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Full Length Research Paper

Diversity and morphological characterization of *Musa* spp. in North Kivu and Ituri provinces, Eastern Democratic Republic of Congo

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Eastern Democratic Republic of Congo constitutes an area where the East African Highland bananas (*Musa*-AAA-EA) and plantains (*Musa*-AAB) meet. However, *Musa* diversity in this region has never been characterized nor represented in national or international collections, yet increasing human activities and build-up of pests and diseases, especially Xanthomonas wilt of banana and banana bunchy top disease, could negatively affect this diversity. This study assessed, collected and morphologically characterized on-farm *Musa* diversity in the North Kivu and Ituri provinces. *Musa* accessions collected were added to the UCG-Butembo *in situ* field collection. A total of 90 and 150 farms were assessed, respectively, in the North Kivu and Ituri provinces. High *Musa* variability was observed in both provinces. Forty-one cultivars (six presumed new) were identified in Ituri Province compared to 38 cultivars (13 presumed new) in North Kivu Province. Nineteen cultivars occurred in both provinces. Beni and Lubero territories in North Kivu and Mambasa territory in Ituri Province had greater *Musa* diversity, varying between 27 and 38 cultivars, approximately double of the number of cultivars observed in the other territories. Twenty-three of the 34 *Musa* descriptors contributed more to the discrimination of the cultivars identified across the provinces and were therefore used for grouping the cultivars using principal component analysis (PCA). The Morisita index of similarity between Ituri Province and North Kivu Province territories was less than 0.5, suggesting dissimilarity in diversity between these sites. Six cultivars: 'Kirisirya', 'Pakuma', 'Nziravahima', 'Vuhindi', 'Tundu' and 'Kisubi musa' were reportedly at risk of genetic erosion.

Key words: Banana, conservation, cultivars, *ex-situ*, genetic erosion, genotypes, plantain.

INTRODUCTION

Bananas and plantains (*Musa* spp.) are an important staple and income-generating crop for millions of people in the tropical and subtropical regions of the world (Robinson and Galán Saúco, 2010). Over 70 million people in the Great Lakes region of Africa rely on banana and plantain, which provide at least 25% of their daily carbohydrate intake (Frison and Sharrock, 1999). In Eastern Democratic Republic of Congo (DR Congo), the per capita consumption of *Musa* spp. is about 200 kg/yr (Ndungo, 2004) and it contributes nearly 70% of total crop production, with 23.5% of the production realized in the North Kivu Province (Bakelana and Ndungo, 2004).

The Congo Basin and the neighbouring countries of the Gulf of Guinea are secondary centres of diversification of plantain (*Musa* AAB) while the East and Central African countries are secondary centres of diversification of highland cooking and brewing banana (*Musa* AAA-EA) (Swennen et al., 1995). Eastern DR Congo constitutes an exceptional area where the East African Highland bananas (AAA-EA genome) and plantains (AAB genome) meet. This exceptionally high *Musa* diversity is attributed to the presence of three agro-ecological zones characterised by high, medium and low altitude sites (Ndungo, 2002; Ocimati et al., 2013b). However, *Musa* diversity has been reported to be eroding in the centres of origin (including DR Congo) because of human development activities, land pressure, pests and diseases, market demands and civil unrest (Okech et al., 2002, 2005; Nsabimana and van Staden, 2005; Doré and Varoquaux, 2006; Ndungo et al., 2008; Ocimati et al., 2013a, b, 2014). For example, the region also experienced armed conflicts for over three decades, resulting in population migrations and abandonment of banana fields. Nsabimana and van Staden (2005) reported similar population migrations in Rwanda to result in the disappearance or retaining of some *Musa* cultivars (with resultant confusion in the nomenclature). *Musa* production and diversity is currently also under high pressure due to plant nutritional problems and various pests and diseases (especially the Xanthomonas wilt of banana (XW) disease and banana bunchy top disease) (Okech et al., 2002, 2005; Ocimati et al., 2013a, 2014). For example, XW has devastated many plantations in the region, with farmers abandoning the crop for alternatives such as cassava, taro, legumes and sweet potato (Ocimati et al., 2016a, b). In addition, the combination of easy vegetative propagation and a slow breeding process due to meiotic failures during gametogenesis (Ortiz et al., 1995; Vuylsteke et al., 1995) increases the vulnerability of the *Musa* crop. This has resulted in a very limited genetic diversity within the African plantain and East African Highland banana cultivars (Noyer et al., 2005; Kitavi et al., 2016), further exposing the crop to the risk of genetic erosion. *Musa* genetic erosion could potentially also be worsened by climate change.

This study therefore sought to understand the *Musa* diversity in the North Kivu and Ituri provinces, morphologically characterize it and conserve new genotypes in the Butembo provincial *Musa* collection for purposes of *Musa* crop improvement and development.

MATERIALS AND METHODS

This study was conducted through a diagnostic *Musa* germplasm survey that sought to collect and characterize all local cultivars present in the North Kivu and Ituri provinces of Eastern DR Congo. North Kivu lies on the equator between latitude 0° 58' North and 02° 03' South, and longitude 27° 14' and 29° 58' East and is bordered to the East by Rwanda and Uganda, North and West by Ituri Province, South West by Maniema Province, and South by South Kivu Province. Whereas, Ituri Province is located in the North-Eastern part of DR Congo between latitude 1° and 3° 40' North and longitude 28° and 31° 15' East. It is bordered to the North, East, South and West respectively, by South Sudan, Uganda, North Kivu and Haut-Uélé provinces, and Tshopo Province. All territories in North Kivu Province (that is, Beni, Lubero, Masisi, Nyirangongo, Walikale and Rutshuru) and Ituri Province (that is, Aru, Djugu, Irumu, Mahagi and Mambasa) were initially targeted for this study. However, only three territories in North Kivu (Beni, Lubero and Rutshuru) were accessible due to insecurity in the other territories.

North Kivu enjoys a wide variability in climatic conditions. It has two wet seasons (mid-August to mid-January and mid-February to mid-July) and two short dry seasons (mid-January to mid-February and mid-July to mid-August) and a mean annual rainfall between 1,000 mm (lowest altitudes) and 3,170 mm (at high altitude areas). Its mean annual temperature varies between 15 and 30°C and an altitude range from 800 to 5,119 m a.s.l. (top of Mount Rwenzori) (Ndungo, 2002; DRC, Ministry of Planning, 2005). It also has a high variability in the soils, with volcanic soils between Goma and Rutshuru; alluvial soils between the plains of the Rutshuru and Semliki River; and naturally weathered deep and humus rich rock soils (DRC, Ministry of Planning, 2005). North Kivu has a rich ethnic composition consisting of the Nande, Lese, Watalinga and Batwa (pygmies) in Beni territory; Nande, Piri and Batwa in Lubero; and the Hutu, Tutsi, Hunde and Nande in Rutshuru (DRC, Ministry of Planning, 2005).

Ituri has an area of 65,659 km^2 (2.79% of the National territory). It has a mean altitude of about 1000 m a.s.l., with its elevation increasing from West (Congo basin; as low as 700 m a.s.l.) to East (Semiliki River and Lake Albert depression; as high as 2420 m a.s.l.). Of the 65,659 km^2, 63,000 km^2 of Ituri Province is occupied by an equatorial forest (Ituri forest), an area varying between 700 to 1,000 m a.s.l. This region is humid (85% relative humidity) with a mean temperature of 31° (Wilkie, 1987). Ituri Province consists of at least seven ethnic groups, the most important of which are Alur (24%), Lendu (22%), Lugbara (15%), Hema (13.6%) and Babira (12%). Others include Bombo 0.31%; Bandaka 0.31% and Batwa (Maindo, 2003). Aru territory is inhabited by Lugbara and Alur; Djugu by Gegere, Lendu, Alur, and Hema; Irumu by the Hema, Lese and Lendu; Mahagi by Alur; and Mambasa by Lese, Bira and Batwa (Saint Moulin, 2006).

The territories of Beni, Aru and Irumu comprise Beni, Aru and

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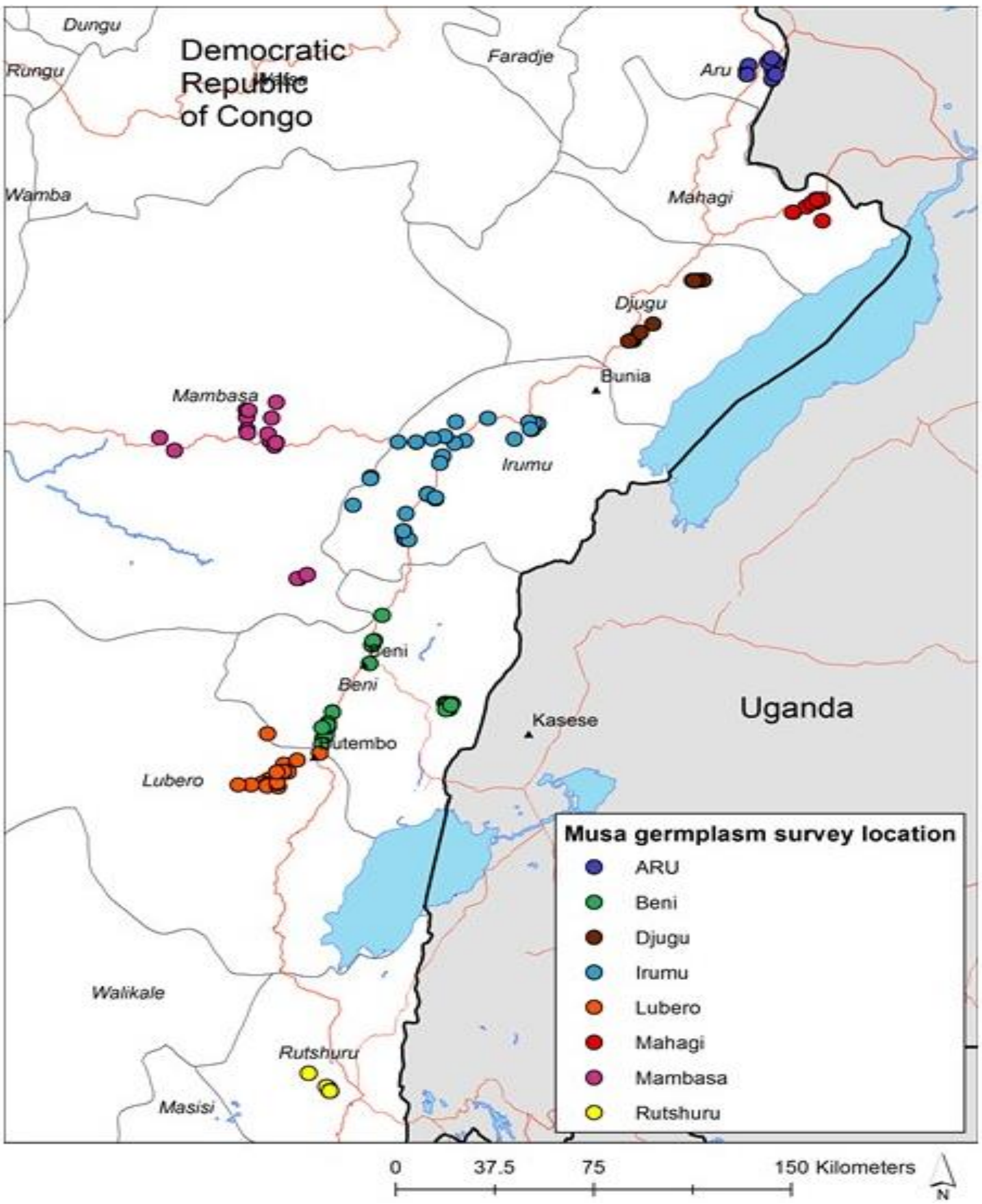

