FARSYMABI PROJECT

'A farming system approach to mainstream biodiversity in the agricultural sector: bridging between the national and local levels'

RESEARCH REPORT
HOW DOES DEFORESTATION AFFECT BIRD POPULATIONS ON MOUNT NAMÚLI?

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I. EXECUTIVE SUMMARY

This report presents a comprehensive overview of how the deforestation of Mount Namuli is affecting the diversity and composition of its bird communities, as well as the occurrence of endemic and threatened bird species. This assessment was based on cross-sectional data (from the Mount Namuli bird inventory, September 2023) used to compare diversity and composition indicators across habitat types that are taken as different stages of deforestation i.e. forests, fallows, and cropland, simultaneously; rather than by examining changes over a period of time.

The diversity and composition changes associated with deforestation are analysed in separate for the montane and low-elevation levels. In fact, montane and low-elevation forests are two ecologically different worlds, with different species compositions, and are also in completely different steps of the deforestation process (low-elevation forests are in a much more advanced stage of the deforestation process).

The main changes in diversity and composition we can associate with deforestation in Mount Namuli are:

- In montane environments, (alpha) species diversity seems not to vary along the deforestation gradient (forest->old fallows->young fallows->cropland). However, there is a loss of threatened and endemic species, which are replaced by cosmopolitan, large-distribution species; there is also a strong turnover of forest species, which are replaced by open-habitat ones. Curiously, many montane open-habitat communities become similar to those of lower-elevation open-habitat communities, a fact that we have captured in our cluster analysis. Both the expansion of cosmopolitan, large-distribution species and the homogenization of montane and lowland communities are local examples of biodiversity loss through the homogenization of biota across the planet.
- In low-elevation environments, species diversity decreases along the deforestation gradient. On the other hand, in low-elevation environments, we did not find any species of conservation concern or restricted range species in any of the count points carried out below 1500 m asl.
- For both the montane and the low-elevation levels, migratory species seem to be circumscribed to open habitats, that is those at more advanced stages of the deforestation process, i.e. young fallows followed by cropland areas, or naturally open habitats (e.g. grasslands). Denser, pristine forest habitats, at both altitude levels seem to be less permeable to migrants, probably because of denser niche filling by resident species.
- For montane environments, family diversity has a minimum in young fallows. For low-elevation environments, median family diversity decreases along the deforestation gradient, similarly to species richness and diversity.
- There is a higher contribution of ground invertivores for pest predation in cropland points in both montane and low-elevation points. Frugivores prefer forests (and also old fallows at montane levels), thus favouring seed dispersal between forest

fragments. Nectarivores show a preference for fallows, with old fallows being more favourable at the montane level and young fallows at the low-elevation level. Seed predation by ground granivores, at the montane and low-elevation levels, is practically absent from forests, suggesting ground granivores preference for open habitats with plenty of seed-producing plants (both crops and wild species). These patterns highlight the importance of landscape-level habitat diversity supporting various ecological functions and suggest complex potential impacts of farmland expansion on the associated ecosystem services. That is the expansion of farmland in the montane mosaic may lead to less seed dispersal in a fragmented forest landscape and the consequent gradual impoverishment of the plant diversity of the forest fragments.

The main impacts of deforestation on the diversity and composition of bird communities in Mount Namuli were also assessed by comparing several clusters representing different types of such communities. Some of the main results of this assessment are:

- At the montane level, the species diversity and also functional diversity (feeding niches) is maximum in forest and minimum in forest-farmland edges and transitions (fallows). Thus, deforestation and forest fragmentation, which expand edge and transition habitats are main drivers of the loss of taxonomic and functional diversity, as well as (as seen above) of the replacement of threatened and restricted-range, endemic species by cosmopolitan ones, leading to biota homogenization.
- At low-elevations, the species and also functional diversity (feeding niches) is maximum in the forest-farmland edges and transitions (old fallows). This may result from the fact that, at low elevations proper, extended forests do not exist anymore. At these levels, the remaining riparian (edge) forest habitats and old fallows may, nevertheless, be important to support ecological functioning and ecosystem services. These habitats seem not to support anymore any threatened or restricted-range, endemic species, whose come back would require extensive ecosystem restoration.

Based on the presented impacts of deforestation, we suggest the following conservation strategies for the conservation of bird diversity in Mount Namuli, and for the contribution of this diversity to local ecological functioning, the conservation of globally threatened species and the prevention of biotic homogenization:

- At the montane level, conservation requires halting deforestation by protecting the remaining forest from further conversion into farmland and reducing forest degradation (fire). Both of these processes are reducing and fragmenting the area of remaining habitat, which is key to conserve threatened and restricted range species and to prevent the expansion of species-poorer, edge habitats and cosmopolitan species. This requires stopping cropland expansion at the montane levels, e.g. by producing more on existing cropland or elsewhere (land sparing) or by the diversification of local livelihoods away from agricultural activities alone.
- At the low-elevation level, conservation requires either:
    - Restoration of low-elevation forest (less cropland) combined with intensification in existing cropland (land sparing); provided that restoration is done in a sufficient scale this strategy could aim at bringing back the

restricted-range, endemic and threatened species that once inhabited lowland and mid-altitude forests in the Namuli.

- The promotion of old fallows (land sharing) through longer rotations with more years of successive cropping, which implies conserving soil fertility during the cropping years and delaying the start of the fallow period. This strategy would not bring back the restricted-range, endemic and threatened species that once inhabited lowland and mid-altitude forests, but could promote ecological functioning and ecosystem services.

II. CONTEXT

The project titled 'A farming system approach to mainstream biodiversity in the agriculture and planning sectors: bridging between the national and local levels', also known as the FARSYMABI project, aims to understand the trade-offs and complementarities between the goals of poverty alleviation, food security, and biodiversity conservation, through a farming systems approach.

In the context of developing countries like Mozambique, where small-scale family farming prevails, and where the expansion of farmland has been cited as the primary threat to biodiversity and ecosystem services, this analysis is essential. It identifies the need and strategies for establishing connections between the national policy framework for mainstreaming biodiversity into agriculture and the socio-ecological context of successful local interventions.

Mount Namuli in the Zambezia province has been selected as one of the case studies for the FARSYMABI research project, owing to its biological diversity, the unique characteristics of its montane forest ecosystem, and its socio-ecological context. This case study aims to identify the main issues, potentialities, and opportunities in order to propose strategies and policies tailored to the context, which will minimize undesirable impacts as well as enhance its potential.

Regarding the bird inventory on Mount Namuli, field records of birds in 139 count points and the description of habitat in each point were made, between the 7th and 28th September 2023, in a file with the format exemplified in Appendix VI.I. For each bird species, the observed number of individuals in each point was divided between individuals observed at a distance < or >= 30 meters. Only bird records at < 30 m distance were used in the analyses.

This report presents a comprehensive overview of how deforestation affects bird populations, drawing on data from the Mount Namuli bird inventory. It concludes with the suggestion of conservation strategies to protect avian biodiversity in this area, as a means to contribute for local ecological functioning and the conservation of globally threatened species. For an in-depth look at our research methods and findings, please refer to Appendix VII.II.

III. IMPACTS OF DEFORESTATION

III.I. IMPACTS OF DEFORESTATION PER HABITAT TYPE

To analyse the impacts of deforestation, we use cross-sectional data to compare areas at different stages of deforestation, i.e. forests, fallows, and cropland, simultaneously, rather than examining changes over a period of time.

The impacts of deforestation need to be analysed in separate for montane and low-elevation forests. Montane and low-elevation forests are two ecologically different worlds with different species compositions. Out of the 88 bird species recorded in the 139 count points carried out in the Namuli, in September 2023, 18 (22) species were only (mostly) observed in montane points, in particular in montane forests, 40 species were only observed at low-elevation points, and 30 species were found on both types of points (4 of which mostly observed at montane levels) (see Table 1 for detailed bird species lists for each environment). Note that a total of 119 species was observed during the field work in July and September 2023 (of course, not all recorded in the count points), 16 of which were not yet recorded in the area of Mount Namuli (not included in the consolidated species list in Timberlake et al 2010).

Table 1. List of observed bird species at montane and low-elevation environments or both

Montane environments:	**Low-elevation environments:**	**Both Montane and Low-elevation environments:**
1. Pternistis hildebrandti;	*1. Streptopelia semitorquata;*	*1. Apus barbatus;*
2. Columba arquatrix;	*2. Turtur afer/chalcospilos;*	*2. Tauraco livingstonii;*
3. Cryptolybia olivacea;	*3. Treron calvus;*	*3. Hieraaetus ayresii;*
4. Chlorophoneus nigrifrons;	*4. Centropus superciliosus;*	*4. Accipiter tachiro;*
5. Corvus albicollis;	*5. Chrysococcyx klaas;*	*5. Apaloderma vittatum**;*
6. Elminia albonotata;	*6. Accipiter minullus;*	*6. Lophoceros alboterminatus;*
7. Apalis lynesi;	*7. Merops pusillus;*	*7. Pogoniulus bilineatus;*
8. Bradypterus lopezi;	*8. Stactolaema leucotis;*	*8. Dendropicos fuscescens;*
9. Arizelocichla milanjensis;	*9. Pogoniulus chrysoconus;*	*9. Batis dimorpha**;*
10. Phyllastrephus flavostriatus;	*10. Indicator minor;*	*10. Dryoscopus cubla;*
11. Phylloscopus ruficapilla;	*11. Campephaga flava;*	*11. Laniarius aethiopicus;*
12. Dessonornis caffer;	*12. Batis soror;*	*12. Dicrurus ludwigii;*
13. Dessonornis anomalus;	*13. Platysteira peltata;*	*13. Apalis melanocephala**;*
14. Pogonocichla stellata;	*14. Tchagra australis;*	*14. Cisticola cantans;*
15. Chamaetylas choloensis;	*15. Tchagra senegalus;*	*15. Cisticola lais**;*
16. Saxicola torquatus;	*16. Melocichla mentalis;*	*16. Iduna natalensis;*
17. Cinnyris fuelleborni;	*17. Apalis flavida;*	*17. Psalidoprocne pristoptera;*
18. Lagonosticta rubricata.	*18. Camaroptera brachyura;*	*18. Cecropis daurica;*
	19. Cisticola natalensis;	*19. Phyllastrephus cabanisi;*
	20. Cisticola brachypterus;	*20. Pycnonotus barbatus;*
	21. Prinia subflava;	*21. Zosterops senegalensis;*
	22. Prinia erythroptera;	*22. Onychognatus morio;*
	23. Schoenicola brevirostris;*	*23. Muscicapa adusta;*
	24. Cecropis abyssinica;	*24. Cyanomitra olivacea;*
	25. Ptyonoprogne rufigula;	*25. Cinnyris manoensis;*
	26. Eurillas virens;	*26. Cinnyris venustus;*
	27. Fraseria plumbea;	*27. Ploceus bicolor;*
	28. Fraseria caerulescens;	*28. Estrilda astrild;*
	29. Hedydipna collaris;	*29. Anthus cinnamomeus;*
	30. Chalcomitra amethystina;	*30. Crithagra hyposticta.*
	31. Chalcomitra senegalensis;	
	32. Euplectes hordeaceus;	
	33. Euplectes ardens;	
	34. Ploceus ocularis;	
	35. Ploceus cucullatus;	
	36. Vidua macroura;	
	37. Anthus lineiventris;	
	38. Macronyx croceus;	
	39. Motacilla clara;	
	40. Crithagra sulphurata.	

(*) This specie typically lives in montane environments. However, we only observed it at lower elevations because our bird inventory was conducted early, in September. At this time, the specie has not yet moved to its nesting habitat. This species undergoes minor altitudinal migrations.
(**) These species were spotted in both environments. However, the vast majority of individuals from these species were predominantly observed in montane environments.

Montane and low-elevation forests are also in completely different steps of the deforestation process. Low-elevation forests are in an advanced stage of the deforestation process, which was already advanced in the 1960's (Timberlake et al., 2009). Most low-elevation forest has already been lost to cropland, which made it very difficult to find pristine forest points to sample during the fieldwork. The team could only find 18 low-elevation forest points to sample (and most corresponding to highly degraded forest edge habitats) compared to the 30 montane forest points found and sampled. Figure 1 represents the four sampled stages along a deforestation gradient that were sampled in both montane and low-elevation environments.

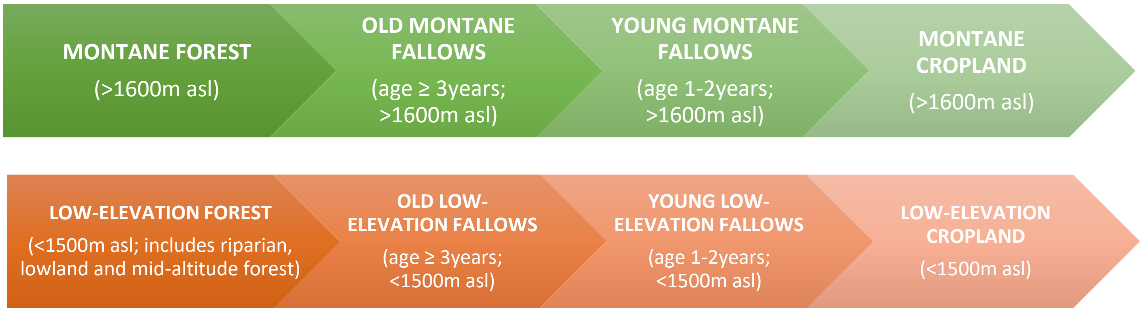

Figure 1. Deforestation gradients of montane and low-elevation forests (green and orange arrows, respectively)

In montane environments, species diversity is practically the same (median Shannon diversity index is approximately 1.5) along the deforestation gradient (Figure 2 green boxes). In low-elevation environments, species diversity decreases along the deforestation gradient. The median Shannon diversity index decreases from approximately 1.8 in low-elevation forest to approximately 1.2 in low-elevation cropland (Figure 2 orange boxes).

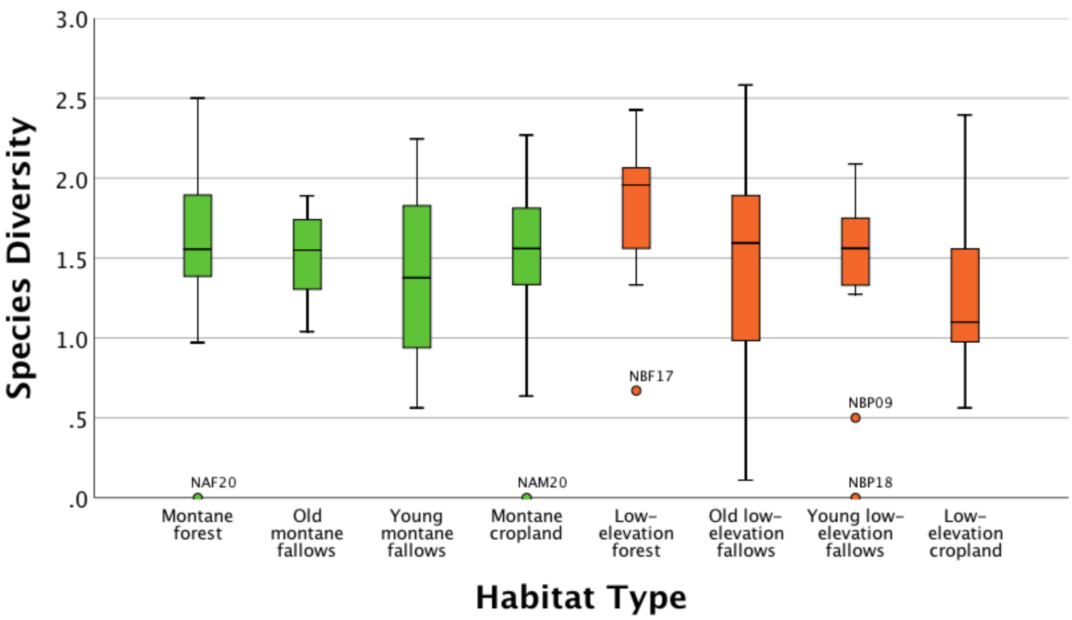

Figure 2. Median and quartile species diversity (Shannon diversity index) per habitat type in both montane (green boxes) and low-elevation (orange boxes) environments

However, for montane forest environments, while there is not a loss of species diversity, there is a loss of endangered (Figure3A - average proportion of species of conservation concern, which decreases from 0.18 in montane forest to 0.06 in montane cropland) and endemic species (Figure 3B dark green - average proportion of restricted range size species decreases from 0.16 in montane forest to 0.06 in montane cropland), which are replaced by cosmopolitan, large-distribution species (Figure 3B light green - average proportion of large range size species increases from 0 in montane forest to 0.17 in young montane fallows). In this case, there may be a local perception of a "biodiversity" gain, which is, in fact part, of a global process of biotic homogenization (spread of cosmopolitan species) and (threatened) species loss. Both the average proportion of species of conservation concern and restricted range size species are statistically significant (*p<0.05*) higher in montane forests than in montane cropland.

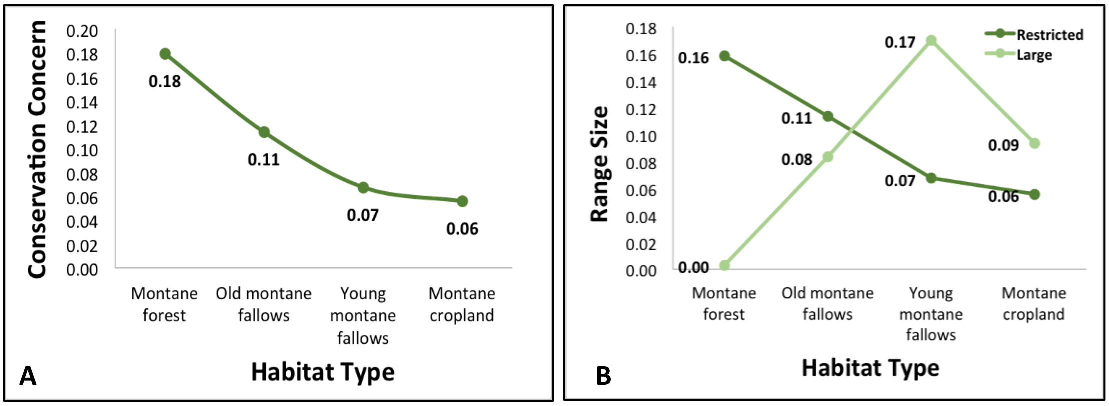

Figure 3. Average proportion by habitat type of **A.** species of conservation concern, classified as either 'critically endangered', 'endangered', 'vulnerable', or 'near threatened' by IUCN red List (IUCN, 2023); **B.** restricted range size species (sensu Birdlife International's endemic bird areas (Stattersfield et al., 1998), that is: species with a distribution range size smaller than 50 thousand km^2) - dark green; large distribution range size species (species with a distribution range size greater than 15 million km^2) - light green

In low-elevation environments, we did not find any species of conservation concern or restricted range species in any of the 139 count points. Therefore, we cannot draw the same conclusions as for montane environments. Two reasons may justify not finding any species of conservation concern or restricted range species at low-elevation environments: (1) low-elevation forests are at a much more advanced stage of the deforestation process, which might mean that these species are already extinct from these areas; (2) we might have conducted our bird inventory too early in the year, and it's possible that some species just hadn't arrived or were not singing and thus not detectable yet. Previous works have, in fact, detected species of conservation concern at these elevation levels, such as *Apalis chariessa*, *Chamaetylas choloensis* and the *belcheri ssp* of *Cryptolybia olivacea* (Timberlake et al., 2009). Note that the latter two species were already actively singing at the montane levels (where they would start breeding later) and all the other *Apalis* species were already singing at both levels. Thus, the former hypothesis is probably the most plausible reason, which may reflect some extinctions at the low-elevation levels since the work by Timberlake et al. (2009) and previous inventories carried out in this century.

For both the montane and the low-elevation levels, migratory species prefer habitats that are at more advanced stages of the deforestation process, i.e. young fallows followed by cropland areas (Figure 4), or naturally open habitats (e.g. grasslands). In more pristine habitats, the competition by local resident species, which would occupy the full niche space, would be stronger. These differences are statistically significant (*p<0.05*).

