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Geographical and altitudinal distribution of birds endemic to the Albertine Rift

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For 37 endemic bird species from the Albertine Rift identified by Stattersfield *et al.* (1998), georeferenced collections of the Royal Museum for Central Africa (Tervuren, Belgium; n = 2266), The Field Museum (Chicago, USA; n = 774) and the Los Angeles County Museum, (Los Angeles, USA; n = 485) were pooled. Geographical distribution maps were plotted and altitudinal profiles (based on data provided by the collectors) were prepared. Because specimen information has an historical component, these data provide a base line for documenting historical changes and can help direct conservation and fieldwork priorities. There is a relationship between horizontal and vertical distributions. In general, more widespread species also occur over a wide range of altitudes. Most species with restricted ranges occur in a small band at the lower edge of the mountane forest, or below that, in transitional forest. Thus, they are submontane and generally have their distribution centres W of the Rift. Poorly known species also appear to fall into this group. These submontane species are of greatest conservation concern and should be a focus for future studies. There are no high altitude specialists among the endemic species. Distribution maps for individual species will be made available on web sites of our institutions. Until maps can be based on global collections and field observations, present plots are working documents. Gaps in information are identified and using a Parsimony Analysis of Endemicity approach, an hypothesis of relationships among the montane areas of the Albertine Rift is presented.

INTRODUCTION

The Albertine Rift encompasses a series of mountain chains adjacent to the Rift lakes in Central-East Africa; the major part is situated in the eastern Democratic Republic of Congo. Most mountain ranges peak between 2000–3500 m, with the Ruwenzori Mountains reaching 5110 m. Historically, montane forest covered the area from 1600–3500 m, frequently mixed with, or replaced by bamboo at higher elevations. Depending on rainfall and altitude, there are different types of montane forest (Vande weghe 1988a), with profound, yet poorly understood effects on bird distribution (Vande weghe 1988a; Dowsett-Lemaire 1990). Above the forest, are afroalpine grasslands, ericaceous shrublands and moorlands, according to humidity, exposition and soil (Prigogine 1985; Davis *et al.* 1994). Rift mountains with endemic birds stretch for some 1200 km from the Lendu plateau, W of Lake Albert at 2°N to the Marungu Highlands at 7°30'S (Stattersfield *et al.* 1998).

Studies of birds in the Albertine Rift date back to Chapin (1932–1954) and Schouteden (1948–1960, 1966, 1968–1969). Reports of field work and reviews for mountains or forests have been published for the areas W of Lake Albert (Vrijdagh 1949), W of Lake Edward (Prigogine 1953), the Virungas (Wilson 1982; Mertens 1986; Pedersen & Languy 1994), the Ruwenzoris (Verheyen 1947; Curry-Lindahl 1960; Francis & Penford 1991), Bwindi (= Impenetrable) forest (Keith *et al.* 1969; Friedmann & Williams 1970; Butynski & Kalina 1989; Kalina & Butynski 1996), W of Lake Kivu (= Kahuzi Biega National Park) (Merz 1995; Programme OBICO Rift Albertine 1996), Idjwi Island (Prigogine 1967, 1973), Nyungwe (= Rugege) (Kunkel & Kunkel 1969; Dowsett *et al.* 1988; Dowsett-Lemaire 1990), Itombwe (Prigogine 1971–1984; Stubbs 1988; Wilson & Catsis 1990), Bururi (Gaugris 1976, Gaugris *et al.* 1981, Vande weghe & Loiselle 1987), Kabobo (Prigogine 1960), Kungwe-Mahale (Moreau 1943; Ulfstrand & Lamprey 1960) and the Marungu (Dowsett & Prigogine 1974).

