
Changing places: how the results of new field work in the Rubeho Mountains influence conservation priorities in the Eastern Arc Mountains of Tanzania

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Abstract

The Rubeho Mountains are a poorly studied mountain block within the Eastern Arc Mountain range of Tanzania and Kenya. We present the results of field surveys for vertebrates undertaken during the period February 2000 to December 2002. One hundred and twelve man-days of surveys recorded 35 mammal, 107 bird, ten reptile and nine amphibian species, including eleven species endemic and seven near-endemic to the Eastern Arc, with one species new to science. Of these, nine species are regarded as threatened with extinction. The new survey data significantly elevate the biological importance of the Rubehos within the Eastern Arc range. Further analyses highlight how the overall biological ranking of the Eastern Arc mountain blocks is correlated with survey effort. The majority of the forest habitat on the Rubehos is contained in three national (Central Government) Forest Reserves (Mang'alisa, Mafwomero and Ukwiva). Our surveys recorded high levels of disturbance to the forest habitat in all three reserves and we draw attention to the need for additional conservation investment in this area.

Key words: Eastern Arc Mountains, endemic vertebrates, Rubehos, Tanzania

Résumé

Les montagnes de Rubeho sont une chaîne de montagnes peu étudiées dans l'Arc Oriental de la Tanzanie et du Kenya. Nous présentons ici les résultats de nos études sur

les vertébrés faites sur le terrain entre février 2000 et décembre 2002. Au cours des 112 jours d'enquête nous avons constaté 35 espèces mammifères, 107 oiseaux, 10 reptiles et 9 amphibiens; dont 11 espèces indigènes et 7 quasi-indigènes à l'Arc Oriental et une espèce nouvelle à la science. Parmi ceci, 9 espèces sont considérées comme espèces en voie de disparition. Les résultats de l'enquête montrent que l'importance biologique des montagnes de Rubeho dans l'Arc Oriental s'avère très élevé. Des recherches supplémentaires démontrent que le classement biologique de l'ensemble de l'Arc Oriental est lié à la fois au niveau de l'effort consacré à l'étude et l'étendue d'habitat forestier restant. La majorité de l'habitat forestier dans les Rubehos se trouve à l'intérieur de 3 réserves nationales (Mang'alisa, Mafwomero et Ukwiva). Nous avons constaté de fortes perturbations dans l'habitat forestier dans chacune de ces réserves et nous constatons qu'un plus grand investissement dans la conservation de cette région s'impose.

Introduction

The Rubeho Mountains are a large granitic and gneissic mountain block within a geologically ancient chain of mountains that extends from southern Kenya to south-central Tanzania – collectively known as the Eastern Arc Mountains (Lovett, 1988, 1990) (Fig. 1). The habitats of the Eastern Arc Mountains support a high concentration of endemic species (Lovett & Wasser, 1993; Burgess, Fjeldså & Botterweg, 1998a; Burgess *et al.*, 1998b; Newmark, 1998, 2002; Rodgers, 1998; Burgess & Clarke, 2000). As a result of this exceptional endemism, these mountains