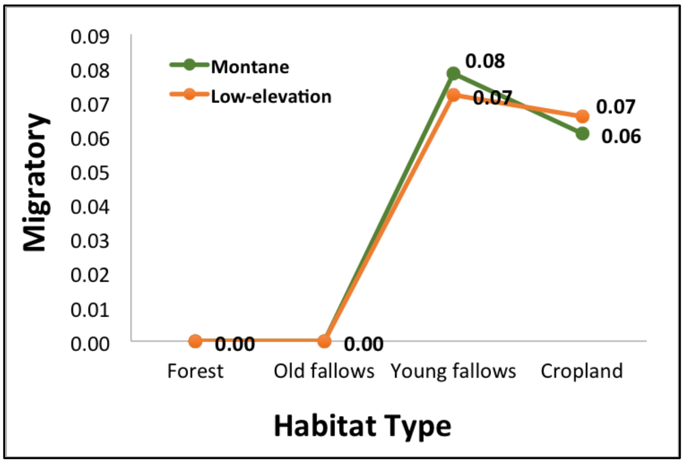

Figure 4. Average proportion of migratory birds by habitat type in montane (green) and low-elevation (orange) environments

For montane environments, family diversity has a minimum in young fallows, where the median family Shannon diversity index is approximately 1.2 (Figure 5 green boxes). For low-elevation environments, median family diversity decreases along the deforestation gradient, from approximately 1.6 in forests to approximately 1.1 in cropland (Figure 5 orange boxes).

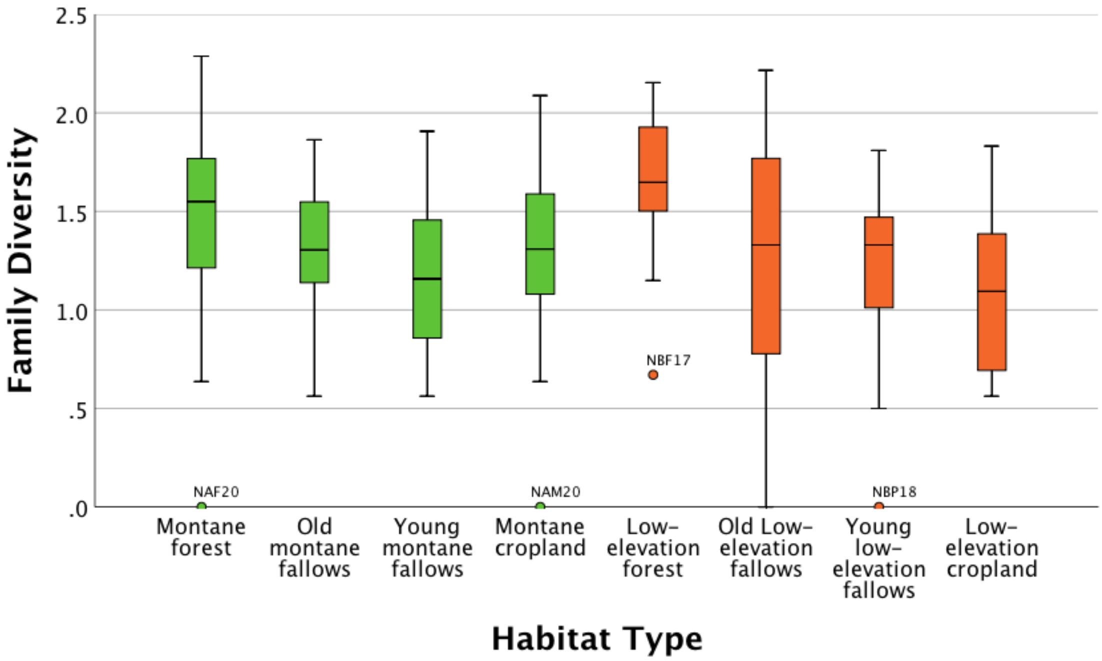

Figure 5. Family diversity (median family Shannon diversity index) per habitat type in montane (green boxes) and low-elevation (orange boxes) environments

Functional composition was used to describe the importance of several feeding niches in each ecosystem or to assess the importance of some ecosystem services (i.e. pest predation, seed dispersal, pollination, and control on seed predators). Table 2 shows that ground invertivores represent a higher average proportion of all birds recorded in cropland points in both montane and low-elevation points, which possibly means a higher contribution for pest predation in these habitats (please note that ground invertivores of montane forests, like *Dessonornis* *anomalus*, were not yet vocalizing during the time of the survey, as a result, they were not recorded). Frugivores prefer forests (and also old fallows at montane levels), thus favouring seed dispersal between forest fragments, an important bird service to conserve plant diversity in fragmented forest landscapes. Nectarivores show a preference for fallows, with old fallows being more favourable at the montane level and young fallows at the low-elevation level, indicating a possible variation in flower availability or nectar production. Seed predation by ground granivores, at the montane and low-elevation levels, is practically absent from forests, suggesting ground granivores preference for open habitats with plenty of seed-producing plants (both crops and wild species). These patterns highlight the importance of habitat diversity for supporting various ecological functions and the potential impact of farmland expansion on ecosystem services.

Table 2. Ecosystem services average proportions by habitat type

	Ecosystem Services Feeding Niche			
Habitat Type	**Pest predation** Ground invertivores	**Seed dispersal** Frugivores	**Pollination** Nectarivores	**Control on seed predators** Ground granivores
Montane				
Forest	0.03	**0.18**	0.06	0.00
Old fallows	0.00	0.17	**0.15**	**0.01**
Young fallows	0.00	0.12	0.10	**0.02**
Cropland	**0.05**	0.03	0.07	**0.01**
Low-elevation				
Forest	0.03	**0.29**	0.07	0.03
Old fallows	0.02	0.14	0.26	**0.10**
Young fallows	0.03	0.16	**0.33**	0.02
Cropland	**0.09**	0.08	0.23	**0.10**

III.II. IMPACTS OF DEFORESTATION PER CLUSTER

The collected bird data was also analysed independently of the pre-established habitat types used to classify the count points (i.e. forest, fallow or cropland types) by running a PC analysis followed by a hierarchical cluster analysis (see Appendix VI.II for detailed methodology and results) to classify the data according to the species diversity and composition at each count point. The average species and functional diversity, as well as species and functional compositions also differed across these clusters, in both montane and low-elevation environments.

At the montane level, the species diversity and also functional diversity (feeding niches) is maximum in forest and minimum in forest-farmland edges and transitions (fallows) (Figure 6 and 7 green boxes). At low-elevations, the species diversity and also functional diversity (feeding niches) is maximum in the forest-farmland edges and transitions (old fallows) (Figure 6 and 7 orange boxes).

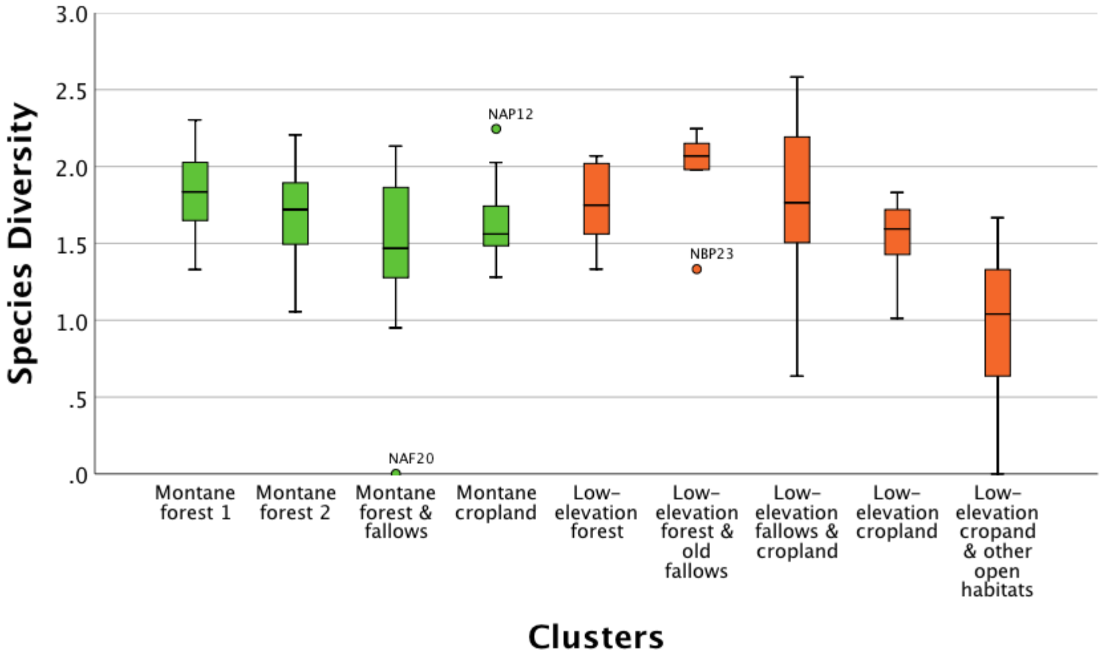

Figure 6. Species diversity (Shannon diversity index) per cluster in montane (green boxes) and low-elevation (orange boxes) environments

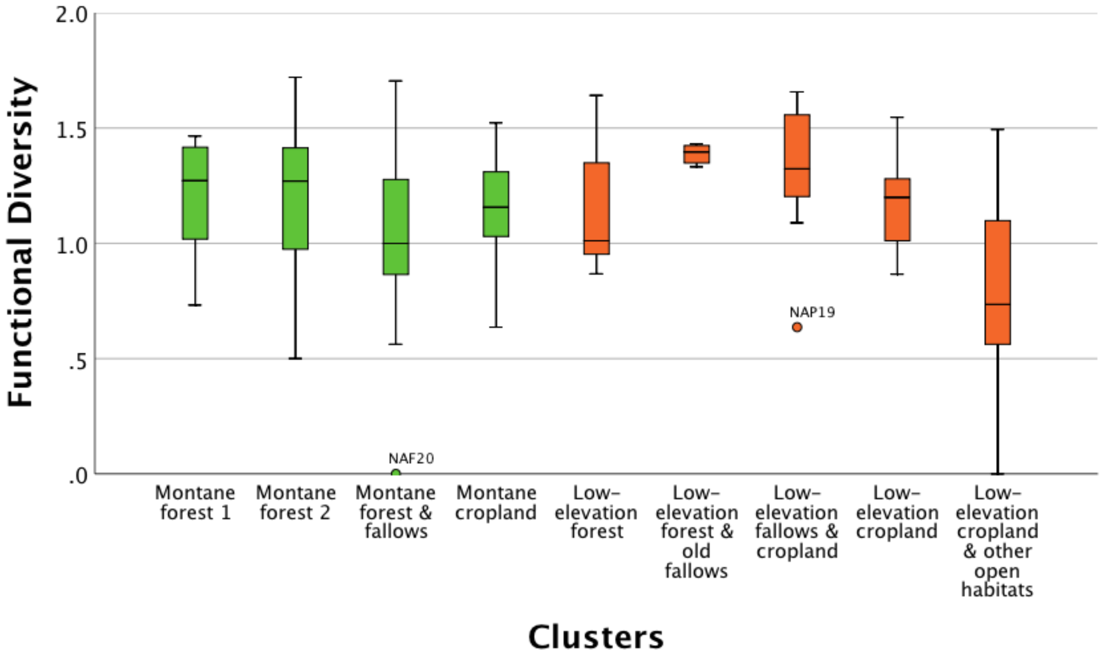

Figure 7. Functional diversity (Shannon diversity index of feeding niches) per cluster in montane (green boxes) and low-elevation (orange boxes) environments

IV. CONSERVATION STRATEGIES

Based on the impacts of deforestation presented on this report, we suggest the following conservation strategies for the conservation of bird biodiversity in Mount Namuli:

- At the montane level, conservation requires halting deforestation by protecting the remaining forest from further conversion into farmland and reducing forest degradation (fire). Both of these processes reduce and fragment the area of remaining habitat, which is required to conserve threatened and restricted range species and prevent the expansion of species-poorer edge habitats and cosmopolitan species. This requires stopping cropland expansion at the montane levels, e.g. by producing more on existing cropland or elsewhere (land sparing).
- At the low-elevation level, conservation requires either:

    a. restoration of low-elevation forest (less cropland) combined with intensification in existing cropland (land sparing) or

    b. the promotion of old fallows (land sharing) through longer rotations with more years of successive cropping (which implies conserving the soil fertility during the cropping years and delaying the start of the fallow period).

    Strategy a. is the one being applied by NITIDAE (planting forest trees, honey production, *coffea*; identifying old fallows ("abandoned land") and earmarking them for forest restoration; strategy a. is possibly more effective in bringing back threatened forest species to the low-elevation area (*Apalis chariessa*, *Chamaetylas choloensis* and *Cryptolybia olivacea ssp belcheri*).

    Strategy b. will be possibly less effective in bringing back threatened forest species to the low-elevation area, but does not require the reduction of cropland area and will thus create less conflict with local people's needs. Strategy b. is less demanding in terms of the required increase in land productivity to face local needs, because there is no cut in cropland area. In this way, it will allow for both higher need satisfaction and less pressure on cropland expansion in the montane level.

V. REFERENCES

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VI. APPENDICES

VI.I. BIRD FIELD RECORD

Namuli	Código do ponto	Data	Hora	Nº Ficha

☐ **Queimado** ☐ **Formiga Guerreira**	**Coberto herbáceo:** ☐ Sem ☐ Denso ☐ Alto	**Coberto arbustivo:** ☐ Sem ☐ Algum ☐ Abundante	**Coberto arbóreo:** ☐ Sem ☐ Algum ☐ Abundante

Tipo de habitat:

☐ **Machamba**	**Ocupação Cultural?**			
☐**Pousio**	**Nº anos?**			
☐**Floresta**	**Manta morta:** ☐ Sem ☐ Alguma ☐ Abundante	**Regeneração natural:** ☐ Sem ☐ Alguma ☐ Abundante	☐ **Fecho de copa**	☐ **Orla** ☐ **Clareira**

Descrição do habitat:
____
____
____
____
____
____
____

Espécies de árvores/arbustos (por ordem de abundância)

1ª____
2ª____
3ª____
4ª____

Outros aspectos relevantes: ____
____
____
____

Nome vulgar	Nome científico	<30m	>30m	Observações/notas
Rola-d'olho-vermelho	*Streptopelia semitorquata*			
Rola-de-manchas-azuis	*Turtur afer*			
Cucal-de-sobrancelhas (de Burchell)	*Centropus superciliosus*			
Turaco de Livingstone	*Tauraco livingstonii*			
Batis do Malawi	*Batis dimorpha*			
Picanço-de-almofadinha	*Dryoscopus cubla*			
Picanço-tropical	*Laniarius aethiopicus*			
Apalis do Namuli	*Apalis lynesi*			
Apalis-de-peito-amarelo	*Apalis flavida*			
Apalis-de-cabeça-preta	*Apalis melanocephala*			
Fuinha-cantora	*Cisticola cantans*			
Prínia-de-flancos-castanhos	*Prinia subflava*			
Prínia-d'asa-vermelha	*Prinia erythroptera*			
Felosa-dos-juncos-africana	*Bradypterus baboecala*			
Andorinha-preta	*Psalidoprocne pristoptera*			
Tuta-negra	*Pycnonotus barbatus*			
Estorninho-de-asa-castanha	*Onychognathus morio*			
Beija-flor-de-barriga-amarela	*Cinnyris venustus*			
Tecelão-de-lunetas	*Ploceus ocularis*			
Bico-de-lacre-comum	*Estrilda astrild*			

VI.II. DETAILED RESEARCH METHODS AND RESULTS

VI.II.I. METHODS NOTE

Field records of birds in 139 count points and the description of habitat in each point were made, between the 7th and 28th September 2023, in a file with the format exemplified in Appendix VI.I. For each bird species, the observed number of individuals in each point was divided between individuals observed at a distance < or >= 30 meters. The format of these records was converted to a point x variable format to be used in the analyses, that only includes the records at < 30 m distance.

The variables included are the following:

- A summary description of the habitat in each point;
- The number of individuals of each bird species;
- 'Abundance' is the total number of individuals of any species observed;
- 'Av p-spec abundance' is average per-species abundance, computed as the quotient between 'Abundance' and 'Species Richness';
- 'Species Richness' is the count of species recorded;
- 'Shannon diversity' is the Shannon diversity index computed for all records (usual formula for the index);
- 'Shannon evenness' is the Shannon evenness index computed for all records ('Shannon evenness' = 'Shannon diversity' / ln ('Species Richness'));
- The proportion of each species in the total number of individuals observed (that is: the proportion of each species in 'Abundance'; the sum of all proportions for the diverse species is 1.000);
- Habitat guilds, according to Tobias et al. (2022):
    - Functional composition: the proportion of each habitat guild species, either 'Forest', 'Shrubland', 'Woodland', 'Grassland', 'Wetland', or 'Rock' according to Tobias et al. (2022), in the total number of individuals of any species.
    - Functional diversity:
        - 'Habitat Richness' is the count of habitats guilds recorded;
        - 'Habitat Shannon Diversity' is the Shannon diversity index computed for all habitat guilds records (usual formula for the index);
        - 'Habitat Shannon Evenness' is the Shannon evenness index computed for all habitat guilds records ('Habitat Shannon Evenness' = 'Habitat Shannon Diversity' / ln ('Habitat Richness')).
- Habitat density, according to Tobias et al. (2022):
    - Functional composition: the proportion of each habitat density species, either 'Closed habitat', 'Semi-open habitats', or 'Open habitats' according to Tobias et al. (2022), in the total number of individuals of any species.
    - Functional diversity:
        - 'Habitat Density Richness' is the count of habitat density recorded;

- 'Habitat Density Shannon Diversity' is the Shannon diversity index computed for all habitat density records (usual formula for the index);
- 'Habitat Density Shannon Evenness' is the Shannon evenness index computed for all habitat density records ('Habitat Density Shannon Evenness' = 'Habitat Density Shannon Diversity' / ln ('Habitat Density Richness')).

- Feeding niches, according to Pigot et al. (2020):
  - Functional composition: the proportion of each feeding niche species, either 'Vertivore aerial', 'Invertivore aerial', 'Invertivore sally air', 'Invertivore glean arboreal', 'Invertivore bark', 'Invertivore sally surface', 'Frugivore glean', 'Nectarivore glean', 'Invertivore sally ground', 'Granivore arboreal', 'Invertivore ground', 'Herbivore ground', 'Granivore ground', 'Generalist', or 'NA' according to Pigot et al. (2020), in the total number of individuals of any species.
  - Functional diversity:
    - 'Feeding Niche Pigot Richness' is the count of Pigot feeding niches recorded;
    - 'Feeding Niche Pigot Shannon Diversity' is the Shannon diversity index computed for all Pigot feeding niches records (usual formula for the index);
    - 'Feeding Niche Pigot Shannon Evenness' is the Shannon evenness index computed for all Pigot feeding niches records ('Feeding Niche Pigot Shannon Evenness' = 'Feeding Niche Pigot Shannon Diversity' / ln ('Feeding Niche Pigot Richness')).
- Feeding niches, according to FARSYMABI classification:
  - Functional composition: the proportion of each feeding niche species, either 'Vertivore aerial', 'Invertivore aerial', 'Vertivore Generalist', 'Invertivore sally air', 'Invertivore glean canopy', 'Invertivore glean understorey', 'Invertivore glean grass', 'Invertivore bark', 'Invertivore sally surface', 'Invertivore Insessorial Generalist', 'Omnivore Omnivore Insessorial', 'Frugivore glean', 'Nectarivore glean', 'Invertivore sally ground', 'Granivore arboreal', 'Invertivore Generalist', 'Granivore Generalist', 'Invertivore ground', 'Omnivore Omnivore Terrestrial', 'Herbivore Omnivore Terrestrial', or 'Granivore ground' according to FARSYMABI, in the total number of individuals of any species.
  - Functional diversity:
    - 'Feeding Niche FARSYMABI Richness' is the count of FARSYMABI feeding niches recorded;
    - 'Feeding Niche FARSYMABI Shannon Diversity' is the Shannon diversity index computed for all FARSYMABI feeding niches records (usual formula for the index);
    - 'Feeding Niche FARSYMABI Shannon Evenness' is the Shannon evenness index computed for all FARSYMABI feeding niches records ('Feeding Niche FARSYMABI Shannon Evenness' = 'Feeding Niche

FARSYMABI Shannon Diversity' / ln ('Feeding Niche FARSYMABI Richness')).

