HABITAT ASSOCIATION OF AN OPEN COUNTRY BIRD (SUPERB STARLING) IN A HUMAN AND LIVESTOCK DOMINATED LANDSCAPE, CENTRAL TANZANIA

Joseph Michael, Robert B. Modest

Department of Wildlife Management, Sokoine University of Agriculture, P.O. Box3073, Morogoro, Tanzania

ABSTRACT

Sustainable conservation of wildlife, particularly during this era of climate change is challenging in absence of sufficient environmental data. For Superb Starling, fine scale habitat association data remain anecdote, and this brings challenges in managing the species as it is hard to tell at what level of habitat association is the threshold for its persistence. A study on Superb Starling habitat association was carried out in Igunga District, Tanzania. The aim was to determine the parameters that are important in influencing its habitat use within woodland and open scrub landscapes. Birds were surveyed along strip transects, and the bird-habitat association models were built using the R software. Four environmental parameters namely; "percent grazed land", "percent shrub cover", "percent grass cover", and "wind" were the most important in influencing the Superb Starling habitat selection pattern. The study concluded that, grazing by ungulates within the woodlands and open scrubs of central Tanzania is an important factor in determining persistence of the Super Starling. The study recommended follow-up research to determine the nature of association of Superb Starling with abandoned bomas (areas for overnight containment of livestock) as these are reported to be important in influencing its habitat use elsewhere in east Africa.

Keywords — Lamprotornis superbus, Woodlands, Scrubs, Igunga, Akaike Information Criterion.

1 INTRODUCTION

Bird-habitat associationis chiefly influenced by environmentalparametersthat determine their basic needs [1].In most circumstances the association is not permanent as some birdstend to shift between habitat in search for resources that maximize their chance of survival (see for example [2, 3, 4]. In that case, distribution of parameters such as water, food, and cover play key roles in determining where an individual bird should go. However, the choice is not random as there are many other factors thatbirds consider before taking decision so as to increased fitness in the preferred habitats [5].

The Superb Starling *Lamprotornis superbus* is endemic in East Africa, occurring in Ethiopia, Kenya, Somalia, Sudan, Tanzania and Uganda. Its global population is not known but the species has an extremely large range and it is considered abundant, and hence does not approach the thresholds for vulnerable under the range size criterion [6]. Being gregarious mainly living in

cooperative breeding groups, the species is the most recognizable savanna bird in East Africa [7]. Its diet includes insects, fruits, fleshy leaves, grasses, wheat and maize grains [8]. Rubenstein, [7] point out that "among-year variation in rainfall, particularly the pre-breeding dry season, influences all aspects of life for Superb Starlings, including breeding roles, stress physiology, immune function, helping behavior, reproductive conflict, and demographic structure".Of the landscape parameters on the other hand, open scrubs and woodlands provides for better habitat of the species, and the associated land use types, mostly traditional agricultural practices and livestock grazingare key factors in determining its perseverance e.g. [7, 9, 10].

In particular, traditional livestock grazing is an important element in influencing Superb Starling's habitatselection pattern within its range[7,10]. For example,Rubenstein, [7] found out that, inLaikipia, Kenya,a Superb Starling'sterritory invariably encompasses at least one abandoned boma(i.e. areas used for the overnight containment of livestock by pastoralist). Rubenstein further points out that "because the large quantities of livestock dung are concentrated in these small areas, both the soil and the vegetation inside are nutrient-rich, with insect abundance more than twice that in neighboring bush land sites. These nutrient-rich hotspots generate a positive feedback loop by attracting ungulate herbivores that continue to urinate and defecate in the glades, thus concentrating nutrients further and enhancing the abundance of insects and wildlife alike". Moreover, the same source point out that these hotspots (i.e. abandoned bomas) "represent predictable patches of resources in otherwise climatically unpredictable environment that allow Superb Starling social groups to persist as dynasties for generations".

Indeed, the above background divulges that at a landscape level,Superb Starling's opulence is enhanced by anthropogenic related activities —mainly traditional livestock grazing systems. But the problem is that,information on fine scale habitat association of the species remains anecdote. This brings challenge on sustainable management of the species, particularly during this era of climate change and unpredictable environments. It is even more challenging on managing the species in agro-pastoral areas such as those in central Tanzania, as it isdifficult to tell at what level of the species-habitat association is the threshold for its persistence.Therefore, the aim of this study was to underscore the habitat selection pattern ofthe Superb Starling in open scrubs and woodlands in central Tanzania, to elucidate the parameters that are essential for the species persistence. The information gathered will be suitable for conservation and management of the species and its habitatto minimize potential future threats.

