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<b>Autor:</b>	Hedberg, O.
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## Studies of adaptation and speciation in the afro-alpine flora of Ethiopia

O. HEDBERG

### SUMMARY

The author discusses the adaptive trends and the taxonomic differentiation in the afro-alpine flora of Southern Ethiopia in comparison with that of Tropical East Africa. The same life-forms and adaptations are found, but in S. Ethiopia there is also a peculiar adaptive trend responding to the activities of the burrowing Giant mole rat.

### RÉSUMÉ

En comparant les tendances d'adaptation et la différenciation taxonomique de la flore afro-alpine de l'Ethiopie méridionale à celles de la flore afro-alpine de l'Afrique tropicale orientale, l'auteur a trouvé que les formes biologiques des espèces y sont les mêmes. Cependant, en Ethiopie du Sud il existe des adaptations particulières en conséquence aux activités des taupes-rats géants.

The high mountains of tropical East Africa display a regular vegetation zonation with a forest belt, an ericaceous belt and an afroalpine belt (Hedberg, 1951). The percentage of endemics and the degree of conspicuous morphological adaptations increase with altitude and the flora of the alpine belt, the afroalpine flora, contains no less than 80 per cent of endemic species (Hedberg, 1961) and displays some remarkable adaptive trends. Its most important vascular plants can be assigned to five main life-forms, namely Giant rosette plants, Tussock grasses, Acaulescent rosette plants, Cushion plants and Sclerophyllous shrubs (Fig. 1). Each of these life-forms exploits a particular method of maintaining the water balance in an environment with "summer every day and winter every night" (Hedberg, 1964a, 1964b), and each of them is represented in similar tropical alpine climates in other parts of the world as well (Hedberg, 1973; cp. Troll, 1948, 1958).

Although the afroalpine flora has been most intensely studied in East Africa, many of its species and all of the life-forms mentioned above occur also in the mountains of Ethiopia. Intense human population pressure in the highlands of that country has influenced the natural vegetation of the mountain slopes to such an extent that it is very difficult to trace any natural vegetation zonation, but the occasional trees and groves still existing on the slopes agree with the same type of zonation that occurs in tropical East Africa. The upper limit of the ericaceous belt seems to lie