- Family:
    - Functional composition: the proportion of each family species, either 'Phasianidae', 'Columbidae', 'Apodidae', 'Cuculidae', 'Musophagidae', 'Accipitridae', 'Trogonidae', 'Bucerotidae', 'Meropidae', 'Lybiidae', 'Indicatoridae', 'Picidae', 'Campephagidae', 'Platysteiridae', 'Malaconotidae', 'Dicruridae', 'Corvidae', 'Stenostiridae', 'Macrosphenidae', 'Cisticolidae', 'Acrocephalidae', 'Locustellidae', 'Hirundinidae', 'Pycnonotidae', 'Phylloscopidae', 'Zosteropidae', 'Sturnidae', 'Muscicapidae', 'Nectariniidae', 'Ploceidae', 'Estrildidae', 'Viduidae', 'Motacillidae', or 'Fringillidae', in the total number of individuals of any species.
    - Functional diversity:
        - 'Family Richness' is the count of families recorded;
        - 'Family Shannon Diversity' is the Shannon diversity index computed for all family records (usual formula for the index);
        - 'Family Shannon Evenness' is the Shannon evenness index computed for all family records ('Family Shannon Evenness' = 'Family Shannon Diversity' / ln ('Family Richness')).
- Range size, according to Tobias et al. (2022):
    - 'Range restricted' is the proportion of restricted distribution range size species (species with a distribution range size smaller than 50 thousand km^2 sensu Birdlife International’s endemic bird areas (Stattersfield et al., 1998)), in the total number of individuals of any species.
    - 'Range large' is the proportion of large distribution range size species (species with a distribution range size greater than 15 million km^2), in the total number of individuals of any species.
- Migration, according to Tobias et al. (2022):
    - 'Sedentary' is the proportion of sedentary species in the total number of individuals of any species.
    - 'Partially migratory' is the proportion of partially migratory species in the total number of individuals of any species.
    - 'Migratory' is the proportion of migratory species in the total number of individuals of any species.
- Conservation status, according to IUCN red List (IUCN, 2023):
    - 'Proportion Conservation Concern' is the proportion of conservation concern species, classified as 'critically endangered', 'endangered', 'vulnerable', or 'near threatened' by IUCN red List plus *Cryptolybia olivacea belcheri ssp*, in the total number of individuals of any species.

    - 'Proportion Threatened' is the proportion of threatened species, classified as 'critically endangered', 'endangered', or 'vulnerable' by IUCN red List, in the total number of individuals of any species.
    - 'Number Conservation Concern' is the count of conservation concern species, classified as 'critically endangered', 'endangered', 'vulnerable', or 'near threatened' by IUCN red List plus *Cryptolybia olivacea belcheri ssp*.
    - 'Number Threatened' is the count of threatened species, classified as 'critically endangered', 'endangered', or 'vulnerable' by IUCN red List.
- Montane endemism:
    - 'Afromontane DL' is the proportion of afromontane species, classified as 'endemic' or 'near-endemic' by Dowsett-Lemaire in Timberlake et al. (2009), in the total number of individuals of any species.
    - 'Montane FARSYMABI' is the proportion of montane species, (that is: those species only recorded> 1 600 m asl during the FARSYMABI fieldwork (2023)) in the total number of individuals of any species.

Note that in all Shannon Evenness calculations, the index was given a zero value when Richness was equal to 1. This was meant to represent the lowest level of evenness: that when all individuals belong to the same category (species, guild, …).

The following habitat types were defined and used in the analyses:

- **Montane forest**: forest (> 1 600 m asl);
- **Old montane fallows**: fallows with 3 or more years (> 1 600 m asl);
- **Young montane fallows**: fallows with 1-2 years (> 1 600 m asl);
- **Montane cropland**: cropland (> 1 600 m asl);
- **Low-elevation forest**: forest (< 1 500 m asl); includes riparian, lowland and mid-altitude forest;
- **Old low-elevation fallows**: fallows with 3 or more years (< 1 500 m asl);
- **Young low-elevation fallows**: fallows with 1-2 years (< 1 500 m asl);
- **Low-elevation cropland**: cropland (< 1 500 m asl).

The six 'Montane' and 'Low-elevation' 'Forest', 'Fallow' and 'Cropland' categories were established a priori (based on land cover cartography and satellite images). The classification of each point in these categories was confirmed/amended based on a previous July 2023 visit (two fallow points were further amended to cropland in the September 2023 field work, when previous fallows start being cropped again).

The age of the fallows were asked from our local field guides in July (confirmed/amended in September) and classified into the two above-mentioned categories (old and young fallows) in the data analysis step. The result is the abovementioned set of 8 habitat types.

The average values of all abovementioned variables were computed and compared across these 8 habitat types. The ANOVA p-value and the Squared ETA were computed for each variable to assess whether the resulting differences are significant ($P < 0.05$) and to assess the power of each variable to separate points by habitat type when only that variable is used for that separation (size of the Squared ETA). The results of this analysis are in Table I.

The 90% confidence intervals (CI) for the average values of most of these variables (the most significant ones, not all with P<0.05) were also computed across habitat types.

These results will be used to select good indicator variables separating well some habitat types. For example, in Figure I.A, average 'Species richness' declines from 'Low-elevation forest' to 'Low-elevation cropland', and separates well these two habitat types (non-overlapping CIs). Low-elevation old and young fallows occupy intermediate positions in the average 'Species richness' scale, as expected but their CI overlap with each other. Nevertheless, low-elevation young fallows have a significantly lower average species richness than that of Low-elevation forest. The results are not so clear for 'Montane' habitat types, where all CI overlap with each other.

Other examples: the species *Cryptolybia olivacea* is a good indicator of Montane forest: the CI for its average proportion in this habitat type is higher than in any other habitat type, where the species has actually not been recorded (Figure I.B). For the same reason *Eurillas virens* is a good indicator of Low-elevation forest (Figure I.C), and, while there is some CI overlap, *Prinia erythroptera* seems a good indicator of Low-elevation young fallows, with lower average values for both Low-elevation old fallows and Low-elevation cropland (Figure I.D).

All species' abundance, diversity and composition variables that passed the ANOVA test (indicated in green in the ANOVA p-value row), that is: which are good in separating the different habitat types were entered in a Principal Component Analysis (PCA), using the corresponding correlation matrix. A total of 37 variables entered the PCA. The PCA was used to eliminate variable redundancy (that is correlation between the variables) before carrying out a cluster analysis aimed at classifying the count points according to their species' diversity and composition (abundance variables were not included in the 37 variables that entered the PCA, as they did not pass the ANOVA test, cf. Table I). The Eigenvalue criterion was used to select the relevant PCs.

The results of the PCA are presented in Table II.A+B. Table II.A presents the 14 selected PCs (the first 14 ones, which have Eigenvalue > 1.000), and informs that these 14 PCs alone retained 64,6% of all the variance in the 37 variables that entered the PCA. Table II.B presents the interpretation of these PC (using their Varimax-rotated version, which facilitates this interpretation) based on their correlations with the 37 initial variables that entered the PCA. In this table, we can e.g. observe that the PC 2 is a species richness/diversity PC, and that *Batis dimorpha* is a species associated with richer/more diverse communities and *Cinnyris venustus* is a species associated with less rich/less diverse bird communities. Another example: bird species positively associated with PC1 (*Cisticola lais*, *Iduna natalensis*, *Dessonornis caffer and Saxicola torquatus*) are characteristic of Montane cropland points, whereas bird species negatively associated with PC1 (*Prinia subflava* and *Cinnyris venustus*) are characteristic of Low-elevation fallow points. So, PC1 separates well Montane cropland from Low-elevation fallows.

The selected 14 PC were then entered in a hierarchical cluster analysis, aimed at classifying the count points according to their species' diversity and composition. The squared Euclidean distance was used as the distance metric and the Ward method was used as the clustering algorithm.

The resulting dendrogram is presented in Figure II (note that the new point codes of points included in each cluster are given in the base of the dendrogram). The 10-cluster solution was selected (represented by the green horizontal line) for further analyses. Cluster 4 (including a single point) was eliminated from further analyses. Other solutions with more clusters (lowering the green line) will possibly reveal more details, but, to keep things simple for this report, we propose the 10 cluster solutions (9 in practice, with the elimination of cluster 4).

The rest of this report is an interpretation of the 9 bird communities of Mount Namuli, which correspond to these 9 clusters.

To support this interpretation, the averages of the variables were computed and compared across these 9 clusters. The ANOVA p-value and squared ETA were also computed for each variable (with the same, abovementioned purpose). The results of this analysis are presented in Table III.

Table IV provides a cross table of the 9 clusters with the abovementioned 8 habitat types, to study the correspondence between the a-priori established habitat types and the 9 bird communities that have been recovered from the cluster analysis of the diversity and species composition of each point, based on actual bird records.

Figure III provides the 90% Confidence Intervals (CI) for the average of the 'Species richness' (Figure III.A.) and 'Shannon diversity" (Figure III.B.) across the 9 clusters.

Table I. Average values of all computed variables by habitat type, with ANOVA p-value and the Squared ETA

Habitat type	N	Abundance	Av p-spec abundance	Species richness	Shannon diversity	Shannon evenness	Pternistis hildebrandti	Columba arquatrix	Streptopelia semitorquata	Turtur afer/chalcospilos	Treron calvus	Apus barbatus	Centropus superciliosus	Chrysococcyx klaas	Tauraco livingstonii	Hieraaetus ayresii
Montane forest	30	10,0	1,6	6,2	1,62	0,91	0,00	0,03	0,00	0,00	0,00	0,02	0,00	0,00	0,08	0,00
Old montane fallows	12	8,0	1,5	5,2	1,53	0,95	0,02	0,01	0,00	0,00	0,00	0,04	0,00	0,00	0,06	0,00
Young montane fallows	8	11,9	2,3	5,3	1,39	0,90	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,04	0,00
Montane cropland	20	11,2	2,0	5,5	1,51	0,90	0,01	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00
Low-elevation forest	18	14,7	2,1	7,5	1,80	0,91	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,08	0,00
Old low-elevation fallows	11	17,9	4,5	6,0	1,42	0,85	0,00	0,00	0,00	0,01	0,02	0,01	0,01	0,00	0,01	0,00
Young low-elevation fallows	13	9,9	2,0	5,3	1,42	0,84	0,00	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,01	0,00
Low-elevation cropland	26	9,3	2,0	4,3	1,23	0,92	0,00	0,00	0,01	0,02	0,02	0,05	0,00	0,00	0,00	0,01
Total	138	11,2	2,1	5,7	1,50	0,90	0,00	0,01	0,00	0,01	0,01	0,02	0,00	0,00	0,04	0,00
ANOVA p value		0,254	0,273	0,010	0,024	0,814	0,265	0,074	0,753	0,439	0,300	0,837	0,112	0,471	0,001	0,796
Squared ETA		0,07	0,06	0,13	0,11	0,03	0,06	0,09	0,03	0,05	0,06	0,03	0,08	0,05	0,17	0,03

Habitat type	Accipiter tachiro	Accipiter minullus	Apaloderma vittatum	Lophoceros alboterminatus	Merops pusillus	Cryptolybia olivacea	Stactolaema leucotis	Pogoniulus bilineatus	Pogoniulus chrysoconus	Indicator minor	Dendropicos fuscescens	Campephaga flava	Batis dimorpha	Batis soror	Platysteira peltata	Dryoscopus cubla	Tchagra australis	Tchagra senegalus	Chlorophoneus nigrifrons	Laniarius aethiopicus	Dicrurus ludwigii	Corvus albicollis
Montane forest	0,01	0,00	0,03	0,01	0,00	0,02	0,00	0,04	0,00	0,00	0,00	0,00	0,04	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,00
Old montane fallows	0,00	0,00	0,01	0,01	0,00	0,00	0,00	0,03	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,01
Young montane fallows	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Montane cropland	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00
Low-elevation forest	0,01	0,00	0,02	0,01	0,00	0,00	0,00	0,05	0,00	0,01	0,01	0,01	0,00	0,02	0,01	0,05	0,00	0,00	0,00	0,02	0,01	0,00
Old low-elevation fallows	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,02	0,00	0,01	0,04	0,00	0,01	0,03	0,00	0,03	0,00	0,01	0,00	0,01	0,00	0,00
Young low-elevation fallows	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,02	0,00	0,00	0,02	0,00	0,00
Low-elevation cropland	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,04	0,00	0,00
Total	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,01	0,00	0,00	0,00	0,01	0,01	0,00
ANOVA p value	0,852	0,471	0,007	0,646	0,477	0,002	0,204	0,007	0,471	0,106	0,120	0,102	0,025	0,030	0,143	0,021	0,001	0,112	0,832	0,650	0,075	0,159
Squared ETA	0,02	0,05	0,14	0,04	0,05	0,16	0,07	0,14	0,05	0,09	0,08	0,09	0,11	0,11	0,08	0,12	0,17	0,08	0,03	0,04	0,09	0,08

Table I. Continuation

Habitat type	Elminia albonotata	Melocichla mentalis	Apalis lynesi	Apalis flavida	Apalis melanocephala	Camaroptera brachyura	Cisticola cantans	Cisticola lais	Cisticola natalensis	Cisticola brachypterus	Prinia subflava	Prinia erythroptera	Iduna natalensis	Schoenicola brevirostris	Bradypterus lopezi	Psalidoprocne pristoptera
Montane forest	0,05	0,00	0,09	0,00	0,20	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,02
Old montane fallows	0,00	0,00	0,11	0,00	0,08	0,00	0,01	0,08	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,03
Young montane fallows	0,00	0,00	0,07	0,00	0,09	0,00	0,03	0,14	0,00	0,00	0,00	0,00	0,05	0,00	0,01	0,09
Montane cropland	0,01	0,00	0,06	0,00	0,05	0,00	0,01	0,17	0,00	0,00	0,00	0,00	0,07	0,00	0,09	0,05
Low-elevation forest	0,00	0,00	0,00	0,03	0,02	0,05	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,00	0,00	0,07
Old low-elevation fallows	0,00	0,02	0,00	0,01	0,00	0,00	0,07	0,01	0,00	0,00	0,13	0,01	0,01	0,00	0,00	0,02
Young low-elevation fallows	0,00	0,01	0,00	0,00	0,00	0,00	0,08	0,00	0,00	0,01	0,11	0,05	0,01	0,00	0,00	0,02
Low-elevation cropland	0,00	0,00	0,00	0,00	0,00	0,00	0,10	0,00	0,02	0,00	0,06	0,01	0,01	0,00	0,00	0,01
Total	0,01	0,00	0,04	0,01	0,06	0,01	0,04	0,04	0,00	0,00	0,04	0,01	0,02	0,00	0,02	0,03
ANOVA p value	0,000	0,239	0,000	0,000	0,000	0,000	0,000	0,000	0,218	0,210	0,000	0,000	0,000	0,786	0,087	0,457
Squared ETA	0,22	0,07	0,27	0,22	0,35	0,40	0,23	0,55	0,07	0,07	0,22	0,22	0,30	0,03	0,09	0,05

Habitat type	Cecropis abyssinica	Cecropis daurica	Ptyonoprogne rufigula	Arizelocichla milanjensis	Eurillas virens	Phyllastrephus cabanisi	Phyllastrephus flavostriatus	Pycnonotus barbatus	Phylloscopus ruficapilla	Zosterops senegalensis	Onychognatus morio	Muscicapa adusta	Fraseria plumbea	Fraseria caerulescens	Dessonornis caffer	Dessonornis anomalus	Pogonocichla stellata	Chamaetylas choloensis	Saxicola torquatus
Montane forest	0,00	0,00	0,00	0,04	0,00	0,03	0,07	0,00	0,01	0,02	0,00	0,00	0,00	0,00	0,01	0,01	0,02	0,02	0,00
Old montane fallows	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,07	0,00	0,00	0,00	0,02	0,00	0,00	0,12	0,00	0,01	0,00	0,01
Young montane fallows	0,00	0,08	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,08	0,02	0,00	0,00	0,07	0,00	0,00	0,00	0,03
Montane cropland	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,02	0,00	0,00	0,00	0,18	0,00	0,00	0,00	0,06
Low-elevation forest	0,03	0,00	0,03	0,00	0,07	0,00	0,00	0,09	0,00	0,02	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Old low-elevation fallows	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,08	0,00	0,00	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Young low-elevation fallows	0,00	0,06	0,00	0,00	0,00	0,00	0,00	0,14	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Low-elevation cropland	0,07	0,01	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	0,02	0,01	0,00	0,01	0,01	0,01	0,02	0,06	0,00	0,01	0,01	0,00	0,00	0,00	0,04	0,00	0,00	0,00	0,01
ANOVA p value	0,038	0,019	0,086	0,000	0,000	0,223	0,000	0,001	0,454	0,159	0,049	0,171	0,471	0,471	0,000	0,419	0,041	0,066	0,001
Squared ETA	0,11	0,12	0,09	0,19	0,37	0,07	0,20	0,17	0,05	0,08	0,10	0,07	0,05	0,05	0,51	0,05	0,10	0,10	0,17

Table I. Continuation

Habitat type	Hedydipna collaris	Cyanomitra olivacea	Chalcomitra amethystina	Chalcomitra senegalensis	Cinnyris manoensis	Cinnyris fuelleborni	Cinnyris venustus	Euplectes hordeaceus	Euplectes ardens	Ploceus ocularis	Ploceus cucullatus	Ploceus bicolor	Lagonosticta rubricata	Estrilda astrild	Vidua macroura	Anthus lineiventris	Anthus cinnamomeus	Macronyx croceus	Motacilla clara	Crithagra hypostica	Crithagra sulphurata
Montane forest	0,00	0,01	0,00	0,00	0,00	0,06	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Old montane fallows	0,00	0,02	0,00	0,00	0,03	0,05	0,10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00
Young montane fallows	0,00	0,00	0,00	0,00	0,00	0,07	0,03	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Montane cropland	0,00	0,00	0,00	0,00	0,00	0,03	0,04	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,05	0,00	0,00	0,01	0,00
Low-elevation forest	0,01	0,01	0,01	0,00	0,01	0,00	0,07	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,02	0,00
Old low-elevation fallows	0,00	0,00	0,00	0,01	0,01	0,00	0,26	0,10	0,00	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,03
Young low-elevation fallows	0,00	0,00	0,00	0,00	0,00	0,00	0,33	0,00	0,00	0,00	0,01	0,00	0,00	0,03	0,01	0,00	0,01	0,00	0,00	0,00	0,02
Low-elevation cropland	0,00	0,00	0,00	0,00	0,00	0,00	0,23	0,03	0,00	0,00	0,00	0,00	0,00	0,04	0,00	0,00	0,06	0,01	0,00	0,03	0,04
Total	0,00	0,00	0,00	0,00	0,00	0,03	0,12	0,01	0,00	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,02	0,00	0,00	0,01	0,01
ANOVA p value	0,471	0,057	0,058	0,684	0,344	0,003	0,000	0,196	0,112	0,670	0,210	0,008	0,019	0,303	0,210	0,471	0,007	0,753	0,017	0,455	0,020
Squared ETA	0,05	0,10	0,10	0,04	0,06	0,15	0,34	0,07	0,08	0,04	0,07	0,13	0,12	0,06	0,07	0,05	0,14	0,03	0,12	0,05	0,12

