

Original Research Article

Classification of Lycophytes and Ferns of Ethiopia and Eritrea, according to the Pteridophyte Phylogeny Group (PPG) – I

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: Data for this study was collected from the National Herbarium of Ethiopia in Addis Abeba (ETH) and other literature [13]. The study was carried out from February 2023 to June 2024.

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 (ETH) 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' (based solely on morphological characterization). Other literatures were consulted for new species [11, 13]. Classification of species were adjusted to conform to PPG-I classification system (a modern, comprehensive classification, community-based approach which uses monophyly as the primary criterion for the recognition of taxa).

Results: This study has produced a comprehensive checklist of documented species of pteridophytes in Ethiopia and Eritrea according to PPG-I. It is comprised of 2 classes, 14 orders, 27 families, 76 genera and 193 species from 36 families, 78 genera, and 193 species.

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.

Keywords: Pteridophytes, fern, lycophytes, PPG, 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]. The role and importance of fern has a wide range of importance; such as pioneer plants, balancing the forest ecosystem, prevention of erosion, regulating water content and helping the process of decaying forest litter [2]. 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 [3], *Ophioglossum reticulatum* L. in South Africa, Swaziland and Zanzibar, *Ceratopteris thalictroides* (L.) Brongn. in Madagascar and Swaziland, *Nephrolepis biserrata* Sw. in DRC and Nigeria [4],[5] and *Ophioglossum polyphyllum* A. Braun in Namibia and South Africa [6,38,39].

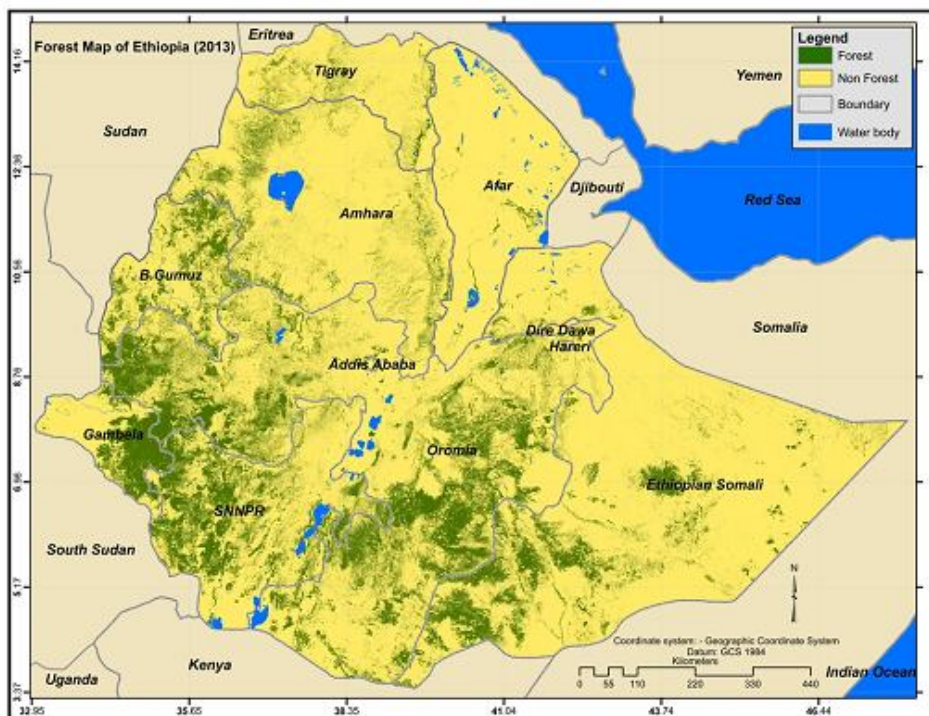
Many years ago, most fern classifications were based on morphology [14]. The most commonly used of these classifications included, [15], [16], [17], [18] and [19]. A modern, comprehensive classification called the Pteridophyte Phylogeny Group (PPG), based loosely on the model employed for flowering plant classification, established a new approach for the classification of pteridophytes called a 'Community-based approach' [14, 20]. 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. This study therefore has conducted an in-depth inventory of the pteridophytes of Ethiopia and Eritrea, classifying them based on the PPG I [20] in order to conform to the new trends in pteridophyte classification. This outcome is suggested to be applied in the ETH herbaria and adopted by researchers of pteridophytes in Ethiopia and Eritrea, for ease of communication internationally.

