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Short Note

Seasonal elevational movements of Eastern Olive Sunbird *Cyanomitra olivacea* in the Uluguru Mountains, Tanzania

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Little is known about the seasonal elevational movements for most tropical avifauna species. Seasonal elevational movements of the Eastern Olive Sunbird *Cyanomitra olivacea* were studied along an elevational gradient from 600 to 1 500 m above sea level in the Uluguru Mountains, Tanzania, between May 2005 and February 2006. The recapture of ringed individuals along an elevational gradient across seasons provided evidence for the seasonal elevational movement of the Eastern Olive Sunbird in the Uluguru Mountains and the first documented evidence for this species in the Eastern Arc Mountains as a whole. Due to forest fragmentation and lack of corridors connecting high- and low-altitude forests in the Uluguru Mountains, the results have implications for conservation of the forest along the entire elevational gradient as well as for other forest bird species that have been documented to make seasonal elevational movements in the Uluguru Mountains and the entire Eastern Arc Mountains.

Keywords: abundance, Eastern Arc Mountains, elevation movement, hot and cold seasons, recapture, ringing, Uluguru Mountains

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The Eastern Olive Sunbird *Cyanomitra olivacea* (A. Smith, 1840) is found in forests, dense woodlands and scrubland from Kenya east of the Rift Valley and Somalia to Eastern Cape province, South Africa, and inland to Malawi and south-eastern Zambia (Fry et al. 2000). Throughout eastern and southern Africa, the Eastern Olive Sunbird is widespread and occurs in forested habitat from sea level to 3 000 m above sea level (asl) (Britton 1980), including the Eastern Arc Mountains (Fry et al. 2000). In the Uluguru Mountains, the Eastern Olive Sunbird occurs between 300 and 1 800 m (Stuart and Jensen 1985) and is found from the forest edge to the interior and in forested and modified habitats (Britton 1980; Stuart and Jensen 1985).

The Eastern Olive Sunbird forages at all levels from forest canopy to floor (Dowsett-Lemaire 1989; Stuart and Jensen 1985; Fry et al. 2000) but primarily in the understory (Dowsett-Lemaire 1989). It has a mixed arthropod–nectar diet (Dowsett-Lemaire 1989; Newmark 1991; Fry et al. 2000; Newmark 2006). Arthropods are taken by poking, gleaning, flycatching or hovering in front of foliage and vegetation debris (Dowsett-Lemaire 1989; Fry et al. 2000).

The male Eastern Olive Sunbirds are territorial and polygynous (Fry et al. 2000). Territories are set by dominant males around favourable flowering plants that provide sufficient nectar (Fry et al. 2000). The territorial males aggressively chase other sunbirds away and allow females to visit the flowers usually after displaying and copulating.

The sunbird has been recorded to breed from September through February (Dowsett-Lemaire 1989; Newmark and Stanley 2011; Mkongewa et al. 2013), records that coincide with the main breeding season of East African forest birds (Moreau 1936). In the Eastern Arc Mountains, most breeding records of this sunbird are from the Usambara Mountains between 920 and 1 150 m asl (Newmark and Stanley 2011; Mkongewa et al. 2013). In the Uluguru Mountains, based on the presence of brood patches, this sunbird has been recorded to breed in November and December usually in high-elevation forests (Svendsen and Hansen 1995; CW pers. obs.).

In the Eastern Arc Mountains, a number of forest-dependent bird species have been documented to breed during the hot season at upper elevations and then move to the lower elevations during the cold season (Stuart et al. 1993; Burgess and Mlingwa 2000). However, the extent of these movements is not well understood due in part to lack of studies that have ringed birds at different elevations in different seasons (Burgess and Mlingwa 2000). Partial elevational movements of Eastern Olive Sunbird, whereby some individuals move while others within a population remain sedentary, have previously been suspected by Burgess and Mlingwa (2000) in the Udzungwa Mountains based on changes in seasonal abundance of individuals. However, unequivocal evidence for seasonal elevational movements of Eastern Olive Sunbird in the Eastern Arc Mountains based on recaptures of ringed individuals is non-existent.

Here I report on the seasonal elevational movements of the Eastern Olive Sunbird based on recapture of ringed individuals at four sites along an elevational gradient in the Uluguru Mountains. I also document seasonal changes in abundance in the Eastern Olive Sunbird along an elevational gradient.

