Journal of Threatened Taxa

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ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

Article

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26 June 2018 | Vol. 10 | No. 7 | Pages: 11831–11843
10.11609/jott.3469.10.7.11831-11843

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 June 2018 | 10(7): 11831–11843

ARTICLE

Association of grassland birds with Saccharum-Imperata patch in a northeastern tea estate of Bangladesh

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ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

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Abstract: *Saccharum-Imperata* grasslands in Bangladesh were once directly associated with 10 native extirpated birds and still harbor many diminutives. These habitats are now pocketed only in northeastern regions of the country due to intensive conversion, overstocked grazing and fire suppression. After a hiatus of about four decades, composition and interaction of grassland specialist birds within a managed habitat of a tea estate was studied between November 2015 and May 2016 at micro-habitat scale using line transects, diversity indices, Bray-Curtis cluster analysis and linear mixed models. Including 819 individuals of 39 grassland specialists, a total of 2,586 individuals of 110 species were recorded. The analyses indicated the landscape to have a significant effect on species richness. Of six micro-habitats, the area along the creek and dense tall grasses are important habitats for grassland specialists. The latter ranked top in Shannon's index (H') for specialists (33 species, H' = 2.988) followed by micro-habitats along the creek (18, 2.592) and sparse short grass (16, 2.401), comparing marked difference with micro-habitats of sparse grass along the road (21, H'=2.279), bush associated (11, 2.206) and crop associated areas (11, 2.124). The effect of slash-and-burn was stark on specialists, no significant association was found with grazing. This has been surmised as relationship among specialists' ecology, long-term treatment effect and unpalatable nature of *Saccharum ravennae* as fodder. Based on the hypothesis, the study emphasizes exigencies of a potential management strategy for avian habitats within tea estates of Bangladesh.

Keywords: Aves, community ecology, composition, grazing, interaction, Poaceae, unpalatable grasses.

DOI: http://doi.org/10.11609/jott.3469.10.7.11831-11843 | **ZooBank:** urn:lsid:zoobank.org:pub:CFD4AEF6-0F4B-437F-B482-66B88B2F02CB

Editor: Hem Sagar Baral, School of Environmental Sciences, Albury-Woodonga, Australia. **Date of publication:** 26 June 2018 (online & print)

Manuscript details: Ms # 3469 | Received 27 April 2017 | Final received 06 May 2018 | Finally accepted 20 May 2018

Citation: Akash, M., T. Khan & S.U. Chowdhury (2018). Association of grassland birds with Saccharum-Imperata patch in a northeastern tea estate of Bangladesh. *Journal of Threatened Taxa* 10(7): 11831–11843; http://doi.org/10.11609/jott.3469.10.7.11831-11843

Funding: The Bangladesh Bird Club financed the project under the Munir Ahmed Khan Bird Conservation Fund raised in memory of the late Ranger Mr. Munir Ahmed Khan of the Bangladesh Forest Department.

Competing interests: The authors declare no competing interests.

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Author Contribution: MA conducted the survey, planned and ran the analytics, drafted and finalized the manuscript. TK participated in the survey and helped with local logistics. SUC helped in securing the fund, study design, supervised the study and edited an earlier version of the manuscript.

Acknowledgements: The authors are thankful to all the contributors of the Munir Ahmed Khan Bird Conservation Fund and selecting this project to support. We are also grateful to the workers and land managers of the Kurma Tea Estate for granting access to the site. The Noazesh Knowledge Centre of WildTeam was of invaluable use as provided significant literary works.

INTRODUCTION

Dominated by monocotyledonous plants of the family Poaceae and specialist fauna, grasslands are universally spread, discrete habitats with characteristic adaptation to periodical disturbances (Singh et al. 1983; Vickery & Herkert 1995). Grasslands are dwindling and so are its denizens. Anthropogenic effects are mounting; as a consequence, grasslands rank high on the list of most threatened and the least studied habitats (Samson & Knopf 1994; Coppedge et al. 2001). Rising levels of CO_2 because of climate change, in addition to these factors, also acts in favor of C3 xyloid woody plants growth over C4 graminoid grasses (Polley et al. 1994; Coppedge et al. 2001). Considering avifauna, over the past three decades, populations of grassland birds are backsliding in a steep and persistent rate primarily due to habitat loss, degradation and alteration (Knopf 1994; Peterjohn 1994; Vickery & Herkert 1995).

The Indian Subcontinent possesses tropical tall grasslands which are strongly latitude dependent and climate driven (Whyte 1977; Singh & Krishnamurthy 1981; Singh et al. 1983; Peet et al. 1999). Of the four major categories, *Phragmites-Saccharum-Imperata* sheets, often known as ‘wet savanna’, enriched with alluvial soil, is spread across the entire northwestern Gangetic plain to the eastern Brahmaputra plain descending along the Ganges-Brahmaputra-Meghna watersheds (Rowntree 1954; Singh et al. 1983; Garrity et al. 1997).

With a loss of nearly 50% of natural formation, grasslands in the Indian Subcontinent have become severely fragmented. Only one percent of today’s remaining grass-scapes are under legal proctection. Yet, with around 200 obligatory specialists from different taxa, these Indo-Gangetic grasslands cover 10 important bird areas (IBA) which harbor about 20 globally threatened bird species (Rahmani et al. 2016).

