

The Chagga Homegardens on Kilimanjaro

Claudia Hemp, Andreas Hemp

Diversity and refuge function for indigenous fauna and flora in anthropogenically influenced habitats in tropical regions under global change on Kilimanjaro, Tanzania

Humans continuously inhabited the slopes of Mt. Kilimanjaro for the last 2000 years (ODNER 1971). However, during the last decades the human population increased dramatically from about 100,000 people in 1913 (RAUM 1914) to 1,053,204 people in 2002 (National Bureau of Statistics 2003). As such, the population has multiplied 10 times in 90 years. Most of the population is concentrated at an altitude between 1000 and 1800 metres, with densities varying from 500 to 1000 people per km² in some areas. Here a very remarkable kind of land use prevails: dense “banana forests” with a scattered upper tree layer, the so-called Chagga homegardens, in English “banana grove”, in German “Bananenhain”, in Chagga language “mndà”. Due to this sustainable and well developed agroforestry system degradation in this vegetation belt is rare, despite the enormous population. In their homegardens the Chagga use four vegetation layers. Under a tree layer, which provides shadow, fodder, medicines, firewood and formerly also construction wood bananas are grown and under the bananas coffee trees, and under these vegetables. This multi-layer system maximizes the use of limited land. The area is irrigated by a network of canals fed by main furrows originating from the montane forest. Rough estimates give over one thousand furrows of varying lengths and capacities (RAMSAY

1965). This farming system evolved over several centuries and did not change much over the last decades compared with the land uses in the lower zones. There is evidence that the first banana gardens and water canals existed already in the 12th century (WINTER, PERS. COM.). This old land use system has formed the identity of the Chagga, who are of multiethnic origin, despite the fact that they belong to the Bantu people.

The agroforestry system of the Chagga homegardens is a unique feature of Kilimanjaro, stretching on the climatically most favourable zone of the southern and south-eastern slopes (FIG. 1) over an area of 1000 km². If one passes from north-east to the south-western end of this belt, one could drive for 120 km through a closed “banana forest” containing about 225 Million banana “trees” – if there was a continuous road. The same type of land use, however with a smaller extension, occurs on the Pare Mountains and Mt. Meru, which shows nearly exact the same floristic and structural composition.

In a recent study Hemp, A. (2006A) described natural flora, vegetation and structure of the Chagga homegardens and Hemp, C. (2005) investigated the function of the Chagga homegardens as a habitat of endangered and endemic grasshopper species. To highlight their function for biodiversity and as a refuge area for natural plants and animals the spe-

