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Full Length Research Paper

Diversity of local varieties of banana and plantain cultivated in Benin

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Banana and plantain are popular fruits considered as major staple foods, and provide significant income to farming communities. A handicap to their development and production remains access to quality suckers. However, their diversity is still unknown in Benin. To assess the knowledge on the diversity of local varieties of both dessert banana and plantain at the community level, ethnobotanical surveys were undertaken using participatory research appraisal tools such as direct observations, group discussions and field visits from 119 interviewees living in 63 villages from 24 communes districts in Central and South of Benin. A total of 121 farmer-named banana and plantain varieties (83 vernacular names for banana and 39 others for plantains) were recorded and gathered into 58 differentiated varieties on the basis of the significance of the vernacular name relying on morphological traits and medicinal uses. Southern ethnic groups hold higher local varieties (*H* = 3.15 bits for the ethnic group Fon and *H* = 2.09 bits for Wemegbé) due to the high rainfall conditions favorable for the development of banana species than those from Central-Benin (*H* = 0.64 bits for the sociocultural group Mahi). The main constraints to these crop productions were drought (23.8% of responses), stealing of the whole bunch (19.0%), pests and diseases (14.3%), susceptibility to flood (9.5%) and pseudostem break by wind (7.8%). *In situ* and *ex situ* conservation should be undertaken to preserve the varieties cultivated by a few households on small areas defining their vulnerability status as well as those most commonly produced in large amounts.

Key words: Banana, plantain, parataxonomy, conservation, varietal diversity, Benin.

INTRODUCTION

The majority of cultivated bananas arise from the *Eumusa,* one of the four groups from the genus *Musa* (Daniells et al., 2001). All *Eumusa* species are almost completely sterile because of the lack of fertilization so

that fruits are parthenocarpic including non-seeded types (Sweenen et al., 1995). Most cultivars are derived from two species, *Musa acuminata* Colla (the most widespread species of *Eumusa* and represented by the symbol A) and *Musa balbisiana* Colla (symbol B). In the tropical and subtropical regions, rural populations depend heavily on various food plant resources to satisfy particular nutritional and therapeutic needs. Banana and plantain are popular fruits, which are considered as major staple food and important components of food security for many households, and provide significant income to the farming community through local and international trade (Crouch et al., 1998). Plantain fruit is rich in carbon hydrate and highly energizing; it is an edible and sweet fruit consumed as dessert or as a cooked crop (plantain and banana). These fruit crops include 90% of banana and 10% of plantain (Lescot, 2006), and represented the second largest fruit crops of the world after citrus with a contribution estimated to be 16% (Debabandya et al., 2010). It represents the fourth world crop (more than 117 tons millions of annual production, Lescot, 2011) after rice, wheat and maize (Lassoudière, 2007). Banana is mainly cultivated for its highly nutritious and digestible mature fruit, which is also considered as a source of energy (Jenny et al*.,* 2003). It is rich in potassium and calcium with low sodium content as well as vitamins A and C, and carotene. However, these component contents vary according to the cultivar ploidy level (Happi et al*.,* 2007; Debabandya et al*.,* 2010). Its richness in glucides leads to its high energetic value close to some large amylaceous products such as yam, sweet potato, taro, and potato (Ongagna et al., 2016). It is consumed under various forms including porridge, chips, crush, and pastries; plantain processed in flour is used to make bread, fritter, foufou (puree from mixing in a mortar of the plantain boiled in water), cracker, cake and to thicken sauces (Tomekpe 2006). Apart from its consumption as fruit, banana is also processed in making local beer in East Africa (particularly in Uganda, Hamilton et al., 2016, Daniells et al., 2001), or to produce alcohol and phytosanitary products. Its importance is expressed through its cultivation in houses as well as in small areas so that fruits and all products are available all through the year. Moreover, in contrast to other crops such as cereals, the cultivation of banana and plantain appears to be a good biological plant species candidate adapted to climate change, because a temperature increase of 3°C remains favorable for their development (Calberto et al*.,* 2016).

With an annual production of 19,000 tons, Benin is a small producer compared to other African producing countries (FAOSTAT 2016). However, banana production is growing each year and large areas are devoted to production mainly in the south and central parts of the country. Unfortunately, little research has been carried out in Benin on these phytogenetic resources often referred to as "miners" crops. There is no report on varietal diversity of cultivated banana and plantain in Benin, as well as the endogenous knowledge related to the production of banana. Recent studies have been undertaken on ethnobotany, production, diseases as well as agronomic performance, morphological genetic variability assessment and their implications for the productivity and sustainability of banana and plantain grown for domestic consumption and trade, improvement and conservation. However, little is known on species' and cultivars' vulnerability level considering their production and constraints in diverse cultivated environments following climate deregulations.

To assess the knowledge on varietal diversity of both banana and plantain at the community level and define strategies for its management in Benin, we used participatory research appraisal tools through ethnobotanical surveys. We addressed the following questions: Do cultivated banana and plantain harbor differentiated local varieties? Are there similar local etymological names that would suggest a good parataxonomy? What is the level of varietal diversity according to district? Are there evidence of producers' varietal preferences criteria and production constraints?

MATERIALS AND METHODS

Sampling and area of study

Investigations were made using questionnaire surveys combining many variables, from vernacular names to pests, uses and perceptions (complemented by direct field observations) from 119 interviewees of both sexes from different age classes. They included producers randomly sampled (n = 62), local farmers' associations and group discussions of people holding on these crops knowledge and living in 63 villages from 24 Communes throughout eight districts in Central and South of Benin where banana and plantain are recognized to be mainly produced (FAOSTAT 2016). Prospected districts are shown in Figure 1. This area is inhabited by nine ethnic groups, among which the most important included Fon, Goun, Kotafon and Adja in South; while Nagô and Fon are predominant in Centre. Annual rainfall ranges from 900 to 1400 mm. Daily relative humidity and temperature vary between 18 and 99%, and 18 and 42°C, respectively; and the yearly average potential evapotranspiration (ETP) is 1550 mm (ASECNA, Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar, 2010). Southern Benin is characterized by a humid subequatorial climate with 4 seasons of unequal

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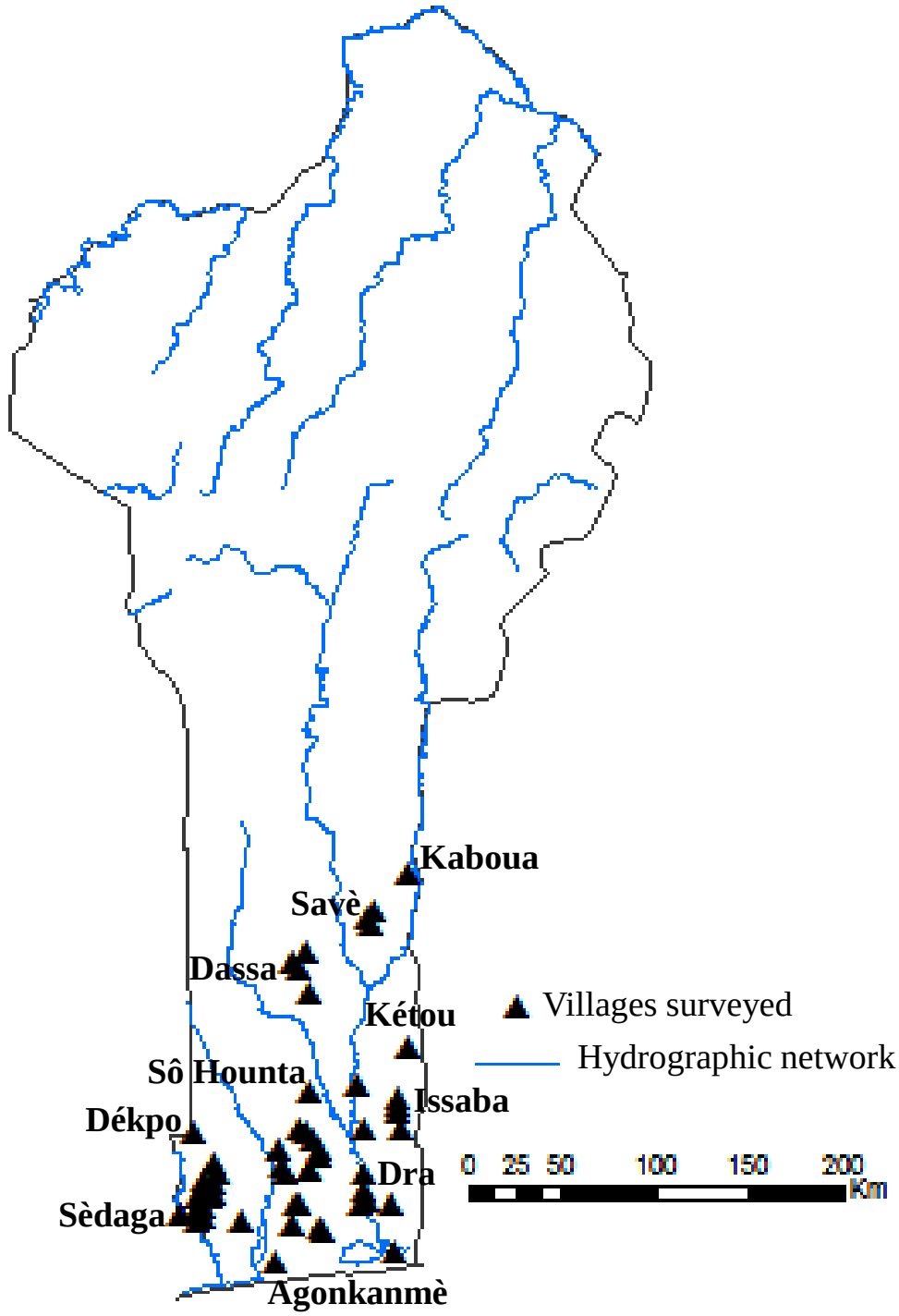

Figure 1. Location of the villages surveyed in Benin.

duration, two rainy seasons alternating with two dry seasons. The short dry season is centered on August while the second dry season extends from November to February. Annual temperature ranges from 25 to 29°C. The Centre of Benin is under the influence of transition between the subequatorial and sub-Sudanian climates. The transition is most marked between semi-deciduous rain forests and savanna woodlands, presenting all intermediate aspects between both plant communities.

Data collection

Ethnobotanical surveys relied on socio-cultural profile of the respondents (age, level of education, and ethnicity), banana and plantain locally grown and their vernacular names and etymology, plantation age and status (ownership or inheritance), uses (dessert, food, medicinal ingredient, etc.), food processing, fruit ripening methods, production area, criteria governing preference in breeding

schemes, age, socio-economic importance, production constraints, susceptibility to climate deregulation and soil, conservation techniques, and diseases. To limit errors in respondents' response, the investigation considered uses already documented, especially those for which part of the plant is solicited. Interviews were followed by observations in the farmers' home gardens/fields for appraisals of traditional morphological descriptors as perceived by local people and for suckers collection for agro-morphological characterization and national collection.

Analysis

An exhaustive list of vernacular names of local species and varieties of banana and plantain was established. Descriptive statistics (frequency, percentage, mean, etc.) were run in R2.12.0 (Venables and Smith 2010) to generate summaries and tables at different scales (villages, departments, and study area). Banana and plantain variety diversity was assessed using several parameters: varietal richness and abundance (at both local and regional levels that is sites and region respectively), while varietal richness, Shannon diversity index (*H*) according to Frontier and Pichod-Viale (1995) and Equitability index of Pielou (*E*) were estimated at ethnic group level.

$H = -\sum(ni/N)*\ln(ni/N)$, where ni = number of citation of the variety i by the farmers from an ethnic group and N = sum of ni for all varieties quoted within the ethic group considered. The varietal diversity was considered as low if $H < 3$ bits, medium if $3 < H < 4$ and high whether $H > 4$ bits.
$E = H/\ln(R)$, while *H* represents the diversity index of Shannon and *R* is the total number of local varieties cited. It varied from 0 to 1. More it is close to 1, more there is a fair citation of varieties within the ethnic group.

