Mollusca of North East Tanganyika

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OBSERVATIONS ON THE ECOLOGY OF THE LAND AND FRESHWATER MOLLUSCA OF NORTH-EAST TANGANYIKA

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1. Introduction

The collections on which these observations are largely based were made by the writer during 1949-50 whilst residing at Amani. Apart from material collected by Dr. Pfeiffer in 1937 and Mr. Loveridge in 1928 little would appear to have been collected since Alfred Craven (1880), and Leopold Conradt (1891) visited the Usambaras. Mollusca have been collected in other areas in the district by travellers and expeditions, mostly whilst on their way to destinations further inland. Von Martens (1898)[1] lists these records in what is still the only work which deals in a general way with the mollusca of East Africa. The Germans during their stay at the Amani research station at the beginning of the century appear to have paid no attention at all to the snails of the district although many of the other groups were studied. The Sjöstedt expedition collected several species in Tanga, and Korogwe on its way to Kilimanjaro and Meru (D'Ailly 1910).[2] A few more results of the collecting by casual collectors are reported on by F. Haas (1936).[3] It seems worthwhile therefore to put on record these present observations. Unfortunately many years will elapse before the present material is worked out and the new species described. Much of the material was collected in spirit after being drowned outstretched, and detailed anatomical studies are to be made. Very few of the snails and slugs of the district have ever had even a cursory examination made of their anatomy. Precise specific identifications are not however necessary in order to give a general picture of the molluscan ecology of the district. This present paper will, it is hoped, provide a background to the future systematic work arising from the collection and will provide habitat details so often omitted from descriptions of species. The material is being studied by the late Dr. Pfeiffer in conjunction with the Senckenberg Museum, Dr. J. Bequaert of Harvard College, U.S.A., and H. Watson, Esq., of Cambridge, England.

2. Physical Features and Vegetation of the Area

The sketch map (Fig. 1) indicates the position of the localities mentioned. The major part of the area is occupied by the Usambara Mountains, an excellent account of the synecology of which has been given by R. E. Moreau (1935).[4] It is therefore only necessary to outline briefly the general features of the region after which the individual habitats studied are described in greater detail. Usambara consists mainly of two por-

tions, the East and the West, separated by the valley through which runs the R. Lwengera. The eastern portion rises in one place to 4,900ft. but the majority of the ridges lie between 3,000 and 4,000ft. The western portion on the other hand contains ridges of well over 7,000ft. in altitude, the dividing valley, a fault trough, being approximately 1,000ft. in altitude. The annual rainfall, approximately 40" at the coast and slightly less further inland, rises to about 80" at Amani. It drops again to 30-40" in the Lwengera valley, but rises steeply to 50/95" on the eastern scarp of the western block. Another drop to below 40" occurs in the centre of the western plateau followed by a rise to 60" at the western edge. This rainfall falls mostly in two periods, the long rains from March until May or June and the short rains from November to December. The rainfall in the remaining months is usually below 4" per month at Amani, the driest months being January and July. In the mountains the demarcation between the periods is not always sharp and during 1950 the period between the two rains was mostly cold and wet with only a very short dry period. The temperature at the coast varies from 17° -35° C (mean 25°) this being the extreme annual range yet recorded. At Amani this range is 9.5°-32.3° (mean 20°) and at Lushoto 2.8° — 30.5° (mean 17°). Ground frosts are recorded for the areas above 5,000ft. and temperatures as low as -3° have been recorded at the N.W. edge of the W. Usambaras. The mean annual humidity at Amani is 84% (though it does drop to 60% outside the forest and to 70% in the forest) and rises to 90%. This corresponds to a mean annual saturation deficit of 2.8 gms/cub. metre, a figure of much more significance from the biological point of view. Heavy dews and mists are of very frequent occurrence. Elsewhere in the area under consideration the climate is equally humid on the eastern edge of the W. Usambaras, but becomes less and less humid in the western edge of the western plateau, the middle of the western plateau, and the coast respectively and is finally least humid in the Lwengera valley.

The geology of the area has been briefly summarised by Milne (1936).[5] The solid geology does not affect the ecology of the Mollusca save where the outcrops are bare. The mountains are chiefly formed of gneiss rocks which vary from basic to acidic in character and the surface deposits are reddish or light brown and technically called loams but to the lay eye they are distinctly clayey in texture. These deposits are predominantly acidic and low in calcium content, two factors of supreme importance in molluscan ecology. Black soils occur in the valley bottoms of the foothills. Nearer the coast the underlying rocks are mainly Jurassic and Cretaceous with over-lying sands and gravels. The soils vary from acidic to calcareous at the surface and are mainly clays and red earths. A flat strip bordering the coast is again different, consisting of red earths on outcrops of coral limestone, sandy red earths on the low ridges, and a widespread complex of pale sands and blackish sandy clays. The top layers in the forested areas are covered with humus (often of very limited thickness) and decaying leafy debris.

The aquatic environments in the area are predominantly lotic. Ponds are infrequent and swampy. Swamps occur in many of the lowlands of the Usambaras and its foothills and also bordering the R. Pangani. The streams and rivers are swift and rush over rocky beds, but become slower rivers in the coastal areas.

The Usambaras were once covered with evergreen forest. Many clearings have been made and subseral communities have developed, where native cultivations have not followed the clearing or have been abandoned. Grasslands liable to firing occur on the western edge of the E. Usambaras and on the western plateau. The foothills and much of the coastal belt were once covered with a drier forest but a great deal of this has been entirely removed and the land is now used for agricultural purposes. Sisal plantations occupy a considerable portion of the flat country. Wooded grassland now occurs in the coastal belt with small forest patches. Further inland bushland and thicket occur. South of the railway much of the country is covered with vegetation which is intermediate between woodland and bushland with islands of open forest.