Figure 1. Map showing the locations of farms sampled for the *Musa* germplasm study in North Kivu and Ituri Provinces, Eastern DR Congo during 2010/12. Beni, Lubero and Rutshuru are territories in North Kivu Province while Aru, Djugu, Irumu, Mahagi and Mambasa are territories in Ituri Province.

Bunia townships (Saint Moulin, 2006), with each having large markets. In each territory, three villages, giving a total of 24 villages, were purposively selected based on *Musa* production levels and diversity (Figure 1). In each village, a focus group discussion was conducted with at least 20 men and 20 women in separate groups to list the different banana cultivars grown and their local names. This gave a quick impression of the banana diversity within the villages. Focus groups also identified cultivars that had been lost from the *Musa* genepool and gave possible reasons for this genetic erosion. Only farmers with at least 20 mats in their fields were selected for field quantification of *Musa* diversity and characterization. Ten farms per village, totalling 240, were identified for this study.

In each field/farm, an interview was conducted to gather information on the different cultivars grown and the cultivar synonyms; the respective quantities (mats per cultivar) were recorded. Cultivars identified in the fields were characterized morphologically using the 34-minimum set of descriptors for banana (IPGRI-INIBAP/CIRAD, 1996; *Musa*Net, 2011). Names of cultivars absent from the checklist of cultivars in the provincial collection at Université Catholique du Graben (UCG), North Kivu Province, DR Congo, were presumed new and their suckers were subsequently collected and planted at the UCG *Musa* collection for further characterization and conservation. GPS coordinates of the sampled fields and presumed new cultivars were recorded for mapping using Geographic Information System (GIS) software.

Morisita's index of similarity was used to measure the similarity or dissimilarity between the sampled communities (Morisita, 1959; Hammer et al., 2008). This index is a good measure of niche overlap. It varies from 0 (no similarity) to 1 (complete similarity). The Morisita index of similarity is nearly independent of sample size, except for samples of very small size. Wolda (1981) recommended Morisita's index as the best overall measure of similarity for ecological use. PAST - PAlaeontological STatistics, ver. 1.77 statistical software (Hammer et al., 2001, 2008) was used to generate the Morisita similarity indices and to generate clusters showing similarity or dissimilarity in cultivar composition between the eight studied territories. Cultivar similarity groupings based on the 34 minimum descriptors were also generated using NTSYSpc (Numerical Taxonomy and Multivariate Analysis System version 2.21) (Rohlf, 2009). MS Excel was used to generate the graphs and histograms.

RESULTS AND DISCUSSION

This study sought to explore *Musa* diversity in the North Kivu and Ituri provinces, morphologically characterize it and conserve newly identified *Musa* cultivars in the Butembo provincial *Musa* collection for purposes of *Musa* crop improvement and development.

Musa diversity

A high *Musa* diversity was uncovered across the two provinces despite pockets of the provinces were unreachable due to presence of armed insurgents. Plantains were dominant in Ituri while cooking AAA-EA dominated the North Kivu. Thirty-eight *Musa* cultivars were collected from farmers' fields in North Kivu Province (9 plantains (*Musa* AAB), 14 cooking (*Musa* AAA-EA), 8 dessert (AAA and AAB) and 7 brewing (ABB and AAA-EA cultivars), while 41 cultivars (26 plantains, 8 cooking, 4 dessert and 3 brewing) were collected in Ituri Province (Table 1). Nineteen cultivars were the same in both provinces (6 plantains, 6 cooking, 4 dessert and 3 brewing) (Table 1). Plantain cultivars represented 59.4% (14.4% French type, 44.5% false horn and 0.5% True horn) of *Musa* diversity in Ituri compared with 29.8% (21.6% French and 8.1% False horn and 0.1% True horn) in North Kivu (Table 2). East African Highland cooking cultivars (AAA-EA) were predominant in North Kivu (34%) compared with 19% in Ituri (Tables 1 and 2). The predominance of plantains in Ituri is due to its agro-ecology, characterized by a low mean altitude of about 1000 m a.s.l., high rainfall and temperature that provide humid conditions suitable for plantain production. Plantains grow well under humid conditions characterized by high rainfall and high temperature conditions (Sebasigari, 1985). In contrast, North Kivu Province has three agro-ecological zones characterised by low, medium and high altitudes that promote the diversity of both plantains and highland banana cultivars (Ocimati et al., 2013b), with the mid-high supporting AAA-EA cooking and beer cultivars, while the low altitude and humid areas supporting plantains. However, the observed *Musa* diversity in North Kivu could still be less than the full diversity of *Musa* in this region, since only three of the six sampled territories in North Kivu were accessible due to the presence of armed conflict.

In North Kivu, the plantain 'Nguma' (19% of the sampled *Musa* area and grown by 10% of the sampled farms) was the dominant cultivar (Table 1). This can be attributed to its large bunch size and high cost in the market per the report of farmers interviewed and key informants. 'Kotina' (6% of the *Musa* area, 4% of farms) was the second most cultivated plantain cultivar in this region. Overall, the brewing cultivar 'Pisang awak' (ABB-genome, 16% of landscape, 9% of farms and known as 'Kisubi Musa'), was the second most important cultivar. For a given bunch weight, 'Pisang awak' was reported by farmers to produce more beer and of better quality compared to the other AAA-EA beer cultivars (Gaidashova et al., 2005). This ABB beer banana is also considered to be more tolerant of adverse growing conditions and low levels of management (Gaidashova et al., 2005). Marketing of beer is more suitable for regions with low market access, because of its longer shelf life when compared with banana bunches which are highly perishable (Gaidashova et al., 2005). Brewing cultivars 'Kisubi mangango' (commonly known as 'Yangambi Km5', AAA-genome, 9% of *Musa* area, 6% of farms) and 'Tundu' (East African Highland banana, *Musa* AAA-EA, 7% of area, 7% of farms) were also widely grown. 'Vulambya' (AAA-EA, 11% of area, 8% of sampled farms) was the only widely grown cooking cultivar in North Kivu Province (Table 1). This cultivar is highly adapted to the region, produces large bunches and is highly marketable.

The plantain cultivar 'Apakumo' (14% of the total sampled area) was the most important cultivar in Ituri Province though only grown by 2% of the sampled farms. This cultivar produces large bunches and is grown by large-scale farmers targeting the plantain market. Other important plantain cultivars in Ituri include 'Baguma' (9% of area and grown in 9% of the farms), 'Mangondi II' (8% of area and 6% of farms) and 'Musilongo' (5% of area, 3% of farms) (Table 1). Beer type 'Pisang awak' (9% of area, 13% of farms) was also popular in Ituri Province. 'Bisamunyu' (*Musa* AAA- EA; 8% of area and 10% of

Table 1. Banana and plantain cultivars observed in and/or collected from Ituri and North Kivu (NK) provinces, their genome groups, type/use, mat frequency (%) and the frequency of farmers growing them in 2010/2012.

