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BRYOPHYTE DIVERSITY ALONG THE EASTERN ARC

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ABSTRACT

The Eastern Arc Mountains possess a bryoflora with high species diversity (about 700 species are known—more than in Uganda). The proportion of endemism (altogether 32 species, 4.57 %) is not high compared to phanerogams, but is high when compared with the bryoflora of similar areas. Monotypic endemic genera are *Cladolejeunea* and *Neorutenbergia*. *Cladolejeunea aberrans* (Steph.) Zwickel occurs in the Usambaras and *Neorutenbergia usagarae* (Dix.) Biz. et Pócs is distributed throughout the Eastern Arc. The latter is a representative of *Rutenbergiaceae* family with its other members living in Madagascar and on the Mascarene Islands. One notable feature of the bryoflora is the high number (45 species, 6.43 %) of Lemurian (Madagascan) species, which is most apparent in the Uluguru Mountains (40 species, 8.16 %). The bryoflora of the Usambara and Uluguru Mountains is well known. We know much less about the Pare, Nguru and Ukaguru Mountains and the bryoflora of Udzungwa Mountains is practically unexplored.

INTRODUCTION

This paper intends to reveal the characteristic features of the bryophyte flora of Eastern Arc Mountains (figure 1) from a biogeographic perspective. The bryoflora of the Eastern Arc has many similarities with the phanerogamic flora, especially its high diversity. But due to the easy dispersal of the diaspores of cryptogam plants, most bryophytes have a wide distribution, hence their rate of endemism is lower than vascular plants (Zanten & Pócs, 1981; Gradstein & Pócs, 1989). On the other hand, due to the older age of more conservative bryophyte groups and their ability to persist in small patches of suitable habitat, they reflect much better the ancient links between the dissected parts of Gondwanaland (Pócs, 1982). For example, in the Eastern Arc Mountains there are higher number of so-called Lemurian (Madagascan) elements, and of palaeotropical species, than in any other part of the African continent!

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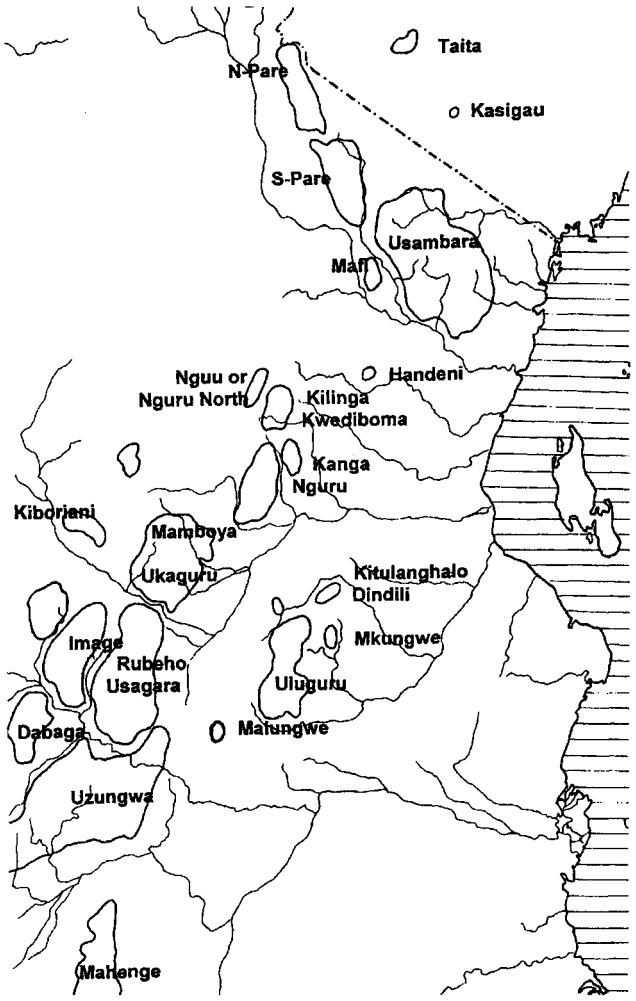

