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The exploration of the East African bryoflora

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Abstract. During the past 5 years intensive bryological explorations were carried out in Tanzania with special emphasize on hitherto undercollected areas (e.g. Nguru mountains, Mafia Island, unknown accesses of Mount Kilimanjaro and Meru) and on special habitats (e.g. rocky semi-desert or heath vegetation and alkaline tolerant epiphytic vegetation along the Rift Valley). These collections (above 8000 numbers) resulted in numerous records, some of them new to the African continent and at least 8 species new to science. The data point to interesting phytogeographical links and help to explain the evolution of the flora of East African volcanoes and crystalline mountains. Hitherto unknown oil bodies of more than 50 liverwort species were investigated. This paper does not give a full account of these studies but only provides examples to illustrate the above points.

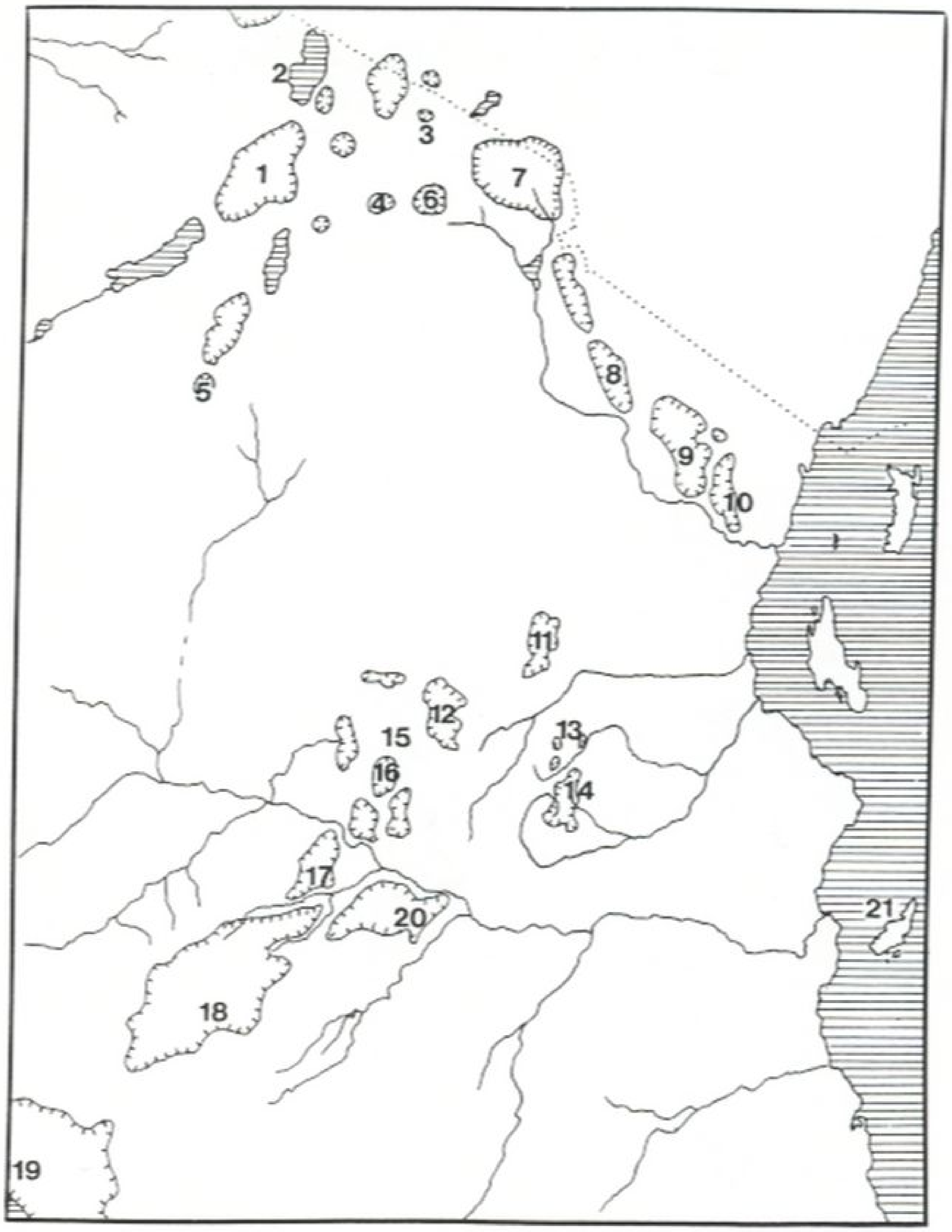
Introduction

The latest accounts of the exploration of the East African bryoflora were given by Pócs (1982) for the Hepaticae and by Kis (1985) for the Musci. Since then the author has had a very good opportunity to collect and to make ecological and phytogeographical observations in Tanzania.