In Bangladesh, around 5% percent of the total forested area is represented by grasslands (IUCN Bangladesh 2015a). At present, patches similar to the characteristic northeastern Indian grass complex, are the worst affected and the least known habitats of the country, and exist as pockets only throughout the northern and southeastern administrative divisions of Sylhet and Chittagong of Bangladesh (Khan 1977; Kabir et al. 2010; IUCN Bangladesh 2015a). Of the country’s 31 extirpated species, 10 of both mammalian and avian species were directly associated with grasslands (IUCN Bangladesh 2015a,b).

In comparison to researches dealing with anthropogenic effects on forest birds, works are much less concentrated on grasslands’ avian specialists (Helzer & Jelinsky 1999). Research interests, however, are increasing worldwide to perceive the least known grassland birds from ecological and evolutionary viewpoints and to determine factors causing the apparently unstoppable declining trend (e.g., Norment et al. 2010; Osborne & Sparling 2013; Manakadan 2014; da Silva et al. 2015; Davis et al. 2016; Duchardt et al. 2016; Rahmani et al. 2016).

As a stark similarity with the ongoing global scenario, these habitats of Bangladesh still yield many rare and globally threatened species including Yellow-breasted Bunting *Emberiza aureola* and Bristled Grassbird *Chaetornis striata.* They also harbor regionally diminishing smaller mammals like the Indian Hare *Lepus nigricollis*, the Bengal Fox *Vulpes bengalensis* as well as the globally Vulnerable Fishing Cat *Prionailurus viverrinus*. Other than the annotation from Khan (1988), any systematic study on the resident and migratory grassland birds is still largely absent in Bangladesh, however. Akash et al. (2017) was the first such attempt after this long hiatus representing status and fluctuation of grassland birds whereas the current work exemplifies their association in a managed habitat.

Based on the aforementioned status of grassland birds, the study aimed (1) to investigate their association with vegetation types, and (2) to provide a baseline for comparative studies to update the shortfall on grassland birds of Bangladesh.

MATERIALS AND METHODS

Study area

The study area is about 17.59ha. The Kurma Tea Estate (24.20306^{0}N & 91.86528^{0}E) located in a synclinal valley of the northeastern administrative district of Moulvibazar of Sylhet division administers the patch. To the north, the site is 10km from Adampur Reserve Forest whereas Moulvibazar municipality is 33km away. The Indian states of Tripura and Assam are 3km on the south and 35km to the east from the study area, respectively. The anticlinal Atharamura-Longtharai hill range straddling from north to south delimits the site horizontally (Saigal 2005). According to the Köppen climate classification system, the region falls under tropical wet savanna climate having characteristic yearly heavy precipitation (Pathak 2005). Winter spans from November to February while May to September constitutes monsoon. Surrounded by the tea garden

