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SHORT COMMUNICATION

Composition and Endemicity of Plant Species in Simien Mountains National Park Flora, North Gondar, Northwestern Ethiopia

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Abstract

Though Ethiopia is endowed with rich biological resources, in the last few decades, these resources are highly threatened by anthropogenic activities. As a result, better vegetation cover is largely found in inaccessible and protected areas only. This work was conducted in Simien Mountains National Park (SMNP) vegetation. SMNP is a spectacular world heritage site having different landforms that encapsulate diverse and unique biodiversity combinations and serve as a refuge for rare and endangered species. The objective of the inventory was to assess the floristic composition, endemicity, and threat status of the endemic plant species in the park. Extensive and frequent field work in SMNP at different times and seasons (2014-2019), examination of the herbarium specimens of Simien from the National Herbarium, Addis Ababa University, and evaluation of botanical information in previous studies were used as a data source. Plant specimens' identification was based on published volumes of the flora of Ethiopia and Eretria. Descriptive statistics were used to analyze the floristic data. A total of 532 vascular plant species representing 102 families were recorded. Asteraceae was the dominant family followed by Poaceae. Out of the species identified, 75 were endemic to Ethiopia, which is included in the preliminarily assessed list for IUCN Red Data List. The study area is found rich in floristic composition and endemicity resulting from environmental heterogeneity that suits different species. Endemic species in the park are found at different threat statuses. Immediate managerial interventions shall be devised for critically endangered and endangered endemic plant species.

Keywords: diverse ecological settings, endemic species, flora, isolation, threat status

Introduction

Ethiopian geological history is characterized by periods of highland uplift and rift formation that led to the division of the highlands into northwestern and southeastern regions by the Great Rift Valley (Mohr, 1983). This was followed by volcanic forces that led to the accumulation of basaltic lava underlying Mesozoic rock that forms uplift (Olson and Dinerstein, 1998). Subsequently, extensive erosion of the basaltic layers over a long period led to the formation of the unique feature of Ethiopian high lands including Simien Mountains National Park (SMNP) (Last, 2009).

Highland uplift forms new habitats with hydrological, elevational, and topographical heterogeneity (Smith *et al*., 2017). This heterogeneity of the land resource has resulted from diverse ecological settings, climate, and topography that have contributed to the formation of diverse ecosystems inhabited by a great diversity of life forms (Zerihun, 1999) with high endemism. The flora of Ethiopia is very heterogeneous and is estimated to possess about 6027species of higher plants, of which about 10% are endemic (Ensermu and Sebsibe, 2014).

However, the rich biodiversity of the country is under serious threat from deforestation, land degradation, and habitat loss (Ensermu and Teshome, 2008). As a result, the northwestern highlands of Ethiopia (from where the study area is found) have no entire undisturbed natural forest rather fragments of natural forests are found scattered and confined to inaccessible and sacred places (Alemayehu *et al.*, 2005). Scattered remnant forest stands suggest that the highlands were once covered by high forests (White, 1983). With the prevailing alarming rate of deforestation, the remaining natural forests could disappear within a few decades, unless appropriate and immediate measures are taken.

Assessing the status of species composition and endemicity of an area help to design intervention mechanisms and appropriate conservation measures. Therefore, the objective of the present survey was to assess the composition and endemicity status of Semien Mountains National Park (SMNP) vegetation which is characterized by extended Afroalpine vegetation and fragments of dry Afromontane forest patches with an ericaceous belt forming a transition between the two.