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 [7], 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 was brought about mainly 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 [8] and other supported findings. The Flora of Ethiopia and Eritrea describes 192 species, 78 genera and 36 families of pteridophytes, which mainly followed the concept of Pichi Sermolli [9], [10]. These species have been found to be mainly confined to forests (45.8%) and woodlands (13.5%). Hence, the distribution of species diversity seems to be influenced by both altitude and vegetation. Endemism (2.1%) is found to be lower than other vascular plants indicating that most of these species also occur outside the flora area. Based on findings from these analyses, it is possible to suggest that pteridophyte diversity can be conserved mainly by focusing on the forests and woodlands between 1500-2500 m in the 'hot spots' identified in the flora area [10]. Majority of the species (123 spp, 64%) are terrestrials while the remaining 46% are aquatic, and epilithic members. These species are abundant in two specific altitudinal zones: between 1500 to 2000 m (132 spp) and between 2000 to 2500 m (112 spp) [10]. After the project of the Flora of Ethiopia and Eritrea was published in 2009, more than 500 new taxa were described during the Ethiopian Flora Project which belonged to the families

Euphorbiaceae, Fabaceae, Lamiaceae, Campanulaceae, Eriocaulaceae and Poaceae [11],[12], but no new species of pteridophytes was found. In 2023, a new species (*Pilularia ethiopica*) of the pteridophytes belonging to Marsileaceae was described [13]. More species of ferns will probably be discovered in years ahead, so there is a need for a proper organization of these species to a modern and most recognized classification method (PPG I) to facilitate research and communication among researchers, which is the aim of this study.

2. MATERIAL AND METHODS

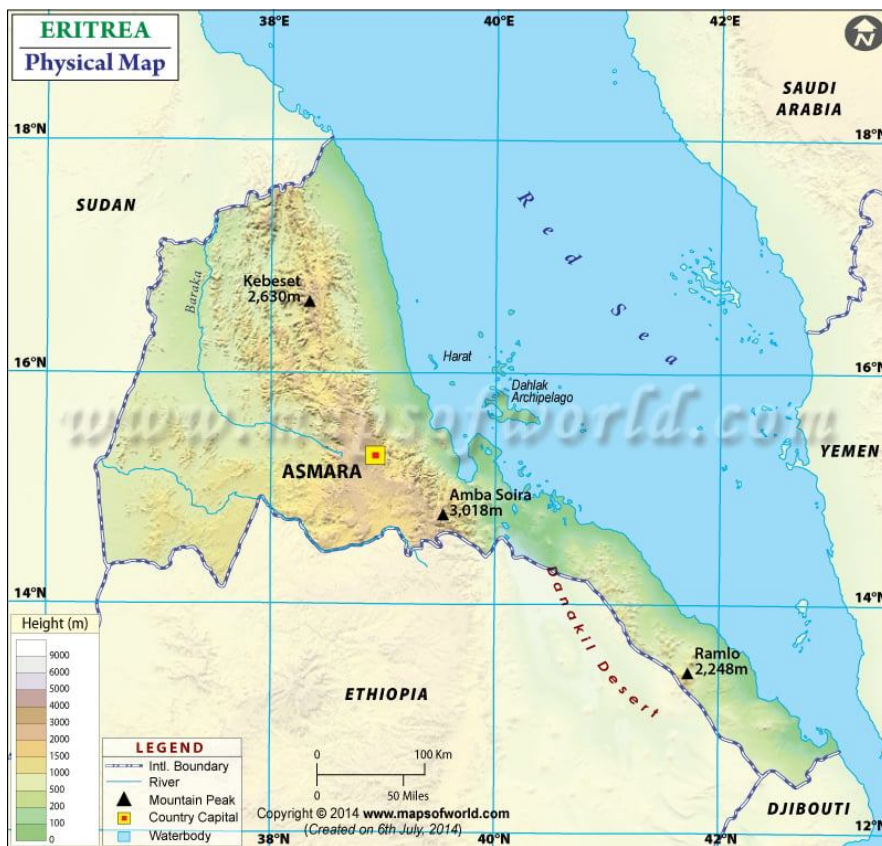
Ethiopia is situated in northeast Africa, in the area known as 'The Horn of Africa'. It is bordered by Eritrea, Sudan, South Sudan, Kenya, Somalia, the self-proclaimed separatist territory of Somaliland and Djibouti. Encompassing an area of 1,104,300 km² and it is completely landlocked and located between 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 [21]. Consequently, these highlands have formed unique vegetation types (Figure 1).



Source: [22]

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 Eritrea include Juniperus forests, riverine forests, coral reefs and traditional farming systems. 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 [21](Figure 2).



Source: [23]

Figure 2: 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 mainly obtained from the volume I of the Flora of Ethiopia and Eritrea in 2009 [8] from the ETH herbarium in Addis Ababa in Ethiopia, and [10], supported by new findings [11, 12].

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 [20] approach where monophyly was used as the primary criterion for the recognition of taxa, showing the relationships between lycophyte and fern families recognized in this PPG I classification (figure 3). This classification is intended to be a summary statement of current hypotheses, derived from the best available data and shaped by those most familiar with the plants in question [20].