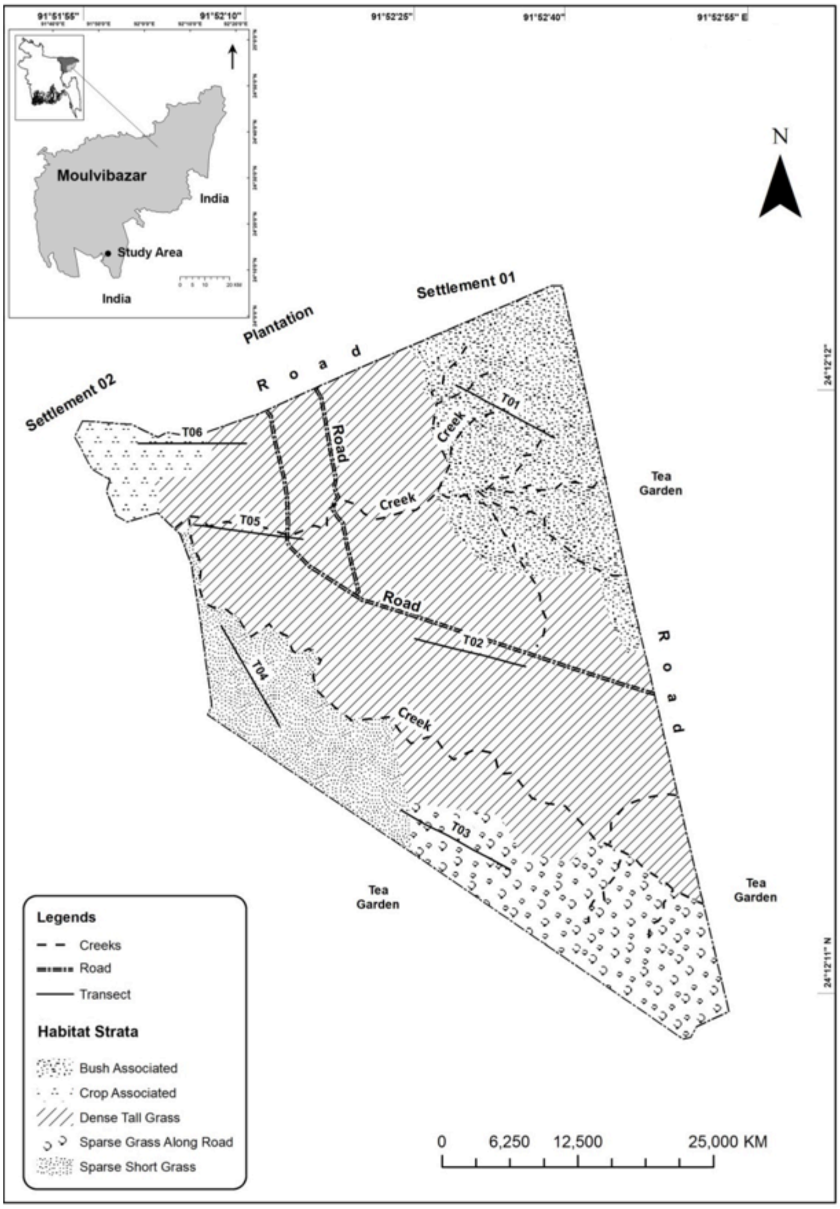

Figure 1. Study Area, microhabitat stratification and layout of transect lines.

except for the northerly located tree plantation area, the study site is traversed by two creeks running from west to east, being the widest westward (Fig. 1).

Micro-habitat stratification

Typical of the northeastern part of Bangladesh, this grassy patch gets the major plant mass from the family Poaceae (Ahmed et al. 2008a). With a typical elephant grass formation, Ravenna Grass *Saccharum ravennae* stands as the most dominant and the tallest species. The grass is harvested yearly, starting from the last week of January depending on the ripening of the Ravenna Grass, which is followed by an immediate burn after completion by mid-February. The whole area is subject to year round random grazing, controlled by the garden workers. The Cogon Grass *Imperata cylindrica* forms the second sheet layer, as a majority where Ravenna Grass is sparse or absent. The Ravenna Grass is completely absent along the southwestern side and sparse on the eastern tip of the study area. The northeastern tip of the grassland supports dense *Clerodendrum infortunatum* and *Lantana camara* growth. *Calotropis gigantea* was the only woody shrub of the area, and *Streblus asper* was also seen but in a trimmed state being subject to regular maintenance.

Considering the spread of the grass species diversity, the study area was classified into six micro-habitats (1) bush associated area with tight predominance growth

Image 1. Study area - habitats

of *Clerodendrum infortunatum* and *Lantana camara* with an average height of 1.0 m (BA), (2) dense tall grass formation with characteristic heavy growth of average 1.5–2 m tall Ravenna Grass (DT), (3) sparse grass along roads with sparse tall Ravenna Grass formation with smaller Cogon Grass and other grasses (SG), (4) sparse short grass with spread of 0.5m tall Cogon Grass (SS), (5) grasses along the creek attributed with tall Ravenna Grass, middle-layered sedges and their integral association within creek emergence with a strong bushy appearance of 1.0m height (AC), and (6) crop associated area with the presence of lentils and only creeping grasses with a height of 0.25m (CA) (Image 1).

Bird survey

Prior to the stratification randomly set six transect lines (T1–T6) were placed across the study site, each being 100m long, a minimum distance of 100m between lines was maintained. A line sprawled across two different micro-habitats was considered for the micro-habitat over which it positioned most. A distance belt for each transect was set at 20m on both sides (Bibby et al. 1992; Pomeroy 1992). The survey continued for a total of seven months, one single-day field trip in each month between November 2015 and May 2016. On an average 15 minutes was spent on each transect line to record observations. Two trained observers conducted transect walks in the early morning hours (07:30–09:30 hr). Even ratio of count sequence among transects was followed carefully. Direct observation and calls were followed when visibility was restricted owing to dense vegetation; distant calls were omitted to avoid observation bias. Overhead fliers were recorded only when identification was confirmed. High-resolution photographs were analyzed for further confirmation. Ahmed et al. (2008a,b), Siddiqui et al. (2008a,b), Grimmett et al. (2011) and IUCN Bangladesh (2015a) were used for taxonomy and categorization. Observed birds were summed up into three separate categories, i.e., passerines and non-passerines, migrants and residents, grassland generalists and grassland specialists. Siddiqui et al. (2008b), Grimmett et al. (2011) and IUCN Bangladesh (2015a) were consulted for nomenclature and categorization.

Data analyses

For examining the adequacy of the sampling effort, the species accumulation curves were analyzed (Peterson & Slade 1998; Magurran 2004). The curves for different micro-habitat layouts went to the plateau universally, thus conferring confidence that most of the species had been sighted as well as to the completeness of the survey effort (Fig. 2).

Shannon's diversity index (H') for total and specialist species was consulted to check the diversity of the avian community of the study area and at the micro-habitat level (Magurran 2004). Alpha-species diversity at the micro-habitat levels for specialist species was described with Whittaker's rank-abundance curves (Magurran 2004). The total number of species in the area was predicted using extrapolation of results with first- and second-order Jackknife (J, J'), Chao (C) and bootstrap (b)

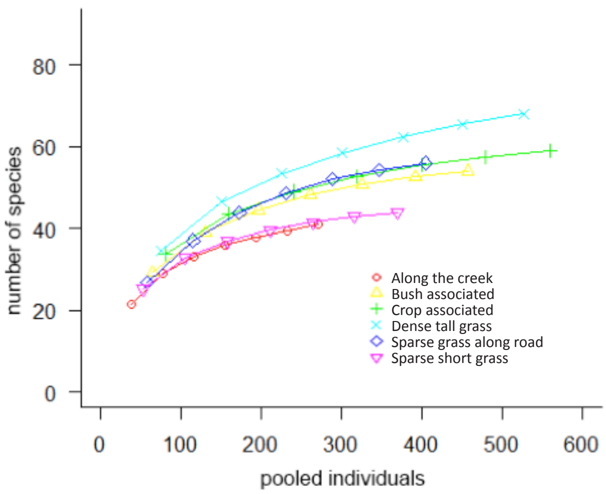

Figure 2. Rarefaction curves for avian species assemblages at the study area.