Allocated areas (large vs. small; that is, < 0.25ha) and frequency of presence of each variety were used to identify unpopular and/or rare varieties (citation frequency < 0.25 and produced at small scale, often found in a home garden). This led to the identification of varieties potentially threatened from those highly abundant. The software ArcGIS version 10.4 was used to draw the map of the study area.

RESULTS

Diversity, vernacular names and etymology of banana and plantain varieties

All banana and plantain species were designated by the same vernacular generic name by each ethnic group across area of study. Indeed, "Kokoe" in Fon and "Oguèdè" in Nagô languages are used for both banana and plantain. Banana varieties were more abundant than those of plantain, varying from 1 to 13, within and among villages and administrative divisions. At the scale of village, the village named Guémé from district of Zogbodomey is the richest site, harboring 13 local varieties. The district of Dangbo with an average of 11 varieties and the department of Ouémé with an average of 7.12 varieties ranked first, respectively, at the district and department levels. The mean number of local varieties varied significantly with district ($p = 0.01$) as well as at the department level ($p = 0.07$; Table 1). A total of 122 farmer-named banana and plantain varieties (83 vernacular names for banana and 39 others for plantains) were recorded from the nine ethnic groups surveyed. Their significance, based on discriminant traits described by farmers, was used to gather them into 58 differentiated local varieties: 16 for plantain and 42 for banana (Table 2).

In total, 15 varieties (25.9% from the 58 varieties recorded) were popular among which five varieties (two plantains and three bananas) economically profitable varieties, were widely cultivated by many households on large scale (> 0.50 ha): plantain of white pulp, plantain of yellowish pulp for plantain varieties, while dessert banana varieties included Planta, Sotoumon, and Gba kokoé. Some rare varieties cultivated by few households (cultivated areas < 0.25 ha) were recorded, gathering 12 plantains with particular traits such as hand number on peduncle, and 26 dessert banana varieties from which many had medicinal uses (Table 2), while others were of poor agronomic performance (e.g., susceptibility to lodging and drought, reduction of the productivity with the age, low market value, pest and diseases).

At the ethnic group level, southern areas of Benin harbored the most varietal diversity. Indeed, Shannon' diversity index was $H = 3.15$ for the ethnic group of Fon and $H = 2.09$ for Wemegbé' ethnic group, displaying an equitable citation of varieties, $E = 0.94$ and $E = 0.87$ respectively. In other words, each variety almost had the similar citation frequency by farmers within an ethnic group. In the opposite, ethnic groups from Centre of Benin such as Mahi, Nagô and Idaasha were less rich especially the sociocultural group Mahi ($H = 0.64$, $E = 0.31$).

Vernacular names often referred to particular diagnostic traits of pseudostem height, peduncle number, rachis number per peduncle, hand number, pericarp or peel color, pulp color at maturity and rachis position. Thus, the vernacular names of the dwarfish banana variety referred to rachis fell vertically facing the ground and named « Dohêzè » or « Gbakokoé » (in Fon), « Kotchou kpoui » (Adja), « Ko dodoé » or « Gnimagnan » (Kotafon), « akêtê » « Fanoukolè », « Ashoféri kanlè », « akalèda » « Agbavlan » (in Nagô) (Figure 2). In respect to the single peduncle that displayed only one hand, a plantain variety was named « Alloga Akpazindokpo » (Fon) while plantain producing only two hands was called « Mandangan alovi awé » (Adja), « Avlandjangan koawé », « Adjangan agbavé » or « Avlan tchèkètè » (Kotafon); in the opposite plantain with two peduncles interpreted as twin was named « Alloga ahovi » (Fon), « Adjangan ayavi awé » (Kotafon), « agbaagba eleri medji » (Nagô), alloga kƆwénon (Aïzo) (Figure 2 for illustrations). In the same way, the vernacular name « alloga ko aton » referred to triplet peduncles produced simultaneously by another plantain variety (Table 2). It must be noticed that the vernacular name « lêkè » or « gnimagnan » of the dwarfish banana

Table 1. Mean number of local varieties recorded in the studied area, based on interviews and fieldwork observations.

District	Mean (± sd)	Division	Mean (± sd)
Kpomasse	2.00 ± 0.00	Littoral	2.00 ± 0.00
Abomey-Calavi	5.00 ± 0.00		
Allada	4.66 ± 2.08	Atlantique	5.13 ± 2.35
Toffo	5.87 ± 2.74		
Torri Bossito	3.00 ± 1.41		
Aplahoué	3.50 ± 3.53		
Djakotomey	4.00 ± 0.00	Couffo	3.71 ± 1.49
Dogbo	3.66 ± 0.57		
thiémé	4.50 ± 2.64		
Houeyogbé	6.00 ± 0.00	Mono	4.80 ± 1.98
Lokossa	4.50 ± 1.91		
Adjohoun	5.75 ± 0.95		
Dangbo	11.00 ± 0.00	Ouémé	7.12 ± 2.47
Sèmè-Kpodji	6.00 ± 0.00		
Ketou	4.00 ± 0.00		
Ouinhi	6.00 ± 0.00	Plateau	5.60 ± 1.50
Pobè	5.00 ± 0.81		
Sakété	8.00 ± 0.00		
Dassa	2.66 ± 0.57		
Glazoué	5.00 ± 1.41	Collines	4.25 ± 1.58
Savè	5.33 ± 1.15		
Za-Kpota	1.00 ± 0.00		
Zagnanado	7.50 ± 2.12	Zou	5.66 ± 4.09
Zogbodomey	6.80 ± 4.26		
Df 45, F 2.22, p = 0.01		Df 65, F 1.97, p = 0.07	

Df = degrees of freedom; sd= standard deviation.

variety is related to the green color of fruits at maturity.

Farmers' perceptions of constraints to dessert banana and plantain production

Banana and plantain were mainly cultivated in lowland and along riversides where it found favourable growing conditions (appropriate rainfall and temperature). However, there was a substantial yield decline and reduction in plantation life due to water availability and pests and diseases especially in the eastern sites of Benin. Fourteen biotic and abiotic constraints were reported as main causes for the decline of banana and plantain genetic resources. Farmers identified susceptibility to drought (23.8% of responses), stealing of the whole bunches (19.0%), pests and diseases (14.3%), susceptibility to flood (9.5%) and break of pseudostem break by wind (7.8%) as the major production constraints (Figure 3). Many criteria were used by farmers in the choice of varieties to put into production. The first criterion was related to the market value of the variety. Taking into account this criterion, plantain varieties appeared to be more expensive than dessert banana. However, the importance of productivity (big bunch supporting many fruits), good taste of the fruit and preferred landraces by consumers, and medicinal uses were factors of preserving varieties. Farmers observed that pest damage was more severe when soil fertility is poor. Farmers used various chemical products to destroy pests. To value the empty space between individuals and improve farmers' incomes, banana dessert and plantain

Table 2. Vernacular names and etymology of banana crops cultivated in Benin. H+A+: varieties cultivated by many households on large areas (> 0.50ha); **H+A-:** varieties cultivated by many households on small areas (< 0.25ha); H-A+: varieties cultivated by few households on large areas (> 0.50ha); **H-A-:** varieties cultivated by few households on small areas (< 0.25ha). N_P: Plantain number per ethnic group; N_B Banana number per ethnic group; *N*: Banana and Plantain number per ethnic group; *H*: diversity index of Shannon; *E:* Equitability index of Pielou.

Crops	Variety local names									Etymology	Area production
	Fon / Sahuè	Kotafon	Mahi	Nagô / Yoruba	Idaatcha	Wémègbé	Adja	Aïzo	Holli		
Plantain	Alloga wewe, Alokpé	Ayavlan, Avlan blanc, Dan vlan, Adjangan, Avlan djangan	Alloga wewe	Agbaagba	Agbaagba	Djavlan, Yivlan, Tchèkè	Mandangan	Adjangan / alloga	Aagba	Long and large fruit, pulp white	H+A+
	Alloga vovo	Avlan vovo	Alloga vovo	Aagba kpikpa	-	-	-	-	Aagba kpikpa	Long and large fruit, yellowish pulp	H+A+
	Alloga ko awé	kôawé Adjangan kôawé	Agokoé	Aagba élérimédji	-	Avlan hoovi	Mandangan ékôvé	alloga kƆwénon	-	Twin (double) peduncles	H+A-
	-	Avlan Côte d'Ivoire	-	-	-	-	-	-	-	Plantain from Ivory Coast	H-A-
	Alloga Akpazinwénon	Avlan tchêkêtê, Avlan djangan "ko awé", Adjangan agbawé	-	-	-	-	Mandangan alovi awé	-	-	Peduncle of two hands	H-A-
	Alloga Akpazindokpo	Avlan djangan ayavi dokpo	-	-	-	-	-	-	-	Peduncle of a single hand	H-A-
	-	Avlan djangan ayavi awé, Avlan hoovi	-	-	-	-	-	Adjangan Aya amèvé	-	A single peduncle shared into two sub-peduncles	H-A-
	Azɔwê	-	-	-	-	-	-	-	-	Peduncle supporting up to 100 fruits	H-A-
	Alloga élancé	-	-	-	-	-	-	-	-	-	H-A-
	Alloga court sucré	-	-	-	-	-	-	-	-	-	H-A-
	-	Adjangan akpahissi	-	-	-	-	-	-	-	-	H-A-
	-	Adjangan allokpoé	-	-	-	-	-	-	-	-	H-A-
	-	So vlan	-	-	-	-	-	-	-	-	H-A-
	Alloga (rouge)	-	-	-	-	-	-	-	-	Red bunch	H-A-
	Alloga ko aton	-	-	-	-	-	-	-	-	Triplet peduncles	H-A-
	Alloga ko ènin	-	-	-	-	-	-	-	-	Quadruplet peduncles	H-A-
Banana	Planta	Planta	-	Planta	-	Planta	Planta	Planta	Gbangan	-	H+A-
	Sotoumon wewe	Sotoumon, Tokpovi	Fon kokoé	-	-	-	Sotchoumon, Akoɖu	Sotoumon	Igbangan	-	H+A+
	Sotoumon wiwi	-	-	-	-	-	-	-	-	-	H+A-
	-	-	-	Oguêdê agbodjouba, Oguêdê iré	Agbodjouba, Abalayé	Ogou kokoé	-	-	-	Authentic /ancient banana	H-A-

Table 2. Contd.

-	-	-	-	-	-	-	-	Omèné egou	Divinity banana	H-A-
-	-	-	-	-	-	-	-	Olori		H-A-
-	-	-	-	-	-	-	-	Kpoko kpoko	-	H-A-
dohêzê, gba kokoé	Ko dodoé, Agba vlan		Olori, Alakpadèrè, Oguêdê ognibo, Fanoukolê, Omèné asho féri kanlè, Ominin oyibo	Akaleda, Okounleda	Dohêzê, Akêtê	Gnimangnan, Kotchoukpoui	-	-	Short and dwarf individual banana of which rachis and male bud falling vertically towards the ground, mature fruit displayed green peel	H+A-
Tchon	-	-	-	-	Tchon, Hlo kokoé	Atchon, Limouvlan	-	-	-	H+A+
-	-	-	-	-	Gbogui	-	-	-	-	H-A-
-	-	-	-	-	Gangni kokoé	-	-	-	-	H-A-
So kokoé, Dan kokoé	-	-	-	Edjo	So kokoé	Dan mandan	-	-	Red morphological traits followed with red fruits, variety used against thunder	H+A-
Djigba kokoé, Gba kokoé	-	-	-	-	Kpododji	-	-	-	Thick-set banana individual of which rachis and male bud falling vertically towards the ground, mature fruit displayed green peel	H+A-
Gangni hoho	-	-	-	-	-	-	-	-	-	H-A-
Gnikpo	-	-	-	-	-	-	-	-	-	
-	-	-	Olori (conf sotoumon)	-	-	-	-	-	-	H-A-
-	-	-	-	-	-	-	-	Kpofou kpofou	-	H-A-
-	-	-	-	-	Gbofoutou	-	-	-	-	H-A-
-	-	-	-	-	-	-	-	-	-	
-	Limou kokoé, Atchon, Limouvlan	-	-	-	-	-	-	-	-	H-A-
Chinoikokoé	Chinois vlan, Chinois avlan	-	-	-	-	-	-	-	introduced by Chineses	H-A+
-	Zodjagué	-	-	-	-	-	-	-	-	H-A-
-	Edɔ mandan, Edan mandan	-	-	-	-	Tokpovi	-	-	-	H-A-
-	-	-	-	-	-	Wontissu	-	-	Dwarf and long variety	H-A-
-	-	-	-	-	-	Ehoun mandan	-	-	-	H-A-
Ma kokoé	-	-	-	-	-	-	-	-	-	H-A-

Table 2. Contd.

