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Pitout JDD, Church DL, Gregson DB, Chow BL, McCracken M, Mulvey M, Laupland KB (2007). Molecular epidemiology of CTXM-producing Escherichia coli in the Calgary Health Region: emergence of CTX-M-15-producing isolates. Antimicrob. Agents Chemother. 51: 1281-1286.

Pelczar JR, Harley JP, Klein DA (1993). Microbiology: Concepts and Applications. McGraw-Hill Inc., New York, pp. 591-603.

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Review

Utilization of pangolins in Africa: Fuelling factors, diversity of uses and sustainability

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Pangolins have attracted considerable attention in recent times due to their high rank in international trade. Whole carcass or body parts of extant pangolin species were used for many purposes which include: food, as a complementary protein source; in traditional medicinal preparations, and as ornaments. Factors responsible for the continued exploitation of pangolins were: low cost and very short time needed to acquire skills required for hunting; little or no further processing before the animals are disposed; high profit margins; general ignorance about conservation status and non-enforcement of the laws governing their trade. Traditional African medicinal practices believed that pangolins have a lot of medicinal, magical or mystical properties, sometimes requiring juvenile and pregnant female animals often rationalising exploitation as more important than conservation. Substituting other animals for pangolins is not always feasible because the possible substitutes were of greater conservation concerns. Local and intercontinental trade in pangolins also created a major challenge to the survival of remaining populations. Available evidence suggested the conservation status of six pangolin species (all four African and two Asian species) is growing worse. There is a need to determine the sizes of isolated populations across their ranges in the region.

Key words: Pangolins, wildlife utilisation, biodiversity conservation, pangolins trade, reducing pangolin demand, sustainability.

INTRODUCTION

Pangolins are mammals that have attracted considerable attention in recent times not for their unique morphological features but for their high rank in international trade (Challender, 2011; Challender and Hywood, 2012; Soewu et al., 2012). The scales that cover the dorsum and tail and which gives them the appearance of a reptile is one reason they are heavily exploited. The scales are used for purposes ranging from ornamental (Soewu, 2013a) to medicinal or trado-medicinal (Brautigam et al., 1994; Sodeinde and Adedipe, 1994; Sodeinde and Soewu, 1999; Soewu and Adekanola, 2011; Anonymous, 2014a) in Asian and African countries where pangolins are found. Hunted for generations for its tasty meat, the scaly-skinned pangolin

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Figure 1. Geographical range of the white-bellied pangolin (*P. stricuspis*). Source: Anonymous (2014b). Range**:** Angola, Benin, Central African Republic, Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Ghana, Kenya, Liberia, Nigeria, Rwanda, Sierra Leone, Sudan, Tanzania, Togo, Uganda, and Zambia- its presence is uncertain in Burundi.

Figure 3. Geographical Range of Temminck's Ground Pangolin (*S. temminckii*). Source: Anonymous (2014b). Range**:** Eastern and southern Africa, including Angola, Botswana, Central African Republic, Chad, Ethiopia, Kenya, Malawi, Mozambique, Namibia, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. Its presence is uncertain in Congo and Rwanda.

Figure 2. Geographical range of the black-bellied pangolin (*P. tetradactyla*). Source: Anonymous (2014b). Range: West and Central Africa, including Cameroon, Congo, Côte d'Ivoire, Democratic Republic of Congo (DRC), Equatorial Guinea, Gabon, Ghana, Liberia, Nigeria, Sierra Leone. Its presence is uncertain in Angola, Benin, Burundi, Central African Republic, Rwanda, Togo, and Uganda. The core of its range lies in Congo, DRC and Gabon.

is under threat in Gabon as demand for the small mammal surges in Asia, where it is used in traditional medicine (Anonymous, 2014a).

Apart from the scales, whole carcass or other body parts of extant pangolin species are used for additional purposes based on their identified values and established uses. In Africa, these uses include: food as a complementary protein source (Ajayi, 1971; Martin, 1983; Ntiamoa-Baidu, 1987; Wallis, 2004; Wright and Priston, 2010); traditional medicinal preparations, and as ornaments (Soewu, 2013b). Pangolin carcass is known as a delicacy of choice while the animal is believed to possess a reservoir of medicinal, sometimes mystical properties (Soewu and Adekanola, 2011). These values ascribed to pangolins, in addition to their aesthetic properties, provide the feasibility for their exploitation (Soewu and Ayodele, 2009). Their populations are increasingly under threat throughout their range due to domestic and international demand for live pangolins, their skin, scales and meat (Mohapatra and Panda, 2013).

Four species inhabit sub-Saharan Africa: Temminck's Ground Pangolin *Smutsia temminckii*, White-bellied Pangolin *Phataginus tricuspis*, the Black-bellied Pangolin *Phataginus tetradactyla* and the Giant Ground Pangolin *Smutsia gigantea* (Kingdon, 2005; Gaudin et al., 2009; Chandeller et al., 2012). *Smutsia temminckii* is found in central and southern Africa*, P. tricuspis* in West and Central Africa, *P. tetradactyla* in West Africa, and *S. gigantea* in West Africa. Their range and distribution are shown in Figures 1 to 4. Within these ranges, each species is known to occupy different habitats.