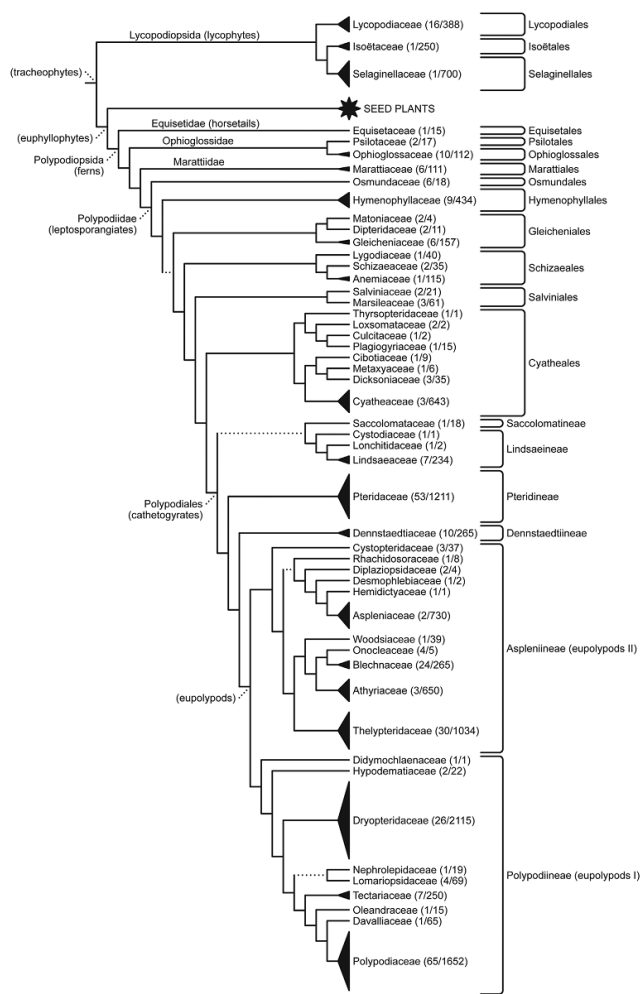


Figure 3: Relationships among lycopodyte and fern families recognized in this PPG I classification [20].

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 lycopodytes 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 evolution with the aim of narrowing the concept. This system was established as a summary statement of current hypothesis, 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. Of the 36 families of pteridophytes, 23 are from Ethiopia and 13 from Eritrea, while of the 78 genera, 40 are from Ethiopia and 38 in Eritrea and of 192 species, 76 species are from Ethiopia while 116 species from Eritrea. [13,24] stated that, the numbers stated were found in Ethiopia. Families with the highest number of species includes; Aspleniaceae (3spp), Sinopteridaceae (17spp),

Dryopteridaceae (14spp), Thelypteridaceae (11spp) and Polypodiaceae (10spp). This in accordance with other researchers [10], who found out that, pteridophyte families in this study area which are diverse in species includes; Aspleniaceae (36spp), Sinopteridaceae (17spp), Dryopteridaceae (14spp), Thelypteridaceae (11spp) and Polypodiaceae (10spp), who also based his research on the Flora of Ethiopia and Eritrea. A total of 12 families (Equisetaceae, Marattiaceae, Osmundaceae, Gleicheniaceae, Anemiaceae, Cryptogrammaceae, Parkeriaceae, Azollaceae, Davalliaceae, Nephrolepidaceae, Dennstaedtiaceae and Cyatheaceae) had only 1 species.

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.) Rolliin.	No change
		<i>Lycopodiella</i> Holub	<i>L. clavatum</i> L.	No change
		<i>Lycopodium</i> L.	<i>L. cernua</i> (L.) Pic.Senn.	No change
2.	Selaginellaceae (8 species)	<i>Selaginella</i> P. Beauv.	<i>S. caffrorum</i> (Milde) Hieron. <i>S. goudotiana</i> Spring <i>S. imbricata</i> (Forssk.) Spring ex Decne <i>S. kraussiaaa</i> (Kunze) A.	No change

Braun

S. philipsiana (Hieron.)

Alston

S. yemensis (Sw.)

Spring

S. kalbreyeri Baker

S. tenerrima A. Braun ex

Kuhn

- | | | | | |
|----|--------------------------------|------------------------|---|-----------|
| 3. | Isoetaceae
(3 species) | <i>Isoetes</i> L. | <i>I. aequinoctialis</i> Welw.
ex A. Braun
<i>I. schweinfurthii</i> A. Braun
ex Baker
<i>I. alstonii</i> C. F. Reed &
Verde. | No change |
| 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. Braun.
<i>O. luso-africanum</i> Welw.
ex Prantl.
<i>O. polyphyllum</i> A. Braun.
<i>O. reticulatum</i> L. | No change |

O. rubellum Welw. ex A.

Braun.

O. vulgatum L. subsp.

africanum Pocock ex

J.E. Burrows.

