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PRINCE RUSPOLI'S TURACO AND THE WHITE-CHEEKED TURACO WITH THEIR HYBRID AND THEIR HABITAT ASSOCIATION IN GUJI ZONE, SOUTHERN ETHIOPIA

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List of Acronyms

ABC – African Birds Club

CR - Critically Endangered

EBAs – Endemic Bird Areas

EMA – Ethiopian Mapping Authority

EN- Endangered

ERA – Ethiopian Road Authority

EWNHS – Ethiopian Wildlife and Natural History Society

IBAs – Important Bird areas

IUCN – International Union of Conservation of Nature and Natural Resources

VU - Vulnerable

Abstract

The present study was carried out from August 2009 to May 2010 in the southern Ethiopia, Oromia Regional Stae, Guji Zone at Anferera-Wadera Forest, focusing on the survey of hybrid, impact of hybridization and habitat association of *T. ruspolii* and *T. leucotis.* The habitats in the study area were categorized in to five variables, viz., forest, woodland, shrubland, agricultural land and plantation. Habitat one was 40% woodland and 60% shrub land; habitat two was 72% woodland, 18% shrubland and 10% agriculture; habitat three was 100% forest; habitat four was 30% woodland and 70% agriculture and habitat five was 25% agriculture and 75% plantation. A total of 46 transects, which consisted of 548 census points was surveyed. Out of the 548 points, at 241 points 333 individuals of *T. ruspoli*, 251 individuals of *T. leucotis* and one hybrid individual were recorded. Prince Ruspoli's Turaco showed positive correlation with woodland and negative correlation with forest. Whereas white-cheeked Turaco showed positive correlation with forest, and negative correlation with woodland. The distribution of *T. leucotis* showed high significance among vegetation cover (χ^2_4 = 64.58.3, $P < 0.01$). The distribution of the two turacos showed differences with the habitat types between the forest and the rest of the habitat types (Kiruskal Wallis Test, $H = 6.608$, $P < 0.01$). Further investigation is needed in the Prince Ruspoli's Turaco's range to know the extent of hybridization of *T. ruspolii* with *T. leucotis* and DNA investigation is needed to be sure that the hybrid is different from the parent turacos.

Key words/phrases: *Combretum-Terminalia, habitat, hybrid, T. leucotis, T. ruspolii*

Introduction

Ethiopia's geographical location and physical features have created a very diverse set of ecosystems, from the humid forest and extensive wetlands in the west and southeast to the desert of the Afar depression in the northeast. These have resulted in the diversification of all forms of life in the country (Addisu Assefa, 2007; EWNHS, 1996). Ethiopia provides habitats for more than 900 species of birds, among them 18 are wholly restricted to the political boundary of the country and are endemic (Ash and Atkins, 2009).

Species diversity of an area is determined by the outcome of many contributing factors. Each of the patterns of variation in species diversity is the result of variation in many different biophysical factors and anthropogenic processes (Oindo *et al*., 2001). An area is said to be important for conservation if it accommodates diversified species and this in turn indicates the heterogeneity of the area. Most terrestrial environments show seasonal changes in habitat structure and food abundance and these changes are likely to influence diversity (Nega Tassie and Afework Bekele, 2008).

Among the several habitats, wetlands and riverine systems are sites for wintering or passing migrants. Reports show that there are 214 Palaearctic migrants occurring in Ethiopia. Of the total, 45 species have been found to over-winter within the boundaries of the country. Many of these birds have breeding populations in Ethiopia (EWNHS, 1996). According to Urban and Brown (1971), Ethiopia is one of the richest countries in the mainland Africa, in terms of avifauna.

Ethiopia is a country where a major habitat block contained within its political boundaries, having a high degree of endemic fauna and flora (Pol, 2001). According to BirdLife International (2004), in recent years, the country has become one of Africa's leading birding destinations. Its avifauna represents an interesting mixture of east and west African, Palaearctic and unusual endemic components.

Most of the endemic species are associated with the extensive areas of Afromontane habitats in the highlands, and many are too widespread to be treated as restricted range-species (Pol, 2001). The lists of endemic, near endemic and threatened species have been compiled from a number of sources including the African Bird Club, BirdLife International and Birds of the World Version 2.0 (ABC, 2008).

Understanding the ecological mechanisms that cause threat to extinction of bird species is fundamental to conservation. It is well understood that not all taxa of birds are equally vulnerable to extinction, but the reasons for these differences are poorly known. This may be, in part, because different taxa are threatened by different mechanisms. Among the 95 Avian families, 1,012 threatened species are registered due to habitat loss and human persecution (Owens and Bennette, 2000; Youth, 2003). Habitat loss is a source of risk for over 70% of the threatened species in addition to human persecution. Many species (54%) were classified as being threatened by either habitat alone or human persecution alone than being threatened by both.

A small proportion are threatened as a result of competition, hybridization and disease (Owens and Bennette, 2000; Collar *et al*., 1994).

Habitat destruction as a result of landuse change is the largest global threat to biodiversity, and Ethiopian bird populations are no exception (Tucker and Evans, 1997; Mengistu Wondafrash and Yilma Dellelegn, 2000). They are, therefore, more sensitive to landuse changes due to the growing human population. Shrinkage of lakes and wetlands, burning of forests and fragmentation of habitats for agricultural expansion are some of the important factors that affect the distribution of birds (Urban and Brown, 1971).

Although birds are distributed in different biogeography of the country, a large proportion of endemic birds are restricted, primarily on the western and southeastern highlands of Ethiopia. The highlands of south Ethiopia are well known as an internationally important Endemic Bird Area (EBA), containing five restricted-range bird species (Stattersfield *et al*., 1998).

According to Stattersfield *et al*. (1998), EBA, by definition encompass of the breeding ranges of two or more restricted-range species. As majority of this restricted-range birds are forest species, the key habitat in the majority of EBAs is forest, mostly tropical lowland forest and montane moist forest. Most EBAs support 2-10 restricted-range bird species, and are under 30,000 km^2 in size. An area that supports one or more restricted-range species, but does not qualify to be an EBA because of fewer than two species entirely confined to it. Such areas are categorized as Secondary Bird Area (Ash and Atkins, 2009).

There are 31 globally threatened species in Ethiopia. Out of these, four are endangered, five are vulnerable and two are near threatened. There are 69 identified IBAs in Ethiopia. Of these IBAs Anferera forest and Arero forest occur in Borena Zone, Oromiya regionand encompass the full range of Prince Ruspoli's Turaco, *Tauraco ruspolii*, which is one of the globally threatened endemic species (EWNHS, 1996; Anteneh Shimelis and Yilma Dellelegn, 2002). According to IUCN Red List Categories and Criteria, *T. ruspolii* is a Vulnerable species (IUCN, 2007).

Many of the problems faced by birds and other wildlife are associated with mishandling of the resources. At present, loss of species can pose by far the greatest threat to birds in particular and biodiversity in general. Timber logging, farming, pasture and settlements have already destroyed almost half of the world's forest (Youth, 2003).

The reasons for extinction of species are many and varied. In some cases, the range is being reduced as a result of habitat destruction. Population density may decline due to increased mortality through over-exploitation (Rands, 1991).

Habitat destruction occurs at varying spatial and temporal scales in different ecosystems (Grindal and Brigham, 1998). The immediate threat that directly affects bird species is habitat destruction where they live (Turner, 1996). Habitat destruction and degradation threaten about 86% bird species and are currently the most serious threat of extinction (Hagan *et al*., 1996). Over-exploitation and the effects of alien species are also major threats for birds as well as hybridization and pollution in addition to climate changes (Dale *et al*., 2000).

Hybridization between animal species in the wild is revealed in an increasing number of studies. In situations when one or both of the taxa involved are rare. A high frequency of hybridization events followed by backcrossing may lead to the formation of a hybrid swarm, thus result in species replacement (Mallet, 2005). Hybridization may have become more frequent in recent times due to population decline, translocation of species outside of their native range, and anthropogenic habitat modifications (Seehausen *et al*., 2008). There is a large disparity in population size between the hybridizing taxa, and the species that is rare and threatened by interbreeding with the common species (Pilgrim *et al*., 1998).

Turacos

Turacos are endemic birds to Africa and grouped in the single family Musophagidae. The habitat of Musophagidae species ranges from tropical forest to grasslands with scattered trees. Members of the family Musophagidae (Turacos and Plantain-eaters) are unique to Africa, associated with habitat specialization from forest to open land overlapping with human activities (Gill, 1995). They are confined to sub-Saharan Africa (Payne, 2003; Birdlife International, 2007).

They are large in size and occupy forest and woodland canopies. They have long tails, short bills and short round wings. They are weak fliers, but they can walk, run and leap on tree twigs and branches. They move well on their feet because they are able to bend their outer toes forward and backward. Many species although quite similar to each other, do not have overlapping range (Fry *et al*., 1998; Stevenson and Fanshawe, 2002; Sinclair and Ryan, 2003). Many turacos have brilliant plumage, coloured by red and green pigments that are unique to the turacos family. They live and feed away from the ground. Turacos are fruit-eaters (frugivores), but they occasionally take and grub insects (BirdLife International, 2007).

Turacos lay a clutch of 2 - 3 eggs, where both parents incubate them. The breeding behaviour of turacos is not well known and documented, except that they live in pairs or in small family groups. Most species are thought to be monogamous (Williams and Arlott, 1993; Tarburton, 2001).

Prince Ruspoli's Turaco, *T. ruspolii* is an endemic, resident in southern Ethiopia, occurring at 1275-1800 m asl in juniper forests and in dense evergreen scrub with *Flacourtia*, mixed broad-leaved scrub with scattered *Acacia*, *Gardenia*, and figs (Brosset and Fry, 1986; Yilma Dellelegn, 1991; Ash and Atkins, 2009). With its colourful plumage and distinctive erect white crest, this long-tailed, arboreal bird forms an impressive sight in the woodlands of southern Ethiopia.

According to Borghesio (1997a), a survey was carried out in 1995, which concluded that *T. ruspolii* was reasonably common with a population size of about 10,000 mature individuals, with highest abundance on the north of its small range of habitat. The closely related species, *T. leucotis* co-occurred in the same region, but they were separated by habitat choice. *T. ruspolii* was found in woodland and forest edges while *T. leucotis* was found in closed-canopy forest. Because of the separated habitat choice, there was no evidence of hybridization between them.

