

## ECOLOGICAL TRAITS PREDICT THE SUSCEPTIBILITY OF AFROMONTANE GRASSLAND BIRD SPECIES TO LIVESTOCK GRAZING IN THE BALE MOUNTAINS, ETHIOPIA

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**ABSTRACT:** Conversion of natural habitats to cultivation and grazing lands are among the major threats to biodiversity globally. However, different species of plants and animals respond differently to such land use change, possibly related to their species-specific ecological traits. Using available information on species-specific ecological traits of Afromontane grassland birds occurring in the Bale Mountains of Ethiopia, we predicted the susceptibility of 32 bird species to livestock grazing. We also collected data (along transects) on abundance of these species in 2014 in livestock grazed and ungrazed sites of the northern Afromontane grassland of the Bale Mountains. Using Generalized Linear Model, we then tested the effects of five species' ecological traits (habitat preference, substrate use, dietary requirements, migratory status and body size) on the observed responses; i.e., whether species predicted to decrease in abundance in the grazed site actually decreased and *vice-versa*. Our findings show that most of species' observed responses to grazing were found to concord with the predictions. However, only habitat and substrate preference traits had significant effects on the observed responses. Species preferring tall grass or shrubby vegetation as their primary habitat or foraging substrate preference were less abundant in the grazed site. This approach enables managers to identify which species are most likely to be affected by over-grazing and can be used to guide proactive management decisions. Further, this is the first study of its kind conducted in the internationally important Bale Mountains and the findings here are further transferable to many similar areas across the globe.

**Key words/phrases:** Birds, Foraging substrate, Habitat use, Land use change, Predictive model, Species-specific traits.

### INTRODUCTION

Land use changes through conversion of natural habitats to cultivation and grazing lands are among the major threats to biodiversity globally (Chown, 2010). Reports indicate that biodiversity degradation is higher in developing

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tropical countries such as Ethiopia due to the high rate of population growth, which in turn has led to increased demand of arable land and grazing areas to meet livelihood requirements (EWNHS, 2001; Mckee, 2005). Thus, understanding the impacts of such land use changes on biodiversity and the underlying mechanisms (i.e., how it impacts) are needed in order to develop mitigation measures against biodiversity loss (Martin and Possingham, 2005; Newbold *et al.*, 2014).

Studies have shown that the abundance of various animal species are reduced in human modified landscapes (Alkemade *et al.*, 2009; Chown, 2010; Phalan *et al.*, 2011). However, different species show widely varying responses to land use change and the degree and form of the responses often depend on species-specific ecological traits (Koh *et al.*, 2004; Kotiaho *et al.*, 2005). For birds, specifically, it has been suggested that species which are large-bodied, sedentary, habitat and dietary specialists, with small population sizes have shown the greatest declines in human disturbed habitats (Owens and Bennett, 2000; Martin and Possingham, 2005; Newbold *et al.*, 2014). However, most of afore-mentioned studies are related to forest ecosystems and little attention has been given to grassland ecosystems, which are the most converted ecosystem globally due to grazing (Hoekstra *et al.*, 2005; Rahmig *et al.*, 2009). Livestock grazing causes changes in the vertical and horizontal structural composition of vegetation through a combination of trampling, vegetation removal, loss of recruitment, and facilitation of encroachments (Jensen, 1985; Kimball and Schiffman, 2003). Such grazing-induced vegetation changes can in turn impact animal diversity, including bird communities, due to changes in quantity and quality of their habitat and food.

In this paper, we examined which species-specific ecological traits determine the response of Afromontane grassland birds to livestock grazing in the Bale Mountains of Ethiopia. The Bale Mountains are recognized as the centre of endemism and evolution for several biological taxa and is part of the Eastern Afromontane Hotspot Biodiversity area (Williams *et al.*, 2004). The area is also identified as one of the 69 Important Bird Areas of Ethiopia (EWNHS, 2001). The montane grassland in the northern slope of the Bale Mountains represents a key habitat for several ungulate species, including the endangered endemic mountain nyala (*Tragelaphus buxtoni*), and near endemic, endemic or globally threatened birds species such as the Abyssinian long-claw (*Macronyx flavicollis*) and Rouget's rail (*Rougetius rougetii*) (Yosef Mamo *et al.*, 2014).