3. Ecology of the Mollusca

In temperate climates mollusca do not form associations of a specific character with one another or with other animals and plants and there is little element of competition. Apparent associations are due to the components having a liking for the same conditions. The distribution of the Mollusca depends more on climate, lime, and history than it does on the presence or absence of certain foods or plants. Soil structure is also of importance, loose mossy debris and a litter of sticks on a porous soil providing the nooks and crannies necessary. British conchologists know very well that it is impossible to be absolutely dogmatic about the habitat which a particular snail favours. Species which appear to be confined to one type of habitat sooner or later turn up in quite a different one although not frequently enough to render generalisations completely valueless. Microgeology and microclimates have a good deal to do with distribution and very often what may macroscopically appear to a human as being a totally different sort of habitat may well be very close indeed to another from the point of view of a small animal. The age of the habitat is certainly of very great importance. Mollusca are very slow indeed to colonise new areas. Subseral plant communities are therefore not suitable habitats unless the destruction of the original vegetation has been carried out in such a way as not to disturb the ground to any extent and the resulting subsere offers conditions approximating to the prisere.

In Tropical Africa the fact that a large proportion of the molluscan fauna comprises carnivorous forms (chiefly *Streptaxidae*) is an added factor of little importance in temperate countries. Certain species form predator-host relationships and competition results. On the whole however it seems that the conditions of importance in the habitat are much the same as in England. Within the area under consideration no species has become anthropophile to the extent of, say, *Limax flavus* L., but the large Urocyclid slugs common at Amani have become adapted to living in waste places, gardens and clearings. *Achatinae* are also to be found in plantatons but are not a pest such as they are in other countries where they have been introduced. With the exception of *Edentulina affinis* Bttgr., a large rapacious snail which preys on *Urocyclidae* and *Achatinae* and is obviously following their increasing adaptation to man made habitats, none of the other forest snails has been found living in plantations and gardens and they are absent from those parts of the forest which have been thoroughly

disturbed. When the disturbance to the ground layer has not been uniformly extensive many species survive under debris, as is the case in parts of the conifer plantations on Mt. Bomole. Wide areas of the forest have no mollusc population left however.

As in temperate regions few species eat green leaves but chiefly subsist on decaying matter in the ground debris. This also applies to the *Achatinae* and slugs which however are not averse to green food. *Ledoulxia* has been observed feeding on faeces of other invertebrates on leaves and many of the snails undoubtedly act as scavengers in this manner. Wood has been found in the intestine contents of *Veronicella* and *Thapsia* which often live under logs but this is ingested presumably along with minute plants growing on it. The *Streptaxidae* are entirely carnivorous so far as is known. From observations made on the stomach contents it would seem that they live on other mollusca entirely. Such remains are difficult to distinguish unless a radula happens to be present in the contents. The few cases of actual feeding observed in the field seem to indicate that some of the predators have preferences. *Edentulina affinis* has only been observed feeding on large Urocyclid slugs of one or two species, whereas the smaller *E. oleacea* Fulton seems to favour juvenile *Achatinae*. *E. affinis* is however known to be an enemy of *Achatinae* and has been introduced into areas to combat them. The observed preference is therefore perhaps illusory or local. The smaller *Gulellae* have been observed to attack other snails in captivity, but since some have been found to be remarkably common in soil full of the weathered pellets of *Hyrax* dung it is possible that they may eat such material.

Birds and reptiles are enemies of Mollusca but only certain species (e.g. the Monitor *Varanus niloticus* (L.) and the Dove *Aplopelia*) show any marked preference for them. The 'Siafu' ants will destroy almost any living thing which they encounter. On one occasion a small brown larval Mantis was observed in the act of feeding on a small slug but how often this remarkable feat takes place is not known. No references to Mantis eating such things have been discovered anywhere. Some of the rapacious snails in the area have very brightly coloured bodies but whether this is a warning coloration cannot be decided without further observations, for instance *Gulella Usambarica* (Cn.) and some of the minute *Gulellae* have bright scarlet tentacles. *Gonaxis craveni* (Sm.) has a pink body and *G. vosseleri* Thiele has vermilion tentacles and a broad vermilion stripe on the back of its otherwise grey body. *Edentulina obesa* (Taylor) and *E. oleacea* Fulton have bright green bodies.

The snail fauna of Tropical Africa is characterised by the preponderance of rapacious types (*Streptaxidae*) and the presence of the distinctive *Achatinidae* and the *Urocyclidae*. The area under review falls within the "East African Region" (as defined by H. Pilsbry) and this is characterised by the occurrence of true *Helicidae*, regular helicoid *Streptaxidae* and certain genera of the operculate *Pomatiasidae*. Throughout Tropical Africa there is a marked poverty of mollusca compared with other tropical countries. Living molluscs are not much in evidence in the forests. This has been attributed to the fact that they are largely nocturnal but the writer has found *Gonaxis, Edentulina, Achatina, Veronicella,* and many of the other genera of snails and slugs to be quite as active during the day as they are at night.

It is possible to generalise to a certain extent about the distribution of the snails and slugs of the area under review and the following account is based on both the writer's collecting and the published records, together with some material sent for examination. It is not possible to rigidly define regions within the area which are characterised by definite mollusca but three areas, (a) 0-2,500ft., (b) 2,500ft.—4,000ft. and (c) 5,000ft.—7,000ft. are fairly natural. They roughly correspond with dry lowland evergreen forest, intermediate evergreen rain forest, and dry upland evergreen forest.

Freshwater and Brackish water species.—

The mangrove swamps are dominated by *Potamides decollatus* (Brug), and D'Ailly[2] records *Lanistes purpureus* Jonas as being common. In Britain members of the *Assimineidae, Hydrobiidae,* and *Ellobiidae* occur in brackish water habitats, and throughout the world there are mollusca which have become adapted to these places. In the tropics *Cerithiidae* and *Melaniidae* are the main forms involved and a single species usually predominates, often occurring in vast numbers. Where the mangrove formations are narrow such as at Mombasa they are chiefly inhabited by littoral and shallow-water marine species, such as *Nerita ornata* Sow, and *Nassa coronata* Bgt.

