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ECOLOGY AND CONSERVATION OF THE LAND-SNAILS OF THE EASTERN ARC MOUNTAINS

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ABSTRACT

The history of the study of the terrestrial molluscs of the Eastern Arc Mountains is summarised and a checklist of species known from each range is presented. Current knowledge of the fauna is patchy but each of the ranges contains endemic species and collectively they support a major proportion of the Tanzanian land-snail fauna.

Recent research in the East and West Usambara, Uluguru and Nguru Mountains has revealed high levels of mollusc diversity in Bomole and Monga Forests (East Usambara Mountains) and in the limestone forest at Kimboza (Uluguru Mountains); these forests support the richest faunas reported so far from East Africa. In contrast, diversity and abundance is low in the forests of the Nguru Mountains. A similarity analysis is used to identify several clusters of sites that are related to geographical position and altitude. The significance of these findings for the conservation of East African land snails is discussed.

INTRODUCTION

Terrestrial molluscs (snails and slugs) belong to the second-most diverse animal phylum on earth. In forest ecosystems they act as soil producers and concentrators of calcium, and provide food for vertebrates. Some molluscs are excellent indicators of environmental conditions; for example, there are species that are confined to undisturbed ecosystems whereas others are indicative of habitats degraded by human misuse. Some terrestrial molluscs are vectors of human and livestock diseases and others have contributed greatly to our understanding of genetics and the process of evolution. Snails are eaten as food in many parts of the world, including the large Achatinidae (giant African land snails) in tropical Africa.

We have three objectives in this paper. First, we provide a summary of the activities of the major collectors and investigators involved in the history of the study of the Eastern Arc

mollusc fauna. Second, we update and expand the only existing checklist of molluscs from an Eastern Arc range (the Usambara Mountains—in Rodgers & Homewood, 1982), and provide lists for the other ranges. Finally, we present preliminary results of the first two years of survey of molluscan diversity and endemism in forests of the Usambara, Uluguru and Nguru Mountains.

HISTORICAL BACKGROUND

Most of the early malacological exploration of the Eastern Arc Mountains was undertaken by British and German collectors and zoologists in the late 19th and early 20th centuries. The publications arising from these studies were largely taxonomic, although some scientists such as Louis Germain (1931) attempted biogeographical analysis of the region's fauna, although not specifically of the Eastern Arc area.

Much of the taxonomic work undertaken in the UK was based on material sent back by non-specialist collectors (such as missionaries, doctors and botanists). Molluscs from the Uluguru and Nguru Mountains were collected by Emin Pasha (also known as Eduard Carl Oscar Theodore Schnitzer, 1840–1892), who in 1889 accompanied Dr Stanley on his journey from Lake Albert (Nyanza) to Zanzibar. Edgar A. Smith, Curator at the Natural History Museum, London, described new species collected by Pasha (Smith, 1890; Verdcourt, 1992). In the same paper Smith (1890) described material sent back by John Last, a missionary at Mamboya in the Nguru Mountains (see Verdcourt, 1980, 1993[1]). This material was unusual for the time, in that it contained a large number of small streptaxid species, suggesting that Last must have been an attentive collector (Verdcourt, 1993). Verdcourt (1979a, b) describes the work of zoologist Alfred Craven (1849/50–1937) who spent some time in the Usambara Mountains studying the land-snails of the region and described seven new species (Craven, 1880). Hugh Preston (1871–1945), a shell-dealer, also obtained shells from these collectors, and using this material, was responsible for many new species descriptions from the Eastern Arc Mountains (*e.g.* Preston, 1910, 1912). During the same period, Louis Germain (Curator at the Natural History Museum in Paris) completed major taxonomic works, mainly on land molluscs of the Kenya and Congo regions. He also described new species from material from the Mahenge Region in the Eastern Arc Mountains (Germain, 1916).

The German Carl Eduard von Martens (1831–1904) undertook some of the earliest, yet most comprehensive work on the Tanzanian and Eastern Arc fauna. His results were published in the major monograph, *Beschalte Weichthiere Deutch-Ost-Afrikas* (1897), which remains the only book on the molluscs of these areas, and provides the basis for more recent research. This work was followed by Johannes Thiele (1860–1935) and Leopold Conradt, who studied species from Usambara Mountains (Thiele 1911, 1933) and later K.L. Pfeiffer (1952) who was based at the Senckenberg Museum (Germany) and described several new species from the Usambara Mountains and the Crater Highlands (see Verdcourt, 1995).

Collections at the Royal Institute of Natural Sciences, Brussels and the Museum of Central Africa at Tervuren (Belgium) provided William Adam with material for undertaking taxonomic revisions of many East African families, especially the Urocyclidae and the Streptaxidae (*e.g.* Adam, 1954, 1965). Adolf van Bruggen (Leiden, Netherlands) and Jackie

[1] Verdcourt (1993 p. 221) notes that there are two localities called Mamboya, but viewed the mission at Mamboya in the Nguru Mountains as the most likely locality.

van Goethem (Brussels) continue his work on these collections. Since the 1950s Bernard Verdcourt (Royal Botanic Gardens, Kew, UK), van Goethem and van Bruggen have contributed most to the study of eastern and central African malacofauna, with new descriptions from the Usambara, Ukaguru, Udzungwa and Uluguru Mountains. Both van Bruggen (*e.g.* 1973, 1982) and Verdcourt (*e.g.* 1972, 1984) have published biogeographical reviews of the malacofauna of Africa south of the Sahara.

Fieldwork on the Eastern Arc mollusc fauna has increased substantially in the 1990s especially through the endeavours of organisations such as Frontier-Tanzania, who have been undertaking systematic surveys in the Usambara Mountains. In 1995 and 1996 Peter Tattersfield started field survey projects in the coastal forests and some of the Eastern Arc forests. A significant advance in these surveys is the routine use of litter-sieving extraction methods to detect micro-molluscs, which were often overlooked by earlier, non-specialist collectors. This developed into a major training project in partnership with the National Museum of Wales, UK and National Museums of Tanzania sponsored by the UK Government as part of its Darwin Initiative programme. The main aims being to train staff in Tanzania to undertake surveys, identify species and to build reference collections and reprint libraries to enable further research in East Africa. This collaborative project undertook field surveys in 1997–1998 in the Uluguru, Udzungwa, Mahenge, and the South and North Pare Mountains. These surveys utilise the same techniques as the earlier work, and the material collected is currently being processed and will be reported in subsequent papers.

As with most invertebrate groups, taxonomic confusion and the poor definition of collecting localities by earlier workers causes major problems for studies on the diversity and distribution of the East African mollusc fauna. Verdcourt (1983) published the only checklist of the East African non-marine mollusc fauna and used this information to compile the only list for one of the Eastern Arc ranges—the Usambara Mountains (Verdcourt in Rodgers & Homewood, 1982). Since these lists were published there have been further additions to the literature. Consequently, in appendix 1 we present a revised edition of this checklist and add the first published lists for other Eastern Arc massifs. The data were extracted from Verdcourt (1983 and his unpublished additions), additional published records and a few are from our survey results. The records for the Nguru, Ukaguru and Udzungwa regions are mainly based on historical sources including papers by Preston (1910) and Smith (1890), with poor locality data and so some caution is required in interpreting the data. See footnote 1 with regard to the interpretation of locality name Mamboya given by Preston and Smith. It should be noted that the systematics used in the list provided in appendix 1 are still undergoing considerable revision. However, until such time as a revised East African list is available we have used Verdcourt's list (1983 and his additions).

PRELIMINARY RESULTS OF ONGOING RESEARCH ON DIVERSITY AND BIOGEOGRAPHY

Our research in the Eastern Arc mountains represents a change in approach from a taxonomy-based, checklist style of data analysis towards a more quantitative assessment of the diversity of the molluscan fauna of the mountain forests. Such methods should provide a more rigorous method of assessing the relative contribution each mountain region makes to the overall mollusc fauna within the Eastern Arc region.