Yosef Mamo *et al.* (2014) have found that livestock grazing in the montane grassland of the Bale Mountains has led to reduced cover and height of shrubs and grass, but increased covers of grass and weedy herbs and bare ground. This grazing-induced vegetation change is found to affect the diversity, composition and abundance of birds of the area (Addisu Asefa *et al.*, 2015). However, the underlying mechanism how livestock grazing affects birds of the area has not been examined. Given that different species respond differently to grazing depending on their species-specific traits, examining the effects of such species' traits on their response to grazing is an important and topical theme both in ecology and conservation as it enables managers to identify which species are most likely to be susceptible to over-grazing and can be used to guide management decisions. Using five species-specific ecological traits (habitat, foraging substrate, dietary requirements, migratory status and body size), we assessed how the impact of grazing on the abundance and frequency of occurrence of Afromontane grassland birds differ among species with different traits. We predicted that: (1) species that prefer shrub or tall grass vegetation for habitat, and species that prefer top, in or under shrub/tall grass as foraging substrates would be negatively affected by grazing due to reduction in vegetation height and cover; (2) in contrast, those species that inhabit open-land habitats, and those that forage in short grass or on open ground layer are favoured as a result of reduced vegetation height; (3) grazing would have a negative impact on insectivores and granivores due to reduction in availability and abundance of insects and grass seeds by grazing actions; (4) migratory species would be less impacted than resident species, as they are being adapted to cope with a broader suite of habitats on migration (Newbold *et al.*, 2014); and, (5) large body-sized species would be more affected than small-sized species probably because body size correlates with traits that directly affect species' vulnerability, such as reproductive rate and abundance.

## MATERIALS AND METHODS

### Study area

The Bale Mountains are located in the south-eastern highlands of Ethiopia at about 400 km southeast of the capital city, Addis Ababa (OARDB, 2007). To date, 78 species of mammals and 278 bird species have been recorded from the region; of which 17 mammals and 6 bird species are endemic to Ethiopia (Addisu Asefa, 2007; 2011). The Bale Mountains are characterized by eight months of rainy season (March–October) and four months of dry

season (November–February) (OARDB, 2007).

This study was carried out in the northern montane grassland area which occurs as a central broad flat valley (central location: 6°53' N and 39°33' E) between two mountainous ranges. The grassland has an area of 37 km<sup>2</sup> of which 15 km<sup>2</sup> is included in the BMNP, thus is lightly grazed (hereafter referred to as ungrazed site). The remaining area that falls outside the Bale Mountains National Park (BMNP) is being used as a communal livestock grazing land by the surrounding local community, thus is heavily grazed (hereafter referred to as grazed site) (Yosef Mamo *et al.*, 2014). Elevation ranges between 3042–3064 m a.s.l in the ungrazed site and between 3049–3072 m a.s.l in the grazed site, and on the average (mean ± S.D.) 1528 ± 86 and 11 ± 6 heads of livestock use the grazed and ungrazed sites, respectively, every day (Addisu Asefa *et al.*, 2015). The vegetation of this grassland is broadly classified into three types: open grassland (areas covered by short grasses), marsh grassland (characterized by swamp grasses and sedges of *Cyperus* and *Scirpus* spp.), and shrubland (dominated by bushes of *Artemesia afra* and *Helichrysum splendidum*) (OARDB, 2007; Yosef Mamo *et al.*, 2014).

## Data collection

### Species-specific trait data

To assess how species with different ecological traits respond to grazing, we used five species' traits: predominant habitat preference, foraging substrate preference, diet requirements, migratory behaviour, and body size.

BirdLife International (2014) classifies the importance of each habitat type inhabited by a species as 'major' or 'suitable' (<http://www.birdlife.org/datazone/info/spchabalt>). For the purposes of this study, a species was considered as shrubland or grassland specialist, if shrubland or grassland was recorded as being of 'major' importance to the species, or as generalists otherwise. Species dietary requirement was classified into four categories, following Gove *et al.* (2013) and Addisu Asefa Mitiku (2013) as: insectivore (species whose food predominantly constitutes invertebrates), granivore (seed eaters), omnivore (species feeding on invertebrates and plant materials), and nectarivore (species feeding on nectars). Following BirdLife International (2014), migratory status was broadly classified as migrant (species arriving from Eurasian and other African countries), and resident (species remaining in the country throughout the year). As we were not able to get access to data on body mass

for most species considered, we used species body length as a proxy measure of its relative body size. Thus, we classified body size into two broad categories as: small- and large-sized (see Appendix).

For substrate use, we used a quantitative primary data previously collected from the study area by the first author (AA) over a three year period (2005–2007). These data were collected along three km transects in each of the two land use types twice each year (totalling to six), and were recorded in eight substrate types, as: on top of shrubs, in shrubs and under (on ground) shrubs, on top of tall grasses/herbs, in tall grasses/herbs or under tall grass/herb (height >50 cm), in short grasses or herbs (<50 cm), and on open ground (i.e., bare ground and rocks). These data were available for all species included in the present study, with 13–78 records of substrate use observations for each species. For the purpose of this study, we classified these substrate types into two broad categories (see Data analysis section): shrub or tall grass layer (species foraging on top, inside or under shrubs, in tall grass or herbs, and short grass (species foraging in short grass, on bare ground, or on rocks).