Materials and Methods

Description of the study area

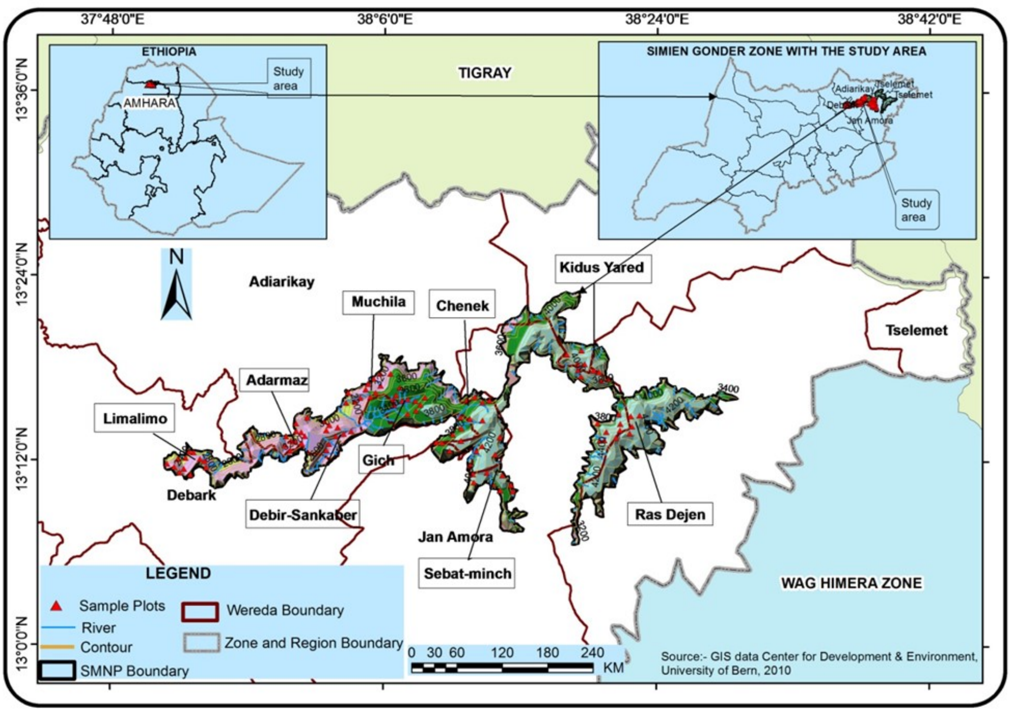

Figure 1: Map of the study area

SMNP, where the study was conducted, is located in the North Gondar Zone of Amhara National Regional State at the northern edge of the central plateau of Ethiopia, 123 km northeast of the historical Gondar town and 860 km north of Addis Ababa (Capital of Ethiopia) lying between 2,000m and 4,530m elevational range, the park includes broad undulating plateau and RasDashen, the highest peak in Ethiopia (Puf and Sileshi, 2001; Friis *et al*., 2010). The current SMNP covers a total area of 412 km2 that extends from 13°06'44.09" N to 13°23'07.85" N latitude to 37°51'26.36"E to 38°29'27.59''E longitude (Figure 1). In recognition of its use as refugia for rare and endemic species and outstanding biophysical features, the park received international attention and was inscribed by UNESCO in 1978 (Hurni and Ludi, 2000).

Data collection and analyses

Major parts of the data were collected through critical survey and observation during the frequent and extensive fieldwork in SMNP that were carried out at different times and seasons (2015-2020) by the author. Additional data were obtained from a critical examination of herbarium specimens of Simien from the National Herbarium, Addis Ababa University, and evaluation of botanical information from Puff and Silesh (2001). Collected and recorded plant specimens were identified using the published volumes of the flora of Ethiopia and Eretria (Hedberg *et al*., 2009) and by comparing with the authentic specimens in National Herbarium. Descriptive statistics (using percentages) were used to analyze the data.

Results

Floristic composition

The floristic analyses of the entire study area yielded 532 species distributed in 102 families. Of the total number of species, 14 pteridophyte, 1 gymnosperm, and 517 angiosperm species were represented in the vegetation. Asteraceae (91 species) was the most species-rich family followed by Poaceae (41 species) and Fabaceae (33 species), respectively.