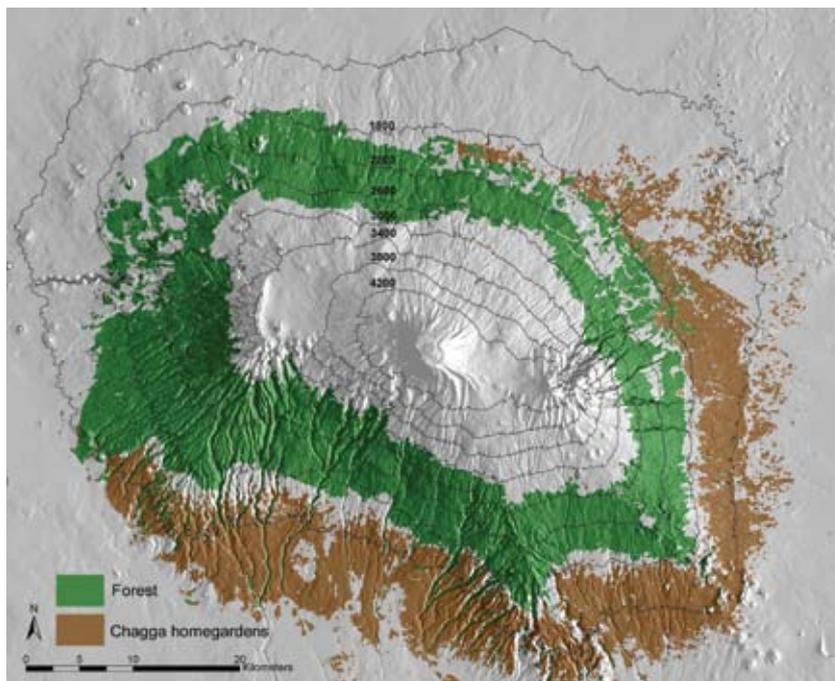


Photo Left: Mount Kilimanjaro; copyright Marc van der Chijs

Figure 1: Distribution of the Chagga homegardens on Kilimanjaro, based on a supervised classification of Landsat ETM images taken on 29 January and 21 February 2000 (source: USGS/UNEP-GRID-Sioux Falls) using the software IDRISI 3.2 and ArcInfo 8.3. Digital elevation model by Christian Lambrechts and Janet Akinyi Ong'injo, Nairobi, based on toposheets at scale 1/1:50,000.

cies composition of this man-made habitat was compared with all vegetation formations of Mt. Kilimanjaro.

Vegetation structure of the homegardens

Fig. 2 shows a vegetation profile of a Chagga homegarden in the area of Kidia (Old Moshi) (ALL DATA FROM HEMP A. 2006A). Typical of the agrisilvicultural system of the Chagga homegardens is their multilayered vegetation structure similar to a tropical montane forest. Therefore the growth form spectrum (FIG. 3) displays beside herbs also trees, shrubs, lianas and epiphytes. Apart from some cultivated fruit trees, e.g. Avocado and Mango or introduced timber trees such as *Grewillea robusta* and *Cupressus lusitanica*, most of the 82 encountered tree species are remnants of the former forest cover. Most widespread are *Albizia schimperiana*, *Rauvolfia caffra*, *Cordia africana*, *Commiphora eminii* and *Margaritaria discoidea*. Nearly all banana fields are covered by at least some trees.

52 liana species were found in the plots. Eleven liana species were cultivated plants with important agricultural crop plants such as three *Dioscorea* and *Passiflora* species

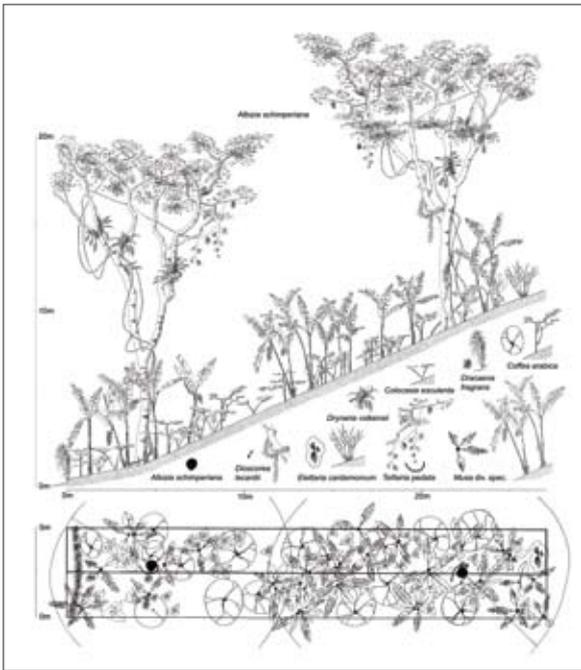
and the Cucurbitaceae *Telphairia pedata* belonging to this growth form.

Similar to the trees, epiphytes and lianas most of the shrubs in the Chagga homegardens were forest species. However, in the shrub layer the most important cultivated plants occurred: Different varieties of *Musa x sapientium* (dessert bananas) and *M. x paradisiaca* (cooking bananas) and *Coffea arabica*. Bananas form a dense (mean cover value 50%) upper shrub layer of about 4-6 m height and coffee trees a lower layer of 1,5-2 m.

Biodiversity of the homegardens

Flora

The Chagga homegardens maintain a high biodiversity with over 500 species including 400 not cultivated plants (ALL DATA FROM HEMP A. 2006). This is about three quarter of the species occurring in the ruderal vegetation formation (i.e. vegetation on road sides, waste places and fallow arable land) on Kilimanjaro. With over 700 species this formation holds rank three in respect of species richness after the forests and grasslands. Most areas of the submontane and lower mon-



From top to bottom

Figure 2: Profile (27 x 2,5 m) and ground plan (27 x 5 m; bold lines indicate the area used for the profile) of a typical Chagga homegarden in Kidia (Old Moshi) at 1400 m asl. Exposition: south west, inclination: 25 degree. An open light upper canopy is formed by *Albizia schimperiana* var. *amanienis*, on which epiphytes such as the fern *Drynaria volkensii* and *Telfairia pedata*, a liana with oil-containing seeds, find habitats. Bananas form a dense upper shrub layer of 4-6 m height, coffee trees a lower shrub layer of 1,5-2 m, intermingled with 1-1,5 m high *Coco Yam* (*Colocasia esculenta*). The lower side of the banana field borders a path; here *Dracaena fragrans* is planted as a hedge.