Methods

During 1995 and 1996 molluscs were sampled in 13 forests in the East and West Usambara, Uluguru and Nguru Mountains and in seven coastal forests (figure 1). The material obtained from the 1995/6 fieldwork has been sorted and partially identified or classified into morpho-species and is assessed in this paper. Data from the coastal forest sites are included for comparison and in order to explore the affinities and biogeographical relationships between coastal and Eastern Arc faunas. The material collected during later surveys (1997/8 surveys in the Uluguru, Mahenge, Udzungwa, and the South and North Pare Mountains) is currently being processed and is not reported in this paper.

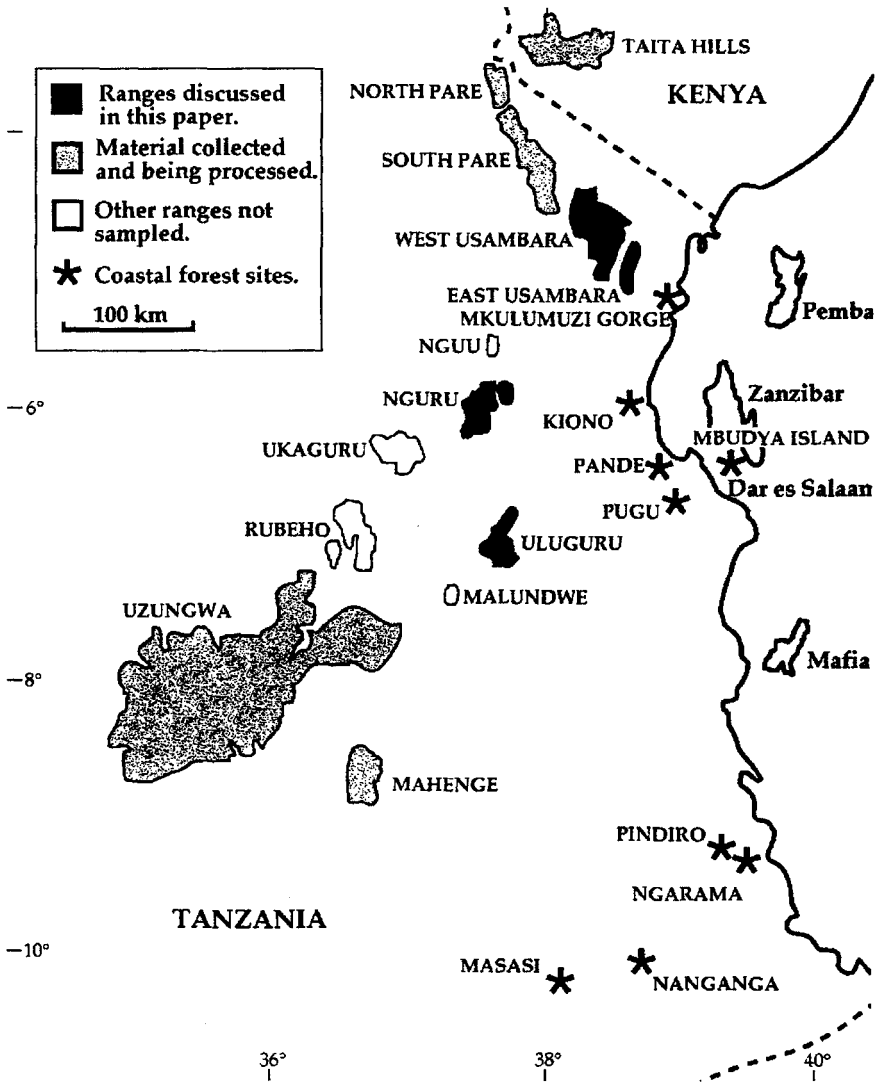


Figure 1. Map of the Eastern Arc region, with locations of the sites surveyed. Names for coastal forests follow Burgess & Muir (1994), with the exception of Nanganga (10°24'S, 39°13'E) and Masasi (10°41'S, 38°50'E).

The study sites and sampling methods

The locations, altitude and number of sites (in the forest) and plots (at the site) in each of the forests sampled are shown in table 1. Tattersfield and a team of Tanzanians sampled molluscs in plots using timed, direct searching and by sieving measured volumes of leaf litter and soil. Fieldwork was undertaken in February and March 1995, and in January 1996. Field conditions were exceptionally dry during the 1996 fieldwork and sampling efficiency may have been reduced for some species. Teams of two people sampled most plots for two hours. These plots varied in size but were mostly about 20–40 m diameter; sampling was restricted to homogeneous forest communities away from forest edges. Replicate sites were sampled in some forests and replicate plots were taken at most sites. Direct searching involved searching molluscan microhabitats such as dead wood, tree trunks, leaf litter, live vegetation etc. A sample of litter/soil (c. 4 litres) was sieved through mesh of 2 mm and 0.5 mm to extract small, litter-dwelling species. Live and dead snails were separated; the live specimens were drowned in water and then preserved in 70% ethanol; the shells of dead snails were stored dry.

Table 1. Eastern Arc forest sites sampled in 1995 and 1996

Eastern Arc Range	Forests Sampled in 1995/6	No of sites (within forest)	No of plots (replicates)	Altitude (m above sea level) (sampled area)
Uluguru	Kimboza Forest Reserve	3	12	350
	Uluguru North Forest Reserve	4	13	1250-1500
Nguru	Nguru South Forest Reserve	1	4	1040
	Manyangu Forest Reserve	1	4	740
	Kwelikwiji Forest Reserve	1	4	540
West Usambara	Mazumbai Forest	2	8	1620-1730
	Ambangulu Forest	2	4	1240
East Usambara	Bomole Forest Reserve (also sampled in 1995)	2	7	1000
	Kwamkoro Forest Reserve	1	1	1000
	Monga Forest Reserve	1	2	960
	Amani-Zigi (1995) Forest Reserve	1	1	500
	Amani-East (1995) Forest Reserve	1	1	520
	Kihuhwi-Zigi (1995) Forest Reserve	1	1	400

N.B. This table does not include the new survey sites (1997–8) which were sampled as part of a collaborative project with the National Museums of Tanzania.

Identification and analysis

About 43% of the taxa collected from these surveys in the Eastern Arc forests have been identified to species level. The remaining taxa have been assigned to morpho-species using mostly shell and external body characters.

Levels of diversity have been expressed as the overall species number (S) (*i.e.* the total number of species recorded from all plots in a forest site), the mean number of species per plot (a) and the Shannon index (H'). Since there was some variation in 'sampling effort' between forests (*i.e.* the number of minutes spent sampling and the number of plots and sites

in the forests) the mean number of species per plot provides the most robust indication of plot richness. The overall species number (S) is more sensitive to variation in sampling effort. The number of molluscs collected per person hour (direct search only) has been used as a standardised measure of mollusc abundance.

Similarities between forests have been examined using the Jaccard Index, which is the number of species shared by a pair of forest expressed as a proportion of the total number of species. This index theoretically ranges from 0 (no shared species) to 1 (identical faunas) although, clearly, the number of co-occurrences will be reduced by sampling inefficiencies so it is unlikely that an index of 1 could be recorded even from areas supporting identical faunas. Co-absences do not contribute to the Jaccard Index. In addition, similarities between site faunas and the relationships between the forests have been explored by constructing similarity trees.

RESULTS AND DISCUSSION

In total, 178 species (and morpho-species) were recorded from all the forests sampled, of which 136 were recorded in the Eastern Arc Forests; 29 (16.29 % of the total recorded) are common to Eastern Arc and coastal forests. The species recorded from the four Eastern Arc ranges represent about 62 % of the Eastern Arc fauna (218 species) listed in Verdcourt (1983) (see appendix 1), 16.7 % of the total known from East Africa (Kenya, Tanzania and Uganda) (1,063 species: Verdcourt, 1983) or 43 % of the Tanzanian non-marine fauna (417 species, excluding Pemba and Zanzibar: Tattersfield, unpublished based on Verdcourt, 1983). At present, five species have been added to the Eastern Arc fauna (see appendix 1), although many more will be added once the identification work has been completed.