Table 1. Species distribution under each Family

Family	***Species no***
Asteraceae	91
Poaceae	41
Fabaceae	33
Lamiaceae	28
Cyperaceae	17
Rubiaceae	16
Apiaceae & Caryophyllaceae each	15
Scrophulariaceae	14
Brassicaceae	11
Acanthaceae, Crassulaceae & Urticaceae each	10
Malvaceae	9
Asclepiadaceae, Orchidiaceae, Ranunculaceae & Rosaceae each	8
Euphorbiaceae &Solanaceae each	7
Commelinaceae, Lobeliaceae & Polygonaceae each	6
Geraniaceae & Oleaceae each	5
Boraginaceae, Celastraceae, Celastraceae, Dipsacaceae, Gentianaceae, Myrsinaceae, Pteridiaceae & Tiliaceae each	4
Anacardiaceae, Asphodelaceae, Aspleniaceae, Balsaminaceae, Campanulaceae, Ericaceae, Hypericaceae, Iridaceae, Moraceae, Polygalaceae, Primulaceae, Rhamnaceae & Verbenaceae each	3
Amarantaceae, Apocynaceae, Araceae, Araliaceae, Capparidaceae, Convolvulaceae, Cucurbitaceae, Dryopteridiaceae, Flacourtiaceae, Loganiaceae, Onagraceae, Plataginaceae, Rutaceae, Sapindaceae & Sinopteridiaceae each	2
Adiantaceae, Aloaceae, Arecaceae, Asparagaceae, Bignoniaceae, Colchiaceae, Combretaceae, Cuppersaceae, Dracaenaceae, Hyacinthaceae, Icacinaceae, Juncaceae, Loranthaceae, Lythraceae, Meliaceae, Melianthaceae, Menispermaceae, Musaceae, Myricaceae, Myrtaceae, Orobanchaceae, , Oxalicaceae Phytolaccaceae, Piperaceae,	

Family	***Species no***
Pittosporaceae, Polypodiaceae, Resedaceae, Rhizophoraceae, Salicaceae, Santalaceae, Sapotaceae, Saxifragaceae, Selaginellaceae, Sterculaceae, Ulmaceae, Valerianellaceae, Vitaceae & Woodniaceae each	1

New records for the Gondar flora area

Of the total plant species, 27 species distributed in 16 families were new records from the Gondar Floristic Region in the Flora of Ethiopia and Eritrea. Eighteen (64.2%) of these species were herbs, 8 (28.6%) shrubs, 1 (3.6%) tree, and 1(3.6%) climber.

Endemism

Out of the taxa identified, 75 were endemic to Ethiopia. These taxa are either confined to SMNP only or also occur in other Ethiopian mountain systems. Accordingly, the endemic taxa accounted for 14% of the total floristic composition of the study area from which 12 taxa were endemic to SMNP. From the endemic plant taxa, herbs represented 70.7% of the total followed by shrubs (22.7%)

Figure 2. Habit proportion of endemic species in SMNP

Asteraceae contributed the highest endemic taxa (36.9%) followed by Lamiaceae (6.8%) and Poaceae (5.4%). The remaining families indicated in Table 2, in total, contributed 50.9% of the endemic taxa of the study area. The endemic species and the level of their preliminconservationtion status assessment results are given (Table 1). Of all endemic species, 30% of species were under least concern threat status followed by 18.7% vulnerable and 17.3% near-threatened species respectively. Eight and 16% of the endemic species were critically endangered and endangered respectively whereas 9.3% of species were not yet been assessed for the IUCN Red List of threatened species (IUCN, 2013).