Several taxonomic papers presented distribution maps (e.g. Prigogine 1975a, 1979a, 1979b, 1980a; Louette *et al.* 2000). Prigogine (1975b, 1980) discussed altitudinal ranges. Otherwise this information is scattered, but Prigogine (1985), Dowsett-Lemaire & Dowsett (1990) and Stattersfield *et al.* (1998) presented overviews of the occurrence of the endemic species in the different mountain ranges. Differences between these sources revolve mainly around different taxonomical views, some errors in Prigogine (1985; see Dowsett-Lemaire & Dowsett 1990), an oversight of Stattersfield *et al.* (1998) concerning Blue-headed Sunbird *Nectarinia alinae* in the Marungu, and the fact that Stattersfield *et al.* (1998) considered six species as typical of lowland forest (Schouteden's Swift *Schoutedenapus schoutedeni*, Sassi's Greenbul *Phyllastrephus lorenzi*, Forest Ground-thrush *Zoothera oberlanderi*, Bedford's Paradise-flycatcher *Terpsiphone bedfordi*, Yellow-legged Weaver *Ploceus flavipes*, Golden-naped Weaver *Ploceus aureonucha*). We are aware of different taxonomic opinions (Prigogine 1985; Short *et al.* 1990; Dowsett-Lemaire & Dowsett 1990; Dowsett & Dowsett-Lemaire 1993), but for convenience, we follow the taxonomic treatment of Stattersfield *et al.* (1998).

Prigogine's studies relied heavily on his specimen collections, deposited in the Royal Museum for Central Africa (RMCA), Tervuren. In the present study, we have enlarged the dataset by pooling computerised specimen data from the holdings of three museums, as part of a larger concerted study of the distribution and conservation of Albertine Rift birds. Relationships between horizontal and vertical distributions are investigated, and some distribution examples are presented.

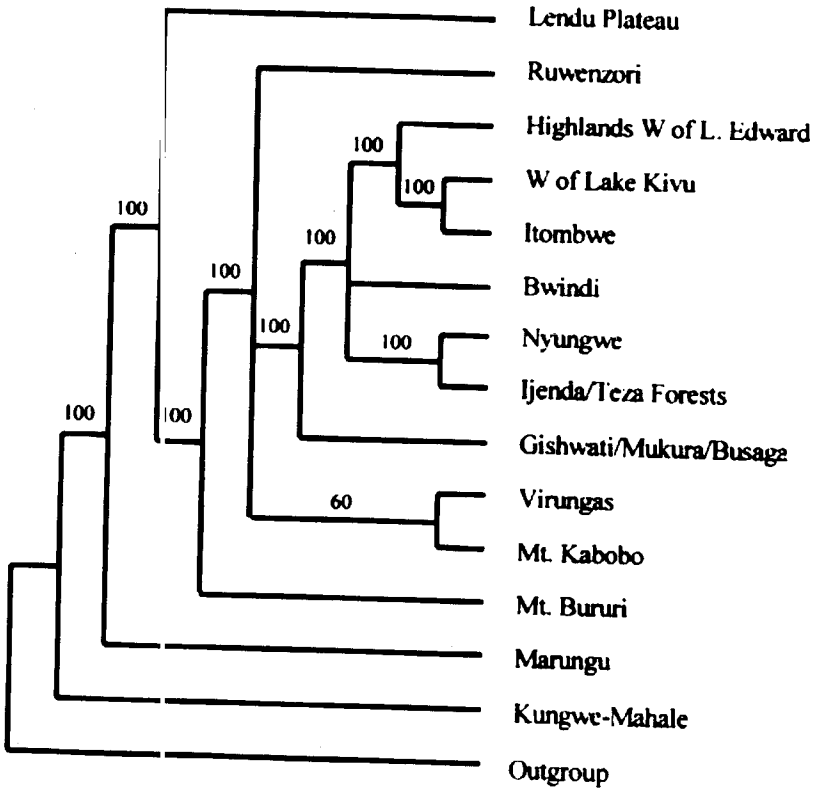

FIG. 1. Results of a Parsimony Analysis of endemism analysis on the presence or absence of endemic bird species in the Albertine Rift highlands. The tree is a 50% majority-rules consensus tree of 15 most parsimonious trees.

RESULTS

The 37 species show a variety of patterns in distribution both with respect to altitude and geography (Table 1). We found one range extension overlooked by Stattersfield *et al.* (1998): an endemic race of *Nectarinia alinae* has been described from the Marungu (Dowsett & Prigogine 1974; Prigogine 1975a; Dowsett-Lemaire & Dowsett 1990).