	Dan yotchio	-	-	-	-	-	-	-	-	-	H-A-
	-	-	-	-	-	-	Dan kodu	-	-	-	H+A-
	-	Dan vlan	-	-	-	-	-	-	-	-	H+A-
	Pantifou, Panfoutou	-	-	-	-	-	-	Pantifou	-	-	H+A-
	Aso honnou	-	-	-	-	-	-	-	-	Not eaten by men	H-A-
	Kpahissi	-	-	-	-	-	-	-	-	Small avlan	H-A+
	-	-	Atchanfan	-	-	-	-	-	-	Introduced by CARDER institute	H-A-
	-	-	Collette	-	-	-	-	-	-	-	H-A-
	-	-	Akokoé	-	-	-	-	-	-	-	H-A-
	-	-	Djanglè	-	-	-	-	-	-	Variety resistant to flood	H-A-
	Amahoui	-	-	-	-	-	Amahoui	-	-	-	H+A-
	-	-	-	Fanta	-	-	-	-	-	-	H-A-
	-	-	-	Oguêdê Ghana	-	-	-	-	-	Introduced from Ghana	H-A-
	-	-	-	Oguêdê atacora	-	-	-	-	-	Introduced by the ethnic group Somba from the department Atacora (North-West Benin)	H-A-
	-	-	-	Oguêdê adjatchè	-	-	-	-	-	Originated from the town Porto-Novo (South-East Benin)	H-A-
	-	-	-	Ominin Gambari	-	-	-	-	-	Banana of the ethnic group Gambari (from Sahelian countries)	H-A-
***N*P**	11	10	3	3	1	2	3	3	2	**4.22 ± 3.63**	-
***N*B**	16	8	5	9	3	9	10	3	6	**7.67 ± 4.06**	
N	27	18	8	12	4	11	13	6	8	**11.89 ± 7.02**	
***H* (bits)**	3.13	1.31	0.64	1.02	0.72	2.09	1.63	0.43	0.84	**1.31 ± 0.85**	-
E	0.94	0.45	0.31	0.41	0.52	0.87	0.68	0.26	0.40	**0.54 ± 0.23**	-

productions were often associated with various cereals especially maize (*Zea mays*) and other food crops such as cassava (*Manihot esculenta*), groundnut (*Arachis hypogea*), watermelon (*Citrullus lanatus*), tomato (*Lycopersicon esculentum*), chilli (*Capsicum annuum*), potato (*Ipomoea batatas*), and taro (*Colocasia esculenta*).

Uses

People used banana and plantain in four main categories: dessert and food (52%), traditional medicine (19%), handicraft (13%) and social well-being (10%) and others (6%). Bunch was often kept on individual plants until fruit maturation before its harvest. Hand fruits were then detached from rachis; banana ripening stepped up under the lee of light in the open air, or it was packed in other plant species' leaves such as *Musa* spp., *Spondias mombin, Albizia adianthifolia, Azadirachta indica, Olax subscorpioides, Lonchocarpus sericeus* within tins or pots

Dwarfish banana variety of which rachis falled vertically facing the ground and named « Dohêzè », « Gbakokoé », « Kotchou kpoui », « Ko dodoé », « Fanoukolè », « Ashoféri kanlè »

Plantain with twin peduncles named « Alloga ahovi », « Avlandjangan koawé », « Adjangan Aya amèvé », « agbaagba eleri medji », alloga kƆwénon (aïzo)

Plantain A = plantain of a single peduncle shared into two units called «Avlan djangan ayavi awé» **Plantain B** = plantain of which peduncle supported up to 100 fruits « Azɔwê », **Plantain C** = plantain producing two hands named « Mandangan alovi awé », « Adjangan ayavi awé », « Adjangan agbavé », « Avlan tchèkètè »
Banana A = thick-set and sweet banana of which rachis and male bud falled vertically towards the ground named « Djigba kokoé » or « Kpododji », **Banana B** = ancient banana, **Banana C** = Red morphological traits followed with red fruits « So kokoé », « Dan kokoé » or « Dan mandan »

Figure 2. Photographies showing distinct fruit traits of some varieties of banana and plantain.

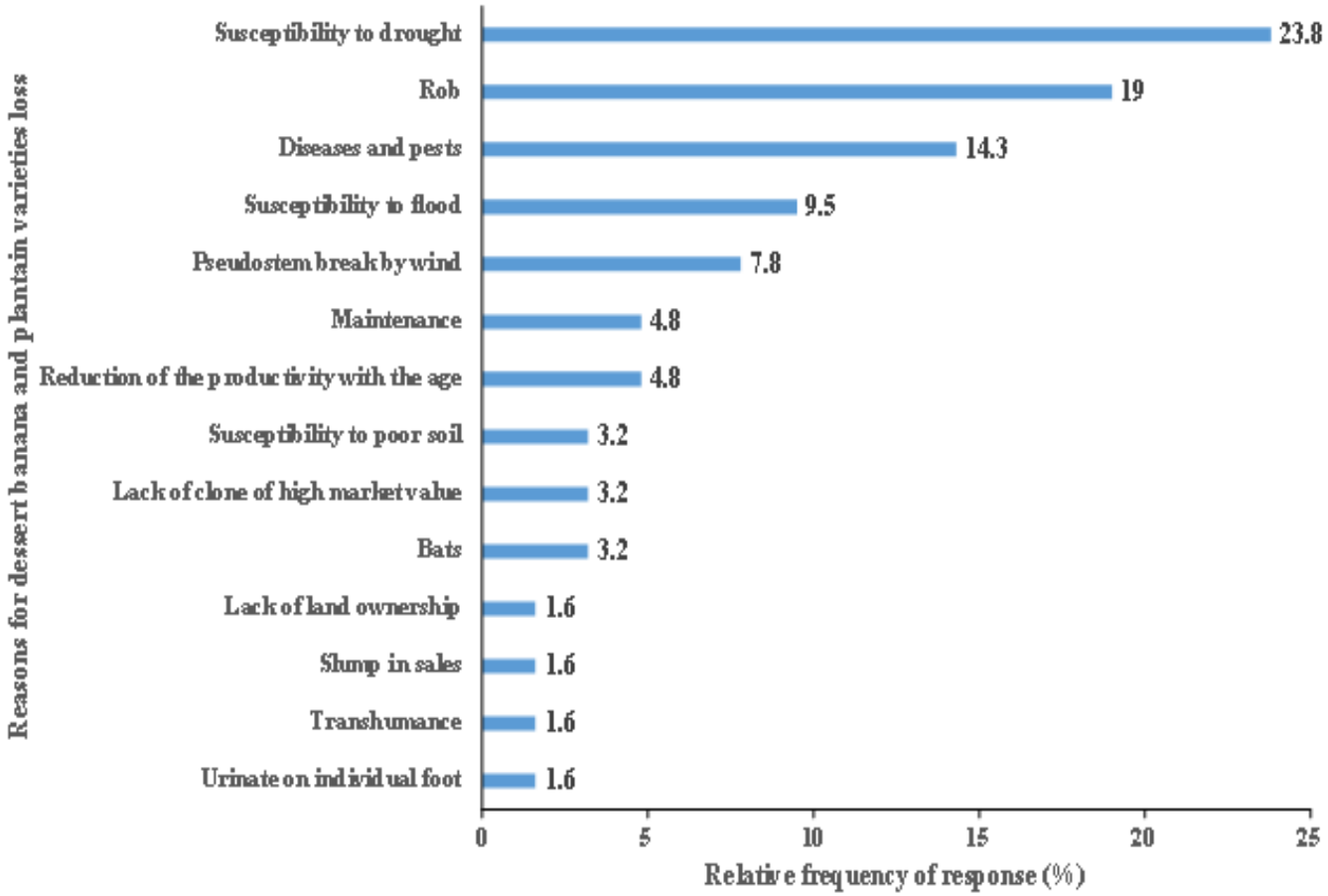

Figure 3. Banana and plantain production constraints in Benin.

including immature tree fruits of *Irvingia gabonensis, Adenopus breviflorus, Elaeis guineensis.* All ethnic groups from South Benin added carbide within packages to accelerate fruit maturation but plantain often displayed black stains on the fruit pericarp.

Mature sweet banana (yellow or white pulp, according to variety) was edible and considered as dessert, while plantain was also consumed as dessert (mature fruit) as well as energetic food (mature and immature fruit). Indeed for sweet banana, fresh pulp is directly consumed as dessert (all varieties), cooking (variety Sotoumon), as well as processed in fried pasta called « talé talé » or as porridge flour for children (varieties Sotoumon, kpokokpoko and Planta). Plantain pulp is edible and consumed fresh as dessert or roasted, cooked and pounded alone or in combination with manioc, fried or processed in « talé talé ». Some variety leaves were used as wrapping for hot (akassa, cake, ablô) and cold food (banana, kola) as well as for buildings and for home clay construction. The banana's peel was used to repulse shrews in rural area. Banana was widely used to treat various diseases in medicinal plans. The frequent diseases are described in Table 3.

DISCUSSION

A total of 122 vernacular names were used to name 58 local varieties of dessert banana and plantain through the nine ethnic groups surveyed, supplying the documentation of these crops names in Benin in comparison with the 113 ones from Togo (Koukouma et al., 2016). Indeed, natural reproductive barriers often occurred within *Eumusa* species from spontaneous chromosome structural changes or recombination events causing subspecies divergence and genetic diversity. African plantains are commonly hybrid triploids (AAB) (Daniells et al., 2001) while dessert banana are diploid, triploids and tetraploids, matching with the high diversity recorded especially in banana used for dessert (Ortiz, 2013).

Some of the vernacular names resulted from discriminant morphological, agronomical and cultural traits that appeared to be similar in several ethnic groups living, or not, in the same geographical area. This suggested a high level in the local taxonomy of these crops. Some of these criteria were commonly used elsewhere as well as in vernacular taxonomy as used for

Table 3. Traditional medicinal uses of banana and plantain.