Figure 1. The position of Eastern Arc Mountains

RESULTS

Two areas in the Eastern Arc are well known bryologically, namely the Usambaras (see Bizot *et al.*, 1978; Jones, 1972, 1974a, 1974b, 1975, 1976, 1977, 1979, 1981, 1985, 1988; Jones & Pócs, 1987; Ochyra & Pócs, 1985; Pócs, 1982, 1985, 1988, 1992; Vanden Berghen, 1976 and many others; for full lists see O'Shea, 1995 and Wigginton & Grolle, 1996), and the Ulugurus (Bizot & Pócs, 1974, 1980, 1983; Orbán, 1977, 1978; Pócs, 1976a, 1980). For some other mountains (Nguru and Ukaguru Mountains) very rich collections are already under investigation by different specialists, but results are not yet available. For other areas (like Pare and Udzungwa Mountains) only preliminary collections are at hand and their bryoflora is still little known. On the basis of existing records, the bryophyte flora of the Eastern Arc Mountains consists of about 700 species, which represents about 58 % of the very rich Tanzanian bryoflora (1,200 species). For comparison, the whole known Ugandan

bryoflora is some 580 species and even the bryoflora of countries such as Cameroon (584), Nigeria (274) and Ethiopia (404) contain fewer taxa! (Kis, 1985; Wigginton & Grolle, 1996; O'Shea, 1995, 1997).

Endemic bryophytes of the Eastern Arc

The endemics can be subdivided into two groups. There are not many of the so called 'narrow endemics' in the sense of Gradstein & Pócs (1989). They are restricted to a small area within each mountain. For example, *Cololejeunea amaniensis* occurs only in two small areas in the Usambara Mountains: near Amani Station and on Shagein Summit. *Diphyscium pocsii* lives in the Uluguru Mountains: on shady granitic cliffs of the west side ridge of Lupanga peak above Morogoro and in the Mlulu valley above Tangeni village.

The endemic taxa of the different parts of Eastern Arc are outlined below.

a) Endemic bryophytes of the Usambara Mountains:
Anthoceros brunnthaleri Steph.
Anthoceros parvifrons Steph.
Cladolejeunea aberrans (Steph.) Zwickel.
Cololejeunea amaniensis Pócs.
Cololejeunea tanneri Pócs.
Isopterygium baurii Broth.
Philonotis usambarica Broth.
Plagiochila austitexta Steph.
Plagiochila rudolfii Pócs.
Pterobryon julaceum Broth.
Radula pseudoflaccida E.W. Jones.

b) Endemic bryophytes of the Nguru Mountains:
Fissidens pocsii Biz. et Dury.
Fissidens inclusus Biz. et Dury ex Pócs.
Plagiochila hiroshiana Pócs, ined.

c) Endemic bryophytes of the Uluguru Mountains:
Cololejeunea borhidiana Pócs.
Cololejeunea grolleana Pócs.
Cololejeunea jonesii Pócs.
Diphyscium pocsii (Biz.) Zander.
Fissidens hirsutus Biz. ex Pócs.
Hookeriopsis pocsii Biz.
Diplasiolejeunea albifolia ssp *orientalis* Pócs, ined.

d) Endemic bryophytes of the Mufindi Escarpment:
Rhynchostegiella tanneri Biz.
Trichosteleum jonesii Biz.

Subendemic bryophyte species of the Eastern Arc

The subendemic species occur on more than one mountain of the Eastern Arc. There is one monotypic endemic genus, *Neorutenbergia,* represented by *N. usagarae* (Dixon) Bizot et Pócs. This species is widespread over all the montane forests in the Eastern Arc (figure 2), where it occurs as a common epiphyte, forming large festoons on the thinner trunks and branches in the mossy forests between 1,500 and 2,200 m altitude. Several other species (*e.g. Pterobryon flagelliferum* Mitt., *Renauldia lycopodioides* Bizot ex Pócs (figures 3, 4) occur in two or three mountains within the Arc. A disjunct distribution pattern between the

Usambaras and Ulugurus is also found in many other species, which might reflect that these are the larger and most persistently wet mountains.

