I in 2016 established a new approach for the classification of pteridophytes called a Community-based approach'. This classification is a comprehensive classification for lycophytes and ferns, from class level down to the genus level. This approach used monophyly as the primary criterion for the recognition of taxa based on morphological and molecular revolution with the aim of narrowing the concept. This system was established as a summary statement of current hypotheses, derived from the best available data and shaped by those most familiar with the plants in question [6]. Table 1 presents the pteridophytes of Ethiopia and Eritrea from the Volume 1 of the Flora of Ethiopia and Eritrea [21].

It contained 36 families, 78 genera and 192 species of Pteridophytes, which mainly followed the concept of Pichi Sermolli [22]. This classification is grounded in evolutionary principles and is therefore phylogenetic [6]. This classification system is good in that; it tells the evolutionary history about the plant, it does not aim to place species in any sort of order and informs about the biological processes that leads to biological diversity. The limitations to this system of classification are that; closely-related species may not always look more alike, while groups that are not closely related yet evolved under similar conditions may appear more similar to each other, in phylogenetic trees, branches do not usually account for length of time and only depict evolutionary order.

Table 1: Inventory of Pteridophytes in the Flora of Ethiopia and Eritrea, with comments on what would change under the PPG I system

S/N	Family	Genera	Species	Comments
1.	Lycopodiaceae (6 species)	<i>Huperzia Bernh.</i>	<i>H. dacrydioides</i> (Baker) Pic.Serm. <i>H. saururus</i> (Lam.) Trevis. <i>H. verticillata</i> (L.f.) Trellis. <i>H.opbioglossoides</i> (Lam.)	No change

Comment [A9]: results and discussion section needs to elaborate

Rollin.

Lycopodiella *L. clavatum* L. No change
Holub

Lycopodium L. *L. cernua* (L.) Pic.Senn. No change

2. Selaginellaceae *Selaginella* P. *S. caffrorum* (Milde) No change
(8 species) Beauv. Hieron.
S. goudotiana Spring
S. imbricata (Forssk.)
Spring ex Decne
S. kraussiaa (Kunze) A.
Braun
S. phillipsiana (Hieron.)
Alston
S. yemensis (Sw.)
Spring
S. kalbreyeri Baker
S. tenerrima A. Braun ex
Kuhn

3. Isoetaceae *Isoetes* L. *I. aequinoctialis* Welw. No change
(3 species) ex A. Braun
I. schweinfurthii A.Braun
ex Baker
I. alstonii C.FReed &
Verde.

4.	Equisetaceae (1 species)	<i>Equisetum</i> L.	<i>E. ramosissimum</i> Desf	No change
5.	Ophioglossaceae (9 species)	<i>Botrychium</i> Sw.	<i>B. chamaeconium</i> Bitter & Hieron.	No change
		<i>Ophioglossum</i> L.	<i>O. caroticaule</i> J.E.Burrows. <i>O. costatum</i> R.Br. <i>O. gomezianum</i> Welw. ex A.Broun. <i>O. lusofricanum</i> Welw. ex Prantl. <i>O. polyphyllum</i> A.Braun. <i>O. reticulatum</i> L. <i>O. rubellum</i> Welw. ex A. Braun. <i>O. vulgatum</i> L. subsp. africanum Pocock ex J.E. Burrows.	No change
6.	Marattiaceae (1 species)	<i>Marattia</i> Sw.	<i>M. fraxinea</i> Sm.	No change
7.	Osmundaceae (1 species)	<i>Osmunda</i> L.	<i>O. regalis</i> L.	No change
8.	Gleicheniaceae (1 species)	<i>Dicranopteris</i> Bernh.	<i>D. linearis</i> (Burm. f.) Underw.	
9.	Grammitidaceae (2 species)	<i>Melpomene</i> A.R. Sm. & R.C. Moran.	<i>M. flabelliformis</i> (Poir.) A.R. Sm. & R.C Moran.	<i>Melpomene</i> has been moved to Polypodiaceae.

			Circumscription sensu [24], [25].
	<i>Lellingeria</i> A.R. <i>L. oosora</i> (Balrer)A.R.		<i>Lellingeria</i> has been
	Sm. & R.C. Sm. & R.C Moran.		moved to
	Moran.		Polypodiaceae
10. Polypodiaceae (10 species)	<i>Platynerium</i> Desv.	<i>P. elephantotis</i> Schweinf	No change
	<i>Pyrrosia</i> Mirb.	<i>P. schimperiana</i> (Kuhn) Alston.	No change
	<i>Drynaria</i> (Bory) J. Sm.	<i>D. volkensis</i> Hieron.	<i>Drynaria</i> has been included in <i>Aglaomorpha</i> , under Polypodiaceae Circumscription newly proposed in PPG I [6].
	<i>Lepisorus</i> (J.Sm.) Ching.	<i>L. excavatus</i> (Willd.) Ching. <i>L. schraderi</i> (Mett.) Ching.	No change
	<i>Microsorium</i> Link.	<i>M. punctatum</i> (L.) Copel.	No change
	<i>Phymatosorus</i> Pic. Serm.	<i>P. scolopendria</i> (Burm. f) Pic. Sum.	<i>Phymatosorus</i> has been moved to <i>Microsorium</i> . Circumscription