- | | | | | |
|-----|-------------------------------|---|---|--|
| 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
[25], [26]. |
| | | <i>Lellingeria</i> A.R.
Sm. & R.C.
Moran. | <i>L. oosora</i> (Balrer)A.R.
Sm. & R.C Moran. | <i>Lellingeria</i> has been
moved to
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 |

Drynaria (Bory) J. Sm. *D. volkensis* Hieron. *Drynaria* has been included in

Aglaomorpha, under Polypodiaceae

Circumscription

newly proposed in

PPG I [20].

Lepisorus (J.Sm.) Ching. *L. excavatus* (Willd.) Ching. No change

L. schraderi (Mett.)

Ching.

Microsorium Link. *M. punctatum* (L.) Copel. No change

Phymatosorus Pic. Serm. *P. scolopendria* (Burm. f) Pic. Sum. *Phymatosorus* has been moved to

Microsorium.

Circumscription

Sensu [27].

Pleopeltis Willd. *P. macrocarpa* (Willd.) No change

Kaulf.

Polypodium L. *P. polypodioides* (L.) No change

Watt.

Loxogramme (Blum.) C Presl. *L. abyssinica* (Baker) No change

M.G. Price.

11. Anemiaceae (1 species) *Anemia* Sw. (1806) *A. schimperiana* C.Presl (1845) No change

12. Negripteridaceae *Negripteris* Pic. *N. scioana* (Chiov.) *Negripteris* has been

(2 species)

Serm.

Pic.Serm.

moved to *Cheilanthes*

N. tricholepifera

under the

Pic.Serm.

Pteridaceae

Circumscription

sensu [28].

13. Sinopteridaceae

Aspidotis (Nutt.

A. scbimperi (Kunze)

Aspidotis has been

(17 species)

ex Hook.) Copel.

Pic.Serm.

moved to

Pteridaceae.

Circumscription

sensu [29]

Notholaena R.Br.

N. marantae (L.) Desv.

Notholaena has been

moved to

Pteridaceae

Circumscription

sensu [29].

Pellaea Link.

P. doniana Hook.

Pellaea has been

P. longipilosa Bonap.

moved to

P. dura (Willd.) Hook.

Pteridaceae

P. calomelanos (Sw.)

Circumscription

Link.

sensu [29].

P. viridis (Forssk.)

Prantl.

P. quadripinnata

(Forssk.) Prantl

Doryopteris J.

D. concolor (Langsd. &

Doryopteris has been

Sm.

Fisch.) Kuhn.

moved to

Pteridaceae

Circumscription

sensu [29].

Cheilanthes Sw.

C. farinosa (Forssk.)

Cheilanthes has been

Kaulf. *C. multifida* (Sw.)

moved to

Sw.

Pteridaceae

C. bergiana Schldl.

Circumscription

C. hirta Sw.

sensu [29].

C. coriacea Decne.

C. erythraea Pic.Serm.

C. acrosticha (Balbis)

Tod.

C. vellea (Ait.)F. Muell.

14. Cryptogrammaceae
(1 species)

Onychium Kaulf.

O. divaricatum (Poir.)

Onychium has been

Alslon.

moved to

Pteridaceae

Circumscription

sensu [29].

15. Actiniopteridaceae
(3 species)

Actiniopteris Link.

A. radiata (Sw.) Link

Actiniopteris Link has

A. dimorpha Pic. Serm.

been moved to

A. semiflabellata Pic.

Pteridaceae

Serm.

Circumscription

sensu [29].

16. Pteridaceae
(9 species)

Pteris L.

P. vittata L.

No change

P. cretica L.

P. hamulosa (Christin)

Christin

P. tripartita Sw. in

Schrad.

P. buchananii Sim.

P. pteridioides (Hook.)

Ballard.

P. dentate Forssk.

P. linearis Poir.

P. catoptera Kunze

17. Adiantaceae
(7 species)

Adiantum L.

A. balfouri Baker.

Adiantum L. has

A. incisum Forssk.

been moved to

A. lunulatum Bunn.f.

Pteridaceae

A. hispidulum Sw.

Circumscription

A. capillus-veneris L.

sensu [29].

A. poiretii Wikstr.

A. raddianum C. Presl.

18. Hemionitidaceae
(2 species)

Anogramma Link.

A. leptophylla (L.) Link.

No change

Coniogramme

C. africana Hieron.

Coniogramme has

Fee.

been moved to

Pteridaceae

Circumscription

sensu [29].

19. Vittariaceae
(3 species)

Vittaria J. Sm.