Table 2. Endemic species in Simien Mountains National Park Vegetation

No	Species	Family	Habit	Status
1	*Acanthopalea ethio-germanica* Ensermu	Acanthaceae	Herb	LC
2	*Acanthus sennii* Chiov.	Acanthaceae	Shrub	LC
3	*Agrostis diffusa* S.M. Phillips	Poaceae	Herb	EN
4	*Argyrolobium schimperianum* Hochst. ex A. Rich.	Fabaceae	Shrub	EN
5	*Artemisia schimperi* Sch. Bip. ex Engl.	Asteraceae	Herb	VU
6	*Biden spachyloma* (Oliv. & Hiern) Cufod.	Asteraceae	Herb	LC
7	*Carduus macracanthus* Sch. Bip. ex Kazmi,	Asteraceae	Herb	LC
8	*Ceropegia sobolifera* N.E.Br.	Asclepiadaceae	Climber	CR
9	*Chiliocephalum schimperi* Benth	Asteraceae	Herb	NT
10	*Cineraria sebaldii* Cufod.	Asteraceae	Herb	VU
11	*Clematis longicauda* Steud. ex A. Rich.	Ranunculaceae	Climber	LC
12	*Conyza spinosa* Sch. Bip. ex Olivo & Hiern	Asteraceae	Shrub	VU
13	*Conyza nana* Sch. Bip. ex Oliv. & Hiern	Asteraceae	Herb	EN
14	*Crassocephalum macropappum* (Sch. Bip. ex A. Rich.) S. Moore	Asteraceae	Herb	LC
15	*Crepis tenerrima* (Sch. Bip. ex A. Rich.) R. E. Fr.	Asteraceae	Herb	VU
16	*Crepis xylorriza* Sch.Bip. ex Babc	Asteraceae	Herb	CR
17	*Cussonia ostinii* Chiov.	Araliaceae	Tree	VU
18	*Cyanotis polyrrhiza* Hochst. ex Hassk.	Commelinaceae	Herb	LC
19	*Cynoglossum coeruleum* Hochst. ex A. DC. in DC. subsp.*coeruleum*	Boraginaceae	Herb	LC
20	*Echinops longisetus* A. Rich.	Asteraceae	Shrub	LC
21	*Erophila verna* subsp. *macrosperma* Sebald	Brasceaeicas	Herb	EN
22	*Festucam acrophylla* Hochst. ex A. Rich.	Poaceae	Herb	VU
23	*Ficinia clandestina* (Steud.) Bock.	Cyperaceae	Herb	VU
24	*Habenaria platyanthera* Rchb.f.	Orchidaceae	Herb	CR
25	*Helichrysum horridum* (Sch. Bip.) A. Rich.	Asteraceae	Shrub	EN
26	*Herniariaa byssinica* Chaudhri	Caryophyllaceae	Herb	EN
27	*Holothrix unifolia* (Rchb.f.) Rchb.f.	Orchidiaceae	Herb	EN
28	*Impatiens tinctoria* subsp. *tinetoria* A. Rich.	Balsaminaceae	Herb	LC
29	*Inula confertiflora* A.Rich.	Asteraceae	Shrub	NT
30	*Kniphofia foliosa* Hochst.	Asphodelaceae	Herb	LC
31	*Kniphofia isoetifolia* Steud. ex Hochst.	Asphodelaceae	Herb	LC
32	*Laggera tomentosa* (Sch. Bip. ex A. Rich.) Oliv. & Hiern	Asteraceae	Herb	NT
33	*Leucasstachy diformis* (Hochst. ex Benth.) Briq.	Lamiaceae	Shrub	NT
34	*Lobelia rhynchopetalum* Hemsl.	Lobeliaceae	Herb	NT
35	*Lobelia schimperi* Hochst. ex A. Rich.	Lobeliaceae	Herb	EN

Table 2. continued ….