Diseases	Banana / Plantain parts	Other plants	Ingredients	Uses
Haemorrhoid	(1) Fresh mature fruit of plantain (2) Male buds of the banana variety « So vlan »	*Cola nitida* fruits	-	(1) Association of plantain fruit with Cola's (2) Association of both plantain and So vlan fruits
Wounds and infant diseases	Sap of pseudostem	-	-	Blood-clot for superficial wound
Crisis and infant high temperature	Sap of pseudostem	-	-	Massage of child body
Bone strengthening for sickly children	Plantain leaf	-	Traditional soap called « Koto »	Infusion of dried leaves were used as bath water using the soap Koto
Malaria	Authentic or ancient banana variety « Ogou kokoé »	-	-	Infusion of dried leaves
Gaping wounds called « djô mahoui »	Roots	Leaf of the plant « Hontou »	Traditional soap called « Koto »	Medicinal ingredients to treat persistant wounds
Post-delivery haemorrhage	Male buds	Spices such as garlic (*Allium sativum*), ginger (*Zingiber officinale*), *Garcinia kola*	Fragments of smoking depository accumulated in kitchen roof	Pounding all ingredients of which filtrat is consumed to stop haemorrhage after delivery
Epilesy	Mature fruit of the banana variety « Planta »	-	-	Consumption treated epilepsy
Powerful aphrodisiac	Plantain banana	Manioc tuber Citron Ginger	-	(1) Porridge flour of plantain pulp alone (2) Porridge flour of dried pulp of plantain banana associated to manioc tuber, including citron and ginger
Medico-magic	Fruits of authentic banana variety « Ogou kokoé »	-	-	Medico-magic property
Rituals by priests from native cults such as « vodoun », « Hèviosso »	Fruits of the varieties: - « Dan madan » (sweet banana), - « So vlan » and « Dan vlan » (Plantain)	-	-	To forbid thunder Not described

agro morphological characterization (Koukouma et al., 2016; Kodjo and Adheka, 2015; Daniells et al., 2011; Sweenen et al., 1995). However, criteria such as unedible fruit, ancestral banana and medicinal uses confirm the character of plant used as a discriminant trait for varietal identification since antiquity (Spichiger et al., 2000).

Banana and plantain varieties required agro-morphological studies

In spite of their traditional morphological descriptors for folk classification based on local knowledge, the 58 local varieties recorded by the ethnobotanical survey cannot express the real varietal diversity of plantain and dessert banana in Benin due to the ploidy status and the probable synonymy and homonymy within and among ethnic groups. Moreover, some mutations such as twin peduncles or three peduncles within an individual are thought to be irregular varying with environmental conditions (Kodjo and Adheka,

2015). Thus, agro-morphological studies combined with molecular analysis are required to confirm the gathering of bananas varieties.

Our results identified some southern ethnic groups producing most local varieties due to the high rainfall conditions favorable to the development of banana species in the South. Moreover, considering socio-economic impacts, south of Benin is the most populated region where demand for agricultural products (including banana and plantain) is higher than elsewhere. These crops' socioeconomic values were so high that wholesalers deposited some money to producers before fruit harvest in this South region. In addition to the introduced varieties from other countries such as Gambari's banana or Ghana's banana, some local varieties identified in Benin have already been described elsewhere: plantain of peduncle with one hand viewed as a very loose bunch: plantain with twin peduncles (named Douala variety in Cameroon (Kodjo et al., 2015).

Factors affecting banana and plantain production

In spite of susceptibility to drought (23% of responses), in contrast to other crops such as cereals, plantain is considered as a good biological plant species candidate adapted to climate change because a temperature increase of 3°C remained favorable for their development (Calberto et al., 2016). Banana and plantain are easy to produce, implying their plantations and production can be beneficial in association with other crops in various environments including home gardens. However, a main handicap for these crops' production remains the quality of suckers (Meutchieye, 2009; Meunier et al., 2011). Most collections of these suckers originated from plantations of old-age often inherited or personal (after 1-2 generations). Such plantations are subjected and vulnerable to pests and diseases (nematodes and the foliar disease, black sigatoka), which spread rapidly reducing yield (Meutchieye, 2009). All banana and plantain varieties from the two administrative Divisions from East Benin (Oueme and Plateau) are currently infested by the Banana Bunchy Top Virus (BBTV), and no cultivars can be collected for conservation. Whether market gardening is associated with these crops for land covering, organic matter supply and to avoid erosion, a high interaction through water requirement is reported when cassava is produced with banana and plantain (Meunier et al., 2011). The regular theft of these staple food crops is commonly described, exhibiting the high poverty line and the importance of growing awareness on the need for more prosperous occupations.

Implications of diseases and fruit maturation on human well-being

The use of chemical pesticides is noxious for human health and environment. Likewise, the maintenance of heat within a vase appeared as a fluent condition for fruit maturation using a relative quantity of various plant leaves. However the addition of chemical components especially carbide in South of Benin must be prohibited through awareness campaigns. Infested leaves, flowers, bunches, individuals and suckers must be removed and their wastes must be burnt out of plantations.

Conclusion

Our survey revealed a total of 58 cultivated varieties of banana and plantain from 122 vernacular names through nine ethnic groups from the centre and south of the country. This diversity cannot express the real varietal diversity of plantain and dessert banana in Benin due to the ploidy status and the probable synonymy and homonymy within the same ethnic group, requiring agro-morphological studies combined with molecular analyses to clarify their taxonomic status. This presents an advantage at identifying varieties, although abnormally gathered within the same name, apart from the issues of etymology. The vernacular name of these crops has relied on agro-morphological characters. Most varieties were cultivated by a few households on small areas defining their vulnerability status. *In situ* and *ex situ* conservation should be undertaken to preserve the entire diversity due to the high rate of variety loss.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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An evaluation of the effectiveness of the co-management approach in selected protected areas of Bangladesh

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This study undertook a qualitative approach to evaluate the perceptions and attitudes of stakeholders towards the effectiveness of planning and management, in three protected areas in Bangladesh. A complex socio-economic context was revealed, within which there were diverse views leading, in some cases, to ongoing conflict and difficulty in law enforcement. While the co-management approach in theory takes the interests of local people into account and so has a better prospect for long term, sustainability, and forest protection, this research revealed that community participation is not currently effective. Recommendations are made to remedy to increase the potential towards achieving the management objectives for these protected areas.

Key words: Co-management, protected areas, Bangladesh.

INTRODUCTION

Historically Protected Areas (PAs) have been seen as an important tool in wildlife conservation. However, in many cases, this marginalised local people are forced to vacate the area (Pimbet and Pretty, 1995; Hutton et al., 2005). This approach has been questioned, regarding both achieving conservation objectives and humanitarian justice (Martin, 2017). At the World Parks Congress, the IUCN called for a new paradigm, a community-based approach that respects the social, economic and cultural rights of people to their land and resources (IUCN, 2003). This increased awareness of the vital importance of community participation for successful conservation initiatives and for co-operation among all stakeholders in PA governance (Niedzialkowski et al., 2012; Borrini-Feyerabend et al., 2013; Chowdhury et al., 2014). This approach has been widely and successfully implemented, for example in Annapurna, Nepal, where local people were given control of their natural resources, deforestation had significantly reduced (Bajracharya et al., 2005), and has now been incentivised across the country (Adhikari et al., 2014).

The 'co-management' approach has been adopted in Bangladesh to promote active collaboration between protected area management teams and local stakeholders (Parr et al., 2013). This began in 2003 when the Forest Department, in collaboration with the United States

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Agency for International Development (USAID), developed the Nishorgo Support Project (NSP) to provide alternative sources of income to counter excessive extraction of forest resources (Roy and DeCoss, 2006). This improved relations between the Forest Department and local communities by involving them in discussions around forest management and their livelihoods. In 2008, this was replaced by the Integrated Protected Area Co-management (IPAC) project, which was more ambitious; aiming to increase co-management to achieve full integration of communities in PA management planning (IRG, 2010). This continued until 2013.

The Forest Department, directed by government guidelines (Forest Department of Bangladesh, 2006,b), is the convenor of the Co-management Committee, in each PA, and 19 community representatives, both male and female, are required to be included on the Co-management Council (Chowdhury, 2008). The primary responsibility of both of the Committee and the Council is to promote sustainable biodiversity conservation by facilitating effective partnerships across all stakeholders (Chowdhury, 2008). For this to be successful, it requires effective involvement of the community and full participation in the co-management process. This research was undertaken to evaluate how effective this has been in Bangladesh.

MATERIALS AND METHODS

Three PAs, Lawachara National Park, Teknaf Wildlife Sanctuary and the Sunderbans Wildlife Sanctuary were selected as case studies from the 37 in Bangladesh. The rationale for this was that, after extensive desk based research, these were identified as being distinctly different from one another in character as well as geographic location (Figure 1). Four villages in the proximity of each PA, 12 in total, were identified for in depth research. The criteria for selection were:

(1) High livelihood dependency on the forest
(2) Proximity to the PA boundary,
(3) Accessibility

Two investigative techniques were employed in fieldwork; in-depth interviews with key contacts and focus group discussions, which provided data for subsequent analysis.

The key contacts were drawn from different stakeholder groups, that is, Forest Department and IPAC staff, and community members who had specific interest in PA management issues. The focus group participants were invited, after discussion with local stakeholders, to attend informal sessions in non-threatening environments such as tea stalls, house and schoolyards. The researcher facilitated lively discussion and interaction between the participants, with the permission of participants, wrote up reflections immediately after each focus group (Remenyi, 2011). Twenty-one focus groups were conducted (5 in Lawachara, 8 in Teknaf, and 8 in Sunderbans) most consisted on mixed genders but in some villages separate discussions were conducted for males and females. Group size varied between six and eleven people, lasted from 1 to 2 h, and discussion focused on management of the PA and the degree of community involvement.

Data analysis

The interviews, conducted in Bengali, were transcribed, translated into English, and then analysed. The first step was open coding to identify ideas, themes, and concerns (Neuman, 2006); similar codes were then grouped together as concepts; finally, these were grouped into themes. This enabled a narrative account to be constructed describing, interpreting and collating results from the different investigative techniques, the in-depth interview and focus group discussions. Triangulation was used to verify accuracy, using data from different sources to enable rich description to express the findings (Creswell, 2009).

RESULTS

Interviews with key informants

All the key informants interviewed were aware of the co-management approach and majority felt this was positive, particularly in reducing illegal tree felling and crime such as deer poaching. It was revealed that in both Lawachara and Teknaf, the co-management committees had formed Community Patrolling Groups comprising former timber fellers responsible for protecting the forest. The success was debatable, with a village elder from Baghmara reporting subsequent serious damage; this was corroborated by a village headman from Magurchara punji (Lawachara) and a journalist who said this effectively endorsed illegal felling. However, Forest Department staff explained that the rationale for including timber thieves, and providing them with an income was that tree theft would stop. In fact, the opposite happened as some members of the community-patrolling group collaborated in the illegal harvesting and selling of timber. It was suggested that Forest Department staff were subject to blackmail reducing their ability to take action. The CEO of IPAC put this into perspective saying, *"In social work, 100% success is hard to achieve, 60% or 70% can be considered progress. There are many complaints about the community patrolling group despite the fact that the tree felling in Lawachara has now reduced to only 400 trees a year from the 1800 recorded previously."*

Teknaf wildlife sanctuary

Despite some reporting that activities of the Co-management Committee were limited, others felt that it was not realistic to raise awareness of the need for forest protection in every village. However, the IPAC coordinator felt that they had been effective saying, *"We are about 70% successful in this area. We have explained to local communities that the forest is their friend and that they*