richness estimators (Kindt & Coe 2005). To evaluate and compare similarities in avian species composition among micro-habitats, single-link, abundance-based Bray-Curtis cluster analysis was conducted (Kindt & Coe 2005). To assess the impact of micro-habitats on specialist species richness, two separate linear mixed effect models (LMEMs) were performed. Richness data for specialist species against microhabitats was used as fixed effects (covariates) whereas data for generalist species and total richness was treated as random effect separately (Arellano-Valle & Genton 2005). Non-parametric Wilcoxon signed rank test was performed to bring out statistical differences for slash-and-burn and grazing effect at microhabitats level on specialists. Abundance data of each survey was evaluated to test the significance of grazing effect whereas data of the month of January and February was to test that of slash-and-burn (Gardener 2012). Normality of data was checked using Q-Q plots, Shapiro-Wilk Test and boxplots. Logarithmic transformation was applied for richness data conducting LMEM simulations.

The dimension of the area, distances, mapping, habitat data attributes were estimated with ArcGIS 10.3.1 (2015) and Google Earth Pro (2015). Ground-truthing of the measurements was carried out by Global Positioning System (GPS) navigator Garmin GPSMAP 62S (2005). All statistical analyses were run with R 3.3.0 (R Core Team 2016) using lme4 (Bates et al. 2015), MASS (Venables & Ripley 2002), nlme (Pinheiro et al. 2017) and BiodiversityR (Kindt & Coe 2005) packages.

RESULTS

Species richness

Of the 110 species of observed birds, 39 were specialists and the remaining 71 were habitat generalists. In comparison to 19 resident grassland specialists, there were 33 migratory species; however, no summer migrant with specialization on grassland was recorded (Table 1, Fig. 3, Images 2–23).

Richness, considering total species, was highest along transects at the microhabitat of dense tall grass (S_{DT} = 68 species) being trailed by crop associated area with 59 species. Species composition were relatively close at bush associated area and the area of sparse grass along roads (S_{BA} = 54, S_{SG} = 56). Minimal number of species (S<50) was seen on transects along sparse short grass and along the creek microhabitats (S_{SS} = 44, S_{AC} = 41). In the context of grassland specialists, the dense tall grass microhabitats held the highest species during the survey whereas bush associated and crop associated microhabitats had the lowest.

With less to no Ravenna Grass growth, highly managed crop associated and bush associated microhabitats had the highest generalist species presence (S_{CAg}=48, S_{BAg}=43). Moderate numbers of generalists were found amidst the dense tall grass and sparse grass along roads (S_{DTg}=35, S_{SGg}=35). Minimal number of generalists (<30) were observed from sparse short grass and along the creek transects (S_{SSg}=28, S_{ACg}=23).

Considering abundances, specialist species comprised 32% (n_s= 829), 79% were contributed by the generalists (n_g = 1757). Microhabitat of crop associated areas had the largest congregation of individuals (n_{CA}=559) followed by other areas, viz., dense tall grass (n_{DT}=526) > bush associated areas (n_{BA}=457) > sparse grass along roads (n_{SG}=404) > sparse short grass (n_{SS}=369) > areas along the creek (n_{AC}=271). Despite this finding, crop associated areas, bush associated areas, microhabitat along the creek and sparse short grass yielded a low percentage (<30%) appraising specialist species' densities (n_{CAs}=74, n_{BAs}=85, n_{ACs}=76, n_{SSs}=104).

In contrast, specialist individuals were the densest in dense tall grass (60%, n_{DTs}=314) followed by sparse grass along road microhabitats (41%, n_{SGs}=166). December was the peak when specialists were characterized with apical numbers in all transects (except) along bush associated and crop associated areas.

Diversity values

Diversity index of Shannon was the highest for dense tall grass (H'_{DT}= 3.68) in terms of total species whereas value produced from the total transects (n=7) along the creek was (H'_{AC}= 3.347) (Fig. 4). For generalists, however, species diversity index climbed higher for crop associated areas (H'_{CAg}= 3.374) followed by sparse grass areas along roads (H'_{SGg}= 3.041) in comparison to that of dense tall grass (H'_{DTg}= 3.032). Taking the specialists into account, diversity values ranked top for dense tall grass and areas along the creek (H'_{DTs}= 2.988, H'_{ACs}=2.592) (Fig.5).

Alpha species diversity in context of grassland specialists have been analyzed using Whittaker curves based on proportional abundance (species abundance/ total abundance) against rank of species (Fig. 6). Among microhabitats, the highest diversity rank of grassland specialist was with the dense tall grass followed by sparse grass along roads and areas integrated with the creek. Bush and crop associated areas positioned lowest for specialist species density.