V. guineensis Desv.

Vittaria has been

V. volkensii Hieron.

moved to

Pteridaceae

Circumscription

		<i>Antrophyum</i> Kaulf.	<i>A. manianum</i> Hook.	sensu [29]. <i>Antrophyum</i> has been moved to Pteridaceae Circumscription sensu [29].
20. Parkeriaceae (1 species)	<i>Ceratopteris</i> Brongn.	<i>C. thalictroides</i> (L.) Brongn.	<i>Ceratopteris</i>	has been moved to Pteridaceae Circumscription sensu [29].
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. <i>M. gibba</i> A. Braun. <i>M. minuta</i> L. <i>M. vera</i> Launert.		No change
	<i>Pilularia</i> L.	<i>P. americana</i> A. Braun. <i>P. ethiopica</i> Fischer		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 [29].
	<i>Histiopteris</i> (J. Agardh) J. Sm.	<i>B. incisa</i> (Thunb.) J. Sm.	<i>Histiopteris</i> has been moved to Dennstaedtiaceae Circumscription sensu [29].
	<i>Hypolepis</i> Bernh.	<i>H. goetzci</i> Hieron. ex Reimers (1934) <i>H. sparsisora</i> (Schrad) Kuhn.	<i>Hypolepis</i> has been moved to Dennstaedtiaceae. Circumscription sensu [29].
	<i>Pteridium</i> Gled.	<i>P. aquilinum</i> (L.) Kuhn	<i>Pteridium</i> has been

ex Scop. subsp. Capense moved to
 (Thunb.) C. Chr. Dennstaedtiaceae.
 Circumscription
 sensu [29].

26. Thelypteridaceae
 (11 species)

Amauropelta *A. oppositifolii* (C. Chr.) No change
 Kunze. Holttum.

A. bergiana (Schltdl.)

Holttum.

Pseudocyclosorus *P. pulcher* (Willd.) No change
 s Ching. Holttum.

Christella Lev. *C. hispidula* (Decne.) No change
 Holttum.

C. dentata (Forssk.)

Brownsey & Jermy.

C. gueinziana (Mett.)

Holttum.

C. chaseana (Schelpe)

Holttum.

Stegnogramma *S. pozoi* (Lagasca) K. No change
 Blume. Iwatsuki.

Thelypteris *T. confluens* (Thunb.) No change
 Schmidel. Morton.

Cyclosorus link. *C. interruptus* (Willd.) H. No change
 Ito.

Pneumatopteris *P. unita* (Kunze) Holttum No change
Nakai.

27. Aspleniaceae
(36 species)

Asplenium L. *A. dalhousiae* Hook.
(1837) No change
A. phillipsia num
(Kummerle) Bir, Fraser-
Jenk & Lovis.
A. sandersonii Hook.
A. monanthes L.
A. elliotii C. H. Wright
A. adamsii Alston.
A. erythraeum Pic.
Serm.
A. friesiorum. C. Chr.
A. warneckeii 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.

28. Woodsiaceae
(5 species)

Hypodematium
Kunze.

D. crenatum (Forssk.)
Kuhn.

Hypodematium has
been moved to
Hypodematiaceae.
Circumscription
sensu [30].

Cystopteris Bernh. *C. fragilis* (L.) Bernh. *Cystopteris* has been moved to Cystopteridaceae. Circumscription sensu [31].

Lunathyrium Koidz. *L. boryanum* (Willd.) H. Ohba. *Lunathyrium* has been moved to the new family Athyriaceae. Circumscription sensu [32]

Athyrium Roth. *A. scandicium* (Willd.) C. Presl. *A. schimperi* Moug. ex Fee. *Athyrium* is now under Athyriaceae. Circumscription sensu [31].

29. Dryopteridaceae
(14 species)

Cyrtomium C. Presl. *C. micropterum* (Kunze) Ching. No change

Didymochlaena Desv. *D. truncatula* (Sw.) J.Sm. *Didymochlaena* has been moved to Didymochlaenaceae. Circumscription sensu[33].

Dryopteris Adans. *D. athamantica* (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.

Nothoperanema (Tagawa) Ching. *N. aquamiseta* (Hook) Ching. *Nothoperanema* now merges with *Dryopteris*, Adans., in Dryopteridaceae. Circumscription sensu [33], [34], [35].

Polystichum Roth. *P. magnificum* F.Ballard. *Polystichum* is now a genus under Dryopteridaceae. *P. transvaalense* N. C.Anthony. *P. wilsonii* H.Christ. Circumscription sensu [36].

30. Tectariaceae (3 species) *Ctenitis* (C.Chr.) C. *cirrrosa* (Schumach.) C. Ching. *Ctenitis* is now a genus under Dryopteridaceae. Circumscription sensu [36].