Lernould and Seitre (2004) reported the first observation of natural hybridization between *T. ruspolii* and *T. leucotis*, which was confirmed by Tolera Kumsa (2008). The survey carried out in the northern part of *T. ruspolii*'s range gave evidence that Turaco hybrids were widespread in the area and tend to occur in agricultural habitats as well as landscape mosaic created by human activities. The result shows that small number of hybrids is observed. It does not allow understanding precisely the current prevalence of the turaco hybrids in the area. Hybridization may be resulted because of the rare occurrence of forest species (*T. leucotis*) that seems to be invading the habitats of the woodland forest and forest edge relative (*T. ruspolii*). Again the role of human-driven habitat change may be another factor for the hybridization.

The main threat is habitat alteration, because of human activities (Collar and Stuart, 1985). Prince Ruspoli's Turaco is sympatric with White-cheeked Turaco and compete for food which resulted in hybridization between them (Lernould and Seitre, 2004). Hybrids symbolize both inferiority and superiority. Hybrids violate racial purity and clan identity (Gill, 1998). Photographs of Prince Ruspoli's Turaco taken by Seitre, R. in southern Ethiopia in February 2001, at a site where this species and White-cheeked Turaco were in contact, proved that at least four individuals were hybrids (Lernould and Seitre, 2004).

Although Prince Ruspoli's Turaco is thought to be undergoing a continuing decline in its population as a result of loss, degradation and fragmentation of its woodland habitat and hybridization with *T. leucotis*. However, recent surveys have revealed that it is, in fact, more common and widespread than once believed (Tolera Kumsa, 2008). Competition with related species, natural rarity and area size and extinction also affects the population of *T.ruspolii* (Yilma Dellelegn, 1991).

According to Borghesio (1997b), within short distance range of *T. ruspolii*, often occurred in the habitat of *T. leucotis* but the *T. leucotis* never occurred in the woodland, which is the habitat of the *T. ruspolii*. The two species replaced each other along the forest edge, with little or no overlap. This suggested competition was not a threat for *T. ruspoli*. Borghesio *et al.* (2004), reassessed the conservation status of *T. ruspoli* and observed that hybrid of *T. ruspolii* and *T. leucotis* around Kibremegist and confirmed that the occurrence of the hybrid may be widespread and likely to occur along most of the area where the two species are overlapping, from Shakiso to Wadera.

Borghesio *et al.* (2004) showed that *T. leucotis* had expanded its range into the habitat of *T. ruspolii* by inhabiting cultivated areas and exotic tree plantations. Around Kibre-Mengist area, *T. leucotis* was much common than *T. ruspolii* in all habitats where it was absent during the 1995 survey.

Lernould and Seitre (2004) indicted that human activities increased very much around Shakiso and Kibre-Mengist since 1995, as general increase in road network and mining (gold, tantalum) have been attracting large number of people. This resulted in habitat changes and deteriorated the ecological barrier between the two species of turacos (*T. ruspolii* and *T. leucotis*), which might increase the possibility of hybridization and competition in the overlap areas.

According to Wolf *et al*. (2001), hybridization is declared as the most rapidly acting genetic threat to rare and endangered species. Hybridization is more complicated to overcome than habitat destruction, and cause a real challenge for the conservation of *T. ruspolii* (Lernould and Seitre, 2004).

General objective

To understand the impact of hybridization and habitat destruction on the survival of Prince Ruspoli's Turaco, *T. ruspolii.*

Specific objectives*:*

- To assess the extent of hybridization between Prince Ruspoli's Turaco and White-Cheeked Turaco;
- To evaluate the impact of human activities in the hybrid zone;
- To assess the proportion of hybrid Turacos and compare with pure *T. ruspolii* and *T. leucotis.*
- To indicate the habitat association *T. ruspolii* and *T. leucotis.*

The study area and Methods

The study area

The study area extends from $5^0$39’ - 5051’N and $38^0$47’ - $39^0$14’E in Guji Zone of Oromia Region of Southern Ethiopia, about 490 km south of Addis Ababa. The study area (Fig. 1) is considered as an internationally important Endemic Bird Area (EBA), containing five restricted range bird species including two, which are globally threatened (Prince Ruspoli’s Turaco, *T. ruspolii*, and Salvadori’s serin, *Serinus xantholaema*) (EWNHS, 1996). It is situated in the northern part of *T. ruspolii* distribution encompassing the woodlands of Anferera-Wadera of southern Ethiopia. This area holds majority of the *T. ruspolii* population (Borghesio *et al*., 2004).

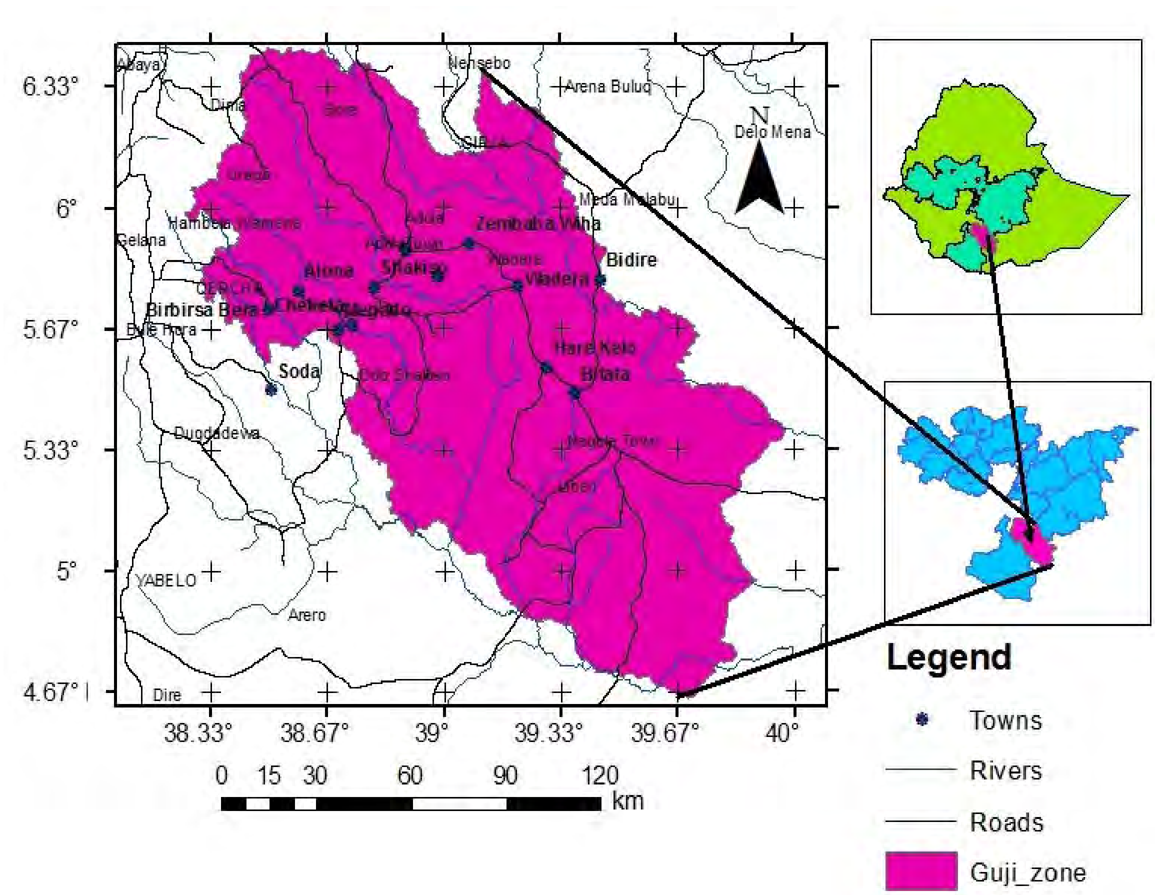

Figure 1 Map of the study area

Topography, Soils and Geology

Most of the study area lies between altitudes from 1600 to 2000 m asl. The topography is rugged and broken with many hills and ridges. The soils in the study area are reddish brown and freely draining. It is subjected to severe erosion on slopes in which the forest cover was removed. Gully formation is common in the agricultural land (Oromia Strategic Plan and Inventory Programme, 2001). The rocks within the southern region fall into basement rocks, Cenozoic volcanic rocks, and undifferentiated Quaternary sediments. The rocks of Guji zone include Precambrian rocks and Mesozoic Era rocks. Limestone is the only Mesozoic sedimentary rock exposed in the area. The area is also known for its mineral deposit. Adola and Shakiso Weredas have precious metal deposits like gold and platinum, and non-ferrous metals (ERA, 2006).

Vegetation

Variation of vegetation in the study area is extensive (Borghesio and Massa, 2000). It is mainly dry forest type (Ash and Atkins, 2009). The dry juniper forests of Borana occur at 1500 – 2200 m asl with range of temperatures at 20^oC – 25^oC and of rainfall from 400 – 700 mm, distributed in two rainy seasons, April – May and September – October. The dry forests in Borana are found at Arero, Yabello, Mega and Negelle. These forests are open, with juniper woodland with a canopy 10 – 15 m high and often associated with woodland or evergreen bushland at the fringes. The undergrowth consists of evergreen bushes with open grassy glades in between. Unfortunately, many of these forests have been depleted by logging and ravaged by fires (Ash and Atkins, 2009). Typical species of the dry forests of Borana include *Acacia abyssinica, A. drepanolobium, A. nilotica, A. seyal, Acanthus* spp., *Podocarpus gracilior, Combretum* spp., *Croton machrostachyus* and *Juniperus procera* (Yilma, 1991, Ash and Atkins, 2009). *Podocarpus falcatus* is the principal species. *Podocarpus* forests with *Celtis Africana, Prunus Africana, Aningeria adolfi-friederic* and *C. machrostachyus* are common (EWNHS, 1996; Borghesio and Massa, 2000)

Agriculture

Cultivation is widespread in the study area as the fertile soil and climate is more favourable for agriculture (Borghesio *et al*., 2004). The principal agricultural crop is maize. Cultivation commences beneath a sparse tree canopy in partially cleared trees by slash and burning. Many large trees, especially *P. falcatus*, and other hardwood trees are often left during clearing operations. Most of these are cut and burnt around the base and through ring barking. Cattle and goats are kept in the forest, especially during the dry season, where the forest vegetation is the only available fodder.

Climate

Mean annual temperature ranges between 13^{o}C – 26^{o}C (Fig. 2). The average annual rainfall is 952.2 mm. The Climatic data were collected from the National Meteorological Agency, Kibre-Mengist Station. The bimodal rainfall occurs from March to May and June to September (Fig. 3), with higher rainfall in the forest areas, which decreases from northwest to southeast (ERA, 2006).