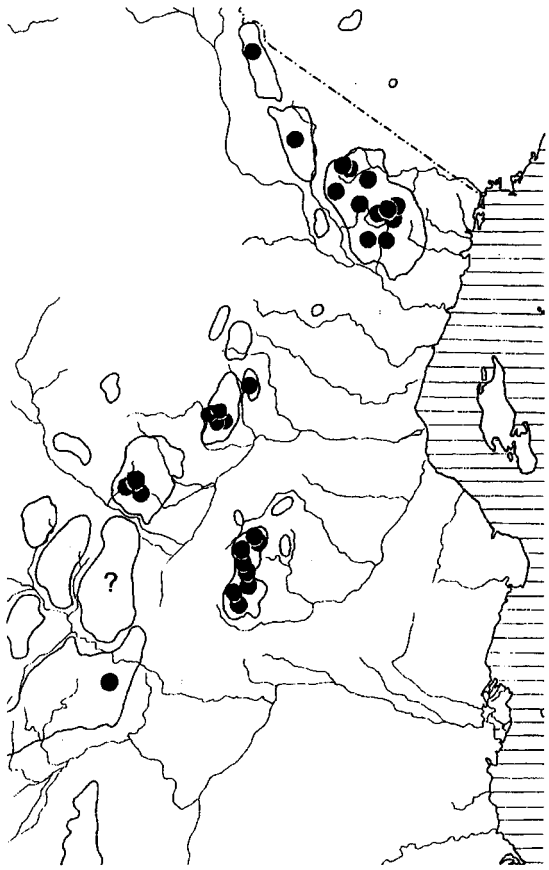

Figure 2. The known distribution of Neorutenbergia usagarae *(Dix.) Bizot et Pócs.*

Such Eastern Arc subendemics are:

Fissidens jonesii Biz (Usambara, Nguru, Ukaguru).
Hyophila holstii Broth. (Usambara, Uluguru).
Leucobryum bistratosum Broth. (Usambara, Uluguru).
Mittenothamnium stuhlmannii (Broth.) Card. (Uluguru + Bukoba).
Neorutenbergia usagarae (Dix.) Biz. et Pócs (From Pare to Udzungwa Mountains, see figure 2).
Pterobryon flagelliferum Mitt. (Usambara, Nguru, Usagara).
Renauldia lycopodioides Biz. ex Pócs (Usambara, Ukaguru, Udzungwa, see figures 3, 4).
Syrrhopodon stuhlmannii Broth. (Usambara, Uluguru).
Syrrhopodon usambaricus Broth. ex Orbán (Usambara, Uluguru).

Other phytogeographically interesting groups

West and Central African species isolated in East Africa

These species are widespread in West Africa, many of them reaching Central Africa, but they occur only sporadically in East Africa after a large gap. This phenomenon is parallel to the eastern occurrence of many phanerogams, mostly lowland rainforest species, like

Palisota schweinfurthii C.B. Cl. They are relics of a once continuous forest belt from West to East Africa broken up several times during drier climatic periods since Tertiary and latest 12–10,000 BC (Moreau, 1966; Hamilton, 1982). Such western lowland forest bryophytes in East Africa are restricted mostly to the rain exposed slopes of the Eastern Arc Mountains. Such species are:

Archilejeunea abbreviata (Mitt.) Vand. Bergh.
Calymperes intralimbatus C. Müll.
Cololejeunea apiculata (E.W. Jones) Schust.
Cololejeunea harrisii Pócs.
Dendroceros africanus Steph.
Distichophyllidium africanum Dem. et P.Varde.
Ectropothecium brevicladulum (C.M.) Broth.
Fissidens parkii Mitt.
Lepidopilidium devexum Mitt.
Lepidopilum dusenii C. Müll.
Macrohymenium megasporum (Duby) Kis.
Rhaphidorrhynchium brevihorridum (Broth.)
Trichosteleum perhamosum Broth.
And others

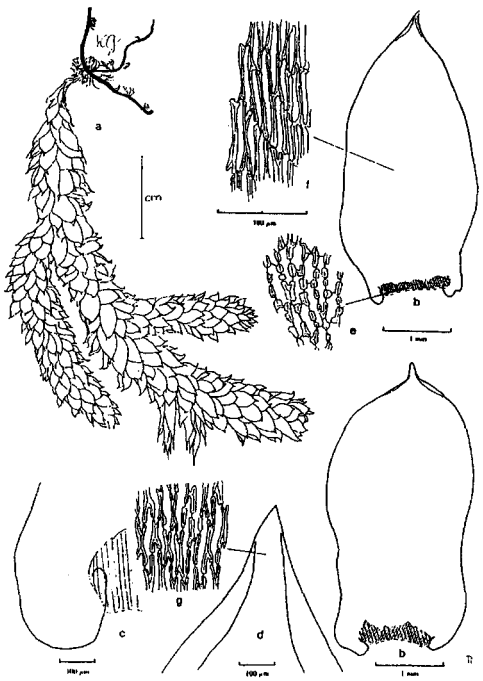

Figure 3. Renauldia lycopodioides *Bizot ex Pócs. a: Habit (drawn by G. Kis); b-g: Leaves (drawn by the author), c: shoulder with auricle, d: apex, e: cells from lamina base, f: median lamina cells, g: apex cells. All drawn from the type.*