The Parsimony Analysis of endemicity analysis yielded 15 most parsimonious trees of 63 steps (Fig. 1, C.I. = 0.552). A 50% majority-rules consensus tree of these trees shows a core group, with more northern and southern areas falling to the base of the tree because they lack many taxa. Within the core, there is evidence for separation of areas W of the Rift (highlands W of Lake Edward, W of Lake Kivu, and Itombwe) from eastern areas (Fig. 1). Seventeen of the 37 species (46%) are distributed in ways that are completely consistent with the most parsimonious trees (these species have a character C.I. of 1.00); 14 others have a C. I. of 0.5 and six have a C.I. of 0.33.

Altitudinal estimates (Table 1) differed between sources: some referred to different altitudinal zones in different mountain ranges (Prigogine 1974, 1975a, 1979a, 1979b, 1980a) or on opposite sides (E *versus* W) of the mountain (Dowsett-Lemaire 1990), possibly in response to the humidity gradient (Vande weghe 1988a, 1988b).

There is a positive relationship between how widespread an endemic species is (how many mountains it occupies) and the altitudinal range it occupies. A similar relationship exists for the maximum altitude species reach (Fig. 2a), but not for the minimum altitude ($r = -0.29$, NS, not shown). Hence, there is a trend caused by a group with small ranges occurring rather low on the mountains (down to the transitional forest), and a group of widespread species that occur over a wide range of altitudes. Indeed, there is a strong positive relation between the altitudinal range and the maximum altitude, but not with the minimum altitude (Fig. 2b). Using current species-level taxonomy, there appear to be no alpine endemic birds in the Albertine Rift.

Many of the 'low-elevation small-range' species appear to be uncommon, and there are few specimens in collections. Recent elevational information on *Phodilus prigoginei* (Butynski *et al.* 1979; Dowsett-Lemaire 1990) suggests it also belongs in this category. The other two most data-deficient species (*Caprimulgus prigoginei, Sylvietta chapini*) may also. In order to provide a basic picture of the collection effort and distribution of specimens from the region we have plotted collecting localities with reference to the respective number of species and specimens that have been collected at each site (Fig. 3a,b). What is apparent from these figures is that although collectors have worked at many sites throughout the region and at all elevations, the number of both species and specimens is quite low at most sites. However, judging from the distribution pattern of widespread species (see e.g Fig. 4a: *Nectarinia regia*), the relatively low samples did not strongly affect the obtained pattern. Consequently, the western bias found

TABLE 1. Range size (number of mountain ranges occupied) and altitudinal ranges of Albertine Rift endemics. Underlined species are those where species rank has been questioned; three poorly known species are in parenthesis.

Species	Code	Number of Specimens	Known from n ranges	Lowest altitude (m)	Highest altitude (m)	Altitudinal range (m)
Francolinus nobilis	Frno	50	11	1050	3700	2650
Ruwenzorornis johnstoni	Rujo	125	10	1770	3700	1930
(Phodilus prigoginei)	Phpr	1	2*	1800	2200	400
Glaucidium albertinum	Glal	4	4	1120	1690	570
(Caprimulgus prigoginei)	Capr	1	1	1280	1280	-
Caprimulgus ruwenzorii	Caru	17	10	1600	3210	1610
Indicator pumilio	Inpu	15	8	1500	2500	1000
Pseudocalyptomena graueri	Psgr	33	3	1730	2480	750
Coracina graueri	Cogr	51	5	1140	1900	760
Chlorocichla prigoginei	Chpr	13	2	1280	1725	445
Prionops alberti	Pral	95	5	1120	2500	1380
Zoothera tanganjicae	Zota	26	10	1520	2900	1380
Alethe poliophrys	Alpo	193	10	1200	3000	1800
Cossypha archeri	Coar	132	10	1600	4300	2700
Kupeornis rufocinctus	Kuru	65	4	1490	3220	1730
Kupeornis chapini	Kuch	34	4	1020	1660	640
Apalis ruwenzorii	Apru	176	11	1550	3100	1550
Apalis personata	Appe	124	11	1270	3000	1730
Apalis argentea	Apar	1	4*	1300	2350	1050
Apalis kaboboensis	Apka	19	1	1660	2480	820
Bradypterus graueri	Brgr	44	7	1900	2600	700
Graueria vittata	Grvi	33	7	1540	2300	760
(Sylvietta chapini)	Sych	3	1	1500	1500	-
Hemitesia neumanni	Hene	48	7	1200	2350	1150
Phylloscopus laetus	Phla	306	12	1110	3210	2100
Melaenornis ardesiacus	Mear	81	7	1290	2450	1160
Muscicapa lendu	Mule	9	4	1470	2150	680
Batis diops	Badi	206	11	1340	2780	1440
Parus fasciiventer	Pafa	100	10	1800	3400	1600
Nectarinia alinae	Neal	367	13	1320	3280	1960
Nectarinia stuhlmanni	Nest	67	1	2020	4070	2050
Nectarinia regia	Nere	513	12	1330	3000	1670
Nectarinia rockefelleri	Nero	11	3	2050	3300	1250
Nectarinia purpureiventris	Nepu	107	9	1480	2680	1200
Cryptospiza jacksoni	Crja	223	12	1250	2600	1350
Cryptospiza shelleyi	Crsh	59	10	1550	3500	1950
Ploceus alienus	Plal	238	11	1500	2700	1200