			Sensu [26].
	<i>Pleopeltis</i> Willd.	<i>P. macrocarpa</i> (Willd.) Kaulf.	No change
	<i>Polypodium</i> L.	<i>P. polypodioides</i> (L.) Watt.	No change
	<i>Loxogramme</i> (Blum.) C Presl.	<i>L. abyssinica</i> (Baker) M.G. Price.	No change
11. Anemiaceae (1 species)	<i>Anemia</i> Sw.	<i>A. schimperiana</i> C.Presl.	No change
12. Negripteridaceae (2 species)	<i>Negripteris</i> Pic. Serm.	<i>N. scioana</i> (Chiov.) Pic.Serm. <i>N. tricholepifera</i> Pic.Serm.	<i>Negripteris</i> has been moved to <i>Cheilanthes</i> under the Pteridaceae Circumscription sensu [27].
13. Sinopteridaceae (17 species)	<i>Aspidotis</i> (Nutt. ex Hook.) Copel.	<i>A. scbimperi</i> (Kunze) Pic.Serm.	<i>Aspidotis</i> has been moved to Pteridaceae. Circumscription sensu Smith et al. (2006b)
	<i>Notholaena</i> R.Br.	<i>N. marantae</i> (L.) Desv.	<i>Notholaena</i> has been moved to Pteridaceae Circumscription sensu [28].

Pellaea Link. *P. doniana* Hook. *Pellaea* has been
P. longipilosa Bonap. moved to
P. dura (Willd.) Hook. Pteridaceae
P. calomelanos (Sw.) Circumscription
Link. sensu [28].
P. viridis (Forssk.)
Prantl.
P. quadripinnata
(Forssk.) Prantl

Doryopteris J. *D. concolor* (Langsd. & *Doryopteris* has been
Sm. Fisch.) Kuhn. moved to
Pteridaceae
Circumscription
sensu [28].

Cheilanthes Sw. *C. farinosa* (Forssk.) *Cheilanthes* has been
Kaulf. *C. multifida* (Sw.) moved to
Sw. Pteridaceae
C. bergiana Schldl. Circumscription
C. hirta Sw. sensu [28].
C. coriacea Decne.
C. erythraea Pic.Serm.
C. acrosticha (Balbis)
Tod.
C. vellea (Ait.)F. Muell.

14. Cryptogrammaceae *Onychium* Kaulf. *O. divaricatum* (Poir.) *Onychium* has been
(1 species) Alslon. moved to

			Pteridaceae
			Circumscription
			sensu [28].
15. Actiniopteridaceae (3 species)	<i>Actiniopteris</i> Link.	<i>A. radiata</i> (Sw.) Link <i>A. dimorpha</i> Pic. Serm. <i>A. semiflabellata</i> Pic. Serm.	<i>Actiniopteris</i> Link has been moved to Pteridaceae Circumscription sensu [28].
16. Pteridaceae (9 species)	<i>Pteris</i> L.	<i>P. vittata</i> L. <i>P. cretica</i> L. <i>P. hamulosa</i> (Christin) Christin <i>P. tripartita</i> Sw. in Schrad. <i>P. buchananii</i> Sim. <i>P. pteridioides</i> (Hook.) Ballard. <i>P. dentate</i> Forssk. <i>P. linearis</i> Poir. <i>P. catoptera</i> Kunze	No change
17. Adiantaceae (7 species)	<i>Adiantum</i> L.	<i>A. balfourii</i> Baker. <i>A. incisum</i> Forssk. <i>A. lunulatum</i> Bunn.f. <i>A. hispidulum</i> Sw. <i>A. capillus-veneris</i> L. <i>A. poiretii</i> Wikstr. <i>A. raddianum</i> C. Presl.	<i>Adiantum</i> L. has been moved to Pteridaceae Circumscription sensu [28].

18. Hemionitidaceae (2 species)	<i>Anogramma</i> Link.	<i>A. leptophylla</i> (L.) Link.	No change
	<i>Coniogramme</i> Fee.	<i>C. africana</i> Hieron.	<i>Coniogramme</i> has been moved to Pteridaceae Circumscription sensu [28].
19. Vittariaceae (3 species)	<i>Vittaria</i> J. Sm.	<i>V. guineensis</i> Desv. <i>V. volkensis</i> Hieron.	<i>Vittaria</i> has been moved to Pteridaceae Circumscription sensu [28].
	<i>Antrophyum</i> Kaulf.	<i>A. mannianum</i> Hook.	<i>Antrophyum</i> has been moved to Pteridaceae Circumscription sensu [28].
20. Parkeriaceae (1 species)	<i>Ceratopteris</i> Brongn.	<i>C. thalictroides</i> (L.) Brongn.	<i>Ceratopteris</i> has been moved to Pteridaceae Circumscription sensu [28].
21. Marsileaceae (Pilulariaceae) (8 species)	<i>Marsilea</i> L.	<i>M. aegyptiaca</i> Willd. <i>M. aethiopica</i> Launert. <i>M. coromandelina</i> Willd. <i>M. farinosa</i> Launert.	No change

		<i>M. gibba</i> A.Braun.	
		<i>M. minuta</i> L.	
		<i>M. vera</i> Launert.	
	<i>Pilularia</i> L.	<i>P. americana</i> A. Braun.	No change
22. Hymenophyllaceae (6 species)	<i>Hymenophyllum</i> Sm.	<i>H. capillare</i> Desv. <i>H. hirsutum</i> (L.) Sw. <i>H. kuhnii</i> C. Chr.	No change
	<i>Didymoglossum</i> Desv.	<i>D. erosum</i> (Willd.) & Beentje.	No change
	<i>Crepidomanes</i> (C. Presl) C. Presl.	<i>C. melanotrichum</i> (Schtdl.) J.P. Roux.	No change
	<i>Polyphlebium</i> Copel.	<i>P. borbonicum</i> (Bosch) Ebihara & Dubuisson.	No change
23. Cyatheaceae (1 species)	<i>Cyathea</i> Sm.	<i>C. manniana</i> Hook.	No change
24. Dennstaedtiaceae (1 species)	<i>Microlepia</i> C. Presl.	<i>M. speluncae</i> (L.) T. Moore.	No change
25. Hypolepidaceae (5 species)	<i>Blotiella</i> R.M Tryon.	<i>B. glabra</i> (Bory) RM. Tryon.	<i>Blotiella</i> R.M has been moved to Dennstaedtiaceae Circumscription sensu [28].