The freshwater species are most abundant in the coastal plain and the following genera occur in the area, *Pila* and *Lanistes* (*Pilidae*), *Cleopatra, Thiara and Melanoides (Thiaridae), Viviparus (Viviparidae), Bulimus* (*Bulimidae*), *Physopsis and Bulinus* (*Bulinidae*). *Planorbis* (*Planorbidae*), *Melampus* (*Ellobiidae*). *Neritina* (*Neritinidae*) and two species of *Spatha* (*Pelecypoda*). A similar fauna is found at low levels inland also, with *Succineidae* and *Ancylidae* added. *Cleopatra* spp. seem to dominate everywhere. In the mountains however the fauna rapidly decreases and in the E. Usambaras only two species occur in the streams. *Lanistes farleri* Craven is found at 1,500ft. in the R. Sigi and above that level the streams are entirely dominated by a single species of *Cleopatra* which is very abundant. The stagnant waters yield *Physopsis, Lymnaea,* and a species of *Ferrisia* (*Ancylidae*) similar to one occurring in Portuguese East Africa. On the W. Usambara plateau *Lymnaea* and *Gyraulus* (*Planorbidae*) are common in the valley-bottom ponds, and *Isidora* occurs. A single species of *Pisidium,* a predominantly temperate genus of bivalve has been found in a swamp in the middle of the western plateau.

Terrestrial Mollusca.

The lowland area is characterised by the complete absence of true *Helicidae.* The operculates are well developed, small species of *Tropidophora* being common everywhere (*T. letourneuxii Bgt.*), whilst large highly sculptured species (*T. calcarea* Sow) are common in the forests of the Pangani area. The *Streptaxidae* are well represented and include *Edentulina affinis, E. obesa, Gonaxis ordinarius* Sm., *Marconia gibbosa* Bgt. *Gulella usambarica*, and the abundant regular helicoid *Tayloria usambarica* (Cvn). Several species namely *Gonaxis craveni* (Sm.), *Gulella grossa* Mts, and *G. follifera* Mts are recorded from the area but they are not common and the writer has not seen them. All three are very characteristic of the Amani area. *Stenogyridae* abound and include several species such as

Opeas magilensis Craven which also occur in the intermediate forest. *Pseudoglessula leroyi* Bgt. occurs in all three regions. The *Achatinae* are abundant and are large thick-shelled species. Eight species of *Enidae* are recorded from the area chiefly *Rachis sp. Succineidae* are recorded and numerous *Helicarionidae* including *Ledoulxia* spp., *Trochozonites leroyi* Bgt., and *Thapsia* spp. *Ledoulxia* is recorded from the intermediate forest but must be rare; both the *Thapsia* and the *Trochozonites* are however common. A *Helicarion* is recorded from Mombasa. The Urocyclidae are represented by few individuals and where found are restricted to places where much of the original forest remains. Two species of *Veronicella* have been collected in the area.

The intermediate area is particularly rich in small species of *Gulella,* thirteen having been found. One of these *G. usambarica* is common to all three regions and one other is common to the W. Usambaras. Three species of the section *Primigulella* occur, one *G. grossa* being common and characteristic. *Edentulina affinis* is the most abundant snail in the region and *E. oleacea* seems to replace the *E. obesa* of the lowland region. *Gonaxis craveni* is a large and characteristic species, and two other species of the genus occur. Both *G. ordinarius* and the variety *obliquior* Haas occur, the latter being confined to the higher ridges. Regular *Streptaxidae* are rare. Operculates are not common. *Cyclophorus elatior* Mts occurs in the forest but no species of *Tropidophora* occur except very sparingly on the grasslands at the western edge of the E. Usambaras. This fact seems to distinguish the regions quite clearly. A species of *Helicidae* is recorded but none was found by the writer. *Stenogyridae* are common and include three species of *Curvella,* several of *Pseudoglessula* and numerous *Subulinae.* A terrestrial species of *Succinea* has been discovered. Few *Enidae* appear to occur and some of those which are recorded may be referable to sections of the genus *Pseudoglessula* since much confusion has occurred. *Achatinidae* are common but have smaller and thinner shells than those occurring in the lowland region. This intermediate area is particularly characterised by the abundance of *Urocyclidae,* a fact which is clearly related to the humid climate. Eleven species have been discovered, only one of which occurs on the grasslands, where it is quite rare. A single species of *Veronicella* has been discovered in the forest near Amani. One species of *Trachycystis* (*Endodontidae*) occurs.

The upland area is rather more distinct from the other two. True *Helicidae* are abundant on the higher mountains to the West. *Tropidophora* again makes an appearance and becomes exceedingly abundant in the same forests as the *Helicidae* favour. The species are small and identical with the small coastal forms. *Cyclophorus* occurs and one *C. volkensii* Mts. is common to Mt. Kilimanjaro. *Streptaxidae* are again well represented. *Edentulina affinis* is rare and no other species seems to occur. *Gonaxis ordinarius* var, *obliquior* occurs. Seven species of small *Gulellae* occur one of which belongs to the section *Plicigulella* and is similar to a species occurring on Mt. Kilimanjaro. Two species of the section *Primigulella* occur in addition to the seven and they are quite distinct from those occurring on the eastern plateau. A species of regular helicoid strepataxid occurs sparingly and is distinct from both the coastal species and the intermediate area species. *Stenogyridae* occur but *Achatinae* appear to be almost entirely absent, only a few very old *Endodontidae*

occur, a species of *Punctum* having been discovered in a swamp in the centre of the plateau. A single specimen of a young *Ledoulxia* was associated with it. Amongst the *Helicarionidae Thapsia* occurs, but only the one *Ledoulxia* and no *Trochozonites* was discovered. Very old shells referable to *Enidae* occur on the high ridges. *Urocyclidae* are small and uncommon, one or two species occurring in swamps and forests in the middle of the plateau.

The differences between the three regions may be summarised.—*Lowland: Helicidae* absent, *Urocyclidae* rare, and *Pomatiasidae* common. *Intermediate: Urocylidae* abundant and *Pomatiasidae* rare. *Upland: Helicidae* frequent, *Achatinidae* absent and *Pomatiasidae* common.

4. Descriptions of the Habitats investigated

A. Mangrove formation north of Tanga Bay.

A formation occurring on sandy salty tidal mud and very poor in quality in this locality due to extensive cutting and coppicing. The vegetation consists of *Rhizophora mucronata* Lam., *Ceriops tagal* (Perr.) C.B. Rob., *Brugiera gymnorrhiza* (L.) Lam., *Heritiera littoralis* Dryand in Ait., *Lumnitzera racemosa* Willdn., *Xylocarpus benadirensis* Mattei, and *Avicennia marina* (Forsk.) Vierh. (on the outer edges) together with the succulent *Suaeda monoica* Forsk, and *Arthrocnemum indicum* Moquin. *Potamides decollatus* (Brug.) dominated the habitat and covered the lower branches of the Mangroves. *Littorina scabra* (L) was the only other species found.