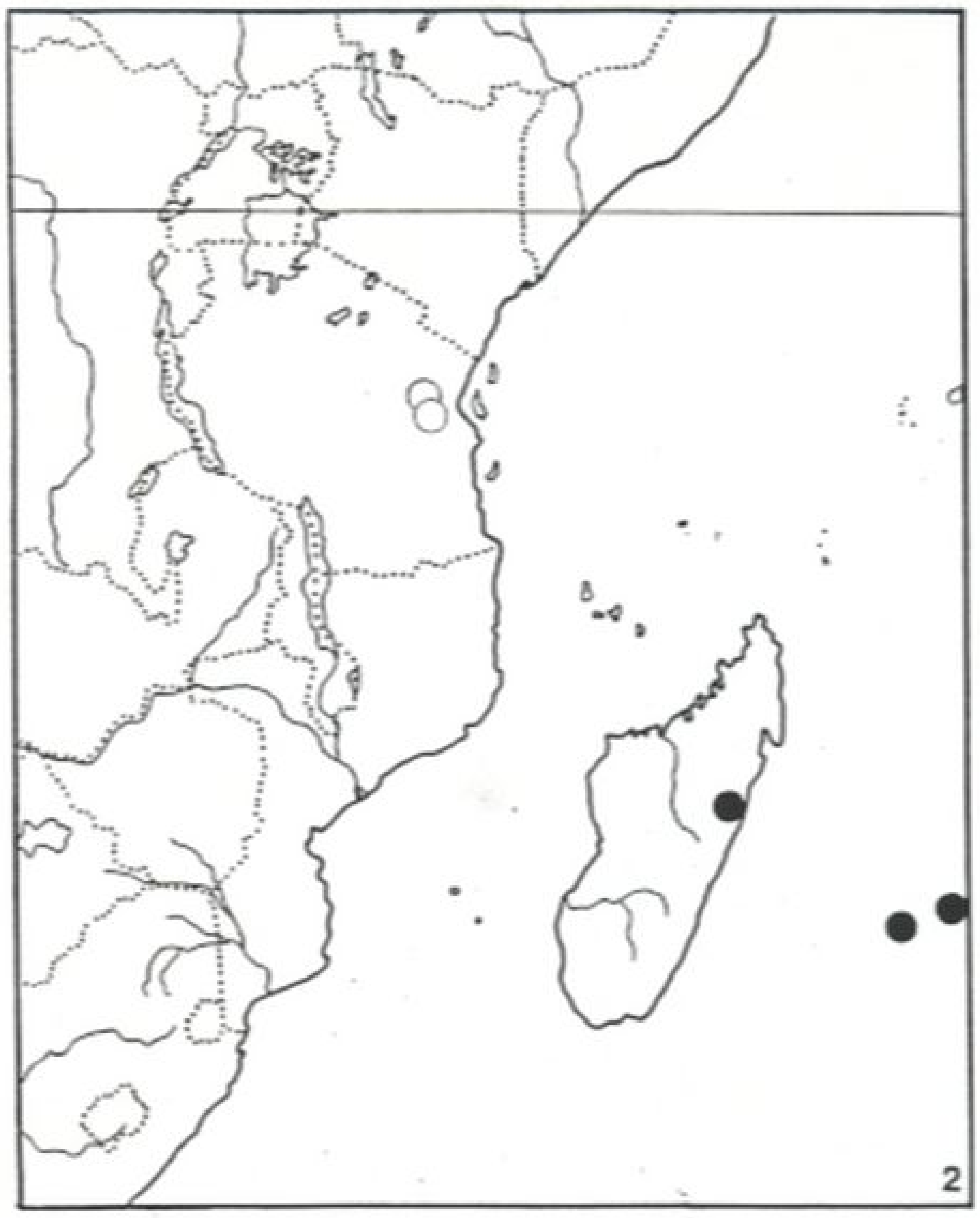
During this time more than 8000 numbers of bryophytes (in sets of at least four) have been collected. The first duplicates from these sets will be deposited in EGR, SUA, MO, and G. The remaining duplicates will be deposited in KRAM, BP, BR, TNS. In addition, an exsiccata based on this material will be edited in co-authorship with R. Ochyra. The specimens have been collected at a number of sites which are given in map 1.

Data on montane bryofloras

The exploration of hitherto bryologically unknown areas (Mafia Island, Mahenge Plateau or Uzungwe Mountains), little known mountains (Nguru or Pare) or poorly known parts of otherwise well known mountains (Uluguru, Meru or Kilimanjaro Mountains) resulted in a more thorough phytogeographical picture of the area. A few examples - *Chandonanthus cavallii* (Gola) S.Arnell, *Gymnomitrium laceratum* (Steph.) Horik., *Riccardia compacta* (Steph.) S.Arnell and *Hylocomium splendens* (Hedw.) B.S.G. - were considered to be very rare elements of the afro-alpine bryoflora previously known in Tanzania only from Mount Kilimanjaro. Mount Meru, described as the driest altimontane habitat in East Africa (Hedberg 1951), was one place these bryophytes were not expected. During repeated visits to the rainy side (the southwest and south) of Mount Meru the above species proved to be common (*Pócs 8687/BN, 8687/AI, 8687/AT, 87169/AB*) in deep gorges with relative wet subalpine *Erica arborea* stands at 2900-3400 m



Map 1: The sites in Tanzania bryologically explored during the past five years. 1: Ngorongoro Conservation area , 2: Lake Natron basin, 3: Longido Hill, 4: Monduli Hill, 5: Mount Hanang, 6: Mount Meru, 7: Kilimanjaro mountain, 8: South Pare mountains, 9: West Usambara mountain, 10: East Usambara mountains, 11: Nguru mountains, 12: Ukaguru mountain, 13: inselbergs N of Morogo, 14: Uluguru mountain, 15: Mpwapwa basin, 16: Usagara mountains, 17: Image Mts., 18: Mufindi Highland, 19: Southern Highlands incl. Mbeya, Rungwe, Poroto and Livingstone mountains, 20: Uzungwe mountain, 21: Mafia Island.



Map 2: The distribution of *Stenorrhipis madagascariensis* (Steph.) Grolle

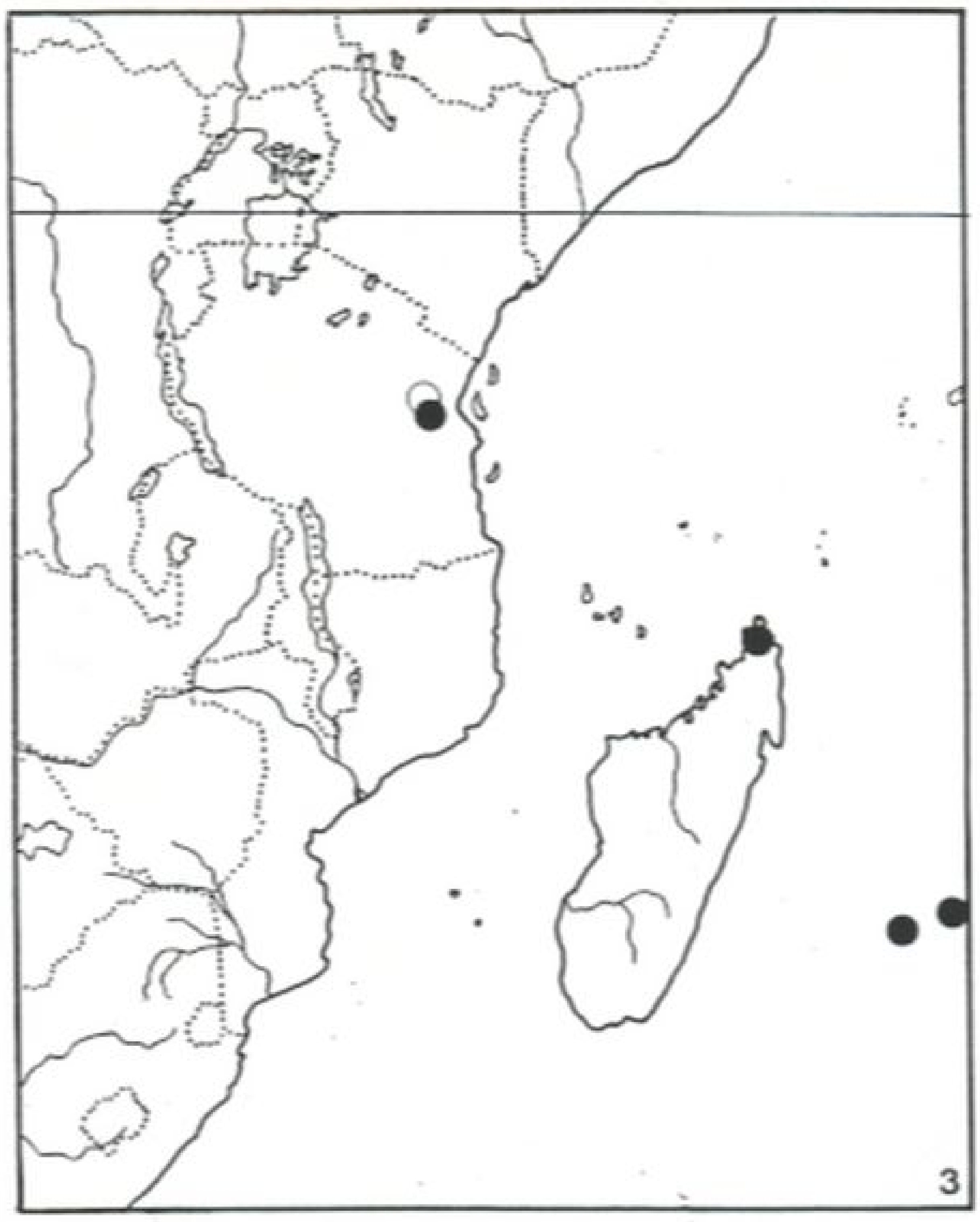
1975a, 1982). Intensive collecting in other areas of the Precambrian crystalline arc of Tanzania resulted in many examples of a similar type of distribution, especially from the Nguru Mountains which will be thoroughly examined by the SAREC sponsored Integrated Rain Forest Project. Examples:

Bazzania borbonica (Steph.)Steph.
Nguru mountains: Chazi and Dikurura Valleys, 1900 m, on shady rocks and on branches in mossy forests (*Pócs 89054/U, 89056/S*). Known distribution: Madagascar, Reunion, Mauritius, on the Afric an continent only from the Uluguru and Ukaguru mountains

Chiloscyphus decurrens (Reinw., Blume et Nees) Nees
West Usambara mountains: Balangai West, 1800 m, ramicolous in Ericaceous heath; Nguru mountains: ridge W of Dikurura Valley, 1900 m, ramicolous in mossy forest (Pócs 88119/E). A species with a palaeotropic distribution (vide Pócs 1976); on the African continent only from the Uluguru and Nguru mountains

Odontoschisma africanum (Pears.) Sim
Nguru mountains: summit on side ridge W of Magole village, 2000 m. On overhanging rock among *Kurzia capillaris* (Sw.) Grolle ssp. *stephanii* (Renauld) Pócs (*Pócs 89056/E*). A South African species known from the Uluguru and Ukaguru mountains *Kurzia capillaris* ssp. *stephanii* is a subspecies of Madagascar-Mascarene (Lemurian) distribution, on the African continent only known from the Uluguru mountains and Malawi.

Pleurozia gigantea (Web) S.O.Lindb.
Nguru mountains: elfin forest at the W end of Dikurura Valley, 1900 m, ramicolous (*Pócs 89056/E*). A Palaeotropic species (vide Pócs 1976)



Map 3: The distribution of *Calyptrochaeta asplenioides* (Brid.) Crosby (Cape localities not shown). Black signs mark previously known, open ones new localities.

known only from the Ukuguru mountains on the African continent.

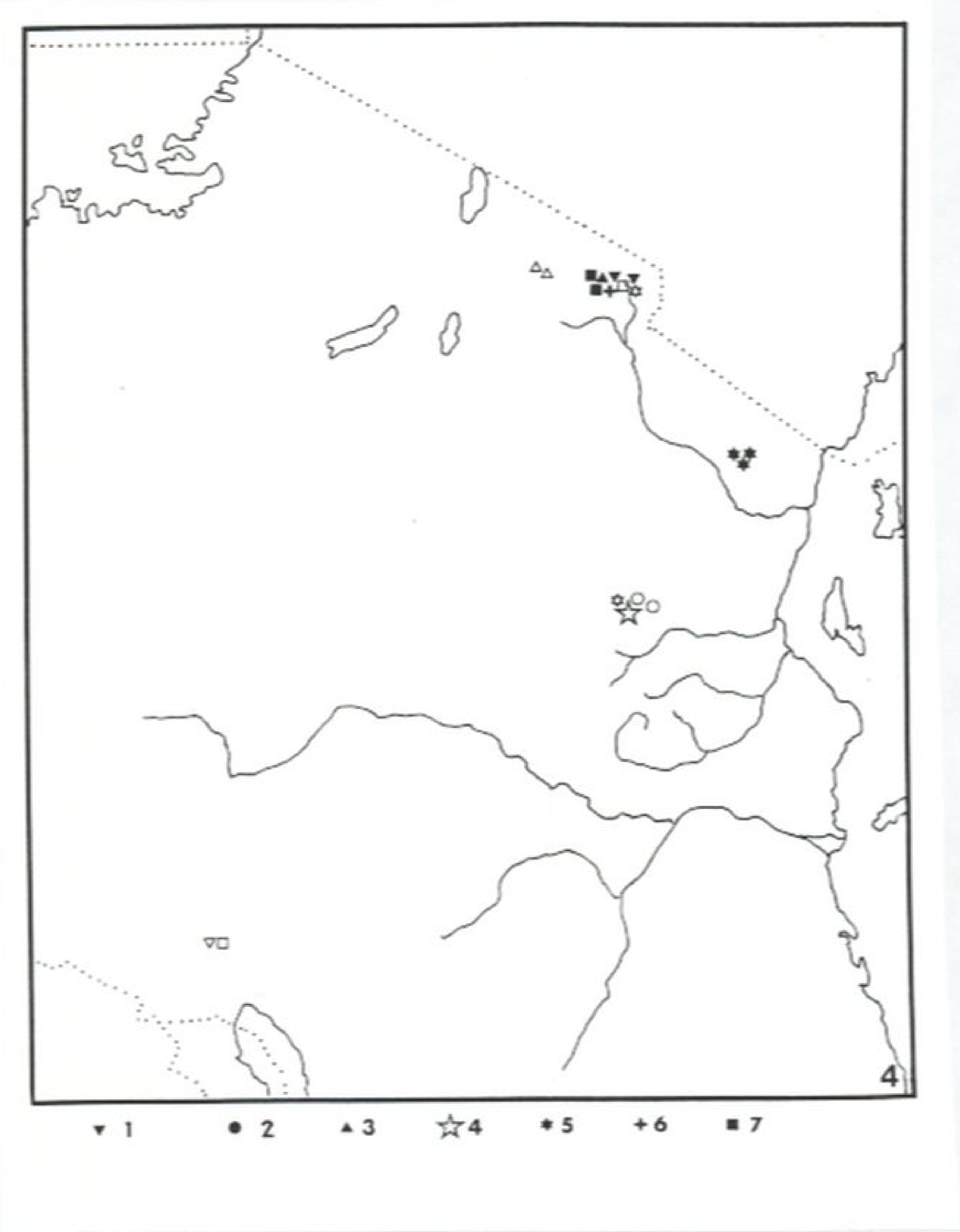
Stenorrhipis madagascariensis (Steph.) Grolle
Uluguru mountains: Mwere Valley, 1600 m, on pebbles in streambed, montane rainforest (*Pócs and van Zanten 86117/D)*, Mgeta Valley, on shady riverside rock in montane mossy forest, 2160 m (*Pócs and Ochyra 88113/BC*); Nguru mountains: Chazi spring valley, 2100 m, on wet rocks near waterfall in montane mossy forest (*Pócs and Orbán 89170/W*). This species was known previously only from Madagascar (Grolle 1963) and the Mascarene Islands (Grolle & Onraedt 1974). Its occurrence in mainland Africa therefore has great significance (see map 2). In addition, some of the African material is fertile, so that data on its sex organs will complete the description of this species which hitherto was known only in a sterile condition.