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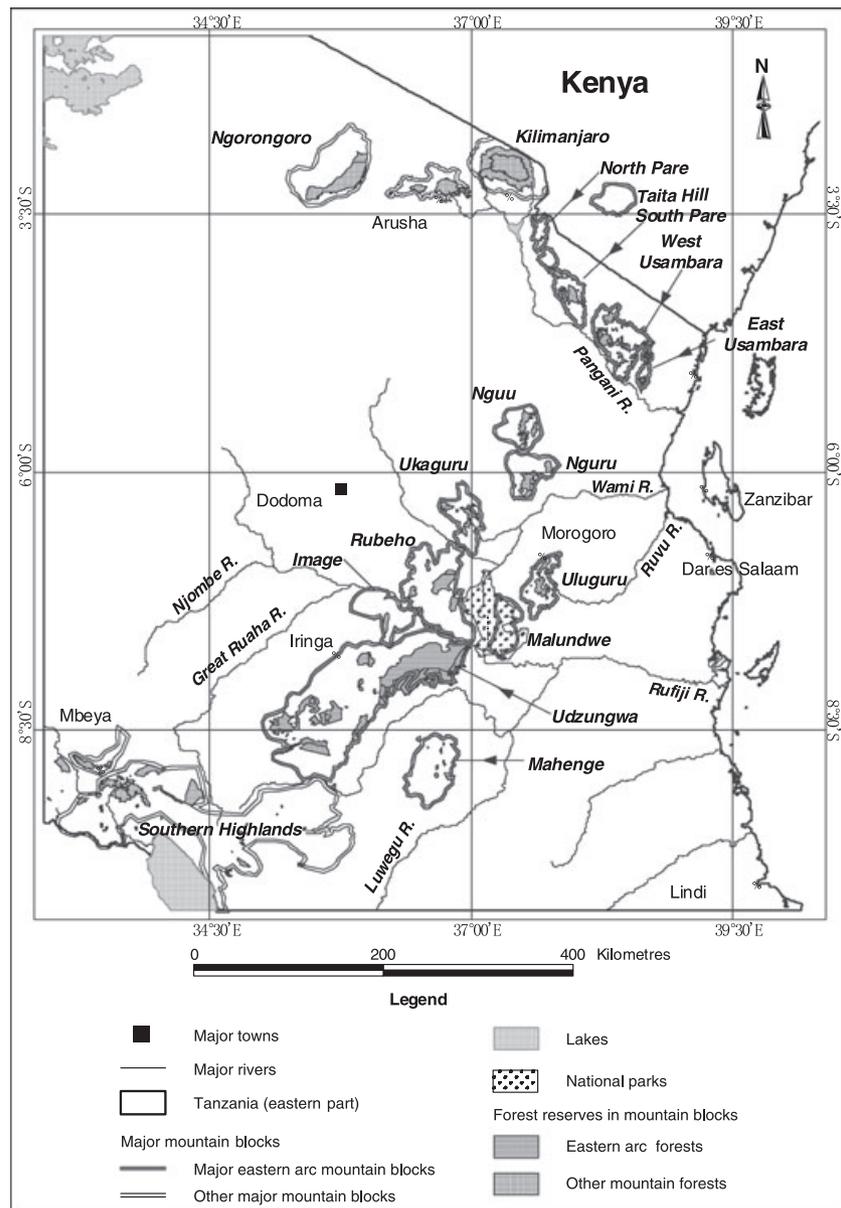


Fig 1 Map showing the thirteen blocks of the Eastern Arc Mountains of Tanzania. Boundary for the Eastern Arc mountain blocks vary as follows: Taita, Rubeho, Nguu (500 m contour); South Pare, West Usambara, East Usambara, Nguu, Ukaguru, Uluguru, Malundwe, Mahenge, Image (600 m contour); North Pare (1000 m contour).

have been identified as a priority region for the conservation of biodiversity in several global conservation prioritization exercises (ICBP, 1992; Mittermeier *et al.*, 1998; Olson & Dinerstein, 1998; Stattersfield *et al.*, 1998; Myers *et al.*, 2000; Burgess *et al.*, 2004).

Previous assessments of the conservation importance of the mountain blocks within the Eastern Arc Mountain range ranked the Rubeho Mountains of low importance for biodiversity conservation (e.g. Burgess, Fjeldså & Botte-nueg 1998a). However, it was suspected that the low

ranking was mainly because little research had been carried out at the site. Differences in research effort across the thirteen Eastern Arc Mountains were recently clarified in a published bibliography of biodiversity research in the region (Isango, 2001). The Rubehos ranks third from bottom in this list in terms of research effort.

This paper reports the results of new field studies in the Rubehos conducted between February 2000 and December 2002. These studies allow the biological importance of the Rubehos to be re-assessed against the

other Eastern Arc Mountain blocks. This study also allows an assessment of how the ranking of biological importance among the different blocks of the Eastern Arc Mountains relates to differences in survey intensity, or forest area. We also use our field knowledge of the site to make recommendations on the conservation needs of the Rubeho Mountains area.

Study site

The Rubeho Mountains are located along the border between the Mpwapwa District of Dodoma Region and Kilosa District of Morogoro Region, in eastern Tanzania (Fig. 2). Although in common use internationally, the validity of the name Rubeho is uncertain at the local level as the people living in the region do not recognize it. Some maps use the name Usagara Mts, but we believe this name applies to mountains above Sagara village – now officially called Kiboriani Mts (north of the town Mpwapwa). For the purposes of this paper, we use the name Rubeho Mountains to cover the highlands north of the Great Ruaha Basin – stretching from the Mkondoa River at 06°32'S in the north to the Great Ruaha River at 07°34'S in the south – with two westerly ridges at Mafwomero and Mang'alisa (the latter isolated west of the main highland). At their western edge, at 036°18'E, the mountains rise steeply from approximately 600 m a.s.l. in the Great Ruaha valley to a plateau at over 1400 m. Further east, a series of ridges rise to over 2000 m a.s.l. At their eastern edge, the Rubeho mountains drop gradually to the Miyombo valley around 036°52'E at an altitude of 600 m

a.s.l. The highest point in the Rubeho Mountains is 2225 m a.s.l.