### **Species abundance and frequency data**

Data on bird frequency of occurrence and abundance were taken from Addisu Asefa *et al.* (2015). These data were collected in June (wet season) and November (dry season) 2014 along systematically established 28 transects (14 in each land use type and at a minimum distance of 300 m apart) of each 1 km long. Birds were counted up to 50 m width on both sides of each transect. All counts were made by the same expert observer, early in the morning (between 07:00–10:00) when birds are thought to be more active, while slowly walking at speed of 2 km hr<sup>-1</sup>. Birds of prey, aerial feeders (e.g. swallows and swifts) and wetland birds (those feeding in water bodies and shorelines) were not recorded as we were primarily interested in those species using terrestrial habitats. We also took altitude data at the start and end points of each transect and counted number of livestock in each site (for detail on methods, see Addisu Asefa *et al.*, 2015).

### **Data analysis**

#### ***A priori* impact-of-grazing model based on substrate preference trait**

Given the predictions made in the introduction, we used our substrate use data to develop a simple impact-of-grazing model that relates a species' substrate preference to its susceptibility to grazing to predict species-specific response to grazing, following Martin and Possingham (2005). The

model assumes that the susceptibility of bird species  $j$  to grazing ( $S_{gj}$ ) is a function of the proportion of time (frequency of record) that species  $j$  was observed using open ground substrate minus the proportion of time species  $j$  was observed using tall grass or shrub layers:

$S_{gj} = (X_{jog} - X_{jgs})/(X_{jtot})$ , where  $X_{jog}$  is the proportion of time species  $j$  forages on open ground substrate;  $X_{jgs}$  is the proportion of time species  $j$  forages in tall grass or shrub; and,  $X_{jtot}$  is the sum of  $X_{jog}$  and  $X_{jgs}$ . Thus, we predicted that positive values of this measure of susceptibility indicate a tendency to increase in abundance in the ungrazed site, while negative values suggest a tendency to decrease in abundance.

### Observed species responses to grazing

The response of birds to disturbances, including to grazing, could generally be change in abundance, frequency of occurrence or a combination of the two (Newbold *et al.*, 2014). Thus we used a combination of the two, and abundance data alone to calculate species response to grazing. To combine information obtained from abundance and frequency of occurrence data, indicator value indices (IndVal) were computed for each species for each land use type using the software IndVal (Dufrene and Legendre, 1997). This method provides an IndVal index ranging between 0 and 1 (for detail, see Dufrene and Legendre, 1997).

Following Martin and Possingham (2005), based on the summed abundances of each species recorded in each site we also calculated the change in abundance, hereafter referred to as relative abundance change (RA), of each species from the ungrazed site to the grazed site as:

$RA_j = (A_{jg} - A_{jug})/(A_{jtot})$ , where,  $RA_j$  is relative change in abundance of species  $j$ ;  $A_{jg}$  and  $A_{jug}$  are abundance of species  $j$  in the grazed site ( $g$ ) and ungrazed ( $ug$ ) site, respectively;  $A_{jtot}$  is the sum of  $A_{jg}$  and  $A_{jug}$ . Relative change in indicator value (RIndVal) was also calculated using similar way. The value of  $RA_j$  (and RIndVal) lies between  $-1$  and  $+1$ : negative values indicate negative response of a species to grazing (i.e., abundance/IndVal is higher in the ungrazed site), positive value indicating positive response and zero value indicating no change.

### Statistical analysis

As preliminary analysis showed that all species-specific responses were qualitatively similar for both abundance and IndVal changes (Table 1), we used only the relative change in abundance data for further analysis and

presentation of results. To examine if species predicted to increase were observed to increase and those predicted to decline observed to decline, we calculated for each prediction the number and percent of species' predictions that coincided with the observed responses. We performed Pearson correlation to test the strength of the relationship between our predictions from the grazing-impact-model developed based on foraging substrate preference trait and the relative change in abundance from ungrazed to grazed site.

We used Generalized Linear Model with normal distribution and identity link function in SPSS, version 20, statistical package (IBM, 2001) to examine the effects of species ecological traits on their responses to grazing. As the change in abundance data values were bounded between -1 and 1, we rescaled these data prior to this analysis by dividing each value to their standard deviation (van den Berge *et al.*, 2006). Substrate use was treated as continuous variable and the other predictor variables as categorical. We modelled all possible combinations of the five predictor variables and used Akaike Information Criterion corrected for small sample size ( $AIC_c$ ) to compare the candidate set of 32 possible models (Burnham and Anderson, 2002). The strongest model has the smallest  $AIC_c$ , however, if the difference between two  $AIC_c$  values ( $\Delta AIC_c$ ) was  $<3$ , models were considered to be equivalent (Symonds and Moussalli, 2011). In the present study, several models fell below  $\Delta AIC_c = 3$ , thus we adopted a model-averaging approach of all candidate models whose cumulative  $\Delta AIC_c$  weights were  $<95\%$  to obtain the final parameter estimates, standard errors, and confidence intervals (Burnham and Anderson, 2002; Symonds and Moussalli, 2011).

