AFRICA ENVIRONMENTAL REVIEW Journal

ISSN: 1727-8341

AER Journal Volume 3, Issue 1, pp. 1-10, 2018

RESEARCH ARTICLE

Available Online at *http://www.aer-journal.info*

The Nesting Success of Taita Thrush *Turdus helleri* in Afrotropical Fragments, Kenya

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Abstract

Nesting behavior and nest success are key components for assessing the conservation status of avian species. This study focused on the critically endangered Taita Thrush (Turdus helleri), endemic to the Taita Hills of southern Kenya. We surveyed all the four remnant forests fragments (Chawia, Yale, Mbololo and Ngangao) where the species survives. Taita thrush nests were placed on well branched trees with at least a climber at an average height of 4.3 m (range 2 m -7 m, N = 38) above the ground. Based on the data from the thirty eight nests found, on average, 34% of all the nests initiated survived to produce fledglings across all the four fragments. Success rates appeared to differ across forest fragments. Daily survival probability was estimated in all the four fragments and later narrowed down to two large fragments that had more than one nest. Daily survival probability for all four fragments was estimated at 0.93 ± 0.03 with a daily survival rate for egg incubation and nestling periods of 0.11. Daily survival probability for Ngangao and Mbololo was estimated at 0.88 ± 0.08 and 0.95 ± 0.06 respectively with a daily survival rate for egg incubation and nestling period(s) of 0.2 and 0.21 respectively. Continuous nest monitoring revealed that nest predation accounted 55.3% (unknown animal predators 76.19% and known animal predation 23.81%), abandoned nests 10.53% (unknown reasons for nest abandonment) and 34.20% fledged nests. The predators included, a Boomslang (Dispholidus typus) snake, a nocturnal rodent(not clearly identified by camera) and an African goshawk (Accipiter tachiro) for both stages of incubation and nestling development(snake-1 nest, bird of prey -1 nest, rodents- 3 nests and unknown predators- 16 nests). Nest predation was highest in Ngangao but this could have been attributed by the fact that the same fragment had more nests observed than all other fragments. The low nesting success of Turdus helleri suggests that conservation efforts should ensure that Taita forest fragments are properly managed to maintain natural habitat.

Keywords: Nesting Success, Taita Thrush *Turdus Helleri*in, Afrotropical Forest Fragments

INTRODUCTION

The Taita hills of Kenya are the northernmost tip of the Eastern Arc, a chain of mountains running through Tanzania and Southern Kenya with extremely high rates of endemism as well as human impact. The Taita forests are the most heavily deforested range in the Eastern Arc (Newmark, 2011). Habitat degradation in the Taita hills continues to date, although at a slower pace (Spanhove, 2014). Habitat loss and fragmentation often negatively affect nest success of forest specialist species (Fahrig, 2003). Increased nest success in the smaller more disturbed forest fragments has also been documented by Spanhove, *et al*. (2009 a,b, 2014).

Taita thrush (*Turdus helleri)*, is a secretive forest specialist, endemic to the Taita Hills in Southern Kenya. It is classified as Critically Endangered in the IUCN criteria due to a combination of extremely small range and an estimated decreasing trend. The species occurs in only four forest fragments (Mbololo, Ngangao, Yale and Chawia), with a total area of 350 ha at an altitude range of 1400-2000 m (Bird Life International, 2018). Globally, the population size of *T. helleri is* currently estimated at 930 individuals (Bird Life International, 2018). Although poor nest success has been reported as one of the reasons for the small population size of *T. helleri,* no studies on nesting success of this species have been published. The only available account of this species nesting success is based on a single nest observed in year 2000 (Samba *et al.,* 2003).

Scientific information on *T. helleri* has not been updated in recent times and therefore an urgent need to reassess the status of the species and describe basic details of its biology including breeding success, nesting patterns and causes of nest failure.