2 METHODOLOGY AND TECHNIQUES USED

2.1 DESCRIPTION OF THE STUDY AREA

The study was conducted around Jogohya village in Igunga District, Tanzania. Igunga District is located at an elevation of about 1126 meters above sea level. Its coordinates are 3°51'and 4°48' S, and 33°22' and 34°8' EFig.1 [11]. Jogohya village is surrounded by four other villages namely

Mwamashimba, Mwabakima, Imalanguzu and Bukama. The landscape is characterized by open woodlands, shrubs, and some bush lands. The dominant vegetationis the acacia species which Superb Starlings use as shades during sunny days. The area receives rainfall in December to April followed by dry periods.The common bird species in the area include; Ashy starling (*Lamprotornis unicolor*), Namaqua dove (*Oena capensis*), Ring-necked Dove (*Streptopelia capicola*) and White-headed Buffalo Weaver (*Dinemellia dinemelli*). The dominant ethnic groups in the area are the Sukuma, Nyamwezi and Nyiramba. Most of the people live in rural areas and they depend on agriculture and livestock keeping as their main activities, both for food and income generation. The main crops cultivated are cotton, maize, sweat potatoes, sorghum, millet, tomatoes, beans, green gram and sunflower. Pastoralism is also practiced in the area, and this brings in clashes with farmersover pasture land and water resource especially during drier periods.

2.2 RESEARCH DESIGN AND SAMPLING PROCEDURES

Sixteen (16) fixed-strip transects of 100 m in length and 60 m width were established in open scrubs, and woodlands habitat respectively cf. [12, 13]. In order to reduce the biasness that can arise due to closeness of transects in each habitat type, transects were arranged in parallel with an inter distance of 250 m[12]. In addition, inside each strip transect, two quadrats of 30 m by 30 m were established at the beginning, and at the end of each transect for sampling of the environmentalparameters associated with Superb Starling habitat.

2.3 FIELD DATA COLLECTION

Data collection commenced during the month of February 2016. Two sets of data were collected, data for estimating bird density, and data for determining bird-habitat association. Density data collection commenced during the morning hours from 06.30 to 10.15. Each strip transect was surveyed once, whereby, the researcher walked slowly along the 32 transects and recorded all the birds seen or heard [12]. The researcher walked along the centers of transects scanning for birds to a maximum of 30 m on each side. Birds were identified visually with the aid of a binocular, and only thosesighted within the 60 m strips were recorded cf. Nilsson*et al.*[13].

The bird-habitat association data was collected inside every 30 m by 30 m quadrats. The following information was collected; percentage coverage of cultivated areas, percentage coverage of grazed lands, percentage coverage of bare grounds, percentage coverage of shrubs, percentage coverage of grasses, number of big acacia trees with DBH>30cm, and number of stumps, see for example [14]. In addition, number of buildings, number of trucks/trails, and number of water ponds were counted along the entire strip transect. Moreover, wind was recorded as windy (1) or not-windy (0), and this was done at the moment an individual bird was sighted. These parameters were determined based on literature review, and the researchers' experience on the environmental parameters that are important in influencing the Superb Staling habitat selection e.g. Newmark, & Stanley, [15].