Figure 4: Chagga homegardens in the area of Kibosho with an open tree canopy and a dense banana undergrowth.

Figure 7: Mixture of partly endemic *Saltatoria* species found within Chagga homegardens.

tane coffee-banana belt resemble woodland with a dense undergrowth of bananas (FIGS. 2 AND 4). Thus, over one third of the plants (193 species) occurring in the homegardens were forest inhabitants, species that need a forest-like habitat structure for surviving (FIG. 5). These are about 17% of the 1225 forest plants of Kilimanjaro (45% of the forest trees and 17% of the forest epiphytes). Some forest plants (e.g. *Pilea tetraphylla*) were only encountered in the banana plantations but in none of the about 600 forest plots established on the mountain, highlighting the important conserving function of the Chagga homegardens, which resemble in fact more “homeforests” than homegardens. Compared with large scale commercial coffee plantations this conserving function becomes evident: Four surveyed commercial plantations harboured only 6 forest species, and three quarter of the species were widespread ruderal or cultivated species.

These findings are in line with the fact that biodiversity in general on Kilimanjaro culminates at 1000-1300 m with over 900 vascular plant species inside the coffee-banana belt, the most densely populated region of the mountain. This is due to the high variety of (moderately) cultivated areas (the Chagga homegardens), forest patches, river gorges and grasslands at this altitude. This (mostly man-made) variety of habitats, the high beta-diversity, promotes alpha-diversity, allowing species from lower altitudes to climb up the mountain. A similar phenomenon was observed in the *Saltatoria* fauna of Kilimanjaro (HEMP & HEMP 2003, SEE BELOW).

Saltatoria

192 *Saltatoria* species (grasshoppers and bush crickets) were recorded for the whole of Mt. Kilimanjaro, the majority in grassland (130 species), followed by waste land (includes fallow arable land, roadsides and open disturbed places) with 83 species, forests with 38 species, and clearings with 47 species (FIG. 6). The Chagga home gardens form an important habitat in respect to biodiversity, with 52 species, about a quarter of the whole *Saltatoria* fauna. Comparatively few species were found in swamps (14 species) and only 6 *Saltatoria* species occur in the afro-alpine zone.

Over 70% of the *Saltatoria* species found in the Chagga home gardens originate from forest communities, the remainder are open land forms. The forest species come from the colline zone (12 species), the sub-montane zone (12 species) and montane zone (4 species). Ten forest species, mainly from colline savanna forest communities, were not found in the homegardens.

One hundred and fifty-four open land species are known; only 24 species (16%) were found in plantations; 8 are open land forms from the colline zone and 15 were found

in the sub-montane zone. Only one species is an inhabitant of the montane zone.

Thirty-two percent of the species in the Chagga home gardens are endemic. Endemism rate for the whole of Mount Kilimanjaro/ Meru area is 16 %. The Chagga home gardens provide habitat to more than half of the endemics occurring from the colline to the afro-alpine zone of Mt. Kilimanjaro. Two endemic species found in plantations originate from habitats of the colline zone, nine from sub-montane and five from montane habitats. 25% of all colline endemics also occur in plantations, as well as 75% of all sub-montane and 63% of all montane endemics of Mount Kilimanjaro.

Although highly influenced by human habitation, the Chagga home gardens serve as important regional refuge for *Saltatoria* species, especially for forest species and endemics. The mixture of retained tree canopies and open patches appears to favour a mix of species typically not found together elsewhere (FIG. 7).