According to Lovett & Pócs (1993), the climate of the Rubeho area is characterized by oceanic rainfall with continental temperatures. The nearest rainfall stations are at Kilosa and Mikumi to the east and at Kisanga Msolwa. The dry season extends between June and November. Mean temperatures vary from a maximum of 25°C (December) to a minimum of 20°C (July) at lower altitudes. Temperatures must fall significantly below this at higher altitudes, but data are lacking. Rainfall is estimated at 1000 mm year⁻¹ in the lower altitude and 1200 mm year⁻¹ at higher altitudes, with an unknown but potentially significant additional precipitation from mist and clouds at higher altitudes. The forests are mainly found on high plateau areas that are often covered in a blanket of mist during the night. The Rubeho Mountains are part of the water catchment areas for the Wami and Great Ruaha Rivers. The Great Ruaha powers the Kidatu Hydroelectric plant providing 37% of Tanzania's electricity output (SMUWC, 2001). The Wami River provides water for many rural settlements and to the town of Chalinze.

The forests of the Rubehos are mainly found within Central Government Forest Reserves, managed by the Forestry and Beekeeping Division of the Ministry of Natural Resources and Tourism (Fig. 2). Mafwomero and Mang'alisa fall within Mpwapwa District, Dodoma Region while Ukwiva lies within Kilosa District, Morogoro Region (Table 1). These are all located at high altitude. There is a sharp change to woodland at lower altitude. Lower-altitude forest is also found along river valleys, with some

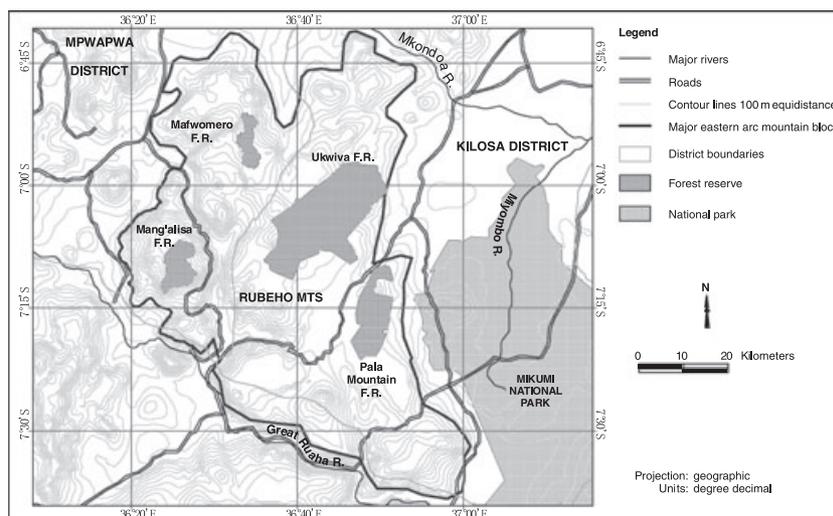


Fig 2 Location of the three Forest Reserves on the Rubeho range, in relation to the District boundaries of Kilosa (Morogoro Region) and Mpwapwa (Dodoma Region).

groundwater forest at 600 m, isolated from the higher-altitude forests.

Until recently, the Rubehos were poorly known biologically. In the 1980s and early 1990s, Jon Lovett visited the dry western edge of Ukwiva and the northern edge of Mang'alisa (Lovett & Congdon, 1989; Lovett & Minja, 1990; Lovett, 1994). Between 18 and 23 September 1993, Jon Fjelds  visited the groundwater forests at the eastern base of the highland and the eastern slope of Ukwiva (Fjelds , Howell & Andersen, 1997). This formed the basis of the biological knowledge of the area prior to the surveys reported here.

Methods

Field surveys

The field methods used during our surveys aimed to list the species of vertebrates occurring in the three large Forest Reserves of the Rubehos, focusing on the forest-dependent species and those of particular conservation concern within the Eastern Arc Mountains. Five separate field surveys were conducted between December 2000 and December 2002. In total, these teams of researchers spent more than 112 team-days in the field, with effort varying somewhat between the three Forest Reserves (Ukwiva FR = 18 days; Mafwomero FR = 80 days; and Man'galisa FR = 14 days). The majority of survey effort was used to determine the species of birds present in the reserves, although significant effort was made during August 2001 and August–September 2002 to identify the species of mammals, reptiles and amphibians. The survey methods are as follows.