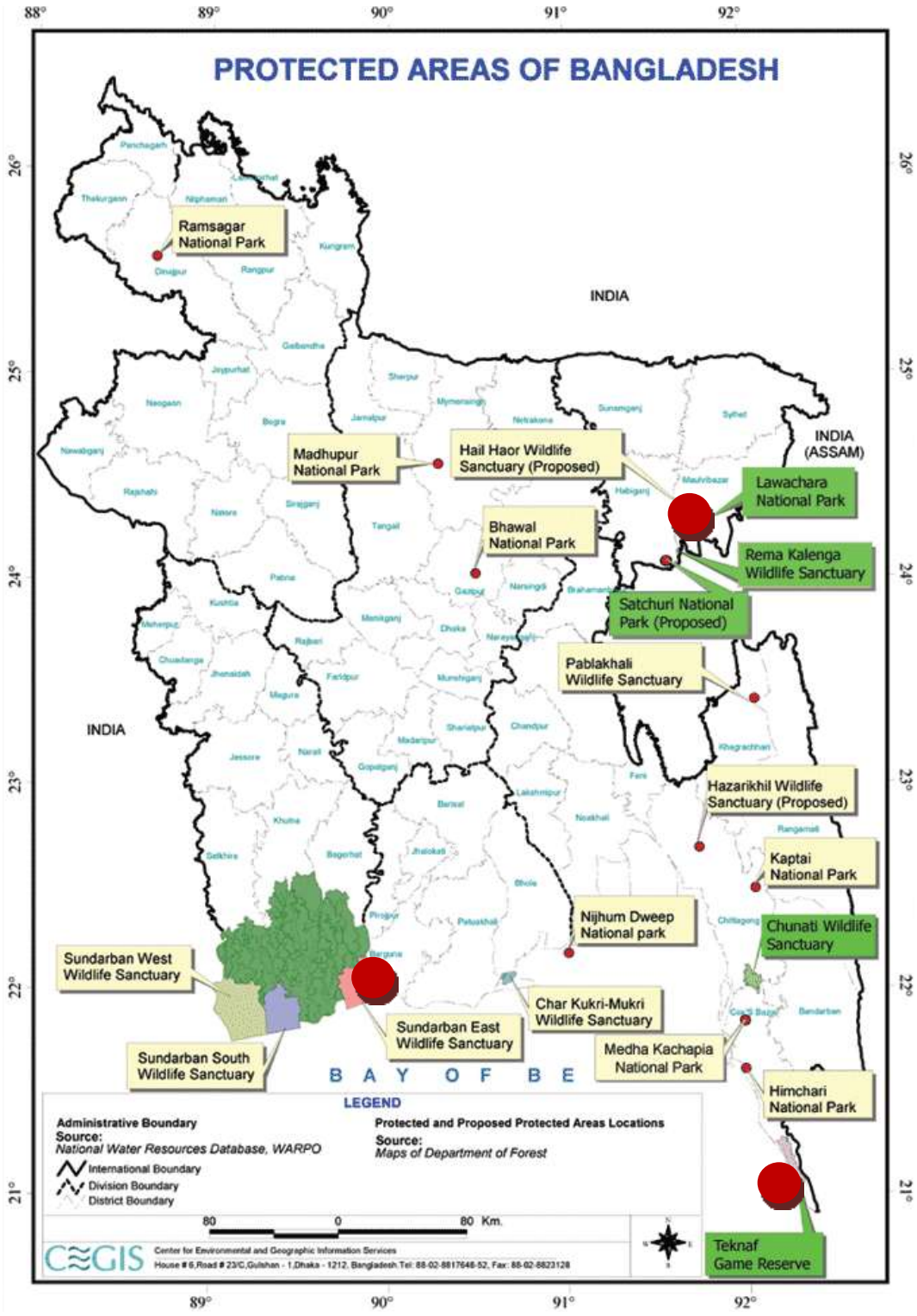

Figure 1. Map showing Protected Areas of Bangladesh.
Source: Mukul et al. (2008).

should tell us if anyone cuts trees. We are providing different training, education, and grants and are able to raise awareness among people; even illiterate women can now talk about carbon trading." A local journalist said that previously trees could be cut and transported out of the forest openly but since the formation of the Co-

Table 1. Participants responses in the focus group discussions.

National Park/Wildlife Sanctuary	Awareness of co-management	Perception of benefit
Lawachara National Park (N=41)	68% (N=28)	39% (N=16)
Teknaf Wildlife Sanctuary (N=62)	54% (N=33)	34% (N=21)
Sunderbans Wildlife Sanctuary (65)	61% (N=40)	43% (N=28)

management Committee, everyone was on the lookout and news would spread quickly even if only one tree were cut down corroborated this. However, it was also suggested that politics was spreading into every village and it was increasingly difficult to keep forest improvement programmes and the work of the Co-management Committee, free from political influence; lack of transparency regarding funding was also raised as an issue.

The Sunderbans wildlife sanctuary

In terms of raising awareness, the Co-management Committee was felt to have been effective, despite lack of financial support. Reported achievements included stopping the sale of deer meat in the bazaar, the closure of four brick fields, reducing demand for fuel wood (despite this resulting in loss of local jobs) as well as repairing roads and bridges. However, the difficulty of keeping the Co-management Committee free from "political influence" was also mentioned.

Focus group discussions

The responses of the focus group participants in the three case study areas are given in Table 1. The results suggest that the effectiveness of the co-management approach is subject to local influence and political pressure. Governance issues were raised in some of the discussions, for example: *"The current co-management committee president is the brother of the chief whip of the present Government. He became the president by the power of the Government not by selection by villagers, so he does not know the situation and tricky issues used by the notorious people of the village"* (Lawachara). Similarly, in Teknaf, *"If a tree feller is caught red handed stealing a tree, they can get released through the actions of influential people, who are in fact involved in this crime."* In the Sunderbans it was stated that *"The president of the Co-management Committee is the Union Parishad Chairman. He can do everything he wishes."* These statements suggest that political pressure, lack of transparency and accountability and potentially corruption may limit the effectiveness of co-management. Despite this, there were positive impacts with Co-management Committees who were perceived as responsible for some infrastructure development and to have been instrumental in providing some facilities for local communities.

DISCUSSION

This research was initiated to explore the way the co-management approach is fundamental to the aims of Protected Area management was implemented in three case study areas in Bangladesh. In both Lawachara and Teknaf Pas, the management plan included an objective to develop and implement a co-management approach to ensure long-term protection and conservation of biodiversity, while permitting sustainable use in designated zones by local stakeholders (FDB, 2006a, b:16). In the management plan for the Sunderbans the equivalent objective was to support and improve co-management activities in both the PA and surrounding landscape (FDB, 2010: 18). This research confirmed the existence of active co-management committees in all these Pas, although determining the impact on forest protection and conservation was challenging.

While all the key informants were aware of the co-management approach, the degree of participation differed across the case study areas. Some acknowledged benefits such as repairing and constructing roads and bridges, arranging tourist trails inside the parks, providing some economic benefits to local people, and conservation education programs that increased public awareness. In Lawachara and Teknaf, the majority of key informants reported the failure of the community-patrolling groups, set up by the co-management committee, to conserve the forest. The logic was that illegal tree felling would stop if convicted timber thieves were given responsibility and paid to protect the forest. It was reported that owners of furniture shops, local administration and some Forest Department staff have effectively created a supply chain making this easier to carry out. Initiatives such as the setting up of Community Patrolling Groups have been extensively criticised in the media and by the public and, as a result, the CMC has been compelled to reform the CPG, without involving former criminals. New Forest Department staff were brought in to overcome the perception that, when tree felling had taken place, the Forest Department tended to automatically charge previously convicted tree fellers rather than carrying out a full investigation.

In Teknaf, the impact of the CMC was restricted to

some, rather than all, the villages and, as in the Sunderbans some significant achievements had been made. However, it was universally felt that to be effective, although awareness had been raised among communities about the need for PA management and conservation of natural resources, CMCs should be free of political influence.

The women in South-east Asian countries, for example India, Nepal and Bhutan, are involved in traditional farming and forest management, playing a key role in reducing deforestation (Kiorboe et al., 2005; Wuyep et al., 2014). However, in Bangladesh, women have rarely been part of local participation initiatives, despite the fact that it is unlikely that success will be achieved without them. Shiva (1989) argued that women tend to be more 'environmentally friendly' than men and, as Bangladeshi women are very knowledgeable about their natural resources, it is perhaps surprising that they are not more actively included in CMCs and empowered to use their traditional ecological knowledge to support sustainable natural resource management and increase employment opportunities (Little, 1994). While there are designated categories of stakeholders to be included on both co-management councils and committees, these do not specify the number or proportion of women (Table 2).

Money was a theme in all interviews, and it seems that the current approach, based on revenue sharing, with some of the PA income supporting community development, has resulted in positive attitudes among local people encouraging and empowering them to engage in conservation. However, it was clear that there are issues in implementing the co-management approach, notably inclusion, equity, empowerment and integration. Schroter et al. (2014), working in Brazil found that negotiation and good communication significantly improved the implementation and enforcement of PA rules. In this research, the extent to which discussions in co-management committee meetings were fed back to local residents was unclear.

Achieving biodiversity objectives through co-management appears promising, despite challenges in turning local people's awareness of the need for this into the positive actions necessary. The incentives and benefits from the PA to the local residents are simply not sufficient to prevent practices such as fish poisoning, illegal deer hunting and, while public awareness campaigns and education undoubtedly part of the solution, change will only result when socio-economic issues are addressed. Roe et al. (2000), have argued that community-based conservation can complement, but not replace, enforcement. The role of central government and strict protection will always be required (Lockwood et al., 2006). In the case of Tsimembo-Manambolomaty, a wetland and dry forest in Madagascar co-managed by the Peregrine Fund and local communities, the focus has been on empowering traditional users to manage their resources more sustainably; income from fishing is thought to have increased as a result (Gardner et al., 2013). This exemplifies that, for co-management to be sustainable and effective, those with most local knowledge and experience should be recognized and actively involved in management and the benefits derived from it must be shared equitably with those who depend on the forest.

This is not currently the case in Bangladesh. Conservation practices are not linked to the subsistence and/or livelihoods of the communities represented in the CMC, particularly when villages are distant from the PA boundary. In Vietnam, multi-level co-management committees have encouraged unified PA management, including both core and buffer zones, providing institutional bridges to link conservation and community development agendas (Parr et al., 2013). However, in the three case study PAs, this research focused on Bangladesh and there was no system to facilitate a similar approach. Government rhetoric supports the idea of a bottom up approach, with local views effectively incorporated into planning and management; however, this research found the reality to be rather different. Additional instruments are required to bring together conservation and development objectives such as conservation education programmes and training opportunities to stimulate small business development such as tailoring, gardening, poultry farming and weaving. This will only be achieved with effective negotiation between CMC members, IPAC workers, local people and Forest Department staff to enable a multi-faceted approach. This would enable the CMC to play a more effective role, particularly if all those involved were honest, open and sincere, and the activities of the CMC was kept free from political influence.

CONCLUSIONS

Effectiveness of the co-management approach

Each case study area had specific underlying problems and requirements but all the co-management initiatives need adequate and enduring financial support and strategies to improve their capacity to represent and empower local communities, particularly as locally influential people may have stakes. Adequate funding is a basic component of effective management and good governance in Pas as this enables strengthening gov-ernance, building administrative and technical capacity in both protected area personnel and community organizations, long-term planning and transparent decision-making.

The co-management approach has not been effective in educating local villagers about the value of wildlife conservation. If it is to be successful, all stakeholders from local governments, socio-economic elite, sawmill operators, brickfield owners, charcoal producers, and

Table 2. The composition of the co-management councils and committees.

Stakeholder group	Designated number of council members	Designated number of committee members
Local government	12	4
Local elites	7	2-3
Resource owning groups	5	2
Forest users groups and federations	9	2
Local youth	2	1
Indigenous communities	3	2
Law enforcing authorities	2	1
Forest Department (ACF/RO)	2	1
Local NGOs/ CBOs	5	1
Other government agencies/departments	4	2
Total members	51	18-19

furniture shop owners all need to engage with this or it will be difficult to convince them to support forest protection and sustainable natural resource management. Timber is important to a wide variety of livelihoods, so supply chain analysis is needed to understand scale of use and whether other materials or timber from other sources could substitute this. A robust monitoring system is required, involving Forest Department representatives, the co-management committee and all those concerned for conservation of the forest resources to measure progress.

RECOMMENDATIONS

Participation of stakeholders

A co-management planning approach that includes wider stakeholder participation is required. This should could enhanced health care and education, the rights of women, the youth and indigenous people, and promote a democratic process of engagement to achieve sustainable livelihoods. This requires a wider range of stakeholders to be actively involved and for these to be on an equal footing with representatives of government departments and international, non-governmental organizations. Empowerment of women is essential and can only be assured through education, training, policies, and improving their access to assets, human and civil rights, job opportunities and participation in decision-making.