B. Limestone outcrop near the Amboni Caves.

A craggy limestone outcrop bordering the valley of the R. Mkulumusi, 200ft. or less in height and covered with remnants of forest. Reference to the soil analysis records at Amani show that soil samples from Amboni had a pH of 7-8 and an exchangeable calcium content of 8 milliequivalents of Cao per 100gm. of soil. The forest on the top of the outcrop was composed of *Cynometra webberi* Bak.f., *Manilkara sulcata* (Engl.) Dubard, *Albizzia, Pandanus, Milletia usaramensis* Taub., and *Encephalartos hildebrandtii* A. Br. and Bouché, together with *Justicia pseudorungia* Lindau, *Whitfieldia stuhlmani* (Liddau) C. B. Clarke, *Coccinia* sp., *Gerrardanthus grandiflorus* Gilg. ex Cogn., *Drimiopsis bussei* Dammer, *Dorstenia zanzibarica* Oliv. and *Crossandra pungens* Lindau. The gorge itself at the bottom of the outcrop is characterised by *Pterygota* sp., *Phialodiscus unijugatus* (Bak.) Radlk., *Erythrina sacleuxii* Hua and *Sterculia* sp. The following mollusca were found there *Ledoulxia mossambicensis* (Pfr.), *Opeas magilensis* Cvn., *Edentulina affinis* Bttgr., *Achatina* sp., *Pseudoglessula* sp. and *Tropidophora* sp. The latter was common and seemed to like crevices in dead tree boles.

C. Thicket Forest, Msubugwe near Pangani.

A coastal forest patch on sandy soil with *Pterocarpus, Brachystegia, Pleurostylia, Sclerocarya caffra* Sond., *Bombax rhodognaphalon* K.Schum., *Croton pseudopulchellus* Pax, *Haplocoelum trigonocarpum*

Radlk., *Ehretia bakeri* Britt *Grandidiera boivini* Jaub., and *Grewia plagiophylla* K.Schum. Outside this forest patch the vegetation is characteristic of the coast belt, e.g. coarse grassland with scattered *Adansonia digitata* L. and *Acacia zanzibarica* (S. Moore) Taub. The only mollusca found here were shells of a large *Achatina*, (*A fulica hamilei Petit*) *Tropidophora* calcarea, *T. letourneuxii* and *Ledoulxia mossambicensis*. *Veronicellidae* occur in the open dry places.

D. Tongwe Mountain.

Early accounts by travellers indicate that the land between the mountain and the coast was once covered with forest and even at the present day a certain amount of forest remains. Coarse grassland with scattered trees surrounds the base of the mountain consisting of the grasses *Roetboellia exaltata* L.f., *Andropogon, Hackelochloa, Bothriochloa, Panicum maximum* L. and *Sporobolus indicus* R.Br., together with the herbs *Pentas, Calotropis busseana* K.Schum., *Gladiolus quartinianus* A.Rich., *Agathisanthemum bojeri* Klotszch, *Bonatea kayseri* Rolfe, and *Nervillea* sp. together with scattered trees and shrubs of *Annona chrysophylla* Boj., *Bauhinia tomentosa* L *Strychnos innocua* Del., *Psorospermum febrifugum* Spach., *Combretum apiculatum* Sond., *Kigelia aethiopica* Decne., *Lannea stuhlmannii* (Engl.)Engl., *Ormocarpum kirkii* S. Moore, and *Dichrostachys glomerata* (Forsk.) Chiov. Lower down there are bare rock domes with such species and genera as *Cyanotis longifolia* Benth., *Selaginella vogelii* Spring., *Anthericum*, and *Eriosema*. The mountain slopes have a rather scrubby forest covering at the base consisting mainly of *Grewia forbesii* Harv.ex Mast., *Albizza, Dombeya, Chlorophora excelsa* (Welw.) Benth. and Hk.f., *Markhamia obtusifolia* (Baker) Sprague, *Oxyanthus, Coffea zanguebarica* Lour., with forest grasses *Olyra latifolia* L., and *Panicum pleianthum* Peter. The forest covering is more continuous dry evergreen forest on the upper slopes with *Celtis, Commiphora, Milletia usaramensis* Taub, *Bosqueia proberos* Baill., *Conopharyngia holstii* Stapf, *Gyrocarpus, Teclea, Erythrina sacleuxii* Hua, *Chrysophyllum zimmermannii* Engl., *Pandanus, Strychnos scheffleri* Gilg., *Chlorophora, Dichapetalum ruhlandii* Engl., *Encephalartos hildebrandtii* A. Br. and Bouché, *Rytigynia, Allophylus, Tricalysia, Hugonia, Erythroxylum emarginatum* Schum. et Thonn, *Schlecterina mitostemmatoides* Harms, with *Polypodium* spp., *Sanseviera*, and *Scleria lithosperma* (L.)Sw. The soils are mostly dark grey sandy loams overlying gneiss rocks.

Few mollusca were found in the grassland and these were represented mostly by shells only—*Marconia gibbosa* Bgt., *Edentulina obesa* Taylor and *Sitala jenynsi* (Pfr.). The most abundant species in the forest itself were a large sculptured species of *Tropidophora* (*T. calcarea* Sow) and the lowland species of regular helicoid streptaxid *Tayloria usambarica* Cr. Other genera and species were *Trochozonites leroyi* Bgt., *Pseudoglessula leroyi* Bgt., *Gulella usambarica, Edentulina affinis* Bgr., *Cyclophorus magilensis* Crvn., *Rachis* sp., *Achatina* sp., *Thapsia* sp. and a Urocyclid slug.