Birds. Birds were surveyed using a combination of mist-netting and combined visual and auditory surveys when walking along trails or randomly through the forest. Mist-nets were opened just before dawn and were closed at dusk. More than 50,000 net-metre-hours of mist netting was undertaken. Observation walks usually occurred at all times of the day, although most often between 07:30 and 10:30 hours. A total of 112 man-days were spent on bird observation. Field identifications were made using accumulated experience from many years of fieldwork in the Eastern Arc and through consultation with relevant field guides (Britton, 1980; Zimmerman, Turner & Pearson, 1996). Nomenclature in the species lists follows Sibley & Monroe (1990, 1993) – with the addition of species described after 1993. Blood samples were taken of all

Table 1 Central Government Forest Reserves of the Rubeho Mountains

Forest Reserve	Government declaration number	Area (ha)	Altitudinal range	Longitude	Latitude	Brief description
Mafwomero	GN 87 of 9/4/1954	3237	1600–2200	036°33'–036°37'E	06°49'–06°59'S	Two patches of montane forest along a north–south ridge
Mang'alisa	GN 187 of 31/8/1951	4988	1900–2200	036°23'–036°28'E	07°07'–07°13'S	Isolated mountain west of the main Rubehos. Fragmented montane forest interspersed with <i>Protea</i> woodland and grassland
Ukwiva	GN 407 of 3/12/1954	54,634	600–2050	036°34'–036°51'E	06°58'–07°21'S	An extensive area of the Eastern escarpment and upland plateau of the Rubehos. Some mature montane forest. Large areas of disturbed forest. Some miombo in the east

mist-netted birds for molecular studies (samples deposited at Zoological Museum of the University of Copenhagen) and where necessary specimens were collected (skins and anatomic specimens) for taxonomic verification.

Mammals. Large mammals were recorded visually and by looking for spoor during extensive walks through the forest. Data were also obtained from discussions with villagers familiar with the forest, using Kingdon's (1997) guide to African mammals as a prompt. Only those species identified as being common were included. A Trailmaster TVM300 phototrap (Goodson & Associates, Inc., Lenexa, Kansas, USA), equipped with a passive infrared and motion sensor was used to photograph all mammals coming within range. This was used for seven nights in Ukwiva, three in Mafwomero and six in Mang'alisa. Night walks along existing paths (47 h Ukwiva, 12 h Mafwomero, 34 h Mang'alisa) were used to identify galagos using torches, binoculars and tape recorders. Galago calls were recorded using a Sony WM C6C tape recorder (Sony Corp., Osaka, Japan) and a Sennheiser K6/ME66 directional microphone (Sennheiser Electronic Kg, Wedemark, Germany). Calls were compared with a library of galago vocalizations held at the Nocturnal Primate Research Group, Oxford Brookes University, U.K. A Chardonneret trap baited with bananas was used to capture galagos alive, which were later released (2 trap-nights Ukwiva, 6 trap-nights Mafwomero, 7 trap-nights Mang'alisa). Rodents and shrews were caught using bucket pitfall traps and Sherman traps (365 trap-nights Ukwiva, 210 trap-nights Mafwomero, 182 trap-nights Mang'alisa). Three 50-m lines of drift fencing, each with 11 buckets at 5-m intervals were erected perpendicular to the slope (110 bucket-nights Ukwiva, 55 bucket-nights Mafwomero, 66 bucket-nights Mang'alisa). Specimens of small mammal species collected during August 2001 have been deposited at the University of Dar es Salaam and at the Frankfurt Zoological Museum in Germany. The nomenclature of the species list follows Wilson & Reeder (1993), except for species described since that time, principally for the galagos where Groves (2001) is followed.

Reptiles. Bucket pitfall traps and diurnal and nocturnal walks were used to record reptiles. During the diurnal walks, the focus was on collecting species living in the leaf litter and under rotting logs. At night, the focus was on locating chameleons and other species living in the lower branches of trees. Discussions were also held with local

people to determine the presence of distinctive species such as rock pythons (*Python natalensis*) and puff adders (*Bitis arietans*). Where necessary, specimens were collected and have been deposited at the University of Dar es Salaam, the Natural History Museum of Zimbabwe and the Zoological Museum University of Copenhagen. Prof. D. G. Broadley in Zimbabwe and Dr Jens B. Rasmussen in Denmark provided identifications.

Amphibians. Amphibian species were recorded using bucket pitfall traps and through diurnal and nocturnal walks. During the diurnal walks, the focus was on species living in the leaf litter and under rotting logs. At night, the focus was on tree frogs and other species living in the lower branches of trees. Specimens have been deposited at the University of Dar es Salaam and at the Natural History Museum, London. Prof. J.C. Poynton of the British Museum of Natural History provided identifications according to the taxonomy of Duellman (1993), except for a species of *Arthroleptis*, which was later described as a new species (Poynton, 2003).