Calyptrochaeta asplenioides (Brid.) Crosby
Nguru mountains: Chazi Valley, 1400 m; "Spirit Lake", 1900 m, Divue headwaters 1800-2000 m, on wet ground of submontane and montane rainforests (*Pócs 89051/C, 89052/AM, 89054/M*). Known from Madagascar, the Mascarenes, the Cape region of South Africa and the Ulugurus (vide Crosby 1976 and map 3).

Other interesting elements:

Anastrophyllum piligerum (Nees) Spruce
Uluguru mountains: Lupanga, NW ridge, on granitic cliffs at 1780 m (*Pócs and van Zanten 86113/G*); Ukaguru mountains: elfin forest on Mnyera ridge, 2100 m, corticolous (*Pócs 6871/W*). A pantropical species, previously known on the African continent only from Zimbabwe.

Andrewsianthus bilobus (Mitt.) Grolle
Uluguru mountains: Mgeta river, valley at the



Map 4: The distribution of certain *Colura* species in Tanzania. 1: *C. berghenii* S. Jov.-Ast, 2: *C. cylindrica* Herz., 3: *C. hedbergiana* Pócs, 4:*C. sp. nov.* in press. 5: *C. usambarica* E.W.Jones, 6: *C. kilimanjarica* Pócs & S.Jov.-Ast, 7: *C. saroltae* Pócs

submontane and montane rainforests (*Pócs 89051/C, 89052/AM, 89054/M*). Known from Madagascar, the Mascarenes, the Cape region of South Africa and the Ulugurus (vide Crosby 1976 and map 3).

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Andrewsianthus bilobus (Mitt.) Grolle
Uluguru mountains: Mgeta river, valley at the E edge of Lukwangule Plateau, on rocks at 2270 m (*Pócs and Ochyra 88113/AZ*).
An Afro-montane species found above 2400 m, new for Uluguru.

Andrewsianthus kilimanjaricus (S.Arn.) Grolle & Vana
Nguru mountains: summit above Chazi Falls, 2000 m, ramicolous in mossy forest. An afroalpine-Andean element, new to the Nguru mountains, in East Africa known only from 2850-3990 m alt.

The above data serve only as examples, the largest part of the material collected is still unnamed. Many earlier collections from East Africa are now being identified by the author or else have already been worked up (Bizot et al. 1979, 1985, Meenks & Pocs 1985, Ochyra & Pocs 1985a, 1985b, 1986, Ochyra & Sharp 1988). Nevertheless, the material known from the Kilimanjaro and Usambara mountains seem to be adequate for a phytogeographical evaluation along the lines previously done by Spence & Pocs (1989) and by Pocs (in press). After all of the collections have been identified more comparative studies will be done on the montane bryofloras of East Africa and on intra-African continental disjunctions that will supplement previous results attained by Pócs (1976) and Gradstein et al. (1983).

Taxonomic studies

The author is presently carrying out detailed studies on the Lepidozioideae and Cololejeuneoideae (Pócs 1975b, 1980a, 1984b 1984c, 1985, Jones & Pócs 1987). These and future studies will contribute to the Bryologia Africana Project. However, the following example will serve to show how far are we from obtaining a complete knowledge of the taxonomy of critical taxa in tropical Africa:

Before the present research period only 4 species of *Colura* were known from continental Africa, namely *C. berghenii* S. Jov.-Ast, *C. digitalis* (Mitt.) Steph., *C. dusenii* Steph. and *C. tenuicornis* Evans (Jovet-Ast 1953, 1954, 1976). *Colura berghenii* inhabits tiny branches of Ericaceae in Afroalpine habitats, the other species are commonly epiphyllous. Intensive collecting in habitats similar to that of *C. berghenii* has resulted in the discovery of 7 additional species of Colura. Two of these species represent distributional extensions: *C. calyptrifolia* (Hook.) Dum. new to tropical Africa and *C. cylindrica* Herz. new to Africa. The remaining five represent species new to science, four have already been described (*C. hedbergiana* Pócs, *C. kilimanjarica* Pócs & S. Jovet-Ast, *C. saroltae* Pócs, and *C. usambarica* E.W.Jones) and one will be described in the near future.

The following distributional data are new (see map 4).

Colura berghenii S. Jov.-Ast
Mount Rungwe, Southern Highlands of Tanzania: N slope of the caldera, 2400 m, on branches of Ericaceae in subalpine heath (*Pócs 89130/G*). This species was previously known only from Mount Kilimanjaro.

this question.

Colura hedbergiana Pócs
Mount Meru: SW ridge between Engare Narok headwaters, 3050 m, W ridge above Laikinoi, 3200 m, on Erica arborea twigs and branches in subalpine heath (*Pócs 89186/AW,P, 89194/AJ*). This species was previously known only from its type locality on Mount Kilimanjaro.

Colura sp. nov.
Nguru mountains: heat above "Spirit Lake" at Chazi headwaters, 2140 m, on twigs (*Pócs 89165/X*), SW ridge of Mafulumula, 2280 m, ramicolous in elfin forest (*Pócs and Orbán 89168/AG*). A distinct new species belonging to section *Eucolura* S.Jov.-Ast, which seems to be restricted to the crystalline block of Nguru mountains in eastern Tanzania.

Colura saroltae Pócs
This very isolated species from section Lingua has since its description been found in a few new localities in the subalpine belt of various volcanic mountains. Kilimanjaro: Machame Route 2800-3300 m (near type locality), on Erica arborea bark (*Pócs & Pócs 87172/C, 88173/K*), Marangu Route above Mandara Hut, 2820 m, on Erica arborea bark (*Pócs & Orbán 89115/AC*); Mount Rungwe, Southern Highlands, N slope of caldera at 2400 m, on Ericaceae bark (*Pócs & Pócs 89130/H,L*).