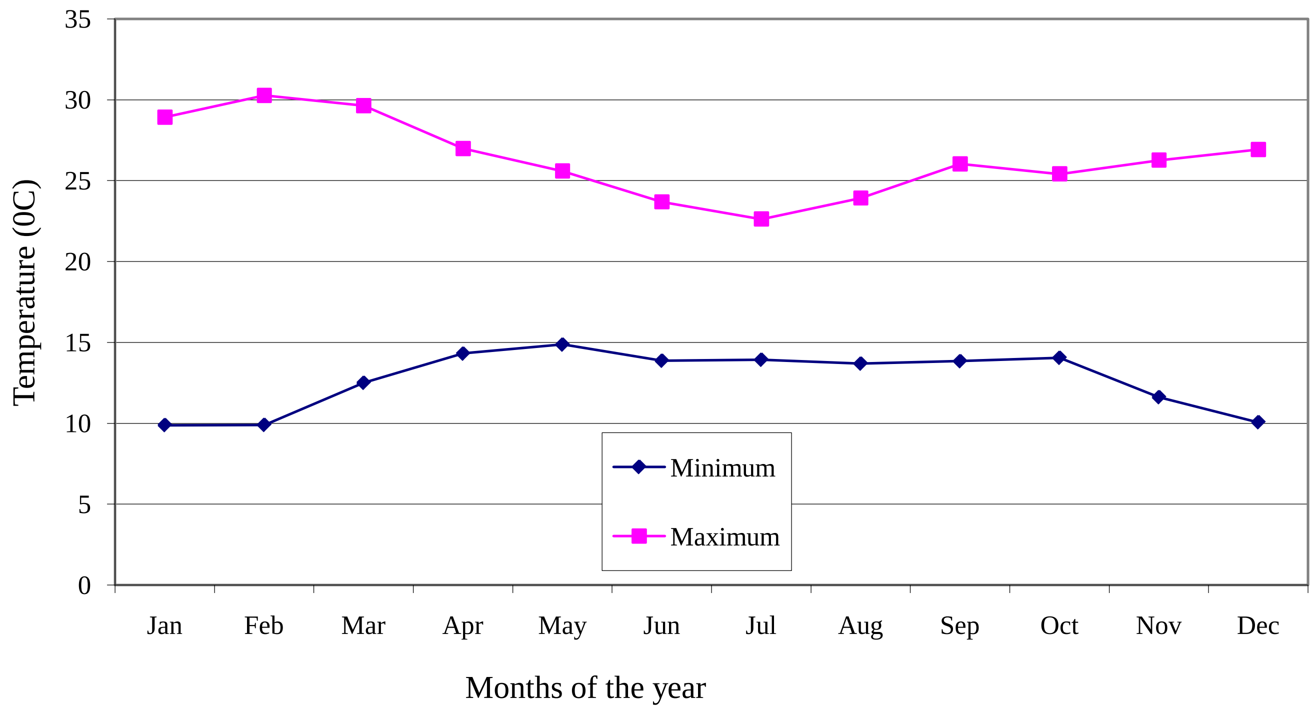

Figure 2. Mean maximum and minimum monthly temperature during 1998 – 2008

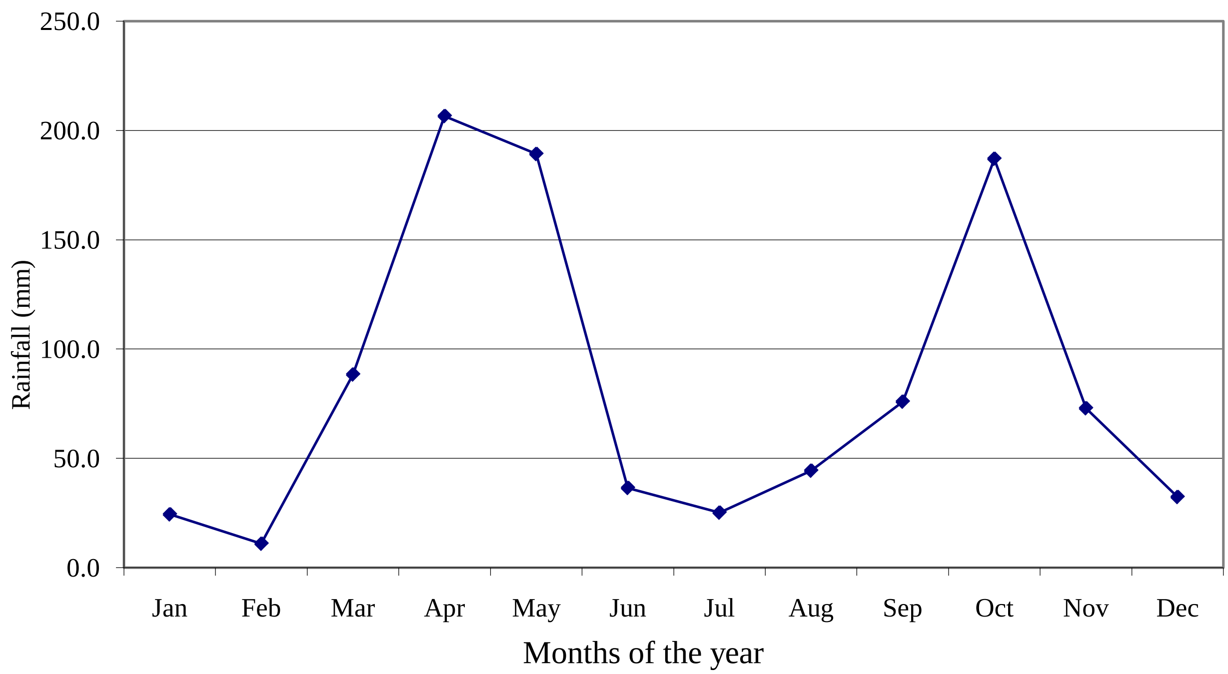

Figure 3. Mean monthly rainfall during 1998 – 2008

Materials

Global Positioning System (GPS 76CSX), digital camera (7.2 Mega Pixels of 3x), compass, binoculars (8 X20), maps of the study area (1:50,000 from Ethiopian Mapping Authority), cassettes with recordings of the species (both *T. ruspolii* and *T. leucotis*), tape recorder (Cassette Playback), data collection forms, printout photos showing head patterns of pure *T. ruspolii*, *T. leucotis* and the hybrids were used during the field work.

Methods

Before initiating the actual study, a pilot survey was conducted during 21 - 30 of August, 2009 for 10 days to identify the research area (habitat ranges of *T. ruspolii* and *T. leucotis*) where the two species of turacos, co-exist and to be familiarize with the habitat types existing in the study area. This was important to obtain the local knowledge on the distribution and habitat type of *T. ruspolii*. After the preliminary survey was carried out, the actual field work was conducted from September, 2009 to May, 2010. During September 27 – October 07, 2009, data were collected from Kibre-Mengist, Wadera, Zembaba Wuha, Sire Buke and Magado, during November 15 – December 10, 2009, data were collected from Wadera, Sokora Jide and Zembaba Wuha, during March 10 – 30, 2010, data were collected from Shakiso, Reji and Bore Obiti and during May 02-17, 2010, data were collected from Kibre-Mengist and Sire Buke. Point-count surveys were conducted at 548 points of 46 transects in different habitats.

Part of the vegetation sampling was adopted from the previous studies on turacos (Borghesio and Ndang'ang'a, 2003). At each way point where the census of turacos were taken, the UTM coordinate of GPS were recorded to indicate the location where the turacos and the hybrids were observed to compare the current data with the previous ones. The percentage of vegetation covers within (forest, woodland, shrub land, agriculture and plantation) 100 m of the central point were estimated visually at five levels. Human impact was recorded by observing the presence and absence of houses and paths in addition to agriculture.

The habitat was categorized in to five variables, that is, forest, woodland, shrubland, agriculture and plantation in the study area. Group one was 40% woodland and 60% shrubland; group two was 72% woodland, 18% shrubland and 10% agriculture; group three was 100% forest; group four was 30% woodland and 70% agriculture and group five was 25% agriculture and 75% plantation. According to the variables, the habitat groups are shown in Table 1.

Table 1. Sample groups of the habitat type in the study area

Habitat type	Sample groups				
	1	**2**	**3**	**4**	**5**
Forest	0	0	100	0	0
Woodland	40	71.7	0	30	0
Shrubland	60	18.3	0	0	0
Agricultural land	0	10	0	70	25
Plantation	0	0	0	0	75

The habitat requirement of *T. ruspolii* was determined with experienced local field guides to find the centre of the habitat range where the two species co-exist (Borghesio, *et al*. 2004). More focus was given on the northern section of *T. ruspolii*’s range, which covers an area of 60 X 40 km because *T. ruspolii* and *T. leucotis* co-exist together and where more hybridswere observed.

In the study area, sample points were separated by 400 m from each other along the transects (Bibby *et al*., 1992). At each sample point, the records of *T. ruspolii* and *T. leucotis* were played for 10 minutes to elicit vocal responses of the species to obtain sufficient sample size of observation. Playback surveys are more efficient and accurate than visual/aural surveys (Kumar and Singh, 2010, Gibbons and Gregory, 2006). Then, the observed or heard species of turacos and hybrids were recorded on the respective data sheets.

The location of each sample point along the transect line and the distance from the sample point to the bird were recorded using GPS.

T. ruspolii, T. leucotis and their hybrids were identified based on their morphological observation and recorded on the data sheet. The study area ranges from areas where natural vegetation is largely untouched to sites where human impact is strong. This helped to test whether the human impact on the habitat is the main driver of hybridization between turacos or not in the study area. The research was carried out across the study area using public transportation where it is available and local transportation (motor cycle) where there is no other transport access.

Bird Census

Bird surveys were conducted using the point count method within 200 m radius. Each locality (Fig. 1) was visited and turacos and their hybrids were recorded in different habitats. The variable distance point count method was employed to sample the birds. Point counts were spaced 400 m from each other and arranged along transects that were positioned randomly in habitat types and were set up along approximately straight line paths using compass with the help of 1:50,000 maps of the study area. Dispersion of transects was planned so as to spread the samples evenly over the study area (Figure 4).