Cultivar	Genome group	Subgroup -type	Main use	% Mats		% Farmers growing cultivar	
				NK	Ituri	NK	Ituri
Nguma	AAB	Plantain (F)	C	18.72	-	9.58	0.00
Pisang Awak	ABB	Pisang Awak	B	16.11	8.9	9.00	13.02
Vulambya	AAA	EA	C	10.68	1.01	8.24	2.38
Yangambi Km5	AAA	Ibota	B	8.73	0.14	5.56	0.63
Tundu	AAA	EA	B	6.94	-	6.90	0.00
Kotina	AAB	Plantain (FH)	C	6.3	0.18	4.41	0.48
Mukingiro II	AAA	EA	B	4.18	-	3.45	0.00
Bagore bararume*	AAA	EA	C	4.13	-	4.60	0.00
Mathoke	AAA	EA	C	3.81	0.55	6.90	2.22
Bisamunyu	AAA	EA	C	3.33	7.75	4.60	9.68
Vuhindi	AAB	Plantain (F)	F	2.76	0.27	3.64	0.48
Pakuma	AAA	EA	C	1.97	1.23	1.92	0.63
Kiware	AAA	EA	C	1.87	-	0.38	0.00
Kamaramasenge	AAB	Ney povan	D	1.84	5.42	6.32	7.14
Nziravahima	AAA	EA	C	1.51	0.18	3.07	0.32
Kitika sukari II	AAA	Cavendish	D	1.39	4.05	1.53	2.06
Musilongo	AAB	Plantain (FH)	C	1.23	5.00	2.68	5.24
Bwazirume	AAA	EA	C	0.83	-	1.53	0.00
Nyamabere *	AAAA	EA	B	0.83	-	3.07	0.00
Kitika sukari I	AAA	Cavendish	D	0.62	5.56	4.60	9.52
Plantain Grand format	AAB	Plantain (FH)	C	0.46	1.41	0.77	1.59
Mukingiro	AAA	EA	C	0.43	-	0.77	0.00
Mudjuva	AAA	EA	C	0.32	0.57	1.72	2.38
Injakara	AAA	EA	C	0.29	-	1.15	0.00
Kingulungulu	AAB	Plantain (FH)	C	0.13	-	0.19	0.00
Kola	AAB	Plantain (F)	C	0.08	-	0,19	0.00
Sanza Ine	AAB	Plantain (H)	C	0.06	0.45	0.57	1.11
Gros Michel II*	AAA	Gros Michel	D	0.05	3.01	0.19	2.70
Kirisirya	AAA	Red banana	B	0.05	0.6	0.38	2.22
Banane noire *	AAB	Ney povan	D	0.05	-	0.19	0.00
Mbogoya*	AAA	Gros Michel	D	0.05	-	0.38	0.00
Nyambururu	AAA	EA	C	0.05	-	0.38	0.00
Pakuma II *	AAA	EA	B	0.05	-	0.19	0.00
UCG 10*	AAA	EA	C	0.05	-	0.19	0.00
Kirisirya Plantain *	AAB	Plantain (F)	C	0.03	-	0.19	0.00
Giant banana*	AAA	Cavendish	D	0.02	-	0.19	0.00
UCG 15 *	AAB	Plantain (F)	C	0.02	-	0.19	0.00
UCG 7*	AAA	Gros Michel	D	0.02	-	0,19	0.00
Apakumo	AAB	Plantain (FH)	C	-	14.6	0.00	1.59
Baguma	AAB	Plantain (F)	C	-	8.86	0.00	8.57
Mangondi II	AAB	Plantain (FH)	C	-	7.57	0.00	5.56
Bakpulu *	AAB	Plantain (FH)	C	-	4.45	0.00	1.90
Agbindolo	AAB	Plantain (F)	C		2.81	0.00	1.11
Akoto	AAB	Plantain (FH)	C	-	3.10	0.00	1.27
Nda II	AAB	Plantain (FH)	C	-	2.48	0.00	1.27
Akobanzi	AAB	Plantain (F)	C		1.76	0.00	0.79
Mangondi	AAB	Plantain (FH)	C	-	1.29	0.00	2.06

Table 1. Contd.

Mangbulu	AAB	Plantain (FH)	C	-	1.25	0.00	1.75
Boofo	AAB	Plantain (FH)	C	-	1.27	0.00	2.86
Bandulu	ABB	Bluggoe	C	-	0.74	0.00	2.22
Sira *	AAA	EA	C	-	0.93	0.00	0.95
Akongo	AAB	Plantain (FH)	C	-	0.56	0.00	1.43
Alambi*	AAB	Plantain (FH)	C	-	0.54	0.00	0.48
Chui	AAB	Plantain (F)	C		0.39	0.00	0.32
Kasilongo	AAB	Plantain (FH)	C	-	0.41	0.00	0.32
Makelekele	AAB	Plantain (FH)	C	-	0.29	0.00	0.16
Adili	AAB	Plantain (F)	C		0.22	0.00	0.63
Akange*	AAB	Plantain (F)	C	-	0.05	0.00	0.32
Mane	AAB	Plantain (FH)	C	-	0.06	0.00	0.32
Ngwende *	AAB	Plantain (FH)	C	-	0.07	0.00	0.16
UCG 8 *	AAB	Plantain (FH)	C	-	0.02	0.00	0.16
Total				100	100	100	100

Dash ('-') denotes the cultivar was missing in the province. EA: East African Highland banana (includes the Lujugira and Mutika groups); B: Brewing banana; C: Cooking banana; D: Dessert banana; F: French Plantain; FH: False horn Plantain; H: Horn Plantain. * Presumed new cultivars.

Table 2. The summary distribution of banana and plantain cultivars found in Ituri and North Kivu provinces, their genome/ use groups, area coverage (%) and the frequency of farmers growing the cultivars.

Cultivar sub groups (genome groups)	Area coverage (%)		Proportion of farmers growing cultivar groups (%)	
	North Kivu	Ituri	North Kivu	Ituri
True horn Plantain (AAB)	0.1	0.5	0.6	1.1
False horn Plantain (AAB)	8.1	44.6	8.1	28.6
French Plantain (AAB)	21.6	14.4	13.8	12.2
Beer type (ABB)	16.1	8.2	9.0	15.2
East African Highland beer type (AAA-EA)	20.8	1.5	19.6	2.8
East African Highland cooking type (AAA-EA)	29.3	12.2	35.5	18.6
Dessert types (AAA and AAB)	4.0	18.0	13.6	21.4
Cooking ABB types	0.0	0.7	0.0	0.0

Data was collected during a germplasm collecting expedition in 2010/12.

farms) was the main cooking cultivar in Ituri. This cultivar is highly adapted to this region and produces large bunches. 'Kitika sukari I' (*Musa* AAA, 6% of area and 10% of farms) and 'Kamaramasenge' (*Musa* AAB, 5% of area and 7% of farms) were the most important dessert cultivars in Ituri (Table 1).

Three territories, Beni (37 cultivars) and Lubero (28 cultivars) in North Kivu and Mambasa (27 cultivars) in Ituri contained the highest *Musa* diversity (Figure 2). The Beni and Lubero territories comprise three agro-ecological zones characterised by altitudes varying between 800 and 2,500 m a.s.l. in a vast area of approximately 150 km^2. This allows for the coexistance of East African Highland banana (AAA-EA) and plantain cultivars (Ndungo, 2002; Ocimati et al., 2013b). In contrast, Mambasa territory lies at a low altitude (between 850 and 1,010 m a.s.l) with a generally flat terrain characterised by high temperature and rainfall that are conducive for plantain growth. This territory showed the highest *Musa* diversity for plantain (AAB) cultivars. The diversity in Mambasa could also be influenced by exchanges in germplasm with Beni and Lubero that border it. The high diversity in Mambasa could also partially be explained by the absence of the key banana diseases, Xanthomonas wilt of banana (XW) and banana bunchy top disease (BBTD), at the time of this study. In contrast, the incidence of XW and BBTD was generally high (60 to 70%) across Djugu, Irumu and Mahagi

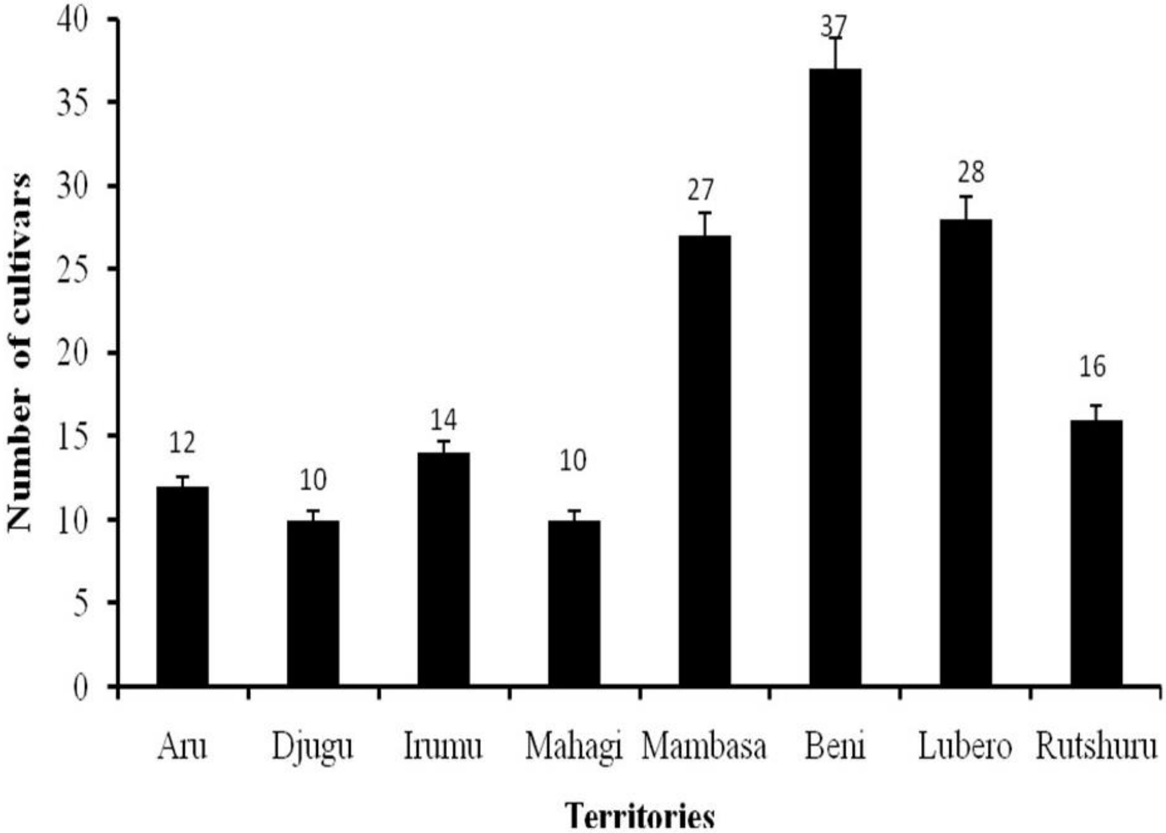

Figure 2. Musa cultivar diversity in selected territories in North Kivu and Ituri provinces, Eastern Democractic Republic of Congo. Data were collected between 2010 and 2012. Bars denote standard error values with a 95% confidence interval. Aru, Djugu, Irumu, Mahagi and Mambasa are territories in Ituri Province while Beni, Lubero and Rutshuru are territories in North Kivu Province.

territories in Ituri Province (Food and Agriculture Organization (FAO), 2010). The prevalence of these diseases in these territories could have influenced the observed *Musa* diversity in them. Farmers affected by these diseases have been reported to substitute/replant their *Musa* fields with other crops such as cocoa, oil palm, coffee, cassava and eucalyptus trees (FAO, 2010; Ocimati et al., 2016a, b).