E. Mt. Mlinga.

This is the highest point of a small range of mountainous ground between the E. Usambaras and the coast. The lower slopes are covered with

native cultivations together with some grassland. The flora here includes *Sorghum verticillatum* Stapf, *Cajanus cajan* (L.) Millsp., *Panicum trichocladum* Hack. ex Engl., *Pentas* spp., *Vernonia iodocalyx* O.Hoffm., *Ageratum conyzoides* L., & *Impatiens walleriana* Hk.f. Patches of relict forest are frequent higher up with *Sersalisia usambarensis* Engl., *Albizzia* spp., *Pterocarpus* spp., *Celtis* spp. with an undergrowth of *Olyra latifolia* L., *Callopsis volkensii* Engl., *Costus*, and *Tectaria*. The forest at 3,000ft. is more continuous and has many of the species which characterise the Amani forests e.g. *Cephalosphaera, Anthocleista, Conopharyngia, Allanblackia, Calva, Hypolytrum, Dolichometra, Dracaena, Parapentas, Memecylon, Isoglossa* and *Leptaspis*. The most characteristic shrub is *Memecylon greenwayi* Brenan.

Ledoulxia mossambicensis (Pfr.) and *Edentulina affinis* Bttgr. occur on the lower slopes together with *Tayloria, Marconia gibbosa* Bgt. *E. obesa* Taylor and *Achatina zanzibarica* Bgt. In the forest *E. affinis, Cyclophorus magilensis* Cvn., and very old shells of *Gulella grossa* Mts. were found. The latter is recorded from the coast and seems a clear indication that rich forest once occurred there.

F. Sigi River Valley.

A portion of this valley extending a few miles below Sigi was investigated. The altitude varies from 1,200 to 1,500ft. The river is edged with dry evergreen forest of *Barringtonia racemosa* (L.)Blume, *Parkia filicoidea* Welw. ex Oliv., *Psychotria abrupta* Engl., *Entada phaseoloides* (L.) Merr., *Grandidiera boivini* Jaub. with *Olyra latifolia* L., and *Pentas* spp. The steeply sloping ground above the river leading up to the road is covered with open to closed bushland or scrub with *Markhamia* spp., *Commiphora* spp., *Stereospermum kunthianum* Cham., *Lannea stuhlmannii* (Engl.)Engl. *Steganotaenia araliacea* Hochst., *Grewia holstii* Burret, *Uvaria leptocladon* Oliv., with *Panicum maximum* Jacq., *Commelina* spp., *Cissus* spp., and *Kaempferia* sp. In this bush there are open areas of rocky slope almost bare of soil with *Aeolanthus, Cyanotis foecunda* Hack., *Euphorbia systyloides* Pax., *Ipomoea mombassana* Vtke., *Merremia angustifolia* (Jacq). Hall.f. var *alatipes* (Dammer) Rendle, *Commelina, Cyperus amabilis* Vahl., *C. oblongoincrassatus* Kuk., *Fimbristylis* sp., *Merremia pinnata* Hall.f., *Jaquemontia tamnifolia* (L.)Griseb. and *Eragrostis ciliaris* R.Br. with scattered bushes of *Gymnolaema newii* Benth. The actual roadside has a mixed flora of *Rhynchelytrum repens* C.E.Hubb., *Ageratum conyzoides* L., *Emilia sagitata* DC., *Imperata cylindrica* Beauv., *Cyperus cyperoides* (L.) Ktze., and *Heinsia densiflora* Hiern. The epiphytic fern *Platycerium angolense* occurs in the dry forest. The molluscan fauna resembles that of the bases of the mountains already mentioned and the following species and genera have been found. *Marconia gibbosa* Bgt., *Tayloria usambarica* Crv. (abundant), *Edentulina affinis* Bttgr., *Gonaxis ordinarius* Sm,. *G. vosseleri* Thiele (one old shell only), *Thapsia* sp., *Ledoulxia mossambicensis* (Pfr.), *Trochozonites leroyi* Bgt., *Rachis* sp., and several *Stenogyridae* including *Pseudoglessula leroyi* Bgt., and other *P.* spp. The large coastal *Achatina fulica hamillei* is common and a single small *Atoxon* (Urocyclidae) was found on vegetation by the river. The *Rachis* was climbing up the bole of a tree, not a common habit with tropical mollusca.

G. Amani; 3,000 to 3,600ft.

Formerly entirely covered with dense evergreen rain forest of the intemediate type, much of the area is now occupied by plantations and residential quarters. The lawns surrounding the houses and some of the meadowland are dominated by the grass *Axonopus compressus* Beauv. together with *Chloris gayana* Kunth., *Euphorbia hirta* L., *Borreria* sp., *Oxalis* spp. and *Centella asiatica* (L.) Urban. These lawns are much mined by the ant *Myrmicaria eumenoides* Gerst. (Koro Koro -Kishambaa) which bring up piles of loose earth and form pits. A snail *Curvella* sp. cf. *conoidea* Mts. seems to be a definite inhabitant of these nests. Large numbers of the shells are found in the loose earth and living ones have been found in the nests and have also been seen being carried by the ants. It is significant to note that Connolly[6] (1939) also states that he has found members of this genus in the nests of ants. The soil here is acid (ph 4.8-5.8) and the calcium content low (0.3.-3 milliequivalents of exchangeable calcium per 100gm of soil). The waste ground and roadsides are characterised by *Asystasia gangetica* (L.) T. Anders., *Pteridium aquilinum* (L.)Kuhn., *Pellaea* spp., *Dissotis rotundifolia* (Sm).Triana, *Polygala paniculata* L., *Hewittia* bicolor Wight et Arn., Lobelia *fervens* Thunb., *Emilia sagitata* DC., *Ageratum conyzoides* L., *Clidemia hirta* D.Don., *Lantana camara* L., regenerating *Harungana madagascariensis* Lam., and *Psidium* spp., *Panicum brevifolium* L., *P. trichocladum* Hack.ex Engl. and *Setaria chevalieri* Stapf. It will be noted from this list that many introduced plants have spread and become quite dominant in certain habitats. They are often pioneer plants. *Clidemia hirta* D.Don. is very abundant by roadsides and forest edges for several miles round Amani. *Lantana camara* L. rapidly covers clearings with an impenetrable thicket which will eventually presumably revert back to forest. Large areas of the forest are covered with tea plantations and though no species of mollusca are yet adapted for living on them the dead shells to be found there are a good indication of the species which lived in the original forest covering. The natural primary forest surrounding Amani consists of very tall trees with straight unbranched boles among which *Piptadenia buchananii* Bak.f., *Myrianthus arboreus* Beauv., *Allanblackia stuhlmannii* (Engl.) Engl., *Odyendea zimmermannii* Engl., *Parinari* spp., *Ocotea usambarensis* Engl., *Tylostemon kweo* Mildbr., *Anthocleista* sp., *Isoberlinia scheffleri* (Harms) Greenway. *Chrysophyllum* spp., *Sersalisea usambarensis* Engl., *Cephalosphaera, usambarensis* (Warb.) Warb., *Anisophyllea obtusifolia* Engl. and V. Brehm. and *Antiaris usambarensis* Engl. with the epiphytic *Aspleniums* and *Orchidaceae,* are the commonest. There is a layer of shrubs and small trees, characteristic ones being *Mesogyne insignis* Engl., *Whitfieldia elongata* (Beauv.) C.B.Cl., *Isoglossa lactea* Lindau, *Dorstenia holstii* Engl., *Rauvolfia rosea* K. Schum., *Leptonychia usambarensis* K.Schum., *Rinorea* spp., *Memecylon* spp., *Psychotria abrupta* Engl., *Conopharyngia holstii* Stapf, and *Achyrospermum radicans* Gurke. The most characteristic herbs are *Costus subbiflorus K. Schum.*, (particularly in the dampest places) *Afromomum* spp., *Olyra latifolia* L. (not so common as in the lowland forest), *Oplismenus* spp., *Pseudechinolaena polystachya* Stapf., *Leptaspis cochleata* Thwaites, *Isachne aethiopica* Stapf and Hubb, (the last six named being forest grasses of distinctive habit), the ferns *Tectaria, Marattia, Pteridium* and *Adiantum* spp., the sedge *Hypolytrum heteriophyllum* Boeck, *Impatiens walleriana* Hk.f. and *Calvoa orientalis* Taub. in damper places. Other common herbs are *Justi-*