Field work was conducted in the Uluguru Mountains, which form one of 12 Eastern Arc Mountains in Tanzania

known for their unusually high numbers of endemic plant and animal species (Burgess et al. 2002; Rovero et al. 2014). Among the Eastern Arc Mountains of Tanzania, the Uluguru Mountains rank second in terms of numbers of endemic plant and animal species (Rovero et al. 2014). In the Uluguru Mountains, there are two main peaks in rainfall, with the heavier long rains occurring from March to May and the lighter short rains from October to December (Pócs 1976). During the long rains, there is an accompanying fall in temperatures. In the Uluguru Mountains the cold season extends from June through September with temperatures dropping below freezing point at the highest elevations (Pócs 1976; Svendsen and Hansen 1995), while the hot season extends from October through May.

I assessed seasonal movements and variation in abundance of Eastern Olive Sunbird along an elevational gradient using mist nets. Mist nets were operated during the cold season in May, June and August 2005 and during the hot season in November 2005 and February 2006. For logistical purposes while ascending the mountain, including carrying field equipment, the lower elevation sites were sampled first (see Table 1 for mist-netting dates). Ten mist nets (3 × 12 m, 4 × 9 m, and 3 × 6 m each 2.5 m high, mesh size 30 mm, four shelves) were deployed at four elevational sites: 650 m, 900 m, 1 200 m and 1 500 m asl (Figure 1, Table 1). Each mist-netting site received a sampling effort of 6 480 metre-net-hours during each season (Table 1). Mist nets were deployed along cleared pathways, approximately 1 m in width, and operated for three consecutive days. Mist nets were opened one hour before sunrise (usually at 06:00) and closed half an hour before sunset (usually at 18:00), to allow time to remove any late catches. Mist-nets were checked every 30 min but more frequently during the morning and evening hours. Mist-nets were closed at night to avoid entangling bats and to prevent net destruction by nocturnal ground-dwelling mammals. All captured birds were ringed with East African Natural History rings and released. While the male and female Eastern Olive sunbirds are alike, sexes can be differentiated based on morphometric data whereby males are relatively larger than females. Morphometric data were not analysed; however, with regard to the focus of the present study, I assessed whether the sunbirds were in breeding condition based on the presence of brood patches.

Differences in the number of individuals captured between the cold and hot seasons were tested using a chi-square test with Yates correction (Zar 1999) assuming an equal number of captures between seasons at each of the elevation sites. Individuals recaptured at the same site during the same mist-netting session were excluded from the analysis.

Between May 2005 and February 2006, 181 Eastern Olive Sunbirds were captured in total across four sites, with 86 individuals captured in the cold season and 95 individuals captured during the hot season (Figure 2). The number of individuals captured varied significantly between seasons at 650 m ($\chi^2 = 4.363$, df = 1, $p < 0.05$) and 1 200 m elevation ($\chi^2 = 4.891$, df = 1, $p < 0.05$), but not between seasons at 900 m ($\chi^2 = 0$, df = 1, $p = 0.99$) or 1 500 m elevation ($\chi^2 = 0.214$, df = 1, $p > 0.5$).

Undisputable evidence for the seasonal elevational movements of Eastern Olive Sunbird is provided by four individuals that were initially ringed at lower elevations during the cold season and were recaptured at higher elevations during the hot season (Table 2).

While none of the mist-netted Eastern Olive sunbirds possessed a brood patch during the cold season (May, July and August), c. 17% (15 of 95) individuals mist-netted during the hot season (November and February) had active brood patches. Three of the four individuals that were recaptured at higher elevations (i.e. those that moved to higher elevations) during the hot season had active brood patches.

Two lines of evidence, the recapture of ringed Eastern Olive Sunbirds at varying elevations across seasons in combination with changes in abundance of the Eastern Olive Sunbird across seasons, provide compelling evidence for seasonal elevational movements in the Eastern Olive Sunbird in the Uluguru Mountains. The abundances of Eastern Olive Sunbirds decreased during the cold season in high-elevation forests, whereas they increased during the cold season in the lower-elevation sites and vice versa. These results also provide the first conclusive evidence for seasonal elevational movements by the Eastern Olive Sunbird in the Eastern Arc Mountains.

The recapture of individuals of the Eastern Olive Sunbird in the higher-elevation forest during the hot season may suggest that they moved upslope to breed, as has been proposed by Stuart (1983) and Stuart et al. (1993). Assessment of ringed Eastern Olive Sunbirds, for example, indicated that three of the four individuals recaptured at higher elevations had active brood patches during November and February. This further suggests that these individuals were females that perhaps moved to higher-elevation forests to breed.