Histiopteris (J. Agardh) J. Sm. *B. incisa* (Thunb.) J. Sm. *Histiopteris* has been moved to Dennstaedtiaceae. Circumscription sensu [28].

Hypolepis Bernh. *H. goetzci* Hieron. ex Reimers (1934) *Hypolepis* has been moved to Dennstaedtiaceae. Circumscription sensu [28].
H. sparsisora (Schrad) Kuhn.

Pteridium Gled. ex Scop. *P. aquilinum* (L.) Kuhn subsp. *Capense* (Thunb.) C. Chr. *Pteridium* has been moved to Dennstaedtiaceae. Circumscription sensu [28].

26. Thelypteridaceae (11 species)
- Amauropelta* Kunze. *A. oppositifolii* (C. Chr.) Holttum. *A. bergiana* (Schldl.) Holttum. No change
- Pseudocyclosorus* Ching. *P. pulcher* (Willd.) Holttum. No change
- Christella* Lev. *C. hispidula* (Decne.) Holttum. No change
C. dentata (Forssk.) Brownsey & Jermy.

		<i>C. gueinziana</i> (Mett.) Holttum.	
		<i>C. chaseana</i> (Schelpe) Holttum.	
	<i>Stegnogramma</i> Blume.	<i>S. pozoii</i> (Lagasca) K. Iwatsuki.	No change
	<i>Thelypteris</i> Schmidel.	<i>T. confluens</i> (Thunb.) Morton.	No change
	<i>Cyclosorus</i> link.	<i>C. interruptus</i> (Willd.) H. Ito.	No change
	<i>Pneumatopteris</i> Nakai.	<i>P. unita</i> (Kunze) Holttum	No change
27. Aspleniaceae (36 species)	<i>Asplenium</i> L.	<i>A. dalhousiae</i> Hook. (1837) <i>A. phillipsia</i> num (Kummerle) Bir, Fraser- Jenk & Lovis. <i>A. sandersonii</i> Hook. <i>A. monanthes</i> L. <i>A. elliotii</i> C. H. Wright <i>A. adamsii</i> Alston. <i>A. erythraeum</i> Pic. Serm. <i>A. friesiorum</i> . C. Chr. <i>A. warneckeii</i> Hieron. <i>A. unilaterale</i> Lam.	No change

A. formosum Willd.
A. erectum Bory ex
Willd.
A. trichomanes L. subsp.
quadrivalens D.E.Mey
emend. Lovis.
A. smedsii Pic. Serm.
A. inaequilaterale Bory
ex Willd.
A. mannii Hook.
A. ceii Pic. Serm.
A. protensum Schrad.
A. dregeanum Kunze.
A. bugoiense Hieron.
A. hypomelas Kuhn
A. linckii Kuhn.
A. uhligii Hieron.
A. demerkense Hieron.
A. balense Chaerle &
Viane.
A. stuhlmannii Hieron.
A. buettneri Hieron. ex
Brause.
A. aethiopicum (Burm.f.)
Bech.
A. lividum Mett. ex Kuhn.
A. theciferum (HBK)
Mett.
A. adiantum-nigrum L.
A. abyssinicum Fee.

A. pumilum Sw.
A. stipicellatum
Pic.Serm.
A. cordatum (Thunb.)
Sw.
A. ceterach L.

28. Woodsiaceae
(5 species)

Hypodematium
Kunze.

D. crenatum (Forssk.)
Kuhn.

Hypodematium has
been moved to
Hypodematiaceae.
Circumscription
sensu [29].

Cystopteris
Bernh.

C. fragilis (L.) Bernh.

Cystopteris has been
moved to
Cystopteridaceae.
Circumscription
sensu [30].

Lunathyrium
Koidz.

L. boryanum (Willd.) H.
Ohba.

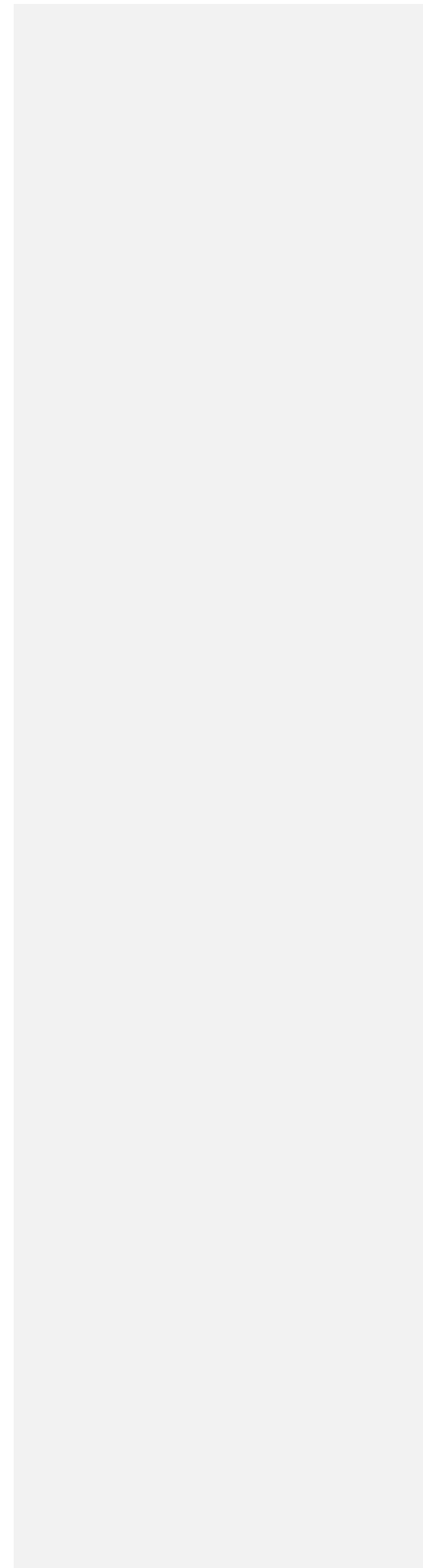
Lunathyrium has
been moved to the
new family
Athyriaceae.
Circumscription
sensu [31].