Colura usambarica E. W. Jones
Since being described from the West Usambaras, it has been discovered in both volcanic and crystalline mountains. Kilimanjaro: Marangu Route near Mandara Hut at 2620-2750 m, in subalpine heath, on Erica arborea bark (*Pócs & Orbán 89145/AA, AB and AM*); Nguru mountains: Mafulumula, SW ridge, in subalpine bush at 2280 m, ramicolous (*Pócs & Orbán 89168/AC*).

The genus *Colura* is only one example of how much is still to be learned about the bryoflora of tropical Africa. Revisions done by other authors in the same period provide similar examples. Jones (1985) reported *Calycularia crispula* Mitt. new to Africa, and when revising *Cheilolejeunea* (Jones 1988) described an East African species new to science (1988). Ochyra and Pócs (1985a, 1985b) reported *Papillaria flexicaulis* (Wils.) Jaeg. and *Homalia pygmaea* new to the African continent. Orbán (198l, 1985, 1987) surveyed the East African Syrrhopodon. Vana (1985) worked on the African species of *Syzigiella* and Gymnomitriaceae. Van den Berghen (1984) revised the genus *Lopholejeunea*, and described several new African taxa. The list does not include all of the work that has been done on African brophytes, a more complete list of papers published since 1984 from the area is contained in the Conspectus of bryolo gical taxonomic literature (Greene & Harrington 1988, 1989).

Studies on oil bodies

Oil body form is a good specific character that is important in understanding the intergeneric and family relationships in the Hepaticae. The oil bodies of numerous East African liverworts were studied during the research period. As a result additional information on the oil bodies of many species have been made as well as observations on oil body form for more than 50 species whose oil body form had previously been unknown. In the following a few examples are given (see Plate 1):

Bazzania borbonica Steph.
Oil bodies 3-7 per cell, simple, Bazzania-type, oval. Specimen examined from the Uluguru mountains, Bondwa-Nziwane ridge, 2100 m (*Pócs 8569/N*). See Fig. 1.

Calypogeia afrocaerulea E. W. Jones
Oil bodies 2-8 per cell, dark indigo blue in color, *Calypogeia*- type. Jones (1976) describes them, as "bright blue" and refers to the relationship of this species to *C. peruviana* Nees & Mont. The oil body color of this group varies from pale azure to deep indigo and from purplish violet through brownish violet to sepia and blue black (Schuster 1969, Breil 1970, Gradstein, Cleef & Fulford 1977, Kis & Pócs 1981). Only a comprehensive revision using living material can determine the value of oil body color in the delimitation of species in this group. Specimen

Colura calyptrifolia (Hook.) Dum.
Poroto mountains, Southern Highlands of Tanzania: SW of Isongole on Mount Ngozi, ramicolous in montane rainforest at 2000 m (*Pócs 89128/U*); Kilimanjaro: Mweka Route near Mandara Hut, on Erica arborea bark and twigs in giant heath at 2700-2800 m (*Pócs and Orbán 89145/ D,Z* and *AD*). Previously known only from the West Usambara mountains in East Africa.

Colura cylindrica Herz.
Nguru mountains: Dikurura at 900 m (*Pócs 89058/H, 89117/A*), Divue, NNW of Mlaguzi village at 1060 m (*Pócs and Orbán 89160/F*). This species was found at both localities on twigs of streamside trees in submontane rainforests. The species was hitherto known only from South America. Jovet-Ast (1953:259) remarks on its close relation to the Asian *C. mosenii* Steph., but as both species were sterile, she maintained them as separate. The African specimens are fertile, therefore once fertile Asian material is it will be possible to answeee examined from West Usambara Mts., Mazumbai, University Forest Reserve, on shady road-cut surface, at 1540 m alt., (*Pócs 8544/A*). See Fig. 2.

Chandonanthus cavallii (Gola) S.Arnell
Oil bodies 2-5 per cell, isodiametric or irregular, finely granulose, *Jungermannia*-type. Examined specimen from Mount Meru in the Engare Narok gorge, on *Erica* bark in subalpine heath at 3300 m (Pócs & Ochyra 88152/C). See Fig. 3.

Cladolejeunea aberrans (Steph.) Zwickel
As mentioned by Pócs (1985), the oil bodies of this species are small, translucent, *Massula*-type and very numerous.
Recent examination of this species under oil immersion has revealed fine vesicular structures in the oil bodies. Apparently, the 'ochraceous bodies' described by Jones (1974) as typical for the *Lejeunea eckloniana* group develop from the disintegration of oil bodies. This fact emphasizes the homogeneity of this group and supports the uniting of the two genera, in which case the name *Cladolejeunea* has priority. Specimens examined from the type locality: East Usambara mountains near Amani, on Trichomanes leaves in submontane rainforest at l000 m (Pócs 87033, 87114/A). See Fig. 4.

Cololejeunea tanzaniae Pócs
5-10 oil bodies per cell, transitional between *Bazzania*- and *Calypogeia*-types. The majority of African have *Calypogeia*- or even *Jungermannia*-types of oil bodies, so the few large vesicules found in this species seems to be a good distinguishing character. Voucher specimen from the West Usambaras above Mazumbai at 1700 m, epiphyllous in montane rainforest (*Pócs 87033*). See Fig. 5.

Colura digitalis (Mitt.) Steph.
Very small, *Massula*-type oil bodies, numerous in each cell. These oil bodies are similar to those of the related species *C. obesa* S. J.-Ast from Madagascar which have been depicted by Jovet-Ast (1953). An interesting new feature of the oil bodies in this species is oil body dimorphism. In the lower part of the lobe the oil bodies are small, oval and very numerous while in the cells of lobule sack apex they are less numerous, much longer and spindle shaped. Examined specimen from the West Usambaras: epiphyllous in montane rainforest above Mazumbai Station, 1700 m (*Pócs 87133/*). See Fig. 6.

Conoscyphus trapezioides (Sande-Lac.) Schiffn.
Oil bodies very large, *Calypogeia*-type, 2-3 per cell. Voucher specimen from the Nguru Mountains above Mhonda Mission, montane rainforest (*Pócs 88184/G*). See Fig. 7.