* Taxon reported in literature from some areas, but no specimens.

MATERIAL AND METHODS

For the 37 endemic species (as identified by Stattersfield *et al.* 1998), the computerised specimen holdings of the RMCA, the Field Museum of Natural History (FMNH), Chicago and the Los Angeles County Museum (LACM) were pooled (3525 fully georeferenced specimens, see Table 1 for samples sizes/species): RMCA, n = 2266; FMNH, n = 774 and LACM, n = 485. Distribution plots were made with ArcView GIS V3.0a by ESRI using their Digital Chart of the World. The number of mountain blocks (*sensu* Stattersfield *et al.* 1998) in which a species has been recorded is used as a simple measure of range size. Three species (Congo Bay-owl *Phodilus prigoginei*, Itombwe Nightjar *Caprimulgus prigoginei* and Chapin's Crombec *Sylvietta chapini*) are so poorly known that they only marginally can be discussed.

Georeferencing the approximate collection localities on labels, and then allocating an altitude to these co-ordinates was considered too imprecise. Thus for altitudinal profiles, records were used only where collectors themselves provided an altitude on the specimen label (i.e. only in about half the specimens). Extremes were viewed with caution, because sometimes 'base-camp' altitudes are stated on labels (Prigogine 1979a). Three specimens were rejected as improbably far out of range: A Ruwenzori Turaco *Ruwenzorornis johnstoni* at 1200 m at Mutwanga in the Virungas, a Red-throated Alethe *Alethe polyophrys* at 960 m at Mahila on Mt. Kabobo and a Yellow-crested Helmet-shrike *Prionops alberti* (the type!) at 4400 m from the top of Mt. Mikeno (a presumed straggler, Prigogine 1975). Literature was scanned (e.g. Britton 1980; Short *et al.* 1990), and minimum, maximum and altitudinal range were determined.

To provide an initial assessment of biogeographical relationships in the region, a Parsimony Analysis of Endemism (following Bates *et al.* 1998) was conducted for the 37 species using our data and a table from Stattersfield *et al.* (1998: p. 367). This approach generates a hypothesis of area relationships using taxa (in this case endemic species) as characters and areas as taxa. Parsimony analyses were conducted using PAUP (version 4.0b4a for Macintosh), written by David L. Swofford. Consistency indices (C.I.) excluding uninformative characters also were calculated. These indices provide information on how well a character or characters fit on a given tree. The data also were investigated using the program MacClade (version 3.05, W.P. and D.R. Maddison, 1992, Sinauer Associates, Sunderland, Massachusetts).