The homegardens and global environmental change

The extinct natural forests of Kilimanjaro's lower slopes

Large-scale environmental change has a long history of over 2000 years on Kilimanjaro: The “banana forest” of the Chagga homegardens replace a natural forest, which covered the lower slopes of Kilimanjaro before human settlement. This lost forest resembled in many aspects the species- and endemic-rich submontane forests of the Pare and Usambara Mts. that belong to the biodiversity hotspot of the Eastern Arc Mts. Today, only the deepest valleys in the cultivated areas harbour forest relicts of that type suggesting a rich forest flora inhabited lower areas of the southern slopes of Mt. Kilimanjaro in former times. Since humans have continuously inhabited the lower slopes of Mt. Kilimanjaro for at least the last 2000 years (ODNER 1971), it can be assumed that many forest species were extirpated together with the forest cover. Thus, the lower degree of endemic forest plants of Kilimanjaro can be explained by wide destruction of the lower montane forests. This is corroborated by the fact that forest species such as members of the grasshopper group *Saltatoria*, who are affected less by forest devastation, have similar numbers of endemic forest species in the submontane and montane zone on Mt. Kilimanjaro (including Mt. Meru) and the East Usambara Mts. Many endemic grasshopper species have coped with the habitat change from forest to plantations (HEMP & HEMP, 2003; HEMP, C., 2005). Therefore, Kilimanjaro can serve as a striking example of the large and long-lasting

From top to bottom

Figure 3: Growth form spectrum of the Chagga homegardens showing species number of the respective stratum in the vegetation plots.

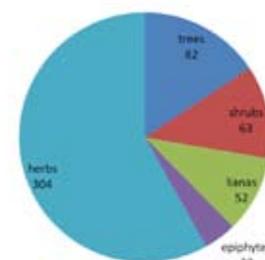


Figure 5: Floristic composition of the banana fields in respect of the different vegetation formations on Kilimanjaro.

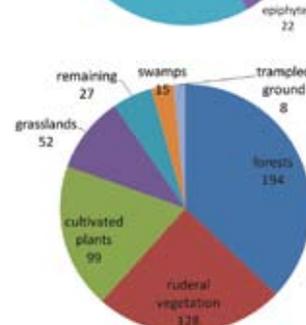
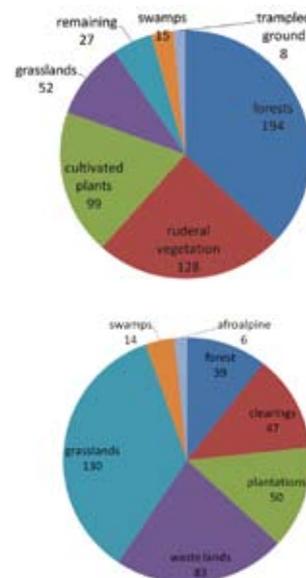


Figure 6: *Saltatoria* species of different habitats on Mt. Kilimanjaro. Numbers are based on 192 species. Many species occur in more than one habitat.



anthropogenic influence on levels of diversity and endemism of African landscape (HEMP 2006B).

Recent changes

In the past few years changes in the management of commercial coffee plantations have been noted. Plantation ownership is changing and new coffee varieties that are less shade-demanding are being planted. There is, therefore, no need to retain a tree canopy layer, and where this has happened hundreds of trees have been removed, e.g. in the Mweka area of Kilimanjaro in 2003. High demand of wood, low coffee prizes on the world market and the introduction of coffee varieties that are sun-tolerant also endanger the traditional homegardens. In some areas of the mountain (e.g. on the eastern slopes) the trees in the banana fields are very scattered or already missing. This has far reaching consequences for biodiversity, microclimate and soil fertility.

Scenarios of future environmental change: evidence from Saltatoria

To understand future processes on fauna and flora of an ecosystem with a changing environment the knowledge about the situation of the past is very valuable. In case of the insect group *Saltatoria* historical data from about 100 years ago are available (SJÖSTEDT 1909). Also the understanding of the