The new and revised checklist (appendix 1) shows that more species are known from the Usambara and to a lesser extent the Uluguru Mountains, where much of the previous collecting efforts were concentrated. However, new species, especially small litter-dwelling taxa, are still being described from both these ranges (Tattersfield, 1998a). By contrast, the other Eastern Arc ranges are much less well known, and it is only recently that significant material has been collected from the Udzungwa Mountains. Thus care needs to be taken with comparison of the faunas from these mountain ranges.

Levels of diversity and abundance

Using the molluscan assemblages from each site, species/site matrices were constructed and the results of the preliminary analysis of the data show considerable variation in S and H' and in specimens per person-hour from the different forest sites and mountain ranges (table 2). The highest levels of diversity (total number of species and Shannon Diversity Index) were recorded in the forests at Bomole and Monga in the East Usambara Mountains, and the limestone forest at Kimboza in the Uluguru Mountains. The association of high molluscan richness and abundance with limestone is well known (*e.g.* Waldén, 1981) and accounts for the higher diversity and abundance at Kimboza. Intermediate diversity levels were recorded from the other East Usambara forests, Uluguru North and the West Usambara Mountains (Mazumbai and Ambangulu). The lowest diversity levels were recorded from the Nguru Mountains (Manyangu, Kwelikwiji and Nguru South), with only between 2.25 and 5.5 species recorded per plot and very low abundance. These low levels of abundance and diversity are not a reflection of poor sampling effort.

The fauna from Bomole Forest in the East Usambara Mountains (57 species recorded to date) has the highest molluscan species richness published from East Africa. These levels are equivalent to the richest land-snail faunas previously reported worldwide—lowland forest on the Manaukau Peninsula, New Zealand (56 species; Solem *et al.*, 1981) and temperate forest sites in Tennessee, USA (57 species; Coney *et al.*, 1982). It also exceeds the 50 species reported from Kakamega Forest, Kenya (Tattersfield, 1996) and 52 species from the most diverse site on Madagascar (Emberton, 1995). Preliminary reports given by Emberton *et al.* (1997) listed 48 species from the same sites on Bomole Hill—the difference in the two figures relate to the sampling methodology and intensity, with litter samples providing several additions to Emberton's data.

Table 2. Diversity and abundance of molluscan faunas of Eastern Arc Forests

E. Arc Blocks	Forests	Number of plots in forest	Total species on site(S)	Mean species per plot (alpha)	S.E.	Speci-mens per hour	Shannon Index H'
Uluguru	Kimboza	12	45	18.75	1.48	26.9	3.15
	Uluguru North	13	34	13.38	0.92	17.2	2.64
Nguru	Nguru South	4	13	5.50	0.87	2.2	2.06
	Manyangu	4	10	4.00	0.91	5.5	1.71
	Kwelikwiji	4	8	2.25	0.75	1.1	2.03
West Usambara	Mazumbai	8	36	16.88	1.04	25.7	2.70
	Ambangulu	4	23	11.75	1.11	12	2.64
East Usambara	Amani-Zigi	1	16	16		6.3	2.49
	Amani-East	1	15	15		37.2	2.22
	Kihuhwi-Zigi	1	15	15		25	2.34
	Bomole	7	57	24.43	2.42	30.7	3.04
	Kwamkoro	1	15	15		9.2	2.10
	Monga	2	29	23	2	21	2.54

Similarities amongst the faunas

Similarities between the forest faunas have been explored by constructing a dendrogram (figure 2) based on the Gamma coefficient using an average linking method. The analysis has been based on presence and absence data giving equal weight to live and dead records. It has been applied to all the Tanzanian data collected during 1995 and 1996. These techniques merely provide an indication of the relative similarity of the faunas. When related to factors such as local ecological conditions, altitude or perhaps what is known about site history, such affinities can provide a clue regarding the determinants and possible origins of the faunas.

The dendrogram (figure 2) reveals that the assemblages from each site seem to group geographically; that is into mountain ranges or regions of the coast. The assemblages from the coastal forests south of Dar es Salaam (Nanganga to Pugu) form one such group, whereas the coastal forest sites north of Dar (Mkulumuzi Gorge (also known as Amboni) near Tanga and Kiono) appear to be distinct, and are more closely related to the lower altitude East Usambara forests of Amani-Zigi (500 m) and Kihuhwi-Zigi (400 m). The other East Usambara forests (Bomole, Amani East, Kwamkoro and Monga) form a relatively tight

group, where the molluscan fauna has an affinity to the forest faunas of Mazumbai and Ambangulu in the West Usambara Mountains. Apart from Amani East (480 m), these forests are at a higher elevation (range 960 m to about 1,730 m), with the highest being in the West Usambara Mountains (appendix 1). The sites in the Nguru Mountains form a readily identifiable cluster. The fauna at Kimboza, and to a lesser extent at Uluguru North, appears to be rather distinct from the other Eastern Arc and coastal forest sites.

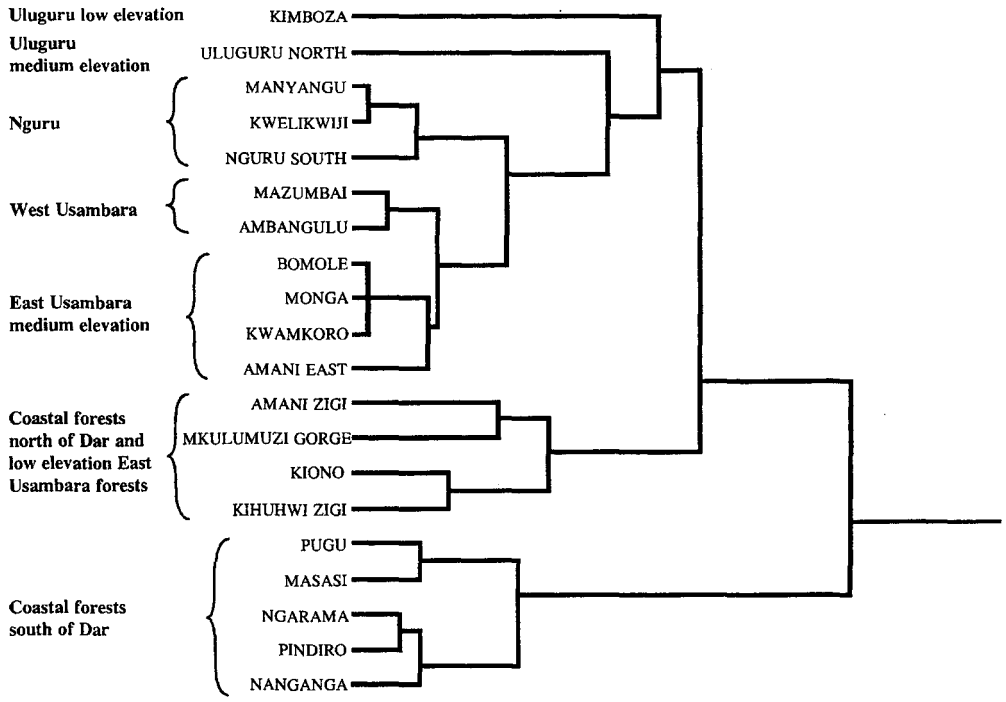


Figure 2. Dendrogram showing the similarity (based on Gamma coefficient) between molluscan assemblages from different geographical regions.