METHODS

Study Area

The Taita Hills are located in south-east Kenya (03^0 20'S, 38^0 15'E), on the dry Tsavo plains that isolate these hills from other highland blocks by over 80 km in either direction (Spanhove *et al.*, 2014). The Taita Hills forest fragments occur at a maximum altitude of 2,220m and are listed as one of the key biodiversity conservation areas in Kenya, based on their high endemism of flora and fauna (Skarbek, 2009). Widespread forest loss over the last four decades has resulted in 12 remnant fragments scattered across hilltops and ridges. These forest remnants include; Mbololo, Ronge, Sagala, Ngangao, Yale, Vuria, Macha, Mwachora, Kichuchenyi, Fururu, Ndiwenyi and Chawia(Brook *et al.*, 1998).Only four out of the twelve fragments (varying in size) host the Taita thrush.These are Mbololo, Ngangao, Yale and Chawia. Mbololo(MB) is the largest (168 ha.), followed by Ngangao (NG), (120.1 ha), Chawia (CH) (86.3 ha) and Yale(YA)which is the smallest (15.5 ha.)(Pellikka *et al.***,** 2009).

Taita hills are inhabited by the Taita people who are mainly farmers. The forest has in the last few decades been characterized by heavy human disturbance especially from excessive logging, firewood collection and clearing for cultivation. However, the remnant indigenous forest has been declared a nature reserve (Himberg, 2011).

Taita hills receive both long and short rains. Long rains begin in March to May, while short rain start from November through to December. Rainy seasons alternate within the Inter-tropical Convergence Zone. Mist and cloud precipitation are on all year round phenomenon in the Taita forests (Beentje and Ndiang'ui, 1988).

The indigenous mountain rain forest fragments on the hills accommodate a variety of endemic and threatened flora and fauna not recognizable elsewhere in Africa (Beentje & Ndiang'ui, 1988). These ancient Precambrian hills belonging to the Eastern Arc mountain chain are classified as one of the world's 34 most important biodiversity hotspots (Lens *et al*., 2002). The hills are known for their moist forests with unique fauna and flora including more than 20 endemic avian species including, Taita thrush *Turdus helleri* and the Taita apalis (*Apalis fuscigularis)* (Brooks *et al.*, 2002).

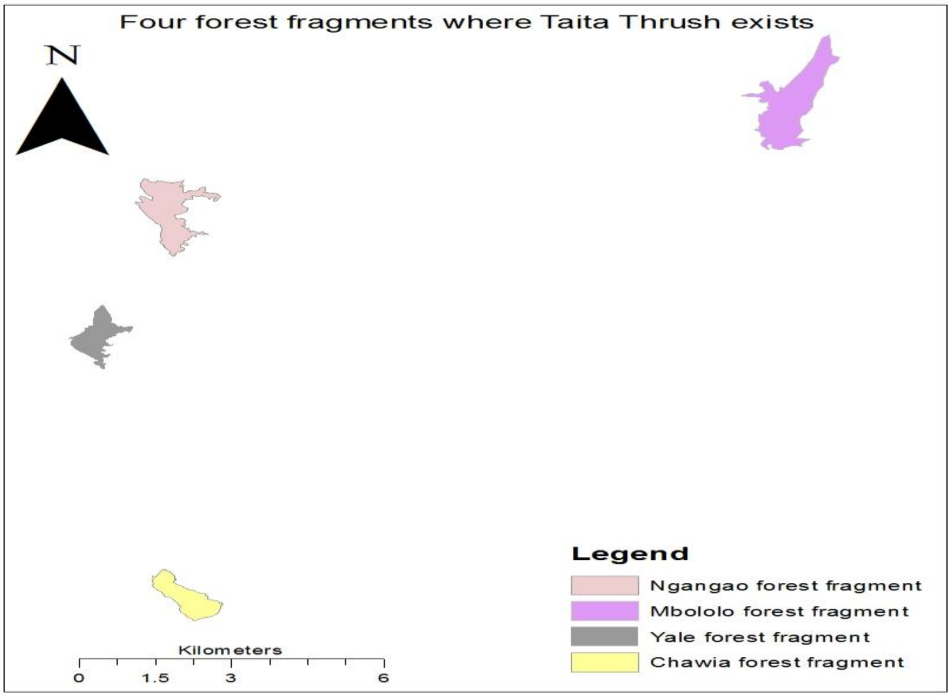

Figure 1. General Map of the Taita Hills where *T. thrush* Exist in 2016

The Study Species

The Taita Thrush is a shy, medium sized forest restricted bird species that reaches a length of 20 to 22 centimeters. Taita thrush was formerly categorized as subspecies of the olive thrush (*Turdus olivaceus*) but is currently regarded as a distinct species since 1985(Brooks *et al*., 1998). The Taita Thrush is endemic to the Taita Hills and is restricted to montane forest at an altitude of 1,500–2,200m (Brooks, 1998). It inhabits the shady, interior understory of intact forest (Wagura *et al.*, 2012).