Social and economic incentives

According to the Durban Treaty (UNFCCC, 2011), good relations with local communities is crucial for effective conservation. The easiest way to encourage a positive attitude among these is to ensure they receive tangible economic benefits from the existence of the PA (Kopylova et al., 2011). This will require identification of realistic, long-term sustainable resource use strategies that are effectively monitored, and to quantify the impact of these on local people's livelihoods; thus the need for alternative opportunities. This could also be done by providing compensation for loss of access to forest resources. This would have to be done fairly, with benefit to all within a target community or there is likely to be long-term resentment between those who have benefited and those who have not.

Sustainable forest resource management

Establishment of sustainable levels of harvesting, development of strong marketing infrastructure and building strong networks among and between producers, traders and companies are all essential elements of a productive silvicultural system. An environmental policy focusing on conservation and protection of resources without taking into account those who have historically depended on forest resources, which is likely to increase both poverty and illegal harvesting. It is bound to fail. Development based on indigenous knowledge and acknowledging the role of traditional livelihoods within sustainable development and the links between environmental management, science and well-being is more likely to succeed.

Development of tourism

The potential for tourism expansion is significant and can increase local incomes; while satisfying ecological imperatives. Management plans should, therefore, be produced to integrate local communities into ecotourism development, and incorporate policies for diversification into this area. For this to be realised, in-depth understanding is needed. Firstly, regarding the

requirements of domestic and international tourists and the potential impact of increasing numbers and secondly, how tourism could provide local livelihood opportunities.

Institutional restructuring and political will

If management plans are to be implemented effectively, devolution and decentralization of authority within and between different layers of government institutions are crucial. The existing management process involves highly bureaucratic and centralized decision-making, with power lying at the higher levels. Institutional restructuring and policy reform are essential to enable inclusion and empowerment of local communities in the co-management approach and equity in benefit sharing. This is likely to be the greatest challenge for effective co-management planning. It will require high-level political support to enable reforms at the local level. Without this, there is a danger that the power of entrenched local interests will hamper implementation of a genuine co-management approach and more effective protected area management.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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A preliminary study on species composition, relative abundance and distribution of bird species in Choke Mountains, East Gojjam, Ethiopia

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Avian diversity is among the key components of the earth's biodiversity. This study was conducted in Choke Mountains from January to April, 2018 to identify the diversity, relative abundance and distribution of avian fauna. Data were collected in three different habitats (natural forest, grazing and protected areas). The sampling areas were selected using stratified random sampling technique. Point count (for forest site) and line transect methods (for grazing and protected habitats) were employed to collect data. Shannon-Weaver diversity index (H`), Encounter Rate, Richness index (RI), Evenness Index (E) and Simpson's similarity index (SI) were used for data analysis. A total of 55 bird species belonging to 11 orders and 27 families were identified during the study period. Wattled Ibis (*Bostrychia carunculata*), Slender billed starling (*Onychognathus tenuirostris*), Alpine chat (*Pinarochroa sordida*), Waller's starling (*Onychognathus walleri*) and White collared pigeon (*Columba albitorques*) were the most abundant species in the study area. Relatively higher diversity of bird species was observed in the natural forest habitat (H' = 2.93) and the lower species diversity was observed in the protected area (H' = 2.56). The evenness diversity index (E) indicated the highest evenness distribution was registered in the protected area (E = 0.89) and relatively, the lowest evenness was in grazing area (E = 0.87). The highest species richness was registered in natural forest habitat (4.40) followed by Grazing (3.36) and protected habitats (2.57). Grazing and protected areas have higher similarity index (0.40) and the lower similarity index was observed between natural forest and grazing areas (0.20). Agricultural expansion, overgrazing of livestock contributed to the deterioration in the diversity and abundance of birds of the study area. Thus, serious action is needed to conserve the biological diversity in Choke Mountains.

Key words: Abundance, birds, Choke Mountains, distribution.

INTRODUCTION

An informed geological history, diverse climate types and physical and topographic features are responsible for the occurrence of varied biological resources in Ethiopia (Brenan, 1978). The country has diverse ecosystems ranging from humid forest and extensive wetlands in the west and southwest to the Afar Depression of the Great

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Rift Valley in the northeast. The fauna and flora of the country are scattered from the highest mountain peaks over 4000 m.a.s.l. to the lowest and hottest place in the Dallol Depression, 116 m.b.s.l. (Ethiopian Mapping Authority, 1988). The fifth largest rank of floristic composition in tropical Africa occurs in Ethiopia, with a high level of endemism (Brenan, 1978). This range of habitats support a rich variety of species, which contributes to the overall biological diversity of the country (Sekercioglu, 2007). Among 1,850 species of birds found in Africa, 926 (with 16 endemic species) are found in Ethiopia (Redman et al., 2009). Including the endemics, 665 species are residents, 30 are migratory and 69 are mainly African (south of the Sahara desert) or tropical species which also occur in the Palaearctic region. According to Yalden et al. (1996), there are 199 Palaearctic winter visitors in Ethiopia, including 21 passage migrants. Of these, 169 are only visitors with no resident forms.

Currently, 669 Biosphere reserves are registered in 120 countries including 16 transboundary sites all over the world (Azeria et al., 2007). Seventy of these are located in 28 African countries. Sub-Saharan Africa is a home for 64 biosphere reserves in 28 countries. Of which, 5 are found in Ethiopia. Namely: Kafa, Sheka, Yayu, Lake Tana and Majang that have been successfully included between 2010 and 2017 in the global Biosphere reserves list. According to Ethiopian wildlife and natural history society investigations, bird fauna in Ethiopia are negligible compared to other near-African countries like Kenya, Uganda, and Tanzania. Diversity of birds is assumed to be different across varied ecological zones of the biosphere reserve (Azeria et al., 2007).

Choke Mountains are the subject of the present study where data on bird diversity and population is still not known. The vegetation cover and animals in this area have been declining due to the development of human and livestock populations, expansion of agriculture, settlement, and pollution in the surrounding towns. Habitat losses due to anthropogenic factors are likely to strictly affect the avifauna and other wild animals living in and around the Mountain ranges. However, the degree of damage on the avifauna is not known. Therefore, the objective of the study was to identify Species Composition, Relative Abundance and Distribution of Bird Species in the study area.

MATERIALS AND METHODS

Study area

The study was conducted in Choke Mountain regions by selecting three sampling sites (Figure 1). Choke Mountain regions are one of Ethiopian highlands located in Amhara National Regional State, East Gojjam Zone, northwest of Debre Markos town. It is about 330 km north of the national capital, Addis Ababa, by road. These highlands lie at latitude of 10° 41'-10° 44'N and longitude 37° 50'-37° 53'E. Especially, the central peak is located at 10° 42'N and 37° 50'E. Elevation of the mountain chains ranges from 2,800 to 4,070 m a.s.l., and they occupy a total area of 1,7443 km^2 (Teferi et al., 2010).

Methods of data collection

Three study sites were selected using a stratified random sampling technique in order to apply a line transect (for common grazing and protected areas) and the point count method (for natural forest habitat). In each point count station, a minimum distance of 150-200 m was maintained using GPS to avoid double counting. To minimize disturbance during the count, a waiting period of 3 to 5 min prior to counting was applied (Hosteler, 2006). Where point count technique in the natural forest area was employed, the radial distance from which birds occurred was estimated and the type and group number of the species were observed. Bird species were identified by using their feather shape and colors, beak, eye colors, legs and body size (Wenny et al., 2011). The numbers, types and locations of birds were recorded during a fixed amount of time at each point. Stations for the point count method were selected depending on the activity and position of birds. The start of point was selected randomly (Bibby et al., 2000).

The survey was carried out in the absence of rain or heavy fog from 6:30-10:00 AM in the morning and from 4:30 to 6:00 PM in the afternoon. According to Bibby *et al*. (2000) this census period is appropriate because the bird's activities tend to be high. The perpendicular distance from which the bird occurred to the point count was estimated and then the type and the group number of species were recorded using direct observation. Photographs and videos were taken to justify the species type for those species which were difficult to identify.

Data analysis

The collected data were analyzed using different techniques. The diversity of bird species was calculated by using Shannon- Weaver diversity index (H`) where

$$H' = -\sum_{i=1}^{s}\left(\frac{ni}{N}\right) \times \ln\left(\frac{ni}{N}\right)$$

(Shannon and Weaver, 1949).

The mean and proportion were used to know the composition and abundance of recorded bird species. Relative abundance was determined using encounter rates that give crude ordinal scales of abundance (abundant, common, frequent, uncommon and rare) (Bibby et al., 2000). Encounter rate for each species was calculated by dividing the number of birds recorded to the number of hours spent searching, giving a figure of birds for each species. The abundance categories (the number of individuals per 100 field hours) were: < 0.1, 0.1-2.0, 2.1-10.0, 10.1-40.0 and > 40. For each category, the following abundance score is given: 1 (rare), 2 (uncommon), 3 (frequent), 4 (common) and 5 (abundant), respectively. To understand birds' community similarity among sites, Sorensen's coeffcient was applied and calculated as follows: $S = \frac{3c}{A+B+C}$. Where S = Sorenson's Coeffcient, c is the number of species that the three communities have in common, A is the total number of species found in community A, B is the total number of species found in community B, and C is the total number of species found in community C (Araya et al., 2013). Species evenness was evaluated using an Evenness Index (E) as follows: E = H'/ Hmax, where E = Evenness Index, H' = Shannon-Wiener diversity Index and Hmax = ln S (that is, natural logarithm of the

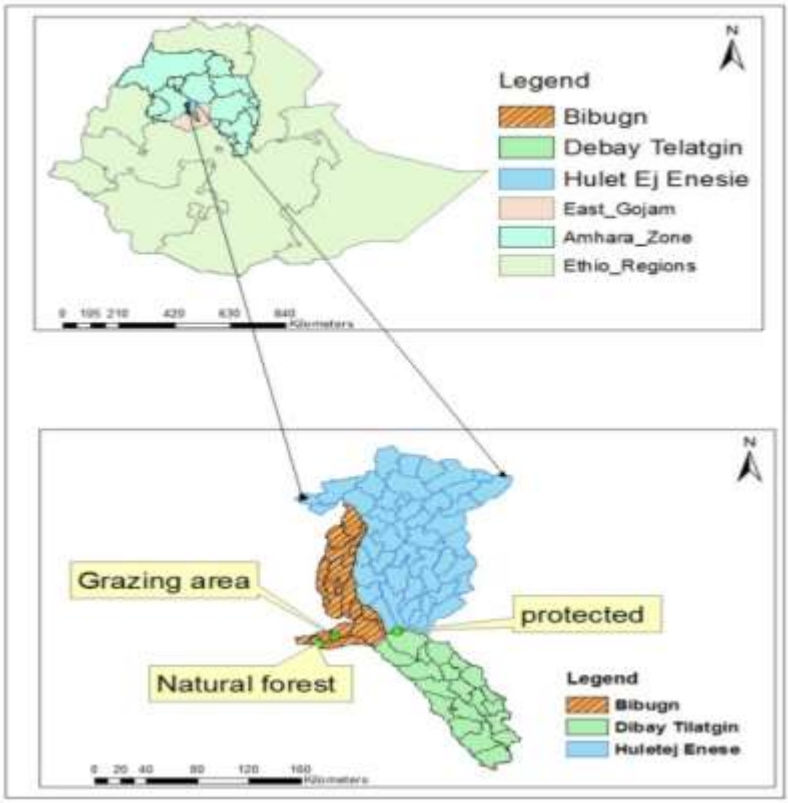

Figure 1. Location map of the study area.

total number of species) (Tramer, 1969). Species richness index (RI) in different sites was calculated by the formula RI = S-1/ln N, where S = number of species in each habitat, N = number of individuals in each species of each habitat and ln = natural logarithm.