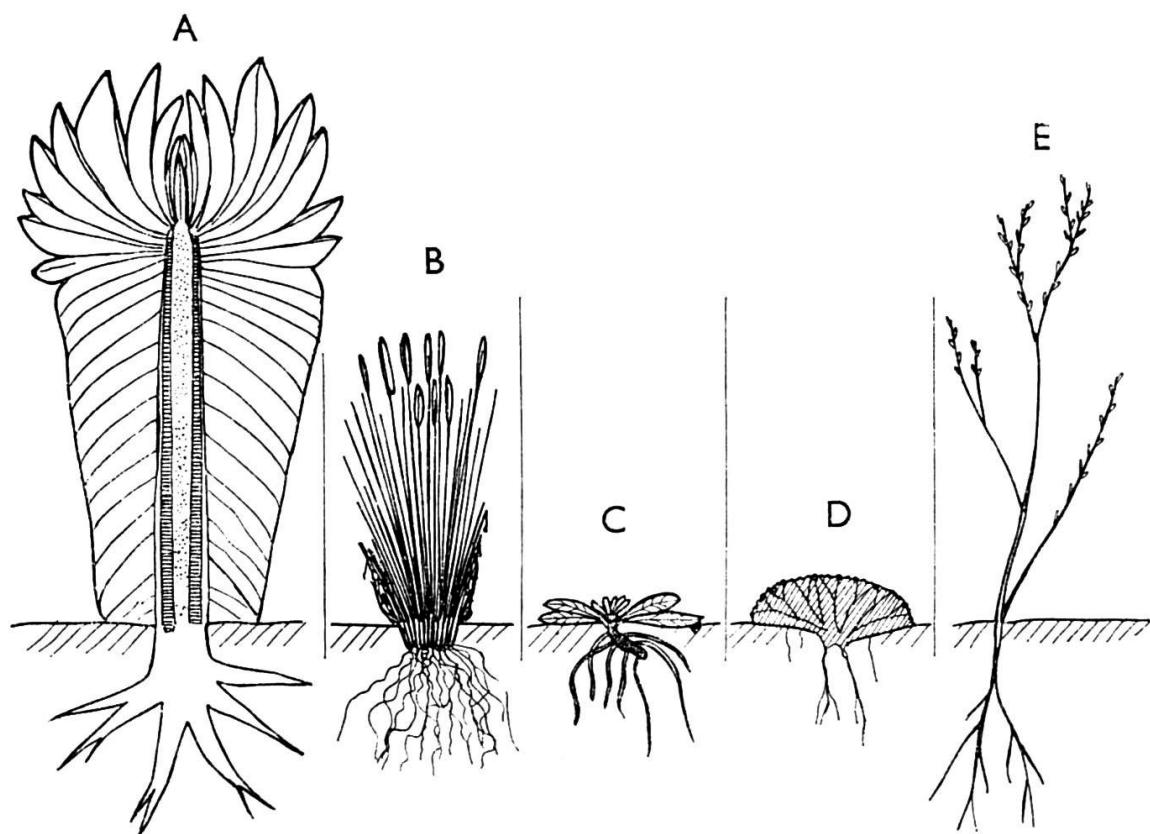


Fig. 1. — Diagrammatic drawings of the five most important phanerogamic life-forms of the afroalpine belt. A, giant rosette plant; B, tussock grass; C, acaulescent rosette plant; D, cushion plant; E, sclerophyllous shrub. (From Hedberg, 1964b.)

often higher than in East Africa, and in the southern half of Ethiopia the limit is partly blurred by the existence of an alpine species of *Philippia*, *Ph. abyssinica* Pichi-Serm. & Hein., which forms groves well up in the afro-alpine belt. Nevertheless it is not very difficult to locate this limit in the field.

Last autumn I had the opportunity to study the high level flora in the two highest mountain areas of Ethiopia, the Simien and Bale Mountains. Their afroalpine flora illustrates the same adaptive trends and contains the same life-forms as that of East Africa. An imposing example of a Giant rosette plant is provided by *Lobelia rhynchopetalum* (Hochst. ex A. Rich.) Hemsl., the most magnificent of all Giant lobelias. Tussock grasses occur in large amounts also in the Ethiopian mountains, e.g. *Festuca obturbans* St. Yves. One of the best examples of acaulescent rosette plants is offered by *Oreophytum falcatum* (Hochst. ex A. Rich.) O. E. Schulz, an endemic genus of the *Cruciferae* first described from Northern Ethiopia. A beautiful representative of the Cushion plants is a variety of *Helichrysum gofense* Cuf. from the Bale Mountains (Pl. I), the cushions of which are so hard that they hardly react when tread upon. The fifth of the afro-alpine life-forms concerned, the Sclerophyllous shrubs, may be exemplified by *Alchemilla haumanii* Rothm.

One of the most characteristic adaptive trends in the afroalpine flora concerns reduced internode length towards higher altitude (Hedberg, 1964a: 43). One of the

best examples of this is provided by the genus *Dipsacus*. At altitudes between 3000 and 3500 m the widespread species *D. pinnatifidus* Steud. ex A. Rich. is often two meters tall or more with richly branched leafy stems. Towards higher levels the development of the stem is less, and around 3800 m altitude we find both in the Simien and Bale Mountains specimens with almost unbranched and scapelike stems less than 0.5 m tall (Pl. IIa, b). The ultimate end of this adaptive trend is found above 4200 m altitude in the Bale Mountains, where there occurs an almost entirely sessile type which at first sight looks extremely different from the tall and richly branched specimens 1000 m lower down (Pl. IIc), but resembles them in most reproductive and vegetative characters. Specimens approaching this extreme (with stems only about 5 cm long) were named by Steudel (in Richard, 1847-1848) *Cephalaria acaulis*, and this taxon was erected by Szabo (1940) into an independent genus, *Simenia*. My preliminary studies indicate that they belong to one continuously varying cline defying taxonomic segregation.