Musa diversity by use groups

Across the two provinces, 76.6% of the *Musa* cultivars were processed through cooking. These predominantly included the plantain (AAB genome) types (52% of the cultivars across the sites) and the green cooking East African Highland banana (Mutika and Lujugira sub-groups) cultivars that accounted for 23.3% of the cultivars identified. The other cooking cultivar identified in the study was ‘Bluggoe’ (ABB genome). The beer cultivars accounted for 11.7% of the cultivars. These beer cultivars included ‘Pisang Awak’ (ABB genome), four East African Highland banana cultivars (AAA genome) and ‘Yangambi Km5’ (AAA genome). The dessert types (11.7% of cultivars) included ‘Gros Michel’ (AAA genome) and its variants, dwarf and giant Cavendish (AAA genome) types and ‘Ney povan’ (AAA-genome).

Presumed new cultivars encountered and sampled

Many presumably new banana and plantain cultivars were collected for further characterization and conservation at the UCG *Musa* collection at Butembo, North Kivu Province, Eastern DR Congo. A total of six cultivars including four plantains (‘Alambi’, ‘Akange’, ‘Bakpulu’ and ‘Ngwende’), one dessert (later identified as ‘Gros Michel II’, because of its similarity to ‘Gros Michel’) and one cooking banana (‘Sira’ AAA-EA) were sampled from Ituri Province. A total of 13 cultivars comprising four plantains (‘UCG 15’, ‘Kirisirya’ Plantain, ‘UCG 8’, ‘Kingulungulu’), three dessert banana types (‘Banana

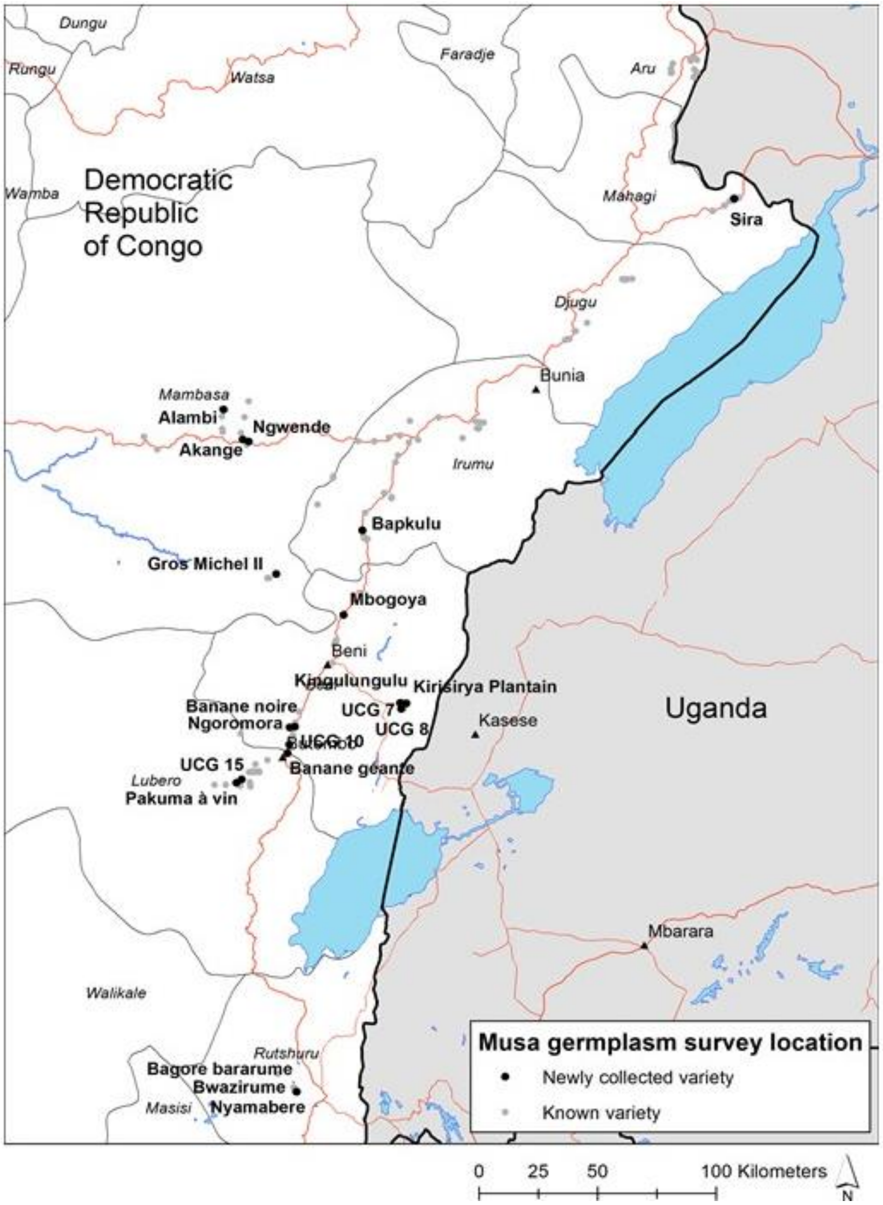

Figure 3. Locations of the already known and conserved *Musa* cultivars and the location of the presumed new *Musa* cultivars collected from the survey sites for further characterization and conservation at the Université Catholique du Graben *Musa* collection. Beni, Lubero and Rutshuru are territories in North Kivu Province while Aru, Djugu, Irumu, Mahagi and Mambasa are territories in Ituri Province.

noire' (AAB), 'Mbogoya' (AAA, sny. 'Gros Michel'), 'Giant banana' (AAA)); four cooking cultivars ('Bwazirume', 'Bagore bararume', 'UCG 10', 'UCG 7') and two beer cultivars ('Pakuma II' (AAA-EA) and 'Nyamabere' (AAA-EA)) were also collected from North Kivu Province. At least four suckers for each of the above sampled cultivars were collected and planted in the *ex situ Musa* genebank collection of the UCG for further characterisation and conservation. The location of the cultivars collected during the study and the presumed new cultivars are shown in Figure 3.

Musa cultivar synonyms in North Kivu and Ituri provinces

Musa cultivars were given a variety of names in the different languages and dialects (Table 3). The two

Table 3. Synonyms used for banana and plantain cultivars in the Ituri and North Kivu provinces, eastern Democratic Republic of Congo.

Cultivar (common name)	Synonyms
'Apakumo'	'Matenetene' (Lese), 'Bolomaise'
'Bapkulu'	'Imbelenga'
'Bisamunyu'	'Mbodo' (Lese), 'Kitika', (Swahili) 'Nyamugabu'
'Bandulu'	'Kipepepe' (Nande), 'Bokora' (Alur, Lugbara), 'Bluggoe', 'Cardaba', 'Yacobi'
'Kamaramasenge'	'Kalole' (Nande), 'Ilole', 'Kamera', 'Manzaka na mukari' (Lugbara), 'Akasukari'
'Pisang awak'	'Kisubi musa', 'Kayinja','Hunda '(Lendu), Nyakisubi (Nande)
'Yangambi Km 5'	'Depre' (Kinyabwisha), 'Kisubi mangango'
'Kitika sukari II'	'Petite naine', 'Angilape' (Lese), Cavendish nain, Kakuyi (Nande)
'Kitika sukari I'	'Opu' (Lugbara), 'Cavendish giant', 'Enee abhua' (Lugbara)
'Kirisirya'	'Figue rose', 'Red banana' (English), 'Ekirisirya' (Nande), 'Ukwiro ringho' (Alur), 'Mundu abhua' (Lugbara), 'Bitabe ya bandele' (Lingala), 'Vonda' (Lendu)
'Kiware'	'Ndabaware (Nande)', 'Maware', 'Imugimira' (Kinyabwisha), 'Abenze' (Lese); 'Nyanza' (Kinande),
'Kotina'	'Kikothina' or 'Kothina' (Nande), 'Libanga likale' (Lingala), 'Buruku' (Kinyabwisha);
'Musilongo	'Munzabo' (Nande), 'Masilongo', 'Masisi';
'Mathoke	'Bambuti' (Lese), 'Kitika', 'Kitoke', 'Kigufi' (Kinyabwisha);
'Nziravahima'	'Inganda' (Kinyabwisha); 'Sira Rouge'
'Ngwende'	'Mamba', 'Egbe-o-mabese I'
'Akobanzi'	'Unega' (Lendu),
'Sanza ine'	'Kingalu' (Nande), 'Sanza moya' (Swahili), 'Sanza mbili' (Swahili), 'Sanza tatu' (Swahili), 'Makaka' (Lese), 'Atuku' (Bira), 'Mangana mbimbi' (Lese), 'Lak-lyech' (Alur), 'Lokusu';
'Pakuma'	'Atititedekudelu' (Lese), 'Kisamunyu' (Swahili), 'Mapkutu', 'Manambolu' (Bira), 'Nyaghenge' (Nande)
'Tundu'	'Intuntu', 'Nyanza' (Kinyabwisha)
'Vuhindi'	'Ayaya' (Bira), 'Mayaya', 'Bitopi' (Lese)
'Vulambya'	'Nyalambia' (Nande), 'Bilaupe' (Bira)
'Chui'	'Masweswe', Leopards
'Adili'	'Litete'
'Agbindolo'	'Bosua'
'Akange'	'Mane' (soleil en Lese), 'Bukubekisi', Plantain rouge I
Gros Michel	Mbogoya

Data was collected in 2010/12. In brackets are the languages in which the synonyms are used.

provinces are home to over 17 tribes with different languages and dialects (Maindo, 2003; DRC, Ministry of Planning, 2005; Saint Moulin, 2006). In this study, a total of 76 cultivar names are listed across the study sites for 22 cultivars. Through the experience of the germplasm curator (six years of experience), synonyms within each region were identified, narrowing the overall cultivar list to 61 cultivars (Table 1). The presence of synonyms in different languages, dialects and countries is a common problem confronting banana taxonomists (Valmayor et al., 2000). The knowledge of synonyms prevents wasteful duplication of basic studies on banana cultivars and promotes regional understanding, communication and banana trade (Valmayor et al., 2000). More synonyms, however, probably exist among the listed 61 cultivars. Coupling molecular approaches that are efficient in elucidating the genetic relationships among species to the morphological characterisation approaches to minimize the confusion due to synonyms is recommended. In addition, the level of genetic variation among the cultivars needs to be elucidated.