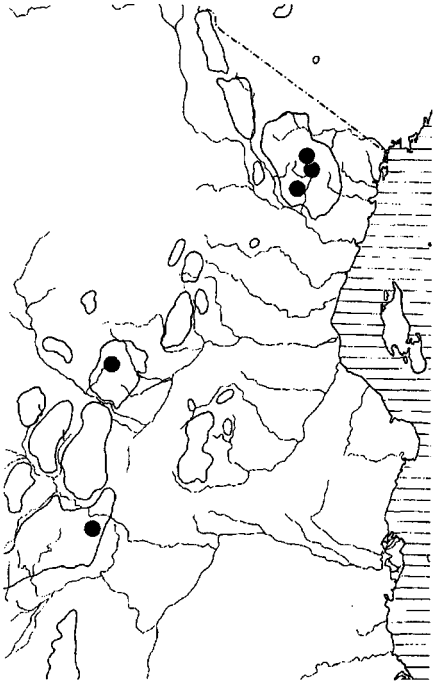

Figure 4. The distribution of Renauldia lycopodioides *Bizot ex Pócs.*

Palaeotropical species

The Eastern Arc Mountains have a stronger affinity to Asia than the rest of continental Africa. There are several Asian species that reach their westernmost occurrence in the Eastern Arc. The disjunct occurrence of species in African and Asian humid forests could be related to the period in the Miocene when the Tethys Sea was closed and before aridification changed Northern Africa and the Middle East (Axelrod & Raven, 1972). This element of the bryoflora has been presented in detail previously (Pócs, 1976b, 1992), so the following species only serve as examples. Their total number in the Eastern Arc Mountains is 114 or 16.29 %, higher than anywhere else in tropical Africa. Example species are:

Calycularia crispula Mitt.
Cuspidatula contracta (Reinw. *et al.*) Steph.
Dendroceros javanicus (Nees.) Nees
Gottschelia schizopleura (Spruce) Grolle
Homaliodendron exiguum (Bosch. & Lac.) Fleisch.
Lejeunea alata Gott.
Pelekium velatum Mitt.
Pleurozia gigantea (F. Web.) Lindb.
and many others.

Lemurian species

The so-called Lemurian elements in the sense of Tixier (1978) and Pócs (1997) are the species of Madagascar and the other Indian Ocean islands (like the Comoros, Seychelles, Réunion and Mauritius), which may occur only sporadically in mainland Africa. In the Eastern Arc Mountains their occurrence is much more typical among bryophytes than among the vascular plants, reflecting the ancient link that existed before the dissection of Gondwanaland, at least before Madagascar split off from the continent (Pócs, 1975). In certain genera (*Leucobryum, Leucoloma, Macromitrium, Syrrhopodon*—Orbán, 1977, 1978, 1985) they are especially frequent. No doubt, air dispersal has also played a role in this affinity, but the phytogeographical contrast between the young volcanic mountains and the old crystalline massifs in East Africa, as it is shown by Pócs (in Bizot & Pócs, 1974; Pócs, 1975), seems to support the above statement.

As there are a large number of Lemurian species in the Eastern Arc Mountains, the list below is only partial and provides examples of the distribution within the Eastern Arc:

Bryum truncorum (Brid.) Brid.—Uluguru.
Daltonia cardotii Biz. et Onraedt—Uluguru.
Diplasiolejeunea villaumei Steph.—Usambara, Uluguru.
Diplasiolejeunea zakiae Tixier—Taita Hills, Uluguru.
Drepanolejeunea cambouena Steph.—Usambara, Uluguru.
Drepanolejeunea madagascariensis (Steph.) Grolle—Taita Hills, Kasigau, Uluguru.
Frullania usambarana Schiffn.—Usambara, Uluguru.
Holomitrium borbonicum Hampe ex Besch.—Uluguru.
Leucobryum isleanum Besch.—Ethiopia, Kilimanjaro, Usambara, Ukaguru, Uluguru, Zambia.
Lepidozia africana Steph.—Nguru, Uluguru.
Leucoloma brotheri Ren.—Uluguru.
Leucoloma grimmioides P.Varde—Uluguru.
Macromitrium mauritianum Schwaegr.—Usambara, Uluguru.
Pilotrichella perrobusta P. Varde—Ukaguru, Uluguru.
Plagiochila cambouena Steph.—Usambara, Nguru, Mufindi.