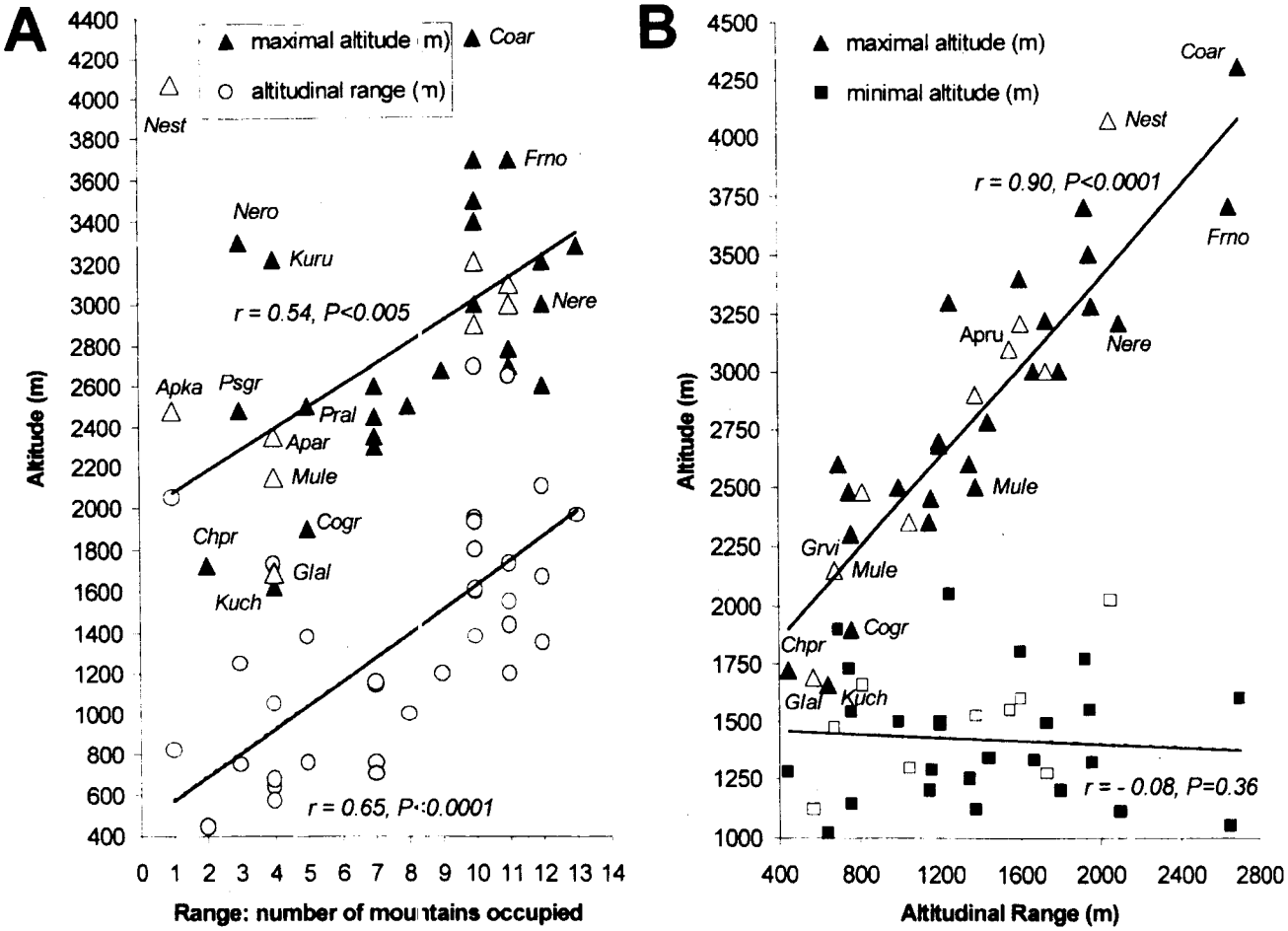

FIG. 2. Range trends for Albertine Rift endemic bird species: (a) Relationship between horizontal distribution (number of mountains occupied) and vertical distribution (maximal altitude and altitudinal range); (b) Relationship between altitudinal range and maximal and minimal altitude of range; Open symbols are species for which the species rank is subject of debate. Species codes (see Table 1) are given for maximal altitude and a few selected species.

in the distribution pattern of the submontane species (e.g. Fig. 4b: *Prionops alberti* and *Graueria vittata*) is genuine and not the result of biased collecting.