Table 1. Number of specialist species in each of six microhabitats along with their feeding guild, migratory habit

Species	Trophic Composition	Residency Status	Threat Status	AC	BA	CA	DT	SG	SS	Total
[nP]Eurasian Wryneck *Jynx torquilla*	Insectivore	M_w	LC	1	1	0	3	0	3	8
[nP]Common Hoopoe *Upupa epops*	Insectivore	R	LC	2	9	12	1	0	2	26
[nP]Indian Roller *Coracias benghalensis*	Insectivore	R	LC	0	5	6	0	9	1	21
[nP]Black-shouldered Kite *Elanus axillaris*	Raptor	R	LC	6	0	0	1	0	0	7
[nP]Barred Buttonquail *Turnix suscitator*	Insectivore	R	LC	0	0	0	1	0	0	1
[nP]Western Marsh Harrier *Circus aeruginosus*	Raptor	M_w	LC	0	0	0	1	1	0	2
[nP]Pied Harrier *C. melanoleucos*	Raptor	M_w	LC	0	0	0	0	2	0	2
[P]Black-headed Bunting *Emberiza melanocephala*	Seed eater	M_w	LC	1	0	0	3	0	0	4
[P]Yellow-breasted Bunting *E. aureola*	Seed eater	M_w	VU	4	0	0	50	2	12	68
[P]Little Bunting *E. pusilla*	Seed eater	M_w	LC	0	0	0	1	0	0	1
[P]Chestnut-eared Bunting *E. fucata*	Seed eater	M_w	LC	0	0	0	1	0	0	1
[P]Common Rosefinch *Carpodacus erythrinus*	Seed eater	M_w	LC	0	0	0	13	0	0	13
[P]Paddyfield Pipit *Anthus rufulus*	Insectivore	M_w	LC	10	0	12	17	20	10	69
[P]Yellow Wagtail *Motacilla flava*	Insectivore	M_w	LC	0	0	0	8	0	3	11
[P]Tricoloured Munia *Lonchura malacca*	Seed eater	R	LC	4	0	2	6	0	0	12
[P]Chestnut Munia *L. atricapilla*	Seed eater	R	LC	0	0	0	11	0	3	14
[P]Scaly-breasted Munia *L. punctulata*	Seed eater	R	LC	8	10	18	41	17	27	121
[P]White-rumped Munia *L. striata*	Seed eater	R	LC	0	0	0	3	2	0	5
[P]Indian Silverbill *Euodice malabarica*	Seed eater	R	LC	0	0	0	11	0	0	11
[P]Red Avadavat *Amandava amandava*	Seed eater	R	LC	1	0	0	11	6	8	26
[P]Baya Weaver *Ploceus philippinus*	Seed eater	R	LC	6	0	2	13	2	0	23
[P]Jerdon's Bush Chat *Saxicola jerdoni*	Insectivore	M_w	DD	0	0	0	8	0	0	8
[P]Pied Bush Chat *S. caprata*	Insectivore	R	LC	0	9	2	2	1	8	22
[P]Common Stonechat *S. torquatus*	Insectivore	M_w	LC	1	10	2	13	3	6	35
[P]Bluethroat *Luscinia svecica*	Insectivore	M_w	LC	0	0	0	4	2	0	6
[P]Siberian Rubythroat *Calliope calliope*	Insectivore	M_w	LC	1	0	0	3	0	0	4
[P]Striated Babbler *Turdoides earlei*	Omnivore	R	LC	0	13	0	13	0	0	26
[P]Yellow-eyed Babbler *Chrysomma sinense*	Insectivore	M_w	VU	0	4	0	13	60	0	77
[P]Dusky Warbler *Phylloscopus fuscatus*	Insectivore	M_w	LC	0	2	0	2	0	0	4
[P]Thick-billed Warbler *Iduna aedon*	Insectivore	M_w	LC	0	0	0	1	2	0	3
[P]Clamorous Reed Warbler *Acrocephalus stentoreus*	Insectivore	M_w	LC	4	0	0	3	1	0	8
[P]Striated Grassbird *Megalurus palustris*	Insectivore	M_w	LC	4	0	0	6	1	0	11
[P]Plain Prinia *Prinia inornata*	Insectivore	R	LC	10	0	9	22	8	7	56
[P]Grey-Breasted Prinia *P. hodgsonii*	Insectivore	R	LC	1	17	5	0	6	0	29
[P]Graceful Prinia *P. gracilis*	Insectivore	R	LC	0	5	0	0	0	0	5
[P]Golden-headed Cisticola *Cisticola exilis*	Insectivore	R	LC	10	0	0	21	13	2	46
[P]Oriental Skylark *Alauda gulgula*	Insectivore	R	LC	2	0	0	0	1	2	5
[P]Greater Short-toed Lark *Calandrella brachydachtyla*	Insectivore	M_w	LC	0	0	0	0	0	1	1
[P]Bengal Bush Lark *Mirafra assamica*	Insectivore	R	LC	0	0	4	7	7	9	27

[nP]Species, non-passerine species, [P]Species, passerine species, M_w, winter migrants, R, residents, LC, Least Concern, VU, Vulnerable, DD, Data Deficient, AC, Along the creek, BA, Bush Associated, DT, Dense Tall Grass, SG, Sparse Grass Along Road, SS, Sparse Short Grass, CA, Crop Associated