Athyrium Roth.

A. scandicinum (Willd.)
C. Presl.
A. schimperi Moug. ex
Fee.

Athyrium is now
under Athyriaceae.
Circumscription
sensu [30].

29. Dryopteridaceae (14 species)	<i>Cyrtomium</i> C. Presl.	<i>C. micropterum</i> (Kunze) Ching.	No change
	<i>Didymochlaena</i> Desv.	<i>D. truncatula</i> (Sw.) J.Sm.	<i>Didymochlaena</i> has been moved to Didymochlaenaceae. Circumscription sensu [32].
	<i>Dryopteris</i> Adans.	<i>D. athamantica</i> (Kunze) Kuntze. <i>D. fadenii</i> Pic. Serm. <i>D. kilemensis</i> (Kuhn) Kuntze. <i>D. pentheri</i> (Krasser) C.Chr. <i>D. rodolfii</i> J.P.Roux. <i>D. schimperiana</i> (Hochst. Ex A.Br.) C.Chr. <i>D. tricellularis</i> J.P. Roux. <i>D. lewalleana</i> Pic.Serm.	No change
	<i>Nothoperanema</i> (Tagawa) Ching.	<i>N. aquamiseta</i> (Hook) Ching.	<i>Nothoperanema</i> now merges with <i>Dryopteris</i> , Adans., in Dryopteridaceae. Circumscription sensu [32], [33], [34].



	<i>Polystichum</i>	<i>P. magnificum</i> F.Ballard.	<i>Polystichum</i> is now a
	Roth.	<i>P. transvaalense</i> N.	genus under
		C.Anthony.	Dryopteridaceae.
		<i>P. wilsonii</i> H.Christ.	Circumscription
			sensu [35].
30. Tectariaceae	<i>Ctenitis</i> (C.Chr.)	<i>C. cirrhosa</i> (Schumach.)	<i>Ctenitis</i> is now a
(3 species)	C.Chr.	Ching.	genus under
			Dryopteridaceae.
			Circumscription
			sensu [35].
	<i>Megalastrum</i>	<i>M. lanuginosum</i> (Willd.	<i>Megalastrum</i> is now
	Holttum.	ex Kaulf) Holttum.	a genus under
			Dryopteridaceae.
			Circumscription
			sensu [35].
	<i>Tectaria</i> Cav.	<i>T. gemmifera</i> (Fee)	No change
		Alston.	
31. Lomariopsidaceae	<i>Bolbitis</i> Schott.	<i>B. heudelotii</i> (Bory ex	<i>Bolbitis</i> is now a
(6 species)		Fee) Alston.	genus under
			Dryopteridaceae.
			Circumscription
			sensu [35].
	<i>Elaphoglossum</i>	<i>E. acrostichoides</i> (Hook.	<i>Elaphoglossum</i> is
	Schottex J.Sm.	& Grev.) Schelpe.	now a genus under

		<i>E. aubertii</i> (Desv.) T. Moore.	Dryopteridaceae. Circumscription
		<i>E. deckenii</i> (Kuhn) C.Ch.	sensu [35].
		<i>E. hybridum</i> (Bary) Brack.	
		<i>E. lastii</i> (Baker) C.Ch.	
32. Nephrolepidaceae (1 species)	<i>Nephrolepis</i> Schott.	<i>N. biserrata</i> (Sw.) Schott.	No change
		<i>N. undulata</i> (Afzel. ex SW.) J.Sm.	
33. Oleandraceae (3 species)	<i>Arthropteris</i> J.Sm ex Hook.f.	<i>A. monocarpa</i> (Cordem.) C.Ch.	<i>Arthropteris</i> is a genus under the Tectariaceae.
		<i>A. orientallis</i> (J.F. Gmel) Posth.	Circumscription sensu [36].
	<i>Oleandra</i> Cav.	<i>O. distenta</i> Kunze.	No change
34. Davalliaceae (1 species)	<i>Davallia</i> Sm.	<i>D. denticulata</i> (Burn.f.) Mett. ex Kuhn.	No change
35. Blechnaceae (2 species)	<i>Blechnum</i> L.	<i>B. attenuatum</i> (Sw.) Mett.	No change
		<i>B. tabulare</i> (Thumb.) Kuhn.	
36. Azollaceae	<i>Azolla</i> Lam.	<i>A. nilotica</i> Decne. ex	<i>Azolla</i> is now a genus

(1 species)

Mett.

under Salviniaceae

Circumscription

sensu [28].