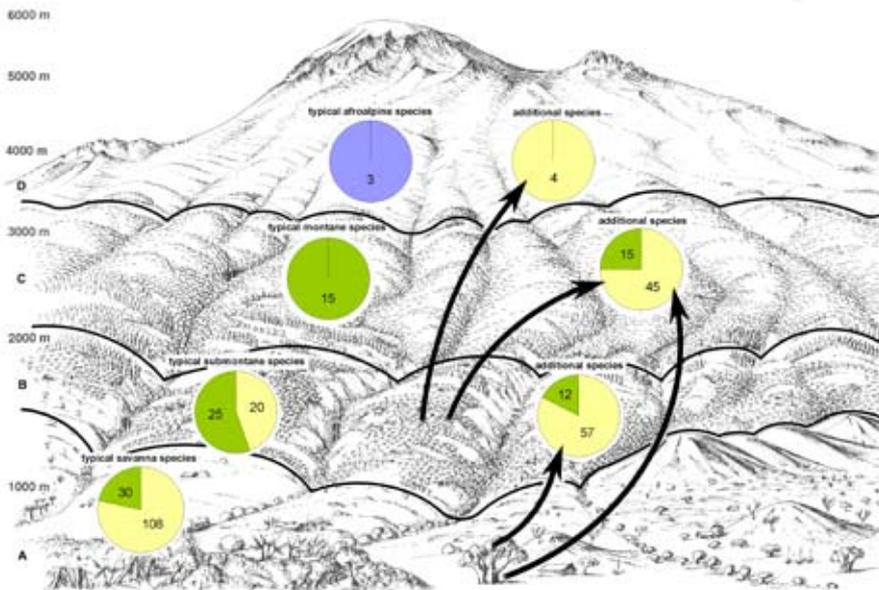


Figure 8: Upward migration of Saltatoria species from lower zones. Left circles giving numbers of species which are typical for this zone; right circles giving numbers of species that are additionally found to the typical species of the respective zone, arrows indicating area from which they migrated upwards. Yellow: openland forms, green: forest forms; blue: afroalpine forms. A: colline lowland savanna area, B: submontane and lower montane zone, C: montane zone, D: (sub)alpine zone.

ecological demands of species is necessary to make predictions of what will happen when the environment changes. In our studies we investigated the habitat demands of Saltatoria using a modified method of Braun-Blanquet (1964), usually applied in plant sociology. In parallel vegetation relevés and Saltatoria assemblages were recorded and united to a table (FOR FURTHER INFORMATION ON THIS METHODS SEE E.G. HEMP & HEMP 2003, HEMP C. 2005).

Thus comparing the historical data and using the information on habitat demands of stenocious species it became clear that many Saltatoria species either “moved” uphill in the past 100 years or suffered from a dramatic population decrease e.g. *Parepistaurus lindneri*, which was found only in remnants of sub-montane forest, along riverine forest and in few plantations fringing rivers in the colline zone. The same stands for *Horatosphaga montivaga* (SJÖSTEDT 1909), which was recorded 100 years ago inside the banana belt. Today this species was not found at the type locality any more due to habitat loss. Typical submontane forest Saltatoria (e.g. *Maura lurida* (FABRICIUS 1781) and *Anoedopoda lamellata* (LINNÉ 1758)) today only occur in small forest relicts, mostly in deep inaccessible gorges. Thus, *A. lamellata* for example, seems to have been a common katydid during Sjöstedts expeditions (SJÖSTEDT, 1909) while today it was found only twice since 1996. *Maura lurida* (submontane forest, PHIPPS, 1970) was not recorded on Kilimanjaro again, since its first record.

A striking example for an upward movement is the endemic grasshopper *Ixalidium sjostedti* Kevan, 1950. Species of the genus *Ixalidium* are bound to litter of semishade

situations preferably of submontane forests. Volkens (1897) reported that this forest type was still present on the lower slopes of Mt. Kilimanjaro 100 years ago and Sjöstedt (1909) reported that *I. sjostedti* occurred from the savanna to the cultivation belt on Mt. Kilimanjaro. Sjöstedt (1909) stated that this species preferably dwells among litter of the plantation belt. In our studies we found *I. sjostedti* beside in submontane plantations frequently also in higher located homegardens and even at the lower border of the montane rain forest and forest paths to elevations of over 1900 m. From the beginning of the last century to today the Chagga people multiplied 10 times and subsequently the cultivated area expanded. With the anthropogenic opening of the closed forest species such as *I. sjostedti* moved upwards

now finding habitat also at higher elevations. Even today this species can still be found in riverine forest remains at 1000 m a.s.l. of the southern slopes of Kilimanjaro showing that it was once a species of colline and submontane forest habitats.