The dendrogram analysis essentially indicates that different faunas are present in the different mountain ranges sampled, and along the coast. It suggests that the lowland forests in the East Usambara Mountains share species with the forests of the coastal belt, and that the faunas from the Uluguru Mountains are different from those of the Usambara and the Nguru Mountains. The analysis also suggests that there are differences in the faunas from low elevation and higher altitude forests in the East Usambara Mountains. Although such clustering can result from an impoverished fauna dominated by widespread species, this is not the case in the analysis. Lovett (1996) has demonstrated strong variations in tree communities related to altitude in Eastern Arc forests; the analysis presented here suggests that there may be similar patterns in the molluscan communities.

Patterns of species distribution

A small proportion of the Eastern Arc fauna comprises widespread species; some of these are present throughout Africa (*e.g. Kaliella barrakporensis*), others have distributions that include eastern and southern Africa (*e.g. Gulella farquhari*) (van Bruggen, 1992). When our

knowledge of the Eastern Arc malacofauna is more complete, variation in the distribution of these species will be more informative. At present, most biogeographical interest comes from examination of the patterns in major species radiations.

The carnivorous snails of the genus *Gulella* (family Streptaxidae) have a major radiation in East Africa with over 175 described species including many geographically restricted forms. The genus is not monophyletic and needs revision, but *Gulella* species are useful for analysis as many have distinctive shell morphologies with complex apertural dentition and surface sculpture. Verdcourt (1984) and van Bruggen (1967) have discussed the biogeography of this group. The genus *Gulella* is especially well represented in Eastern Arc Mountains; Rodgers and Homewood (1982) report that the Usambara Mountains support 27 species of *Gulella* out of a total of 96 terrestrial species. Our revised checklist (appendix 1) lists 122 terrestrial species recorded for the Usambara Mountains, but only three of the additions are *Gulella* species (Tattersfield, 1998a). However, the Streptaxidae still comprises 38 % of the combined East and West Usambara malacofauna. This checklist does not include the morphospecies obtained on recent survey work by Tattersfield (paper in preparation) and hence this estimate is conservative.

The family Streptaxidae represents about 23 % of the whole East African terrestrial mollusc fauna (analysis from Verdcourt, 1983) and thus it is clear that with 33–41 % of the fauna (table 3), this family is disproportionately represented in the Eastern Arc, confirming the observations in Emberton *et al.* (1997). Many streptaxids show strong patterns of geographical replacement in the region, this is especially prominent in the coastal forests (Tattersfield, 1998b) but further work is needed to identify the scale and patterns of distribution and endemism in the Eastern Arc ranges.

In total, 46 taxa (comprising both identified species and currently un-named morpho-species) of *Gulella* were recorded in our fieldwork in 1995 and 1996, but only 24 % of these were recorded from more than one of the broad biogeographical areas (Eastern Arc ranges or the coast). Table 4 shows the percentage of species of *Gulella* shared by each area, and emphasises the higher degree of similarity (33.3 %) between *Gulella* faunas from the East and West Usambara forests compared to those of the other areas.

CONSERVATION IMPLICATIONS

Our research to date has several implications for the conservation of forest molluscs in Tanzania. First, it is clear that the fauna of the Eastern Arc, and of Tanzania as a whole, must be substantially larger than the 223 and 417 species currently known from these areas respectively. The Eastern Arc ranges clearly support a substantial proportion of the total Tanzanian mollusc fauna. There is thus an urgent need to record, describe and gain a better understanding of the Eastern Arc mollusc fauna. At present the fauna from the Usambara and the Uluguru Mountains is much better documented than for any of the other Eastern Arc ranges. Until comparable data for other Eastern Arc forests are available, it will not be possible to analyse whether the degree of endemism in the Mollusca reflects that reported for millipedes (Hoffman, 1993) and linyphiid spiders (82%; Scharff, 1993). Neither will it be possible to analyse the patterns of geographical species replacement across the Eastern Arc forests. Although many species are clearly endemic to a particular Eastern Arc range, subsequent work in the Udzungwa and Mahenge has revealed the presence of some small species that were formerly known only from the Usambara and Uluguru ranges. Further fieldwork is needed to establish whether these species are components of a general Eastern Arc fauna or whether they are more widespread in Tanzania, and other adjacent countries.

Table 3. Analysis of the percentage of malacofauna represented by each family in each Eastern Arc mountain range.

Families	East Usambara	West Usambara	Uluguru	Ukaguru/ Nguru	Taita	Rubeho	Mahenge	South Pare	Udzungwa
Achatinidae	5.32	6.25	7.79	4.48	0	0	33.33	0	50
Bradybaenidae	1.06	1.56	0	1.49	0	0	0	0	0
Cyclophoridae	1.06	0	1.3	1.49	0	0	0	0	0
Endodontidae	4.26	6.25	1.3	0	0	0	0	0	0
Enidae	4.26	3.13	5.19	5.97	7.69	25	0	100	0
Euconulidae	1.06	3.13	2.6	1.49	0	0	0	0	0
Ferussacidae	1.06	0	0	0	0	0	0	0	0
Helicarionidae	1.06	0	1.3	0	0	0	0	0	0
Hydrocenidae	0	0	1.3	0	0	0	0	0	0
Maizaniidae	2.13	4.69	3.9	2.99	7.69	0	0	0	0
Pomatiasidae	3.19	3.13	2.6	1.49	0	0	0	0	0
Streptaxidae	37.23	37.5	36.36	37.31	46.15	33.33	33.33	0	33.33
Subulinidae	14.89	18.75	20.78	28.36	0	16.67	33.33	0	0
Succineidae	1.06	0	0	0	0	0	0	0	0
Urocyclidae	17.02	15.63	10.39	14.93	38.46	25	0	0	16.67
Vallonidae	2.13	0	1.3	0	0	0	0	0	0
Veronicellidae	3.19	0	0	0	0	0	0	0	0
Vertiginidae	0	0	3.9	0	0	0	0	0	0
Total taxa	94	64	77	67	13	12	3	1	6
% of E. Arc fauna (i.e. 223 spp)	41.78	28.44	34.22	29.78	5.78	5.33	1.33	0.44	2.67

Second, altitudinal variation in the fauna is clearly very strong in at least some mountain ranges. The low and high altitude areas in the Ulugurus support essentially different faunas. This contrasts with at least some temperate faunas, where high altitude sites have a similar but impoverished mollusc fauna compared with lower elevation ones (Dance, 1972). Whether this reflects a true discontinuity or clinal variation in the fauna needs further study. A similar pattern of diversity is seen in analysis of the linyphiid spiders from the Eastern Arc Mountains (Scharff, 1993) where the Usambara, Uluguru and Udzungwa faunas harbour closely related species, which replace each other on different mountains, and the faunas gradually change altitudinally on the mountains. Such altitudinal variation means that conservation efforts need to be directed at the low elevation forests, which are especially threatened and highly depleted.

Table 4. Percentage of species in the genus Gulella *common to each pair of biogeographical areas (*i.e. *Jaccard Index x 100).*

	Coast	E. Usambara	W. Usambara	Uluguru	Nguru
Coast	-	3.7	0.0	8.3	0.0
E. Usambara		-	33.3	9.7	5.0
W. Usambara			-	7.2	5.6
Uluguru				-	0.0
Nguru					-

Little is currently known about the effects of different forms of silvicultural management on tropical forest mollusc faunas. However, in temperate woodlands, management practices such as coppicing can have a severe impact on mollusc faunas (Berry, 1973). Furthermore, some species in temperate faunas are only associated with sites with stable micro-environmental conditions. The implications of changes in forest structure (*e.g.* canopy fragmentation caused by logging) on the relatively stable, humid, molluscan niches in undisturbed forests are likely to be more severe in tropical zones where levels of incident solar radiation are higher. This suggests that analyses of molluscan assemblages may provide a useful tool to indicate changes in forest condition and disturbance. For example, research carried out on indigenous and plantation forests in Kakamega Forest in Kenya (Tattersfield, 1996; Tattersfield *et al.*, in prep.) shows that some plantations (*e.g. Bischofia javanica* Blume and *Maesopsis eminii* Engl.) can maintain reasonable levels of gross molluscan diversity but that some species are restricted to indigenous forest habitats. If equivalent indicator taxa can be established in the Eastern Arc forests, they would provide a potentially valuable tool for forest monitoring. Molluscs have several strong advantages over other groups in this respect—they are exceptionally simple and rapid to sample (local foresters can easily carry out sampling programmes), they are relatively robust to store and they can be surveyed throughout the year (unlike many arthropods which need to be sampled during seasonal flight periods).