The Pteridophytes of Ethiopia and Eritrea were adjusted to conform to PPG I [6] classification system. As a result of this adjustment, the number of families reduced from 36 to 27 and the number of genera from 78 to 76. In all this, the number of species remained unchanged (192 species) since no circumscription was done at their level (Table 2). Four species were moved from one genus to another (*Drynaria* merged with *Aglaomorpha*, *Phymatosorus* merged with *Microsorium*, *Negripteris* merged with *Cheilanthes* and *Nothoperanema* merged with *Dryopteris*) and 30 genera moved from one family to another, for example; *Melpomene* and *Lellingeria* moved from Grammitidaceae to Polypodiaceae [24], [25], *Ctenitis* moved from Tectariaceae to Dryopteridaceae [35], *Azolla* moved from Azollaceae to Salviniaceae [28] Table 2. All of these changes were done because monophyly is the primary criterion for the recognition of taxa in PPG I [6]. So, genera that were paraphyletic were moved where they became monophyletic.

Table 2: Pteridophyte genera that were merged and those moved from one family to another

S/N	Genera	Old families	New families	References
1.	<i>Melpomene</i>	Grammitidaceae	Polypodiaceae	[24], [25].
2.	<i>Lellingeria</i>	Grammitidaceae	Polypodiaceae	[24], [25].
3.	<i>Drynaria</i> now merges with <i>Aglaomorpha</i>	Polypodiaceae	Polypodiaceae	[6]
4.	<i>Phymatosorus</i> now merges with <i>Microsorium</i>	Polypodiaceae	Polypodiaceae	[26]
5.	<i>Negripteris</i> now merges with <i>Cheilanthes</i>	Negripteridaceae	Pteridaceae	[27]
6.	<i>Aspidotis</i>	Sinopteridaceae	Pteridaceae	[28]
7.	<i>Notholaena</i>	Sinopteridaceae	Pteridaceae	[28]

8.	<i>Pellaea</i>	Sinopteridaceae	Pteridaceae	[28]
9.	<i>Doryopteris</i>	Sinopteridaceae	Pteridaceae	[28]
10.	<i>Cheilanthes</i>	Sinopteridaceae	Pteridaceae	[28]
11.	<i>Onychium</i>	Cryptogrammeaceae	Pteridaceae	[28]
12.	<i>Actiniopteris</i>	Actiniopteridaceae	Pteridaceae	[28]
13.	<i>Adiantum</i>	Adiantaceae	Pteridaceae	[28]
14.	<i>Coniogramme</i>	Hemionitidaceae	Pteridaceae	[28]
15.	<i>Vittaria</i>	Vittariaceae	Pteridaceae	[28]
16.	<i>Antrophyum</i>	Vittariaceae	Pteridaceae	[28]
17.	<i>Ceratopteris</i>	Parkeriaceae	Pteridaceae	[28]
18.	<i>Blotiella</i>	Hypolepidaceae	Dennstaedtiaceae	[28]
19.	<i>Histiopteris</i>	Hypolepidaceae	Dennstaedtiaceae	[28]
20.	<i>Hypolepis</i>	Hypolepidaceae	Dennstaedtiaceae	[28]
21.	<i>Pteridium</i>	Hypolepidaceae	Dennstaedtiaceae	[28]
22.	<i>Hypodematium</i>	Woodsiaceae	Hypodematiaceae	[29]
23.	<i>Cystopteris</i>	Woodsiaceae	Cystopteridaceae	[30]

24.	<i>Lunathyrium</i>	Woodsiaceae	Athyriaceae	[31]
25.	<i>Athyrium</i>	Woodsiaceae	Athyriaceae	[30]
26.	<i>Didymochlaena</i>	Dryopteridaceae	Didymochlaenaceae	[29]
27.	<i>Nothoperanema</i> now merges with <i>Dryopteris</i>	Dryopteridaceae	Dryopteridaceae	[32], [33], [34]
28.	<i>Ctenitis</i>	Tectariaceae	Dryopteridaceae	[35]
29.	<i>Megalastrum</i>	Tectariaceae	Dryopteridaceae	[35]
30.	<i>Bolbitis</i>	Lomariopsidaceae	Dryopteridaceae	[35]
31.	<i>Elaphoglossum</i>	Lomariopsidaceae	Dryopteridaceae	[35]
32.	<i>Arthropteris</i>	Oleandraceae	Tectariaceae	[36]
33.	<i>Azolla</i>	Azollaceae	Salviniaceae	[28]

Three new families were added to the Pteridophytes of Ethiopia and Eritrea, they include; Salviniaceae (which accommodated the genus *Azolla* from Azollaceae), Cystopteridaceae (which accommodates *Cystopteris* from Woodsiaceae) and Athyriaceae (which accommodates *Lunathyrium*, *Athyrium* from Woodsiaceae). Twelve (12) families were removed from the Pteridophytes of Ethiopia and Eritrea due to this conformity, but their genera were transferred to different families. Nine (9) of these families were transferred to Pteridaceae and they include **Grammitidaceae**, Negripteridaceae, Sinopteridaceae, Cryptogrammeaceae, Actinopteridaceae, Adiantaceae, Vittariaceae, Hemionitidaceae and Pakeriaceae. While Azollaceae's only genus was transferred to Salviniaceae, species of Woodsiaceae were transferred to Hypolepidaceae, Cystopteridaceae and Athyriaceae. Two species from the genus *Negripteris* were transferred to genus *Cheilanthes* in the Pteridaceae. This includes *Negripteris scioana* (Chiov.) Pic.Serm. and

Comment [A10]: Still in Polyodiaceae family as per PPG I

Negripteristricholepifera Pic.Serm. Their genus name was changed from *Negripteris* to *Cheilanthes* (Table 3). The above changes were made in order for all the taxa to meet up with the criteria of monophyly from paraphyletic [6].