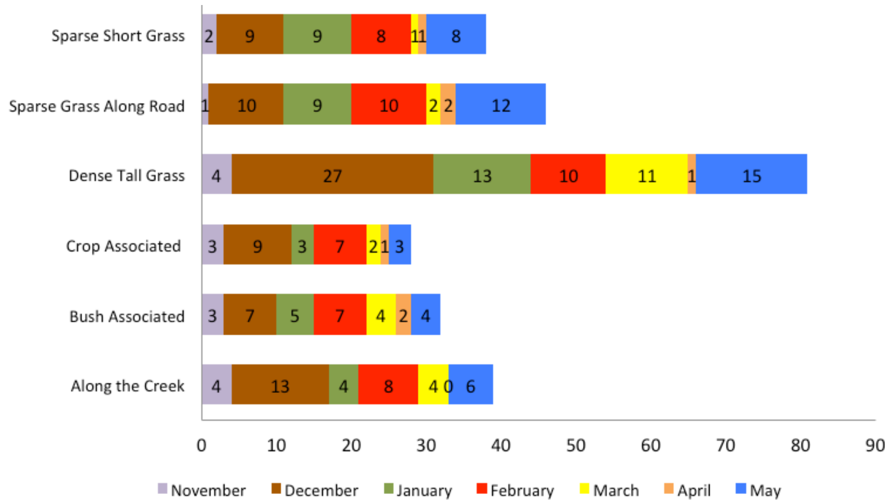

Figure 3. Number of specialist species observed in each microhabitat in each month of the study period.

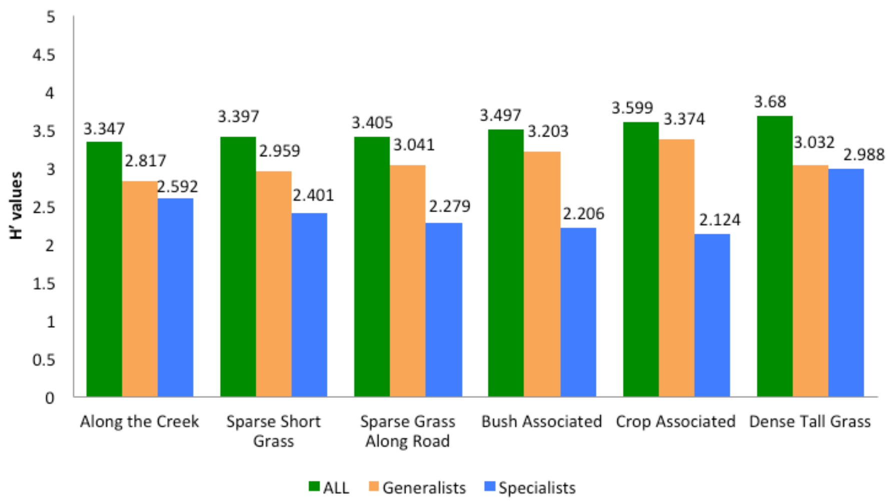

Figure 4. Shannon index for microhabitat types of the study area with variation considering all species, generalists and specialists.

Association of specialists with habitats and management attributes

LMEM models showed the significance of different microhabitats to the grassland species (Table 2). Considering richness of generalists and total richness as random effects separately and microhabitats as fixed effects, both models ($LMEM_{total}$, $LMEM_{generalists}$, respectively) depicted that over other microhabitats, area along the creek stood as most positive for specialists being trailed by the areas associated with dense tall grass. It became evident that both microhabitats along the creek and of dense tall grass were significant for the grassland specialists over the adapters.

Abundance of specialists showed a marked drop in each transect surveyed before and after slash-and-burn treatment. Wilcoxon signed rank test on these paired data supported this sharp sink in density with significance (p = 0.04); however, the effect of grazing

Table 2. Parameters estimates of microhabitat types on the grassland specialists richness from $LMEM_{total}$ and $LMEM_{generalists}$ outputs

$LMEM_{total}$			
Microhabitat types	Std. Error	t-value	p-value
Intercept	0.189	10.32	<0.001
Bush Associated Area	0.244	-0.764	0.46
Crop Associated Area	0.318	-1.111	0.29
Dense Tall Grass	0.219	2.188	0.056
Sparse Grass Along Road	0.252	0.462	0.65
Sparse Short Grass	0.187	-0.664	0.52
$LMEM_{generalists}$			
Intercept	0.227	8.833	<0.001
Bush Associated Area	0.327	-1.029	0.316
Crop Associated Area	0.361	-0.943	0.36
Dense Tall Grass	0.199	3.427	0.002
Sparse Grass Along Road	0.267	-1.015	0.323
Sparse Short Grass	0.284	-0.0845	0.9335

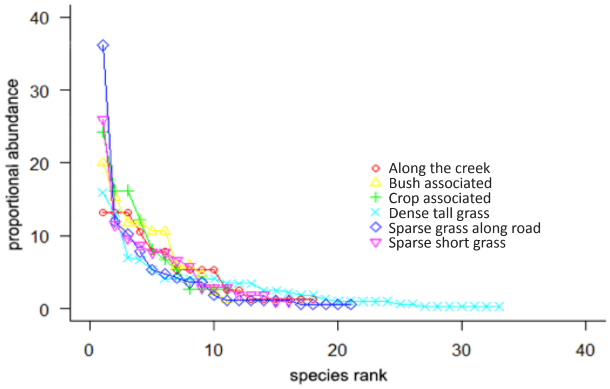

Figure 5. Rank-abundance curve (grassland specialists) for microhabitats of the study area.