As described in an earlier work (Hedberg, 1964a: 29, 64, 92) solifluction phenomena have very important effects on the afroalpine vegetation in tropical East Africa. Similar effects are very obvious in the high Ethiopian mountains, notably above 4000 m. On the Bale mountains the instability of the soil is made even more pronounced by the burrowing of the giant mole rat, whose activities keep most of the afroalpine vegetation in a permanent pioneer phase. This peculiar ecological situation has caused the appearance of an ephemeral vegetation and caused an interesting adaptive trend in a couple of vascular plants. Thus I found here an afroalpine species of the genus *Polygonum* (Pl. IIIa). It seems to be closely related to *P. afromontanum* Greenway, which occurs at altitudes of about 3000 to 3500 m on these mountains as well as in East Africa, but deviates by having short and little branched aerial shoots, the main branching being effected through subterranean shoots. In this way the plant is able to colonize the soil heaps thrown up by the mole rats in a very efficient manner and has developed into an alpine taxon reaching well above 4000 m altitude.

A similar example is provided by *Euryops prostratus* B. Nord., the prostrate rooting stems of which enable it to form firm and resistant carpets (Pl. IIIb). All other tropical species of the genus have erect stems, but the prostrate growth of this one has evidently conferred a decided selective advantage in the unstable "mole rat environment".

A significant difference between the afroalpine floras of Ethiopia and tropical East Africa lies in the greater importance of ephemeral ("annual") plants in the former. Their occurrence is presumably favoured not only by the instability of the soils, especially in the Bale Mountains, but also by the more pronounced seasonality further from the equator. Among these Ethiopian ephemerals are found *inter alia* *Thlaspi alliaceum* L., *Veronica arvensis* L. and *Valerianella microcarpa* Lois., all very rare in East Africa, and an unnamed species of the genus *Erophila*.

Whereas much remains to be done concerning the taxonomy of some of the plants I have mentioned here, my results certainly go to show that the Ethiopian afroalpine flora is even more interesting than was earlier expected from both ecological and phytogeographical point of view.