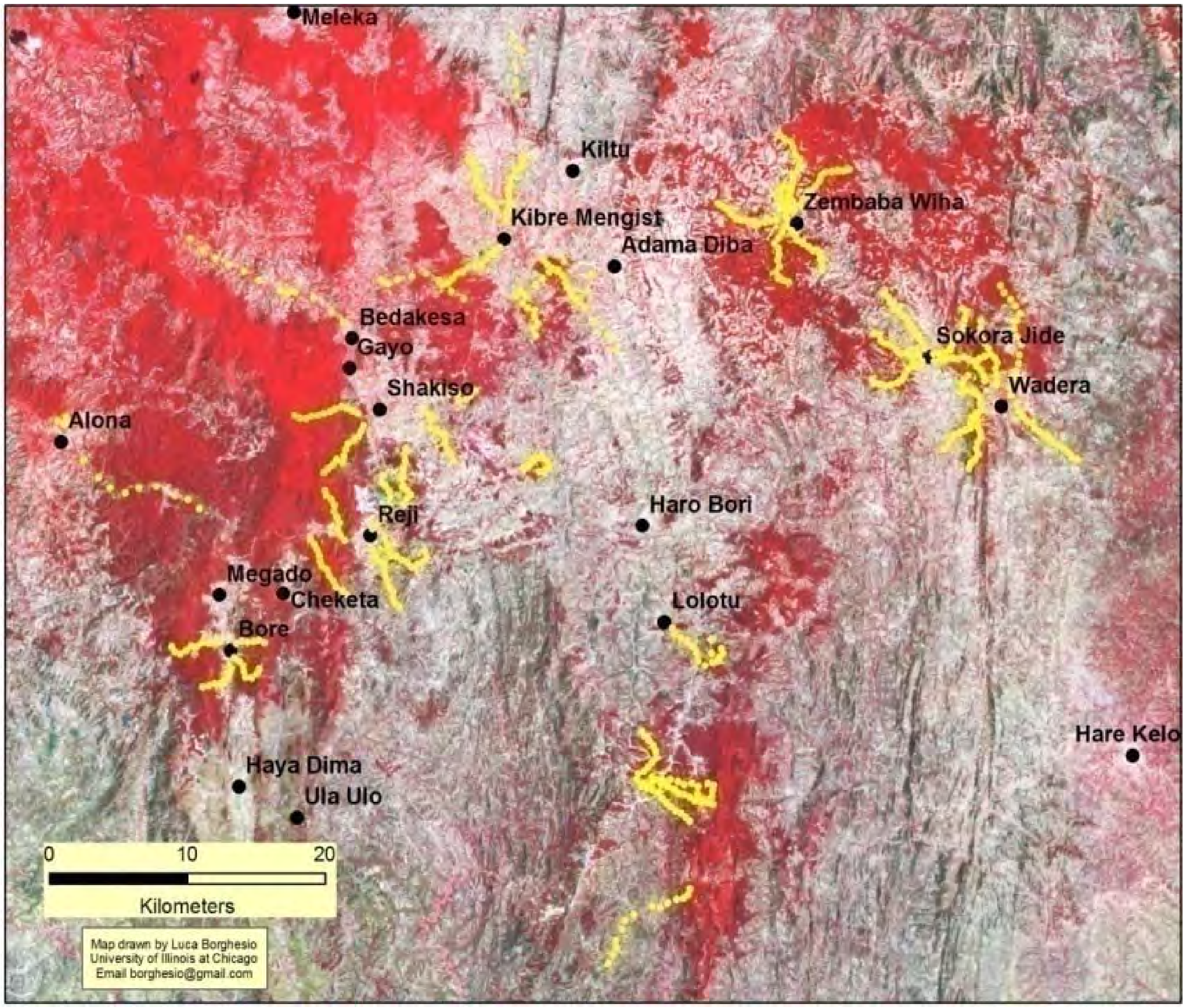

Figure 4. Transects covered during the survey in the sample area

These transects were located far apart at approximately 500 m from each other. Census points were marked along the transects at interval of 400 m with a GPS. The bird census was carried out in the hours of maximum detectability of birds from 6:00 to 10:30 a.m. in the morning (Borghesio, 1997a). The tape recorded calls were supplied by the National Sound Records of the British Library to elicit the response of birds. Careful observation was made to differentiate the two species and their hybrids recognizing their head patterns (Fig. 5).

The distance between two successive point counts was estimated at least twice the maximum hearing distance of the recordings. The presence and absence of turacos and their hybrids were recorded. Bird census was taken in the absence of rain and heavy mist. The number of individuals seen in each species and the hybrids were recorded on the data collecting forms (see appendices). When approaching a census point, if any bird was flushed from the plot, these were recorded as being present during the census period.

(a)

(b)

(c)

Figure 5. Turacos and their hybrid

(a) Pure Prince Ruspoli’s Turaco (Photo: Paul Donald, June 2010)
(b) Pure White-cheeked Turaco (Photo: Roland Seitre 2002)
(c) Hybrid Prince Ruspoli's x White-cheeked Turaco (Photo: Roland Seitre, 2002)

Data analysis

The analysis was conducted using the SPSS version 17.0 statistical package. One way ANOVA was used to describe habitat variables. Variables that could not satisfy the assumption of parametric test were analyzed using non-parametric test (Borghesio and Ndang'ang'a, 2003).

Results

Out of a total of 548 census points in all habitat categories, the presence of turacos was confirmed at 241 points. The distribution of turacos was highest in woodlands for Prince Ruspoli's Turaco and in forest for White-cheeked Turaco. The two species were observed in all habitat types in the study area, but for the plantation (Table 2).

Table 2. Comparison of the past and present studies of Prince Ruspoli's Turaco and White-cheeked Turaco (Borghesio, 1997, Borghesio and Massa, 2000, Tolera Kumsa, 2008).

	Past studies				Present study	
	1997 and 2000		2008		2010	
Habitat type	*T. ruspoli*	*T. leucotis*	*T. ruspoli*	*T. leucotis*	*T. ruspoli*	*T. leucotis*
Forest	Absent	Common	Absent	Common	Uncommon	Common
Forest edge	Common	Uncommon	Common	Common	Common	Common
Woodland	Common	Absent	Common	Common	Common	Common
Modified habitat	----------	-----------	Uncommon	Uncommon	Uncommon	Uncommon

In the study area there was habitat variation, which is significantly different (Table 3).

Table 3. Analysis of Variance among the habitats in the study area

Habitat		Sum of Squares	Df	Mean Square	F	Sig.
Forest	Between Groups	710336.09	4	177584.022	1742.250	.00
	Within Groups	55143.03	541	101.928		
	Total	765479.12	545			
Woodland	Between Groups	544555.21	4	136138.80	585.68	.00
	Within Groups	125752.71	541	232.45		
	Total	670307.92	545			
Shrub land	Between Groups	102730.93	4	25682.73	399.77	.00
	Within Groups	34755.56	541	64.24		
	Total	137486.49	545			
Agriculture	Between Groups	434139.13	4	108534.78	423.57	.00
	Within Groups	138623.37	541	256.24		
	Total	572762.50	545			
Plantation	Between Groups	103412.35	4	25853.09	510. 90	.000
	Within Groups	27376.34	541	50.60		
	Total	130788.69	545			

The distribution of the turacos in different habitats of the sample areas is given in Figure 6. Distribution of the turacos also shows significant variation among the habitats (Table 4).

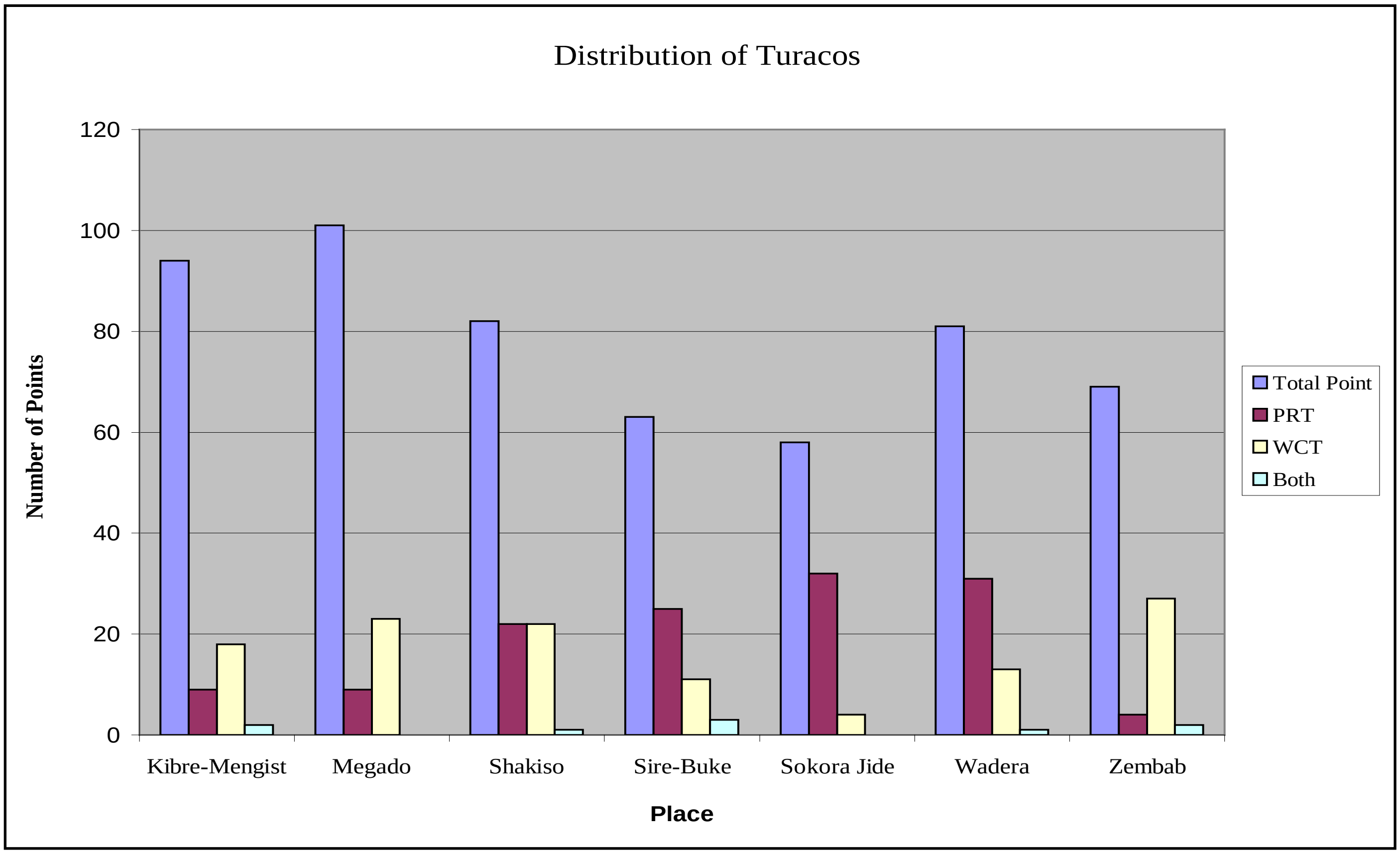

Figure 6. Frequency distribution of Turacos across the census points

Table 4. Distribution of Turacos in the study area

Species		Sum of Squares	df	Mean Square	F	Sig.
PRT	Between Groups	124.56	4	31.14	16.34	.00
	Within Groups	1031.34	541	1.91		
	Total	1155.91	545			
WCT	Between Groups	49.35	4	12.34	13.84	.00
	Within Groups	482.27	541	.09		
	Total	531.61	545			

The distribution of turacos shows variation between the habitats (Figure 6).