RESULTS

Species composition

In this study, a total of 55 species of birds belonging to 11 orders and 27 families were recorded (Table 1). Among them, Abyssinian Long claw (*Macronyx flavicollis*) and Black-winged Lovebird (*Agapornis taranta*) are endemic to Ethiopia. Wattled Ibis (*Bostrychia carunculata*), Thick-billed Raven (*Corvus crassirostris*) and White-collared pigeon (*Columba albitorques*) are endemic to Ethiopia and Eritrea.

In the study area, the natural forest contains relatively more number of species (28), than in the grazing areas (22 species), and protected areas (18 species).

Distribution and abundance

From 55 identified bird species in three sites of the study area, Augur Buzzard (*Buteo augur*), Alpine chat (*Pinarochroa sordida*), Slender billed starling (*Onychognathus tenuirostris*), Wattled Ibis (*Bostrychia carunculata*) and Black kite (*Milvus migrans*) were found in three sites (Table 2). A total of 1727 individuals of birds, 465 in natural forest, 521 in grazing area and 741 in protected area were recorded (Figure 2).

Among the recorded birds, the most abundant in the study area were: Wattled Ibis (*B. carunculata*). Slender billed starling (*O. tenuirostris*), Alpine chat (*P. sordida*), Waller's starling (*Onychognathus walleri*), and White collared pigeon (*Columba albitorques*). But, Plate flycatcher (*Agricola pallidus*), Rüppell's robin-chat *(Lamprotornis purpuropterus*), Yellow billed kite (*M. migrans*), and White faced scops-owl (*Ptilopsis leucotis*) were species with low individuals in the study area. Relative abundance of birds in the study area showed that 50.9% species of birds were abundant, 45.45% common, and 20% frequent. Relative abundance of birds in the natural forest habitat showed that 42.86/% (12/28) of bird species are common, 32.14% (9/28) abundant, and 25% (7/28) frequent (Figure 3). Relative abundance of birds in the grazing habitat showed that 45.45% (10/22) of birds were abundant, 40.9% (9/22) common and 18.18% (4/22) frequent (Figure 4). Relative abundance of birds in the protected habitat showed that

Table 1. Bird species composition in Choke Mountains.

Order	Family	Scientifc name	Common name
Acipcitriformes	Accipitridae	*Buteo augur*	Augur buzzard
		Necrosyrtes monachus	Hooded vulture
		Aquila wahlbergi	Wahlberg's eagle
Apodiforms	Apodidae	*Apus barbatus*	African black swift
Bucerotiformes	Bucerotidae	*Tockus fasciatus*	African pied hornbill
Ciconiformes	Ardeidae	*Bubulcus ibis*	Cattle egret
Columbiformes	Columbidae	*Streptopelia lugens*	Dusky turtle-dove
		Columba guinea	Speckled pigeon
		Columba albitorques	White collared pigeon
Falconiformes	Accipitridae	*Milvus migrans*	Yellow billed kite
		Lophaetus occipitalis	Long-crested eagle
		Milvus migrans	Black kite
Galliformes	Phasianidae	*Pternistis erckelii*	Erckels frankolin
Passeriformes	Thamnophilidae	*Mucicapa boehmi*	Bohm's flycatcher
	Motacillidae	*Macronyx flavicollis*	Abyssinian longclaw
		Matacilla aguips	African pied Wagtail
		Motacilla capensis	Cape wagtail
		Anthus novaeseelandiae	*Grassland pipit*
		Anthus trivialis	Tree pipit
	Turdidae	*Turdus abyssinicus*	Abyssinian thrush
		Turdus olivaceus	Olive thrush
		Geokichla guttata	Spoted ground thrush
	Estrildidae	*Lagonosticta rubricate*	African firefinch
		Lagonosticta senegala	Red billed firefinch
	Monarchidae	*Terpsiphone viridis*	African paradise flycatcher
	Muscicapidae	*Pinarochroa sordida*	Alpine chat
		Psophocichla litsitsirupa	Ground scraper thrush
		phoenicurus	Black redstart Phoenicurus
		Agricola pallidus	Plate flycatcher
		Cossypha semirufa	*Rüppell's robin-chat*
	Campephagidae	*Campephaga flava*	Black cucko-shrike
		Coracina caesia	Grey cucko-shrike
	Corvidae	Corvus capensis	Cape crown
		Carvussplendens	House crow
		Corvus albus	Pied crow
		Corvus crassirostris	Thick-billed raven
	Pycnonotidae	*Pycnonotus barbatus*	Common bulbul
	Nectariniidae	*Anthreptes rectirostris*	Green sunbird
		Nectarinia johnstoni	*Scarlet malachite tufted sunbird*
		Cinnyris venustus	Variable sunbird
	Passeridae	*Passer-griseus*	Grey-headed sparrow
		Ploceus velatus	Vitelline masked weaver
	Malaconotidae	*Malaconotus bocagei*	Grey-green bush sherik
		Malaconotus multicolor	Many coloured bush shrike
	Laniidae	*Lanius minor*	Lesser grey shrike
	Sturnidae	*Lamprotornis purpuropterus*	Ruppell's long-tailled starling
		Onychognathus tenuirostris	Slender billed starling
		Cinnyricinclus leucogaster	Violate backed starling
		Onychognathus walleri	Waller's starling
	Fringillidae	*Crithagra burtoni*	Thick-billed seed eater

Table 1. Contd.

		Crithagra leucopygia	White rumped seed eater
	Ploceidae	*Euplectes capensis*	Yellow bishop
Psittaciformes	Psittaculidae	*Agapornis taranta*	Black-winged lovebird
Pelecaniformes	Threskiornithidae	*Bostrychia carunculata*	Wattled ibis
Strigiformes	Strigidae	*Ptilopsis leucotis*	White faced scops-owl

Table 2. Distribution of bird species in three sites of the study area.

Common name	Scientific name	Natural forest	Grazing area	Protected area
Abyssinian longclaw	*Macronyx flavicollis*	-	-	+
African black swift	*Apus barbatus*	-	+	+
African firefinch	*Lagonosticta rubricate*	+	-	-
African paradise flycatcher	*Terpsiphone viridis*	+	-	-
African pied hornbill	*Tockus fasciatus*	+	-	-
African pied Wagtail	*Matacilla aguips*	+	-	-
Alpine chat	*Pinarochroa sordida*	+	+	+
Augur buzzard	*Buteo augur*	+	+	+
Black cucko-shrike	*Campephaga flava*	+	-	-
Black kite	*Milvus migrans*	+	+	+
Black redstart	*Phoenicurus phoenicurus*	-	+	-
Black-winged lovebird	*Agapornis taranta*	+	-	-
Bohm's flycatcher	*Mucicapa boehmi*	+	-	-
Cape crown	*Corvus capensis*	-	+	+
Cape wagtail	*Motacilla capensis*	-	-	+
Cattle egret	*Bubulcus ibis*	-	+	-
Common bulbul	*Pycnonotus barbatus*	+	-	-
Dusky turtle-dove	*Streptopelia lugens*	-	+	-
Grassland pipit	*Anthus novaeseelandiae*	-	+	-
Green sunbird	*Anthreptes rectirostris*	+	-	-
Grey cucko-shrike	*Coracina Caesia*	+	-	-
Grey-headed sparrow	*Passer-griseus*	-	+	-
Grey-green bush sherik	*Malaconotus bocagei*	+	-	-
Ground scraper thrush	*Psophocichla litsitsirupa*	-	+	+
Erckels frankolin	*Pternistis erckelii*	+	-	-
Hooded vulture	*Necrosyrtes monachus*	+	-	-
House crow	*Carvus splendens*	-	-	+
Lesser grey shrike	*Lanius minor*	+	-	-
Long-crested eagle	*Lophaetus occipitalis*	-	+	-
Many coloured bush shrike	*Malaconotus multicolor*	+	-	-
Olive thrush	*Turdus olivaceus*	+	-	-
Pied crow	*Corvus albus*	-	-	+
Plate flycatcher	*Agricola pallidus*	-	+	-
Red billed firefinch	*Lagonosticta senegala*	-	+	-
Rüppell's robin-chat	*Cossypha semirufa*	+	-	-
Ruppell's long-tailled starling	*Lamprotornis purpuropterus*	+	-	-
Scarlet malachite tufted sunbird	*Nectarinia johnstoni*	+	-	+
Slender billed starling	*Onychognathus tenuirostris*	+	+	+
Speckled pigeon	*Columba guinea*	-	+	-
Spoted ground thrush	*Geokichla guttata*	-	-	+
Thick-billed raven	*Corvus crassirostris*	-	-	+

Table 2. Contd.

Thick-billed seed eater	*Crithagra burtoni*	-	+	-
Tree pipit	*Anthus trivialis*	-	+	-
Variable sunbird	*Cinnyris venustus*	+	-	-
Violate backed starling	*Cinnyricinclus leucogaster*	+	-	-
Vitelline masked weaver	*Ploceus velatus*	-	+	-
Wahlberg's eagle	*Aquila wahlbergi*	-	+	-
Waller's starling	*Onychognathus walleri*	-	-	+
Wattled Ibis	*Bostrychia carunculata*	+	+	+
White faced scops-owl	*Ptilopsis leucotis*	+	-	-
White rumped seed eater	*Crithagra leucopygia*	-	-	+
White collared pigeon	*Columba albitorques*	-	+	-
Yellow bishop	*Euplectes capensis*	+	-	-
Yellow billed kite	*Milvus migrans*	-	-	+
Total		28	22	18

+ denotes the species present and − denotes the species absent in the above figure.

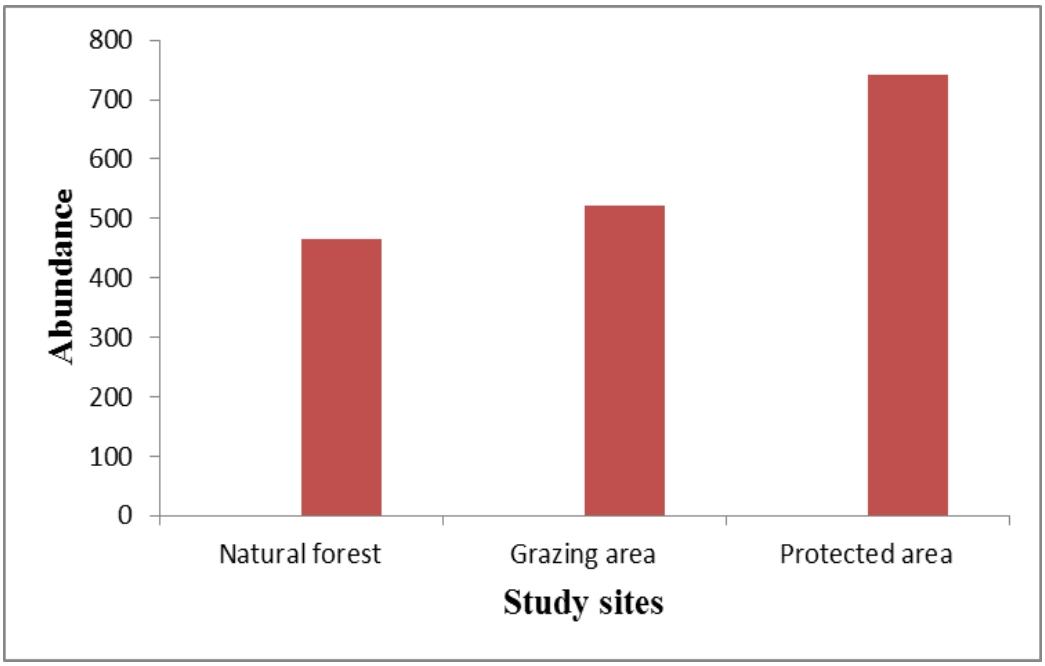

Figure 2. Spatial variation of birds in three study sites.