Analysis

We used the vertebrate data collected in the Rubeho Mountains to update analyses of biodiversity priorities in the Eastern Arc Mountains. We also investigated to what extent the priority rankings of Eastern Arc Mountain blocks are correlated with differences in survey effort or habitat area, to assess whether the rankings are robust or likely to undergo further changes with additional field survey work. For comparative purposes, our analyses follow Burgess *et al.* (1998a) in distinguishing between Eastern Arc endemic and near-endemic species where the near-endemic species are those shared with the adjacent lowland Coastal Forests and with the Tanzanian Southern Highlands portion of the Malawi Rift.

Biological ranking. Two sets of data were used to determine biological importance for each of the 13 Eastern Arc Mountain blocks: first, the number of Eastern Arc endemic and near-endemic species (Burgess *et al.*, 1998a – updated for Rubehos) and secondly the number of red-listed threatened species of plants and animals in the different mountains (IUCN, 2002; Nature Kenya & WCST, 2003). Biological importance was analysed in two ways: first without correcting for the area of forest in each mountain block and secondly after correcting the results for forest

area. The procedure of area correction aimed to illustrate the number of endemic species per unit area of forest, and hence reduce the potential bias in the prioritization approach – where larger forests contain more species simply because of the species–area relationship (Rosenzweig, 1995). Area correction was performed using the equation:

$$\text{BVd} = \frac{\text{BV}}{A^z}$$

where z is the species–area exponent, BV is the biological value in question, A is area (km^2) and BVd is the biological value corrected for area. We set $z = 0.2$ as this corresponds to empirical results for a wide variety of taxa and terrestrial ecosystems (Rosenzweig, 1995).

Correlation with survey effort. We used the number of publications listed by Isango (2001) as a simple measure of survey effort in each of the thirteen Eastern Arc Mountain blocks. This bibliography includes 908 references including 409 relating directly to biodiversity research in the Eastern Arc Mountains. Although probably not complete, it represents a single source providing an index of survey effort across the region. The East Usambara Mountain block has 264 biodiversity-related papers, with other blocks ranked as follows: West Usambara (163), Udzungwa (109), Uluguru (83), Nguru (twenty), Nguu (fifteen), North Pare (eleven), Taita Hills (eleven), South Pare (nine), Ukaguru (seven), Rubeho (five), Malundwe Hill (three) and Mahenge (one). We plotted the number of known endemic and red-listed species against survey effort to see whether there was a relationship and tested the significance of this using Spearman's rank correlation.

Correlation with forest area. We used forest area statistics of Burgess *et al.* (1998a) as our source of data, to allow direct comparison with the results of that paper. These data do not indicate the altitudinal range of the forest, merely total area. We plotted the number of known endemic and red-listed species against forest area to see whether there was a relationship and tested the significance of this using Spearman's rank correlation.

Results

Field survey data

There are at least 35 mammal, 107 bird, ten reptile and nine amphibian species in the three Forest Reserves visited

during these surveys. The species richness varies between reserves with Ukwiva having the highest number of vertebrate species (127), followed by 110 species in Mang'alisa and 103 in Mafwomero.

The surveys recorded eleven species endemic to the Eastern Arc Mountains and seven Eastern Arc near-endemic species. Several of these species were not recorded in the lists provided by Burgess *et al.* (1998a). Amongst these are a very distinctive endemic sub-species of the Udzungwa partridge (*Xenoperdix udzungwensis obscurata*). Since submitting this paper, this taxon has been elevated to species level, *Xenoperdix obscuratus* (Bowie & Fjeldså 2005), which has only been recorded from Mafwomero Forest Reserve (Fjeldså & Kiure, 2003), and a new species of frog (*Arthroleptis nikeae*), also from the Mafwomero Forest Reserve (Doggart, 2003; Poynton, 2003). In addition, populations of the newly described akalat *Sheppardia aurantiithorax*, which is also known from the Ukagurus (and one bird from the lowlands of the Ulugurus) (Beresford, Fjeldså & Kiure, 2004), and representatives of the greater double-collared sunbird complex (Bowie, 2003; Bowie *et al.*, 2004) are present.

The Rubehos are also an important location for species threatened with extinction, as assessed against the IUCN Red Data List (IUCN, 2002). Three vertebrate species are categorised as 'endangered' and six as 'vulnerable' (Table 2). The threatened status of some mammals and most reptiles has not been fully established – and some species, particularly chameleons must be of conservation concern. In the case of plants, the Rubehos contain just a single threatened species (Nature Kenya & WCST, 2003), but the area has received little attention by botanists and the plant red data list is itself inadequate and in need of extensive updating for this region (R.E. Gereau and Q. Luke, pers. comm.).

Ranking of the Rubehos for conservation. Plotting numbers of endemic and near-endemic vertebrates allows the different Eastern Arc Block Mountains to be ranked in terms of their conservation priority (Fig. 3a). Data from Burgess *et al.* (1998a) rank the Rubeho Mountain block in the ninth place within the eleven main mountain blocks used in the analysis, just above two smaller areas of uncertain status. The addition of the data presented here changes the ranking considerably, with the Rubehos rising to fifth position, behind the East Usambaras, Ulugurus, Udzungwas and Ngurus.