The molluscs of many parts of the Eastern Arc ranges are clearly under threat from forest clearance and disturbance. The Usambara fauna was reviewed as part of the selection of species for inclusion in the *1996 Red List of Threatened Animals* (IUCN, 1996) and 45 of endemic, range-restricted molluscs were included in the 'Data Deficient' category (36% of Usambara malacofauna). In other Eastern Arc areas such as the Taita Hills, three taxa were placed on the list as 'Critically Endangered' due to the rates of forest loss and likelihood of extinction where the species are, at present, only known from these localities. Recent work on habitat loss and the distribution of Eastern Arc molluscs means that it will be possible to

specify more precisely the threats to such species. It is expected that many of these will be retained in the next Red List review in the year 2000, and they may well qualify for a higher threat category.

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REFERENCES

Adam, W. (1954). Etudes sur les mollusques de l'Afrique centrale et des regions voisines. I. Vertiginidae et Vallonidae. *Volume Jubilaire Victor van Straelen, Bruxelles* **2**: 725–817.

Adam, W. (1965). Mollusques Streptaxidae. Mission Zoologique de l'I.R.S.A.C. en Afrique Orientale. *Annales Musée Royal de l'Afrique Centrale Zoologie* **138**: 1–52.

Berry, F.G. (1973). Patterns of snail distribution at Ham Street Woods National Nature Reserve, East Kent. *Journal of Conchology, London* **28:** 23–35.

Bruggen, A.C. van (1967). An introduction to the pulmonate family Streptaxidae. *Journal of Conchology, London* **26:** 181–188.

Bruggen, A.C. van (1973). Distribution patterns of the genus *Gulella* (Gastropoda, Pulmonata, Streptaxidae) in southern Africa. *Malacologia* **14:** 419–425.

Bruggen, A.C. van (1982). Some reflections, mainly biogeographical, on the land operculates (Mollusca, Gastropoda, Prosobranchia) of the Afrotropical Region. *Netherlands Journal of Zoology* **32:** 284–299.

Bruggen, A.C. van (1992). Studies on the Streptaxidae (Mollusca, Gastropoda, Pulmonata) of Malawi 2. *Gulella farquhari* (M. & P.) in Malawi. *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen* **95(4):** 405–421.

Burgess, N.D. & C. Muir (eds) (1994). *Coastal Forests of Eastern Africa: Biodiversity and Conservation*. Society for Environmental Exploration/Royal Society for the Protection of Birds, Sandy.

Coney, C.C., W.A. Tarpley, J.C. Warden & J.W. Nagel (1982). Ecological studies of land-snails in the Hiwassee River Basin of Tennessee, USA. *Malacologia* **27**: 341–355.

Craven, A.E. (1880). On a collection of land and freshwater shells made during a small expedition to the Usambara country in eastern Africa, with a description of seven new

species. *Proceedings of the Zoological Society of London* **2**: 216-219, plate 22, figs 1-4, 6,7,9.

Dance, S.P. (1972). Vertical range of Molluscs on Ben Lawers, Scotland. *Journal of Conchology, London* **27**: 509–515

Emberton, K. (1995). Land-snail communities morphologies of the highest diversity sites of Madagascar, North America and New Zealand, with alternatives to height diameter plots. *Malacologia* **36:** 43–66.

Emberton, K., T.A. Pearce, P. Kasigwa, P. Tattersfield & Z. Habibu (1997). High diversity and regional endemism in land-snails of eastern Tanzania. *Biodiversity and Conservation* **6**: 1123–1136.

Germain, L. (1916). Contributions à la fauna malacologique de l'Afrique Équatoriale XLIV. Mollusques terrestres recueillis dans les provinces de Kilwa et de Mahenge. *Bulletin du Muséum de l'Histoire naturelle, Paris* **22**: 243–259.

Germain, L. (1931). La faune malacologique des hautes montagnes de l'Afrique Orientale. *Mémoires de la Société de Biogéographie, Paris* **2**: 337–356.

Hoffman, R.L. (1993). Biogeography of East African Montane forest millipedes. In J.C. Lovett & S.K. Wasser (eds), *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge. Pp 103–114.

IUCN, (1996). *The IUCN 1996 Red List of Threatened Animals.* IUCN, Cambridge & Gland.

Lange, C., M. Seddon & P. Tattersfield (1998). *Gulella spinosa*: new to Kenya. *Journal of Conchology, London*, **36 (4)**: 48 - 49.

Lovett, J.C. (1996). Elevational and latitudinal changes in tree associations and diversity in the Eastern Arc mountains of Tanzania. *Journal of Tropical Ecology* **12(5)**: 629–650.

Martens, C. von (1897). *Beschalte Weichthiere Deutch-Ost-Afrikas.* In Mobius, Deutch Ost-Afrika 4, Abt 1. 308 pp, 7 pl. Berlin.

Pfeiffer, K.L. (1952). Neue Landschnecken aus Ostafrika. *Archiv fur Molluskenkunde* **81:** 89–102.

Preston, H.B. (1910). Additions to the non-marine molluscan fauna of British and German East Africa and Lake Albert Edward. *Annals and Magazine of Natural History*, series 8, **6**: 526–536.

Preston, H.B. (1912). Diagnoses of new species of terrestrial and fluviatile shells from British and German East Africa, with a description of a new genus (*Eussoia*) from the Eusso Nyiro River. *Proceedings of the Zoological Society of London* 1912: 183–193.

Rodgers, W.A. & K.M. Homewood (1982). Species richness and endemism in the Usambara Mountain forests, Tanzania. *Biological Journal of the Linnean Society* **18**: 197–242.

Scharff, N. (1993). The linyphiid spider fauna (Araneae: Linyphiidae) of mountain forests in the Eastern Arc mountains. In J.C. Lovett & S.K. Wasser (eds), *Biogeography and Ecology of the Rain Forests of Eastern Africa.* Cambridge University Press, Cambridge. Pp 115–132.

Smith, E.A. (1890). List of land and freshwater shells collected by Dr. Emin Pasha in central Africa, with descriptions of new species. *Annals and Magazine of Natural History*, Series 6, **6**: 146–168, plate 5, 6.

Solem, A., F.M. Climo & D.J. Roscoe (1981). Sympatric species diversity of the New Zealand land-snails. *New Zealand Journal of Zoology* **8**: 453–485.

Tattersfield, P. (1996). Local patterns of land-snail diversity in a Kenyan rain forest. *Malacologia* **38**: 161–180.

Tattersfield, P. (1998a). Three new species and a new subgenus of *Gulella* (Gastropoda: Streptaxidae) from Tanzania. *Journal of Conchology* **38:** 31–42.

Tattersfield, P. (1998b). Patterns in diversity and endemism in East African land snails, and the implications for conservation. In I.J.Killeen, M.B. Seddon & A.M. Holmes (eds), Molluscan Conservation: A Strategy for the 21st Century. *Journal of Conchology Special Publication* **No. 2:** 77–86.

Tattersfield, P., M. Seddon & C. Lange (in prep). Land-snail faunas in indigenous rainforest and commercial plantations in Kakamega forest, Western Kenya. *Biodiversity & Conservation.*

Thiele, J. (1911). Mollusken der Deutschen Zentralafrika-Expedition. In *Wissenschaftliche Ergebnisse der deutschen Zentral-Afrika-Expedition 1907–1908 unter Adolf Freidrichs Herzog zu Mecklenburg* **3(6):** 175–214.