No	Species	Family	Habit	Status
36	*Mikaniopsis clematoides* (Sch. Bip. ex A. Rich.) Milne-Redh.	Asteraceae	Climber	LC
37	*Millettia ferruginea* subsp *ferruginea*,(CUf) Gil-len	Fabaceae	Tree	LC
38	*Otostegia tomentosa* subsp. *steudneri* (Schweinf.) Sebald	Lamiaceae	Shrub	VU
39	*Paronychia bryoides* A.Rich.	Caryophyllaceae	Herb	NA
40	*Pennisetum humile* Hochst. ex A.Rich.	Poaceae	Herb	NA
41	*Pentas chististrisetoides* (Hochst. ex Steud.) Pilg.	Poaceae	Herb	NT
43	*Peucedanum petitianum* A.Rich.	Apiaceae	Herb	NA
42	*Peucedanum mattirolii* Chiov.	Apiaceae	Herb	NT
44	*Phagnalon phagnaloides* (Hochst.A. Rich.) Cufod.	Asteraceae	Herb	LC
45	*Phragmanthera macrosolen* (A.Rich.) M.Gilbert	Loranthaceae	Shrub	NA
47	*Pimpinella pimpinelloides* (Hochst.)Wolff	Apiaceae	Herb	CR
46	*Plectranthus garckeanus* Vatke) J.K.Morton	Lamiaceae	Herb	LC
48	*Primula verticillata* subsp. *simensis* (Hochst.) W.W.Sm. & Forest	Primulaceae	Herb	CR
49	*Pseudognaphalium melanosphaerum* (Sch.Bip. ex A.Rich.) Hillard	Asteraceae	Herb	VU
50	*Rosularia semiensis* (A. Rich.) Ohba	Crassulaceae	Herb	EN
51	*Sagina abyssinica* subsp. *abyssinica* Hochst.exA. Rich.	Caryophyllaceae	Herb	NT
52	*Satureja unguentaria* (Schweinf.) Cufod.	Lamiaceae	Shrub	EN
53	*Saxifraga hederifolia* A. Rich.	Saxifragaceae	Herb	NA
54	*Senecio farinaceous* Sch. Bip. ex A. Rich.	Asteraceae	Herb	EN
55	*Senecio fresenii* Sch. Bip. ex Oliv. &Hiern	Asteraceae	Herb	NT
56	*Senecio myriocephalus* Sch. Bip. ex A. Rich.	Asteraceae	Shrub	LC
57	*Senecio nanus* Sch.Bip. ex A.Rich.	Asteraceae	Herb	EN
58	*Senecio steudelii* Sch. Bip. ex A. Rich.	Asteraceae	Herb	VU
59	*Senecio schultzii* Hochst. ex A. Rich.	Asteraceae	Herb	NT
60	*Senecio unionis* Sch.Bip. ex A.Rich.	Asteraceae	Herb	VU
61	*Sisymbrium maximum* Hochst. ex Fourn.	Brassicaceae	Herb	VU
62	*Snowdenia mutica* (Hochst. ex Fresen.) Pilg.	Poaceae	Herb	CR
63	*Solanecio gigas* (Vatke) C. Jeffrey	Asteraceae	Shrub	LC
65	*Solanum macracanthum* A. Rich.	Solanaceae	Shrub	LC
64	*Solanum hirtulum* Steud. ex A. Rich.	Solanaceae	Herb	LC
66	*Solanum marginatum* L.f.	Solanaceae	Shrub	LC
67	*Sonchus melanolepis* Fresen.	Asteraceae	Herb	VU
68	*Stachys hypoleuca* Hochst. ex A.Rich.	Lamiaceae	Herb	VU
69	*Thalictrums chimperianum* Hochst. ex Schweinf.	Ranunculaceae	Herb	NT

Table 2. continued ….

No	Species	Family	Habit	Status
70	*Trifolium calocephalum* Fresen.	Fabaceae	Herb	NT
71	*Urtica simiensis* Steud.	Urticaceae	Herb	LC
72	*Verbascum benthamianum* Hepper	Scrophulariaceae	Shrub	LC
73	*Verbascum stelurum* Murb.	Scrophulariaceae	Herb	VU
74	*Verbascum arbusculum* (A.Rich.) Huber-Morath	Scrophulariaceae	Shrub	CR
75	*Vernonia cylidericа* Sch. Bip. ex Walp	Asteraceae	Shrub	VU

EN = Endangered, LC = Least concerned, NT = Near threatened, VU = Vulnerable, CR = Critically endanger, NA = Not Applicable (Source, **IUCN, 2013)**

Discussion

Higher plant species richness in SMNP flora (532) is due to the mountain's geographical position and different altitudinal belts as well as its variable topographic features with gorges, crests, precipices, rocks, and flat areas. All these factors create a mosaic of different habitats that suit different species promoting species richness (Puff and Sileshi, 2001). Thus, the study area had higher species richness than the AbuneYosef mountain range with 199 species (Kflay *et al*., 2019) and Arsi Mountains National Park with 191 species (Zerihun *et al*., 2018) whereas had lower species richness than the Bale Mountains National Park with 1321 species (BMNP, 2007) and Kilimanjaro Vegetation with 1200 (Hemp, 2006). Species richness variation among these mountain ecosystems might be due to differences in area coverage, management level, proximity to the equator, the topographic variability (habitat heterogeneity). Herbs dominate in all the aforementioned mountain ecosystems since they appear in various life forms (Hedberg, 1964) that enable them to tolerate the harsh mountain climatic conditions, especially in the Afroalpine region but can easily be removed by grazing and trampling, this calls for immediate conservation measures.

Like SNMP, Asteraceae followed by Poaceae were the most species-rich families in AbuneYosef (Kflay *et al*., 2019) and Arsi (Zerihun *et al*., 2018) mountain vegetation. The successes of these two families are related to the presence of parachute-like dispersal structure in Asteraceae and tiny seed production in Poaceae that aid in widespread flotation of the diaspore.