*Megalastrum*Holttt *M. lanuginosum* (Willd.) *Megalastrum* is now

	um.		ex Kaulf) Holttum.	a genus under Dryopteridaceae. Circumscription sensu [36].
		<i>Tectaria</i> Cav.	<i>T. gemmifera</i> (Fee) Alston.	No change
31. Lomariopsidaceae (6 species)		<i>Bolbitis</i> Schott.	<i>B. heudelotii</i> (Bory ex Fee) Alston.	<i>Bolbitis</i> is now a genus under Dryopteridaceae. Circumscription sensu [36].
		<i>Elaphoglossum</i> Schottex J.Sm.	<i>E. acrostichoides</i> (Hook. & Grev.) Schelpe. <i>E. aubertii</i> (Desv.) T. Moore. <i>E. deckenii</i> (Kuhn) C.Chr. <i>E. hybridum</i> (Bary) Brack. <i>E. lastii</i> (Baker) C.Chr.	<i>Elaphoglossum</i> is now a genus under Dryopteridaceae. Circumscription sensu [36].
32. Nephrolepidaceae (1 species)		<i>Nephrolepis</i> Schott.	<i>N. biserrata</i> (Sw.) Schott. <i>N. undulata</i> (Afzel. ex SW.) J.Sm.	No change
33. Oleandraceae		<i>Arthropteris</i> J.Sm	<i>A. monocarpa</i> (Cordem.)	<i>Arthropteris</i> is a

(3 species)	ex Hook.f.	C.Chr. <i>A. orientallis</i> (J.F. Gmel)	genus under the Tectariaceae.
		Posth.	Circumscription sensu [38].
	<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. <i>B. tabulare</i> (Thumb.) Kuhn.	No change
36. Azollaceae (1 species)	<i>Azolla</i> Lam.	<i>A. nilotica</i> Decne. ex Mett.	<i>Azolla</i> is now a genus under Salviniaceae Circumscription sensu [28].

Classification of these pteridophytes according to the PPG- I

The Pteridophytes of Ethiopia and Eritrea were adjusted to conform to PPG-I [20] 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, the number of species remained unchanged (193 species) since no circumscription was done at the species 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 [25], [27], *Ctenitis* moved from Tectariaceae to Dryopteridaceae [36], *Azolla* moved from Azollaceae to Salviniaceae [30] Table 2. Families with the highest numbers of species after the updating are; Pteridaceae (43spp), Aspleniaceae (36spp), Dryopteridaceae (22spp), Polypodiaceae (12spp) and Thelypteridaceae (11spp). A total of 10 families (Equisetaceae,

Marattiaceae, Osmundaceae, Gleicheniaceae, Anemiaceae, Cryptogrammeaceae, Azollaceae, Davalliaceae, Nephrolepidaceae and Cyatheaceae) had only one species. All of these changes were done because monophyly was applied as the primary criterion for the recognition of taxa in PPG I [20]. So, genera that were paraphyletic were moved were they became monophyletic.

The classification system used by PPG-I is grounded on evolutionary principles and is therefore phylogenetic [20]. This classification system is advantageous in that; it tells of the evolutionary history of the plants, 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 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	[25], [26].
2.	<i>Lellingeria</i>	Grammitidaceae	Polypodiaceae	[25], [26].
3.	<i>Drynaria</i> now merges with <i>Aglaomorpha</i>	Polypodiaceae	Polypodiaceae	[20]
4.	<i>Phymatosorus</i> now merges with <i>Microsorium</i>	Polypodiaceae	Polypodiaceae	[27]
5.	<i>Negripteris</i> now merges with <i>Cheilanthes</i>	Negripteridaceae	Pteridaceae	[28]
6.	<i>Aspidotis</i>	Sinopteridaceae	Pteridaceae	[29]
7.	<i>Notholaena</i>	Sinopteridaceae	Pteridaceae	[29]

8.	<i>Pellaea</i>	Sinopteridaceae	Pteridaceae	[29]
9.	<i>Doryopteris</i>	Sinopteridaceae	Pteridaceae	[29]
10.	<i>Cheilanthes</i>	Sinopteridaceae	Pteridaceae	[29]
11.	<i>Onychium</i>	Cryptogrammaceae	Pteridaceae	[29]
12.	<i>Actiniopteris</i>	Actiniopteridaceae	Pteridaceae	[29]
13.	<i>Adiantum</i>	Adiantaceae	Pteridaceae	[29]
14.	<i>Coniogramme</i>	Hemionitidaceae	Pteridaceae	[29]
15.	<i>Vittaria</i>	Vittariaceae	Pteridaceae	[29]
16.	<i>Antrophyum</i>	Vittariaceae	Pteridaceae	[29]
17.	<i>Ceratopteris</i>	Parkeriaceae	Pteridaceae	[29]
18.	<i>Blotiella</i>	Hypolepidaceae	Dennstaedtiaceae	[29]
19.	<i>Histiopteris</i>	Hypolepidaceae	Dennstaedtiaceae	[29]
20.	<i>Hypolepis</i>	Hypolepidaceae	Dennstaedtiaceae	[29]
21.	<i>Pteridium</i>	Hypolepidaceae	Dennstaedtiaceae	[29]
22.	<i>Hypodematium</i>	Woodsiaceae	Hypodematiaceae	[30]
23.	<i>Cystopteris</i>	Woodsiaceae	Cystopteridaceae	[31]