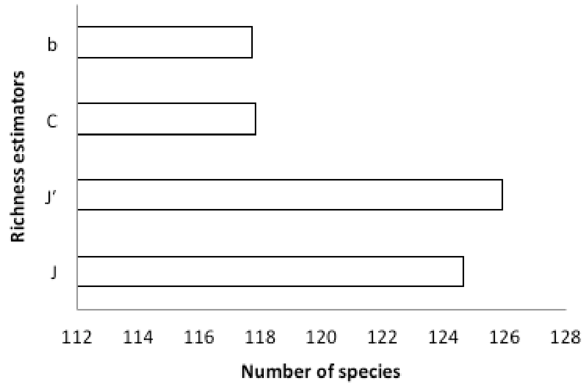

Figure 7. Estimation of total avian species presence in the study area. Richness estimators: first- and second-order Jackknife (J, J'), Chao (C) and bootstrap (b).

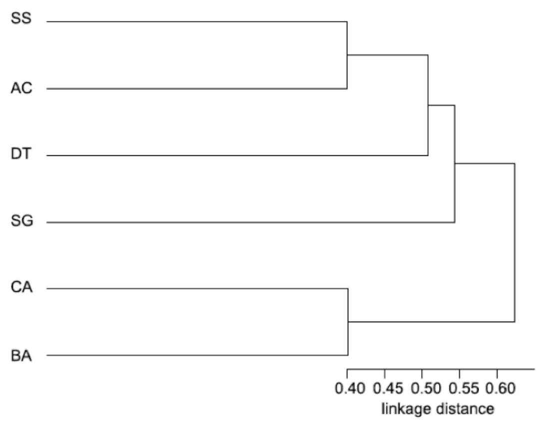

Figure 6. Clusters of microhabitats considering species composition. Microhabitats: AC - along the creek, BA - bush associated area, DT - dense tall grass, SG - sparse grass along road, SS - sparse short grass, CA - crop associated area.

pressure did not show any statistical difference ($p>0.05$).

Similarity in community structure

Resemblance of these micro-landscapes in species composition had been delineated with linkage distance applying Bray-Curtis cluster analysis (single link) (Fig. 7). It appeared that composition found in areas associated with bush and crops held strong differences compared to others, most evident with that of microhabitats of sparse short grass and areas along the creek. The distances also showed that species composition in roadside sparse grass and dense tall grass differed significantly from the clade of BA and CA.

Prediction analysis

Total species for the study area had been estimated using extrapolation of results with first- and second-order Jackknife (J, J'), Chao (C), and bootstrap (b) richness estimators (Fig. 7). Richness estimators yielded close results within a range of 117-126 species for the grassland patch.

DISCUSSION

These 110 species observed from the survey yielded about 15% of the country's total bird species. Though generalist birds made the most chunk of the area's avifauna (65%), the presence of 39 specialists in the area—35% of the total composition, up to half in comparison with Khan (1988)—was pertaining to the specialization of the study site's potentiality to harbor habitat specific fauna.

All specialists have shown significant association in preference to the dense tall grass and area along the creek in comparison to the remaining four microhabitats. Yet crop associated area exceeds the index for generalists, dense tall grass stands with the highest diversity status for total composition as well as for the specialists. From this micro-landscape, together with the area along the creek, most rare sightings for the area are noted, like all five estrildid finches of Bangladesh, one fringillid finch, one ploceid, four emberizids, viz., Yellow-breasted Bunting *Emberiza aureola*, Black-headed Bunting *E. melanocephala*, Yellow-eyed Babbler *Chrysomma sinense*, Jerdon's Bushchat *Saxicola jerdoni*, and species from the genera *Prinia, Calliope* and *Luscinia* (Table 1). Yellow-eyed Babbler and Yellow-breasted Bunting both are threatened in Bangladesh, the latter is Critically Endangered at the global scale (IUCN Bangladesh 2015a).

From the microhabitat of dense tall grass, the maximum single count of Common Rosefinch *Carpodacus erythrinus* (n=13) and Yellow-breasted Bunting (n=50) was recorded being the largest congregation in terms of single survey attempt (Round et al. 2014; Thompson et al. 2014; IUCN Bangladesh 2015a). Sighting of Black-headed Bunting was only the fourth national record to the country (Chowdhury 2016). The grass patch is also the only known breeding ground of Golden-headed Cisticola *Cisticola exilis*.

Appraising the composition for the microhabitat, bush-associated and crop-associated areas gave the most generalized avian community. Community architecture was comparatively the most unlikely for the area along the creek and for sparse short grass. Microhabitat of sparse short grass had the third highest diversity index on the list but produced species which were less abundant or even absent in some surveys for dense tall grass and area along the creek. Sparse short grass specifically gave records for Pied Bush Chat *Saxicola caprata* and species like the Oriental Skylark *Alauda gulgula*, Greater Short-toed Lark *Calandrella brachydactyla*, the Bengal Bush Lark *Mirafra assamica,* Common Hoopoe *Upupa epops*, the Eurasian Wryneck *Jynx torquila*, pipits *Anthus* spp., and wagtails *Motacilla* spp. having preference for less dense sparse grass and open areas (Table 1) (Siddiqui et al. 2008b).