Table 2 Eastern Arc endemic, near-endemic, and IUCN Red Data-listed species found in the Rubeho Mountains

Species	Eastern Arc endemic or near-endemic	IUCN Red Data List Status (8 February 2005)	Forest Reserve	Recorded range
Mammals				
<i>Galagoides orinus</i> – Usambara galago	E	DD	Mf, Mn, Uk	East Usambara, Uluguru, Rubeho, Nguru, Udzungwa
<i>Rhynchocyon cirnei</i> – chequered elephant shrew		VU	Mn	East Africa
<i>Dendrohyrax validus</i> – Eastern tree hyrax	NE	VU	Mf, Mn	Eastern Arc and Coastal Forests
<i>Loxodonta africana</i> – African elephant		VU	Uk, Mf	Africa
Birds				
<i>Bubo vosseleri</i> – Usambara eagle-owl	E	VU	Mn	E. & W. Usambara, Uluguru, Rubeho, Nguru, Udzungwa, possibly S. Pare
<i>Xenoperdix udzungwensis</i> – Udzungwa mountain partridge	E	EN	Mf	Udzungwa, Rubeho
<i>Sheppardia aurantiithorax</i> – Akalat	E	Not evaluated	Uk, Mf	Ukaguru, Rubeho, Uluguru
<i>Sheppardia sharpei</i> – Sharpe's akalat	NE	LC	Uk	South Pare, E. & W. Usambara, Nguru, Rubeho, Uluguru, Udzungwa (Mufindi) and Rungwe
<i>Modulatrix stictigula</i> – Spot-throat	NE	LC	Mf, Mn, Uk	E. & W. Usambara, Nguru, Rubeho, Ukaguru, Uluguru and Udzungwa (E & W) and Mt Rungwe
<i>Orthotomus metopias</i> – African tailor-bird	NE	LC	Mf, Mn, Uk	E. & W. Usambara, Nguru, Rubeho, Ukaguru, Uluguru, Udzungwa, Matengo Highlands and Njesi Plateau (last in Mozambique)
<i>Scepthomycter winifredae</i> – Mrs Moreau's warbler	E	VU	Uk	Uluguru, Ukaguru, Rubeho, Udzungwa
<i>Ploceus</i> sp.			Mn, Uk	Possible new species
Reptiles				
<i>Crotaphopeltis tornieri</i>	NE	Not evaluated	Uk	E. & W. Usambara, Nguru, Uluguru, Rubeho, Udzungwa, S. Highlands, N. Malawi (Mt Misiku)
<i>Rhampholeon</i> aff. <i>Uluguruensis</i>	E	Not evaluated	Mf	Uluguru, Rubeho
<i>Bradypodion oxyrhinum</i> – Uluguru one-horned chameleon	E	Not evaluated	Mf	Uluguru, Rubeho and Udzungwa
<i>Chamaeleo werneri</i> – Werner's three-horned chameleon	E	Not evaluated	Mn, Uk	Uluguru, Ukaguru, Rubeho and Udzungwa
Amphibians				
<i>Arthroleptis affinis</i>	NE	LC	Mf, Uk	E. Usambara, Nguu, Nguru, Uluguru, Rubeho, Udzungwa and Coastal Forests
<i>Nectophrynoides minutus</i>	E	EN	Mn, Uk	Uluguru, Rubeho
<i>Nectophrynoides viviparus</i>	E	VU	Mf, Uk	Uluguru, Rubeho, Udzungwa and Rungwe
<i>Scolecormorphus kirkii</i>	NE	LC	Mf	Uluguru, Rubeho, Mahenge, Southern Highland, S. Malawi
<i>Arthroleptis nikeae</i>	E	EN	Mf	Rubeho

Red Data list: EN, endangered; VU, vulnerable; LC, locally common; Not evaluated, has not been evaluated by IUCN.

Endemism: E, endemic to the Eastern Arc; NE, near-endemic to the Eastern Arc.

Forest Reserves: Uk, Ukwiva; Mn, Mang'alisa; Mf, Mafwomero.