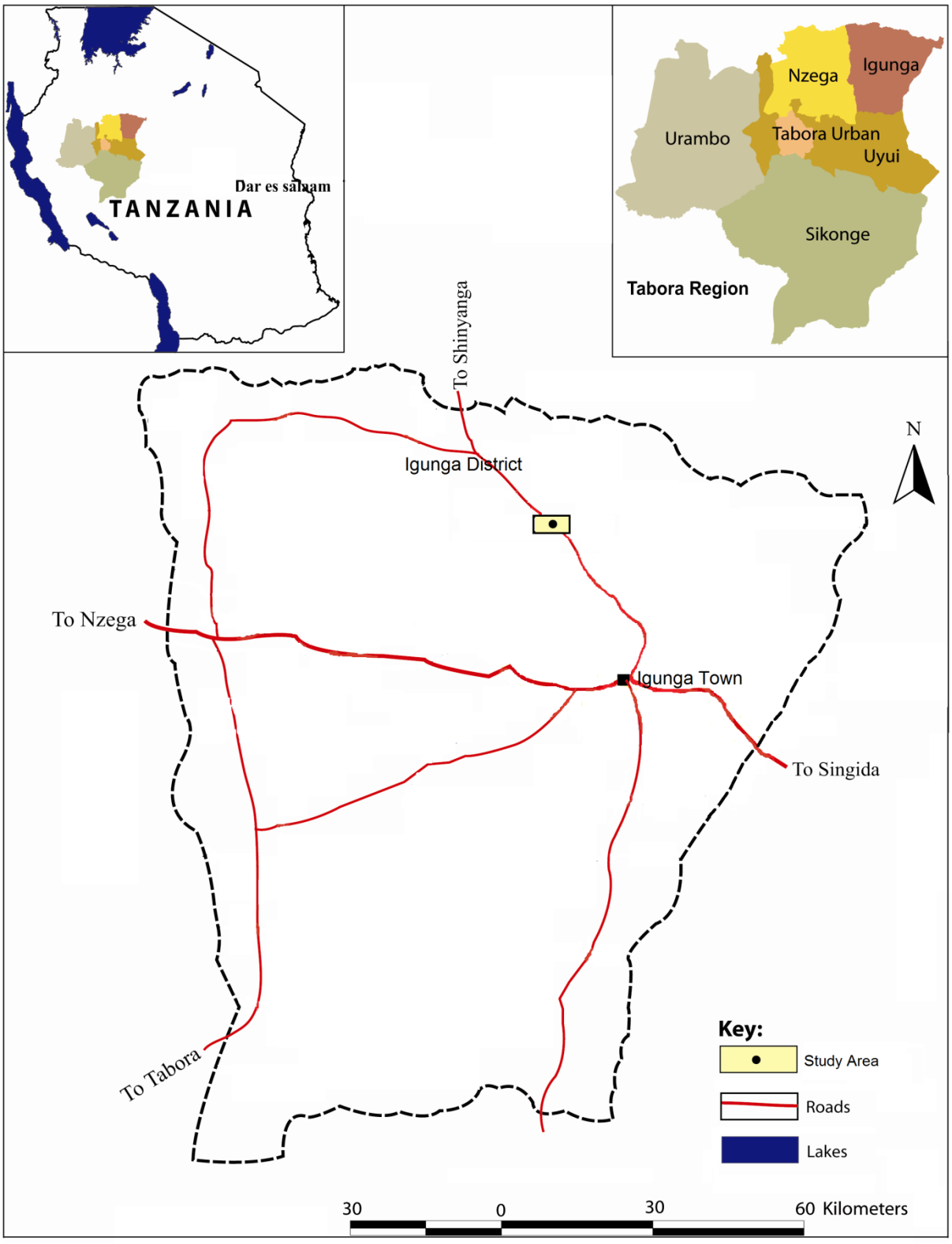

Fig 1: Map showing the study area. Modified after Bugumba, [11].

2.4 DATA ANALYSES

Bird densities were estimated by dividing the numbers of birds counted in each strip transect over area. Birds-habitat association patterns were established by building regression models using densities as response variables and environmental parameters as predictor variables. Models were built using package glmulti of the R software [16, 17]. Selection of the best performing models was achieved by the use of the Akaike Information Criterion, AIC [18]. Since AIC approach yields sets of competing models, for those models bearing Akaike values within the range of ≤ 2 were averaged using package MuMin [19]. To determine the significance of habitat parameters in influencing the bird species, the Confidence Intervals (CI) and Variable Importance Values were also determined [20, 21]. All these statistical analyses were performed using the R software version 3.33 [17].

3 RESULTS AND DISCUSSION

3.1 RESULTS

The overall density of the Superb starling was 2 individuals per ha. The birds-habitat association models as revealed aftermultiple regressionsare presented in Table 1. Four parameters namely "percent grass cover", "percent grazed land", "percent shrub cover", and "wind" were retained in the best model, and are displayed at the top of the model list. A combination of these parameters yielded the Akaike weight of 0.27, whereby,other combinations showed progressively lower Akaike weights. In addition, the AIC value of the best model was the smallest compared to values in the rest of the models.

Table 1: Multiple regression model on bird density against environmental parameters: df = degree of freedom, AICc = second order Akaike Information Criterion, Delta = difference between maximum and minimum Akaike value of competing models, Weight = Akaike Weight.