An alternative explanation for the detected movements is that Eastern Olive Sunbird has the ability to move widely, as has been found in other Eastern Arc Mountains of Tanzania and Kenya. For example, in the Usambara Mountains, Korfanta et al. (2012) reported that the species has the ability to cross forest gaps. Moreover, it has been reported to move between forest and *Eucalyptus* plantations in the East Usambara Mountains (John and Kabigumila 2011). Furthermore, in the Taita Hills, Kenya, the mobility of the Eastern Olive Sunbird has been detected whereby one individual was ringed at Chawia and recaptured at Ngangao 22 days later, about 18 km away (Department of Ornithology 1997). Nevertheless, the data presented here confirm

Table 1: Mist-netting dates for each elevation site during the cold and hot seasons. Each mist-netting site received mist-netting effort of 6 480 metre-net-hours during each season

Site (m asl)	Mist-netting dates during the cold season	Mist-netting dates during the hot season
650 m	11–13 May 2005, 26–28 July 2005	11–13 November 2005, 1–3 February 2006
900 m	15–17 May 2005, 30 July–1 August 2005	16–18 November 2005, 5–7 February 2006
1 200 m	21–23 May 2005, 3–5 August 2005	19–22 November 2005, 8–11 February 2006
1 500 m	26–28 May 2005, 7–9 August 2005	25–27 November 2005, 13–16 February 2006

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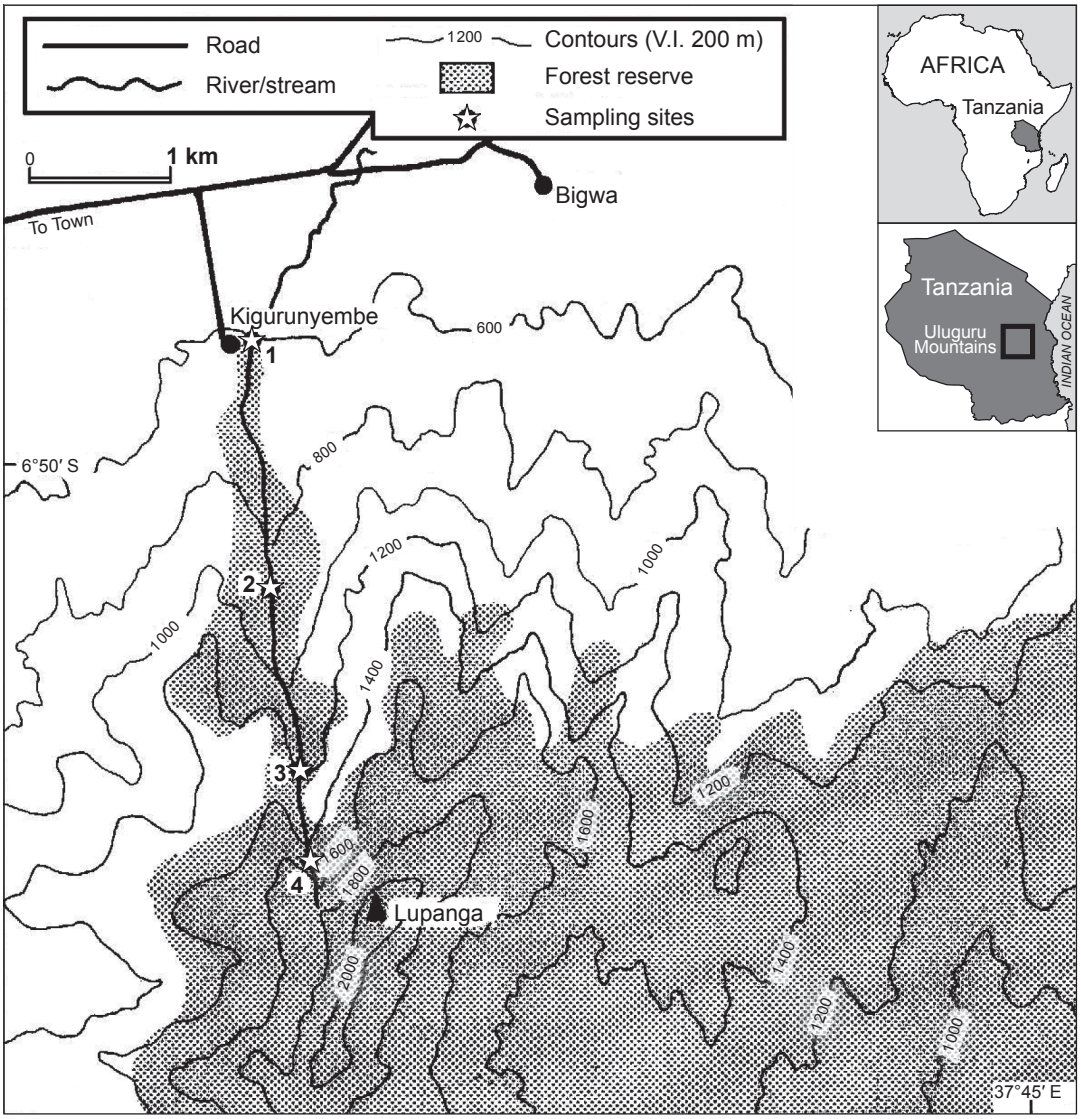