Morphological characterization of *Musa* cultivars across the study regions

Simmonds (1962) established that morphological characterization of bananas is the principal way to classify banana cultivars into different genomic groups. A total of 34-minimum set of descriptors have been developed for characterising banana (IPGRI-INIBAP/CIRAD, 1996; *Musa*Net, 2011) (Table 4). Twenty three out of these 34 descriptors were used for discriminating and grouping the *Musa* cultivars identified

Table 4. The 34-minimum set of descriptors of banana (IPGRI-INIBAP/CIRAD, 1996) and principal components of those used to discriminate *Musa* cultivars identified and/or sampled from Ituri and North Kivu provinces between 2010 and 2012.

Code	Descriptors for banana	PC 1 scores	PC 2 scores
C621	Pseudostem height	-	-
C625	Predominant underlying colour of the pseudostem	-	-
C626	Pigmentation of the underlying pseudostem	0.0121	**-0.3265**
C627	Sap colour	-	-
C631	Blotches at petiole base	0.0156	**-0.4131**
C633	Petiole canal leaf III: open or closed	0.1165	0.2006
C634	Petiole margins	0.1523	0.1616
C636	Petiole margin colour	-0.0813	-0.2350
C637	Edge of petiole margin (rim)	-	-
C6322	Colour of outer surface of cigar leaf	-	-
C646	Bunch position	0.0962	-0.1252
C647	Bunch shape	0.1814	0.1608
C6412	Rachis position	-0.0598	-0.1256
C6413	Rachis appearance	-0.2460	0.2222
C6415	Male bud shape	-0.2489	0.0134
C6416	Male bud size at harvest	-	-
C651	Bract base shape	-	-
C652	Bract apex shape	**-0.3133**	0.0956
C653	Bract imbrication	**-0.3250**	0.0496
C654	Colour of the bract external face	**-0.3246**	-0.1711
C655	Colour of the bract internal face	-	-
C6512	Bract behaviour before falling	**-0.3361**	0.1520
C662	Compound tepal basic colour	-0.2873	0.1086
C664	Lobe colour of compound tepal	**-0.3200**	0.1960
C6613	Anther colour	-	-
C6624	Dominant colour of male flower	-0.2723	0.0677
C710	Number of hands	-0.1034	-0.0764
C672	Number of fruits on the third hand	-	-
C673	Fruit length	0.2277	0.2177
C674	Fruit shape	0.1947	0.2959
C676	Fruit apex	-0.0171	-0.0817
C677	Remains of flower relicts at fruit apex	0.0776	0.2129
C678	Fruit pedicel length	-0.0054	**0.4275**
C6711	Fusion of pedicel	-	-

Dashes ('-') denote descriptors not used in the study. Principal component (PC) values in bold depict the descriptors that contributed most in differentiating *Musa* cultivars.

across the study regions (Table 4). The 23 descriptors were found to be more discriminating and therefore used for the final grouping of the cultivars in these regions. In a similar study, Karamura et al. (2013) used 25 of the 34 minimum descriptors for characterization of *Musa* clones (from mixed genome groups) as the other seven descriptors were unable to differentiate between the clones.

The first two principal components (PCs) following a principal component analysis explained 42% of the variaion, while together with the third PC they accounted for 52%. The variation in PC1 was mainly explained by the male bud bract characteristics, while in PC2 by the fruit pedicel length (C678), the blotches at the petiole base (C631) and the pigmentention of the underlying pseudostem (C626) (Table 4). The plot of PC1 and PC2 for the 61 *Musa* cultivars (after removing synonyms) resulted in three major clusters (Figure 4). The first cluster comprised the French plantains that are characterised by the presence of a complete male inflorescence. The second cluster was composed of the false horn and horn plantains (AAB) that are,

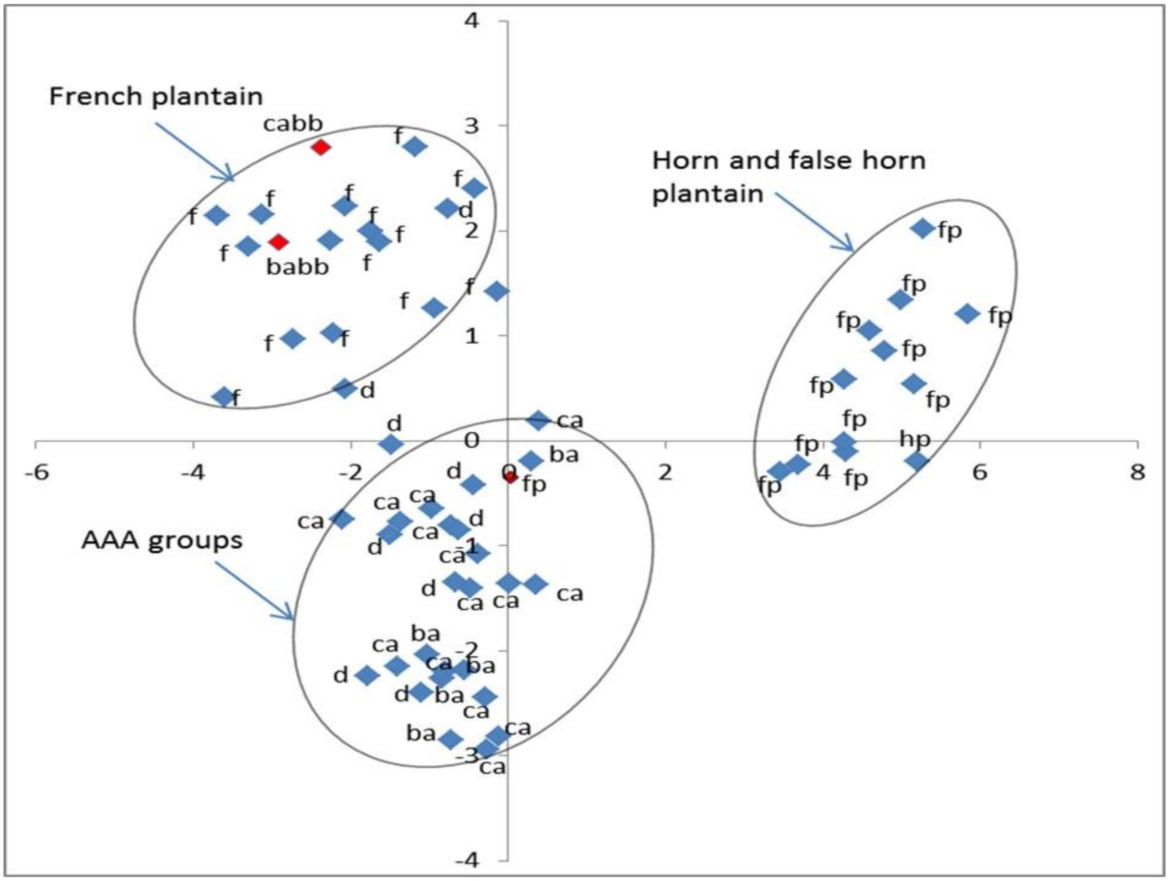

Figure 4. The clustering of the different *M*usa cultivar groups observed on farmers fields in North Kivu and Ituri provinces, eastern Democractic Republic of Congo. 'd', 'babb' and cabb respectively, denote dessert, ABB beer cultivar and ABB cooking cultivar.

respectively, characterised by a reduced and an absent male infloresence part and, in some cases, relatively few hands. The third cluster comprised varieties that had a complete inflorescence, being a mixture of cooking and beer East African Highland bananas (AAA-EA genome). Most of the dessert cultivars (AAA-genome) grouped with the East African Highland types, with a few grouping between the East African Highland types and the French plantains and one dessert variety grouping with the French types. The ABB-genome clustered within the French plantains (Figure 4).

Cultivar similarity between territories in Ituri and North-Kivu provinces

The Morisita similarity index between Ituri and North Kivu province territories was less than 0.5 (Figure 5). This suggests a dissimilarity among the cultivars recorded in the territories of Ituri and those recorded in North Kivu. However, similarity was recorded (Morisita index: 0.55) in the diversity of cultivars in the territories within North Kivu (Figure 5). This could be explained by the similarity in the agro-ecologies in these territories. Within North Kivu, a higher similarity (Morisita index: 0.90) was observed between Beni and Lubero territories. This could be attributed to the fact that Beni (1057 to 1974 m a.s.l.) and Lubero (1348 to 1847 m a.s.l.) are similar in their agro-ecologies. In addition, these territories share a common border that possibly allows for free exchange of *Musa* germplasm (Figures 1 and 3). In contrast, Rutshuru is separated from these territories by the Virunga National Park and borders Uganda and Rwanda, with a possible influence of these two countries on its cultivar composition (Figures 1 and 2). For example, in a *Musa* expedition in Ugandan districts bordering Eastern DR Congo, Karamura et al. (2013) noted a mixed Uganda–DR Congo *Musa* composition. Several names of both plantains and the highland bananas were associated with dialects across both Uganda and DR Congo. For example, 'Nyalambya'/'Nyarambi' in Uganda (called 'Vulambya' in North Kivu), 'Ndyabawali' in Uganda (called