Field Work

Field work covered the entire four forest fragments where the Taita thrush occurred. Data collection was carried out between the months of September 2016 and March 2017 (Table 3).

Data Collection Methods

Nest Searching

Nest searching commenced on September, which marked the beginning of the breeding season in all four fragments (figure 1). Due to the complexity of the weather and terrain, study fragments were divided into plots (these were, Mbololo- 4 plots, Ngangao-3 plots, Chawia- 4 plots and Yale- 1 plot). Nest searching was intensively done in the plots where individual birds showed signs of breeding activity, these included, intensive calling, courtship and carrying food away from feeding areas. Individual birds showing these signs were identified and followed at a distance of not less than 15m, to avoid interruption. It was noted whether or not the bird was carrying nest-building materials or sitting near them. It was also noted whether the male or female constructed the nest. Observers avoided leaving dead-end trails leading to nests to minimize observer effects on nest predation. Nests were located during early stages of nest construction or when nests were had eggs or nestlings.

Nest Monitoring

Once the nest was located, flags to mark the site were tied on the vegetation 5m to the north of the nests and the GPS coordinates were recorded. For each successfully hatched nest, the nestling-stage period was calculated from the day of first egg-hatching until the young were fledged, or taken by a predator, or till the end of the study period (Cresswell, 1997). Nests were visited every 2-5 days over the next 16 days (normal incubation period for Taita thrush) (Githiru *et al.*, 2005) and inspected using a mirror mounted on a 3.5m-long telescopic pole, as nests were often built on trees. A nest was declared successful when it fledged at least one chick of Taita thrush or failed, when no chicks had fledged (Martin and Geupel, 1993). If the nest was found empty and fledglings had been present during the monitoring period, (if the nest had no camera trap to record their fledging) a search for the fledglings was done for 1 week within a radius of 200-300 m from the nest site. If, there was no evidence of their presence or their remains, it was assumed that fledging had failed (Mayfield, 1961, 1975). The study materials included binoculars, nest check data sheets, GPS gadget, camera traps and digital camera.

Causes of Nest Failure

Camera traps were mounted on trees or branches at approximately 30 cm from the nest to monitor the activities within and around the nest throughout its entire active period with minimal disruption of the nests site (Cox *et al.*, 2012). Camera traps were to capture what exactly happened to the nests before it failed. For instance, foreign nest intruders like human being, birds of prey, snakes, rodents or any other animal.

Data Analysis

Since different nests were discovered at different stages of their nest-cycle, they had different probabilities of success. The nest-days concept (Mayfield, 1961, 1975) was used to estimate the probability of nest survival. This method only uses information collected in the period during which nests are under observation, and thus places all nests on a comparable basis (Githiru, 2004). For the nests whose fate remained unknown by the end of the study, the last observed active date was used to calculate number of days of exposure and was assumed to have been successful for that duration (Githiru, 2004). Daily nest mortality rates (m) were obtained by dividing the number of nests that failed, by the total number of nest-days (exposure) (Mayfield, 1961, 1975). Thus, the probability of survival, for one day was calculated as (1-m), while the respective probability of surviving the 30day nestling period was calculated as (daily survival probability)^t (Mayfield, 1975). Standard error (SE) for each of the survival estimates was calculated as the square root of its variance, where variance was calculated as the negative inverse of the quantity obtained from the formula [-(exposure)3]/[(exposure-losses)*losses] (Johnson, 1979). Confidence limits were calculated as the daily survival probability ± Standard Error. Exposure is the total number of nest-days while losses are the total number of nests depredated during the exposure period. Overall nest survival (from the start of egg laying to fledging) was estimated as the product of the survival probabilities from the season.

RESULTS

A total of 38 (13 succeeded and 25 failed) nests were located and monitored in the four forest fragments (Table 1).