Though human-caused slash-and-burn management gave a significant reduction to the avian density (both adapters and specialists) of the area, grazing–which was observed being carried out throughout the survey–did not exert significant effect on the birds. Additionally, even after burning the patch which was a sudden and rapid disturbance, specialists did not disappear completely from the area, rather they showed a gradual departure (Fig. 3). The presence of several specialists even after complete torching of the site in February and insignificant end result of grazing might have had a relation to the centralized position of the dense tall grass area (core area), also to the ecology of the specialists. Most of the specialists were small passerines with edge avoidance tendency (Johnson & Lgl 2001; Sliwinski & Koper 2012; Ellison et al. 2013; Besnard et al. 2016). Relevantly, it should be enumerated that the only ground-dwelling species observed from the area was a single individual of Barred Buttonquail.

Furthermore, Ravenna Grass is highly unpalatable and has a noxious effect on cattle, being typical of a *Saccharum*, as mentioned by Seifert & Beller (1969), Henty (1982), Pandey et al. (2012), and Gul et al. (2014). Along with noxiousness of *Saccharum*, the low palatable rate of Cogon Grass has also been noted (Khatri & Barua 2011; Goroshi et al. 2015). Such unpalatable grasses, in turn, have been assumed to be ideal for proper avian breeding, feeding and roosting ground (Callaway et al. 2000). Besides, the study site is a pocketed grassland patch, heavily managed and has to support routine grazing activities which might act as a trigger for the less palatable and unpalatable, fire-resistant plant species' ascendancy as well as replacing or ousting most obligate grassland species (Knopf 1994; Zalba & Cozzani 2004; Pandey et al. 2015). Avian composition, management practices and grazing avoiding attribute of *Saccharum* and *Imperata* could be the possible causations for association of specialists' presence with dense tall grass and the area along the creek and sparse short grass in a respective sequence, amidst clear dominance of the generalists and other factors.

Unpalatable nature of grasses is a common phenomenon. As of Moore & Jung (2001), with low nitrogenous nutrient content, unpalatable grass species are used to protect themselves from grazing by storing high amount of acid-unhydrolizable fractions (AUF) in the form of structural carbohydrate. Amalgamation of unpalatable neighbors with edible grass species in naturally or semi-naturally maintained grassland ensures avoidance from being grazed totally, thus, together with sparse grazing effect from wild herbivores, confirm complete ecosystem functioning (Fretwell & Barach 1977; Milchunas et al. 1987; Peart 1989; McNaughton 1993; Frank & Evans 1997; Callaway et al. 2000).

In total, *Saccharum* dominated grasslands and habitats comprise about 0.8 million hectares in Bangladesh (IUCN Bangladesh 2015a). Cultivation of sugarcane *S. officinarum* encompasses about another 0.16 million hectares throughout the northern and northwestern districts (Ahmed et al. 2008a). While Ravenna Grass is mainly concentrated towards northeastern regions throughout the country's 174 tea gardens, another congener *S. spontaneum* occupies the central region as well as the vast sand bars on the Ganges and the Jamuna (Ahmed et al. 2008a; Ahammed 2012). Though enigmatic grassland specialists have gone from Bangladesh, this existing *Saccharum* spread is still of importance for many species, yielding records at regular intervals (Round et al. 2014; Khan et al. 2015). Together with sugarcane, *Saccharum* species hold significant economic benefits. For example, materials for making huts and cottage industries are extracted on a yearly basis (Ahmed et al. 2008a).

As timely intervention after Khan (1988), the study, along with Akash et al. (2017), presented specialist avian diversity from any anthropogenic grassland, their interaction with such habitats and stands as an updated reference for further researches and comparative studies. Conserving tea garden grasslands might act as an advantage for mending feasible conservation strategies for grassland birds, as *Saccharum* has a natural resistance against grazing, noteworthy economic benefits and still supports specialized avian diversity. The results of this study further illustrate the value of habitats still present in tea estates for globally and nationally threatened birds. The authors suggest that conservation attempts for the country's last grasslands and their denizens should be considered of low grazing importance and marked seasonality in commercial value of *Saccharum* sp. as well as a form of eco-birding, particularly, for northeastern tea gardens.

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Image 2. Baya Weaver

Image 3. Bengal Bushlark

Image 4. Black-winged Kite

Image 5. Bluethroat

Image 6. Chestnut-eared Bunting

Image 7. Common Hoopoe

Image 8. Golden-headed Cisticola

Image 9. Graceful Prinia

Image 10. Grey-breasted Prinia

Image 11. Indian Roller

Image 12. Paddyfield Pipit

Image 13. Pied Bushchat

Image 14. Plain Prinia

Image 15. Red Munia

Image 16. Scaly-breasted Munia

Image 17. Striated Babbler

Image 18. Tricolored Munia

Image 19. White-rumped Munia

Image 20. White-tailed Stonechat

Image 21. Yellow Wagtail

Image 22. Yellow-breasted Bunting

Image 23. Yellow-eyed Babbler

Journal of Threatened Taxa

www.threatenedtaxa.org

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

June 2018 | Vol. 10 | No. 7 | Pages: 11831–11998
Date of Publication: 26 June 2018 (Online & Print)
DOI: 10.11609/jott.2018.10.7.11831-11998

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