Thiele, J. (1933). Die von Oskar Neumann in Abbessinien gesammelten und einige andere afrikanische Landschnecken. *Sber. Ges. Naturf. Freunde Berl.* **1933:** 280–323.

Verdcourt, B. (1972). The zoogeography of the non-marine Mollusca of East Africa. *Journal of Conchology, London* **27:** 291–348.

Verdcourt, B. (1979a, b). Collectors in East Africa. No. 1: A. Craven (1849/50–1937) *The Conchologists Newsletter* **69**: 147–153, part 2 (literature), **70**: 165–167.

Verdcourt, B. (1980). Collectors in East Africa. No. 2: J.T. Last (1849–1933). *The Conchologists Newsletter* **74:** 248–249.

Verdcourt, B. (1983). A list of the non-marine Mollusca of East Africa (Kenya, Uganda, Tanzania excluding Lake Malawi). *Achatina* **11**: 200–239.

Verdcourt, B. (1984). Discontinuities in the distribution of some east African land snails. In A. Solem & A.C. van Bruggen (eds), *World Wide Snails.* Leiden, Netherlands.

Verdcourt, B. (1992). Collectors in East Africa. No. 15: Emin Pasha (Eduard Carl Oscar Theodore Schnitzer, 1840–1892). *The Conchologists Newsletter* **120**: 439–448.

Verdcourt, B. (1993). Collectors in East Africa. No. 19: Supplements to parts 2, 3, and 4. *The Conchologists Newsletter* **126:** 217–223.

Verdcourt, B. (1995). Collectors in East Africa. No. 23: K.L. Pfeiffer (1874–1952). *The Conchologists Newsletter* **133**: 490–494.

Waldén, H. (1981). Communities and diversity of land molluscs in Scandinavian woodlands. 1. High diversity communities in taluses and boulder slopes in SW Sweden. *Journal of Conchology, London* **30**: 351–372.

APPENDIX I. CHECKLIST OF THE SPECIES RECORDED FROM EASTERN ARC MOUNTAIN REGIONS.*

Sources. **V**: Verdcourt (1983 and Verdcourt unpublished updates); **T**: Tattersfield surveys 1995-6; **D**: *UK Darwin Initiative Molluscan Biodiversity Project*; **E**: Emberton surveys 1995 **L**: Lange *et al.* (1998) and **F**: *Frontier-Tanzania* records (identifications by Tattersfield or Verdcourt). ? indicates that there is uncertainty about the presence of this species in the range.

Nomenclature follows Verdcourt (1983, Verdcourt unpublished updates and additional taxa as described).

PROSOBRANCHIA

Family Hydrocenidae

Hydrocena cf. *kenyana* Connolly, 1929; T: Uluguru.

Family Maizaniidae

Maizania hildebrandti elevata Verdcourt, 1964; V: East Usambara, West Usambara, Uluguru; T: Nguru.

Maizania marsabitensis Verdcourt, 1963; T: West Usambara; V: Taita.

Maizania olivacea Bourguignat, 1889; T: Uluguru; V: Ukaguru and Nguru.

Maizania volkensii von Martens, 1895; V: East Usambara, West Usambara; T: Uluguru.

Family Cyclophoridae

Cyathopoma azaniense Verdcourt, 1978; T: East Usambara, Uluguru, Nguru.

Family Pomatiasidae

Tropidophora calcarea (Sowerby II, 1847); V: East Usambara?, West Usambara?

Tropidophora letourneuxi (Bourguignat, 1889); V: East Usambara?, West Usambara?

Tropidophora letourneuxi var. *leroyi* (Bourguignat, 1889); V: Uluguru.

PULMONATA

Family Achatinidae

Achatina albopicta Smith, 1878; V: East Usambara, West Usambara; T: Uluguru.

Achatina arthuri Bequaert, 1950; V: East Usambara, Uluguru.

Achatina fulica Bowditch, 1822 (incl. *rodatzi* Dunker, 1852); V: East Usambara, West Usambara; T: Uluguru, Nguru.

Achatina grandidieriana (Bourguignat, 1889); V: East Usambara; T: Uluguru, Nguru.

Achatina loveridgei (Clench & Archer, 1930); V: Uluguru.

Achatina zanzibarica Bourguignat, 1879; T: East Usambara, West Usambara, Nguru; V: Uluguru; D: Mahenge, Udzungwa.

Archachatina gebhardti Knipper, 1956; V: Udzungwa.

Archachatina saski Knipper, 1956; V: Udzungwa.

Archachatina sp. (of Verdcourt, 1983); V: West Usambara.

Family Bradybaenidae

Halolimnohelix conradti (von Martens, 1895); V: East Usambara; IUCN, Data deficient.

Halolimnohelix sp. (of Verdcourt, 1983); V: Ukaguru and Nguru.

Halolimnohelix sp. (of Verdcourt, 1983); V: West Usambara.

Family Chondrinidae

Granaria frumentum (Draparnaud, 1806) [syn. genus *Abida*]; V: Uluguru.

Family Endodontidae

Afrodonta kempi (Connolly, 1925); T: East Usambara, West Usambara.

Afropunctum seminium (Morelet, 1873); V: East Usambara.
Punctum hottentotum mkusiensis Verdcourt, 1952; V: East Usambara?, West Usambara?
Trachycystis ariel (Preston, 1910); V: East Usambara, West Usambara.
Trachycystis cf. *lamellifera* (Smith, 1903); T: Uluguru.
Trachycystis sp. nr. *lamellosa* Pfeiffer, 1952; V: West Usambara.

Family Enidae

Edouardia alycaeoides Verdcourt, 1957; V: Uluguru.
Edouardia gracillima (Haas, 1936); V: South Pare.
Edouardia hanningtoni (Sowerby III, 1889); V: Ukaguru and Nguru?, Rubeho?
Edouardia metula (von Martens, 1895); V: East Usambara, Uluguru.
Rhachidina braunsii (von Martens, 1895); V: East Usambara, West Usambara.
Rhachidina braunsii quadricingulata (Smith, 1890); V: East Usambara, Uluguru, Ukaguru and Nguru.
Rhachidina chiradzuluensis (Smith, 1889); V: West Usambara; T: Uluguru.
Rhachidina usagarica agg. Smith, 1890; V: East Usambara, Ukaguru and Nguru, Rubeho?
Rhachistia rhodotaenia von Martens, 1878; V: Taita.
Rhachistia sticta von Martens, 1856; V: Ukaguru and Nguru? Rubeho?

Family Euconulidae

Afroconulus iredalei (Preston, 1910); V: West Usambara; T: Uluguru.
Afroguppya quadrisculpta (Connolly, 1939); T: East Usambara, Uluguru, Nguru.
Afroguppya rumrutiensis (Preston, 1911); V: West Usambara.

Family Ferussaciidae

Micractaeon koptawelilensis (Germain, 1934); T: East Usambara.

Family Helicarionidae

Kaliella barrakporensis (Pfeiffer, 1852); V: East Usambara; T: Uluguru.