Marsupella africana Steph. ex Bonner
Typical *Jungermannia*-type, very finely

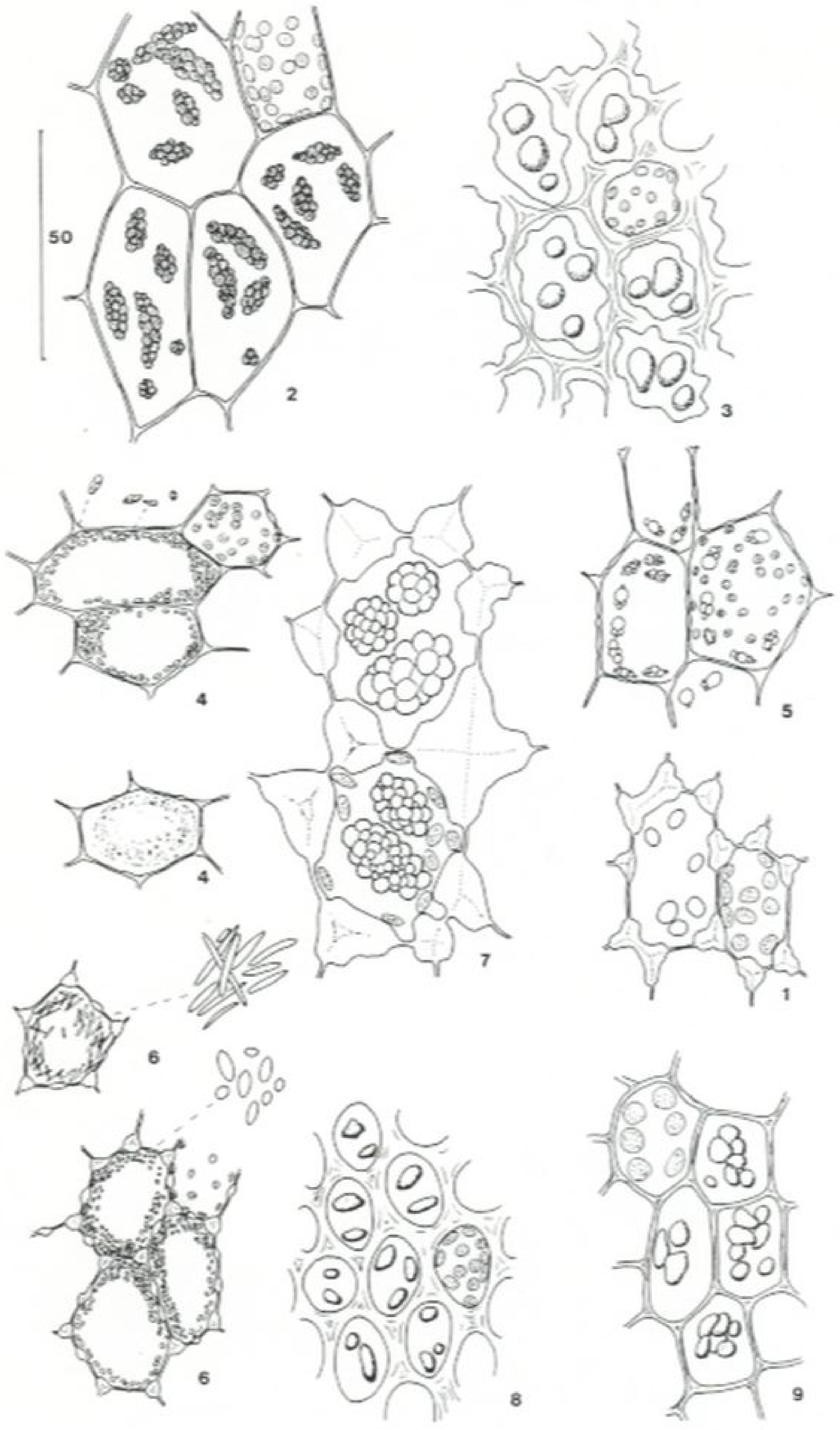


Plate 1: Oil bodies of Tanzanian liverworts. 1: *Bazzania borbonica* Steph., 2: *Calypogeia afrocoerulea* E.W.Jones, 3: *Chandonanthus cavallii* (Gola) S.Arnell, 4: *Cladolejeunea aberrans* (Steph.) Zwickel above living oil bodies, a few by higher magnification, below desintegrating cytoplasm with "ochraceous bodies", 5: *Cololejeunea tanzaniae* Pócs, 6: *Colura digitalis* (Mitt.) Steph., 7: *Conoscyphus trapezioides* (Sande-Lac.) Schiffn., 8: *Marsupella africana* Steph. ex Bonner, 9: *Stenorrhipis madagascariensis* (Steph.) Grolle

granulated oil bodies, ovate or irregular, 2-4 per cell. Specimen from Mount Meru: Engare Narok gorge, on wet lava rocks at 3400 m (*Pócs & Ochyra 88152/Q*). See Fig. 8.

Stenorrhipis madagascariensis (Steph.) Grolle
Large, shiny, irregular shaped or oval, extremely fine granulated oil bodies (typical for Lophozioideae), 2-8 per cell. Examined specimen from the Uluguru mountains: Mgeta valley, 2160 m (*Pócs & Ochyra 88113/BC*). See Fig. 9.

Ecological observations

The author has had a good opportunity to continue his previous studies (Pócs 1976, 1980b) on the epiphytic bryovegetation within the framework of the Ngorongoro Ecological Monitoring Program. The biomass, interception, humus accumulation and the overall composition of the epiphytic vegetation have been examined in permanent plots with a special reference to possible changes through time. The investigation area lies at the left side of the eastern, so called, Gregory Rift Valley. The author has observed for a long time the peculiarities of the epiphytic vegetation in the mountains along this branch of the Rift Valley. These peculiarities are manifested in the absence of numerous, mostly acidiphilous, elements and in the large, localized occurrence of species otherwise not common in the montane rainforest or other habitats rich in bryophytes.

Group 1, epiphytes absent or rarely encountered in the montane forests near the Eastern Rift.

1. Absent: Lepidoziaceae (e.g. *Arachniopsis*, *Bazzania*, or *Lepidozia*); Calymperaceae (e.g. *Calymperes* or *Syrrhopodon*); epiphyllous liverworts (with the exception of *Metzgeria agnewii*.)

2. Rarely encountered: Dicranaceae (e.g. *Dicranoloma* and *Leucoloma* are absent but a few *Campylopus* do occur); Hookeriaceae (except *Lepidopilum* and *Lepidopilidium* which are found on bamboo).

Group 2, epiphytes of indifferent distribution that occur in large quantity in montane forests both near to and far from the Rift.