DISCUSSION

For the species with small samples (Table 1), little new range information can be added to published knowledge with the present dataset. For completeness, Table 1 does include some entries for species that are not currently documented by museum specimens. World-wide consolidation of information from all specimens and field observations is recommended here, and will be attempted in future. Additional field data also will be essential to improve our knowledge.

One might predict that species that occur at lower altitudes would be more likely to disperse widely to the base of other mountains, while species occurring at higher altitudes should be more likely to become isolated on different mountains. The endemic birds of the Albertine Rift appear to exhibit the opposite trend: species that occur at higher elevations also occupy more mountain ranges, while those restricted to fewer mountains have narrow altitudinal ranges on the lower slopes (Fig. 2). Taxa with uncertain species rank do not affect this relationship (Fig. 2). Only Stuhlmann's Double-collared Sunbird *Nectarinia stuhlmanni* is exceptional, when considered an endemic of the Ruwenzoris (Fig. 2a). Although there is some circularity in this argument, its aberrant position rather suggests it might better be lumped with the group of similar taxa, that occupies the remainder of the Rift mountains (see also Prigogine 1979a; Sibley & Monroe 1990; Dowsett & Dowsett-Lemaire 1993). In contrast to other high mountains in Africa, the Albertine Rift is not known to have any endemic bird species restricted to high altitudes. There are endemic taxa for the alpine zone (e.g. Prigogine 1975), but their subspecific status has not been questioned. Compared to other afromontane faunas, the Rift is lacking endemic species of scops owl, cisticola or prinia, bush shrike, starling, white-eye and canary.

Vande Weghe (1988a) offers an intriguing hypothesis for the wide distribution of montane species. They do not appear to be so strictly dependent on forest, and may during drier periods have been more widespread, occupying drier habitat. Therefore, their wide altitudinal distribution is not so much due to a 'tolerance' of drier and more open habitats at high altitudes, but instead that they are capable of using lower elevation forest to some extent. Data on habitat preferences and abundance in different forest types could help solve this enigma. It is also likely that the wide altitudinal ranges of some species contain elements of altitudinal migration: see e.g. the comments of Kunkel (1966) on sunbirds, Prigogine (1980b) on cuckooshrikes, and Prigogine (1971, 1975b) on unexpected wanderings of *Prionops alberti* (both, above and