cia whytei Sp.Moore and other small *Acanthaceae* together with some small geophytes of distinctive habit such as *Dolichometra leucantha* K.Schum., *Geophila* sp., and *Crossandra usambarensis* Mildbr. Soil analysis records give figures as high as pH 7 for leaf litter in the forest and pH 6.2 for the surface soil from the forest near Monga. At Ndarema pHs of 4.7-5.0 are the rule coupled with a very low calcium content of the order of 0.4 milli-equivalents per 100gm of soil. The soils at Amani are in general red -brown laterised loams easily water-permeable and leached, always acid and with a low calcium content.

Mt. Bomole to the west of Amani has been more extensively searched than other parts of the forest. It rises to 3,600ft. and is mainly forested but large clearings planted with quinine and now covered with *Lantana camara* L. and other pioneer vegetation occur. Near the summit under old plantations of *Cryptomeria japonica* (L.f.)D.Don and *Cupressus macrocarpa* Hartw., snails have been found to be rather abundant under mossy debris which has numerous weathered pellets of *Hyrax* dung intermixed with it. The pH here is 6 and the soil is rather bare save for a few mosses and stick debris though *Setaria chevalieri* Stapf., *Oplismenus* spp., *Panicum brevifolium* L., *Cynorchis uncata* Kraenzl, *Asystasia gangetica* (L.)T.Anders., *Justicia whytei* S.Moore, *Lefeburia longipedicellata* Engl., *Parapentas* sp., *Clidemia hirta* and *Tectaria* occur. Soil records for the clearings on the lower slopes give the pH as 4.5 -5 and the calcium content as 1.3 milli-equivalents of exchangeable calcium per 100gm of soil. The summit of the mountain has rounded domes of gneiss with a flora of *Melinis minutiflora* Beauv, *Cleome serrulata* Pax, *Pteridium aquilinum* (L.)Kuhn., *Justicia whytei* Sp.Moore, *Cyanotis* sp., *Triumfetta* sp. and *Bidens* spp. Mossy debris occurs in the crevices and the habitat can hold a certain amount of standing water.

As one descends from Amani through the forest the vegetation gradually becomes of the dry forest type and *Olyra latifolia* L. becomes more abundant and such species as *Callopsis volkensii* Engl. appear.

About fifty species of mollusc occur around Amani and some are listed below.

Streptaxidae.—Gonaxis craveni (Sm.) is a large and characteristic species in the forest. *G. vosseleri* Thiele and *G. ordinarius* (Sm.) are rarer although the var. *obliquior* Haas of the latter is very common under debris near the summit of Bomole. *Edentulina affinis* Bttgr. is much commoner at the edges of roads than it is in the forest, but *E. oleacea* Fulton is a rarer forest species. Three *Primigulellae* occur but only one, *Gulella grossa* Mts. is common. *G. foliifera* is rare and a third species (*G. usagarica* Crosse) has only been found as very old shells. *G. usambarica* (Crv.) is gregarious under rotting logs in primaeval forest. Twelve minute species of *Gulella* occur and they are particularly abundant near the summit of Bomole. Several appear to be undescribed species. The coastal species, *Tayloria usambarica*, occurs up to 2,800ft. but is rare. Another species of regular helicoid streptaxid has been found near the top of Bomole, but the group is very clearly of nothing like the same importance as it is at the coast. *Helicarionidae.—Trochozonites leroyi* Bgt. is common on the vegetation by river banks. The young are

abundant in August and are remarkable for the fact that heir long caudal horn is continuously in motion, the tip describing a circle. No explanation can be offered for this fact. A species of *Thapsia* (probably *T. leroyi* Bgt.) which also possesses a long caudal tail is common in the forest and is also occasionally seen on roads.

Urocyclidae.—Eleven species including several new ones have been collected at Amani chiefly in waste places and in the damp river-side forest. One large white species which attains a length of six inches is particularly abundant after the rains.

Endodontidae.—No species of this family seem to be recorded for the Territory but a single juvenile found in the damp river side forest has proved on examination by the writer to belong to the section *Psichion* of the genus *Trachycystis* and to the species *ambigua* Connolly which occurs in Portuguese East Africa but the genus is characteristic of the Cape.

Achatinidae.—One or two closely related species (chiefly *A. zanzibarica* Bgt.) are common in the forest. During the dry months they burrow a short distance below the surface debris and form a tough epiphragm.