Table 1. Summary of Nest Observations and their Fate 2016 - 2017

Fragment Fate	Ngangao	Mbololo	Iyale	Chawia	Total
Successful nests	5	7	1	0	13
Failed nests	16	8	0	1	25
Total	21	15	1	1	38

Nine were found at their construction stage, twenty one discovered with eggs and eight with nestlings. Out of the total number of nests only 4 were followed with camera traps. All nests were located on well branched trees (with at least one climber) at an average height of 4.3 m above the ground (Table 2). There were 20 tree species and 9 climber species on which the nests were placed (Table 2).

Table 2. Fates of the 38 Nests of *Turdus helleri* in the Taita Hills Fragments in the Year 2016 and 2017; Also Indicating Fate, Height and Days of Exposure for Each Nest

Nest	Fragment	Exposure days	Fate	Height	Tree and climber
1	Ngangao	2	Fail	4.5	*Cola greenwayi and Dichapetalum eickii*
2	Ngangao	16.5	Success	5	*Dasylepis integra and Landolphia buchanani*
3	Ngangao	1	Fail	6	*Dasylepis integra*
4	Ngangao	14	Fail	6	*Ritchiea albersii and Dichapetalum eickii*
5	Ngangao	0.5	Fail	1.8	*Tabernaemontana stapfiana and Dichapetalum eickii*
6	Ngangao	29.5	Success	3.5	*Dracaena steudneri and Dichapetalum eickii*
7	Ngangao	11	Fail	4	*Newtonia buchananii and Dichapetalum eickii*
8	Ngangao	0.5	Fail	5	*Tabernaemontana stapfiana and Dichapetalum eickii*
9	Ngangao	9	Fail	4	*Tabernaemontana stapfiana and Uvaria lucida*
10	Ngangao	10	Success	3.5	*Celtis gomphophylla and Landolphia buchanani*
11	Ngangao	1.5	Fail	6	*Pouteria adolfi-friedericii and Ficus thonningii*
12	Iyale	33	Success	3.5	*Vangueria volkensii and vangueria volkensii*
13	Ngangao	-	Fail	3.5	*Strombosia scheffleri, and Dichapetalum eickii*
14	Ngangao	2	Fail	4.4	*Garcinia volkensii and Dichapetalum eickii*
15	Ngangao	9.5	Success	4.2	*Newtonia buchananii and Landolphia buchanani*
16	Ngangao	7.5	Fail	4	*Syzigium guineense and Culcasia falcifolia*
17	Ngangao	-	Fail	5	*Dracaena steudneri and Tiliacora funifera*
18	Ngangao	9.5	Fail	4	*Strombosia scheffleri and Tiliacora funifera*
19	Ngangao	5.5	Success	2.2	*Cola greenwayi and Dichapetalum eickii*
20	Ngangao	2	Fail	6	*Macaranga capensis and Dichapetalum eickii*
21	Ngangao	-	Fail	6	*Croton megalocarpus and Senecio syringifolius*
22	Chawia	1.5	Fail	4	*Cyathea manniana and Culcasia falcifolia*
23	Ngangao	5	Fail	10	*Ochna holstii and Dichapetalum eickii*
24	Mbololo	31	Fail	3	*Leptonychia usambarensis and culcasia fulcifolia*
25	Mbololo	-	Fail	4	*Coffea fadenii and Heinsenia diervilleoides*

26	Mbololo	6.5	Fail	7	*Garcinia volkensii*
27	Mbololo	4.5	Success	2.5	*Coffea fadenii and Culcasia falcifolia*
28	Mbololo	1.5	Success	5	*Garcinia volkensii and Culcasia falcifolia*
29	Mbololo	4	success	4	*Newtonia buchananii and Culcasia falcifolia*
30	Mbololo	3	Fail	4	*Caffea fadenii and Culcasia falcifolia*
31	Mbololo	1	Fail	2	*Coffea fadenii*
32	Mbololo	1.5	success	4.5	*Xymalos monospora*
33	Mbololo	-		6	*Garcinia volkensii andCulcasia falcifolia*
34	Mbololo	1	success	4	*Garcinia volkensii*
35	Mbololo	22	success	2	*Pauridiantha paucinervis*
36	Mbololo	8.5	success	3	*Coffea fadenii and Culcasia falcifolia*
37	Mbololo	7	fail	4	*Coffea fadenii and Culcasia falcifolia*
38	Mbololo	17	fail	5	*Garcinia volkensii*