## RESULTS

Overall, 32 bird species were recorded in the entire study area: 24 species in the ungrazed and 25 in the grazed sites (see the Appendix). A preliminary examination of the concordance of species' predictions and observed responses based on habitat specialization and substrate preference traits (traits with most explanatory power, see below) indicated that 81% and 88%, respectively, of species' predictions had corresponded with the observed change in species' abundances from the ungrazed site to the grazed site (Table 1). Of these, 88% (15 species) and 90% (18) of species predicted to decline were observed to decline and 73% (11) and 83% (10) of species predicted to increase did increase in the grazed site for habitat and substrate use predictions, respectively (Table 1). The Pearson correlation coefficient between the predictions from the impact-of-grazing model based

on foraging substrate preference and changes in relative bird abundance was also high ( $r = 0.797$ ,  $n = 32$ ,  $P < 0.001$ ).

Table 1. Summary of *a priori* predictions (based on species-specific habitat and substrate preference traits) and observed relative change in abundance from ungrazed to grazed sites for 32 Afromontane grassland bird species in the Bale Mountains of Ethiopia.

Prediction	Relative change	Habitat		Substrate	
		No. of species	%	No. of species	%
Decrease	Decrease	15	88	18	90
Increase	Increase	11	73	10	83
Decrease	Increase	2	12	2	15
Increase	Decrease	4	27	2	17

Note:- In this analysis, substrate preference was treated as categorical variable by considering species with positive relative substrate use values as positive response to grazing and those species with negative substrate use as negative response to grazing.

In general, bird abundance was on average 6.8% lower in the grazed site compared to the ungrazed site. However, there was substantial variation among species in observed responses to grazing as a function of species-specific individual, or combinations of traits. As measured using  $AIC_c$ , of the 32 models with different combinations of traits considered, the “null” model was ranked 21<sup>st</sup> in terms of its fit to the data (Table 2). Habitat specialization and substrate preference characteristics had the most substantial effect on observed species responses to grazing; both had sum of  $AIC_c$  weights  $>0.6$  and weighted average parameter estimates that did not overlap with zero (Table 3). Bird species that are shrubland or tall grass habitat specialists, or that prefer shrub or tall grass substrates occur at lower abundances in the grazed site in comparison to the ungrazed site. Whereas, species with openland habitat, or open ground or short grass foraging substrate preferences showed the opposite response (Fig. 1a and b). The effect of other traits on the response was weak although nectarivore and omnivore species generally tended to show negative responses (Fig. 1c-e). However, considering the interactive effects of other traits with habitat preference trait, habitat specialist species in all categories of the other traits showed more negative responses than habitat generalist species (Fig. 2a-c).



Table 2. The best model (with the lowest AIC<sub>c</sub>) explaining the response (i.e., change in abundance from the ungrazed site to grazed site) of 32 Afromontane grassland bird species to grazing in the Bale Mountains of Ethiopia, and change in AIC<sub>c</sub> ( $\Delta$ AIC<sub>c</sub>), AIC<sub>c</sub> weights (AIC<sub>c</sub> Wi), cumulative AIC<sub>c</sub> Wi and log-likelihood ratios (LL ratio) for set of candidate models whose cumulative AIC<sub>c</sub> Wi is  $\approx$  95%.

Model rank	Model	AIC <sub>c</sub>	$\Delta$ AIC <sub>c</sub>	AIC <sub>c</sub> Wi	Cumul. AIC <sub>c</sub> Wi	LL Ratio
1	Habitat + Substrate	91.085	0.000	0.212	0.212	20.254
2	Habitat + Diet +Substrate	91.109	0.024	0.209	0.421	29.416
3	Habitat	91.602	0.517	0.164	0.585	17.113
4	Habitat + Body size + Substrate + Diet	93.117	2.032	0.077	0.662	31.001
5	Habitat + Body size + Substrate	93.674	2.589	0.058	0.720	20.491
6	Habitat + Migratory status + Substrate	93.705	2.620	0.057	0.777	20.460
7	Habitat + Body size	93.985	2.900	0.050	0.827	17.354
8	Habitat + Migratory status + Diet + Substrate	94.109	3.024	0.047	0.873	30.010
9	Habitat + Migratory status	94.198	3.113	0.045	0.918	17.121
10	Habitat + Body size + Diet	95.159	4.074	0.028	0.946	25.366
21	Null model	106.514	15.429	0.000		0.000