Model	df	LogLik	AICc	Delta	Weight
percent grass cover + percent grazed land + percent shrub cover +wind	6	-52.19	119.74	0.00	0.27
percent grass cover + percent grazed land +percent shrub cover+ scrub + wind	7	-51.16	120.98	1.24	0.15
percent grass cover + percent grazed land + percent shrub cover + scrub + wind + woodland	7	-51.16	120.98	1.24	0.15
percent grass cover + percent grazed land + percent shrub cover + wind + woodland	7	-51.16	120.98	1.24	0.15

percent grazed land + percent shrub cover + scrub +wind + woodland	6	-53.25	121.86	2.12	0.09
percent grazed land + percent shrub cover + wind + woodland	6	-53.25	121.86	2.12	0.09
percent grazed land + percent shrub cover + scrub + wind	6	-53.25	121.86	2.12	0.09

Table 2 shows significance level of the parameters regressed. Again the four parameters displayed in best model namely "percent grass cover", "percent grazed land", "percent shrub cover" and "wind" significantly influenced the bird's density—all having p values of less than 0.05.

Table 2: Significance levels of the regressed parameters.

Parameter	**Estimate**	**Std. Error**	**p-value**
Intercept	2.147	1.157	0.070•
percent grass cover	-0.023	0.011	0.041 *
percent grazed land	0.022	0.007	0.004 **
percent shrub cover	0.041	0.017	0.023 *
wind	-1.620	0.508	0.002 **
scrub	-1.042	0.663	0.131
woodland	1.042	0.663	0.131
Significance. codes: 0 '***'; 0.001 '**' ; 0.01 '*' ; 0.05 '•'; 0.1 ' '; 1			

The confidence intervals and importance values of the parameters regressed is presented in Table 3. Each of the three parameters that appeared in the best performing model i.e."percent grazed land", "percent shrub cover" and "wind" had an importance value of 1. In addition, the confidence intervals of these parameters did not cross zero suggesting that, among those parameters regressed these three were the most significant ones in influencing the species in the area.

Table 3: Confidence intervals and importance values of the regressed parameters. The parameters whose confidence intervals did not cross zero are bolded.

Parameter	**Confidence Interval**		**Importance Value**
	2.50%	**97.50%**	
(Intercept)	-0.174	4.468	
percent grazed land	**0.007**	**0.037**	1.0
percent shrub cover	**0.005**	**0.077**	1.0
wind	**-2.661**	**-0.578**	1.0
percent grass cover	**-0.0441**	**-0.001**	0.7
scrub	-2.394	0.310	0.5
woodland	-0.309	2.394	0.5

3.2 DISCUSSION

Our study has revealed three parameters namely "percent coverage of grazed land", "percent coverage of shrubs" and "wind",being the most important environmental variablesin influencing the density of the Superb Starling in central Tanzania's rangelands.This is sobecause the parameters met these criteria: (i) they appeared in the best model of the species,Table 1;(ii) each had an important value of 1, cf. Papanikolaou *et al.*[20]; and (iii) their confidence intervals did not cross zero, see for example,Santos *et al.* [21],Table 3. For detailed explanation on use of these criteria see Burnham &Anderson, [18].

While the coverage of grazed land, as well as shrubsdetermined increase in density of the species, wind determined the decrease, Table 2.The positive association of the Superb Startling with grazed land, as well as shrub cover in the human and livestock dominated landscape in central Tanzania could be an indication that this species is an ungulate follower i.e. the species prefers tracking grazing ungulates.Moreover, the species showed a negative association with increasing grass cover, whichcould be due to the fact that individual mobility, ability to detect and capture prey, and visibility to see potential predators are impaired in areas with high grass cover e.g.Purcell, [22].Superb Starling is a ground foragerbird feeding largely on beetles, flies, ants, termites, grasshoppers, mantids and caterpillars [8]. These arthropod food resources especially beetles and even some species of flies are associated with bare grounds particularly those formed following heavy grazing intensity. This argument is based on the fact that, in pastoralists' dominated landscapes, heavy grazing (especially by ungulate grazers), normally leads to formation of bare grounds that are dominated by unpalatable shrubs [23]. Therefore, the association of Superb Starling,of shrub dominated, heavily grazed areas with reduced grass cover the current study has revealed justifies that, ungulate grazers,particularly cattle are important component for persistence of the species in the open scrubs and woodlands of central Tanzania,cf. Rubenstein, [7]. Indeed, as open landscapesis a characteristic state of rangelands in central Tanzania followinga long term associationwith large herds of cattle,any change in land use systems in the region (especially exclusion of ungulate grazers, particularly cattle) might be associated with profound negative consequence on Superb Starling.