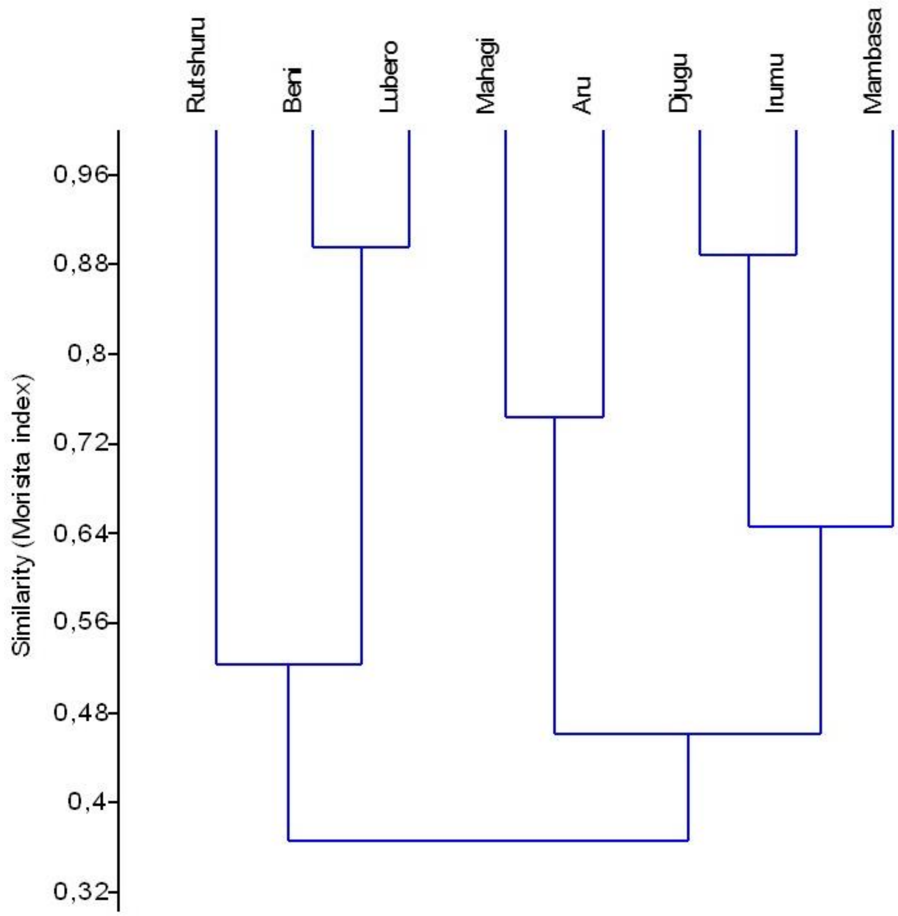

Figure 5. Dendogram showing the similarity and dissimilarity in *Musa* cultivars recorded across territories in North Kivu and Ituri provinces using the Morisita index (data of abundance). Beni, Lubero and Rutshuru are territories in North Kivu Province while Aru, Djugu, Irumu, Mahagi and Mambasa are territories in Ituri Province.

'Kiware' or 'Maware' in North Kivu), plantain 'Namutobisho' in Bundibugyo, Uganda (called 'Vuhindi' in North Kivu) are widely grown in both Uganda and Eastern DR Congo. Karamura et al. (2013) attributed this border *Musa* composition to the similar border ecologies, ethnic groups and ethnic migrations across the borders.

On the other hand, dissimilarity was observed in territories within the province of Ituri (Figure 5). Mahagi and Aru territories were observed to form a separate cluster from Djugu, Irumu and Mambasa that formed another cluster. Djugu and Irumu were further observed to have a high similarity (Morisita index: 0.88) (Figure 5). Mahagi (1616 to 1884 m a.s.l.) and Aru (1158 to 1456 m a.s.l) share similar agro-ecologies and a common border, that possibly allows for easy exchange of *Musa* germplasm. Djugu (1434 to 1740 m a.s.l.) and Irumu (864 to 1118 m a.s.l) territories, though variable in altitude, share a common border. Mambasa on the other hand, has a low altitude (851 to 1008 m a.s.l) which is like that in Irumu (864 to 1118 m a.s.l), thus permitting growth of similar *Musa* cultivars. Additionally, Mambasa and Irumu territories share a common border (Figure 3).

Musa cultivar erosion

Across the study sites only six *Musa* cultivars were perceived by farmers to be under threat of genetic erosion or to have been eroded (Table 5). However, this was only perceived by between 2 and 8% of respondents in Ituri and North Kivu, respectively. Only two of these cultivars ('Kirisirya' and 'Pakuma') were reported to be threatened across the study sites. Customary beliefs such as cultivar restriction to/consumption by women or the elderly were some of the reasons for the perceived threat or erosion of the cultivars. Other reasons included varietal degeneration (small size of banana fruits), low preference by farmers and vulnerability to XW (Table 5).

Table 5. Disappearing cultivars in the North Kivu and Ituri provinces.

Cultivar	% of farmers reporting		Reasons for cultivar erosion
	North Kivu	Ituri	
Vuhindi	-	0.7	Reserved for the elderly and women do not eat it
Kirisirya	1.1	6.6	Degenerating, produces very small bunches and fields abandoned due to armed conflict
Kisubi musa	2.2	-	Highly susceptible to Xanthomonas wilt of banana
Nziravahima	7.8	-	Used for customary rites and by traditional healers
Pakuma	4.4	0.7	Small bunches, restricted to women
Tundu	1.1	-	Produces wine that is not liked by many farmers

Low farmer preference for cultivars has been reported to influence the selection of cultivars maintained on farm and hence their diversity in Burundi and Rwanda (Ocimati et al., 2013b, 2014). Pests and diseases, especially XW, Fusarium wilt and Bunchy Top Disease (BBTD), have also been cited as responsible for the erosion of *Musa* cultivars in Burundi, Rwanda and Uganda (Okech et al., 2005; Karamura et al., 2013; Ocimati et al., 2013b, 2014). The banana crop has also been abandoned in XW-affected sites in, for example, Uganda and parts of Eastern DR Congo, in favour of alternatives such as sweet potato, taro, legumes and cassava (Karamura et al., 2006; Kalyebara et al., 2007; Ocimati et al., 2016a, b). *Musa* conservation strategies need to integrate the management of diseases such as XW and BBTD that are fast spreading and indescriminately affecting the *Musa* crop in the region. The threatened cultivars in this study were collected and planted in the *Musa* germplasm collection at Université Catholique du Graben (UCG).

CONCLUSION AND RECOMMENDATIONS

This study revealed a high diversity of plantains (*Musa* AAB) and East African Highland bananas (*Musa* AAA) in both the North Kivu and Ituri provinces. Only a few cultivars (6) were reportedly at risk of erosion. However, the increasing burden of pests and diseases could negatively impact on this rich diversity. Efforts are therefore needed to manage and minimise the impact of these diseases on farm. Planting of these cultivars in the *in-situ* collection at Butembo is a positive step towards conservation and further evaluation of these cultivars. These cultivars could also be duplicated in other collections in the country and the international *Musa* spp. collection at the International Transit Center, Leuven, Belgium. Expanding this *Musa* germplasm collection expedition to cover the entire Eastern DR Congo is recommended to have a picture of the whole *Musa* diversity. Robust molecular characterization techniques need to be used to further understand the genetic base and diversity of these cultivars.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Knowledge of conservationists on the effect of lead toxicity on the conservation status of African mourning dove (*Streptopelia decipiens*) in Ibadan, Nigeria

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The role of humans in any conservation action is vital and plays a key role in the success of biodiversity and wildlife conservation. The awareness and related activities of people to the risk of lead contamination as a threat to the conservation status is evaluated, particularly with respect to the status of the mourning dove. Lead pollution and toxicity has been reported in mourning dove with associated health and mortality patterns, and is therefore a recognised threat to the conservation of the species. This study therefore aimed to assess the knowledge, attitude and perception of conservationists, who are the custodian of knowledge, on the conservation status of African mourning dove (*Streptopelia decipiens*) as a species model, and lead toxicity as an associated threat. The result shows that all the correspondents had varying degree of knowledge about the conservation of African mourning dove (*S. decipiens*) and the associated threat of lead toxicity. 16.3% of the respondents showed very high level of attitude, while 27.6 and 46.9% showed an average and high level of attitude to the conservation of African mourning dove (*S. decipiens*) and the associated threat of lead toxicity. Based on perception scores, 41.8% showed average level, while 28.6 and 5.1% showed high and very high level of perception, respectively; but 13.3% of the respondents showed low level of perception. Higher educational status corresponds to a higher knowledge, but less significant relationship to attitude and perception. It is concluded that, knowledge about conservation would affect the attitude and perception, though there are no significant gender and age differences regarding the topic.

Key words: African mourning dove (*Streptopelia decipiens*), biodiversity, wildlife conservation.

INTRODUCTION

The conservation status of a species indicates the status of its continued existence and the likelihood of becoming extinct in the near future [International Union for Conservation of Nature (IUCN), 2015]. One of the

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greatest challenges facing wildlife and environmental conservation is how to balance anthropogenic impact and influence with environmental stability (Kioko et al., 2010). As such, the role of humans in any conservation action is very vital. Humans play a key role in the success of biodiversity and wildlife conservation plans, but anthropogenic activities also pose a major threat to wildlife and biodiversity (Gemeda et al., 2016). The effect of a dual assault in the form of urbanization and industrialization has led the human population to interface with natural habitats impacting negatively on wildlife (Gupta and Bakre, 2013). There are several factors taken into account when assessing the conservation status of species; which includes rate of decline, population size, area of geographic distribution, breeding rates, and known associated threat (IUCN, 2012). Among the known threats are environmentally associated impacts such as desertification, climate change, and environmental pollution. Exposure to environmental pollutants are often regarded insignificant, but may constitute threat to the survival of species such as *Streptopelia decipiens* (Primack et al., 2008). Environmental pollutants such as heavy metals have been reported to have caused global-scale environmental contamination with subsequent poisoning of the humans and animals (Tong et al., 2000). The effects of heavy metal poison, such as reported in lead poisoning, could pose a threat to the conservation status of all known species.