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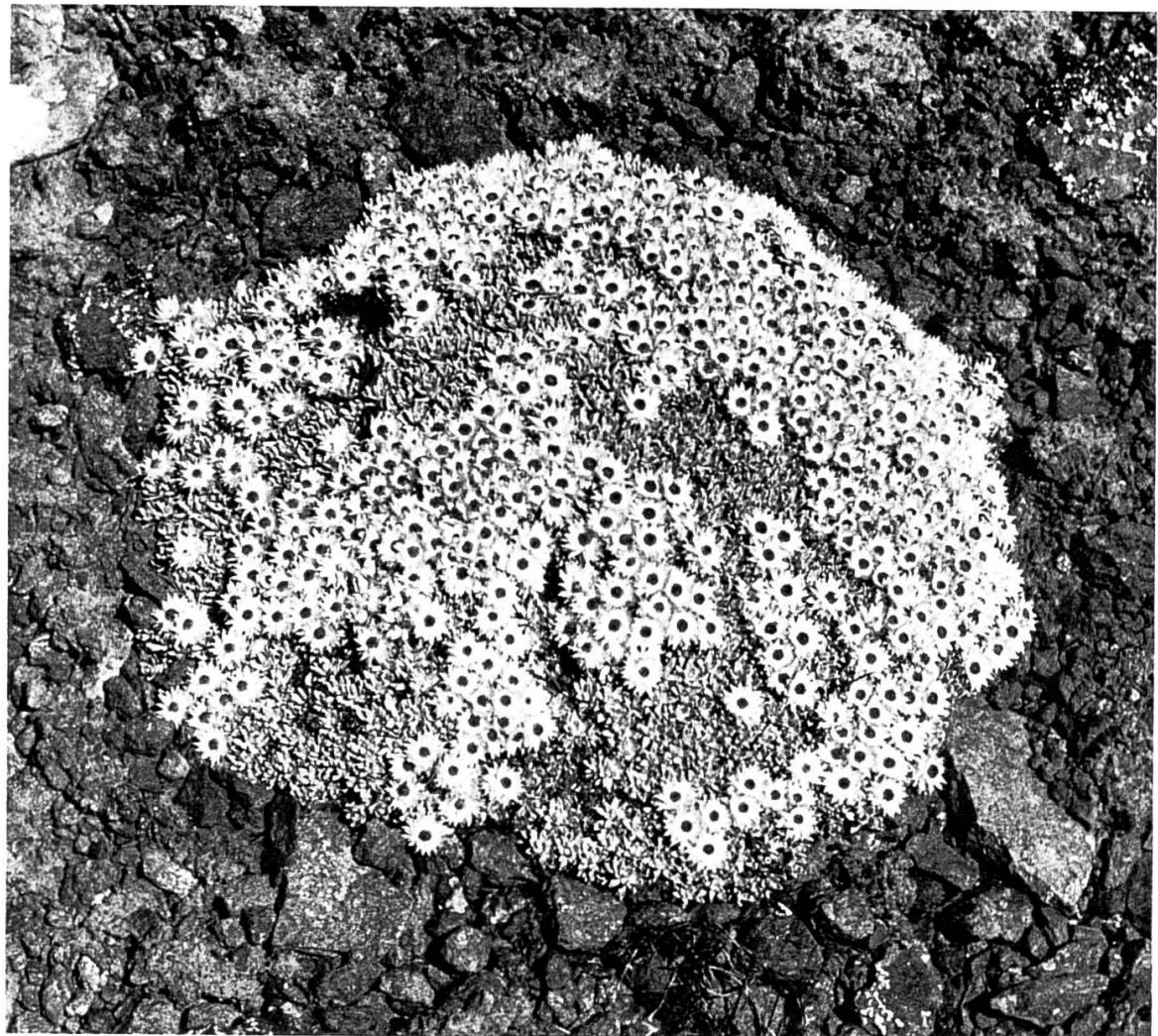
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Ethiopia, Bale Prov., Bale Mts National Park, Mt Batu, 4300 m. Dense and firm cushion of *Helichrysum gofense* Cuf., var. Photo O. Hedberg, 31.10.1973.

a



b



c



a-c: Ethiopia, Bale Prov., Bale Mts National Park, *Dipsacus pinnatifidus* Steud. ex A. Rich. at various altitudes, photographed by O. Hedberg, October 1973.

a, National Parks Headquarters, 3200 m, in *Hypericum* woodland, stem about 2 m tall.

b, near Garba Goracha Camp, 3950 m, in alpine scrub, stem about 0.3 m tall.

c, Mt Batu, 4150 m, on exposed ridge, stem about 2 cm tall.



a



b

a, Ethiopia, Bale Prov., Bale Mts National Park, Little Batu camp, 3650 m. Specimen of *Polygonum* n. sp. aff. *P. afromontanum* Greenway from heavily disturbed ground, showing large amounts of subterranean shoots. Photo O. Hedberg, 3.11.1973.

b, Ethiopia, Bale Prov., Bale Mts National Park, S slope of Tullu Deemtu, 4150 m, on rock adjoining to ground disturbed by Giant mole rat. Prostrate mat of *Euryops prostratus* B. Nord. In the upper right hand corner a rosette of *Lobelia rhynchopetalum* (Hochst. ex A. Rich.) Hemsl.