Stenogyridae.—*Opeas magilense* Crvn. is rare in the forest but several small *Subulinae* are common near the summit of Bomole. *Pseudoglessula leroyi* Bgt. is a common and variable species in the forest, and one other species occurs which is also to be found in the W. Usambaras. A species of *Curvella* is rare in the forest.

Enidae.—A single specimen of *Buliminus* (cf. *metula* Mts.) has been found at the summit of Bomole.

Succineidae.—A species of this usually semi-aquatic genus has been found between the crevices in the rocks at the summit of Bomole.

Cyclophoridae.—A large species (*Cyclophorus elatior* Mts.) occurs in the forest but no live specimens have been seen.

An interesting relict habit which proved to have a considerable snail population (all belonging to a single species of *Curvella*) occurred in the middle of a tea plantation on red and brown soil at Ndarema. This habitat consisted of a small low flat-topped rock dome of gneiss bare save for small patches of dark brown soil scattered over it bearing a species of *Kyllinga* sedge as the dominant plant. The roots of these provided the habitat for the *Curvella*. The pH of the soil at the roots was 4.7 (that of the rock itself being 6.5) and the general flora at the edges of the outcrop being—*Commelina* sp., *Ageratum conyzoides* L., *Bidens pilosa* L., *Triumfetta* sp., *Hewittia bicolor* Wight and Arn., *Polygala paniculata* L., *Lantana camara.* L., *Dissotis rotundifolia* (Sm.) Triana, *Impatiens walleriana* Hk.f., and *Plectranthus amaniensis* Gürke.

H. Ndola Grasslands.

These grasslands occupy a relatively small area. The pH is 6 and the calcium content 7.5 milliequivalents of calcium per 100gm. soil. They are

however subject to fires which makes them unsuitable for mollusca. The main constituents of the grassland are *Cymbopogon* sp., *Hyparrhenia* sp., *Themeda triandra* Forsk., *Melinis minutiflora* Beauv., *Setaria sphacelata* Stapf and Hubbard ex. M. B. Moss, *Bothriochloa insculpta* Camus, and *Sporobolus indicus* R.Br. with the herbs *Polygala gomesiana* Welw. ex. Oliv., *Gladiolus quartinianus* A. Rich,., *Commelina africana* L., *Pentas* sp., *Pteridium aquilinum* (L.)Kuhn., *Dissotis* sp., *Habenaria praestans* Rendle, *Urginea comosa* Welw., *Micromeria* sp., *Hypoxis* sp., *Helichrysum* spp., *Aristea alata* Bak., *Vernonia natalensis* Sch. Bip., and *Calotropis busseana* K. Schum. and also scattered shrubs of *Annona chrysophylla* Boj., *Vitex doniana* Sweet and *Heeria mucronata* Bernh. ex Krauss. There is a patch of forest at the headwaters of the R. Sigi in the middle of this grassland. The soil is blackish here and the same trees occur as in the Amani forest. Some nearby slopes have a scrub of bracken and *Aspilia* and may be reverting to forest.

Very few mollusca have been found in either the grassland or the forest. *Gonaxis craveni* (Sm.) and *Cyclophorus* are rare in the latter and one species of *Tropidophora* (*T. letourneuxii* Bgt.) and a small species of *Atoxon* occur very sparingly on the grasslands.

I. Escarpment of the W. Usambaras.

This was examined between Lushoto and Mombo very briefly at an altitude of 1,500ft. The area is covered with rocky outcrops and bushland with trees. The most characteristic species being *Dombeya* sp., *Cordia abyssinica* R.Br., *Acacia* spp., *Isoberlinia paniculata* (Benth) Hutch. ex Greenway, *Albizzia* spp., *Sclerocarya caffra* Sond., *Commiphora* spp., *Terminalia brownei* Fresen., *Euphorbia mbaluensis* Pax and other related spp., and *Steganotaenia araliacea* Hochst. together with *Adenia keramanthus* Harms, *Tridax procumbens* L., Heliotropium sp., *Amaranthaceae*, and the fern *Actiniopteryx australis* (L.) Link.

The only species of snail found here was a large form of *Ledoulxia mossambicensis* (Pfr.)

J. Mkusi Forest, on the plateau of the W. Usambaras (5,500ft.)

The annual rainfall here is of the order of 35", and the forest is of a very different type from that at Amani. The soils are chocolate brown, and the characteristic components of the forest are *Podocarpus* sp., *Ocotea usambarensis* Engl., *Cassipourea* spp., *Erythroxylum emarginatum* Schum. et Thonn., *Parinari* sp., *Xymalos monospora* (Harv.) Baill. with *Crotalaria* spp., *Tinea vesiculosa* Gurke, *Pilea* sp., *Impatiens walleriana* Hk.f., *Vernonia iodocalyx* O.Hoffm., *Cardamine* sp., and *Oplismenus* sp. The molluscan fauna is quite rich. *Edentulina affinis* Bttgr., and *Gonaris ordinarius* Sm. var. *obliquior* Haas are scarce. A large *Gulella* of the section *Primigulella* is frequent and besides *G. usambarica* Crv. six minute species occur, two of which also live on Mt. Bomole. Shells of a species of *Tayloria* have been found. *Thapsia* occurs and several *Subulinae* are common. Two species of *Pseudoglessula* occur including *P. leroyi* Bgt. Only

one Urocyclid slug was discovered. A species of *Tropidophora* is frequent at the edge of the wood and the small *Cyclophorus volkensii* Mts., occurs.

K. Sungwe.

A few specimens collected by M. Gane, Esq. have been seen from this locality. These were collected along an old railway tramline that passes through some old Cypress plantations near Sungwe Mountain. The tall trees cast a lot of shade and there is practically no ground flora save for patches of regenerating cypress and the ground is covered with dead leaves. The same *Primigulella* as occurs at Mkusi is common here and the collection also contained a large *Thapsia* and the upland species of *Tayloria*.