These processes in Saltatoria due to landcover changes can be observed in several stenocious taxa on Mt. Kilimanjaro as well as on adjacent mountains (e.g. North and South Pare, West and East Usambara). Thus all those species are affected by landcover changes that show narrow habitat demands such as species from the genera *Parepistaurus*, *Altiusambilla*/*Rhainopomma*, *Odontomelus*, *Gymnbothroides*, *Amytta*, or *Chromothericles*. With increasing influence of humans, that means that more and more submontane forest was changed into agroforestry systems in the past 100 years, species of these genera coped and found habitat in the now anthropogenic influenced environment. Some of them even enlarged their area of occurrence since they now occur also in higher elevations while others (e.g. pure forest species) got extinct in the homegardens.

If the observed trend towards a drier and warmer climate on Mt. Kilimanjaro (SEE HEMP A. 2005) proceeds lower vegetation zones of Kilimanjaro will move up-wards and will get more and more fragmented. Savanna species will spread from lower altitudes to the submontane, montane and even afroalpine zone due to loss of forest and a warmer microclimate. Saltatoria species show this trend very clearly even today (FIG. 8). About 100 years ago the submontane zone was still partly covered by forest and comparatively few Chagga homegardens concentrated in favourable areas. 45 Saltato-

ria species are typical inhabitants of the submontane zone. Due to the dense human population many areas have been opened up creating habitat for openland species which are typical for savanna habitats. Thus, nowadays 69 savanna species are found on grasslands, pathways and fallow land of the submontane zone. Also the montane zone is affected by these changes. Beside 15 typical montane Saltatoria species, all of them forest species, 60 species originating from lower zones were recorded during our studies, e.g. on montane meadows, forest paths and clearings and also in the forest. And even the alpine zone is affected by these changes: originally harbouring 3 purely endemic species, 4 Saltatoria species from lower zones are found occasionally also in this habitat. With an ongoing fragmentation, especially of the montane forest zone will be affected most. From the lower edge in the densely populated cultivated zone the forest belt is opened up by fires, illegal logging and cattle grazing while wild fires of the afroalpine zone lead to a downshift of vegetation belts from the upper zone (SEE HEMP 2005). Highly endangered will be mainly endemic and stenoecious species of the forest belt that will suffer loss of habitat and even will get extinct in the near future if this trend continues as we recorded it for the past 15 years. The Chagga homegardens in its present form still offer habitat for some of the stenoecious species. However, depending on a steady water outflow from the forest belt the homegardens are already suffering from a reduced water yield of burnt cloud forests (HEMP 2005). If this sustainable agroforestry system is lost Mt. Kilimanjaro will lose most of its endemic inhabitants as studied in the group Saltatoria.

Conclusions

In summary, the Chagga homegardens maintain not only a high biodiversity, they are an old and very sustainable way of land use that meets several different demands. Beside crop production, the sparse tree layer provides people with firewood, fodder and timber. But the high demand of wood, low coffee prizes on the world market and the introduction of coffee varieties that are sun-tolerant endanger this effective system. In order to reduce the pressure on the forest, it is necessary, to support the tree planting in the Chagga homegardens with their unique agroforestry system. Similar to environmental programs for farmers in the European Union (e.g. for the protection of wetlands or dry meadows), there should be a program that rewards farmers to have a certain share of their land covered by trees. It can be estimated that a homegarden supplies $\frac{1}{4}$ to $\frac{1}{3}$ of the fuelwood requirements

of a family (FERNANDES ET AL. 1984). As the banana belt is nearly as extensive as the forest reserve, this will of course have major effects in terms of forest protection and the water balance. In combination with new marketing and farming strategies for growing organic coffee through traditional methods an advertising campaign should be started especially in European countries where the awareness of environmental problems is high.

Dr. Claudia Hemp, University of Bayreuth, Dept. of Animal Ecology II, 95440 Bayreuth, Tel./Fax: 09246/980979, Mail: andreas.hemp@uni-bayreuth.de

PD Dr. Andreas Hemp, University of Potsdam, Dept. of Biochemistry and Biology, Biodiversity Exploratories, 14469 Potsdam, Tel.: 03331/296891, Mail: andreas.hemp@uni-potsdam.de



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The authors are members of MRI's Global Change Research Network in African Mountains

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