Currently, the Tanzania's government is advocating countrywide land use planning, see for example [24] — a campaign that will likely affect Super Starling perseverance in many areas of the country, particularly in central Tanzania.This is due to the fact that, most of cattle herds that used to roam freely will be restricted only to thoseareas set aside as pastureland. This complete abandonment (with no recurrent visitation) of previously grazing areas will likely modifySuperb Startling's habitat with subsequent reduction in its home range.This is sobecause it has been reported by a number of scholars that complete exclusionof long term traditional grazing regimes poses negative effect on birds adapted to the system e.g. [25, 26]. For example, Spottiswoode *et al.*[26] reports thatthe Sidamo lark *Heteromirafra sidamoensis*is in danger of disappearing from

Liben Plain grassland in southern Ethiopia following replacement of traditional grazing systems with permanent settlements, andmechanized agriculture. This same phenomenon was also observed in an experimental study on European Starlings, whereby,exclusion of grazing led to declining in the species abundance [22].

Indeed, the observed negative association of the Super Starling with wind, on the one hand, could be an indication that speeding windsinterrupts the bird'sflight. On the other hand, as the Super Starling diet is mainly composed of insects, the speeding wind probably disrupts insect diversity, and thus, reducing its catch efficiency. Møller, [27]points out that wind play a key role in determining abundance and distribution of flying insects,with subsequent influence on insectivorous species including birds. For example, the same study reportedadult barn swallows having lower body mass in years with windy summers, and the chances of them surviving to the coming year decreased further as wind speed increased.

4. CONCLUSIONS AND RECOMMENDATIONS

In conclusion,thegeneral observation under this study is that,grazing by ungulate particularly cattle is an important factor in determining the persistence of the Super Starling in the woodlands and scrubs of the Igunga district in central Tanzania. Field observation under the current study revealed that,Super Starling preferred tracking grazing cattle, and particularly withindisturbed areas that were formed following heavygrazing.Therefore, complete exclusion of livestock in the study area could lead to reduction in the numbers of the species. This has been observed in other studies such as that by Heldbjerga *et al.*[28], who found outthat decline in livestockdensity was coupled with decrease in abundance of birds adapted to the grazed systems.Finally, the current study recommend a followed up research to determine the nature of association of Super Starling with abandoned bomas as these are said to be important in influencing itshabitat use elsewhere in east Africa. Moreover, extensive studies on influence of wind on the species, as well as its association with cultivated landscapes are recommended.

5. ACKNOWLEDGMENT

The funding to conduct this study was provided by the Tanzania Higher Education Student's Loan Board (HESLB). The Department of Wildlife Management at SUA is thanked for coordinating the study.

6. REFERENCES

[1]Rajpar, M.N. & Zakaria, M. (2011). Bird Species Abundance and Their Correlationship with Microclimate and Habitat Variables at Natural Wetland Reserve, Peninsular Malaysia, *International Journal of Zoology*, Article ID 758573, doi:10.1155/2011/758573.

[2]Honghai, Z. & Yuewei, Y. (2000).Winter habitat selection of red-crowned crane (*Grus japonensis*). *Journal of Forestry Research,* 11(1) 44–46.

[3]Matthews, S.N., Iverson, L.R., Prasad, A.M. & Peters, M.P. (2011). Changes in potential habitat of 147 North American breeding bird species in response to redistribution of trees and climate following predicted climate change. *Ecography*, 34, 933-945.

[4]Okes, N.C., Hockey, P.A.R. & Cumming, G.S. (2008). Habitat Use and Life History as Predictors of Bird Responses to Habitat Change. *Conservation Biology*, 22(1)151–162.

[5]Jones, J. (2001). Habitat Selection Studies in Avian Ecology: A Critical Review. *The Auk*, 118(2)557-562.

[6]BirdLife International. (2016). Species factsheet: *Lamprotornis superbus*. Downloaded from http://www.birdlife.org.

[7]Rubenstein, D.R. (2016). Superb starlings: cooperation and conflict in an unpredictable environment. In, W.D. Koenig & J.L. Dickinson (Eds), *Cooperative Breeding in Vertebrates: Studies of Ecology, Evolution, and Behavior*, Cambridge University, Cambridge University Press.