L. Ndamanyilu, 5 miles west of Malindi in the W. Usambaras (5,800-7,000ft.)

The rainfall here is about 30" or perhaps even less and the soils are reddish, chocolate or grey-black. This area consists of hills separated by grassy valleys, and the hills bear a very disturbed dry upland evergreen forest. The trees are not very tall (c. 50ft.) and are rather widely spaced there being many open clearings. The dominant tree is *Juniperus procera* Hochst. ex A.Rich., together with *Trichocladus malosanus* Bak., *Maba* sp., *Trimeria* sp., *Buddleia* sp., *Euclea* sp., *Scutia* sp., *Rhus* sp., *Rhoicissus erythrodes* (Fres.) Planch., *Catha edulis* Forsk., *Casearia* sp., *Flacourtia* sp., *Scolopia* sp., *Warburgia* sp., *Rawsonia* sp.. *Manilkara* sp., *Clausena anisata* (Willdn.) Oliv., *Psiadia* sp., *Aloe* sp.. *Kalanchoe* spp., *Helichrysum* sp., *Pennisetum clandestinum* Hochst. ex Chiov., and *Sida schimperiana* Hochst. ex A.Rich. this latter also being common in the valleys. The ground layer chiefly consisted of a species of *Justicia* possibly a very depauperate form of *J. pinguior* C.B.Cl.

Mollusca are abundant in the ground layer in individuals if not in species. A species of *Halolimnohelix* inhabited the loose earth under the tussocks of *Justicia*, and a small species of *Tropidophora* was also abundant. A small species of *Primigulella,* closely allied to the one which occurs elsewhere on the western plateau, was discovered together with a few shells of the upland species of *Tayloria,* and *Gonaxis ordinarius* (Sm.) var. *obliquior* Haas. *Streptaxidae* form however a very insignificant part of the fauna.

M. Mkomazi.

The vegetation here is very arid, the annual rainfall being some 10". Scrubby trees and bushes of *Acacia* spp., *Salvadora persica* L., and *Delonix elata* (L.)Gamble occur and the ground is bare but for *Cissus quadrangularis* L., *Barleria* sp., and *Caralluma* sp. A large smooth species of *Tropidophora* (*T.anceps* Vn. Marts.) and a large thick shelled *Achatina* (cf *A. lactea* Reeve) are the dominant snails.

N. Aquatic Environments.

1.) R. Kwamkuyu and R. Dodwe. These small rivers support no truly aquatic plants and the water rushes over masses of loose rocks. *Cleopatra*

africana (Mts.) is the only mollusc which has been found in the streams. It is exceedingly abundant particularly in pools at the edges where the water is slow moving.

2.) R.Sigi. At the mouth of this river the fauna previously mentioned in § 3 occurs and also for some distance from the mouth. In the foot hills however only *Lanistes farleri* Cvn. has been found in the mud at the banks.

3.) Two ponds on the E.Usambara plateau have been examined. One at Ngua has the bottom choked with dead leaves from the surrounding trees which cast a good deal of shade. The soil on which it rests is black. The dominant plants are *Lemna minor* L. and *Wolffia arrhiza* (L.)Wimm., there being no reed zone. The only snail found in the pond was *Physopsis africana* Krauss. A pond at Ndarema on red soil had a distinct reed zone of *Syperus colymbetes* Kotschy Peyr., and semiaquatic plants including the introduced *Sagittaria montevidensis* Cham. et Schlecht. *Nymphaea* sp. occurs in the more open parts, and the pond degenerates into a swamp at one end with the fern *Dryopteris gongylodes* (Schk.)O.Ktze. dominating. *Physopsis africana* Krauss and *Lymnaea natalensis* Krauss occur. An artificial lake at Amani planted with water lilies, *Ceratophyllum,* and *Sagittaria* has also become sparingly populated with snails. *Physopsis africana* Krauss is infrequent on the marginal plants and a single specimen of *Ferrisia* sp. (*Ancylidae*) related to a Portuguese East African species has been discovered.

4.) R. Pangani at Mauri near Korogwe.

Small pools on bare rock where the R. Pangani nearly touches the main road have a more prolific fauna than the plateau ponds. These pools are muddy and dry up during the dry season, but they are covered with water during the wet period. The truly aquatic plants are represented by *Pistia stratiotes* L., *Azolla,* and *Ceratophyllum. Panicum repens* L., *Cyperus* spp., and *Asteracantha longifolia* (L.)Nees also occur in the mud. The river rushes through a very narrow rocky bed at this point and extensive *Papyrus* swamps exist to the south.

Cleopatra amoena (Morel.) dominates these pools and shells of the following were also found *Ancylidae, Melanoides tuberculata* (Mull), *Viviparus unicolor* (Ol.), *Pila* sp., *Bulinus forskali* (Ehrgb.) *Physopsis africana* Krauss, *Planorbidae,* and *Succinea* sp.

5.) Two ponds and one swamp on the western plateau have been investigated.

A pond in the grassland between the ridges at Ndamanyilu contained *Typha* sp., *Lythrum rotundifolium* Hochst., *Potamogeton schweinfurthii* A.Benn., and *Polygonum* sp. as the dominant plants. A species of *Gyraulus* was abundant at the roots of the *Lythrum* and a species of *Bulinus* occurs. A very similar artificial pond at Mkusi also contained the same *Gyraulus* (but very sparingly) together with *Lymnaea* sp. which was feeding on the *Potamogeton.* A swamp next to this artificial pond had an extremely interesting though sparse fauna. This habitat is dominated by *Typha* sp., together with *Nasturtium officinale* R.Br. and *Crassocephalum picridifolium* (DC.)Sp.Moore. A species of *Punctum,* a genus not recorded from

East Africa was scarce at the roots of grass at the edge of the swamp together with a species of *Pisidium*, a genus of minute bivalves which have only rarely been recorded from Tanganyika. A single shell of a *Lymnaea* closely resembling the European *L. truncatula* (Mull) (the carrier of the liver fluke), a small Urocyclid slug and a small juvenile of a *Ledoulxia* sp. also occurred with the *Punctum*.

5. Summary and Acknowledgements :

An attempt is made to correlate the distribution of land and freshwater mollusca in N.E. Tanganyika Territory with the vegetation regions. A selection of habitats is described. Three zones are distinguished, the lowland zone, the intermediate zone and the upland zone. The intermediate zone is distinguished from the other two by the paucity of *Pomatiasidae* and the abundance of the Urocyclid slugs. The upland zone is distinctive through the presence of true *Helicidae* in abundance and the absence of the genus *Achatina*.

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