Table 3. Sum of AIC<sub>c</sub> weights (AIC<sub>c</sub> Wi) and average parameter estimates (Av. Bi (SE)) for five species characteristics to explain observed responses (i.e., change in abundance from the ungrazed site to grazed site) of 32 Afromontane grassland bird species. (Sum of AIC<sub>c</sub> weights were calculated from all models containing a given characteristic, from a set of models fitting all possible combinations of characteristics. Average parameter estimates and their 95% standard errors (SE) of each characteristic were computed from all candidate models whose cumulative  $\Delta$ AIC<sub>c</sub> weights were  $\approx$  95%). The explanatory power of each characteristic was considered to be statistically significant if the 95% CIs of the averaged parameter estimates do not overlap with zero (Reference category: habitat = generalist, body size = large, MS = migrant, diet = omnivore).

Variables	Sum of AIC <sub>c</sub> Wi	Average parameter estimates	
		Variable category	Av. Bi (SE)
Habitat	0.998	Specialist	-1.492 (0.113)
Substrate	0.691		0.377 (0.033)
Body size	0.254	Small	-0.380 (0.431)
Migratory status	0.192	Resident	0.097 (0.120)
Diet	0.391	Granivore	1.593 (0.324)
		Insectivore	0.840 (0.211)
		Nectarivore	1.829 (0.505)