[8]Craig, A. & Feare, C. (2017). Superb Starling (*Lamprotornis superbus*). In del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A. & de Juana, E. (eds.). *Handbook of the Birds of the World Alive.* Barcelona, Lynx Edicions. Retrieved from http://www.hbw.

[9]Mengesha, G., Mamo, Y., & Bekele, A. (2011). A comparison of terrestrial bird community structure in the undisturbed and disturbed areas of the Abijata Shalla lakes national park, Ethiopia. *International Journal of Biodiversity and Conservation*, 3(9)389-404.

[10]Rubenstein, D.R. (2007). Territory quality drives intraspecific patterns of extra pairpaternity. *Behavioral Ecology*, 18 (6)1058-1064.

[11]Bugumba, M.E.M. (2010).*Women's Empowerment and Fertility in Rural Tanzania: A Case of Igunga District* (Master's thesis). Sokoine University of Agriculture, Tanzania.

[12]Bibby, J.C., Burgess, N.D., Hill, A.D. & Mustoe, S.H. (2000). *Bird Census Techniques*. London, Academic Press.

[13]Nilsson, L., Ogonowski, M., & Staveley, T.A.B. (2016). Factors affecting the local distribution of the Long-tailed Duck *Clangula hyemalis* in Baltic offshore waters. *Wildfowl*, 66, 142–158.

[14]Modest, R.B. *et al.* (unpublished). Contrasting preference of vertical floristic structures in two sympatric greenbuls differing in susceptibility to environmental degradation.

[15]Newmark, W.D. & Stanley, T.R. (2016). The influence of food abundance, food dispersion and habitat structure on territory selection and size of an Afrotropicalterrestrial insectivore, *Ostrich*, 87(3)199-207.

[16]Calcagno, V. (2012). glmulti: Model selection and multimodel inference made easy. R package version 1.0.6.Retrieved from http://CRAN.Rproject.org/package=glmulti.
com/node/60900.

[17]R Development Core Team (2016). "R: A language and environment for statistical computing". R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0. Retrieved from http://www.opensourceimaging.org/project/r-project-statistical-computing/

[18]Burnham, K.P. & Anderson D.R. (2002). *Model selection and inference: a practical information-theoretic approach*. 2nd edition. New York, Springer-Verlag.

[19]Barton, K. (2012). MuMIn: Multi-model inference. R package ver.1.7.11. Retrieved from http://CRAN.Rproject.org/package=MuMIn.

[20]Papanikolaou, A.D., Kühn, I., Frenzel, M., Schweiger, O. (2016). Semi-natural habitats mitigate the effects of temperature rise on wild bees. *Journal of Applied Ecology*, 54 (2)527–536.

[21]Santos, M.J., Rosalino, L.M., Santos-Reis, M. & Ustin, S.L. (2016).Testing remotely-sensed predictors of meso-carnivore habitat use in Mediterranean ecosystems. *Landscape Ecology*,31(8)1763–1780.

[22]Purcell, K.L. (2015). Foraging behavior of European starlings: implications for mitigating their impact on native species. In: Standiford, R.B.; Purcell, K.L. tech. cords. *Proceedings of the 7th California oak symposium: managing oak woodlands in a dynamic world* (73-81).Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

[23]Skarpe, C. (1990). Shrub Layer Dynamics under Different Herbivore Densities in an Arid Savanna, Botswana. *Journal of Applied Ecology*, 27(3)873-885.

[24]Tanzania: Councils Directed to Set Funds for 'Own Land Use' (2016 December, 26). Tanzania Daily News.

[25]Gregory, N.C., Sensenig, R.L., & Wilcove, D.S. (2010). Effects of Controlled Fire and Livestock Grazing on Bird Communities in East African Savannas. *Conservation Biology*, 24(6)1606-1616.

[26]Spottiswoode, N., Wondafrash, M., Gabremichael, M.N., Abebe, Y.D. Mwangi, M.A.K., Collar, N.J. & Dolman, P.M. (2009). Rangeland degradation is poised to cause Africa's first recorded avian extinction. *Animal Conservation*, 12(3) 249-257.

[27]Møller, A.P. (2013). Long-term trends in wind speed, insect abundance and ecology of an insectivorous bird. *Ecosphere*, 4(1)1–11.

[28]Heldbjerga, H., Fox, A.D., Levin, G., Nyegaar, T. (2016). The decline of the Starling *Sturnus vulgaris* in Denmark is related to changes in grassland extent and intensity of cattle grazing. *Agriculture, Ecosystems and Environment*, 230,24–31.