'-' means not active

All nests initially had a clutch size of two nestlings regardless of whether or not nesting was successful. The nests were located within natural forest at an altitude of 1,425–2,078m and nests were normally bowl shaped with small inner bowl that varied in dimension. Both parents were responsible for nests construction. Nest construction took about 7 days and commenced with the pilling of dry leaves on a branch or stem supported by a climber. A complex knitting of small dry branches was done on an outer cup leaving an inner smaller cup at the center of the nest. Inner cups were furnished with dry palm tree fiber or dry leaves while the other parts of the nests were camouflaged with green mosses. Average diameter and height of the outer cup of the nest was 12.4 and 13 .3 cm respectively while the inner cup was 7.2 and 5.3 cm (21 nests measured at Ngangao forest) (figure 2).

Figure 2. Inner Part of a Complete Taita Thrush Nest with Two Eggs in Ngangao Forest, Kenya, 2016

Taita Thrush laid two white oval eggs with irregular brown patches all around and dark large spot at the base of every egg of about 2.8 - 3cm in length. Females were responsible for incubating eggs for about the 16 days while the feeding of the nestlings was done by both parents for about 14 days (3 nests observed by camera traps and one of the two individuals had a metal/color ring) (Figure 2). Nesting stages (nest construction stage (7days) - egg incubation stage (16 days) - nestling stage (14 days) of the Taita thrush did not vary with fragments size (Figure 5).

Figure 5. *Turdus helleri* Nestlings at Ngangao Forest, Kenya, 2016

Thirty three nests were considered active (had at least an egg or nestling) and they had 299 days of exposure (20 failed while 13 succeeded). Successful nests were observed in this order, 1 in Yale, 5 in Ngangao and 7 in Mbololo. Further, 9 of the 13 nests that fledged were assessed as probably successful, since they were empty on the last visit, but had previously contained feathered, close to fledging nestlings inside. Predation events weren't excluded in the very last stages of the nesting and therefore it was assumed that most of the "probable" fledging was actually successful ones.

Assuming that all 'probable' successful nests were actually successful, the respective daily survival probability(s) for the four fragments was 0.93±0.03 while the approximate 95% confidence limits for this were equal to 0.96 and 0.90. The daily survival rate for 30 days was 0.11 with confidence limits of 0.29 and 0.04. Daily survival probability(s) for Ngangao were 0.88 ± 0.08 and the approximate 95% confidence limits for this were equal to 0.96 and 0.8. Daily survival rate for 30 days was 0.02 and the Confidence limits for this are 0.29 and 0.00. Daily survival probability(s) for Mbololo was 0.95 ± 0.06 and the approximate 95% confidence limits for this were equal to1.0 and 0.89. Daily survival rate for 30 days was 0.21 and the Confidence limits for this are 1.0 and 0.03.

Broad causes of nest failure in the four fragments was due to nests predation (84%) and nests abandonment (16%) (Figure3).

Figure 3. Causes of Nests Failure in all the Four Fragments

Further nest failure was broken down into humans (4%), weather (4%), birds (8%), snakes (4%), rodents (8%) and unknown causes (72%) (Figure4).