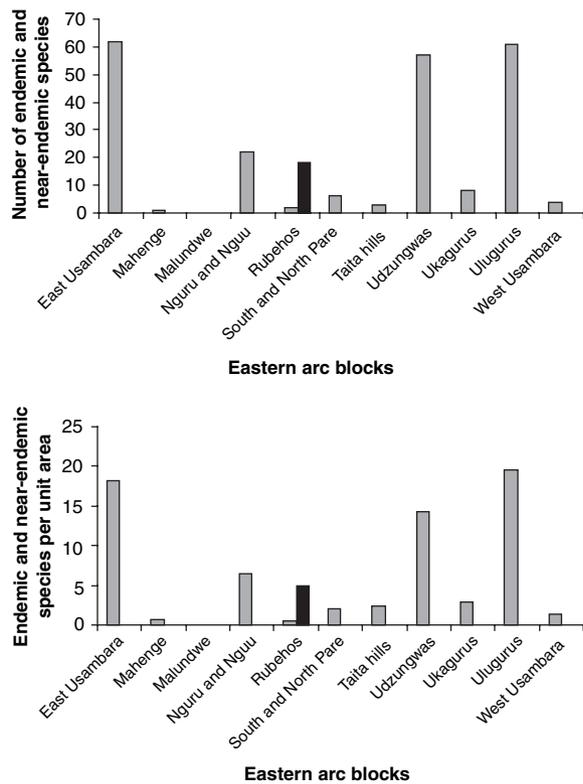


Fig 3 Ranking of Eastern Arc Mountain Blocks according to combined strict and near endemic vertebrate species. (a) Simple summation of Eastern Arc endemic and near-endemic species; (b) index of Eastern Arc endemic and near-endemic species per unit area (for area-correction procedure – see Methods). Both graphs use data from Burgess *et al.* (1998a,b) for grey bars, and the additional new data for the Rubehos from this publication (black bars).

Correction for forest area. Correcting the biological rankings of the Eastern Arc blocks by forest area changes the sequence of importance among the blocks. Specifically, the Ulugurus rank higher than the East Usambaras, followed in rank order by the Udzungwa, the Nguru and Nguu and the Rubeho Mountains (Fig. 3b).

Correlation with survey effort and forest area. The biological ranking of Eastern Arc Mountain blocks is correlated with the number of biodiversity-related references on an area (Fig. 4a,b). For endemic plus near-endemic species, the correlation with number of studies is significant (Spearman's rank correlation coefficient $r_s = 0.79$, $P < 0.005$), and is more significant for red listed species and the number of studies ($r_s = 0.94$, $P < 0.001$) (Fig. 4a,b). The ranking is also influenced by the area of forest remaining,

but only positive trends are seen against endemic plus near-endemic species ($r_s = 0.58$, ns), or threatened species ($r_s = 0.42$, ns).

Discussion

This study shows that the biodiversity of the Rubeho Mountains is richer than previously presented (e.g. in Burgess *et al.*, 1998a), and contains a number of endemic and near-endemic vertebrates, some of which are regarded as threatened by extinction. These new biodiversity data elevate the importance of the Rubeho range within the Eastern Arc, but still place the area behind the East Usambara, Uluguru or Udzungwa Mountains (and possibly below the Ngurus – Romdal, 2001a,b). However, for several groups – e.g. reptiles and amphibians – studies of the Rubeho forests have been far from comprehensive. In addition, there have been no adequate surveys of plants, nor any invertebrate animals – both of which show exceptional endemism in the region. Further studies in the Rubeho Mountain block are almost certain to discover additional new species of vertebrates, plants and invertebrates.

In terms of biogeographical affinities, the fauna of the Rubehos is typical of the Eastern Arc Mountains (Lovett & Wasser, 1993; Burgess *et al.*, 1998b; Burgess *et al.* 2004). The Rubehos share eleven Eastern Arc endemic or near-endemic species with the Ulugurus (Doggart *et al.*, 2001; Burgess, Doggart & Lovett, 2002) and ten with the Udzungwas (e.g. Jensen & Brøgger-Jensen, 1992; Frontier Tanzania, 2001). Seven species are shared with the more distant Usambara Mountains (Burgess *et al.*, 1998a). The affinities of the fauna are higher with the nearby Eastern Arc mountain ranges than with those further distant, an issue that is explored more fully by Fjeldså *et al.* (in press). The avifauna of the upper montane forests of the Udzungwas and Rubehos are particularly similar, but the Rubehos lack forest species typical of the lower montane and submontane zone as there is little forest cover at the relevant altitudes.