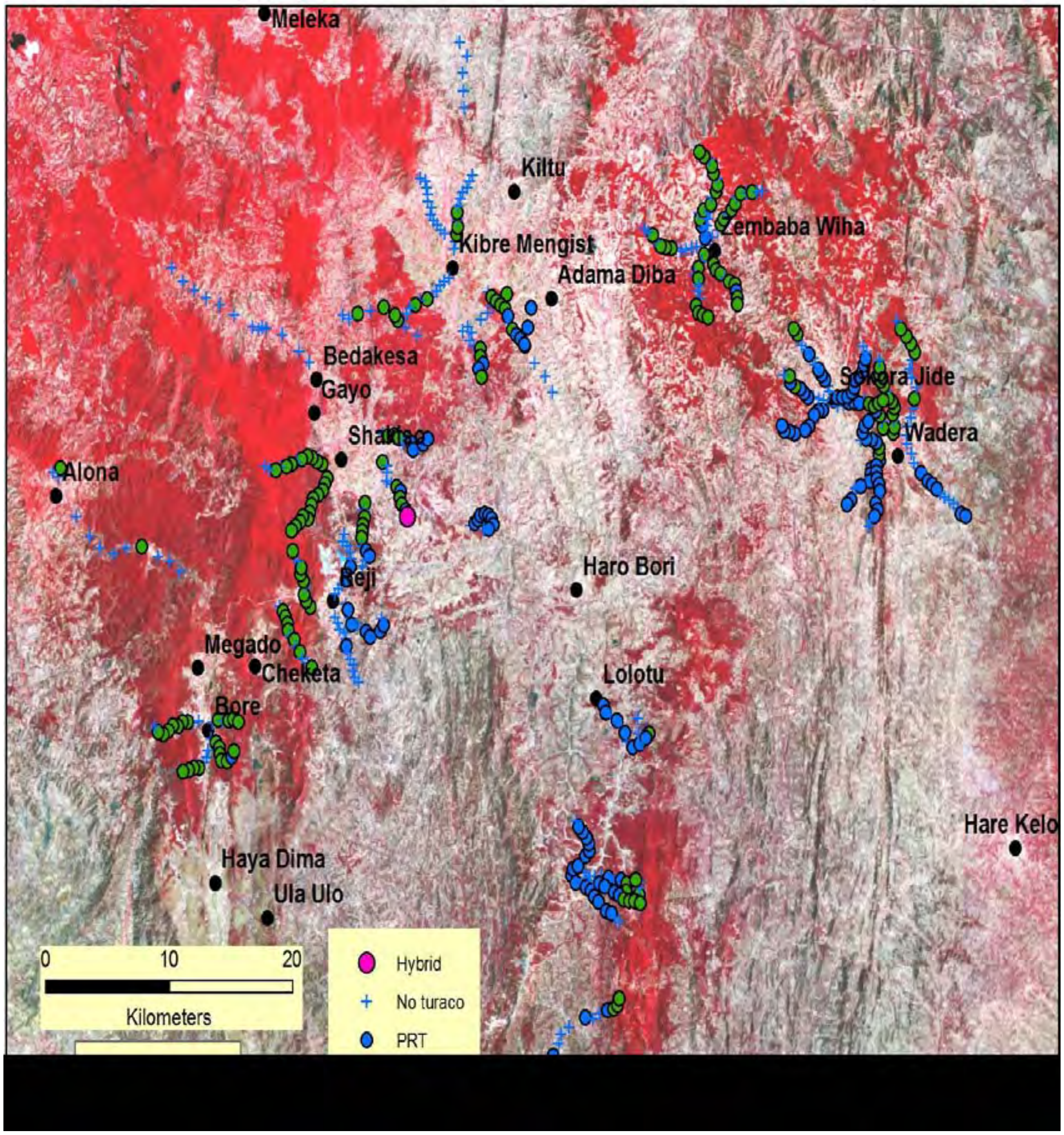

Figure 7. Transects that show the distribution of the turacos and the hybrid

High forest coverage was observed at Sire Buke (36%) followed by Zembaba Wuha, which has 31% forest habitat but scattered (Table 5). Shakiso also has good forest habitat, which is about 28% but disturbed by settlement, agriculture and mining. Sekora Jide and Wadera had high woodland habitats that are suitable habitats for the Prince Ruspoli’s turaco.

Table 5. Percentage of habitat types in the study area

Place	Forest	Woodland	Shrub land	Agriculture	Plantation
Kibre-Mengist	7.55	22.39	0.85	60.37	9.68
Megado	19.70	33.81	8.76	37.90	0.20
Shakiso	27.80	30.55	5.98	34.45	1.22
Sire-Buke	35.87	38.41	10.16	15.56	0.00
Sokora Jide	10.95	71.21	0.00	17.33	0.52
Wadera	19.38	54.14	0.00	18.89	7.59
Zembaba Wuha	30.80	28.99	6.01	28.99	4.93

The distribution of turacos across the habitat shows some constant correlation. Prince Ruspoli's Turaco shows positive correlation with woodland and shrubland habitats and negative correlation with forest and modified habitats (agriculture and plantation). White-cheeked Turaco shows positive correlation with forest, plantation and shrubland habitats and negative correlation with woodland and agriculture (Table 6). The two species are sympatric at the forest edge and shrubland habitats.

Table 6. Correlations of turacos with the habitat

Variable		PRT	WCT	Forest	Woodland	Shrub	Agriculture	plantation
PRT	Pearson Correlation	1	-.174**	-.152**	.386**	.014	-.222**	-.060
	Sig. (2-tailed)		.000	.000	.000	.744	.000	.162
	N	547	547	547	547	547	546	547
WCT	Pearson Correlation	-.174**	1	.290**	-.204**	.006	-.138**	.035
	Sig. (2-tailed)	.000		.000	.000	.894	.001	.408
	N	547	547	547	547	547	546	547
Forest	Pearson Correlation	-.152**	.290**	1	-.553**	-.157**	-.445**	-.084*
	Sig. (2-tailed)	.000	.000		.000	.000	.000	.049
	N	547	547	547	547	547	546	547
Woodland	Pearson Correlation	.386**	-.204**	-.553**	1	-.088*	-.302**	-.207**
	Sig. (2-tailed)	.000	.000	.000		.039	.000	.000
	N	547	547	547	547	547	546	547
Shrub	Pearson Correlation	.014	.006	-.157**	-.088*	1	-.194**	-.040
	Sig. (2-tailed)	.744	.894	.000	.039		.000	.345
	N	547	547	547	547	547	546	547
Agriculture	Pearson Correlation	-.222**	-.138**	-.445**	-.302**	-.194**	1	-.125**
	Sig. (2-tailed)	.000	.001	.000	.000	.000		.003
	N	546	546	546	546	546	546	546
Plantation	Pearson Correlation	-.060	.035	-.084*	-.207**	-.040	-.125**	1
	Sig. (2-tailed)	.162	.408	.049	.000	.345	.003	
	N	547	547	547	547	547	546	547

Turacos and hybrid observed at the present study areas are shown by table 7.

Table 7. Turacos and hybrid observed in the study area

Place	Point at PRT seen	Point at WCT seen	Point at both species seen	Point at hybrid seen	Total point
Megado	9	19	0	0	101
Kibre-Mengist	9	18	2	0	94
Shakiso	22	22	1	1	82
Sire Buke	25	11	2	0	63
Sokora Jide	32	4	0	0	58
Wadera	31	13	1	0	81
Zembaba Wuha	4	27	0	0	69

At Megado, woodland and forest habitats were disturbed with illegal settlements held by the traditional gold miners (Fig. 8).

Figure 8. Settlement in the forest at Megado (Photo: Alazar Daka, March 2010)

At Kibre-Mengist habitat alteration is highly observed. Almost 60% of the total census points were in farm areas and 10% was in plantation. Only about 20% was in woodland, which is the suitable habitat of the *T. ruspolii* (Fig. 8).

Figure 9. Agricultural expansion at Kibre-Mengist (Photo: Alazar Daka, May 2010)

At Shakiso one hybrid was observed with four individuals of *T. ruspolii*.

At Sire Buke, *T. ruspolii* was revealed at the forest edge of Tsede Forest and *T. leucotis* in the forest. This showed that the habitat overlap of the two species. *T. leucotis* was observed totally in the Tsede forest (Fig. 9), which is thick *Podocarpus falcatus*.

Figure 10 Tsede Forest, thick *Podocarpus falctus* (Photo: Alazar Daka, May 2010)

Sokora Jide is a typical habitat of *T. ruspolii*, with 55% (32/58 = 0.55), census points had *T. ruspolii*. Wadera had the most population of *T. ruspolii* (104 individuals) ware recorded at 31 point counts, which is more than the sum of the population of *T. ruspolii* in Kibre-Mengist, Megado, Shakiso and Zembaba Wuha had 102. In Zembaba Wuha, *T. ruspolii* was widespread and isolated. Only eight individuals were seen at four census points out of 69 census points.

Prince Ruspoli's Turaco was observed in 132 census points out of the total 548 census points in the whole of the present study area. The distribution of the *T. ruspolii* was high in the woodland habitat and less in agriculture and forests. Out of the 333 individuals of *T. ruspolii*, 302 were recorded in 50 – 100% woodland habitat, which covers the census point. As the percentage of woodland habitat increased, the number of *T. ruspolii* increased. Woodland habitat showed a positive correlation with *T. ruspolii* (Fig. 10).