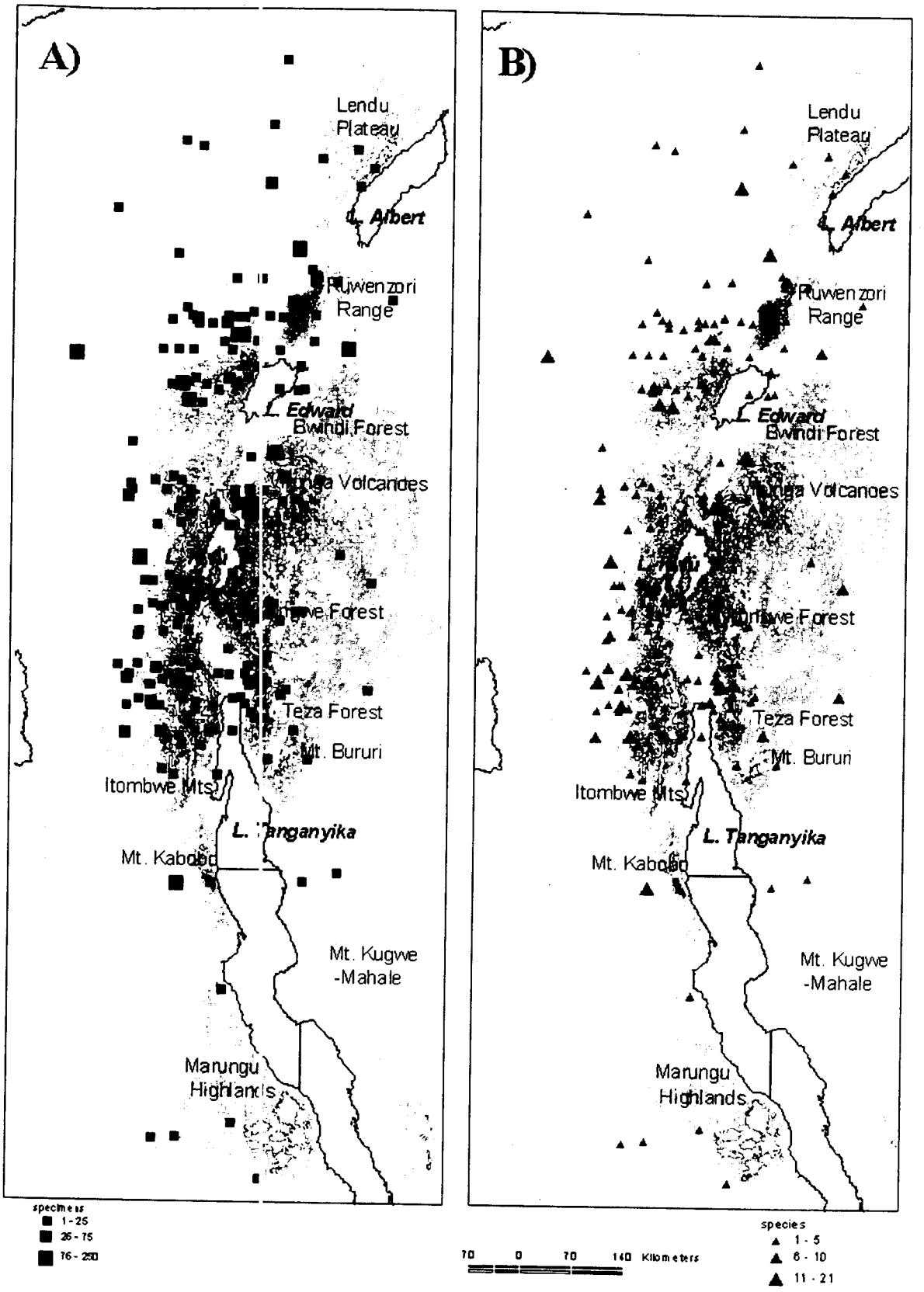

FIG. 3. Plots of collection localities for Albertine Rift endemics. (a) Symbols reflect the number of specimens from a site. (b) Symbols reflect the number of species collected from a site. Collection localities for individual species are available on the World Wide Web.