Lead poisoning was first reported in wild birds in a sporting and scientific paper in the United States of America in the late 1800s, which cited the occurrence in waterfowls (Grinnell, 1894; Lewis and Legler, 1968). Despite the early warnings, the situation persisted during years of investigation and controversies, complicated by the dynamics of human interface with wildlife and wildlife conservation. The story remains unchanged with increase in anthropogenic contact with wildlife and the interaction of wildlife with humans due to further encroachment by humans into the wild. Poisoning from ingestion of spent lead shot in mourning dove has been identified as a conservation and management issue, with a need for a better understanding of its potential population effects (Tomlinson et al., 1994). There have been reports of ingested lead shots of 0.3 to 6.4% in mouring doves (Kendall, 1996; Schulz et al., 2002). Kendall (1996) estimated the frequency of ingestion of lead shot, based largely on data from Mourning dove to be about 3%, indicating the importance of lead toxicity to the species' conservation and associated threat to conservation in general.

Several authors have reviewed the exposure and effect of exposure of environmental lead poisoning in the mourning dove, and reported effects ranging from ill health to mortalities in the wild (Castrale, 1991; Schulz et al., 2006) and experimentally (Schulz et al., 2007).

Despite international awareness of lead poisoning in wildlife, including wild birds and mourning dove, there is still insufficient data on the knowledge and practice of their conservation; and particularly in relation to the connection between conservation and environmental pollution in the species, particularly as addressed in this case study in Nigeria. Mourning dove has been identified as a source of meat internationally, and is eaten by locals in Nigeria; it is regarded as a delicacy and among the list of meat called bush meat by locals (Green, 2005; Natala et al., 2009). There has been no report of the knowledge and practice of the locals on the conservation status of Mourning doves, as most issues are assumed to be naturally controlled (Baskett et al., 1994). Data was collected using a cross sectional design, by distributing a well-structured questionnaire each containing 34 items to 100 potential respondents, and 98% responded.

The assessment of peoples' knowledge, attitudes and perceptions (KAP) towards conservation and its associated threat has become significant in the study of wildlife conservation (Newmark et al., 1993). Presently, there is a lack of adequate understanding of the KAP in wildlife conservation issues (Kioko et al., 2010). Assessing attitudes, knowledge and perceptions of students and staff of conservation-related institutions toward wildlife can provide insights on their role to ensure and contribute to the conservation of wildlife (Carter et al., 2013). This study therefore aimed to assess the knowledge, attitude and perception of conservationists on the conservation status of African mourning dove (*S. decipiens*) as a model of species conservation, and better insight into lead toxicity as an associated threat, particularly given its widespread occurrence ecologically, and its use as a source of meat.

MATERIALS AND METHODS

In a cross sectional design, sampling was done using a well-structured questionnaire with 34 items, distributed to 100 people and 98% responded to the distributed questionnaires. The questionnaires were pretested and administered to a purposively selected sample of conservationists at the Departments of Wildlife and Ecotourism Management (WEM), Forest Resources Management (FRM) at the University of Ibadan, and Forest Conservation and Protection (FCP) at the Forest Research Institute of Nigeria. The participants were students and staff of institutions concerned with the study of conservation; therefore, a representative of people with related knowledge, and also a likely mirror of the opinions of some members of society on conservation matters. Based on the population of the study areas (Figure 1), 29.6% of the questionnaires (29 copies) were administered at WEM, 39.9% (39 copies) at FRM, and 30.6% (30 copies) of the questionnaires were administered at FCP; 98 copies in total. The questionnaire was structured into four sections: (1) socio-demographic characteristics of the respondents, (2) the level of their awareness and concepts related to the subject (used to assess their Knowledge), (3) attitudes as related to activities in relation to the subject, and 4) perception on conservation status, as assessed by the effect of the information that they possess about the subject has on the mode of action to be taken by the participants. Upon

Table 1. Knowledge, attitude and perception scores of respondents on conservation status and the effect of lead toxicity, expressed as number (n) and percentages (%).

Score	Knowledge number (%)	Attitude number (%)	Perception number (%)
Low	0 (0)	0 (0)	13 (13.3)
Average	15 (15.3)	27 (27.6)	41 (41.8)
High	50 (51.0)	46 (46.9)	28 (28.6)
Very high	19 (19.4)	16 (16.3)	5 (5.1)
Missing	14 (14.3)	9 (9.2)	11 (11.2)
Total	98 (100.0)	98 (100.0)	98 (100.0)

return of the questionnaires, the authors assessed it by assigning a score to the quality of each response using a nominal scale as follows: For categories related to *knowledge*, an "exceptional response" was scored as 40; "very high quality" (above 35), "high quality" (31 to 35), "average quality" (26 to 30), and "low quality" (below 26). For categories related to *Attitude*, the corresponding quality scores are as follows: "exceptional" (36); "very high" (above 30), "high" (26 to 30), "average" (20 to 25), and "low" (below 20). with regard to quality of perception, the scoring scheme was: "exceptional" (28); "very high" (above 24), "high" (20 to 24), "average" (15 to 19), and "low" (below 15). There were 34 items all-totalled: socio-demographic details (8), knowledge (10), attitude (9), and perception (7).

Statistical analysis and interpretation of the results were done by descriptive statistics and correlation analysis using SPSS version 22. Correlation analysis was also carried out to test if significant relationships existed between items assessing knowledge, attitude and perception of the respondents.

RESULTS

Socio-demographic characteristics of respondents

A majority of the respondents [59 (60.2%)] were males, while 39 (39.8 %) were females. The largest number of respondents [41 (41.8 %)] was in the age group of 15 to 24 years followed by 25 to 34 years [24(24.6%)], 35 to 44 years [12(12.2%)] and 45 to 54 years [6(6.1%)], respectively; though 15 (15.3%) respondents did not give their ages. The youngest (15 years) were freshmen. Based on the marital status of the respondents, majority were single [69 (72.4%)], while 28 (26.5%) were married. Furthermore, most of the respondents [71 (72.4%)] were Christians, while 26 (26.5%) were Muslims. Only one person (1%) did not give a religious affiliation. Undergraduate students formed the largest group of the respondents [58 (59.2%)] followed by post graduate students [29 (29.6 %)], and then lecturers [10 (10.2 %)].

Knowledge, attitude and perception (KAP) of respondents on conservation status and the effect of lead toxicity

The qualitative categorical analyses (Table 1) showed that majority of the respondents [50 (51.0%)] had a high knowledge level of conservation issues with reference to African mourning dove (*S. decipiens*), 15 (15.3%) of the respondents showed average knowledge while only 19 respondents (19.4%) showed very high knowledge, and none of the respondents had scores indicating low or lack of knowledge. Based on attitude scores, the largest part of the respondents [46 (46.9%)] showed a high level of attitude towards conservation, 27 respondents (27.6%) showed an average level of attitude, while only 16 respondents (16.3%) showed a very high level of attitude. Moreover, none of the respondents had a low attitude score. Based on the perception scores, most of the respondents [45 (41.8%)] showed average level of perception of the conservation status of African mourning doves, while 28 respondents (28.6%) showed a high level of perception on their conservation status, and five respondents (5.1%) showed a very high level of perception, whilst 13 respondents (13.3%) showed a low level of perception.

Relationship between KAP and respondents' gender on conservation status and associated threat

Table 2 shows the relationship between knowledge and respondents' gender. A majority of the male respondents [32 (54.2%)] had high level of knowledge of conservation status with reference to African mourning dove (*S. decipiens*) and the associated effect of lead toxicity as a threat; while only 10 (16.9%) of the male respondents had very high knowledge with merely 8 (13.6%) of them having average knowledge. Similarly, most of the female respondents [18 (46.2%)] had a high level of knowledge; while only 9 (23.1%) of the female respondents had a very high knowledge, with only 7 (17.9%) of them having average knowledge. Based on the relationship between attitude and respondents' gender, a majority of the male respondents [23 (39%)] had high level of attitude towards conservation status and the associated effect of lead toxicity as a threat; while only 19 (32.2%) of the male respondents had average attitude with only 12 (20.3%) of

Table 2. Relationship between KAP and respondents' gender, expressed as number (n) and percentages (%).

Gender	Grade	Knowledge number (%)	Attitude number (%)	Perception number (%)
Male	Low	0 (0)	0 (0)	9 (15.3)
	Average	8 (13.6)	19 (32.2)	29 (49.2)
	High	32 (54.2)	23 (39)	14 (23.7)
	Very high	10 (16.9)	12 (20.3)	1 (1.7)
	Missing	9 (15.3)	5 (8.5)	6 (10.2)
	Total	59 (100)	59 (100)	59 (100)
Female	Low	0 (0)	0 (0)	4 (10.3)
	Average	7 (17.9)	8 (20.5)	12 (30.8)
	High	18 (46.2)	23 (59.0)	14 (35.9)
	Very high	9 (23.1)	4 (10.3)	4 (10.3)
	Missing	5 (12.8)	4 (10.3)	5 (12.8)
	Total	39 (100)	39 (100)	39 (100)

them having very high attitude. In the same way, most of the female respondents [23 (59.0%)] had a high level of attitude towards conservation status and the associated effect of lead toxicity as a threat; while only 8(20.5%) of them had an average attitude, and merely 4(10.3%) of them had a very high attitude.

Based on the relationship between perception and respondents' gender, a majority of the male respondents [29 (49.2%)] had average level of perception of conservation status and the associated effect of lead toxicity as a threat; while only 14 (23.7%) of the male respondents had a high perception score with only 1 (1.7%) of them having a very high perception score. On the contrary, most of the female respondents [14 (35.9%)] had a high level of perception; while 12 (30.8%) of them had an average perception, and only 4 (10.3%) of them had a very high perception. It is noteworthy that only 4 (10.3%) of the female respondents had a low perception as compared to 9 (15.3%) of the male respondents.