24.	<i>Lunathyrium</i>	Woodsiaceae	Athyriaceae	[32]
25.	<i>Athyrium</i>	Woodsiaceae	Athyriaceae	[31]
26.	<i>Didymochlaena</i>	Dryopteridaceae	Didymochlaenaceae	[30]
27.	<i>Nothoperanema</i> now merges with <i>Dryopteris</i>	Dryopteridaceae	Dryopteridaceae	[33, 34, 35.]
28.	<i>Ctenitis</i>	Tectariaceae	Dryopteridaceae	[36]
29.	<i>Megalastrum</i>	Tectariaceae	Dryopteridaceae	[36]
30.	<i>Bolbitis</i>	Lomariopsidaceae	Dryopteridaceae	[36]
31.	<i>Elaphoglossum</i>	Lomariopsidaceae	Dryopteridaceae	[36]
32.	<i>Arthropteris</i>	Oleandraceae	Tectariaceae	[37]
33.	<i>Azolla</i>	Azollaceae	Salviniaceae	[29]

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. Eight (8) of these families were transferred to Pteridaceae and they includes; Negripteridaceae, Sinopteridaceae, Cryptogrammaceae, 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 *Negripteristricholepifera* Pic.Serm. Their genus name was changed from *Negripteris* to *Cheilanthes* (Table 3). All of these changes were done

because monophyly was applied as the primary criterion for the recognition of taxa in PPG I [20]. So, genera that were paraphyletic were moved where they became monophyletic.

The classification system used by PPG-I is grounded on evolutionary principles and is therefore phylogenetic [20]. This classification system is advantageous in that; it tells of the evolutionary history of the plants, 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 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.	Lycopodiopsid	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.		Isoëtiales	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 Selaginella S. caffrorum (Milde) Hieron.
 s ae S. goudotiana Spring.
 (8 species) S. imbricata (Forssk.) Spring
 ex Decne
 S. kraussiaaa (Kunze) A.
 Braun
 S. phillipsiana (Hieron.)
 Alston.
 S. yemensis (Sw.) Spring.
 S. kalbreyeri Baker
 S. tenerrima A. Braun ex
 Kuhn.

4. Polypodiopsida Equisetales Equisetaceae Equisetum L. E. ramosissimum Desf.
 (1 species)

5. Ophioglossales Ophioglossaceae Botrychium B. chamaeconium Bitter &
 es eae Sw. Hieron.
 (9 species)
 Ophioglossum L. O. caroticaule J.E.Burrows.
 O. costatum R.Br.
 O. gomezianum Welw. ex
 A.Broun.
 O. lusoaffricanum Welw. ex
 Prantl.
 O. polyphyllum A.Braun.
 O. reticulatum L.
 O. rubellum Welw. Ex A.
 Braun
 O. vulgatum 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> Sm. | <i>B. capillare</i> Desv.
<i>B. hirsutum</i> (L.) Sw.
<i>B. kuhnii</i> C. Chr.

<i>Didymoglossum</i> Desv.
<i>D. erosum</i> (Willd.) & Beentje.

<i>Crepidomanes</i> (C. Presl) J.P. Roux.
<i>C. Presl.</i>

<i>Polyphlebium</i> Copel.
<i>P. borbonicum</i> (Bosch) Ebihara & Dubuisson. |
| 9. | Gleicheniales | Gleicheniaceae | <i>Dicranopteris</i> Bernh. | <i>D. linearis</i> (Burm. f.) Underw.
(1 species) |
| 10. | Schizaeales | Anemiaceae | <i>Anemia</i> Sw. | <i>A. schimperiana</i> C.Presl
(1 species) |
| 11. | Salviniales | Salviniaceae | <i>Azolla</i> Lam. | <i>A. nilotica</i> . Decne. ex Mett.
(1 species) |
| 12. | Salviniales | Marsileaceae | <i>Marsilea</i> L. | <i>M. aegyptiaca</i> Willd.
<i>M. aethiopica</i> Launert.
<i>M. coromandelina</i> Willd.
<i>M. farinosa</i> Launert |

M. gibba A. Braun.

M. minuta L.

M. vera Launert.

Pilularia L.

P. americana A. Braun

P. ethiopia

13.

Cyatheales

Cyatheaceae

Cyathea Sm.

C. manniana Hook.

(1 species)

Polypodiales

Pteridaceae

Pteris L.

P. vittata L.

14.

(43 species)

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* (Poir.) Alston.
Kaulf.

Cheilanthes *C. farinosa* (Forssk.) Kaulf.
Sw. *C. multifida* (Sw.) Sw.
C. bergiana Schtdl.
C. hirta Sw.
C. coriacea Decne.
C. erythraea Pic.Serm.
C. acrosticha (Balbis) Tod.
C. vellea (Ait.)F. Muell.

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

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

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. *D. concolor* (Langsd. & Fisch.)