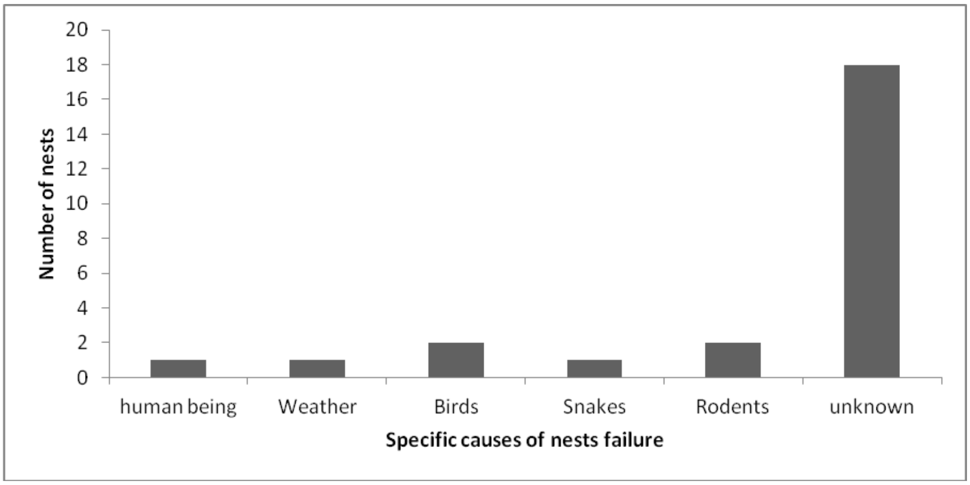

Figure 4. Breakdown of the Causes of Nests Failure in all the Four Fragments

DISCUSSION

Due to the small number of nests observed during this study, only preliminary conclusions can be reached at this stage. The 2016-2017 breeding season was affected by a major drought. Nesting in Ngangao was restricted to 2 months only, while occasional observations in previous years suggested that the normal breeding season usually lasted for at least 4 months. While work in Mbololo was restricted to only 6 weeks during the months of February and March, breeding was still active at that time (15 active nests found in 41 days), though there was no signs of breeding in Ngangao, Yale and Chawia.

Table 3. Number of Nests Found in the Four Forest Fragments from 1st Nov 2016 to 28th Feb 2017 (Nesting Phenology)

M/F	SEPT 1	SEPT II	NOV I	NOV II	DEC I	DEC II	JAN I	JAN II	FEB I	FEB II	MAR I	MAR II
C	0	0	0	0	0	0	1	0	0	0	0	0
M	NS	NS	NS	NS	NS	NS	NS	NS	5	9	1	0
N	0	0	0	5	5	10	1	0	0	0	0	0
Y	NS	NS	0	0	0	1	0	0	0	0	0	0

Key: M = Month; F = Fragment; C= Chawla; M = Mbololo; N = Ngangao; Y = Yale; NS = No Search

This indicated that the breeding season stopped much earlier. Although Ngangao held the second largest Taita thrush population, only 21 nests were located in 3 months of search while 15 nests were found at Mbololo during the last 6 weeks of the breeding season. Daily survival probability was estimated from thirty three nests which were termed as active. Nests success rates were higher in Mbololo than in Ngangao (46.67% versus 23.80%) respectively. In Yale there was only one nest observed which successfully fledged while the only nest located in Chawia was rapidly predated. Therefore, daily nest survival rates in Yale and Chawia could not be estimated because only one nest was found in each fragment. Details on the nesting biology of Taita thrush agree with what is already known on other forest Turdidae (nest cup-shaped, built in the forest middle layers, nestling stage lasting *30 days*). The most common cause of failure appears to be predation, but due to camera failure and low sample size, this study could not obtain a sufficient number of observations to assess the identity of the main predators of Taita thrush. The few observations recorded suggest that the African goshawk and nocturnal rodents predate on Taita thrush nests, as it was observed in a parallel study of Taita apalis nesting biology. One observation of a snake near a nest suggests that snakes could also be predators.

One problem of this study was that in most cases the fledging of juveniles from the nests could not be observed directly and therefore, the study assumed that nests were successful if they were found empty and without obvious signs of predation while on the previous visit the same nest had feathered nestlings that looked ready to fledge. This assumption might not always be correct, as predation can occur during the latest stages of nesting. Thus, success rates estimated through this study must be considered maximum, probably overestimated rates. The results are in general agreement with published studies on nest predation (e.g. see Ammon and Stacey 1997, Martin and Roper 1988). Future research should concentrate more closely on the assessment of Ngangao population, and on studying the causes of nest failure that appear to be lower in Mbololo. Action is urgently needed in Chawia and Yale to avoid the impending extinctions of the local subpopulations of these two forest fragments.