Table 3: Updated list of Pteridophytes of the Flora of Ethiopia and Eritrea in conformity with PPG I approach of classification

S/N	Class	Order	Family	Genera	Species
1.	Lycopodiopsida	Lycopodiales	Lycopodiaceae (6 species)	<i>Huperzia</i>	<i>H. dacrydioides</i> (Baker) Pic.Serm. <i>H. saururus</i> (Lam.) Trevis. <i>H. verticillata</i> (L.f.) Trellis. <i>H.opbioglossoides</i> (Lam.) Rollin.
				<i>Lycopodiella</i>	<i>L. clavatum</i> L.
				<i>Lycopodium</i>	<i>L. cernua</i> (L.) Pic.Senn.
2.		Isoetales	Isoetaceae (3 species)	<i>Isoetes</i> L.	<i>I. aequinoctialis</i> Welw. Ex A. Braun <i>I. alstonii</i> C.FReed & Verde. <i>I. schweinfurthii</i> A.Braun ex Baker.
3.		Selaginellales	Selaginellaceae (8 species)	<i>Selaginella</i>	<i>S. caffrorum</i> (Milde) Hieron.

Comment [A11]: Families are not arranged according to the PPG I classification.

S. goudotiana
 Spring.
S. imbricata
 (Forssk.) Spring ex
 Decne
S. kraussiaaa
 (Kunze) A. Braun
S. phillipsiana
 (Hieron.) Alston.
S. yemensis (Sw.)
 Spring.
S. kalbreyeri Baker
S. tenerima A.
 Braun ex Kuhn.

4.	Polypodiopsida	Equisetales	Equisetaceae (1 species)	<i>Equisetum</i> L.	<i>E. ramosissimum</i> Desf.
5.		Ophioglossales	Ophioglossaceae (9 species)	<i>Botrychium</i> Sw.	<i>B. chamaeconium</i> Bitter & Hieron.
				<i>Ophioglossum</i> L.	<i>O. caroticaule</i> J.E.Burrows. <i>O. costatum</i> R.Br. <i>O. gomezianum</i> Welw. ex A.Broun. <i>O. lusoaffricanum</i> Welw. ex Prantl. <i>O. polyphyllum</i> A.Braun. <i>O. reticulatum</i> L.

				<i>O. rubellum</i> Welw.
				Ex A. Braun
				<i>O. vulgatum</i> L.
				subsp. africanum
				Pocock ex J.E.
				Burrows
6.	Marattiales	Marattiaceae	<i>Marattia</i> Sw.	<i>M. fraxinea</i> Sm.
		(1 species)		
7.	Osmundales	Osmundaceae	<i>Osmunda</i> L.	<i>O. regalis</i> L.
		(1 species)		
8.	Hymenophyllales	Hymenophyllaceae	<i>Hymenophyllum</i>	<i>B. capillare</i> Desv.
		(6 species)	<i>m</i> Sm.	<i>B. hirsutum</i> (L.)
				Sw.
				<i>B. kuhni</i> C. Chr.
			<i>Didymoglossum</i>	<i>D. erosum</i> (Willd.)
			<i>m</i> Desv.	& Beentje.
			<i>Crepidomanes</i>	<i>C. melanotrichum</i>
			(C. Presl) C.	(Schtdl.) J.P.
			Presl.	Roux.
			<i>Polyphlebium</i>	<i>P. borbonicum</i>
			Copel.	(Bosch) Ebihara &
				Dubuisson.
9.	Gleicheniales	Gleicheniaceae	<i>Dicranopteris</i>	<i>D. linearis</i> (Burm.
		(1 species)	Bernh.	f.) Underw.

10.	Schizaeales	Anemiaceae (1 species)	<i>Anemia</i> Sw.	<i>A. schimperiana</i> C.Presl
11.	Salviniales	Salviniaceae (1 species)	<i>Azolla</i> Lam.	<i>A. nilotica</i> Decne. ex Mett.
12.	Salviniales	Marsileaceae (8 species)	<i>Marsilea</i> L.	<i>M. aegyptiaca</i> Willd. <i>M. aethiopica</i> Launert. <i>M. coromandelina</i> Willd. <i>M. farinosa</i> Launert <i>M. gibba</i> A.Braun. <i>M. minuta</i> L. <i>M. vera</i> Launert.
			<i>Pilularia</i> L.	<i>P. americana</i> A. Braun
13.	Cyatheales	Cyatheaceae (1 species)	<i>Cyathea</i> Sm.	<i>C. manniana</i> Hook.
14.	Polypodiales	Polypodiaceae (12 species)	<i>Platyserium</i> Desv.	<i>P. elephantotis</i> Schweinf.
			<i>Pyrosia</i> Mirb.	<i>P. schimperiana</i> (Kuhn) Alston.
			<i>Aglaomorpha</i> Schott.	<i>A. volkensis</i> Hieron.
			<i>Lepisorus</i> (J.Sm.) Ching.	<i>L. excavatus</i> (Willd.) Ching.

L. schraderi (Mett.)

Ching.

Microsorium M. punctatum (L.)

Link. Copel.

M. scolopendria

(Burm. f) Pic. Sum.

Pleopeltis P. macrocarpa

Willd. (Willd.) Kauf.