A high number of newly recorded species (27) (not previously recorded in the Gondar Flora Area) indicated that SimienMountains have not been exhaustively explored botanically in the past. Botanical collections were restricted to areas easily and safely accessible (Puff and Sileshi, 2001). In the previous study (Puff and Sileshi, 2001), nineteen taxa were newly recorded in the Gondar flora region. Moreover, in the present study, 27 taxa were newly recorded in the same flora region. The large difference between the new records of the previous and the present study can be taken as evidence of exhaustive botanical exploration in the study area. Only six species were common as new records in both the previous and present studies and the remaining newly recorded species were different from the previous. *Erica trimera, Crassulaalsinoides, Conyzaspinosa, Eulophiastreptopetala, Artemisia afra* and *Capsella bursa-pastoris* were common newly recorded species in both the previous and present studies. This revealed that the area (lowlands, cliffs, deep gorges, and other inaccessible parts) is not still exhaustively explored botanically. Most of the newly recorded taxa were Afromontane because this part of the area possesses extremely difficult topography from which plant exploration is not easy.

Based on IUCN Red List Categories and Criteria and available literature (Ensermu *et al.,* 1992; Vivero *et al*., 2005), endemic taxa with their threat status are presented in the result section. Compared to Bale Mountains National Park (163) (BMNP, 2007), a lower number of endemic plant species was recorded in SMNP (75) but a higher figure was recorded than AbuneYosef (42) (Kflay *et al*., 2019) and Arsi Mountains National Park (20) (Zerihun *et al*., 2018); even low endemism was recorded in Kilimanjaro vegetation (exact figure not indicated) (Hemp 2006). Variation of endemicity among these vegetations can be explained in terms of area coverage, topographic variability resulting in isolation, and past historical events (glaciations, etc.). The high mountains of Africa are known for their characteristic endemic flora (Hedberg, 1957). Endemism is particularly high in the afro-alpine vegetation zone and the dry evergreen montane forest and grassland complex of the plateau (Solomon *et al*. 1996; Friis *et al*., 2010; Steinbauer *et al.,* 2013). In general, the Afromontane region is one of the seven centers of endemism in the afro-tropical realm (Huntley, 1988). The mountainous region of Ethiopia is, thus, rich in endemicity (Yohannes *et al*., 2012).

SMNP as part of African mountains, with its unique magnificent scenery, supports endemic taxa confined either to SMNP or occur in other Ethiopian mountain systems. The result of the present study revealed that 14.1% (73 taxa) (Table 1) of the collected specimens were endemic from which 12 taxa were confined to SMNP. This proportion is comparable to other similar studies which ranged between 10-15% of the total number of species (Fekadu *et al*., 2012; Teshome and Ensermu, 2013). Puff and Sileshi (2001) reported about 43 endemic species in Simien Mountains including species outside the park boundary.

Simien endemics can be rare (e.g. *Ceropegiasobolifera*) or well represented with very specialized ecological niches (e.g. *Rosularia semiensis)*.

Some taxa are limited to two or three floristic regions (e.g. *Primula verticillata* subsp. *semiensis*) preferring high humidity with low radiation but others are widely distributed in the northern highlands of Ethiopia, e.g. *Senecio farinaceus*. Other species that link northern and southern highlands are *Lobelia rhynchopetalum* and *Saxifraga hederifolia*.

High endemicity is largely due to the unique topographic features of the study area. In mountain ecosystems like SMNP, differences in altitudinal belts and variable topographic features create physical barriers. Due to reduced connectivity, mountains can be represented as islands that reduce available channels for pollination or dispersal which results from the isolation of species. The long isolation of species leads to evolution and speciation (Vetaas and Grytnes, 2002) which eventually result in endemic species, adapted to mountain habitats through hybridization between previously isolated populations followed by polyploidy formation (Stebbins, 1984).

The study area is used as refugia for rare and endangered endemic species as a result of topographic variability (that led to long isolation) and environmental heterogeneity that creates different ecological niches which suit different species. Therefore, for sustainable utilization of natural resources in SMNP, immediate action shall be taken to conserve critically endangered and endangered endemic plant species.

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