Relationship between KAP and respondents' educational level on conservation status and associated threat

Table 3 shows the relationship between knowledge and respondents' educational status; the results show that majority of the undergraduates [29 (50.0%)], postgraduates [17 (58.6%)] and lecturers [4(40%)], respectively, had a high level of knowledge of conservation status with reference to African mourning dove (*S. decipiens*). Based on the relationship between attitude and respondents' educational status, most of the undergraduates [31 (53.4%)] had a high attitude score with respect to conservation status of the African mourning dove (*S. decipiens*). Moreover, with respect to the associated effect of lead toxicity as a threat, 12 (20.7%) of them had an average attitude score. The postgraduates [11 (37.9%)] had an average attitude score; while 10 (34.5%) had a high attitude score. Meanwhile, among the lecturers 4 (40%) scored both average and high in their attitude.

With respect to the relationship between perception and respondents' educational status, the results show that 22 (37.9%) and 18 (62.1%) of undergraduates and postgraduate respondents, respectively, had an average perception score; while 19 (32.8%) and 4 (13.8%) of these respondents, respectively, had a high perception score. Among the lecturer respondents, 4 (40%) had a high perception score; while only 1 (10%) had an average perception score. Also, as expected, among the undergraduates, 7 (21.1%) had the highest incidence of low perception score, followed by postgraduates 4(13.8%) and lecturers 2(20%) as shown in Table 3.

Correlation between knowledge, attitude and perception (KAP) on conservation status and associated threat

Table 4 shows the correlation between knowledge, attitude and perception of respondents on conservation status with reference to African mourning dove (*S. decipiens*) and the associated effect of lead toxicity as a threat. The *r* - values between knowledge and attitude, knowledge and perception, and attitude and perception are 0.309**, 0.347** and 0.227*, respectively; showing that correlations are consistently positive among pairs of data for knowledge, attitude and perception. This

Table 3. Relationship between KAP and respondents' educational status, expressed as number (n) and percentages (%).

Educational status	Grade	Knowledge number (%)	Attitude number (%)	Perception number (%)
Undergraduates	Low	0 (0)	0 (0)	7 (21.1)
	Average	9 (15.5)	12 (20.7)	22 (37.9)
	High	29 (50.0)	31 (53.4)	19 (32.8)
	Very high	11 (19.0)	9 (15.5)	5 (8.6)
	Missing	9 (15.5)	6 (10.3)	5 (8.6)
	Total	58 (100)	58 (100)	58 (100)
Postgraduates	Low	0 (0)	0 (0)	4 (13.8)
	Average	4 (13.8)	11 (37.9)	18 (62.1)
	High	17 (58.6)	10 (34.5)	4 (13.8)
	Very high	4 (13.8)	5 (17.2)	0 (0)
	Missing	4 (13.8)	3 (10.3)	3 (10)
	Total	29 (100)	29 (100)	29 (100)
Lecturers	Low	0 (0)	0 (0)	2(20)
	Average	1 (10)	4 (40)	1 (10)
	High	4 (40)	4 (40)	4 (40)
	Very high	4 (40)	2 (20)	0 (0)
	Missing	1 (10)	0 (0)	3 (30)
	Total	10 (100)	10 (100)	10 (100)

Table 4. Correlation between Knowledge, Attitude and Perception (KAP).

	Knowledge	Attitude	Perception
Knowledge		0.309**	0.347**
Attitude	0.309**		0.227*
Perception	0.347**	0.227*	

** Significant at the 0.01 level (2-tailed); * Significant at the 0.05 level (2-tailed).

suggests that a good knowledge of conservation status could promote a better attitude and perception with respect to conservation of species such as the African mourning dove (*S. decipiens*). Although the correlations are all statistically significant, the correlations are not exceptionally strong, accounting for only approximately 12% of the variance. However, the correlation data are sufficient to suggest a positive relationship between improved knowledge and better attitudes toward conservation of the African mourning dove.

Also, the evidence in this study showing a positive correlation between perception and attitude suggests that a favourable perception would enhance a better attitude toward conservation of species. Moreover, the positive correlations among knowledge, attitude, and perception of the effect of lead toxicity as an associated threat to the conservation status of the species, were apparent.

DISCUSSION

This study has shown that the majority of the respondents 59 (60.2%) were males; while females were 39 (39.8 %). The greatest number of the respondents 41 (41.8 %) were in the age group of 15 to 24 and single; while undergraduate students formed the largest group of the respondents 58(59.2%).

The general KAP of respondents on conservation status using African mourning dove as a species model, and the associated effect of lead toxicity as a threat, showed that majority of the respondents had a high knowledge and favourable attitude scores, but an average perception score. Knowledge is not exclusive in determining attitude, but it is often a contributing factor. The high knowledge and attitude scores can be attributed to the fact that the respondents are active in the field of conservation either as students or lecturers. Knowledge has also been described as an essential precursor to attitude (Asunta, 2003). In fact, research on environmental topics has shown that the higher a person's actual knowledge, the better their attitude (Trewhella et al., 2005; Sexton and Stewart, 2007; Prokop et al., 2009).

Surprisingly, most of the respondents in the research reported here had an average perception score. This was among the least expected results from a practical standpoint, because the respondents are involved in conservation, directly or indirectly, and was expected to have very high knowledge as shown in this study which should influence the level of perception. The success of wildlife conservation depends on the attitudes of people towards conservation (Katrina, 2000). Conservation education is very imperative to change the attitude of the people towards wildlife (Kahan and Ali, 2015). Understanding the knowledge, attitude and perception (KAP) of people towards conservation and associated threat is also an important element for wildlife conservation and evaluating the success of conservation projects, in general (Soto et al., 2001; Sundaresan et al., 2012).

A number of significant results have been presented in other research and in the study reported here indicating substantial differences in gender knowledge, attitudes and perceptions towards animals. On the relationship between KAP and respondents' gender on conservation status with reference to African mourning dove (*S. decipiens*) and associated threat, the male respondents had higher knowledge score than the females. This is consonant with the research by Kellert and Berry (1987) and Tikka et al. (2000) who reported that males significantly have higher knowledge scores towards wildlife than females. By contrast, the female respondents were found to have a higher attitude and perception scores than the male respondents. Substantial published evidence shows that females have stronger and more affective attitudes towards animals than males. For instance, Borden and Francis (1978) and Van Liere and Dunlap (1980) reported that females exhibit higher perceptions concerning the environment than males. Tikka et al. (2000) also observed that females show a higher degree of environmental concern through their daily activities than men. As summarized by Kellert and Berry (1987), gender is among the most important socio-demographic influences on attitudes towards animals in our society.

On the relationship between KAP and respondents' educational level on conservation status with reference to African mourning dove (*S. decipiens*) and associated threat, in this study the lecturers had higher knowledge, attitude and perception scores compared to postgraduate and undergraduate respondents. This further supports the assertion that there is a positive association between KAP on wildlife issues and level of schooling or educational status (Pashby and Weis, 2002). Favourable attitudes toward wildlife conservation were found to be higher among the people in the upper school classes as reported by Kioko et al. (2010). Also, earlier findings associated higher education and/or increase in educational status to more compassion for wildlife (Bradley et al., 1999). On the correlation between Knowledge, Attitude and Perception (KAP) on conservation status with reference to African mourning dove (*S. decipiens*) and associated threat, the results show that a significant relationship exists between Knowledge, Attitude and Perception of respondents as regards conservation of the African mourning dove. For this reason, identifying knowledge, attitude and perception of people on wildlife conservation is very likely a pre-requisite for conservation action (Ebua et al., 2011). And the Knowledge, Attitude and Perception of the effect of lead toxicity as an associated threat will further be a strong asset in promoting conservation efforts by emphasizing the environmental impact on the species.

The greatest enemy to wildlife conservation is ignorance of the issues related to conservation and management of natural resources (Ebua et al., 2011). For an effective wildlife conservation action, it is crucial to understand the issues beyond the need of individual wildlife species, to promote an understanding as well of the human, cultural and economic aspects that overwhelmingly affect conservation efforts (Baillie et al., 2004). Therefore, understanding the factors that influence attitudes is important to enable wildlife managers and conservationists to implement approaches that attract support of stakeholders and the general public (Ebua et al., 2011). People tend to develop a negative attitude towards conservation, especially when they do not believe that they are receiving benefits and yet must bear the costs of living in harmony with wildlife (Omondi, 1994; Hill, 1998). Nonetheless, despite the costs of living with wildlife, some people and/or communities have retained a positive attitude towards conservation (Newmark et al., 1993; DeBoer and Baguete, 1998). Information on Knowledge, Perceptions and Attitudes of people is imperative to identify management programmes and strategies that best suit conservation efforts of biodiversity and wildlife resources (Kideghesho et al., 2007). People's attitudes and perceptions are results of not just personal experiences, but also a wide variety of social factors including fundamental socio-demographics (Kleiven et al., 2004; Majić and Bath, 2010), extending more broadly to encompass wider societal experiences, cultural norms, expectations and beliefs (Dickman, 2008).

Conclusion

This study has established that people in the field of nature conservation within the study areas have higher knowledge and attitude than perception of conservation status and the associated effect of lead toxicity as an anthropogenic threat to wildlife. There is a positive relationship between Knowledge and Attitude, Knowledge and Perception as well as Attitude and Perception in members of the surveyed institutions. This means that, better knowledge about conservation will promote good attitude and enhance positive perception. Higher educational status such as postgraduate programmes is important to a very high knowledge of conservation but less significant to attitude and perception. Though, there is no known study on evaluation of Knowledge, Attitude and Perception (KAP) of people that are not in the field of nature conservation, but taken inference from this study, it can be expressed that the little or no knowledge on conservation would affect the attitude and perception.

RECOMMENDATIONS

Conservation education should be incorporated into school curricula across all levels of education, and taught in secondary schools and higher institutions to educate people on conservation of natural resources. There should be more public enlightenment on radio, television and other mass media about the effects of threats to the environment and wildlife, including the release of environmental pollutants such as lead resulting from anthropogenic activities, such as mining, ore processing, smelting, refining ore, and the recycling or disposal of leaded battery, and leaded ammunition; especially, emphasizing the importance for survival of wildlife species and the effect on their conservation status.

Further research is needed to establish guidelines mitigating the effects of lead toxicity on the health and reproductive success of *S. decipiens* (African mourning dove). There is also a need to encourage community conservation and participatory management of wildlife resources for effective conservation and/or sustainable utilization.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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