Polypodium L. P. polypodioides

(L.) Watt.

Loxogramme L. abyssinica

(Blum.) C Presl (Baker) M.G. Price.

Melpomene M. flabelliformis

A.R. Sm. & (Poir.) A.R. Sm. &

R.C. Moran. R.C Moran.

Lellingeria A.R. L. oosora

Sm. & R.C. (Balrer)A.R. Sm. &

Moran. R.C Moran.

15.

Pteridaceae

(43 species)

Pteris L. P. vittata L.

P. cretica L.

P. hamulosa

(Christin) Christin.

P. tripartita Sw.

P. buchananii Sim.

P. pteridioides
(Hook.) Ballard.
P. dentate Forssk.
P. linearis Poir.
P. catoptera
Kunze.

Adiantum L. *A. balfouri* Baker.
A. incisum Forssk.
A. lunulatum
Bunn.f.
A. hispidulum Sw.
A. capillus-veneris
L.
A. poiretii Wikstr.
A. raddianum C.
Presl.

Actiniopteris *A. radiata* (Sw.)
Link. Link.
A. dimorpha Pic.
Serm.
A. semiflabellata
Pic. Serm.

Onychium *O. divaricatum*
Kaulf. (Poir.) Alslon.

Cheilanthes *C. farinosa*
Sw. (Forssk.) Kaulf.

C. multifida (Sw.)

Sw.

C. bergiana

Schltld.

C. hirta Sw.

C. coriacea Decne.

C. erythraea

Pic.Serm.

C. acrosticha

(Balbis) Tod.

C. vellea (Ait.)F.

Muell.

Aspidotis (Nutt. ex Hook.)
Copel. *A. schimperi*
(Kunze) Pic. Serm.

Notholaena
R.Br. *N. marantae* (L.)
Desv.

Pellaea Link. *P. doniana* Hook.
P. longipilosa
Bonap.
P. dura (Willd.)
Hook.
P. calomelanos
(Sw.) Link.
P. viridis (Forssk.)
Prantl.
P. quadripinnata
(Forssk.) Prantl.

Doryopteris J. Sm. in Hook. *D. concolor* (Langsd. & Fisch.) Kuhn.

Cheilanthes Sw., *Syn. Fil.* *C. scioana* (Chiov.) Pic.Serm.
C. tricholepifera Pic.Serm.

Coniogramme Fee. *C. africana* Hieron.

Vittaria J. Sm. *V. guineensis* Desv.
V. volkensii Hieron.

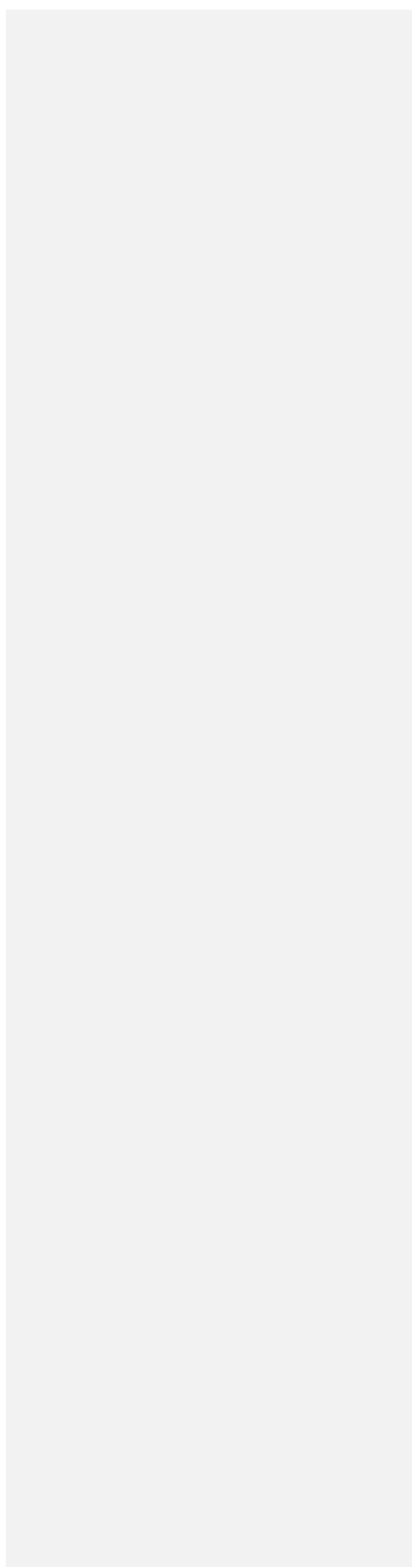
Antrophyum Kaulf. *A. mannianum* Hook.

Ceratopteris Brongn. *C. thalictroides* (L.) Brongn.

Anogramma Link. *A. leptophylla*. (L.) Link.

16.

Dennstaedtiaceae *Microlepia* C. *M. speluncae* (L.) Presl. T. Moore.
(6 species) *Blotiella* R.M *B. glabra* (Bory Tryon. RM. Tryon.



Histiopteris (J. Agardh) J. Sm. *B. incisa* (Thunb.) J. Sm.

Hypolepis Bernh. *H. goetzci* Hieron. ex Reimers
H. sparsisora (Schrad) Kuhn.

Pteridium Gled. ex Scop. *P. aquilinum* (L.) Kuhn subsp. Capense (Thunb.) C. Chr.

17.

Thelypteridaceae (11 species) *Amauropelta* Kunze. *A. oppositiformi*. (C. Chr.) Holttum. A. *bergiana*(Schltdl.) Holttum.