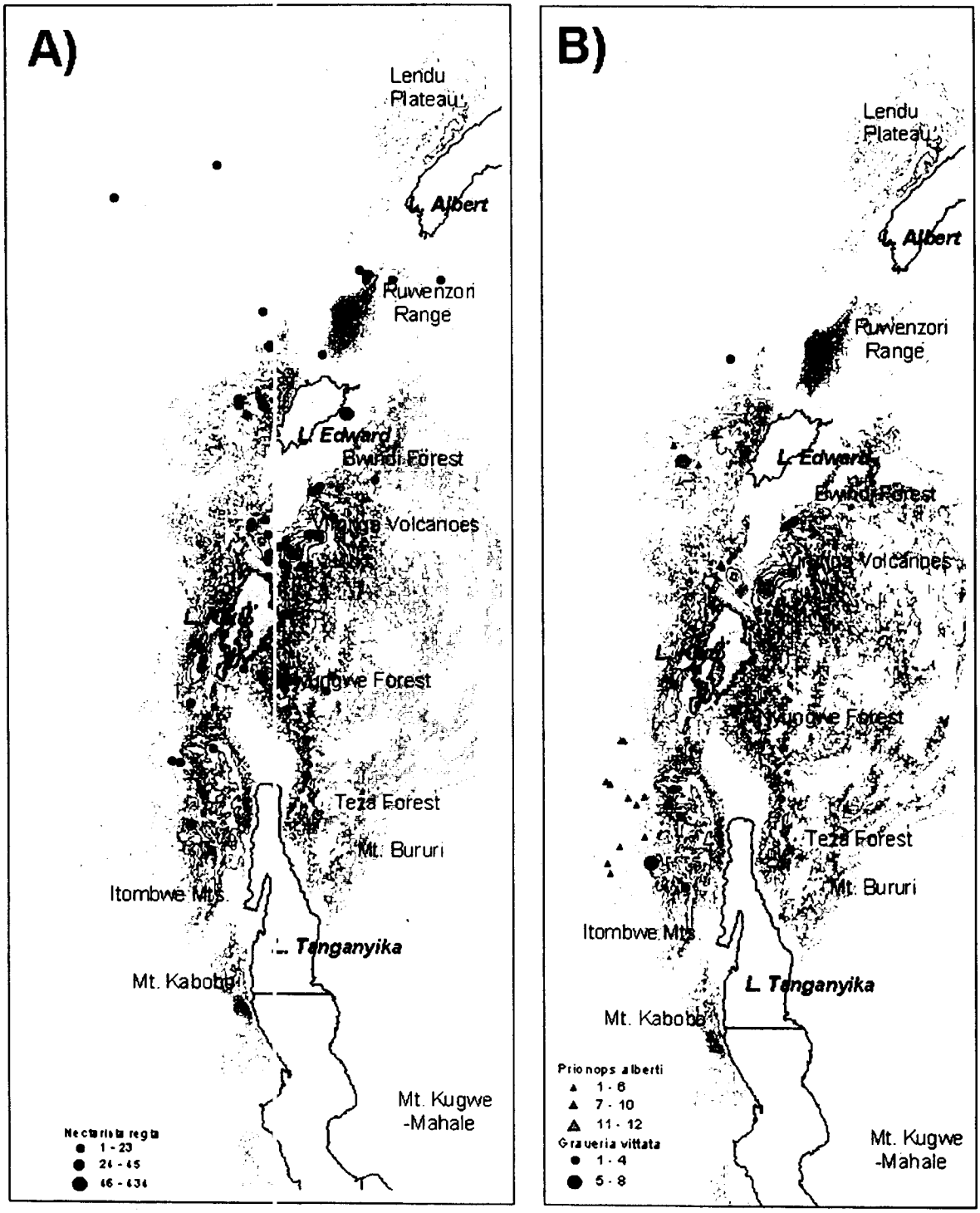

FIG. 4. Specimen plot of a widespread montane species (a: *Nectarinia regia*) and two low-elevation montane species (b: *Prionops alberti* and *Graueria vittata*).

below the normal range). Possible altitudinal movements of birds remain to be studied in the Albertine Rift.

Thus, the Albertine Rift endemics could be split into a group of montane species and a group of submontane rain forest species. Four of the six species that define the eastern Congo Basin Endemic Bird Area also reach well into the transitional forest (Stattersfield *et al.* 1998), and it can be argued that their separation from the Albertine Rift submontane forest group is arbitrary. We would suggest that these two adjacent EBA's would best be combined into a single unit for conservation planning.

Generally, there is more area at lower altitudes and less at higher altitudes on a mountain. Assuming that lower altitudes also are generally more accessible to collectors, the small numbers collected for several of the submontane endemics is puzzling. Unless sampling was persistently biased towards higher altitudes (for which there is no evidence), this appears to suggest that many of the lower-altitude species have always been uncommon. Given that the lower slopes are first subjected to deforestation (Prigogine 1985; Stattersfield *et al.* 1998), this points to an inherent vulnerability of these taxa. Clearly, there is a high priority for the collection of further field data in what remains of the transitional forests and the lower ranges of the montane forests, and for the conservation of these sites. However, when a species has been rarely collected from the more accessible, initially larger areas of low-altitude forest, what are the chances that it might have been encountered on the more difficult to reach and smaller land surfaces on the higher slopes? Possibly, some of these rare and apparently submontane species have not yet been discovered at higher altitudes. Similarly, the complete absence of high altitude specialists suggests that something may have been overlooked. Additional fieldwork at higher altitudes should not be ignored.

We hope to further collate and share information on the Albertine Rift fauna and we hope to collaborate with others in this endeavour. While museum collections may reconstruct and clarify some of the historical' data, information on the current situation in the field is most critical for conservation. Prigogine (1985) already expressed uncertainty whether any forests remained on the Lendu Plateau, and large portions of mid elevation forest have been lost from other regions. The great need for additional study of the biodiversity of the Albertine Rift was highlighted recently by Myers *et al.* (2000) who could not include the region among their global hotspots because they did not consider the region well enough known.

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