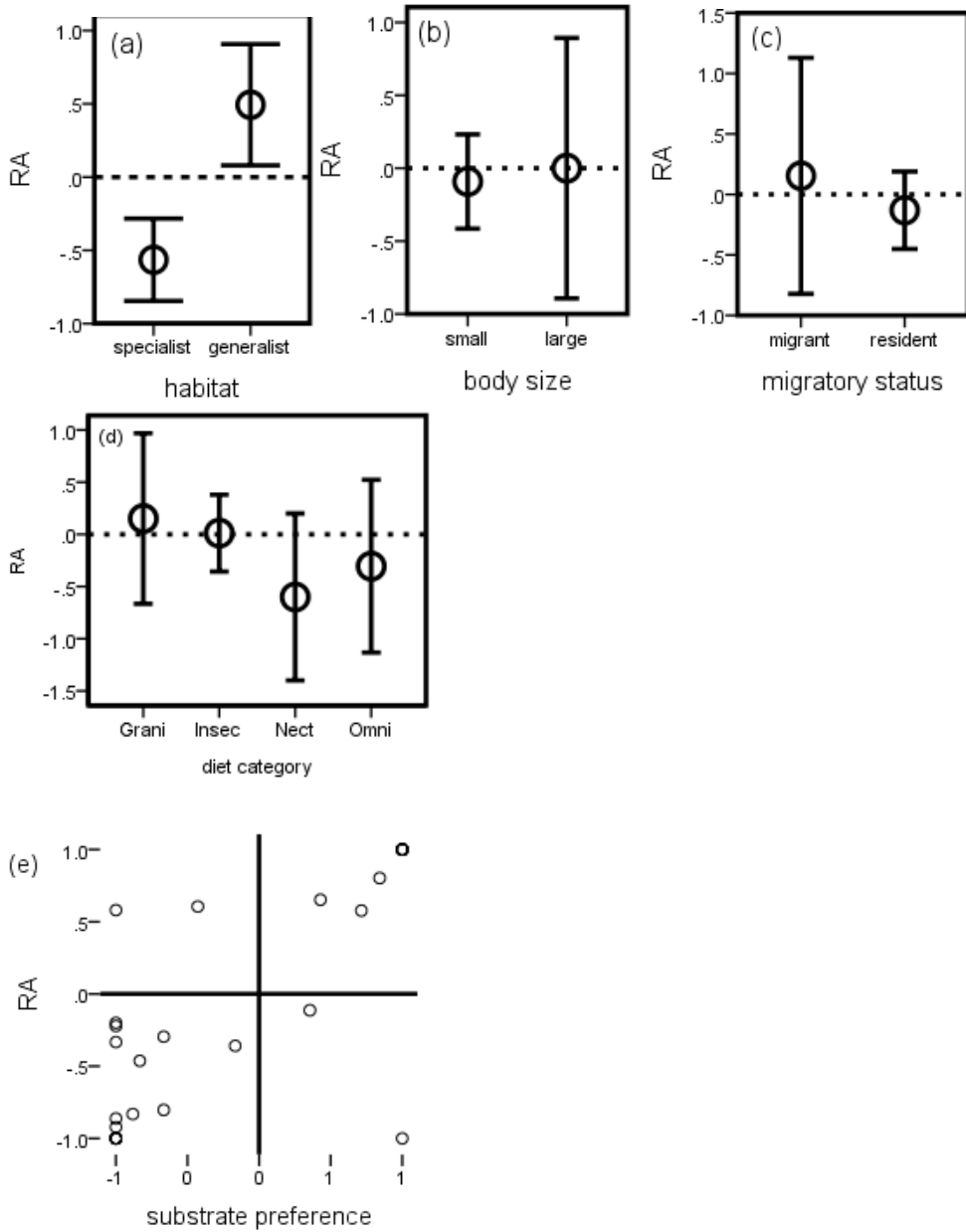


Fig. 1. Change in relative abundance (RA; mean  $\pm$  SE) of 32 bird species in the grazed relative to the ungrazed sites in the Bale Mountains of Ethiopia. RAs were modelled as functions of species' traits (a = habitat; b = body size, c = migratory status, d = diet, e = substrate). The horizontal broken line ( $y = 0$ ) in Fig. 1a-d indicates no difference in abundance between the grazed and ungrazed sites. Fig. 1e shows the relationship between relative change in proportion of species' substrate use and change in relative abundance.

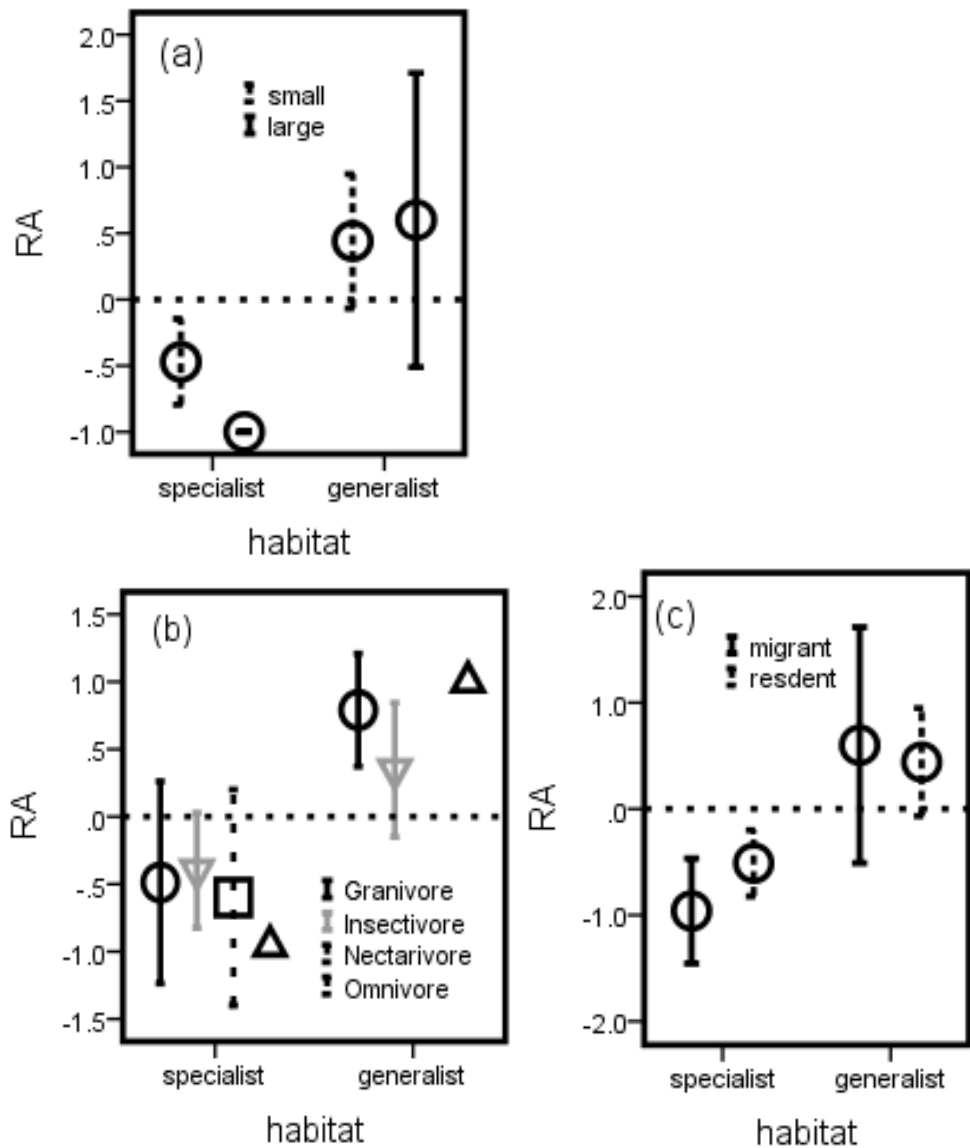


Fig. 2. Change in relative abundance (RA; mean  $\pm$  SE) in the grazed site relative to the ungrazed site for 32 Afromontane grassland bird species in the Bale Mountains of Ethiopia. RAs were modelled as functions of combinations of species' habitat preference with each of three other traits (body size = a, diet = b, and migratory status = c). The horizontal broken line ( $y = 0$ ) indicates no difference in abundance between the grazed and ungrazed sites.