	HABITAT GUILDS									HABITAT DENSITY					
	Functional Composition						Functional Diversity			Functional			Functional Diversity		
Habitat type	Forest	Shrubland	Woodland	Grassland	Wetland	Rock	Habitat Richness	Habitat Shannon Diversity	Habitat Shannon Evenness	Closed habitats	Semi-open habitats	Open habitats	Habitat Density Richness	Habitat Density Shannon Diversity	Habitat Density Shannon Evenness
Montane forest	0,95	0,00	0,03	0,00	0,00	0,02	1,27	0,11	0,16	0,74	0,26	0,00	1,83	0,20	0,29
Old montane fallows	0,63	0,05	0,19	0,08	0,00	0,05	2,42	0,64	0,64	0,38	0,51	0,11	2,42	0,30	0,37
Young montane fallows	0,48	0,11	0,11	0,22	0,00	0,08	2,63	0,70	0,61	0,23	0,44	0,33	2,25	0,28	0,34
Montane cropland	0,48	0,14	0,07	0,25	0,00	0,05	3,20	0,93	0,79	0,23	0,43	0,33	2,40	0,28	0,32
Low-elevation forest	0,55	0,06	0,33	0,03	0,00	0,03	2,56	0,69	0,72	0,34	0,58	0,09	2,22	0,26	0,32
Old low-elevation fallows	0,07	0,30	0,45	0,13	0,01	0,03	2,73	0,71	0,66	0,05	0,78	0,16	1,82	0,11	0,13
Young low-elevation fallows	0,04	0,27	0,58	0,10	0,00	0,01	2,77	0,81	0,78	0,02	0,86	0,12	1,77	0,11	0,15
Low-elevation cropland	0,06	0,26	0,37	0,26	0,00	0,05	2,73	0,80	0,83	0,05	0,71	0,24	1,81	0,18	0,24
Total	0,45	0,14	0,24	0,13	0,00	0,04	2,43	0,63	0,62	0,30	0,54	0,16	2,03	0,21	0,27
ANOVA p value	0,000	0,000	0,000	0,000	0,112	0,926	0,000	0,000	0,000	0,000	0,000	0,000	0,002	0,000	0,001
Squared ETA	0,75	0,37	0,48	0,27	0,08	0,02	0,33	0,43	0,44	0,64	0,44	0,26	0,16	0,22	0,17

Table I. Continuation

	FEEDING NICHE PIGOT																
	Functional Composition														Functional Diversity		
Habitat type	Vertivore aerial	Invertivore aerial	Invertivore sally air	Invertivore glean arboreal	Invertivore bark	Invertivore sally surface	Frugivore glean	Nectarivore glean	Invertivore sally ground	Granivore arboreal	Invertivore ground	Herbivore ground	Granivore ground	Generalist	NA	Feeeding Niche Pigot Richness	Feeeding Niche Pigot Shannon Diversity	Feeeding Niche Pigot Shannon Evenness
Montane forest	0,00	0,04	0,06	0,44	0,00	0,07	0,18	0,06	0,00	0,00	0,03	0,00	0,00	0,06	0,06	3,97	1,08	0,79
Old montane fallows	0,00	0,06	0,04	0,30	0,00	0,03	0,17	0,15	0,01	0,00	0,00	0,02	0,01	0,13	0,07	4,25	1,21	0,86
Young montane fallows	0,00	0,17	0,02	0,39	0,00	0,00	0,12	0,10	0,03	0,00	0,00	0,00	0,02	0,07	0,08	3,50	0,97	0,84
Montane cropland	0,00	0,08	0,01	0,44	0,00	0,01	0,03	0,07	0,06	0,00	0,05	0,01	0,01	0,22	0,02	3,75	1,03	0,78
Low-elevation forest	0,00	0,13	0,03	0,26	0,01	0,05	0,29	0,07	0,00	0,00	0,03	0,00	0,03	0,07	0,03	4,67	1,23	0,83
Old low-elevation fallows	0,00	0,03	0,00	0,16	0,04	0,03	0,14	0,26	0,00	0,00	0,02	0,00	0,10	0,18	0,04	4,45	1,13	0,79
Young low-elevation fallows	0,00	0,09	0,00	0,18	0,00	0,00	0,16	0,33	0,00	0,01	0,03	0,00	0,02	0,18	0,00	4,08	1,11	0,79
Low-elevation cropland	0,01	0,13	0,02	0,15	0,00	0,00	0,08	0,23	0,00	0,00	0,09	0,00	0,10	0,18	0,01	3,62	1,00	0,85
Total	0,00	0,09	0,03	0,30	0,01	0,03	0,14	0,14	0,01	0,00	0,04	0,00	0,04	0,13	0,04	4,01	1,09	0,81
ANOVA p value	0,836	0,416	0,044	0,000	0,120	0,000	0,000	0,000	0,001	0,210	0,012	0,265	0,045	0,006	0,113	0,370	0,450	0,858
Squared ETA	0,03	0,05	0,10	0,31	0,08	0,19	0,23	0,25	0,17	0,07	0,13	0,06	0,10	0,14	0,08	0,06	0,05	0,02

Table I. Continuation

	FEEDING NICHE FARSYMABI																							
	Functional Composition																					Functional Diversity		
Habitat type	Vertivore aerial	Invertivore aerial	Vertivore Generalist	Invertivore sally air	Invertivore glean canopy	Invertivore glean understorey	Invertivore glean grass	Invertivore bark	Invertivore sally surface	Invertivore Insessorial Generalist	Omnivore Omnivore Insessorial	Frugivore glean	Nectarivore glean	Invertivore sally ground	Granivore arboreal	Invertivore Generalist	Granivore Generalist	Invertivore ground	Omnivore Omnivore Terrestrial	Herbivore Omnivore Terrestrial	Granivore ground	Feeeding Niche Farsymabi Richness	Feeding Niche Farsymabi Shannon	Feeeding Niche Farsymabi Shannon
Montane forest	0,00	0,04	0,01	0,06	0,41	0,03	0,00	0,00	0,07	0,02	0,06	0,18	0,06	0,00	0,00	0,03	0,00	0,03	0,00	0,00	0,00	4,30	1,21	0,84
Old montane fallows	0,00	0,06	0,00	0,04	0,21	0,01	0,09	0,00	0,03	0,01	0,06	0,17	0,15	0,01	0,00	0,12	0,00	0,00	0,01	0,02	0,01	4,67	1,41	0,94
Young montane fallows	0,00	0,17	0,00	0,02	0,16	0,06	0,17	0,00	0,00	0,00	0,08	0,12	0,10	0,03	0,00	0,07	0,00	0,00	0,00	0,00	0,02	4,50	1,24	0,88
Montane cropland	0,00	0,08	0,01	0,01	0,11	0,16	0,18	0,00	0,01	0,01	0,02	0,03	0,07	0,06	0,00	0,18	0,02	0,05	0,00	0,01	0,01	5,00	1,41	0,88
Low-elevation forest	0,00	0,13	0,01	0,03	0,21	0,05	0,00	0,01	0,05	0,06	0,03	0,29	0,07	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,03	5,28	1,41	0,87
Old low-elevation fallows	0,00	0,03	0,00	0,00	0,05	0,01	0,10	0,04	0,03	0,14	0,04	0,14	0,26	0,00	0,00	0,00	0,05	0,02	0,00	0,00	0,10	4,91	1,27	0,83
Young low-elevation fallows	0,00	0,09	0,00	0,00	0,01	0,06	0,11	0,00	0,00	0,13	0,00	0,16	0,33	0,00	0,01	0,00	0,05	0,03	0,00	0,00	0,02	4,77	1,33	0,84
Low-elevation cropland	0,01	0,13	0,00	0,02	0,02	0,03	0,10	0,00	0,00	0,09	0,01	0,08	0,23	0,00	0,00	0,00	0,08	0,09	0,00	0,00	0,10	4,12	1,18	0,91
Total	0,00	0,09	0,00	0,03	0,17	0,05	0,08	0,01	0,03	0,06	0,03	0,14	0,14	0,01	0,00	0,05	0,03	0,04	0,00	0,00	0,04	4,63	1,29	0,87
ANOVA p value	0,836	0,416	0,852	0,044	0,000	0,001	0,000	0,120	0,000	0,000	0,158	0,000	0,000	0,001	0,210	0,000	0,006	0,012	0,159	0,272	0,045	0,510	0,477	0,653
Squared ETA	0,03	0,05	0,02	0,10	0,50	0,17	0,31	0,08	0,19	0,18	0,08	0,23	0,25	0,17	0,07	0,43	0,14	0,13	0,08	0,06	0,10	0,05	0,05	0,04

Table I. Continuation

	FAMILY																																			
	Functional Composition																																		Functional Diversity		
Habitat type	Phasianidae	Columbidae	Apodidae	Cuculidae	Musophagidae	Accipitridae	Trogonidae	Bucerotidae	Meropidae	Lybiidae	Indicatoridae	Picidae	Campephagidae	Platysteiridae	Malaconotidae	Dicruridae	Corvidae	Stenostiridae	Macrosphenidae	Cisticolidae	Acrocephalidae	Locustellidae	Hirundinidae	Pycnonotidae	Phylloscopidae	Zosteropidae	Sturnidae	Muscicapidae	Nectariniidae	Ploceidae	Estrildidae	Viduidae	Motacillidae	Fringillidae	Family Richness	Family Shannon Diversity	Family Shannon Evenness
Montane forest	0,00	0,03	0,02	0,00	0,08	0,01	0,03	0,01	0,00	0,06	0,00	0,00	0,00	0,04	0,01	0,01	0,00	0,05	0,00	0,29	0,00	0,03	0,02	0,15	0,01	0,02	0,00	0,05	0,07	0,02	0,00	0,00	0,00	0,00	5,33	1,47	0,90
Old montane fallows	0,02	0,01	0,04	0,00	0,06	0,00	0,01	0,01	0,00	0,03	0,00	0,00	0,00	0,02	0,00	0,02	0,01	0,00	0,00	0,29	0,01	0,00	0,03	0,08	0,00	0,00	0,00	0,16	0,20	0,00	0,00	0,00	0,00	0,01	4,42	1,32	0,92
Young montane fallows	0,00	0,00	0,00	0,00	0,04	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,33	0,05	0,01	0,17	0,06	0,00	0,00	0,08	0,12	0,10	0,00	0,02	0,00	0,00	0,00	4,25	1,18	0,87
Montane cropland	0,01	0,00	0,02	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,01	0,00	0,00	0,01	0,00	0,28	0,07	0,09	0,06	0,03	0,00	0,00	0,02	0,23	0,07	0,00	0,02	0,00	0,05	0,01	4,50	1,29	0,87
Low-elevation forest	0,00	0,01	0,00	0,00	0,08	0,01	0,02	0,01	0,00	0,05	0,01	0,01	0,01	0,03	0,07	0,01	0,00	0,00	0,00	0,13	0,00	0,00	0,13	0,16	0,00	0,02	0,00	0,02	0,10	0,06	0,00	0,00	0,02	0,02	6,33	1,63	0,89
Old low-elevation fallows	0,00	0,02	0,01	0,01	0,01	0,00	0,00	0,00	0,00	0,03	0,01	0,04	0,00	0,03	0,04	0,00	0,00	0,00	0,02	0,23	0,01	0,00	0,03	0,08	0,00	0,00	0,03	0,00	0,27	0,10	0,02	0,00	0,00	0,03	4,82	1,21	0,76
Young low-elevation fallows	0,00	0,01	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,05	0,00	0,00	0,00	0,01	0,26	0,01	0,00	0,08	0,14	0,00	0,00	0,00	0,00	0,33	0,02	0,03	0,01	0,01	0,02	4,15	1,20	0,83
Low-elevation cropland	0,00	0,06	0,05	0,00	0,00	0,01	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,00	0,00	0,19	0,01	0,00	0,09	0,06	0,00	0,00	0,00	0,00	0,24	0,03	0,04	0,00	0,07	0,08	3,88	1,10	0,89
Total	0,00	0,02	0,02	0,00	0,04	0,01	0,01	0,00	0,00	0,03	0,00	0,01	0,00	0,02	0,03	0,01	0,00	0,01	0,00	0,24	0,02	0,02	0,07	0,10	0,00	0,01	0,01	0,07	0,16	0,03	0,02	0,00	0,03	0,02	4,78	1,32	0,88
ANOVA p value	0,265	0,318	0,837	0,189	0,001	0,921	0,007	0,646	0,477	0,000	0,106	0,120	0,102	0,120	0,063	0,075	0,159	0,000	0,239	0,047	0,000	0,113	0,111	0,005	0,454	0,159	0,049	0,000	0,000	0,327	0,360	0,210	0,007	0,022	0,006	0,010	0,486
Squared ETA	0,06	0,06	0,03	0,07	0,17	0,02	0,14	0,04	0,05	0,20	0,09	0,08	0,09	0,08	0,10	0,09	0,08	0,22	0,07	0,10	0,30	0,08	0,08	0,14	0,05	0,08	0,10	0,47	0,23	0,06	0,06	0,07	0,14	0,12	0,14	0,13	0,05

Table I. Continuation

	RANGE SIZE		MIGRATION			CONSERVATION STATUS				MONTANE	
Habitat type	Restricted	Large	Sedentary	Partially migratory	Migratory	Porportion Conservation Concern	Proportion Threatened	Number Conservation Concern	Number Threatened	Afromontane DL	Montane FARSYMABI
Montane forest	0,16	0,00	0,96	0,04	0,00	0,18	0,11	1,33	0,77	0,37	0,46
Old montane fallows	0,11	0,08	0,91	0,09	0,00	0,11	0,11	1,17	0,50	0,34	0,37
Young montane fallows	0,07	0,17	0,80	0,12	0,08	0,07	0,07	0,88	0,25	0,30	0,27
Montane cropland	0,06	0,09	0,81	0,12	0,06	0,06	0,06	1,25	0,40	0,50	0,43
Low-elevation forest	0,00	0,14	0,89	0,11	0,00	0,00	0,00	0,00	0,00	0,03	0,00
Old low-elevation fallows	0,00	0,08	0,96	0,04	0,00	0,00	0,00	0,00	0,00	0,01	0,00
Young low-elevation fallows	0,00	0,20	0,90	0,03	0,07	0,00	0,00	0,00	0,00	0,00	0,00
Low-elevation cropland	0,00	0,06	0,85	0,08	0,07	0,00	0,00	0,00	0,00	0,00	0,00
Total	0,06	0,09	0,89	0,08	0,03	0,06	0,05	0,62	0,28	0,20	0,21
ANOVA p value	0,000	0,000	0,163	0,555	0,014	0,000	0,000	0,000	0,000	0,000	0,000
Squared ETA	0,36	0,24	0,08	0,04	0,12	0,39	0,31	0,52	0,39	0,64	0,66

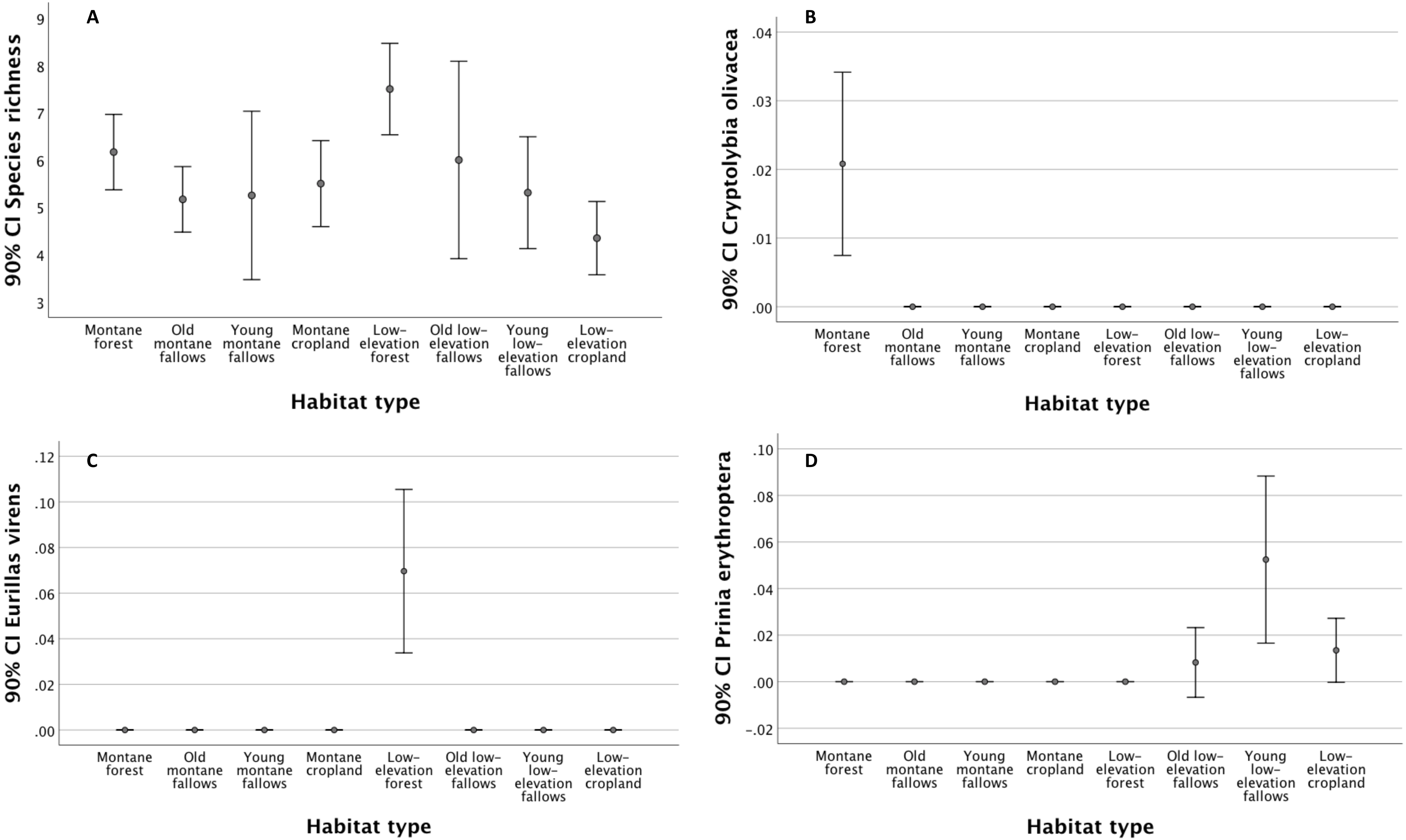


Figure I. Confidence Intervals (90%) per habitat type of **A.** Species richness, **B.** Proportion of *Cryptolybia olivacea,* **C***.* Proportion of *Eurillas virens,* and **D***.* Proportion of *Prinia erythroptera*

Table II.A. Total explained variance by each non-rotated PC and PCs with eigenvalue > 1.000

Variância total explicada

	Autovalores iniciais			carregamentos ao quadrado			ao quadrado		
Componente	Total	% de variância	% cumulativa	Total	% de variância	% cumulativa	Total	% de variância	% cumulativa
1	3,429	9,269	9,269	3,429	9,269	9,269	2,658	7,183	7,183
2	3,141	8,490	17,759	3,141	8,490	17,759	2,434	6,578	13,761
3	2,563	6,927	24,686	2,563	6,927	24,686	2,182	5,896	19,658
4	2,060	5,568	30,254	2,060	5,568	30,254	1,859	5,025	24,682
5	1,642	4,438	34,692	1,642	4,438	34,692	1,739	4,699	29,381
6	1,470	3,974	38,665	1,470	3,974	38,665	1,610	4,350	33,731
7	1,445	3,907	42,572	1,445	3,907	42,572	1,596	4,314	38,045
8	1,312	3,546	46,118	1,312	3,546	46,118	1,576	4,259	42,304
9	1,285	3,474	49,592	1,285	3,474	49,592	1,558	4,212	46,515
10	1,208	3,264	52,856	1,208	3,264	52,856	1,498	4,049	50,565
11	1,163	3,144	56,000	1,163	3,144	56,000	1,342	3,627	54,191
12	1,105	2,986	58,986	1,105	2,986	58,986	1,342	3,626	57,818
13	1,052	2,842	61,828	1,052	2,842	61,828	1,317	3,559	61,376
14	1,031	2,785	64,613	1,031	2,785	64,613	1,198	3,237	64,613
15	0,967	2,613	67,227						
16	0,929	2,511	69,738						
17	0,905	2,447	72,185						
18	0,879	2,376	74,560						
19	0,858	2,319	76,880						
20	0,833	2,252	79,132						
21	0,766	2,071	81,203						
22	0,747	2,018	83,222						
23	0,714	1,930	85,151						
24	0,641	1,732	86,883						
25	0,594	1,607	88,490						
26	0,557	1,506	89,996						
27	0,541	1,461	91,457						
28	0,519	1,403	92,860						
29	0,462	1,250	94,110						
30	0,431	1,166	95,276						
31	0,392	1,058	96,334						
32	0,329	0,890	97,224						
33	0,311	0,842	98,066						
34	0,267	0,721	98,788						
35	0,221	0,598	99,385						
36	0,175	0,473	99,858						
37	0,053	0,142	100,000						

Método de Extração: análise de Componente Principal.