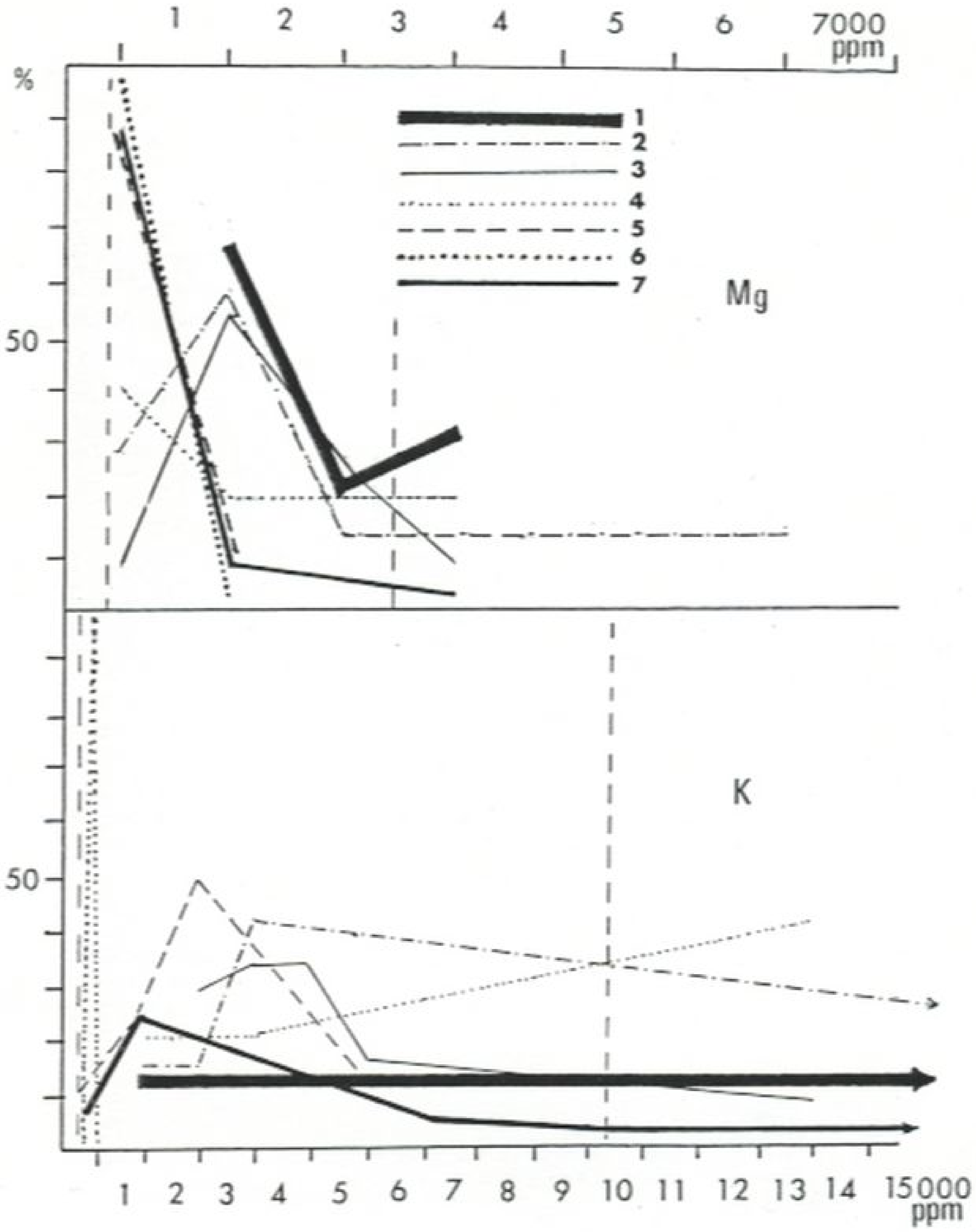
In montane dry evergreen forests and woodlands: *Frullania ericoides; Plagiochila squamulosa; Braunia arbuscula* (as well other species of the genus); *Cryphaea robusta; Erythrodontium subjulaceum; Forsstroemia producta; Leptodon beccarii; Leucodon dracaenae; Macrocoma abyssinica and M. tenuis; Orthotrichum rupestre; Pterogonium gracile; Ramalina celastri and R. hoehneliana;* and species of *Parmotrema.*

In montane rainforests: *Metzgeria limbato-setosa; Plagiochila sinuosa; Porella hoehnelii; Ptychanthus striatus; Aerobryiidium subpiligerum; Papillaria africana; Pilotrichella ampullacea* and *P. cuspidata; Prionodon ciliatus*; and *Squamidium brasiliense.*

Group 3, normally rare epiphytes that are very common in the Gregory Rift Valley: *Cololejeunea minutissima* ssp. *myriantha; Metzgeria agnewii; Metzgeria quadrifaria; Streptopogon erythrodontus* ssp. *rutenbergii; Tortula fragilis; Heterodermia comosa.*

There are a number of possible explanations for these peculiarities.

a. The first explanation centers on the geological age of the mountains. This theory, which has been discussed by Pócs (1982) works best in explaining the differences that are found between the bryofloras of the old crystalline massifs (e.g. Uluguru) and the younger volcanoes