## DISCUSSION

Overall, the results show a slight impact of livestock grazing on the local abundance of Afromontane grassland birds when all species were taken together. However, the effect of grazing on the birds differed among species depending on their specific traits, consistent with the results of several previous studies on a wide range of grassland bird species (Muchai *et al.*, 2002; Evans *et al.*, 2006; Berghesio *et al.*, 2013). Based on habitat and substrate use traits, most bird species predicted to decline did decline and those predicted to increase did increase; species that primarily depend on shrubland or tall grass vegetation for habitat or for foraging substrate showed greater declines than generalist species in the grazed site compared to the ungrazed site.

The effect of habitat specialization and substrate use traits on the response of species to land use changes have been shown previously to affect abundance of birds (e.g. Martin and Possingham, 2005; Sekercioglu, 2007). In grassland ecosystems, particularly, species that are dependent on tall grass or shrubby vegetation as a habitat and foraging substrate are likely to be more adversely impacted by livestock grazing than species with broader habitat preferences (Evans *et al.*, 2006; Whitehorn *et al.*, 2011; Berghesio *et al.*, 2013). In our study, with greater than 80% of species' predictions being consistent with observed responses in both cases, habitat specialization and substrate use traits were found to be the most important predictors of Afromontane grassland bird species' vulnerability to livestock grazing. This is particularly true for conservation concern species (endemics or globally threatened), such as Abyssinian long-claw, Rouget's rail and Ethiopian Siskin (*Serinus nigriceps*), that are reported to rely on tall grasses or shrubby vegetation for foraging, nesting or shelter (Addisu Asefa and Kinahan, 2013; Yosef Mamo *et al.*, 2014; Addisu Asefa *et al.*, 2015). The negative response of these species to grazing may be attributed to reduced cover and height of grasses and shrubs, which in turn leads to reduced quality and quantity of habitat and feeding resources available to them (Fensham and Skull, 1999). In contrast, abundances of near endemic species, such as wattled ibis (*Bostrychia carunculata*) and thick-billed raven (*Corvus crassirostris*), that prefer openland/short grass habitats were found to be favoured by livestock grazing (see the Appendix).

The effect of other species traits on the response was weak. Diet has been reported to have a strong effect on the responses of birds to human-induced habitat changes, especially insectivore species, which results from a

reduction in the abundance of invertebrates (Sekercioglu, 2007). However, we found little evidence of such effect of diet on species' responses to grazing although nectarivore and omnivore species generally tended to show negative responses. Such unpredicted response could occur due to two main reasons. First, most nectarivore and omnivore species included in our study are those that require tall grass or shrub habitat, suggesting that reduction of vegetation height and cover might have led to decrease in their abundance in the grazed site. Second, although livestock grazing activities could result to reduced abundance and diversity of invertebrates, it could also result to increment by attracting invertebrate species that use livestock dung as foraging and breeding substrate (Vickery *et al.*, 2001). Thus reduction of invertebrate abundance due to grazing may be off-set by increase in their abundance in the grazed site, resulting to less change in abundance of insectivore species to grazing. Nonetheless, habitat specialist insectivore species tended to respond negatively to grazing and the opposite was found for habitat generalist insectivores.

Overall, the use of species-specific traits has improved our ability to understand species' responses and to explain observed changes in the abundance of Afromontane grassland birds. However, our results should be interpreted cautiously as there are many reasons why our model should fail: (i) an effect of traits of the species not captured in the models (e.g. generation length, range size, etc); (ii) a degree of subjectivity in the assignment of species to the different categories of some of the traits (e.g. body size could be treated as a continuous variable); (iii) lack of grazing transitions (we compared one grazed site with one ungrazed site - it would be ideal if sites with different grazing levels (such as sites with no, low, moderate, high and very high grazing levels) were compared to be able to see if species' responses were monotonic). The latter issue is particularly important because moderate level of livestock grazing, as well fire, disturbances, has been used as a management tool to promote bird diversity in grassland ecosystems globally (Evans *et al.*, 2006; Berghesio *et al.*, 2013). Under moderate level, grasses and shrubs are grazed to varying degrees, resulting to increased structural diversity which may provide new foraging or nesting resources (Martin and Possingham, 2005).