Pseudocyclosorus Ching. *P. pulcher* (Willd.) Holttum.

Christella Lev. *C. hispidula* (Decne.) Holttum.
C. dentata (Forssk.) Brownsey & Jermy.
C. gueinziana (Mett.) Holttum.

C.
chaseana(Schelpe)
Holttum,

Stegnogramma S. *pozo*i (Lagasca)
Blume. K. Iwatsuki.

Thelypteris T. *confluens*
Schmidel. (Thunb.) MorTon..

Cyclosorus C. *interruptus*
link. (Willd.) H. Ito.

Pneumatopteris P. *unita* (Kunze)
s Nakai. Holttum.

18.

Aspleniaceae
(36 species)

Asplenium L. A. *dalhousiae*
Hook.
A. *phillipsianum*
(Kummerle) Bir,
Fraser-Jenk &
Lovis.
A. *sandersonii*
Hook.
A. *monanthes* L.
A. *elliottii* C. H.
Wright.
A. *adamsii* Alston.
A. *erythraeum* Pic.
Serm.
A. *friesiorum*. C.

Chr.

A.

warnecke Hieron.

A. unilaterale Lam.

A. formosum Willd.

A. erectum Bory ex

Willd.

A. trichomanes L.

subsp.

quadrivalens

D.E.Mey.

emend. Lovis.

A. smedsii Pic.

Serm.

A. inaequilaterale

Bory ex Willd.

A. mannii Hook.

A. ceii Pic. Serm.

A. protensum

Schrad.

A. dregeanum

Kunze.

A. bugoiense

Hieron.

A. hypomelas

Kuhn.

A. linckii Kuhn.

A. uhligii Hieron.

A. demerkense

Hieron.

A. balense Chaerle

& Viane.

A. stuhlmannii

Hieron.

A. buettneri Hieron.

ex Brause.

A. aethiopicum

(Burm.f.) Bech.

A. lividum Mett. ex

Kuhn.

A. theciferum

(HBK) Mett.

A. adiantum-

nigrum L.

A. abyssinicum

Fee.

A. pumilum Sw.

A. stipicellatum

Pic.Serm.

A. cordatum

(Thunb.) Sw.

A. ceterach L.

19. Hypodematiaceae *Hypodematium* *H. crenatum*
e Kunze. (Forssk.) Kuhn.
(1 species)
20. Cystopteridaceae *Cystopteris* *C. fragilis* (L.)
Bernh. Bernh.
(1 species)
21. Athyriaceae *Deparia* Hook. *D.*

22.

(3 species) & Grev. *boryanum*(Willd.)
H. Ohba.

Athyrium Roth. *A. scandicinum*
(Willd.) C. Presl.
A. schimperi Moug.
ex Fee.

Dryopteridaceae *Cyrtomium* C. *C. micropterum*
(22 species) Presl. (Kunze) Ching.

Didymochlaena *D. truncatula* (Sw.)
Desv. J.Sm.

Dryopteris *D. athamantica*
Adans. (Kunze) Kuntze.

D. fadenii Pic.
Serm.

D. kilemensis
(Kuhn) Kuntze.

D. pentheri
(Krasser) C.Chr.

D. rodolfii
J.P.Roux.

D. schimperiana
(Hochst. Ex A.Br.)

C.Chr.

D. tricellularis J.P.
Roux

D. lewalleana

Pic.Serm.

D. aquamiseta

(Hook) Ching.

Polystichum *P. magnificum*

Roth. F.Ballard.

P. transvaalense

N. C.Anthony.

P. wilsonii H.Christ.

Ctenitis *C. cirrhosa*

(C.Chr.) C.Chr. (Schumach.)

Ching.

Megalastrum *M. lanuginosum*

Holttum. (Willd. ex Kaulf)

Holttum.

Bolbitis Schott. *B. heudelotii* (Bory
ex Fee) Alston.

Elaphoglossum *E. acrostichoides*

Schottex J.Sm. (Hook. & Grev.)

Schelpe.

E. aubertii (Desv.)

T. Moore.

E. deckenii (Kuhn)

C.Chr.

E. hybridum (Bary)

Brack.

E. lastii (Baker)

C.Chr.

23.	Tectariaceae 3 species)	<i>Tectaria</i> Cav.	<i>T. gemmifera</i> (Fee) Alston.
		<i>Arthropteris</i> J.Sm ex Hook.f.	<i>A. monocarpa</i> (Cordem.) C.Chr. <i>A. orientalis</i> (J.F. Gmel) Posth.
24.	Nephrolepidaceae e (2 species)	<i>Nephrolepis</i> Schott.	<i>N. biserrata</i> (Sw.) Schott. <i>N. undulata</i> (Afzel. ex SW.) J.Sm.
25.	Oleandraceae (1 species)	<i>Oleandra</i> Cav.	<i>O. distenta</i> Kunze.
26.	Davalliaceae (1 species)	<i>Davallia</i> Sm.	<i>D. denticulata</i> (Burn.f.) Mett. ex Kuhn.
27.	Blechnaceae (2 species)	<i>Blechnum</i> L.	<i>B. attenuatum</i> (Sw.) Mett. <i>B. tabulare</i> (Thumb.) Kuhn.

4. CONCLUSION

This study has revised the classification of pteridophytes of Ethiopia and Eritrea to conform to the PPG I [6] classification approach. This resulted in 27 families, 76 genera and 192 species, with changes recorded at all levels of classification except the number of species. This outcome is therefore suggested to be applied in the herbaria and adopted by researchers of pteridophytes in Ethiopia and Eritrea, for ease of communication internationally.

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