Table II.B. Interpretation of each rotated PC (only PC with eigenvalue > 1.000) based on the 37 variables that entered the analysis

Matriz de componente rotativa[a]

Variable	Componente													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Species richness		0,88							0,12			0,19		
Shannon diversity		0,91	0,10						0,13					
Tauraco livingstonii	-0,16		0,13		-0,12			0,78					0,11	
Apaloderma vittatum	-0,12		0,49	0,61	-0,21				0,17			-0,14		
Cryptolybia olivacea				0,16	0,75	0,12								
Pogoniulus bilineatus	-0,22	0,27	0,26			-0,21		0,37	-0,15	0,12	-0,23		-0,21	
Batis dimorpha	-0,12	0,35	-0,10		0,41	-0,30	-0,17		-0,16	0,16	-0,14	-0,16	-0,24	
Batis soror		0,21			-0,23	0,26	-0,22			0,20	0,16	0,44	-0,11	0,24
Dryoscopus cubla	-0,13	0,13	0,47			-0,15	0,26	-0,13				0,36		-0,19
Tchagra australis							0,73							
Elminia albonotata		0,18		0,22		-0,10		-0,17	0,67		-0,22	-0,18	-0,14	
Apalis lynesi	0,11	0,14	-0,16	-0,14	0,16	-0,17	-0,12	0,38	0,25	0,25	-0,32	-0,32	-0,23	
Apalis flavida	-0,11	0,14			-0,12	0,76							-0,11	
Apalis melanocephala		-0,20	-0,10	0,61	0,22			0,33		0,10				
Camaroptera brachyura			0,78			0,27		0,11						
Cisticola cantans	-0,20	-0,19		-0,23	-0,14	-0,12	-0,13	-0,37			0,31		0,30	0,26
Cisticola lais	0,81													-0,29
Prinia subflava	-0,31		-0,18	-0,19	-0,26	0,14	-0,12	-0,32		0,14	0,20			0,18
Prinia erythroptera	-0,12						0,71	-0,12			0,22			
Iduna natalensis	0,63	0,19					-0,13	-0,12	-0,14		0,16	-0,13	0,30	
Cecropis abyssinica	-0,16									-0,75	-0,16			
Cecropis daurica						-0,12	0,15				0,64	-0,15		
Arizelocichla milanjensis				-0,13	0,65				0,41					
Eurillas virens			0,89					0,11						
Phyllastrephus flavostriatus	-0,10			0,82										
Pycnonotus barbatus		0,15		-0,17	-0,12	0,19	0,46	-0,11			-0,23	0,25	0,45	
Onychognatus morio							-0,13							-0,83
Dessonornis caffer	0,74		-0,11	-0,13						0,12	-0,15			
Pogonocichla stellata		0,10							0,80					
Saxicola torquatus	0,64												-0,15	0,30
Cinnyris fuelleborni	0,26	0,21		0,12		-0,13		-0,13		0,20	-0,50	-0,26		0,23
Cinnyris venustus	-0,29	-0,41		-0,33	-0,14			-0,35	-0,15					
Ploceus bicolor			0,17		0,44	0,71								
Lagonosticta rubricata													0,81	
Anthus cinnamomeus	0,25							-0,14		-0,63				0,17
Motacilla clara		0,15										0,68		
Crithagra sulphurata	-0,16	0,25	-0,12		-0,15	0,12			-0,12	-0,47	0,22	-0,33		

Método de Extração: análise de Componente Principal.
Método de Rotação: Varimax com Normalização de Kaiser.
a. Rotação convergida em 17 iterações.

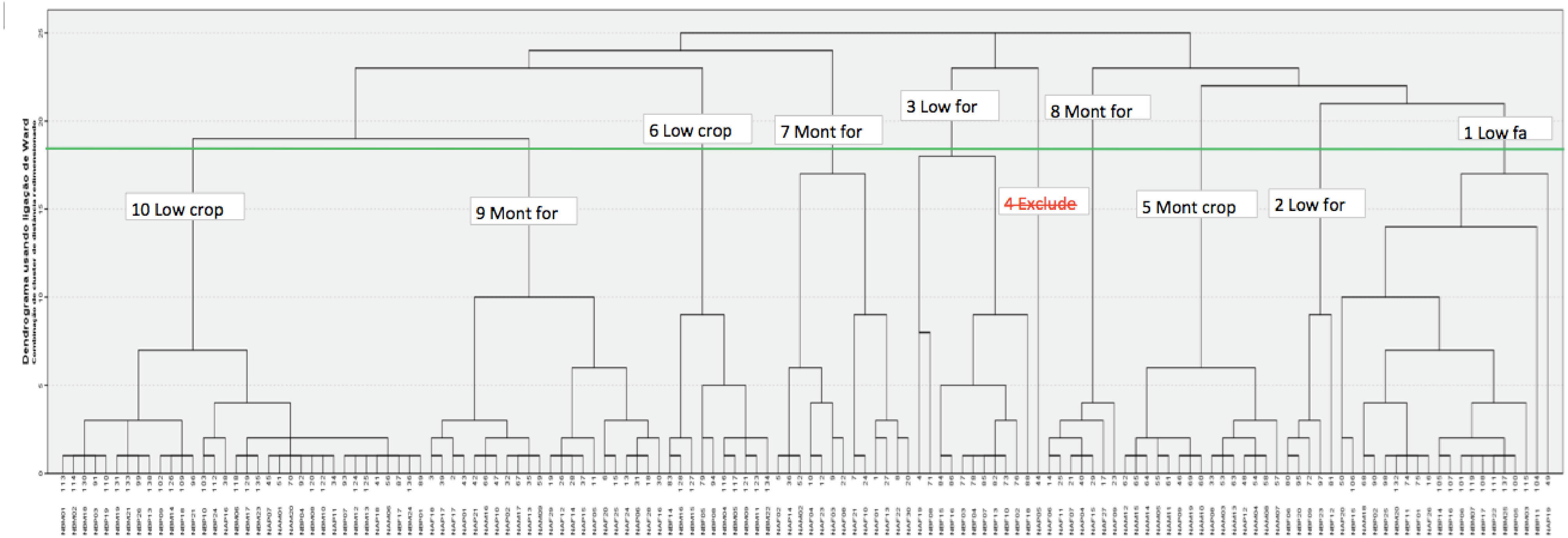


Figure II. Dendrogram of the cluster analysis of species diversity and composition of each point

Table III. Average values of all computed variables by cluster, with ANOVA p-value and the Squared ETA

Cluster		N	Abundance	Av p-spec abundance	Species richness	Shannon diversity	Shannon evenness	# SPECIES	Pternistis hildebrandti	Columba arquatrix	Streptopelia semitorquata	Turtur afer/chalcospilos	Treron calvus	Apus barbatus	Centropus superciliosus
8	Montane forest 1	7	9,3	1,3	7,1	1,83	0,96	24	0,00	0,00	0,00	0,00	0,00	0,00	0,00
7	Montane forest 2	13	9,8	1,6	6,2	1,68	0,95	25	0,00	0,03	0,00	0,00	0,00	0,00	0,00
9	Montane forest and fallows	22	8,9	1,7	5,2	1,47	0,89	32	0,02	0,03	0,00	0,00	0,00	0,03	0,00
5	Montane cropland	15	11,8	2,0	5,8	1,65	0,96	21	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3	Low-elevation forest	11	9,6	1,4	6,5	1,77	0,96	30	0,00	0,00	0,00	0,00	0,00	0,00	0,00
2	Low-elevation forest and old fallows	5	13,2	1,6	8,2	1,96	0,95	24	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1	Low-elevation fallows and cropland	20	15,1	2,0	8,0	1,83	0,93	58	0,00	0,00	0,00	0,01	0,01	0,02	0,00
6	Low-elevation cropland	10	14,2	2,3	5,9	1,54	0,89	26	0,00	0,00	0,00	0,01	0,02	0,01	0,00
10	Low-elevation cropland and other open habitats	34	10,5	3,1	3,3	0,94	0,81	33	0,00	0,00	0,01	0,02	0,01	0,05	0,00
Total		137	11,2	2,1	5,7	1,49	0,90	-	0,00	0,01	0,00	0,01	0,01	0,02	0,00
ANOVA p-Value			0,713	0,678	0,000	0,000	0,070	-	0,306	0,096	0,937	0,748	0,836	0,641	0,937
Squared ETA			0,04	0,04	0,39	0,44	0,11	-	0,07	0,10	0,02	0,04	0,03	0,05	0,02

Cluster	Chrysococcyx klaas	Tauraco livingstonii	Hieraaetus ayresii	Accipiter tachiro	Accipiter minullus	Apaloderma vittatum	Lophoceros alboterminatus	Merops pusillus	Cryptolybia olivacea	Stactolaema leucotis	Pogoniulus bilineatus	Pogoniulus chrysoconus	Indicator minor	Dendropicos fuscescens	Campephaga flava	Batis dimorpha	Batis soror	Platysteira peltata	Dryoscopus cubla	Tchagra australis	Tchagra senegalus
8	0,00	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00
7	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,02	0,00	0,04	0,00	0,00	0,00	0,00	0,11	0,00	0,00	0,00	0,00	0,00
9	0,00	0,13	0,00	0,02	0,00	0,01	0,01	0,00	0,00	0,00	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
5	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
3	0,00	0,08	0,00	0,01	0,00	0,04	0,02	0,00	0,02	0,00	0,05	0,00	0,01	0,01	0,01	0,00	0,00	0,02	0,04	0,00	0,00
2	0,01	0,07	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,05	0,01	0,03	0,00	0,00	0,00	0,12	0,00	0,05	0,00	0,00
1	0,00	0,02	0,01	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,01	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,05	0,02	0,00
6	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,01	0,00	0,00
Total	0,00	0,04	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,01	0,00	0,00
ANOVA p-Value	0,000	0,000	0,368	0,273	0,674	0,000	0,410	0,673	0,061	0,005	0,002	0,000	0,000	0,744	0,424	0,000	0,000	0,244	0,000	0,063	0,674
Squared ETA	0,19	0,30	0,06	0,07	0,04	0,24	0,06	0,04	0,11	0,16	0,17	0,19	0,23	0,04	0,06	0,51	0,74	0,08	0,20	0,11	0,04

Table III. Continuation

Cluster		Dessonornis caffer	Dessonornis anomalus	Pogonocichla stellata	Chamaetylas choloensis	Saxicola torquatus	Hedydipna collaris	Cyanomitra olivacea	Chalcomitra amethystina	Chalcomitra senegalensis	Cinnyris manoensis	Cinnyris fuelleborni	Cinnyris venustus	Euplectes hordeaceus	Euplectes ardens	Ploceus ocularis	Ploceus cucullatus	Ploceus bicolor	Lagonosticta rubricata	Estrilda astrild	Vidua macroura	Anthus lineiventris	Anthus cinnamomeus	Macronyx croceus	Motacilla clara	Crithagra hyposticta	Crithagra sulphurata
8	Montane forest 1	0,02	0,00	0,07	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,03	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
7	Montane forest 2	0,02	0,01	0,00	0,02	0,00	0,00	0,01	0,00	0,00	0,00	0,09	0,01	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
9	Montane forest and fallows	0,07	0,00	0,00	0,01	0,00	0,00	0,01	0,00	0,00	0,02	0,04	0,03	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00
5	Montane cropland	0,18	0,00	0,00	0,00	0,10	0,00	0,01	0,00	0,00	0,00	0,05	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,07	0,00	0,00	0,01	0,00
3	Low-elevation forest	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,07	0,00	0,00	0,00	0,00	0,12	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,00
2	Low-elevation forest and old fallows	0,00	0,00	0,00	0,00	0,00	0,05	0,01	0,01	0,01	0,00	0,00	0,13	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,06	0,00	0,01
1	Low-elevation fallows and cropland	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,16	0,01	0,00	0,00	0,01	0,00	0,00	0,01	0,00	0,00	0,01	0,00	0,00	0,01	0,01
6	Low-elevation cropland	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,12	0,00	0,00	0,01	0,00	0,00	0,00	0,03	0,00	0,00	0,10	0,00	0,00	0,04	0,14
10	Low-elevation cropland and other open habitats	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,28	0,05	0,00	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,01	0,01	0,00	0,01	0,00
Total		0,04	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,03	0,12	0,01	0,00	0,00	0,00	0,01	0,00	0,01	0,00	0,00	0,02	0,00	0,00	0,01	0,01
ANOVA p-Value		0,000	0,012	0,000	0,469	0,000	0,000	0,606	0,038	0,064	0,783	0,005	0,000	0,696	0,937	0,277	0,674	0,000	-	0,628	0,674	0,674	0,001	0,937	0,000	0,864	0,000
Squared ETA		0,33	0,14	0,59	0,06	0,39	0,19	0,05	0,12	0,11	0,04	0,15	0,28	0,04	0,02	0,07	0,04	0,38	-	0,05	0,04	0,04	0,18	0,02	0,30	0,03	0,50

Table III. Continuation

		HABITAT GUILDS									HABITAT DENSITY					
		Functional Composition						Functional Diversity			Functional			Functional Diversity		
Cluster		Forest	Shrubland	Woodland	Grassland	Wetland	Rock	Habitat Richness	Habitat Shannon Diversity	Habitat Shannon Evenness	Closed habitats	Semi-open habitats	Open habitats	Habitat Density Richness	Habitat Density Shannon Diversity	Habitat Density Shannon Evenness
8	Montane forest 1	0,93	0,02	0,05	0,00	0,00	0,00	1,57	0,20	0,24	0,61	0,39	0,00	2,00	0,28	0,40
7	Montane forest 2	0,95	0,01	0,03	0,02	0,00	0,00	1,46	0,15	0,16	0,66	0,32	0,02	2,00	0,24	0,33
9	Montane forest and fallows	0,80	0,02	0,09	0,06	0,00	0,03	1,77	0,38	0,40	0,63	0,31	0,06	2,14	0,22	0,26
5	Montane cropland	0,38	0,22	0,06	0,32	0,00	0,02	3,47	1,08	0,90	0,10	0,47	0,44	2,53	0,30	0,35
3	Low-elevation forest	0,66	0,02	0,30	0,00	0,00	0,02	2,18	0,58	0,68	0,46	0,52	0,02	2,00	0,26	0,35
2	Low-elevation forest and old fallows	0,36	0,13	0,49	0,01	0,00	0,00	2,60	0,79	0,86	0,22	0,71	0,08	2,40	0,28	0,28
1	Low-elevation fallows and cropland	0,15	0,17	0,43	0,16	0,00	0,09	3,40	0,92	0,76	0,09	0,66	0,25	2,20	0,19	0,23
6	Low-elevation cropland	0,10	0,32	0,21	0,35	0,00	0,01	3,10	0,91	0,83	0,03	0,62	0,35	2,00	0,21	0,27
10	Low-elevation cropland and other open habitats	0,20	0,22	0,39	0,14	0,00	0,06	2,21	0,58	0,67	0,14	0,72	0,14	1,62	0,14	0,19
Total		0,45	0,14	0,24	0,13	0,00	0,04	2,42	0,62	0,61	0,30	0,54	0,16	2,03	0,21	0,27
ANOVA p-Value		0,000	0,000	0,000	0,000	0,937	0,456	0,000	0,000	0,000	0,000	0,000	0,000	0,001	0,005	0,011
Squared ETA		0,65	0,31	0,38	0,31	0,02	0,06	0,39	0,43	0,37	0,56	0,30	0,36	0,19	0,15	0,14

		FEEDING NICHE PIGOT																	
		Functional Composition															Functional Diversity		
Cluster		Vertivore aerial	Invertivore aerial	Invertivore sally air	Invertivore glean arboreal	Invertivore bark	Invertivore sally surface	Frugivore glean	Nectarivore glean	Invertivore sally ground	Granivore arboreal	Invertivore ground	Herbivore ground	Granivore ground	Generalist	NA	Feeding Niche Pigot Richness	Feeeding Niche Pigot Shannon Diversity	Feeeding Niche Pigot Shannon Evenness
8	Montane forest 1	0,00	0,06	0,16	0,33	0,00	0,01	0,07	0,03	0,00	0,00	0,00	0,00	0,00	0,20	0,13	4,71	1,19	0,77
7	Montane forest 2	0,00	0,00	0,07	0,47	0,00	0,17	0,09	0,09	0,00	0,00	0,03	0,00	0,00	0,03	0,04	4,15	1,18	0,84
9	Montane forest and fallows	0,00	0,06	0,02	0,43	0,00	0,02	0,25	0,07	0,00	0,00	0,01	0,02	0,01	0,10	0,03	3,41	1,00	0,84
5	Montane cropland	0,00	0,05	0,01	0,41	0,00	0,00	0,03	0,08	0,10	0,00	0,07	0,00	0,01	0,22	0,03	4,00	1,14	0,85
3	Low-elevation forest	0,00	0,05	0,01	0,37	0,01	0,05	0,32	0,07	0,00	0,00	0,00	0,00	0,03	0,06	0,04	4,00	1,17	0,87
2	Low-elevation forest and old fallows	0,00	0,01	0,02	0,21	0,00	0,12	0,29	0,13	0,00	0,00	0,08	0,00	0,00	0,09	0,04	5,20	1,39	0,85
1	Low-elevation fallows and cropland	0,01	0,14	0,03	0,24	0,02	0,01	0,13	0,17	0,00	0,01	0,04	0,00	0,03	0,10	0,07	5,55	1,33	0,83
6	Low-elevation cropland	0,00	0,21	0,03	0,11	0,00	0,00	0,10	0,12	0,00	0,00	0,11	0,00	0,05	0,25	0,01	4,50	1,19	0,81
10	Low-elevation cropland and other open habitats	0,00	0,12	0,00	0,18	0,01	0,00	0,09	0,29	0,00	0,00	0,04	0,00	0,09	0,17	0,01	2,94	0,81	0,75
Total		0,00	0,09	0,03	0,30	0,01	0,03	0,14	0,14	0,01	0,00	0,04	0,00	0,03	0,13	0,04	4,00	1,09	0,81
ANOVA p-Value		0,166	0,112	0,000	0,000	0,744	0,000	0,000	0,000	0,000	0,674	0,033	0,306	0,214	0,002	0,027	0,000	0,000	0,631
Squared ETA		0,09	0,09	0,30	0,28	0,04	0,66	0,30	0,21	0,39	0,04	0,12	0,07	0,08	0,17	0,12	0,33	0,26	0,05