In conclusion, in an attempt to prevent biodiversity degradation, ecological studies should consider the mechanisms underlying change rather than search for patterns to infer change, as it would enable to predict which species are most vulnerable to grazing and facilitates a proactive, rather than reactive, approach to the management of habitats. The method reported here

has allowed us to demonstrate that species' habitat and substrate type preference traits are significant predictors of bird species susceptibility to livestock grazing. This approach can be applied to other grassland areas where landscapes are in a state of conversion.

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Appendix. Species' predictions (based on substrate use) and observed responses (change in abundance), and ecological characteristic categories assigned to each of the 32 bird species [in the Bale Mountains, southeast Ethiopia] included in the study. Predicted responses (RSU) were expressed as the relative proportion of open ground/short grass substrate use compared to tall grass/shrub substrate use and observed responses as the relative abundance (RA) in the grazed site compared to the ungrazed site. (Abbreviations for trait categories are defined as follows: habitat: spc = specialist, gen = generalist; migration: R = resident, M = migratory; diet: ins: insectivore, omn = omnivore, gra = granivore, nec = nectarivore).

Common name	Scientific name	RA	RSU	Habitat	Body size	Migration	Diet
	<i>Macronyx</i>						
Abyssinian longclaw	<i>flavicollis</i>	-0.80	0.67	spc	small	R	ins
Alpine chat	<i>Cercomela sordida</i>	-0.36	-0.17	spc	small	R	ins
Baglafecht weaver	<i>Ploceus baglafecht</i>	-0.22	-1.00	gen	small	R	ins
Cape canary	<i>Serinus canicollis</i>	0.61	-0.43	spc	small	R	gra
Ethiopian siskin	<i>Serinus nigriceps</i>	-0.11	0.35	spc	small	R	gra
Cape crow	<i>Corvus capensis</i>	1.00	1.00	Gen	large	R	omn
Chestnut-naped francolin	<i>Francolinus castaneicollis</i>	-1.00	1.00	Spc	large	R	omn
Cinnamon-bracken warbler	<i>Bradypterus cinnamomeus</i>	-1.00	-1.00	Spc	small	R	ins
Common fiscal	<i>Lanius collaris</i>	-0.33	-1.00	Gen	small	R	ins
Common quail	<i>Coturnix coturnix</i>	-1.00	1.00	Spc	large	M	omn
Common stone chat	<i>Saxicola torquatus</i>	-0.92	-1.00	Spc	small	M	ins
Common waxbill	<i>Estrilda astrild</i>	-0.86	-1.00	Spc	small	R	gra
	<i>Anthus</i>						
Grassland pipit	<i>cinnamomeus</i>	1.00	1.00	Gen	small	M	ins
Grey wagtail	<i>Motacilla cinerea</i>	1.00	1.00	Gen	small	M	ins
Ground scraper thrush	<i>Turdus litisitsirup</i>	0.80	0.84	Gen	small	R	ins
Issabelline wheatear	<i>Oenathe isabellina</i>	-1.00	1.00	Gen	small	M	ins
Malachite sunbird	<i>Nectaniria famosa</i>	-0.20	-1.00	Spc	small	R	nec
	<i>Francolinus</i>						
Moorland francolin	<i>psilolaemus</i>	-1.00	1.00	Spc	large	R	omn
Red-breasted wheatear	<i>Oenathe bottae</i>	0.65	0.43	Spc	small	R	ins
Red-throated pipit	<i>Anthus cervinus</i>	1.00	1.00	Gen	small	M	ins
Rouget's rail	<i>Rougetius rougetii</i>	-1.00	1.00	Spc	small	R	ins
	<i>Threkiornis</i>						
Sacred ibis	<i>aethiopicus</i>	1.00	1.00	Gen	large	M	ins
	<i>Oegnathus</i>						
Slender-billed starling	<i>tenuirostris</i>	-1.00	-1.00	Gen	small	R	omn
Streaky seedeater	<i>Serinus striolatus</i>	-0.83	-0.88	Spc	small	R	gra
Tacazze sunbird	<i>Nectaniria tacazze</i>	0.58	-1.00	Gen	small	R	nec
Tawny-flanked prinia	<i>Prinia subflava</i>	-1.00	-1.00	Spc	small	R	ins
Thekla lark	<i>Galerida theklae</i>	0.58	0.71	Gen	small	R	ins
Thick-billed raven	<i>corvus crassirostis</i>	1.00	1.00	Gen	large	R	omn
	<i>Bostrychia</i>						
Wattled ibis	<i>carunculata</i>	1.00	1.00	Gen	large	R	ins
Winding cisticola	<i>Cisticola galactotes</i>	-0.46	-0.83	Spc	small	R	ins
Yellow bishop	<i>Euplectes capensis</i>	-0.30	-0.67	Spc	small	R	gra
Yellow wagtail	<i>Motacilla flava</i>	1.00	1.00	Gen	small	M	ins