Plagiochila drepanophylla Sande-Lacoste—Usambara.
Schlotheimia excorrugata C. Müll. ex Card.—Ukaguru, Uluguru.
Schlotheimia robillardii Duby—Usambara.
Sematophyllum sinuosulum (Besch.) Broth.—Taita Hills, Usambara, Uluguru.
Syrrhopodon insularum Bizot ex Onraedt—Uluguru.

CONCLUSIONS

As can be seen from the above (see figure 5 and table 1), the bryoflora of Eastern Arc Mountains can be characterised by a high overall species diversity, a relatively high proportion of endemism compared to other montane bryofloras in Africa and by the high number of Lemurian (Madagascan) species. The last is especially marked in the Uluguru Mountains, where 40 such species occur, which forms 8.16 % of the bryoflora (compared to the 23 such species in the Usambaras and only eight on the volcanic Kilimanjaro). This group of Eastern Arc-Madagascar species, together with the palaeotropic (African-Asian disjunct) element are likely to be biogeographical relics.

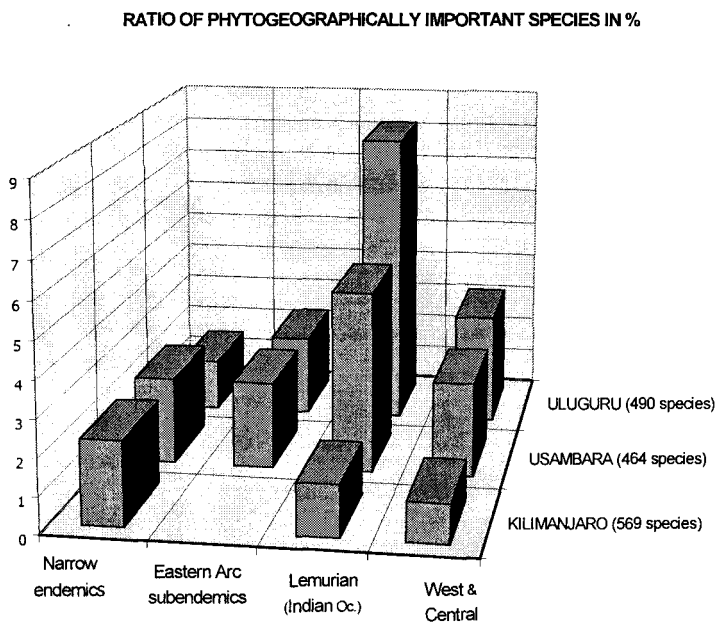

Figure 5. The percentage of narrow endemic (occurring only in one mountain area), subendemic (in more than one mountain of the Eastern Arc), Lemurian (reaching the Eastern Arc from Madagascar and Indian Ocean islands), West and Central African (mostly lowland) species in the two well known mountains, compared with those of Kilimanjaro.

Further collections in less well known areas and the identification of previously collected specimens (about 30,000) will almost certainly reveal interesting records and probably taxa new to science, some of them endemic to different Eastern Arc Mountains.

Table 1. Percentage of narrow endemic (occurring only in one mountain area), subendemic (in more than one mountains of the Eastern Arc), Lemurian (reaching the Eastern Arc from Madagascar and Indian Ocean islands), West and Central African (mostly lowland) species in the two well known mountains, compared with those of Kilimanjaro.

	Uluguru Mountains		Usambara		Kilimanjaro	
Total species	490	% of total	464	% of total	569	% of total
Narrow endemics	7	1.43	11	2.37	13	2.28
Eastern Arc subendemics	11	2.24	11	2.37	-	-
Lemurian (Indian Ocean)	40	8.16	23	4.96	8	1.40
West and Central African species	15	3.06	12	2.59	6	1.05

The mossy elfin forests and other rainforests of the Eastern Arc Mountains are renowned for their richness in bryophyte species. But we believe that attention should also be directed towards the almost unknown bryoflora of temporarily dry habitats, like the mist-effected miombo and other woodlands, cliffs and Velloziaceae stands of granitic inselbergs.

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