Table III. Continuation

Cluster		Vertivore aerial	Invertivore aerial	Vertivore Generalist	Invertivore sally air	Invertivore glean canopy	Invertivore glean understorey	Invertivore glean grass	Invertivore bark	Invertivore sally surface	Invertivore Insessorial Generalist	Omnivore Omnivore Insessorial	Frugivore glean	Nectarivore glean	Invertivore sally ground	Granivore arboreal	Invertivore Generalist	Granivore Generalist	Invertivore ground	Omnivore Omnivore Terrestrial	Herbivore Omnivore Terrestrial	Granivore ground	Feeeding Niche Farsymabi Richness	Feeding Niche Farsymabi Shannon Diversity	Feeding Niche Farsymabi Shannon Evenness
		FEEDING NICHE FARSYMABI																							
		Functional Composition																					Functional Diversity		
8	Montane forest 1	0,00	0,06	0,00	0,16	0,29	0,02	0,02	0,00	0,01	0,09	0,13	0,07	0,03	0,00	0,00	0,11	0,00	0,00	0,00	0,00	0,00	5,29	1,53	0,94
7	Montane forest 2	0,00	0,00	0,00	0,07	0,41	0,04	0,02	0,00	0,17	0,01	0,04	0,09	0,09	0,00	0,00	0,03	0,00	0,03	0,00	0,00	0,00	4,62	1,32	0,87
9	Montane forest and fallows	0,00	0,06	0,02	0,02	0,35	0,02	0,06	0,00	0,02	0,01	0,03	0,25	0,07	0,00	0,00	0,07	0,00	0,01	0,00	0,02	0,01	4,05	1,18	0,85
5	Montane cropland	0,00	0,05	0,00	0,01	0,06	0,11	0,24	0,00	0,00	0,01	0,03	0,03	0,08	0,10	0,00	0,18	0,03	0,07	0,00	0,00	0,01	5,33	1,56	0,94
3	Low-elevation forest	0,00	0,05	0,01	0,01	0,29	0,07	0,00	0,01	0,05	0,04	0,04	0,32	0,07	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,03	4,82	1,37	0,90
2	Low-elevation forest and old fallows	0,00	0,01	0,00	0,02	0,14	0,03	0,04	0,00	0,12	0,08	0,04	0,29	0,13	0,00	0,00	0,00	0,01	0,08	0,00	0,00	0,00	5,80	1,55	0,90
1	Low-elevation fallows and cropland	0,01	0,14	0,00	0,03	0,09	0,07	0,09	0,02	0,01	0,06	0,07	0,13	0,17	0,00	0,01	0,01	0,03	0,04	0,00	0,00	0,03	6,35	1,61	0,90
6	Low-elevation cropland	0,00	0,21	0,00	0,03	0,03	0,03	0,05	0,00	0,00	0,08	0,01	0,10	0,12	0,00	0,00	0,00	0,17	0,11	0,00	0,00	0,05	5,30	1,43	0,88
10	Low-elevation cropland and other open habitats	0,00	0,12	0,00	0,00	0,03	0,05	0,10	0,01	0,00	0,12	0,00	0,09	0,29	0,00	0,00	0,02	0,03	0,04	0,00	0,00	0,09	3,09	0,90	0,81
Total		0,00	0,09	0,00	0,03	0,17	0,05	0,08	0,01	0,03	0,06	0,04	0,14	0,14	0,01	0,00	0,05	0,03	0,04	0,00	0,00	0,03	4,62	1,29	0,87
ANOVA p-Value		0,166	0,112	0,273	0,000	0,000	0,539	0,000	0,744	0,000	0,005	0,015	0,000	0,000	0,000	0,674	0,000	0,000	0,033	0,937	0,314	0,214	0,000	0,000	0,292
Squared ETA		0,09	0,09	0,07	0,30	0,50	0,05	0,29	0,04	0,66	0,15	0,13	0,30	0,21	0,39	0,04	0,31	0,25	0,12	0,02	0,07	0,08	0,36	0,36	0,07

Table III. Continuation

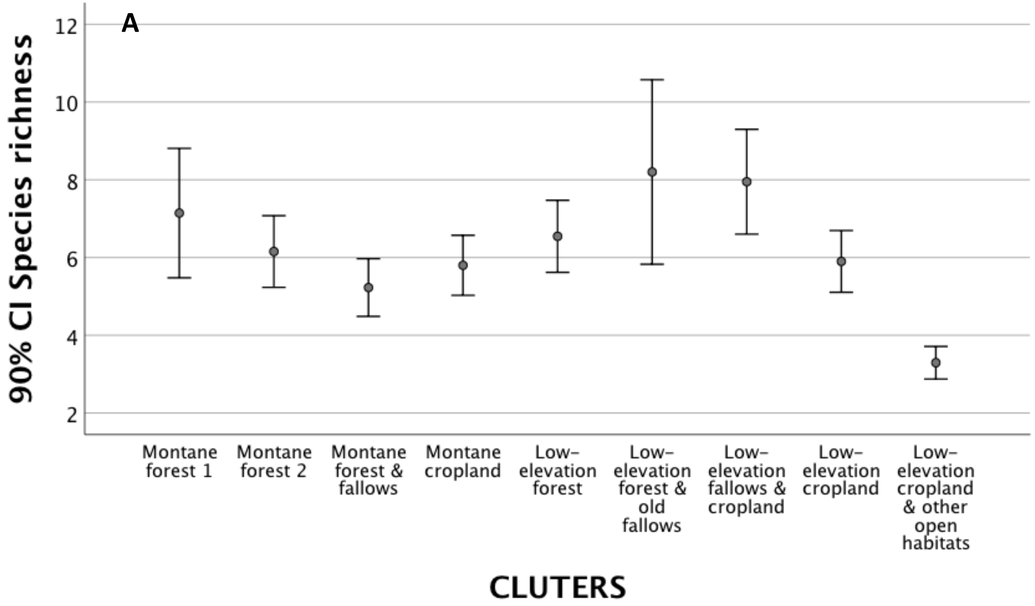
Cluster		Phasianidae	Columbidae	Apodidae	Cuculidae	Musophagidae	Accipitridae	Trogonidae	Bucerotidae	Meropidae	Lybiidae	Indicatoridae	Picidae	Campephagidae	Platysteiridae	Malaconotidae	Dicruridae	Corvidae	Stenostiridae	Macrosphenidae	Cisticolidae	Acrocephalidae	Locustellidae	Hirundinidae	Pycnonotidae	Phylloscopidae	Zosteropidae	Sturnidae	Muscicapidae	Nectariniidae	Ploceidae	Estrildidae	Viduidae	Motacillidae	Fringillidae	Family Richness	Family Shannon Diversity	Family Shannon Evenness
		FAMILY																																				
		Functional Composition																																		Functional Diversity		
8	Montane forest 1	0,00	0,00	0,00	0,00	0,03	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,01	0,02	0,04	0,00	0,09	0,00	0,26	0,00	0,02	0,06	0,23	0,01	0,01	0,00	0,13	0,04	0,01	0,00	0,00	0,00	0,00	6,00	1,56	0,93
7	Montane forest 2	0,00	0,03	0,00	0,00	0,00	0,00	0,06	0,00	0,00	0,06	0,00	0,00	0,00	0,11	0,01	0,01	0,00	0,06	0,00	0,27	0,01	0,04	0,00	0,17	0,00	0,02	0,00	0,05	0,10	0,01	0,00	0,00	0,00	0,00	5,46	1,57	0,94
9	Montane forest and fallows	0,02	0,03	0,03	0,00	0,13	0,02	0,01	0,01	0,00	0,05	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,37	0,00	0,02	0,03	0,05	0,01	0,01	0,00	0,10	0,10	0,00	0,00	0,00	0,00	0,01	4,27	1,25	0,87
5	Montane cropland	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,01	0,00	0,30	0,10	0,01	0,05	0,03	0,00	0,00	0,02	0,28	0,09	0,00	0,03	0,00	0,07	0,01	4,60	1,36	0,91
3	Low-elevation forest	0,00	0,00	0,00	0,00	0,08	0,01	0,04	0,02	0,00	0,06	0,01	0,01	0,01	0,02	0,06	0,01	0,00	0,00	0,00	0,16	0,00	0,00	0,05	0,19	0,00	0,04	0,00	0,01	0,08	0,12	0,00	0,00	0,00	0,03	5,82	1,64	0,95
2	Low-elevation forest and old fallows	0,00	0,00	0,00	0,01	0,07	0,00	0,00	0,00	0,00	0,09	0,03	0,00	0,00	0,12	0,05	0,00	0,00	0,00	0,00	0,15	0,00	0,01	0,01	0,14	0,00	0,00	0,00	0,02	0,22	0,00	0,00	0,00	0,06	0,01	6,80	1,75	0,95
1	Low-elevation fallows and cropland	0,00	0,02	0,02	0,00	0,02	0,01	0,00	0,00	0,02	0,02	0,00	0,02	0,00	0,01	0,09	0,00	0,00	0,00	0,00	0,20	0,01	0,00	0,13	0,10	0,00	0,00	0,06	0,02	0,18	0,02	0,01	0,00	0,01	0,02	6,20	1,56	0,90
6	Low-elevation cropland	0,00	0,03	0,01	0,00	0,01	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,00	0,16	0,02	0,01	0,21	0,06	0,00	0,00	0,00	0,01	0,13	0,01	0,03	0,00	0,10	0,18	5,20	1,35	0,84
10	Low-elevation cropland and other open habitats	0,00	0,04	0,05	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,01	0,00	0,00	0,04	0,00	0,00	0,00	0,01	0,22	0,00	0,05	0,07	0,07	0,00	0,00	0,00	0,02	0,29	0,05	0,03	0,00	0,02	0,01	3,00	0,86	0,78
Total		0,00	0,02	0,02	0,00	0,04	0,01	0,01	0,00	0,00	0,03	0,00	0,01	0,00	0,02	0,03	0,01	0,00	0,01	0,00	0,24	0,02	0,02	0,07	0,10	0,00	0,01	0,01	0,07	0,16	0,03	0,01	0,00	0,03	0,02	4,76	1,31	0,87
ANOVA p-Value		0,306	0,814	0,641	0,597	0,000	0,412	0,000	0,410	0,673	0,000	0,000	0,744	0,424	0,000	0,018	0,020	0,937	0,000	0,681	0,011	0,000	0,858	0,048	0,000	0,447	0,082	0,117	0,000	0,001	0,170	0,628	0,674	0,004	0,000	0,000	0,000	0,084
Squared ETA		0,07	0,03	0,05	0,05	0,30	0,06	0,24	0,06	0,04	0,24	0,22	0,04	0,06	0,50	0,13	0,13	0,02	0,31	0,04	0,14	0,48	0,03	0,11	0,20	0,06	0,10	0,09	0,44	0,18	0,08	0,05	0,04	0,16	0,29	0,34	0,37	0,10

Table III. Continuation

Cluster		RANGE SIZE		MIGRATION			CONSERVATION STATUS				MONTANE	
		Restricted	Large	Sedentary	Partially migratory	Migratory	Porportion Conservation Concern	Proportion Threatened	Number Conservation Concern	Number Threatened	Afromontane DL	Montane FARSYMABI
8	Montane forest 1	0,21	0,02	0,94	0,06	0,00	0,22	0,09	1,57	0,57	0,52	0,48
7	Montane forest 2	0,15	0,00	1,00	0,00	0,00	0,17	0,11	1,38	0,85	0,38	0,53
9	Montane forest and fallows	0,15	0,03	0,94	0,06	0,00	0,16	0,15	1,14	0,73	0,36	0,38
5	Montane cropland	0,03	0,13	0,78	0,14	0,08	0,03	0,03	1,20	0,27	0,45	0,38
3	Low-elevation forest	0,03	0,16	0,95	0,05	0,00	0,05	0,02	0,27	0,09	0,07	0,05
2	Low-elevation forest and old fallows	0,00	0,14	0,96	0,04	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1	Low-elevation fallows and cropland	0,01	0,18	0,83	0,07	0,09	0,01	0,01	0,30	0,15	0,06	0,05
6	Low-elevation cropland	0,00	0,06	0,86	0,04	0,10	0,00	0,00	0,00	0,00	0,00	0,00
10	Low-elevation cropland and other open habitats	0,00	0,07	0,86	0,13	0,01	0,00	0,00	0,12	0,00	0,08	0,08
Total		0,06	0,09	0,89	0,08	0,03	0,06	0,05	0,62	0,28	0,20	0,21
ANOVA p-Value		0,000	0,000	0,064	0,367	0,002	0,000	0,000	0,000	0,000	0,000	0,000
Squared ETA		0,44	0,23	0,11	0,06	0,17	0,43	0,45	0,42	0,41	0,50	0,53

Table IV. Cluster x Habitat type cross-tabulation

Cluster		Habitat type								Total
		Montane forest	Old montane fallows	Young montane fallows	Montane cropland	Low-elevation forest	Old low-elevation fallows	Young low-elevation fallows	Low-elevation cropland	
8	Montane forest 1	6	1	0	0	0	0	0	0	7
7	Montane forest 2	11	1	0	1	0	0	0	0	13
9	Montane forest and fallows	11	6	2	3	0	0	0	0	22
5	Montane cropland	0	1	2	12	0	0	0	0	15
3	Low-elevation forest	1	0	0	0	10	0	0	0	11
2	Low-elevation forest and old fallows	0	0	0	0	3	2	0	0	5
1	Low-elevation fallows and cropland	1	0	2	1	2	2	8	4	20
6	Low-elevation cropland	0	0	0	0	2	1	0	7	10
10	Low-elevation cropland and other open habitats	0	3	1	3	1	6	5	15	34
Total		30	12	8	20	18	11	13	26	138


A
90% CI Species richness
12
10
8
6
4
2
Montane forest 1
Montane forest 2
Montane forest & fallows
Montane cropland
Low–elevation forest
Low–elevation forest & old fallows
Low–elevation fallows & cropland
Low–elevation cropland
Low–elevation cropland & other open habitats
CLUTERS

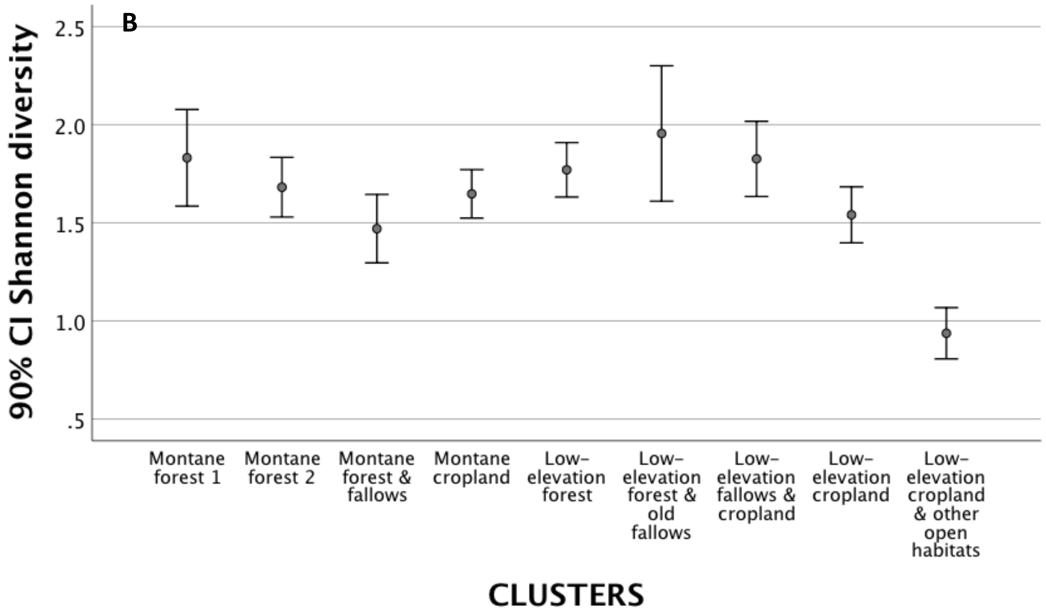

B
90% CI Shannon diversity
2.5
2.0
1.5
1.0
.5
Montane forest 1
Montane forest 2
Montane forest & fallows
Montane cropland
Low–elevation forest
Low–elevation forest & old fallows
Low–elevation fallows & cropland
Low–elevation cropland
Low–elevation cropland & other open habitats
CLUSTERS

Figure III. Confidence Intervals (90%) per cluster for **A.** species richness and **B.** Shannon diversity

VI.II.II. THE 9 BIRD COMMUNITIES OF MOUNT NAMULI

(Cluster interpretation)

A) Montane-forest bird communities

28 (out of 30) points selected to represent montane forest habitats were included in three clusters (cf. clusters 8, 7 and 9, in the dendrogram, Fig. II, and Table IV). In each of these clusters, montane forest points represent at least half of all points within the cluster. None of these clusters include any Low-elevation (< 1600 m asl) point (Table IV).

These clusters do not group in a single, higher-order cluster, which would represent "montane forests as a whole" (cf. dendrogram; Fig. II). This means a significant degree of distinction between the three mountain-forest bird communities, as regards their diversity and composition indicators, that is: there are high levels of beta diversity (or species turnover) among them.

In all of these three clusters, forest species represent, on average, at least 80% of all birds recorded less than 30 m away - a percentage that is even higher than 90% in clusters 8 and 7 (Table III). No other cluster reaches a similar value: cluster 3, low-elevation forest, gets only a 66% figure, and, in all other clusters, the proportion of forest species is clearly below 50% (Table III). Habitat diversity is minimal in these three montane forest clusters (Table III), revealing that, invariably, almost all birds recorded in any point correspond to forest species.

A similar contrast between these three clusters and all other clusters is the percentage of recorded birds that require closed habitats, which is between 61 and 66% in these three clusters and below (in most cases, much below) 50% in all other clusters (Table III).

These clusters are also unique in that they get the maximum proportion of the feeding niche Invertivore glean canopy, which represents, in average, between 29 and 41% of all birds recorded less than 30 m away (only cluster 3, low-elevation forest, reaches the smaller of these figures) (Table III).

These clusters are also those with the maximum average proportions of endemic/restricted-range species (15 to 21% of all birds recorded less than 30 m away) and the lowest proportions of cosmopolitan/wide-range species (less than 5% of all birds recorded less than 30 m away) (Table III). The number of threatened species is also maximum in these clusters: the average number of threatened species (per point) is between 0.6 and 0.9 (no other cluster reaches a similar figure) (Table III). Thus, montane forests are the single most important habitat in Namuli when it comes to protect endemic and threatened bird species.

Together with clusters 3 and 2 (including low-elevation forests), montane forest clusters are also unique in that no fully migratory species was recorded in these clusters (Table III).

C1) Montane forest 1 (cluster 8)

In cluster 8, 6 points (out of 7, that is: 86%) are mountain forest points, and another one is a montane old fallow point (Table IV). The former represent relatively closed forest habitat, with only one including edge, and none including clearings. Half of the forest points have full canopy cover, all have abundant natural regeneration, five have abundant leaf litter, and five have some or abundant understorey. Five are between 1700 and 1800 m elevation, in colder (Timberlake et al., 2009) Manho forest, and one at circa 1660 m, in warmer Kahli. The fallow point is a 3-years-old fallow with dense grass cover, abundant understorey and some tree cover, located at the edge of Manho forest at circa 1740 m elevation.

This is a very homogenous cluster in terms of the diversity and composition of the bird community (Fig.II); it is also very distinct from all other clusters (Fig.II).

The bird community captured by cluster 8 is characterized by relatively high average levels of species richness and Shannon diversity, well above the corresponding sample averages (all 137 points; Table III). These levels are also significantly higher than those of cluster 9 (Montane forest and fallows; $P<0.05$), higher (non-significant differences) than those of clusters 7 (Mountain forest 2) and 5 (Mountain cropland), and similar ($P>0.05$) to those of clusters 3 (Low-elevation forest), 2 (Low-elevation forest and old fallows) and 1 (Low-elevation fallows and cropland) (Fig.III). Combined with the high distinctiveness of this bird community in relation to others in Namuli (beta diversity = species turnover across communities; cf above and Fig. II), these high levels of alpha diversity imply a relevant contribution of the Mountain forest 1 community for (gamma) bird diversity in the Mount Namuli as a whole.

The species composition of this Montane forest community is characterized by maximum importance of *Dicrurus ludwigii*, *Elminia albonotata* (*), *Arizelocichla milanjensis*, *Phyllastrephus cabanisi* (*) and *Pogonocichla stellata* (*), which represent 41% of all birds recorded at less than 30 m (Table III). High levels of relative importance were also recorded for *Apalis lynesi* and *Apalis melanocephala*, which represent another 24% of all birds recorded at less than 30 m (Table III). Among species that do not reach significant differences across clusters (ANOVA test), the following have in Montane forest 1 its maximum relative importance: *Psalidoprocne pristoptera*, *Phylloscopus ruficapilla*, *Muscicapa adusta*, *Cyanomitra olivacea* (*) (Table III). This set of species reflects a good balance between ground and understorey species (the four marked with asterisk) and canopy, mid-level and aerial feeders (the 7 unmarked species). The coexistence, in this bird community, of many canopy and ground/understorey species suggests that its high levels of species richness and diversity are supported by its complex, multi-layered ecosystem structure.