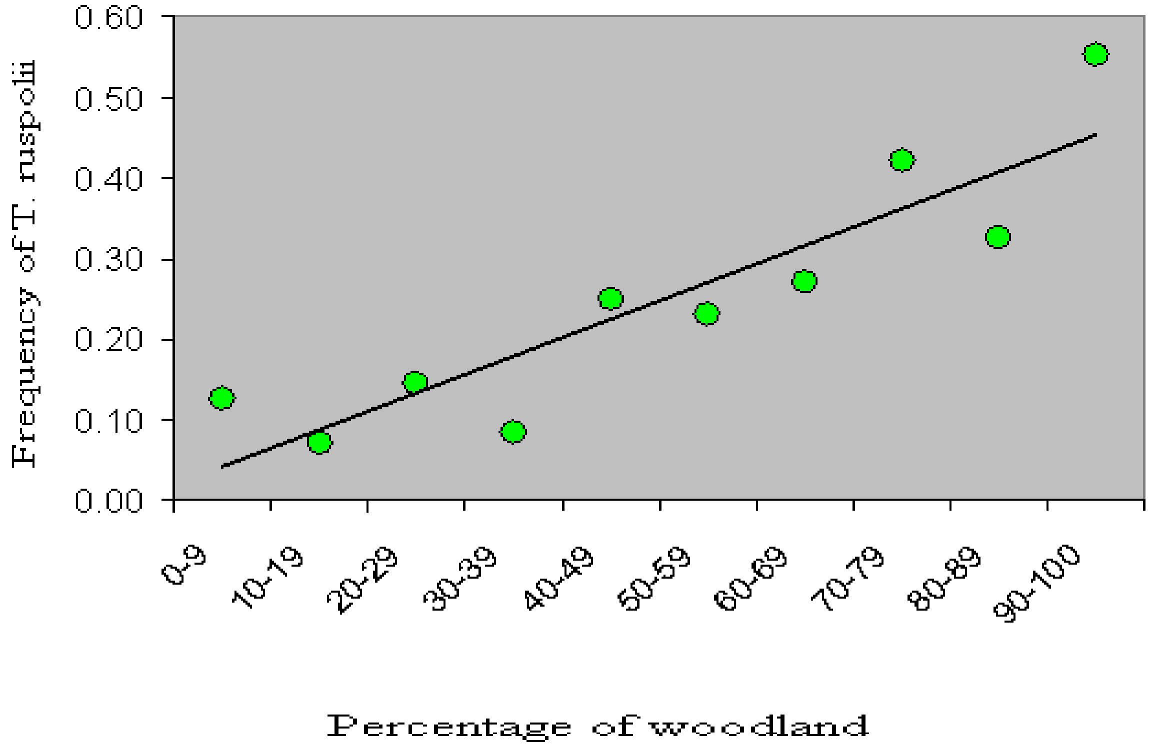

Figure 11. The frequency of *T. ruspolii* increases strongly with the extent of open woodland.

The presence of White-Cheeked Turaco was recorded in 118 census points out of 548 the total census points. They were observed more in the forest habitat. There were 126 individuals in the complete (100%) forest habitat of the census points. White-cheeked Turaco was concentrated at Sire Buke, in Tsede forest. More than 61% of the *T.leucotis*, (11 individuals out of 18 individuals) was observed at Sire Buke in the Tsede forest.

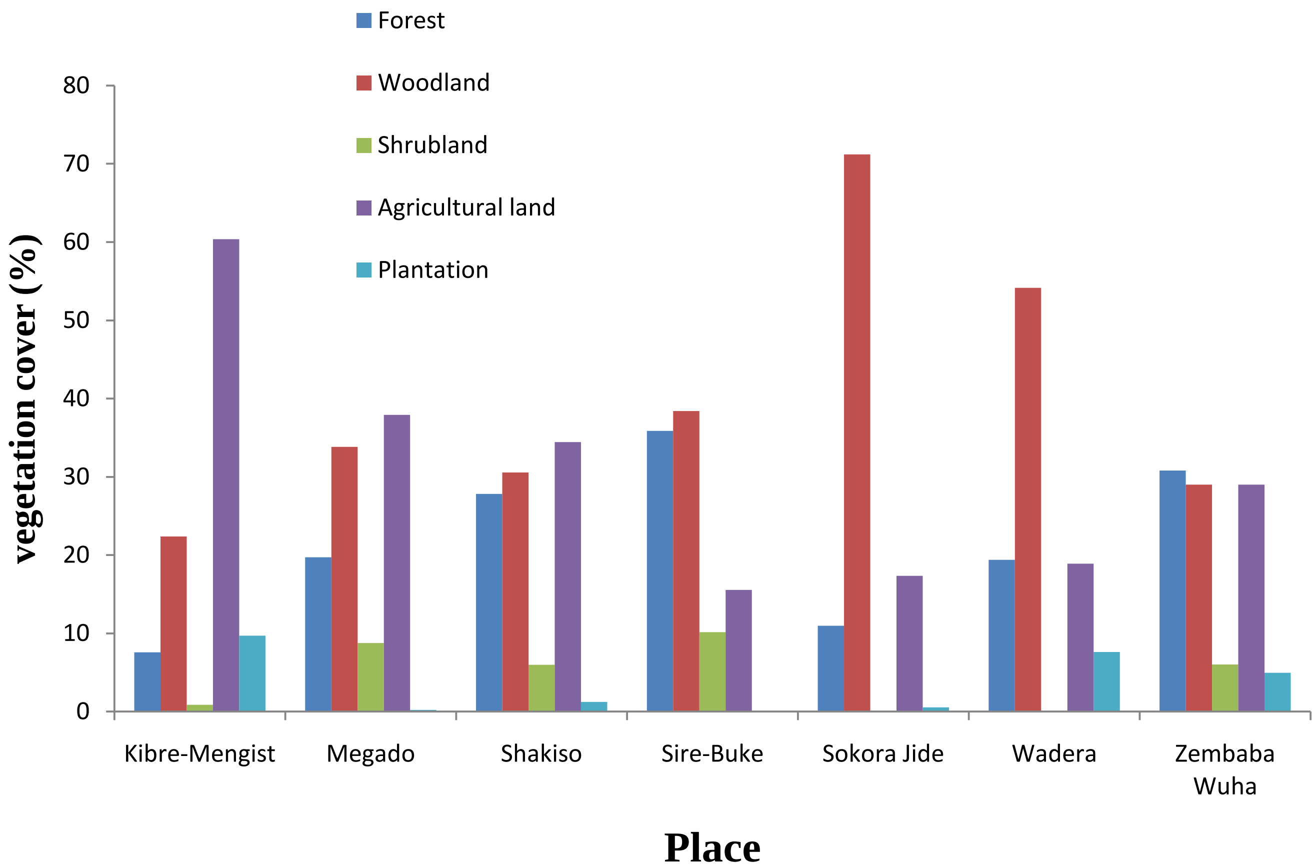

Figure 12. Vegetation covers of the study area

The vegetation cover of the study area is shown in figure 12. At Sire Buke more forest cover was observed.

High frequency distribution of Prince Ruspoli's Turaco was observed in the woodland habitats and less frequency in the agricultural land and in plantation. The number of Prince Ruspoli's Turaco observed in the forest during the census was low. out of the total 548 census points two individuals in Shakiso, two in Wadera and 10 in Sire Buke were in forest habitat. There was significant difference in the presence of them in the forest and in other ($H = 6.608$, $P < 0.01$).

The distribution of White-cheeked turaco was recorded in 118 out of the total 548 census points. They were observed in all habitats except in plantation and in agricultural land at Sire Buke, which had high forest cover (Fig. 13). Their distribution was the highest in the forest than the other habitats. The distribution of *T. leucotis* showed high significances among vegetation cover (χ^2_4 = 64.58.3, P < 0.01). But, this was not statistically significant compared to the other habitats (H = 2.143, P = 0.315), except in the plantation habitat (H = 8.506, P < 0.01).

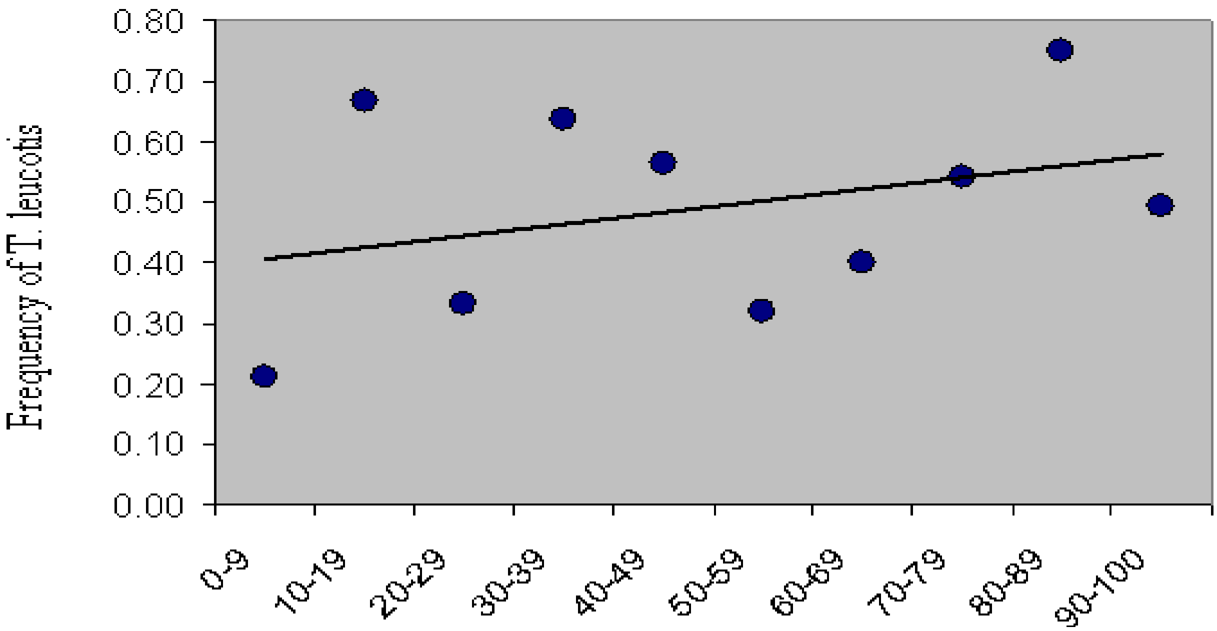

Figure 13. The frequency of *T. leucotis* increases as the forest increases

In the forest habitat, the number of *T. ruspolii* decreased in response to the increase of forest cover. At Sire Buke, at forest edge, more *T. ruspolii* was observed and few in the forest (Fig. 13).