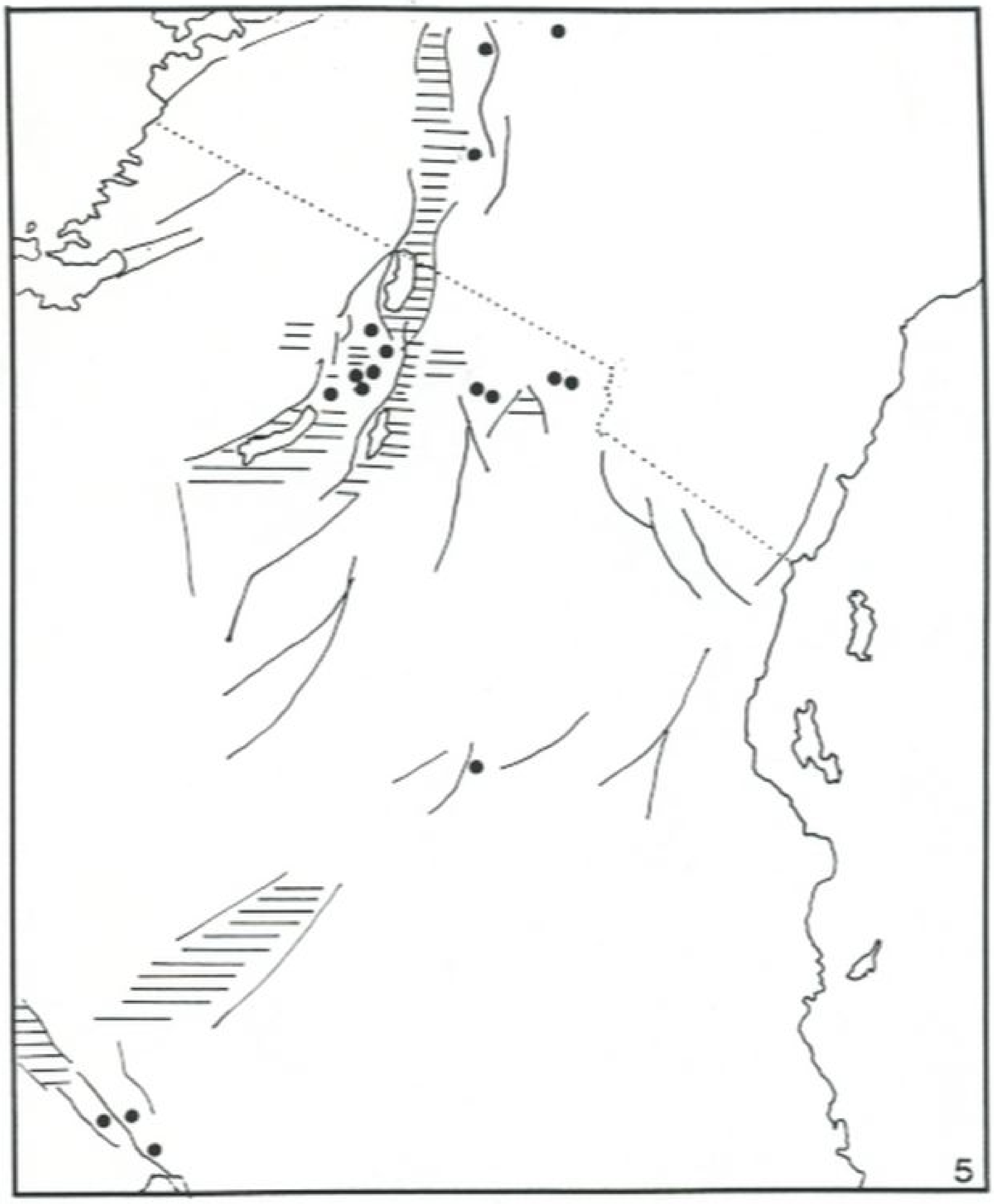
Graph 1 : The alkaline content of different soils and epiphytes in ppm. Upper graphs: Mg, lower graphs: K . 1: Ngorongoro, vascular epiphytes, 2: Ngorongoro, epiphytic lichens, 3: Ngorongoro, epiphytic bryophytes, 4: Ngorongoro, epiphytic (aerial) humus, 5: Nguru mountains, epiphytic bryophytes, 6: Mkata basin, soils, 7: Ngorongoro caldera bottom, soils (e.g. Mount Kilimanjaro). This theory fails in the case of the Gregory Rift Valley because the rainforests of Mount Kilimanjaro have the epiphytic components (Lepidoziaceae, Calymperaceae, etc.) that are missing in the nearly same-aged Ngorongoro area. On the other hand, the mossy forests on the isolated precambrian crystalline block of the Longido Hills at the edge of the Rift do not have the same elements found in the bryoflora of the Ngorongoro volcanoes. So the age of the mountains alone is not helpful in solving this problem.

b. The second explanation is based on an analysis of climatic conditions, especially the relative precipitation and other causes of variable air humidity. But many forests on the outer slopes of the Ngorongoro caldera and especially on the SW slopes of the Oldeani volcano have the same amount and distribution of rainfall as the slopes of Mount Kilimanjaro.

c. The third and best explanation concerns the special kind of alkaline volcanism that occurs along the Eastern Rift Valley. Since the pioneer works of Blanford (1870) and Gregory (1896) it has been known that the volcanoes of the area produced high alkaline (i.e. with a high Na, K, or Mg content) lavas that release their alkaline content by surface erosion (Baker et al. 1972). In addition, the active volcanoes (e.g Oldoinyo Lengai in the investigation area) spew large amount of free soda into the atmosphere with each eruption. As a result the soil, the surface water and the underground water in the area are very alkaline. Furthermore, the undrained basins of the Rift contain alkaline lakes that partly or fully dry out during the dry seasons. These variously dried alkaline lakes are subject to wind erosion thus making available a mixture of loose soil and salts for the further alkalinization of the area. Dust devils are especially common during the dry, hot months (August-December). From the dry bottom of the Rift and adjoining dry basins the alkalines are taken in the form of dust and aerosols high in the atmosphere and then deposited by dustfall and rain on the adjoining areas. The alkaline deposits thus create a special, highly selective substrate for the epiphytes near the Rift Valley.

In order to test the alkaline theory the author investigated the alkaline content of: 1. the basin soils in the bottom of Ngorongoro caldera; 2. the epiphytic humus and; 3. the epiphytes found in the rich woodlands and rainforests on the Ngorongoro caldera rim at 2000-2400 m. These figures were then compared with those taken at the Mkata basin and the Nguru mountains in the Morogoro Region, a distance of 400 km from the Rift. The results of the soil and plant analyses are summarized on graph 1. This graph shows that near the Rift the substrates on which the epiphytes grew contained higher amounts of alkalines than the substrates from other habitats. Apparently, some bryophytes growing near the Rift can tolerate such conditions and a few of these tolerant bryophytes are able to accumulate high amounts of alkalines (especially K) in their tissues. On the other hand, high alkaline content appears to be able to cause the absence of many epiphytic bryophytes either directly by their large amounts or indirectly by raising the pH to an intolerable level. Regardless of the cause, there appears to be three types of reactions to increased alkaline contend that characterize the three groups of plants listed above: 1. alkaline avoiding groups; 2. alkaline tolerant groups and; 3. alkaline favoring grops.

When the geographic distribution of the alkaline favoring and alkaline tolerant epiphytes is examined, it is apparent that they belong to widespread groups, i.e. are cosmopolitan, pantropical or at least are common tropical African elements. Some of them have 'weedy' characteristics and many of them are xerophytes. The



Map 5: The African distribution of *Metzgeria agnewii* Kuwahara with the indication of the major faults of the Eastern Rift. Horizontally stripped areas are the rift bottom and adjoining basins with higher alkaline accumulation

presence of these elements is likely to be explained by the very young age of the alkaline volcanoes in that part of the Rift.

According to Baker et al. (1972) the alkaline volcanism of the Rift occurred mostly in the Quaternary. Hence there has not been enough time for the evolution of special adaptations to these conditions. This new alkaline environment could select only from the more halotolerant, neutrophilic and basiphilic elements present or in some cases from xerophilic elements also present. Only the alkaline preference of Group 1 shows signs of specific adaptation. This is especially true for *Metzgeria agnewii* which shows obvious correlations with other alkaline volcanic formations of the Eastern Rift (see Map 5).

It is interesting that the alkaline avoiding species in the Rift bryoflora are absent only for a certain distance from the Rift. At about 100 km to the east of the Rift these elements begin to reappear in the epiphytic vegetation. Although these elements are rare in some areas (e.g. Mount Meru) they are common and widespread in other areas (e.g. Mount Kilimanjaro) in which the volcanic groundstone is alkaline poor even though the climatic conditions are similar. Further investigations are needed to reveal the details in distribution and alkaline tolerance of these species.

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