Sm. in Hook. Kuhn.

Cheilanthes *C. scioana* (Chiov.) Pic.Serm.

Sw., Syn. Fil. *C. tricholepifera* Pic.Serm.

Coniogramm *C. africana* Hieron.

e Fee.

Vittaria J. *V. guineensis* Desv.

Sm. *V. volkensis* Hieron.

Antrophyum *A. mannianum* Hook.

Kaulf.

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

Brongn.

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

Link.

Dennstaedtiac *Microlepia* C. *M. speluncae* (L.) T. Moore.

eae Presl.

(6 species) *Blotiella* R.M *B. glabra* (Bory) RM. Tryon.

Tryon.

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

(J. Agardh) J.

Sm.

15.

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

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

16. Cystopteridaceae *Cystopteris* *C. fragilis* (L.) Bernh.
Bernh.
(1 species)

17. Aspleniaceae *Asplenium* L. *A. dalhousiae* Hook.
(36 species) *A. phillipsianum* (Kummerle)
Bir, Fraser-Jenk &
Lovis.
A. sandersonii Hook.
A. monanthes L.
A. elliotii C. H. Wright.
A. adamsii Alston.
A. erythraeum Pic. Serm.
A. friesiorum. C. Chr.
A. warneckei 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.

18. Blechnaceae *Blechnum* L. *B. attenuatum* (Sw.) Mett.
 (2 species) *B. tabulare* (Thumb.) Kuhn.
- Athyriaceae *Deparia* *D. boryanum* (Willd.) H. Ohba.
 (3 species) Hook. &
 Grev.

20.

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

21.

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

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

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

Stegnogramma *S. pozoi* (Lagasca) K.
 Blume. Iwatsuki.

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

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

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

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



22.

Dryopteridaceae	<i>Cyrtomium</i> C. Presl.	<i>C. micropterum</i> (Kunze) Ching.
(22 species)	<i>Didymochlaena</i> Desv.	<i>D. truncatula</i> (Sw.) J.Sm.
	<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.
		<i>D. aquamiseta</i> (Hook) Ching.
	<i>Polystichum</i> Roth.	<i>P. magnificum</i> F.Ballard.
		<i>P. transvaalense</i> N. C.Anthony.
		<i>P. wilsonii</i> H.Christ.
	<i>Ctenitis</i> (C.Chr.) C.Chr.	<i>C. cirrhosa</i> (Schumach.) Ching.
	<i>Megalastrum</i> Holttum.	<i>M. lanuginosum</i> (Willd. ex Kaulf) Holttum.
	<i>Bolbitis</i> Schott	<i>B. heudelotii</i> (Bory ex Fee)

			Alston.
		<i>Elaphoglossum</i> Schottex J.Sm.	<i>E. acrostichoides</i> (Hook. & Grev.) Schelpe. <i>E. aubertii</i> (Desv.) T. Moore. <i>E. deckenii</i> (Kuhn) C.Chr. <i>E. hybridum</i> (Bary) Brack. <i>E. lastii</i> (Baker) C.Chr.
23.	Nephrolepidaceae (2 species)	<i>Nephrolepis</i> Schott. J.Sm.	<i>N. biserrata</i> (Sw.) Schott. <i>N. undulata</i> (Afzel. ex Sw.) J.Sm.
24.	Tectariaceae (3 species)	<i>Tectaria</i> Cav. J.Sm ex Hook.f.	<i>T. gemmifera</i> (Fee) Alston. <i>A. monocarpa</i> (Cordem.) C.Chr. <i>A. orientalis</i> (J.F. Gmel) Posth.
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.	Polypodiaceae (12 species)	<i>Platyserium</i> Desv.	<i>P. elephantotis</i> Schweinf.
		<i>Pyrrosia</i> Mirb.	<i>P. schimperiana</i> (Kuhn)

Alston.

Aglaiomorpha *A. volkensis* Hieron.

Schott.

Lepisorus *L. excavatus* (Willd.) Ching.

(J.Sm.) *L. schraderi* (Mett.) Ching.

Ching.

Microsorium *M. punctatum* (L.) Copel.

Link. *M. scolopendria* (Burm. f) Pic.

Sum.

Pleopeltis *P. macrocarpa* (Willd.) Kaulf.

Willd.

Polypodium *P. polypodioides* (L.) Watt.

L.

Loxogramme *L. abyssinica* (Baker) M.G.

(Blum.) C Price.

Presl

Melpomene *M. flabelliformis* (Poir.) A.R.

A.R. Sm. & Sm. & R.C Moran.

R.C. Moran.

Lellingeria *L. oosora* (Balrer) A.R. Sm. &

A.R. Sm. & R.C Moran.

R.C. Moran.

4. CONCLUSION

This study has revised the classification of pteridophytes of Ethiopia and Eritrea to conform to the PPG I [20] 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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