This suggestion is reinforced by the fact of cluster 8 reaching the maximum feeding niche richness and diversity among the three mountain forest clusters, as well as the maximum habitat-density diversity and evenness (Table III).

As regards functional composition (per feeding niche), and reflecting its feeding niche richness and diversity, bird communities in this cluster, while recording a relatively high proportion of Invertivore glean canopy (as all forest mountain clusters), also record (differently from all other montane forest clusters) high proportions of other feeding niches such as: (1) Invertivore sally to air (*Dicrurus ludwigii*, *Elminia albonotata*, *Muscicapa adusta*), (2) Invertivore Insessorial Generalist (*Pogonocichla stellata*); (3) Omnivore, Omnivore Insessorial (*Arizelocichla milanjensis*, *Cyanomitra olivacea*), and (4) Invertivore Generalist (*Phyllastrephus cabanisi*) (Table III).

Thus, this cluster of montane forests, predominantly located in cooler Manho, has not only the highest species richness and diversity, but also the highest family-level taxonomic richness and the highest functional (feeding niche) diversity among all three montane forest clusters (Table III).

C2) Montane forest 2 (cluster 7)

In cluster 7, 11 points (out of 13, that is: 85%) represent mountain forest, other is a montane old fallow and another is montane cropland (Table IV). Four mountain-forest points (out of 11) include semi-open features: 3 include forest edge, and another one includes a clearing. Eight (in 11) forest points have full canopy cover, all have abundant natural regeneration, nine have abundant leaf litter, and only two have some (none has abundant) understorey. Summarizing, semi-open microhabitats are more frequent in this cluster than in cluster 8; canopy cover seems fuller, and understorey less frequent and abundant, which is consistent with fuller canopy cover but not so much with more edge and clearing micro-habitats. Six forest points are located in warmer (Timberlake et al., 2009) Kahli forest, and five in colder Manho. Four are below 1700 m elevation and seven between 1700 and 1800 m elevation.

The fallow point is a partly burnt 3-years-old fallow with dense and high grass and bracken cover, some understorey and some tree cover, located in Murethxa, above Manho forest, at circa 1820 m elevation. The cropland point is a burnt field prepared to seed potato, with some understorey and scarce trees, located in Murethxa, above Manho, at 1894 m elevation, with a forest area lower down in a gulley.

This cluster is relatively heterogeneous, as it includes two sub-clusters that are quite different (cf. dendrogram; Fig. II) in terms of the diversity and/or composition of their bird communities.

The bird communities included in cluster 7 are characterized by average levels of species richness and Shannon diversity that are intermediate between the higher levels of cluster 8 (Mountain forest 1) and the lower levels of cluster 9 (Montane forest and fallows) (Table III and Fig. III). These differences are, however, not statistically significant ($P>0.05$) (Fig.III), which is possibly due to the small size of the three clusters and the internal heterogeneity of clusters 7 and 9 (see dendrogram; Fig.II).

The species composition of the Montane forest 2 community is characterized by maximum importance of *Apaloderma vittatum*, *Batis dimorpha* (*), *Apalis melanocephala*, *Phyllastrephus flavostriatus*, *Dessonornis anomalus* (*), and *Cinnyris fuelleborni*, which represent 56% of all birds recorded at less than 30 m (Table III). High levels of relative importance were also recorded for *Pogoniulus bilineatus*, *Elminia albonotata* (*), and *Apalis lynesi*, which represent another 19% of all birds recorded at less than 30 m (Table III). Among species that do not reach significant differences across clusters (ANOVA test), one was only recorded in this cluster: *Chlorophoneus nigrifrons*; some were recorded here its maximum relative importance: *Columba arquatrix*, ex-aequo with cluster 9, *Cryptolybia olivacea*, and *Chamaetylas choloensis* (*) (Table III). This set of species reflects the higher importance of mid-level and canopy feeders (the 9 unmarked species) when compared to understorey and leaf-litter feeders (the four marked with asterisk), which may be related with the higher frequency of full canopy cover and lower abundance of understorey in the points in this cluster when compared with cluster 8. Note that five of the abovementioned 13 species (*Columba arquatrix*, *Apaloderma vittatum*, *Chlorophoneus nigrifrons*, *Dessonornis anomalus* and *Chamaetylas choloensis*) the first three of which are canopy feeders, were not recorded in Montane forest 1 points (cf. Table III). This reinforces the higher importance of the canopy micro-habitat in Montane forest 2, but note that a characteristic bird species of Montane forest 1 (*Phylloscopus ruficapilla*, also a canopy dweller) does not occur in Montane forest 2 points (Table III). While complex, these patterns of functional composition of the different montane-forest bird communities are confirmed by our functional diversity and composition results. Thus, the apparently lower feeding niche diversity of the montane forest 2 cluster, when compared with montane forest 1, seems to be related with the higher (actually the highest) importance of the Invertivore glean canopy (*Apalis melanocephala*, *Phyllastrephus flavostriatus*, *Apalis lynesi*, *Chlorophoneus nigrifrons*) and the Invertivore sally to surface (*Apaloderma vittatum* and *Batis dimorpha*) niches in the former (Table III).

The importance of the warmer Kahli forest habitat, with higher army ant activity than colder Manho, for the obligate ant-follower *Chamaetylas choloensis* was underlined by Timberlake et al. (2009). This ecological driver probably explains the recorded association between *Chamaetylas choloensis* and the Montane forest 2 community (Table III).

C3) Montane forest and fallows (cluster 9)

In cluster 9, 11 points (out of 22, that is: 50%) are mountain forest points, 8 (36%) are montane fallow points and 3 (14%) are montane cropland points (Table IV). Five (out of 11) of the mountain-forest points have semi-open features: three include forest edge, and two include clearings. Seven forest points have full canopy cover, only 8 have abundant natural regeneration, 8 have abundant leaf litter, and five have some or abundant understorey. Summarizing, semi-open microhabitats are more frequent in this cluster than in clusters 7 and 8; canopy cover seems less developed than in cluster 7, and understorey is more abundant than in cluster 7 (similar to cluster 8), which is consistent with the importance of edge and clearing micro-habitats. Five forest points are located in warmer Kahli forest, and six in colder Manho. Nine are between 1700 and 1800 m elevation, and two slightly below 1700 m asl.

Six montane fallow points correspond to 3-5 years-old fallows, and two are 1-2 years old fallows. Six fallow points are between 1800 and 1900 m of elevation, one between 1700 and 1800 m asl, and one between 1600 and 1700 m asl. Many fallow points, in particular the lower ones, are close to the edge of Manho forest or surrounded by degraded forest patches in the Murethxa plateau; others, higher up in plateaux or in rocky areas, are farther from forest remains. Most fallows have dense grass cover, including bracken, some or abundant understorey and some tree cover. The three montane cropland points have been seeded with potato, have no or scarce tree cover and are surrounded by riparian forest (one case) or old fallows (two cases). All are located high up in Murethxa, two above 1900 m elevation and one between 1800 and 1900 m.

This cluster has some internal heterogeneity. It includes two sub-clusters that are somewhat different (not as different as the two sub-clusters in cluster 7; cf. dendrogram; Fig. II) in terms of the diversity and/or composition of their bird communities.

The bird communities included in this cluster have average levels of species richness and Shannon diversity that are similar/slightly below the corresponding sample (137 points) averages, and smaller than those of montane-forest clusters 8 (statistically significant differences; $P<0.05$) and 7 (non-significant differences; $P>0.05$) (Table III, Fig. III). They are even smaller than those of Montane cropland (cluster 5; non-significant differences; $P>0.05$) (Table III, Fig. III). Although this cluster includes many non-forest points (half of all points in the cluster), its lower diversity levels are not due to this cause, as the separate averages of its forest points alone are identical to the corresponding cluster averages. It might be probably related with their edge/clearing nature of their micro-habitats or other non-observed structural attributes of the vegetation that may indicate forest degradation (cf. forest inventory).

The species composition of the Montane forest and fallows community is characterized by maximum importance of *Tauraco livingstonii*, *Pogoniulus bilineatus* and *Apalis lynesi*, which represent 32% of all birds recorded at less than 30 m (Table III). Note that two of these three species (the former) are frugivore (which may indicate more fruit available in edge environments) and not restricted to mountain forest (they also occur in low-elevation forest). Note also that the endemic *Apalis lynesi* seems, in this way, to be also associated with degraded forest. A high level of relative importance was also recorded for *Apalis melanocephala*, which represent another 14% of all birds recorded at less than 30 m (Table III). Among species that do not reach significant differences across clusters (ANOVA test), one was only recorded in this cluster: *Pternistis hildebrandti*; and some recorded here its maximum relative importance: *Columba arquatrix*, ex-aequo with cluster 7, *Accipiter tachiro* and *Cinnyris manoensis* (Table III). Note that none of these characteristic species of this (degraded) Mountain forest and fallows cluster is an understorey or leaf litter specialist (species that we marked with an asterisk in the previous two clusters). Understorey and leaf litter specialists are often proposed as good indicators of preserved evergreen tropical forests. Note also the inclusion of another frugivore (*Columba arquatrix*). As regards *Cinnyris manoensis*, there was a single record in a fallow point (1840 m asl), whose flowering peak of *Tetradenia*, *Tecomaria* and namuresse attracted a group of these nectarivores, probably after the breeding season (they probably breed at lower elevations).

Note that, while Montane forest and fallows (cluster 9) are the less species-rich and species-diverse of the three Montane forest clusters, this only occurs at the point level. If we replace the point-level average of species richness by the total number of species recorded in all points in the cluster (# SPECIES in table III), the reverse happens: this cluster has the maximum number of species across the three Montane forest clusters. A closer look reveals that many of these species are not Montane forest endemics, nor even restricted to forest, but simply habitat generalists that take advantage from forest degradation and open habitats and micro-habitats created by deforestation and subsequent ecological succession (second growth). A good example is *Pycnonotus barbatus*, whose strongholds above 1600 m elevation are in this and the next (Montane cropland) cluster (Table III), whereas it is absent from preserved Montane forest.

Our functional indicators also reflect the more open character of these Montane forest and fallows communities: the importance of non-forest birds, that is woodland, grassland and rock birds, is higher here than in the previous two clusters, and thus habitat richness, diversity and evenness are also higher (Table III). The Frugivore glean guild (*Tauraco livingstonii*, *Pogoniulus bilineatus*, *Columba arquatrix*) reaches here its maximum among all montane bird communities, so confirming the importance of forest edge habitats for frugivores.

B) Montane-cropland bird communities

12 (out of 20) points selected to represent montane cropland were included in a single cluster (cf. Table IV, and cluster 5 in the dendrogram; Fig. II). These 12 montane cropland points represent 80% of a total of 15 points included in this cluster (Table IV). All the other three points are (mostly young) montane fallows (Table IV). This cluster does not include any low-elevation point (< 1600 m asl; cf. Table IV)).

This Montane cropland cluster does not directly group in a higher-order cluster with any Montane forest cluster; instead, it first groups with a low-elevation cluster, which includes low-elevation forest and fallows (cf. clusters 2 and 1, respectively, in the dendrogram; Fig. II).

This means a striking contrast between Montane cropland and the three montane-forest bird communities, as regards their diversity and composition indicators, meaning that there are high levels of beta diversity (or species-turnover) between Montane cropland and Montane forests. An even higher level of contrast exists between Montane and Low-elevation cropland clusters (cf. the location of cluster 5 versus those of clusters 6 and 10 (Low-elevation cropland) in the dendrogram; Fig. II).

The Montane cropland cluster is characterized by a balanced weight of grassland, shrubland and forest species, which is reflected in high (the highest) levels of habitat richness, diversity and evenness (Table III), in strong contrast with montane forests. Birds of open habitats, as well as habitat-density richness and diversity also reach here their maxima among all bird communities in the Namuli (Table III).

The functional composition (feeding niches) of the montane cropland bird community is quite distinct, due to the highest importance here of: (1) Invertivore glean grass (*Cisticola lais*), (2) Invertivore glean understorey (*Iduna natalensis*), (3) Invertivore sally ground (*Saxicola torquatus*), (4) Invertivore generalist (*Dessonornis caffer*), as well as a relatively high importance of (5) Invertivore ground (*Anthus cinnamomeus*) (Table III). All of these patterns, as well as the almost absence of Invertivore glean canopy, are in strike contrast with the functional composition of the three previous montane forest clusters. Note that, really, Ground invertivore are probably more important in montane forest than our results suggest. In fact, we acknowledge that we have (partly or fully) missed some important species is this niche (e.g. *Dessonornis anomalus*, *Geokichla gurneyi*, and *Arcanator orostruthus*), that were not yet actively singing (and were thus extremely difficult to detect) when we did our count points in September. As a result of this diversified functional composition of the montane cropland community, it has relatively high levels of feeding niche richness, diversity and evenness (Table III), which are comparable with those of Montane forest 1 (the most diverse montane forest community).

The average importance of endemic/restricted-range species (only 3% of all birds recorded less than 30 m away) is much lower in montane cropland than in montane forest (Table III). On the other hand, cosmopolitan/large-range species (13%) are much more important in montane cropland (insignificant in montane forests) (Table III). Likewise, the average number of threatened species per point is much lower in montane cropland than in montane forests, but it is higher than in any low-elevation cluster (Table III). Similarly with montane forests, the importance of Afromontane endemics in montane cropland is very high (45% of all birds recorded less than 30 m away) (Table III).

In contrast with montane forest, but similarly with low elevation open-habitat clusters (clusters 1, 6 and 10), migratory and, in particular, partly migratory species have a significant presence in Montane cropland (Table III).

C4) Montane cropland (cluster 5)

The 12 montane-cropland points in this cluster are located in the Murethxa and Nachona plateaux (the latter flanking the western slopes of Mts Pilani and Pesse, and extending north to the headland of the Licungo basin). All of them are at high elevation levels: five in the 1800-1900 m range; six in the 1900-2000 m range, and one above 2000 m asl. They are all far above the edge of the Manho forest. The natural vegetation here was a mosaic of peaty grassland with montane forest patches and rocky peaks, rather than continuous forest (Timberlake et al., 2009). Eight of them had been recently burnt to prepare the land for seeding potato and other crops, mixed with potato; four had grassy and scrubby cover restricted to the field edge, five had some spared trees, often also restricted to the field edge; some were close to riparian vegetation or the remains of small forest fragments. The three montane fallow points included in this cluster are located on the edge of the Murethxa plateau, well above Manho forest, at elevations between 1870 and 1900 m asl, and are not close to forest patches. They include two 2-years-old fallows and another fallow that was probably 3-years old; they had some to dense grass cover, some to abundant understorey, and no to scarce tree cover.

This cluster is internally homogenous (almost as homogeneous as cluster 8, cf. dendrogram; Fig. II) as regards the diversity and composition variables used in the analysis. It includes two sub-clusters, but these are quite close to each other. It is also quite distinct from all other clusters (cf. dendrogram; Fig. II).

The Montane-cropland bird community has relatively low levels of species richness and Shannon diversity, which are similar to the corresponding sample averages (all 137 points) (Table III). Species richness and diversity seem to be lower in this cluster than in Montane forest clusters 8 and 7, and higher than in Montane forest and fallows (cluster 9), but all these differences are not statistically significant (P>0.05) (Table III and Fig. III). The lower Shannon diversity of Montane cropland when compared with Montane forest clusters 8 and 7 seem to be related to higher abundance and lower evenness (Table III), but these differences are also not statistically significant.

The relatively low levels of species richness and diversity of the Montane-cropland bird community are similar to those of Low-elevation cropland (cluster 6), but significantly higher (P<0.05) than those of Low-elevation cropland and other open habitats (cluster 10) (Table III and Fig. III).

The total number of species recorded (#SPECIES) in points classified in this cluster (21 species) is the minimum across all clusters (Table III).

The species composition of the Montane-cropland bird community is characterized by maximum importance of *Cisticola lais*, *Iduna natalensis*, *Dessonornis caffer* and *Saxicola torquatus*, which represent 59% of all birds recorded at less than 30 m (Table III). These species are the most associated with the first PC in the PCA (the one accounting for more variance; Table II.B), and are almost absent from the previous three (Montane forest) clusters, except in open micro-habitats present, in particular in cluster 9 (Montane forest and fallows) (Table III). This reflects the unique composition of this bird community (as reflected also in the dendrogram) and its striking contrast with montane forest. The fact that the characteristic species of the Montane-forest clusters (except the users of open micro-habitats, in particular in cluster 9) are absent from Montane cropland (Table III) also reinforces this uniqueness of the Montane cropland bird community, which gives it a relevant (beta diversity) contribution for the gamma (landscape-level) diversity of high elevation areas in Mount Namuli. The abovementioned four characteristic species of Montane cropland were almost for sure present in the peaty grassland component of the natural forest-grassland mosaic in the plateaux (Timberlake et al., 2009), and are not recent invaders that took advantage of deforestation. They have simply adapted to use cropland as a habitat, which they use together with surrounding natural grasslands, and probably expanded their populations and range to areas that were previously occupied by forest patches, which have meanwhile been lost for cropland expansion.

A high level of relative importance was also recorded for *Cinnyris fuelleborni* and *Anthus cinnamomeus*, which represent another 12% of all birds recorded at less than 30 m (Table III). Among species that do not reach significant differences across clusters (ANOVA test), one was recorded here its maximum relative importance: *Estrilda astrild* (Table III). Although absent from montane forest habitat, these three additional species would also be present in the grassland, rocky and edge components of the natural forest-grassland mosaic of the high plateaux of Murethxa and Nachona. On the other hand, *Pycnonotus barbatus* (present, with low abundance, in the Montane cropland community; Table III) probably is a recent invader (absent here in 2007; cf. Timberlake et al., 2009).

C) Low-elevation forest bird communities

13 (out of 18) points selected to represent low-elevation forest habitats were included in two clusters (cf. clusters 3 and 2, in the dendrogram, Fig. II, and Table IV). In cluster 3, low-elevation forest points represent 91% of all points within the cluster. In cluster 2, low-elevation forest points represent 60% of a total of 5 points included in this cluster; the other two points are old low-elevation fallows (Table IV). Cluster 3, includes one montane forest (> 1600 m asl) point but cluster 2 does not include any montane point (Table IV).

These clusters do not group in a single, higher-order cluster, which would represent "low-elevation forests as a whole" (cf. dendrogram; Fig. II). This means a significant degree of distinction between the two low-elevation-forest bird communities, as regards their diversity and composition indicators, that is: there are high levels of beta diversity (or species turnover) among them.

In cluster 3 (Low-elevation forest), forest species represent the majority (66%) of all birds recorded less than 30 m away while woodland species represent 30%. The inverse happens for cluster 2 (Low-elevation forest and old fallows), where woodland species represent the majority (49%) of all birds recorded less than 30 m away while forest species represent 36% (Table III). There is some habitat diversity in these two low-elevation forest clusters (Table III), which is much higher than that of the three montane forest clusters.

Accordingly, in the Low-elevation forest cluster, the majority of recorded birds require closed habitats (46%) while in Low-elevation forest and old fallows the majority of recorded birds require semi-open habitats (71%) (Table III).

Cluster 3 and 2 are also unique in that they get the maximum proportion of the feeding niche Frugivore glean, which represents, on average, 32% and 29% of all birds recorded less than 30 m away, respectively (Table III).

These cluster are also those with the maximum family diversity among all clusters (1.64 to 1.75 Shannon diversity index) (Table III).

These two clusters together with cluster 1 (Low-elevation fallows and cropland) are also those with the maximum average proportions of cosmopolitan/wide-range species (16 to 18% of all birds recorded less than 30 m away). The number of threatened species is minimum in these clusters: the average number of threatened species (per point) is between 0.0 and 0.1 (only cluster 1 reaches a higher figure of 0.2 in low-elevation clusters) (Table III).