Family Streptaxidae

Edentulina obesa bulimiformis (Grandidier, 1887); V: East Usambara, Uluguru, Taita.
Edentulina obesa obesa (Taylor, 1877); V: Uluguru.
Edentulina oleacea (Fulton, 1903); V: East Usambara, Uluguru?
Edentulina ovoidea (Bruguière, 1789); V: East Usambara, West Usambara, Uluguru; T: Nguru.
Edentulina ulugurensis (Bequaert & Clench, 1936); V: Uluguru.
Edentulina usambarensis (Bequaert & Clench, 1936); V: East Usambara, West Usambara, Taita?; IUCN: Data deficient.
Gonaxis bloyeti Bourguignat, 1889; V: Uluguru, Ukaguru and Nguru ? Rubeho?
Gonaxis breviculus (Smith, 1890); V: Ukaguru and Nguru ? Rubeho?
Gonaxis craveni (Smith, 1880); V: East Usambara, Taita; T: West Usambara.
Gonaxis cressyi Connolly, 1922; V: West Usambara.
Gonaxis denticulatus (Dohrn, 1878); V: West Usambara; T: Uluguru.
Gonaxis enneoides von Martens, 1878; V: East Usambara.
Gonaxis gibbonsi Taylor, 1889; V: East Usambara.
Gonaxis kibweziensis Smith, 1895; V: Taita.
Gonaxis loveridgei Bequaert & Clench, 1936; V: Uluguru.
Gonaxis mamboiensis Smith, 1890; V: Ukaguru and Nguru.
Gonaxis recta Bourguignat, 1889; V: Ukaguru and Nguru ? Rubeho?
Gonaxis ukamicus Thiele, 1911; V: Uluguru.

Gonaxis ulugurensis Verdcourt, 1965; V: Uluguru.
Gonaxis usambarensis Verdcourt, 1961; V: East Usambara; IUCN: Data deficient.
Gonaxis vosseleri Thiele, 1911; V: East Usambara; T: West Usambara, Nguru? IUCN: Data deficient.
Gulella aenigmatica Smith, 1890; V: East Usambara, Ukaguru and Nguru.
Gulella alleni Verdcourt, 1974; V: West Usambara; IUCN: data deficient.
Gulella amaniensis Verdcourt, 1953; V: East Usambara; IUCN: data deficient.
Gulella amboniensis Tattersfield, 1998; E: East Usambara.
Gulella amicta Smith, 1890; V: Ukaguru and Nguru.
Gulella augur van Bruggen, 1988; V: Udzungwa.
Gulella baccata Preston, 1913; V: Uluguru.
Gulella bomolensis Verdcourt, 1953; V: East Usambara; T: West Usambara?, Uluguru? IUCN: data deficient.
Gulella bondi Verdcourt, 1962; V: Uluguru.
Gulella conradti conradti von Martens, 1895; V: East Usambara.
Gulella conradti reductidentata Verdcourt, 1956; V: East Usambara; IUCN: data deficient.
Gulella consanguinea Smith, 1890; V: Ukaguru and Nguru.
Gulella curvilamella Smith, 1890; V: Ukaguru and Nguru.
Gulella cuspidata Verdcourt, 1962; V: West Usambara.
Gulella farquhari Melvill & Ponsonby, 1895; V: Ukaguru and Nguru.
Gulella foliifera von Martens, 1895; V: East Usambara.
Gulella fortidentata (Smith, 1890); V: Ukaguru and Nguru.
Gulella gouldi globulosa Pfeiffer, 1952; V: East Usambara, West Usambara; IUCN: data deficient.
Gulella greenwayi Verdcourt, 1962; V: West Usambara; IUCN: data deficient.
Gulella grossa von Martens, 1892; V: East Usambara; IUCN: data deficient.
Gulella gwendolinae agg. Preston, 1910; V: West Usambara; T: Uluguru; IUCN: data deficient.
Gulella habibui Tattersfield, 1998; F: East Usambara; T: Uluguru; D: Mahenge.
Gulella handeiensis Verdcourt, 1953; V: East Usambara.
Gulella inconspicua (Thiele, 1911); V: East Usambara, West Usambara.
Gulella intrusa Verdcourt, 1956; V: East Usambara, West Usambara.
Gulella jaquelineae Adam, 1965; V: Uluguru.
Gulella kidundae Adam, 1965; V: Uluguru.
Gulella labiotuberculata Connolly, 1942; V: Udzungwa.
Gulella lendix (Smith, 1890); V: Ukaguru and Nguru.
Gulella lobidens Thiele, 1911; V: Uluguru.
Gulella lornae lornae Verdcourt, 1953; V: East Usambara; IUCN: data deficient.
Gulella lornae major Verdcourt, 1953; V: West Usambara; IUCN: data deficient.
Gulella ludwigi Verdcourt & Venmans, 1953; V: West Usambara; IUCN: data deficient.
Gulella ndamanyiluensis Venmans, 1956; V: West Usambara; IUCN: data deficient.
Gulella nepia Connolly, 1925; V: Uluguru.
Gulella newtoni (Smith, 1890); V: Ukaguru and Nguru.
Gulella paucidens Verdcourt, 1953; V: East Usambara, West Usambara; T: Nguru; IUCN: data deficient.
Gulella peakei continentalis van Bruggen, 1975; T: East Usambara.
Gulella peculiaris (Smith, 1890); V: Ukaguru and Nguru.

Gulella percivali kilimae Pfeiffer, 1952; V: Ukaguru and Nguru.
Gulella pervitrea (Preston, 1913); V: Uluguru.
Gulella sexdentata (von Martens, 1869); V: Uluguru.
Gulella soror (Smith, 1890); V: Ukaguru and Nguru.
Gulella sp. (of Verdcourt, 1983); V: Ukaguru and Nguru.
Gulella sp. nr *princei* (of Verdcourt, 1983); V: Uluguru.
Gulella spinosa Tattersfield, 1998; L: Taita.
Gulella strictilabris (Ancey, 1897); V: Ukaguru and Nguru.
Gulella subflavescens (Smith, 1890); V: Ukaguru and Nguru.
Gulella subhyalina addita (von Martens, 1897); V: East Usambara; IUCN: Data deficient.
Gulella subhyalina subhyalina (Smith, 1890); V: Ukaguru and Nguru.
Gulella subringens (Crosse, 1886); V: Ukaguru and Nguru? Rubeho?
Gulella taitensis Verdcourt, 1963; V: Taita; IUCN: Critically Endangered B1 + B2a, c.
Gulella translucida Pfeiffer, 1952; V: East Usambara; T: West Usambara.
Gulella ulugurensis Verdcourt, 1962; V: Uluguru.
Gulella unidentata Pfeiffer, 1952; V: West Usambara.
Gulella usagarica agg. (Crosse, 1886); V: East Usambara, West Usambara, Uluguru; T: Nguru; IUCN: data deficient.
Gulella usambarica (Craven, 1880); V: East Usambara, West Usambara; IUCN: data deficient.
Gulella vicina vicina (Smith, 1899); V: East Usambara.
Ptychotrema usambarense Verdcourt, 1958; V: East Usambara, West Usambara.
Streptostele taylori (Gibbons, 1879); V: East Usambara.
Tayloria amaniensis Verdcourt, 1960; V: East Usambara; IUCN: data deficient.
Tayloria angustestriata Pfeiffer, 1952; V: West Usambara; IUCN: data deficient.
Tayloria hyalinoides (Thiele, 1911); V: East Usambara; IUCN: data deficient.
Tayloria iterata von Martens, 1897; V: Uluguru.
Tayloria sp. (of Verdcourt, 1983); V: Uluguru.
Tayloria sp. (of Verdcourt, 1983); V: Uluguru.
Tayloria usambarica (Craven, 1880); V: East Usambara.
Tayloria usambarica leroyi (Bourguignat, 1889); V: Uluguru, Ukaguru and Nguru.