ACKNOWLEDGMENTS

We gratefully acknowledge the Nature and Biodiversity Conservation Union (NABU) for funding this study. Camera-trap equipment was loaned by the Royol Society for Protection of Birds (RSPB) and by Dr Bernhard Walter (Biologische Station Gütersloh / Bielefeld). Field work was carried out with permission from the Kenyan National Commission of Science and Technology (NACOSTI). Our appreciation to Mr. Maina, Mr. Emmanuel Kemboi, Mr Ababew, Mr. Nicholus Amisi and Ms. Juliet Kananu for their support in data collection and helpful comments in the various stages of writing this manuscript.

REFERENCES

Beentje, H. J. and Ndiang'ui, N. (1988). An ecological and floristic study of the forests of the Taita Hills, Kenya. *UTAFITI, Occas. Pap. Nation. Mus. Kenya, 1*(2), 23-66.

BirdLife International (2018). IUCN Red List for birds. Retrieved from http://www.birdlife.org

Borghesio, L., Githiru, M., Wagura, L. and Gichia, J. M. Final report for the proposal: Reassessment of the status of the Critically Endangered Taita thrush A project funded by the African Bird Club.

Brooks, T. M., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A., Rylands, A. B., Konstant, W. R. and Hilton-Taylor, C. (2002). Habitat loss and extinction in the hotspots of biodiversity. *Conservation biology, 16* (4), 909-923.

Brooks, T., Lens, L., Barnes, J., Barnes, R., Kihuria, J. K. and Wilder, C. (1998). The conservation status of the forest birds of the Taita Hills, Kenya. *Bird Conservation International, 8* (2), 119-139.

Callens, T. O. M., Galbusera, P., Matthysen, E., Durand, E. Y., Githiru, M., Huyghe, J. R. and Lens, L. U. C. (2011). Genetic signature of population fragmentation varies with mobility in seven bird species of a fragmented Kenyan cloud forest. *Molecular Ecology, 20* (9), 1829-1844.

Cox, W. A., Pruett, M. S., Benson, T. J., Chiavacci, S. J. and Thompson III, F. R. (2012). Development of camera technology for monitoring nests.

Cresswell, W. (1997). Nest predation: the relative effects of nest characteristics, clutch size and parental behaviour. *Animal Behaviour, 53* (1), 93-103.

Fahrig, L. (2003). Effects of habitat fragmentation on biodiversity. *Annual review of ecology, evolution, and systematics, 34* (1), 487-515.

Githiru, M., and Lens, L. (2004). Using scientific evidence to guide the conservation of a highly fragmented and threatened Afrotropical forest. Oryx, 38 (04), 404-409.

Githiru, M., Lens, L. and Cresswell, W. (2005). Nest predation in a fragmented Afrotropical forest: evidence from natural and artificial nests. Biological conservation, 123 (2), 189-196.

Himberg, N. (2011). Traditionally Protected Forests Role within Transforming Natural Resource Management Regimes in Taita Hills, Kenya.

Martin, T. E. and Geupel, G. R. (1993). Nest-Monitoring Plots: Methods for Locating Nests and Monitoring Success (Métodos para localizar nidos y monitorear el éxito de estos). *Journal of field Ornithology*, 507-519.

Mayfield, H. (1975). Nesting success calculated from exposure. *The Wilson Bulletin*, 255-261.

Newmark, W. D., and Stanley, T. R. (2011). Habitat fragmentation reduces nest survival in an Afrotropical bird community in a biodiversity hotspot. Proceedings of the National Academy of Sciences, 108 (28), 11488-11493.

Skarbek, C. (2009). A review of endemic species in the Eastern Arc Afromontane Region: Importance, inferences, and conservation. Macalester Reviews in Biogeography, 1 (1), 3.

Spanhove, T., Callens, T., Hallmann, C. A., Pellikka, P., and Lens, L. (2014). Nest predation in Afrotropical forest fragments shaped by inverse edge effects, timing of nest initiation and vegetation structure. Journal of Ornithology, 155(2), 411-420.

Spanhove, T., Lehouck, V., Boets, P., Lens, L., (2009). Forest fragmentation relaxes natural nest predation in an Afromontane forest. Animal Conservation 12, 267–275

Wagura, L., Githiru, M., & Borghesio, L. (2012). Notes on the nesting biology of Taita Apalis Apalis fuscigularis. *Bulletin of the African Bird Club, 12*, 42-46