Figure 1: Location of the study sites along an elevation gradient in the Uluguru Mountains, Tanzania. Sites: 1 = at 600–700 m, 2 = at 900 m, 3 = at 1 200 m and 4 = at 1 500 m

partial seasonal elevational movements of the Eastern Olive Sunbird. In particular, partial migration was demonstrated by seasonal changes in abundance of Eastern Olive Sunbird. For instance, almost twice as many individuals were captured during the cold season at low elevations compared with the hot season, implying that while some individuals in the population moved, others were sedentary. These results concur with the findings of Burgess and Mlingwa (2000) who reported that individuals of this sunbird in the Udzungwa Mountains (which are also part of the Eastern Arc Mountains) vacate high-elevation forests during the cold season and become abundant again towards the end of the cold season in early September.

While seasonal differences in the abundance of bird species also may be explained by differences in detectability and chance (Burgess and Mlingwa 2000), the recapture of individual birds at different elevations between seasons provides conclusive evidence for seasonal elevational movements in at least a subpopulation of the Eastern Olive Sunbird in the Uluguru Mountains. Given the existing forest

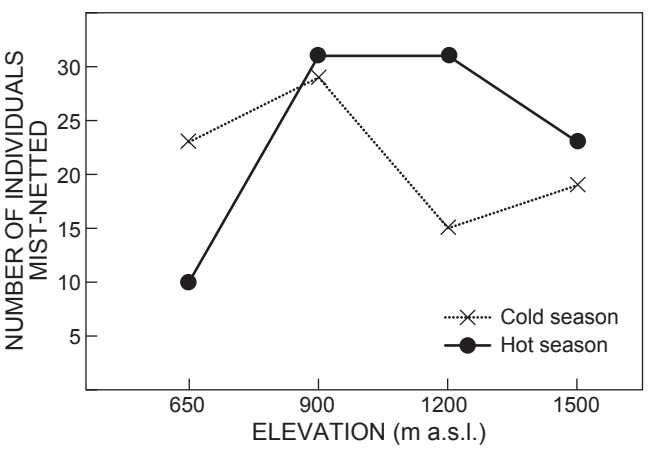


Figure 2: Number of individuals of Eastern Olive Sunbird mist-netted at the study sites along an elevation gradient during the cold and hot seasons in the Uluguru Mountains, Tanzania

Table 2: Evidence of the elevational movements of Eastern Olive Sunbird based on the recaptured individuals

Ring number	Date and elevation of the first ringed individuals	Date and elevation of recaptured individuals	Change in elevation	Duration between first ringing and recapture dates
T48268	1 August 2005 at 900 m	25 November 2005 at 1 500 m	600 m	>3 months
T48281*	30 July 2005 at 900 m	19 November 2005 at 1 200 m	300 m	>3 months
T48281*	30 July 2005 at 900 m	9 February 2006 at 1 200 m	300 m	>6 months
T48287**	1 August 2005 at 900 m	27 November 2005 at 1 500 m	600 m	>3 months
T48287**	1 August 2005 at 900 m	14 February 2006 at 1 500 m	600 m	>6 months
T48303	4 August 2005 at 1 200 m	25 November 2005 at 1 500 m	300 m	>3 months

* and ** indicate separate individuals

fragmentation in the Uluguru Mountains, the seasonal elevational movements of Eastern Olive Sunbird have implications for conservation of the remaining forest and other forest bird species that make seasonal elevational movements. As some elevational migrants have been documented to avoid crossing open areas along elevational gradients that they use during the migratory cycle (Loiselle and Blake 1991, 1992; Blake and Loiselle 2000), these results suggest that the forest covering the entire elevational gradient is important for conservation of bird species that make seasonal elevational movements. Should this forested gradient be cleared, the seasonal elevational movements of this species and perhaps other elevational migrants will be negatively affected. This is due to the fact that the Eastern Olive Sunbird and other elevational migrants are forest-dependent meaning that they need the presence of a forest to maintain its population. The present study suggests that lowland forests in the Uluguru Mountains are important cold-season refuges of Eastern Olive Sunbird and perhaps other forest species that make seasonal elevational movements and spend a non-breeding season in the lower-altitude forests.

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