Family Subulinidae

Curvella afra Boettger, 1917; V: Mahenge.
Curvella associata (Smith, 1890); V: Ukaguru and Nguru.
Curvella disparilis (Smith, 1890); V: Ukaguru and Nguru.
Curvella mathildae Preston, 1910; V: Ukaguru and Nguru? Rubeho?
Curvella pertranslucens fallooni (Connolly, 1923); V: Uluguru.
Curvella sp. nr *calorhaphe* (of Verdcourt, 1983); V: East Usambara; T: Uluguru.
Curvella sp. a (of Verdcourt, 1983); V: East Usambara, West Usambara.
Curvella subvirescens (Smith, 1890); V: Uluguru, Ukaguru and Nguru.
Curvella whytei (Smith, 1899); V: Uluguru.
Euonyma magilensis (Craven, 1880); V: East Usambara.
Hypolysia connollyana (Pfeiffer, 1952); V: West Usambara; IUCN: data deficient.
Hypolysia usambarica Verdcourt, 1957; V: East Usambara; T: West Usambara, Uluguru; IUCN: data deficient.
Opeas crenatum Verdcourt, 1957; V: East Usambara; T: West Usambara.
Opeas delicatum (Taylor, 1887); V: East Usambara; Uluguru.

Opeas lineare var. *levis* Connolly, 1910; V: Uluguru.
Opeas sp. nr *P. bitzeensis* (of Verdcourt, 1983); V: East Usambara.
Opeas stenostomum (Smith, 1890); V: Ukaguru and Nguru.
Pseudoglessula acutissima Verdcourt, 1967; V: West Usambara; IUCN: data deficient.
Pseudoglessula boivini (Morelet, 1860); V: East Usambara, West Usambara, Uluguru.
Pseudoglessula conradti (von Martens, 1895); V: East Usambara, West Usambara; IUCN: data deficient.
Pseudoglessula gracilior (Smith, 1904); V: West Usambara, Uluguru, Ukaguru and Nguru?
Pseudoglessula introversa (Smith, 1890); V: Ukaguru and Nguru.
Pseudoglessula kidetensis (Smith, 1890); V: Ukaguru and Nguru? Rubeho?
Pseudoglessula kirkii (Dohrn, 1865); V: East Usambara, West Usambara.
Pseudoglessula lasti (Smith, 1890); V: Ukaguru and Nguru.
Pseudoglessula leroyi agg. (Bourguignat, 1889); V: East Usambara, West Usambara, Ukaguru and Nguru; T: Uluguru; IUCN data deficient
Pseudoglessula prestoni Smith, 1904; V: Uluguru.
Pseudoglessula subcarinifera (Smith, 1890); V: Ukaguru and Nguru.
Pseudoglessula uniplicata (Smith, 1890); V: Ukaguru and Nguru.
Pseudopeas ukaguruensis Verdcourt, 1996; V: Ukaguru and Nguru.
Subulina conradti von Martens, 1895; V: East Usambara, Ukaguru and Nguru.
Subulina intermedia (Taylor, 1887); T: Uluguru; V: Ukaguru and Nguru.
Subulina lasti Smith, 1890; V: Ukaguru and Nguru.
Subulina mamillata Craven, 1880; V: East Usambara.
Subulinscus chiradzuluensis (Smith, 1899); V: Uluguru.
Subulona clavaeformis (Thiele, 1911); V: Uluguru.
Subulona ischna (Pilsbry, 1919); V: Uluguru.
Subulona mamboiensis (Smith, 1890); V: Uluguru, Ukaguru and Nguru.
Subulona ordinaria (Preston, 1910); V: East Usambara.
Subulona ucamica Thiele, 1911; V: Uluguru.
Subulona usagarica usagarica (Smith, 1890); V: West Usambara? Ukaguru and Nguru.
Subulona usamabarica (Pfeiffer, 1952); V: West Usambara; IUCN data deficient.

Family Succineidae

Succinea spp; V: East Usambara.

Family Urocyclidae

Anisotoxon deconincki Van Goethem, 1975; V: Uluguru.
Atrichotoxon sp. (of Verdcourt, 1983); V: Taita.
Atrichotoxon usambarense (Verdcourt, 1961); V: East Usambara; IUCN: data deficient.
Bukobia uhehensis Verdcourt, 1965; V: Udzungwa.
Elisolimax rufescens (Simroth, 1894); V: East Usambara; IUCN: data deficient.
Leptichnus bernardi Van Goethem, 1975; V: East Usambara; IUCN: data deficient.
Polytoxon robustum (Simroth, 1896); V: East Usambara, West Usambara.
Sitala leroyi (Bourguignat, 1889); V: East Usambara, West Usambara, Ukaguru and Nguru.
Sitala mazumbaiensis Verdcourt, 1977; V: West Usambara; IUCN: data deficient.
Sitala (gen. nov.?) sp. (of Verdcourt, 1983); V: East Usambara.
Thapsia buraensis Verdcourt, 1982; V: Taita; IUCN: Critically Endangered B1 + B2a, c.
Thapsia curvatula von Martens, 1897; V: East Usambara, Uluguru.

Thapsia depressior (Smith, 1890); V: Ukaguru and Nguru.
Thapsia eminiana (Smith, 1890); V: Ukaguru and Nguru.
Thapsia eucosmia Pilsbry, 1919; V: East Usambara.
Thapsia grandis Verdcourt, 1982; V: West Usambara; IUCN: data deficient.
Thapsia hanningtoni (Smith, 1890); V: Ukaguru and Nguru.
Thapsia lasti (Smith, 1890); V: Ukaguru and Nguru.
Thapsia leroyi Grandidier, 1887; V: East Usambara, Ukaguru and Nguru? Rubeho?
Thapsia masukuensis Smith, 1899; V: Uluguru?
Thapsia microsculpta Verdcourt, 1982; V: West Usambara; IUCN data deficient.
Thapsia pinguis (Krauss, 1848); V: Uluguru.
Thapsia sp. (of Verdcourt, 1983); V: Ukaguru and Nguru.
Thapsia sp. (of Verdcourt, 1983); V: Ukaguru and Nguru.
Thapsia sp. nr *hanningtoni* (of Verdcourt, 1983); V: Uluguru.
Thapsia sp. nr *usambarensis* (of Verdcourt, 1983); V: West Usambara.
Thapsia ulugurensis Verdcourt, 1982; V: Uluguru.
Thapsia usambarensis Verdcourt, 1982; V: West Usambara; IUCN data deficient.
Trichotoxon heynemanni Simroth, 1888; V: East Usambara, Uluguru.
Trichotoxon martensi (Heynemanns, 1882); V: East Usambara, West Usambara.
Trichotoxon sp. Verdcourt & Polhill (of Verdcourt, 1983); V: East Usambara.
Trochonanina elatior (von Martens, 1866); V: East Usambara, West Usambara.
Trochonanina episcopalis (Smith, 1890); V: Ukaguru and Nguru? Rubeho?
Trochonanina gwendolinae (Preston, 1910); V: Ukaguru and Nguru? Rubeho?
Trochonanina pseudojenynsi (Thiele, 1911); V: Uluguru.
Trochonanina sp. (of Verdcourt, 1983); V: Taita.
Trochonanina monozonata (Preston, 1910); V: East Usambara.
Trochozonites sp. (of Verdcourt, 1983); V: Taita.
Trochozonites usambarensis Verdcourt, 1982; V: East Usambara; T: West Usambara; IUCN data deficient.
Unidentified genus (prob. subfamily of slugs near to Durgellinae); V: East Usambara.
Zingis radiolata von Martens, 1878; V: Taita; IUCN: Critically Endangered B1 + B2a, c.

Family Valloniidae

Pupisoma cf. *orcula* (Benson, 1850); T: East Usambara.
Pupisoma harpula Reinhardt, 1886; T: East Usambara; Uluguru.

Family Veronicellidae

Laevicaulis somalicus (Colosi); V: East Usambara.
Laevicaulis vosseleri (Simroth, 1912); V: East Usambara.
Laevicaulis zanzibaricus (Forcart, 1953); V: East Usambara.

Family Vertiginidae

Nesopupa cf. *bisulcata* (Jickeli, 1912); T: Uluguru.
Nesopupa cf. *peilei* (Madge, 1938); T: Uluguru.

*For anyone needing it, a Microsoft Excel landscape version of this table may be obtained from the authors.