61.1% (11/18) of birds are abundant, 22.2% (4/18) common and 16.7% (3/18) are frequent (Figure 5).

Species diversity

Diversity index (H') and evenness (E) of bird species varied between the three habitats. The highest diversity was observed in the natural forest habitat (H'= 2.93) and relatively, the lowest diversity index was observed in the protected area (H'= 2.56) (Table 3).

Species richness

The distribution of birds within the three habitat types differs among each other at family and order level. The highest richness was registered in natural forest habitat (4.396). Grazing and protected habitats have richness index of 3.357 and 2.573, respectively (Table 4).

Table 3. Species diversity, evenness and abundance between habitats.

Habitat	No of species	Abundance	H'	H'max	E(H'/H'max)
Natural forest	28	465	2.93	3.33	0.88
Grazing area	22	521	2.70	3.09	0.87
Protected area	18	741	2.56	2.89	0.89

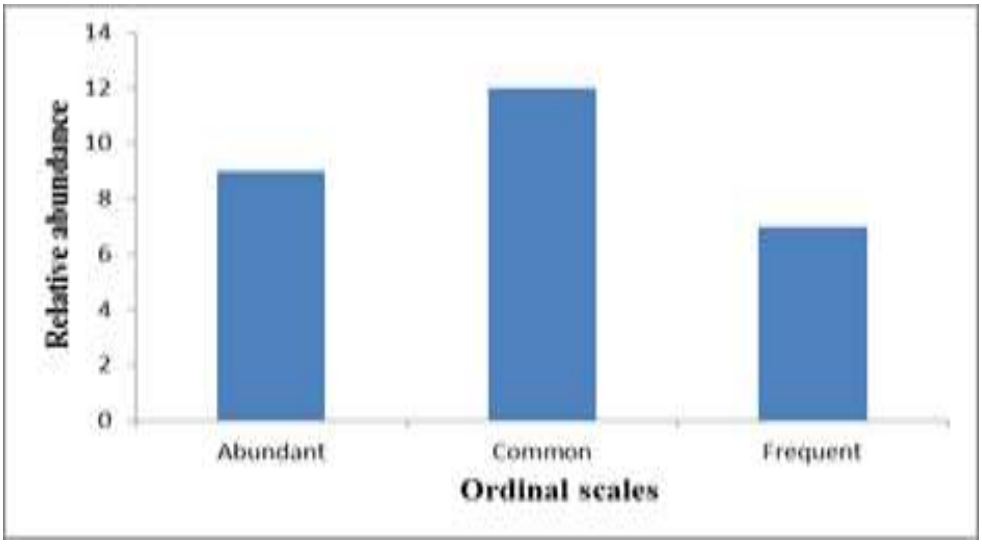

Figure 3. Relative abundance of birds in natural forest habitat.

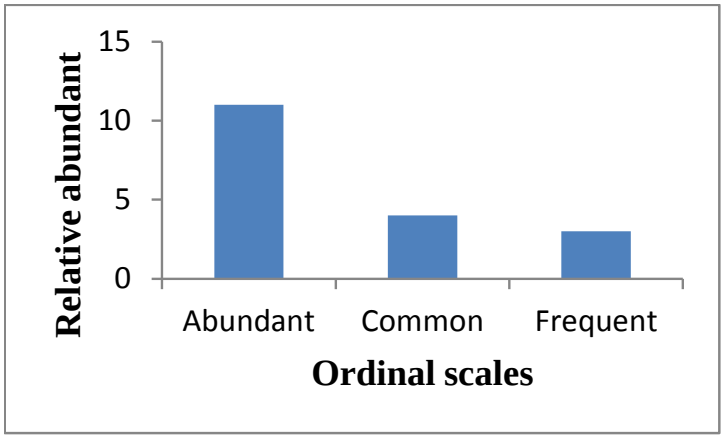

Figure 4. Relative abundance of birds in grazing area.

Species similarity

Simpson similarity index (SI) of the three study sites in Choke Mountain bird species showed that grazing and protected areas have a higher similarity index (0.4) compared to a lower similarity index that was observed between natural forest and grazing areas (0.2 and 0.26, respectively) (Table 5).

DISCUSSION

Assessment of bird species available in different micro habitats of Choke Mountains was conducted to show the spatial variations in distribution, abundance and species diversity of birds. According to Mehra et al. (2017), bird species richness, distribution and abundances are directly or indirectly affected by special variations and

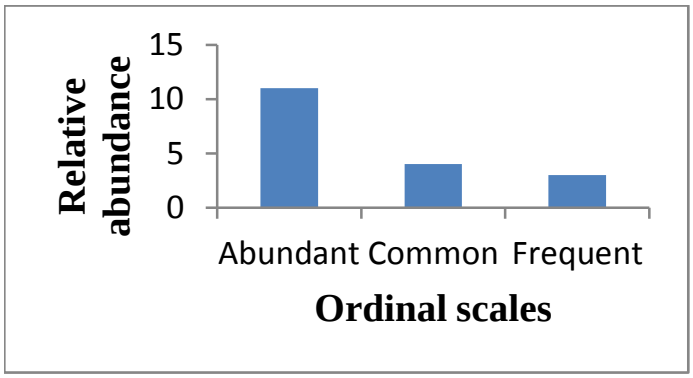

Figure 5. Relative abundance of birds in protected area of Choke Mountains.

Table 4. Species richness index in tree habits of the study area.

Study sites	Richness index
Natural forest	4.40
Grazing area	3.36
Protected area	2.57

Table 5. Bird species similarity index between the three habitats in study area.

Habitat	Grazing area	Protected area
Natural forest	0.20	0.26
Grazing area	-	0.40
Protected area	-	-

rate of anthropogenic activities. Anthropogenic activities such as over grazing and deforestation, which are the main causes of habitat loss, fragmentation, degradation, and climate change can ultimately cause migration and extinction of bird species that are present in that habitat (Gibbs et al., 2010).

In the present study, a total of 55 bird species were recorded in 11 orders and 27 families in three micro-habitats (natural forest, grazing and protected areas) of the Choke Mountains. The natural forest accounts for 28 species; whereas, 22 and 18 species were recorded in grazing and protected areas, respectively. The intensity of predation pressure, available food, disturbance, and the particular habitat selection nature of birds might be the responsible factors for differences in species number among micro-habitats (Esayas and Bekele, 2011; Girma et al., 2017). Habitat size and quality, foraging modes of birds and floristic composition also may have great influence in the distribution of the avian species in the above variations (Aynalem and Bekele, 2008; Girma et al., 2017). In addition, energy supply and productivity and temperature of the area have been alternatively considered as key factors in determination of animals (Aynalem and Bekele, 2008).

The number of species recorded in the present study is less than reported by previous studies conducted in different parts of Ethiopia. These previous studies include: Esayas and Bekele (2011) in Entoto National park, Desalgn and Subramanian (2015) in Angereb Forest and adjacent farm land, Girma et al. (2017) in and around Wondo Genet Forest, Genet and Ejigu (2017) in Apini and Dikuma forest patches, Awi Administrative Zone, Moges et al. (2018) in Gonde Teklehimanot and Aresema monasteries in North Gondar. This difference might be associated with geographical variations as the present study area ranges up to 4,070 m. a.s.l., and include extreme climatic factors such as very cold temperatures.

Moreover, anthropogenic activities such as over grazing and deforestation which are the main causes of habitat

loss, fragmentation, degradation, and climate change in the study area may take the lion share for this variation. Conspicuousness of birds, the skill of the researcher for identification and the technique employed during the survey can also be considered as factors for this variations (Poulsen, 2002). Five endemic bird species are recorded in the present study. It is obvious that as altitude increases, the biodiversity decrease but endemicty of species increases (Poulsen, 2002; Esayas and Bekele, 2011).

The highest diversity of species in the natural forest of the study area may be due to favorite breeding sites, availability of food in microhabitats which favored certain varieties of bird species, cover from predators, and less disturbance compared to other areas (Sethy et al., 2015). Floristic composition and vegetation structure are repeatedly stated as variables that determine the number of species of a given area (Campbell and John, 2012; Moges et al., 2018). The present study is in line with previous findings conducted by Aynalem and Bekele (2009), Esayas and Bekele (2011), Tadele et al. (2014), Desalgn and Subramanian (2015) and Girma et al. (2017). The second highest number of species was recorded in the grazing habitat. This may be associated with adaptability of birds to live in human modified habitats, where food is available. The openness of the grazing site, compared to protected habitat might have also contributed for easy identification of birds (Esayas and Bekele, 2011). According to Hailu (2008), open areas are easily accessible for counting and locating bird species.

Relatively, the lowest number of species was observed in protected areas. This might be possibly associated with altitudinal effect on avian diversity as the protected areas are located above 3,500 m a.s.l. (Poulsen, 2002; Waterhouse et al., 2002; Esayas and Bekele, 2011). Mengesha et al. (2011), and Asefa (2013) also found higher number of species in the disturbed habitat than in the undisturbed ones. The difference of bird species preference is influenced by the individual species specific requirement to each specified habitat. Some species require habitats with short grasses and little cover while others require the reverse (Tadele et al., 2014).

Abundance scores of species were varied among habitats. These might be due to the variations in resources/food availability among the three habitats. Moges et al. (2018) reported that the variation in abundance of bird species between habitats is determined by food availability and breeding sites. Baker et al. (2010) also reported that variation in abundance of bird species was observed between different habitats than between seasons. The higher evenness distribution in protected areas might be due to fewer disturbances of human and other animals, since this area is free of direct contact of human and animals (Nabaneeta and Gupta, 2010; Esayas and Bekele, 2011). The highest abundant of birds might be due to favorable weather conditions of the area during the study period and suitability of the area to count birds (dry season). According to Sagarin and Gaines (2002) weather had an impact on bird habitats by generating food and cover, which improve their ability to reproduce and survive hence increasing their abundance. The variation in the abundance of birds species observed in different microhabitats could be triggered by the temporal and spatial movements of bird species following specific species requirement, such as nesting sites and breeding site for survival and reproduction (Esayas and Bekele, 2011; Girma et al., 2017). The highest species similarity between the two habitats, which are spatially closer, is expected since these habitats share some bird species (Sethy et al., 2015). Tubelis and Cavaicanti (2001) noted that similarity of avian species composition between habitats indicates a tendency for similar habitats to have similar species composition. This concept agreed with the present result as the two nearby habitats (grazing and protected) have higher similarity index. As the researcher clearly observed during data collection, agricultural expansion, excessive grazing of cattle and sheep, deforestation and climate change, all of which can ultimately cause migration and extinction of bird species, present in that habitat are the major threats of birds in the study area.

Conclusions

Relative abundance of birds in the study area showed that most of the species were abundant. Diversity index and evenness of bird species varied between the three habitats. The highest diversity of bird species was observed in the natural forest and relatively, the lowest diversity index was observed in the protected area. The highest even distribution was registered in the protected area and relatively, the lowest evenness was in the grazing area. The highest richness was registered in the natural forest habitat. Simpson similarity index (SI) showed that grazing and protected areas have higher similarity index; whereas, the lower similarity index was observed between natural forest and grazing areas. Agricultural expansion, excessive grazing of cattle and sheep and deforestation cause migration and extinction of bird species present in that habitat; and these are the major threats of birds in the study area.

RECOMMENDATIONS

(i) Choke Mountains need immediate protection from overgrazing and agricultural expansion to save the biodiversity
(ii) Further ornithological surveys should be conducted in detail including wet season.
(iii) Cooperation among different stakeholders (that is, ecologists, environmentalists, local communities and bird

watcher groups) is required to ensure the sustainability of the area.
(iv) Surrounding governmental offices should be integrated for habitat management in wild fauna and flora
(v) The fauna and flora of Choke Mountain should be assessed and monitored regularly.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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