The documented biological importance of the different Eastern Arc Mountain forest blocks appears to be significantly affected by the amount of biological study that has been expended, assessed here as the number of publications relating to that area (Fig. 4a,b). However, there are additional factors to consider. For example, in the smaller forest sites, only a few surveys are required to assess their biological importance. For the larger and more complicated

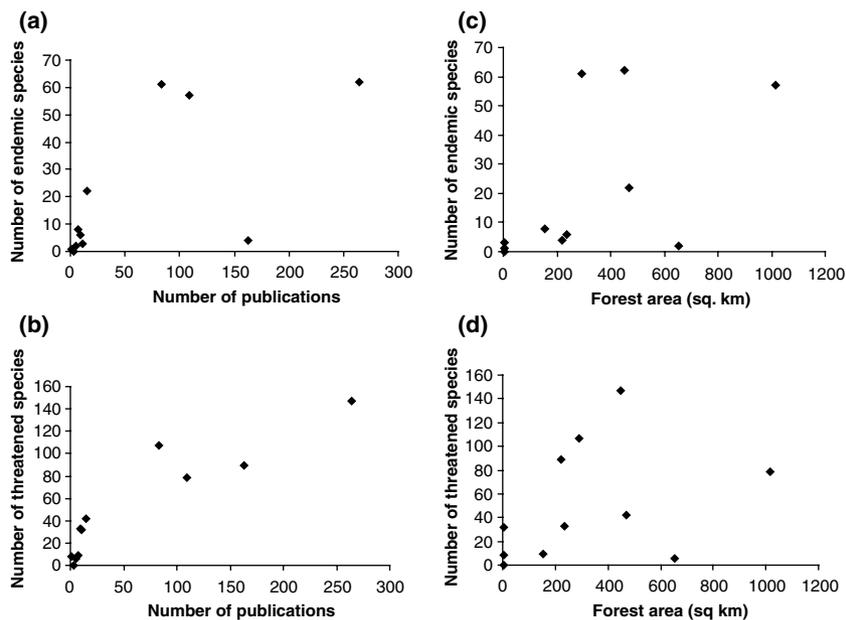


Fig 4 Relationships between number of biodiversity-related publications (Isango, 2001) and (a) number of endemic and near-endemic species (Burgess *et al.*, 1998a,b, updated), or (B) number of Red Data Book threatened species (IUCN, 2002) and between forest area (Burgess *et al.*, 1998a) and (c) number of endemic and near-endemic species, or (d) number of Red Data list threatened species.

sites, several surveys are required to fully characterize the area. Historical and logistical factors have mainly led to the imbalance of survey effort. Particularly in the case of the larger forests, this seems to have resulted in a skewed interpretation of the relative importance of some mountain blocks. Priorities for future biological investigation, in addition to additional studies of the Rubeho forests, are the Ukaguru range, Malundwe forest within Mikumi National Park, the Nguu and Nguru Mountains. There are also other smaller forested outliers of the Uluguru range, and several of the other poorly known blocks. These may also contain biologically valuable forest habitats.

The biological importance of the different blocks is also related to the area of forest remaining. Our studies are quite simplistic in this regard as we simply sum up the known forest area. In fact, the altitudinal variation of the forest will also affect the species assemblage and consequently the importance of the block. Data are not available on the altitudinal distribution of forest across the Eastern Arc mountains, and hence the area of forest remaining at different altitudinal bands is unknown. These data are being generated by the project 'Conservation and Management of the Eastern Arc Mountain Forests' funded through the Global Environment Facility (GEF), using remote sensing data across the Eastern Arc, but the data are not yet available. Despite this limitation, using overall forest area as an analytical layer provides a

first approximation on the effects of forest area on biological importance, which can be tested and refined as further data become available.

Finally, our field surveys to the Rubeho forests have also permitted a general understanding of the threats facing these forests. The three main areas of forest on the Rubeho Mountains – Ukwiva, Mafwomero and Mang'alisa – are all gazetted as Central Government Forest Reserves managed 'principally for the purpose of protection of watersheds, soil conservation and the protection of wild plants' (Ministry of Natural Resources and Tourism, 2002). They are administered from Kilosa in Morogoro Region (Ukwiva) and Mpwapwa in Dodoma Region (Mang'alisa and Mafwomero). With the exception of Mang'alisa, the reserve boundaries appear to have been respected. In Mang'alisa, at least 20 ha (0.4%) of forest had been cleared between 2000 and 2001 to provide land for bean and tobacco farms, which are supplying commercial markets in Malolo. Although no systematic surveys of disturbance were undertaken, based on our experience in other Eastern Arc Mountains, there was a relatively high rate of pitsawing in Mafwomero. In Ukwiva, we observed low levels of logging and pole cutting, as well as several hunting camps. We received reports that elephants are being poached in the reserve for meat and ivory. The management capacity of the forestry department in this area is weak and

it is hard for their limited staff and tiny budgets to adequately manage the reserves. As a result of the high conservation importance of these Forest Reserves, and the conservation needs identified, there is a need for additional support for forest management in this area. In conclusion, there is much scope for effective conservation action in the Rubehos. A well-designed and implemented project could do much to reduce threats and improve the prospects for the long-term survival of the forests and their biodiversity.

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