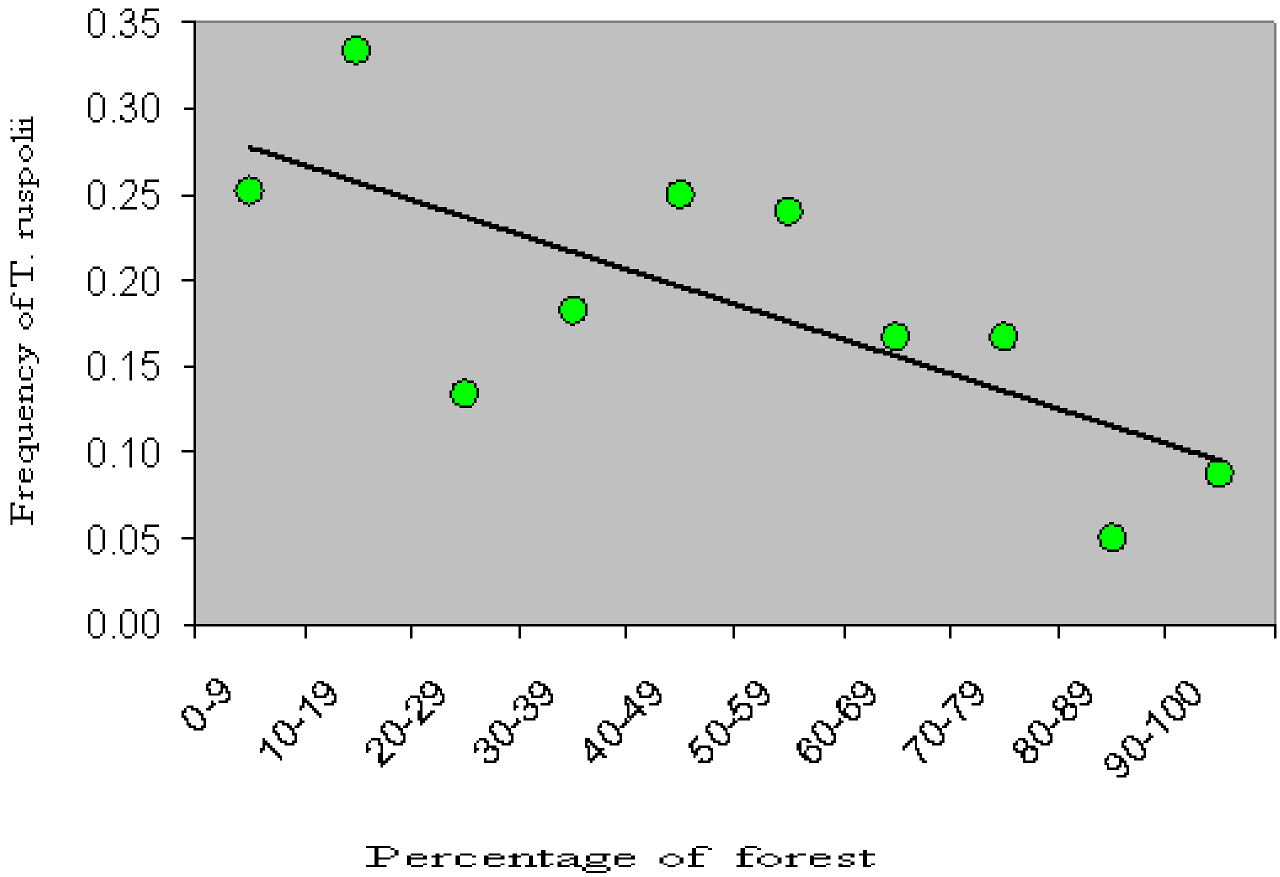

Figure 14. The frequency of *T. ruspolii* decreases as the forest increases

The habitat where the two species previously inhabited has been changed since 1995. In the study area, the range expansion of *T. leucotis* into the *T. ruspolii* habitat was observed. Out of the total census points, 127 individuals out of 251 were observed outside the forest habitat and 52 individuals of *T. leucotis* were observed in complete 100% woodland, which is the habitat of *T. ruspolii*.

Discussion

The previous study by Borghesio (1997a) revealed that density of *T. ruspolii* in *Podocarpus* forest was low. It was suggested that *T. ruspolii* avoided the *Podocarpus* forest probably due to competition from *T. leucotis*. The two species replaced each other along habitat transition, with little or no overlap, and competition was not likely to be a severe problem (Borghesio, 1997a, Borghesio and Massa, 2004). The findings of the present study confirmed that *T. ruspolii* was highly distributed in open woodland and almost absent in the forest. However, the range of the two species highly overlapped by habitat destruction that formerly isolated the two species.

Observations and reassessment of the conservation status of *T.ruspolii* were made at different times (Borghesio, 1997b; Borghesio and Massa, 2000; Lernwould and Seitre, 2002 and 2004; Borghesio *et al*., 2004; Tolera Kumsa, 2008). The present study focused on the habitat destruction, hybridization and habitat association of the *T.ruspolii* and *T.leucotis* in their distribution range and where they are sympatric. There was an increase in villages and towns due to the increase of human population in the area. The habitat reduction and the highly fragmented *Combretum-Terminalia* woodland threatened the survival of *T.ruspolii* (Borghesio *et al.*, 2004). The habitat modification of *Combretum-Terminalia* woodland might lead *T. ruspolii* to concentrate in certain areas and possibly would expose the species to competition and hybridization through geographic range expansion of *T. leucotis* into the range of the *T. ruspolii*. It was mentioned by Borghesio (1997a) that *T. ruspolii* and *T. leucotis* were allopatric with minimum overlap before 1995, but have long been sympatric over large areas (Borghesio, *et al*., 2004). During the present and 2008 studies (Tolera Kumsa, 2008), *T. ruspolii* and *T. leucotis* were observed in many points mixed together and hybrids were observed where *T. leucotis* is expanding the range to the forest edges, encountering *T. ruspolii*.

The occurrence of *T. ruspolii* decreased with increased patch isolation and reduction patch size in the study area. However, the present study indicated that forest margins and *Combretum-Terminalia* woodland habitats did not show significant differences in the distribution of

T. leucotis compared to *Podocarpus* forests. According to Mooney and Cleland (2001), the consequences of habitat fragmentation are specific where less dispersed species are more affected. This made *T. ruspolii* difficult to overcome the problems as their habitat is not continuous due to increasing competition in the present study area (Borghesio and Massa, 2000).

Habitat destruction and modification observed in the present study area further threatens *T. ruspolli* because the range of the species is very restricted (Borghesio, 1997a). The northern distribution of this species is affected by human settlements and agricultural expansion. Agriculture holds a huge proportion of the land encroaching into the wild habitat of *T. ruspoll.* Fertile soils in the study area led to the expansion of agriculture highly affecting the *Combretum-Terminalia* woodland used as habitat of *T. ruspolii* (Borghesio *et al*., 2004). During the present study, it was observed that many areas formerly occupied by *Combretum-Terminalia* woodland was recently replaced by cultivated fields. This had triggered high rate of habitat destruction and further reduction of the range of *T. ruspolii.*

In addition to the restricted range, *T. ruspolii* is restricted by altitudinal distribution, which certainly reduces the chance of distribution (Borghesio, 1997a). This condition imposes additional threat because of the reluctant behaviour of the species to move to higher altitudes, regardless of suitable habitats. Rymer and Simberloff (1996) suggested that whenever species of birds become concentrated in one location, such as in fragmented habitats, the population is at risk from localized destruction of the habitat.

In the northern distribution of *T. ruspolii*, continuous reduction of *Podocarpus* forests probably causes a threat to *T. ruspolii*, as the species is rarely seen in the forest (Borghesio, 1997b). In sympatric distribution of turacos, the destruction of *Podocarpus* forests break the barrier between the two species. *T. leucotis* had apparently expanded into the range of *T. ruspolii* and most likely imposes an indirect effect through competition and hybridization. *Tauraco leucotis* is most likely to adapt more easily and that they can survive in open lands and has the ability to penetrate and colonize every locality (Borghesio, 1997b). During the present study, *T. ruspolii* occurred almost everywhere in the study area, including agriculture landscapes. Moreover, the mixed group of the two species was observed in many localities, which might lead to the increase in competition and hybridization. The exact mechanism other than habitat destruction that leads to the mixing of the two species is not clear. Mallet (2005) described that population size, and the strength of reproductive barriers that isolate the two species are some of the ecological parameters that might influence the risk trough hybridization. In the present study area, the strength of reproductive barrier isolated the two species apparently decreased. The present data are not enough to estimate the proportion of hybrids within the total population. The occurrence of hybrids expected to spread over the rest areas of the contact zone is not covered in the present study. To estimate the incidence of hybridization and to compare the proportion of hybrids with that of pure *T. ruspoliii* and *T. leucotis*, further investigations are needed to incorporate rest of the areas.

The mixed groups of the two species were recorded during the survey of 2003 (Borghesio *et al*., 2004). However, during the present survey, the mixed groups increased by far most likely due to the expansion of habitat changes, which lowered the ecological barrier between the two turacos (Lernould and Seitre, 2002). The current situation of habitat destruction and mixing of the two species in the study area is a sign that the two species are blend together leading to hybridization. The occurrence of hybrids and the extent of the problem of hybridization might increase in the area. *Taurac leucotis* appears to over-dominate *T. ruspolii* and overlapping widely, probably out-competing following the habitat destruction. There was alsona sign of further penetration into the historical range of *T. ruspolii*.

Tauraco leucotis is widely distributed and dominates over *T. ruspolii* throughout its range. This new interaction of niche displacement apparently resulted from food competition between the two species as they might prefer the same type of food (*Ficus* species) in the disturbed and resource limited habitats. Though *T. ruspolii* favours fruits in the low canopy of open land, they are to be expected poor dispersers to exploit the available food in the fragmented habitats crossing the unfavourable habitat such as abandoned agricultural landscape. *T. ruspolii* were highly distributed in forest edges habitats and *Combretum-Terminalia* woodland with localized and fragmented areas.

Higher resource use efficiency has been implicated in the competitive superiority of *T. leucotis* in their new habitat and the new interactions brought by *T. leucotis*. This might be due to the nature of competition for a long period among its members at the time of food shortage in the forest. Mooney and Cleland (2001) examined the mechanisms of competitive displacement of native birds by non-natives and suggested s competition for food resources resulting in the displacement of the native species in resource deficient areas. Most frugivorous species normally travel long distances in the course of their foraging activities. Such generalist feeders are unlikely to be constrained like the specialized feeders (Johns, 1988).

Moreover, many of the pioneer tree species that re-colonize the cleared *Combretum-Terminalia* woodland are not used by *T. ruspolii*. Once the limited food source of *T. ruspolii* is destroyed, the food type is unlikely to be obtained until regenerating seedlings of the primary forest trees reach maturity. *Ficus* and *Podocarpus* species may take several years to bear fruit (Gessesse Dessie, 2007). The problem is exacerbated at Zembab Wuha planting exotic species, which deflects the natural regeneration of the forest (Borghesio *et al*., 2004).