Together with clusters 8,7 and 9 (including montane forests), low-elevation forest clusters are also unique in that no fully migratory species was recorded in these clusters (Table III).

C5) Low-elevation forest (cluster 3)

In cluster 3, 10 points (out of 11, that is: 91%) are low-elevation forest points, and another is a montane forest point (Table IV). The former represent mostly forest edge (more than half of the forest points are riparian gallery edge and 3 points are middle-elevation forest of Mount Muresse (1300-1500 m)), with only two relatively closed forest habitat, and none including clearings. More than half of the forest points have abundant natural regeneration; and four have abundant leaf litter and understorey. The montane forest point is within the interior of a relatively dense and tall forest (>20m) with abundant natural regeneration and leaf litter, located near Malema waterfall at circa 1631 m elevation. This is among the lowest mountain forest point.

This cluster is relatively heterogeneous, as it includes two sub-clusters that are quite different (cf. dendrogram; Fig. II) in terms of the diversity and/or composition of their bird communities.

The bird communities included in cluster 3 are characterized by average levels of species richness and Shannon diversity that are intermediate between the higher levels of both cluster 2 (Low-elevation forest and old fallows) and cluster 1 (Low-elevation fallows and cropland) and the lower levels of cluster 10 (Low-elevation cropland and other open habitats) and cluster 6 (Low-elevation cropland) (Table III and Fig. III). These differences are, however, only statistically significant ($P<0.05$) with cluster 10 (Low-elevation cropland and other open habitats) (Fig. III).

The species composition of low-elevation forest community is characterized by maximum importance of *Pogoniulus bilineatus*, *Camaroptera brachyura*, *Eurillas virens*, and *Ploceus bicolor*, which represent 33% of all birds recorded at less than 30 m (Table III). High levels of relative importance were also recorded for *Tauraco livingstonii*, *Apaloderma vittatum*, *Dryoscopus cubla*, and *Apalis flavida,* which represent another 19% of all birds recorded at less than 30 m (table III). Among species that do not reach significant differences across clusters (ANOVA test), one was only recorded in this cluster: *Fraseria plumbea* (Table III); at the low-elevation level, some species were only recorded in this cluster: *Accipiter tachiro, Arizelocichla milanjensis, Phyllastrephus cabanisi,* and *Zosterops senegalensis* (Table III).

As regards functional composition (per feeding niche), and reflecting its feeding niche richness and diversity, bird communities in this cluster, while recording a relatively high proportion of Frugivore glean (as the other low-elevation forest cluster), also records (differently from the other low-elevation forest cluster) high proportions of other feeding niches such as: (1) Invertivore glean canopy (*Ploceus bicolor, Dryoscopus cubla, Apalis flavida)*, and (2) Invertivore glean understorey (*Camaroptera brachyura)* (Table III).

Unlike the other low-elevation forest cluster (cluster 2), in which there is no record of any endemic/restricted-range species, threatened species, or Afromontane endemics, this cluster has some (though residual) presence of such species (Table III).

C6) Low-elevation forest and old fallows (cluster 2)

In cluster 2, 3 points (out of 5, that is: 60%) are low-elevation forest points, and 2 (40%) are low-elevation old fallow points (Table IV). All low-elevation forest points are riparian gallery forest edge: two have abundant natural regeneration and 1 only some; two have some leaf litter and in 1 leaf litter is absent. The three low-elevation forest points are located along the margins of Malema river. One of the low-elevation old fallow points corresponds to a 10 years-old fallow and the other one is a 5 years old fallow. Both low-elevation old fallow points are located very close to the Malema river (in between the low-elevation forest points of this cluster). Both fallows have dense grass cover, some understorey and some tree cover. All five points are between 1150 and 1300 m elevation.

This cluster is internally homogenous (almost as homogeneous as cluster 5, cf. dendrogram; Fig. II) as regards the diversity and composition variables used in the analysis. It is also quite distinct from all other clusters (cf. dendrogram; Fig. II).

The bird community captured by cluster 2 is characterized by the highest average levels of species richness and Shannon diversity, well above the corresponding sample averages (all 137 points; Table III). These levels are also significantly higher than those of cluster 10 (Low-elevation cropland and other open habitats; $P<0.05$), higher (non-significant differences) than those of clusters 7 (Mountain forest 2), cluster 9 (Montane forest and fallows), 5 (Mountain cropland), 6 (Low-elevation cropland), and 3 (Low-elevation forest), and similar ($P>0.05$) to those of clusters 8 (Mountain forest 1), and 1 (Low-elevation fallows and cropland) (Fig. III). These high levels of alpha diversity imply a relevant contribution of the low-elevation forest and old fallows community for bird diversity in the Mount Namuli as a whole.

The species composition of low-elevation forest and old fallows community is characterized by maximum importance of *Chrysococcyx klaas, Stactolaema leucotis, Pogoniulus bilineatus, Pogoniulus chrysoconus, Indicator minor, Batis soror, Apalis flavida,* and *Hedydipna collaris*, which represent 33% of all birds recorded at less than 30 m (Table III). High levels of relative importance were also recorded for *Tauraco livingstonii, Dryoscopus cubla, Prinia subflava, Cinnyris venustus*, and *Motacilla clara,* which represent another 37% of all birds recorded at less than 30 m (Table III). Among species that do not reach significant differences across clusters (ANOVA test), two were only recorded in this cluster and cluster 6: *Schoenicola brevirostris* and *Chalcomitra senegalensis* (Table III); at the low-elevation level, some species were only recorded in this cluster: *Cyanomitra olivacea* (Table III)*;* and some recorded here its maximum relative importance: *Pycnonotus barbatus* (11% of all birds recorded at less than 30 m) (Table III).

As regards functional composition (per feeding niche), and reflecting its feeding niche richness and diversity, bird communities in this cluster, while recording a relatively high proportion of Frugivore glean (as the other low-elevation forest cluster), also records (differently from the other low-elevation forest cluster) high proportions of other feeding niches such as: (1) Invertivore sally surface (*Batis soror)*, and (2) Nectarivore glean (*Cinnyris venustus)*, and (3) Invertivore ground (*Motacilla clara, Schoenicola brevirostris*) (Table III).

Thus, this cluster of low-elevation forest has not only the highest species richness and diversity, but also the highest family-level taxonomic richness and diversity among all clusters (Table III).

D) Low-elevation open-habitat bird communities

26 (out of 26) points selected to represent low-elevation cropland habitats were included in three clusters (cf. clusters 1, 6 and 10, in the dendrogram, Fig. II, and Table IV). In cluster 1, low-elevation young fallow and cropland points represent, together, 60% of a total of 20 points included in this cluster (Table IV). In cluster 6, low-elevation cropland represents 70% of a total of 10 points included in this cluster; the other three points are low-elevation forests (2 points) and old fallows (1 point) (Table IV). In cluster 10, low-elevation cropland and young

fallows represent, together, 59% of a total of 34 points included in this cluster; the other points are mostly from open habitats: old and young fallows either in low-elevation or montane points (Table 4). With the exception of cluster 6, all these clusters include some montane (> 1600 m asl) points (Table IV).

These clusters do not group in a single, higher-order cluster, which would represent "low-elevation cropland or open habitats as a whole" (cf. dendrogram; Fig. II). This means a significant degree of distinction between the three low-elevation open-habitat bird communities, as regards their diversity and composition indicators, that is: there are high levels of beta diversity (or species turnover) among them.

In all of these three clusters, forest species have the lowest representation among all clusters. These 3 clusters are mainly constituted by shrubland, woodland and grassland species (sum of the 3 habitat guilds is greater than 74%). Clusters 1 (Low-elevation fallows and cropland) and 10 (Low-elevation cropland and other open habitats), are dominated by woodland species (43 and 39%, respectively) while cluster 6 (Low-elevation cropland) is dominated by both grassland (35%) and shrubland (32%) species (Table III). Habitat diversity is among the highest in clusters 1 and 6, only behind cluster 5 (montane cropland) (Table III).

A similar contrast between these three clusters and all other clusters is the percentage of recorded birds that require semi-open habitats, which is between 62 and 72% in these three clusters and below 52% in all other clusters (Table III). Habitat-density diversity is the lowest in these three clusters (Table III).

Clusters 1 and 10 get the maximum proportion of the feeding niche Nectarivore glean, which represents 17% and 29%, respectively, of all birds recorded less than 30 m away. Cluster 6 gets the maximum proportion of the feeding niche Invertivore aerial, which represents 21% of all birds recorded less than 30 m away.

Clusters 6 and 10 have some of the lowest family diversity among all clusters, while cluster 1 has intermediate family diversity (Table III).

These 3 clusters, together with cluster 2 (Low-elevation forest and old fallows), are also those with the lowest average proportions of endemic/restricted-range species (0 to 1% of all birds recorded less than 30 m away) and have intermediate (cluster 6: 6%, cluster 10: 7% of all birds recorded less than 30 m away) to the highest (cluster 1: : 18%) average proportion of cosmopolitan/wide-range species (Table III). The number of threatened species is minimum in clusters 6 and 10: the average number of threatened species (per point) is 0.0 (Table III). In cluster 1, the average number of threatened species (per point) is 0.2 (Table III).

In contrast with both montane and low-elevation forest, but similarly to montane cropland (cluster 5), migratory species have a significant presence in low-elevation open-habitat bird communities (Table III).

C7) Low-elevation fallows and cropland (cluster 1)

In cluster 1, 8 points (out of 20, that is: 40%) are low-elevation young fallow points, 4 (20%) are low-elevation cropland points, 2 (10%) are low-elevation old fallow points, 2 (10%) are low-elevation forest points, 2 (10%) are montane young fallow points, 1 (5%) is a montane cropland point, and 1 (5%) is a montane forest point (Table IV). All 8 low-elevation young fallow points have dense grass cover, 7 (out of 8) have some understorey, and 6 have no or scarce tree cover. 3 (out of 4) low-elevation cropland points have no grass cover, but have some tree cover; half of the low-elevation cropland points have some understorey while the other half has no understorey. 3 out of 4 are mixed cropping of maize, cassava and other annual crops while the other point is the combination of plots of inhame, tobacco, sugar cane, banana, and other tree crops. The 2 low-elevation old fallow points correspond to 7-10 years-old fallows with dense grass cover, abundant understorey and some tree cover. The 2 low-elevation forest points are riparian gallery forest edge with either no or some leaf litter, some natural regeneration and some understorey. The 2 young montane fallow points have both some understorey, one has dense and the other one has only some grass cover; both have abundant and dense cover of *Pteridium aquilinum*. The montane cropland point, on cropland itself has no grass cover, understorey or tree cover, only potato (*Nacional*) seedlings; on the edge, it has dense understorey with the presence of abundant and dense *Pteridium aquilinum*. The montane forest point located on Kahli is a forest clearing with some leaf litter and abundant natural regeneration. The 3 Murethxa montane points are at elevations higher than 1850 m, while Kahli montane point is at 1614 m asl.

This cluster is relatively heterogeneous, as it includes sub-clusters that are quite different: one big group of sub-clusters separated from a very small (one point) sub-cluster (cf. dendrogram; Fig. II), in terms of the diversity and/or composition of their bird communities. This means high beta diversity among points within the cluster. The total number of species recorded (#SPECIES) in all points classified in this cluster (58 species) is the maximum across all clusters (Table III), which also reflects the high (beta) diversity within this cluster.The bird community captured by cluster 1 is characterized by some of the highest average levels of (alpha) species richness and diversity, well above the corresponding sample averages (all 137 points; Table III). These levels are also significantly ($P<0.05$) higher than those of cluster 10 (Low-elevation cropland and other open habitats), 6 (Low-elevation cropland), 9 (Montane forest and fallows), and 5 (Mountain cropland), higher (non-significant differences) than those of clusters 7 (Mountain forest 2), and 3 (Low-elevation forest), and similar ($P>0.05$) to those of clusters 8 (Mountain forest 1), and 2 (Low-elevation forest and old fallows) (Fig. III).

The species composition of the low-elevation fallows and cropland community is characterized by maximum importance of *Dryoscopus cubla, Prinia erythroptera,* and *Cecropis daurica*, which represent 19% of all birds recorded at less than 30 m (Table III). A high level of relative importance was also recorded for *Cinnyris venustus*, which represent another 16% of all birds recorded at less than 30 m (Table III). Among species that do not reach significant differences across clusters (ANOVA test), nine were only recorded in this cluster: *Hieraaetus ayresii, Accipiter minullus, Tchagra australis, Tchagra senegalus, Cisticola brachypterus, Fraseria caerulescens, Ploceus cucullatus, Vidua macroura,* and *Anthus lineiventris*; and some recorded here its maximum relative importance: *Merops pusillus, Dendropicos fuscescens, Ptyonoprogne rufigula* (ex-aequo with cluster 3), and *Onychognatus morio* (Table III).

This cluster reaches the maximum feeding niche richness and diversity among all clusters (Table III). As regards functional composition (per feeding niche), and reflecting its feeding niche richness and diversity, bird communities in this cluster, record many feeding niches none of them with high proportions (Table III).

Cluster 1 is the one with the highest average proportion of cosmopolitan/wide-range species (18%), among all clusters under analysis (Table III).

C8) Low-elevation cropland (cluster 6)

In cluster 6, 7 points (out of 10, that is: 70%) are low-elevation cropland points, 2 points (20%) are low-elevation forest points, and 1 point (10%) is a low-elevation old fallow point (Table IV). All 7 low-elevation cropland points have not been recently affected by the presence of fire; 5 out of 7 have dense grass cover; 6 out of 7 have some understorey; and 4 out of 7 have some tree cover. 4 out of 7 are mixed cropping of maize, cassava and other annual crops while the other 3 points are plots of cassava and other crops such as sugar cane. All low-elevation cropland points are between 1140 and 1320 m elevation. The 2 low-elevation forest points are riparian gallery forest edge along the Malema river: both have abundant natural regeneration and some leaf litter; one of the points (NBF14) had a bat colony . The low-elevation old fallow point corresponds to a 3 years-old fallow with dense grass cover and abundant understorey but no tree cover.

This cluster is internally homogenous as regards the diversity and composition variables used in the analysis. It includes two sub-clusters, but these are quite close to each other. It is also quite distinct from all other clusters (cf. dendrogram; Fig. II).

The low-elevation cropland bird community has relatively low levels of species richness and Shannon diversity, which are similar to the corresponding sample averages (all 137 points) (Table III). Species richness and diversity are lower (statistically significant; P<0.05) in this cluster than in clusters 2 (Low-elevation forest and old fallows) and 1 (Low-elevation fallows and cropland), and higher (statistically significant; P<0.05) than in low-elevation cropland and other open habitats (cluster 10) (Table III and Fig. III). The relatively low levels of species richness and diversity of the low-elevation cropland bird community are similar to those of montane cropland (cluster 5) (Table III and Fig. III).

The species composition of low-elevation cropland community is characterized by maximum importance of *Prinia subflava, Cecropis abyssinica,* and *Crithagra sulphurata*, which represent 43% of all birds recorded at less than 30 m (Table III). High levels of relative importance were also recorded for *Apalis flavida, Cisticola cantans, Cinnyris venustus,* and *Anthus cinnamomeus*, which represent another 29% of all birds recorded at less than 30 m (Table III). Among species that do not reach significant differences across clusters (ANOVA test), two species recorded here its maximum relative importance: *Treron calvus* and *Ploceus ocularis* (Table III).

As regards functional composition (per feeding niche), and reflecting its feeding niche richness and diversity, bird communities in this cluster, while recording a relatively high proportion of Invertivore aerial (*Cecropis abyssinica*), also record (differently from all other clusters) high proportions of other feeding niches such as: (1) Granivore generalist (*Crithagra sulphurata*), and (2) Invertivore ground (*Anthus cinnamomeus*) (Table III).

C9) Low-elevation cropland and other open habitats (cluster 10)

In cluster 10, 15 points (out of 34, that is: 44%) are low-elevation cropland points, 6 (18%) are low-elevation old fallow points, 5 (15%) are low-elevation young fallow points, 3 (9%) are montane cropland points, 3 (9%) are montane old fallow points, 1 (3%) is a low-elevation forest point, and 1 (3%) is a montane young fallow point (Table IV).

8 out of 15 low-elevation cropland points do not have grass cover or understorey, 6 have dense grass cover and dense understorey, and 1 has some grass cover and scarce understorey;

5 do not have tree cover, 5 have tree cover and 5 have some tree cover. 12 out of 15 are mixed cropping of maize, cassava and other annual crops or sugar cane, 2 are only of cassava, and one is only of tomato. 3 out of the 6 old low-elevation fallow points correspond to 3 year-old fallows with dense grass cover, some understorey and some tree cover; 2 correspond to 1-4 years-old and 5 years-old fallows with dense grass cover, abundant understorey, and some tree cover; and one is a 7 years-old fallow with dense grass cover, some understorey, and scarce tree cover. 4 out of the 5 young low-elevation fallow points have dense grass cover and some tree cover, and one does not have any grass or tree cover; 2 out of 5 have abundant understorey, 2 have some understorey and one does not have any understorey. The 3 montane cropland points do not have any grass cover or understorey; and 2 out of 3 do not have any tree cover and one has scarce tree cover. All montane cropland points are of potato: one "*angonia*", one "*nacional*" and one where "*nacional*" was recently sown and "*angonia*" was already with long sprouts and mixed cropped with cabbage. 2 out of the 3 old montane fallow points correspond to 3 years-old fallows, and one to a 3.5 years-old fallow; all 3 points have dense grass cover and some understorey; 2 have some and one has scarce tree cover. The low-elevation forest point corresponds to forest edged by mixed cropland of maize and tomato; it has abundant leaf litter and natural regeneration. The young montane fallow point has high grass cover, only some understorey, and almost no tree cover (80%). These points correspond mostly to relatively open habitats.

This cluster has some internal heterogeneity. It includes two sub-clusters that are somewhat different (not as different as the two sub-clusters in cluster 7 or 9; cf. dendrogram; Fig. II) in terms of the diversity and/or composition of their bird communities.

The bird community captured by cluster 10 is characterized by the lowest average levels of species richness and diversity, well below the corresponding sample averages (all 137 points; Table III). These levels are also significantly (P<0.05) lower than those of all other eight clusters (Cluster 8, 7, 9, 5, 3, 2, 1, and 6) (Fig. III). However, the total number of species recorded (#SPECIES) in all points classified in this cluster (33 species) is the second highest across all clusters (Table III), which reveals the high within-cluster (beta) diversity, possibly associated with the different sub-clusters

The species composition of the low-elevation fallows and cropland community is characterized by maximum importance of *Cisticola cantans, Prinia subflava*, and *Cinnyris venustus* (alone representing 28% of all birds recorded at less than 30 m), which, together, represent 48% of all birds recorded at less than 30 m (Table III). Among species that do not reach significant differences across clusters (ANOVA test), six were only recorded in this cluster: *Streptopelia semitorquata, Centropus superciliosus, Corvus albicollis, Cisticola natalensis, Euplectes ardens,* and *Macronyx croceus*; and six recorded here its maximum relative importance: *Turtur afer/chalcospilos, Apus barbatus, Laniarius aethiopicus, Melocichla mentalis, Bradypterus lopezi,* and *Euplectes hordeaceus* (Table III). *Bradypterus lopezi* is somewhat dislocated in this set of species, and its relative importance here results from high proportions of the species in a limited number of montane points; it reflects, however, how much this species of the understorey of montane forest enters open areas in the forest-cropland and fallows mosaic. This abundance of B. lopezi in open and semi-open montane areas, in Namuli, may reflect the absence here of Bradypterus cinnamomeus, which occupies these habitats in Mulanje and further north in East Africa (Dowsett-Lemaire, 2008).

This cluster reaches the minimum feeding niche richness and diversity among all clusters (Table III). As regards functional composition (per feeding niche), bird communities in this cluster, record a relatively high proportion of Nectarivore glean (*Cinnyris venustus)* (Table III).

VI.II.III. REFERENCES

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