During the present survey, only one hybrid was observed at Shakiso with four *T. ruspolii* individuals, where the habitat was 50% woodland 50% agricultural (grazing land and cultivation) habitats.

Although only one individual of hybrid was observed during the census, it does not mean that hybridization between *T. ruspolii* and *T. leucotis* is low. The census point technique was random sampling, and it did not cover the whole study area.

Eight hybrid individuals of the two species were had been seen by Tolera Kumsa (2008) and four hybrid individuals were seen by Lernould and Seitre (2004) and Borghesio *et al*. (2004). The difference in the number of the hybrids that is observed in the study area is not significant when compared to the distribution of the species. The previous studies and the current study covered only sample areas.

Prince Ruspoli's Turaco is a threatened species categorized as "Vulnerable" under the IUCN category. At Zembaba Wuha where high human population lives in and around the *Combretum-Terminalia* woodland is a threat for *T. ruspolii*. Agricultural encroachment, logging and mining activities are the main causes of the habitat loss in the range of the species. In Zembaba Wuha, Sokora Jide and Kibre-Mengist, utilization of the open land forest for agriculture has been increasing (Borghesio *et al*., 2004). *Combretum-Terminalia* woodland around the new settlement area is cleared totally.

The human population size is increasing from time to time, living near and in the town (Kibre-Mengist; 26, 694 and in Shakiso; 18,000) (ERA, 2006). This expansion would attract continuous flow of fuel wood and timbers for the use of town dwellers. This is a threat for the remaining patches of *Combretum-Terminalia* woodland along the river, hill and road sides, which is the habitat of Prince Ruspoli's Turaco. The plantations, Eucalyptus and *Cupresus* sp. are other threats for the Prince Ruspoli's Turaco in the study area. In Kibre-Mengist and Zembaba Wuha, now the habitats are covered by plantations, the habitat of the Prince Ruspoli's Turaco (Fig. 15).

Borghesio *et al*. (2004) reported that the habitat of Prince Ruspoli's Turaco was highly degraded in the southern range of the species because of the total removal of *J. procera.* Intensive grazing in the forest is also another threat that can reduce tree generation capacity of the habitat. This has major effect not only on the Prince Ruspoli's Turaco but also on the whole ecosystem in the area. In Shakiso and Kibre-Mengist, the threat includes mining of gold and other minerals such as tantalum (sAppendix 5).

(a) (b)

Figure 15. Plantation: (A) Eucalyptus at Zembaba Wuha (B) *Cupresus sp*. at Kibre-Mengist

Conclusion and Recommendation

The focuses of international concern and conservation policies in recent years have shifted from single species towards the biodiversity in any area. In this respect, the study area is unique with its diversity of plants and most crucial for the global survival of some globally threatened and near-threatened bird species.

The current study shows that the people who live in the study area are among the low income class societies, who depend on shifting cultivation for source of food. They will be the first to feel the consequence of deforestation. From the current observation, the extent of *T. ruspolii*'s habitat destruction is high. Unless it can be clearly stated through ecological and economical benefit of the local communities, under the present situation, there is little opportunity to develop any kind of conservation programme in this area.

Forest priority areas were identified by Oromiya Regional State Forest and Wildlife Agency and established to conserve this area as a high forest priority area. The aim of the agency is to develop management plans for the area, including the IBAs of the southern highlands of Ethiopia (Anferara Wadera Forest area). This includes the habitat of *T. ruspolii*. The above project is innovative in that it would promote establishment of an efficient fiscal system to collect revenues from resource use and to redistribute revenues to support conservation of resources. Planting fast growing exotic trees in the area may solve some of the needs for native trees, but this cannot replace natural habitats that have essential resources for the *T.ruspolii*. Therefore, protection of the area is mandatory for wildlife conservation especially for bird species to get enough feeding, nesting and breeding sites, and to maintain the natural ecological balance of the area.

In order to conserve this forest priority area, which is an IBA and EBA and based on the present findings, the following recommendations are made:

- ✓ Measures must be taken to ensure that the natural habitats of *T. ruspolii* and the other wildlife species of the study area to be protected from different threats.
- ✓ The need and interest of the local communities should be further studied in detail before a sound management plan can be proposed to conserve the habitat of *T. ruspolii* and other wildlife of the study area, through communal management programmes.
- ✓ Conducting public meetings and awareness creating programmes to create public awareness about issues regarding the biodiversity of the area including the importance of *T. ruspolii*.
- ✓ Detail studies should be carried out to what extent plantations of exotic fast growing trees in the study area affect the habitat of *T.ruspolii.*
- ✓ The development agents of the area should be given awareness to know the habitat and biodiversity of the area including *T. ruspolii* to assist conservation and awareness creation.
- ✓ Officials of the Zone, Woreda and Kebele administrations should be given awareness to enforce the laws and regulations for the conservation of the forest priority area, which is the habitat of the *T. ruspoilii* and other wildlife.
- ✓ Areas with high potential for eco-tourism should be carefully developed to ensure the local communities receive a fair share of economic benefits, as the area possesses five endemic bird species.
- ✓ Evaluation of the role of human impacts on the habitat of *T. ruspolii* should be considered in order to incorporate the indigenous knowledge of the local communities to work out socio-economic development plans for the area.

- ✓ Further investigation is needed in the *T. ruspolii* range to know the nesting site and success, extent of hybridization of *T. ruspolii* with *T. leucotis* and molecular analysis is needed to be sure that the hybrid is different from the parent turacos.

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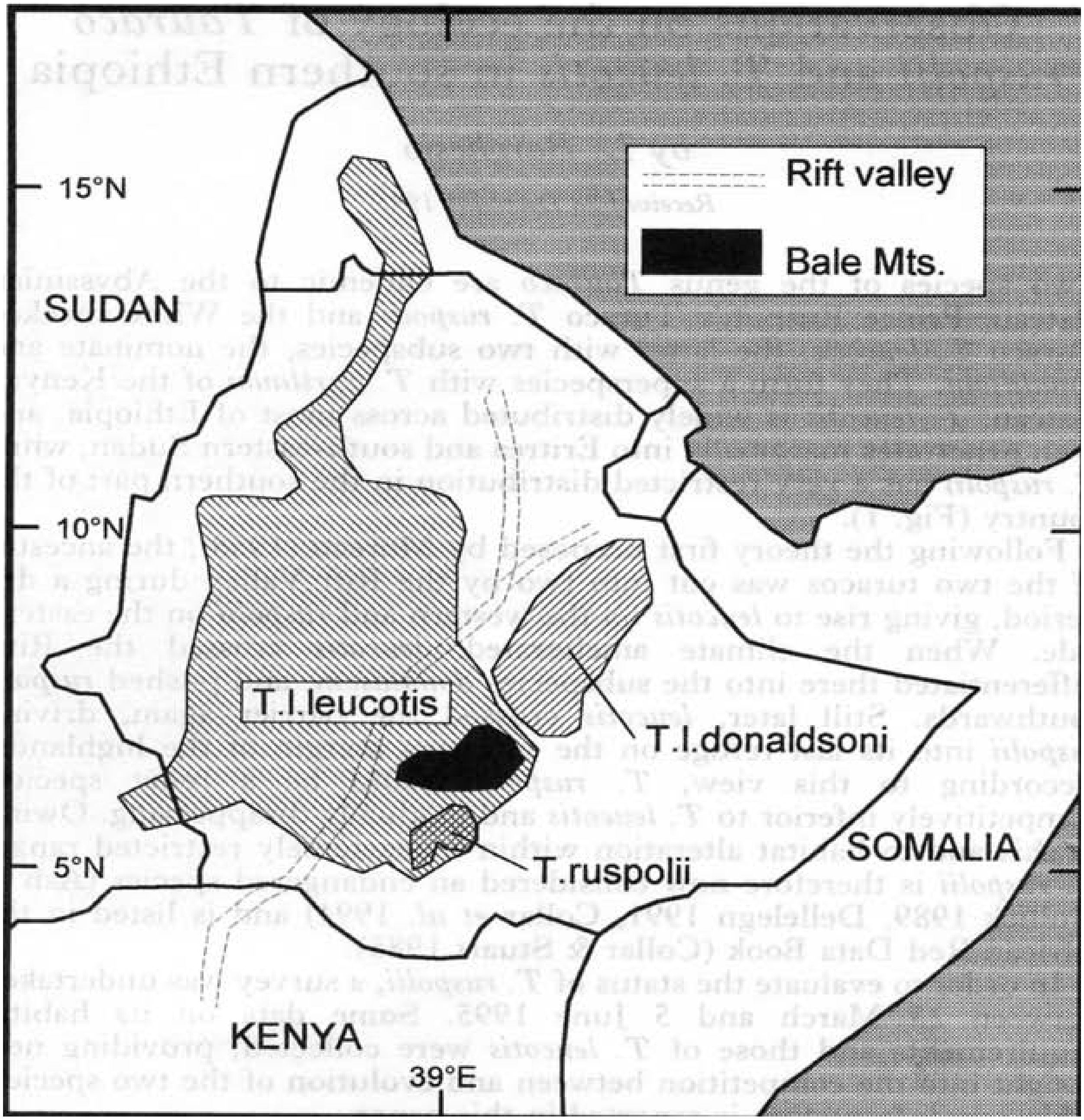
Appendices

Appendix 1. Distribution of Prince Ruspoli's Turaco and White-cheeked Turaco



(Source: Map reproduced from article by Borghesio, L. (1997) in *Bull. Brit. Ornithol. Club*. **117**: 11 – 18)

Appendix 2. Transect Description for habitat data

Date	Team
Transect No.	No. of points in the transect
From	To
Note	

Id. Point	UTME	UTMN	Habitat types (estimate percent)	Land mark and Notes

Appendix 3. Census form of Turaco species

Date		Team
Point done		Weather
Start hour		End hour
Trans number		From To
Note		

Id. point	Species	No. of indiv.	Dist (m)	Seen	Heard	Habitat type	Notes

Appendix 4. Hybrid observation Form

Place						Hour			
UTM						Date			
Habitat									
Notes									
Group size	PRT			WCT			Hybrid		
Id No.	Crest			.	Cheek patch			Eye spot	
	Cream	Shade	Green	No	Shaded	White	No.	Shaded	White

Appendix 5. Photos taken during the research.

Preliminary Study

Preliminary Study, with Tolera Kumsa

With field assistant

With field assistant

With my co-advisor, Luca Borghesio

Traditional gold mining at Shakiso

Agriculture in open woodland

Deforestation for agriculture expansion