Regarding their conservation status, all African pangolins were previously regarded as near threatened on IUCN Red Data Book except *P. tetradactyla* and *S.*

Figure 4. Geographical Range of the Giant Ground pangolin (*S. agigantea*). Source: Anonymous (2014b). Range: Cameroon, Central African Republic, Congo, DR Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Senegal, Sierra Leone, Uganda and United Republic of Tanzania.

temminckii, which were categorized as least concern (IUCN, 2010). Presently, they are all regarded as vulnerable in the IUCN Red Data List (IUCN, 2014). All four African species are listed in Class B of the 1968 African Convention on Nature and Natural Resources (Soewu and Ayodele, 2009; OAU, 1968). Species in Class A are totally protected throughout the entire territory of the contracting states; the hunting, killing, capture or collection of specimens is permitted only on the authorization in each case of the highest competent authority and only if required in the national interest or for scientific purposes. Species in Class B are totally protected but may be hunted, killed, captured or collected under special authorization granted by the competent authority in the contracting country state. Also, all living Asian and African species of pangolin are listed in Appendix II of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). Appendix II contains species that are not necessarily now threatened with extinction but may become so unless trade is closely controlled. It also includes "look-alike species", which is, species whose specimens in trade look like those of species listed for conservation reasons. International trade in specimens of Appendix II species may be authorized by the granting of an export permit or re-export certificate. No import permit is necessary for these species under CITES (although a permit is needed in some countries that have taken stricter measures than CITES requires). Permits or certificates are only granted if the relevant authorities are satisfied that certain conditions conditions are met, particularly important is that trade will not be detrimental to the survival of the species in the wild (Chandeller and Hywood, 2012; CITES, 2013).

Natural history

Pangolins occupy a variety of habitats ranging from tropical, sub-tropical and flooded forests, to thick brush, savannah grasslands and cleared cultivated areas. Their distribution is understood to be linked to the presence of key prey species, though the solitary, predominantly nocturnal and highly secretive nature of pangolins makes it difficult for scientists to study them. Much about their behaviour and habits remains unknown (Anonymous, 2014b).

All pangolin species persist on a diet comprised predominantly of ants and termites. Emerging in the evening to forage, pangolins use their strong claws to dig into ant nests, termite mounds and rotting logs while using their flexible tails for support and balance. Pangolins locate insect nests using a well-developed sense of smell and capture their prey with long and extremely sticky tongues. They are protected from attacking insects by specially adapted muscles that seal their nostrils and ears shut. Arboreal species such as the White-bellied pangolin sleep and nest in the hollows of trees and can grasp and hang from branches using only their prehensile tails. Ground-dwelling pangolins tunnel underground to create burrows for nesting and shelter. Pangolins have an insatiable appetite and perform the important ecological role of regulating social insect populations. It has been estimated that an adult can consume more than 70 million insects annually.

Pangolins deter predators by hissing and puffing, and can protect themselves by rolling into a ball-their tough scales make them impenetrable to most predators. They identify their territories by scattering their faeces and scent marking with urine and secretions from a special gland. Scientists suspect that these odours advertise dominance and sexual status and may also help individuals recognize each other (Anonymous, 2014b; Soewu and Ayodele, 2009).

The longevity of pangolins in the wild is unknown though individuals have lived to almost 20 years in captivity. Males are generally larger than females, the latter reaching sexual maturity towards the end of their first year and giving birth to a single offspring. Pangolin mothers nurture their young in nesting burrows or trees. Scales are soft and pale at birth and begin to harden by the second day. A juvenile pangolin will cling to its mother's tail on foraging trips away from the nest and remain with her for a period of approximately three to four months. Ants and termites can be eaten from around one month old (Anonymous, 2014b).

Of the eight extant pangolin species, four occur in Asia: *Manis pentadactyla* (the Chinese Pangolin), *Manis*

javanica (the Sunda or Malayan Pangolin), *Manis culionensis* (the Philippine Pangolin), and *Manis crassicaudata* the Indian or Thick-tailed Pangolin. The four African species include *S. temminckii* (the Cape or Temminck's Ground Pangolin), *S. gigantea* (the Giant Ground or Giant Pangolin), *P. tricuspis* (the Tree or African White-bellied Pangolin), and *P. tetradactyla* (the Long-tailed or Black-bellied Pangolin). The Asian species are distinguished from the African species by the presence of hair between their scales (Anonymous, 2014b).

The utilization of pangolins for various purposes (briefly identified) continues to drive the annihilation of the species found in the African continent (Soewu, 2013a). To be able to realistically formulate management strategies to foster their long term survival, we need to know how pangolins are utilized in the continent, their role in the livelihood and culture of African people, the extent of use, and whether continued use at current levels is healthy or sustainable on the long run. In this paper, we present information on the factors that drive the uses of pangolins such as perception and conservation awareness, the diversity and prevalence of uses, trado-medicinal value and economic value. We also assessed the impact on the long term sustainability of such uses given the natural history of the species and their habits and habitats.

FACTORS THAT PROMOTE CONSUMPTIVE USE OF PANGOLINS

Some of these factors can be regarded as fuelling factors which includes:

i) Perception of pangolin values and conservation awareness;
ii) Economic value and local trade.

Perception of pangolin value and conservation awareness

Perception is one major factor fuelling the unregulated exploitation of pangolin in most parts of Africa. All renewable natural resources, including terrestrial and aquatic ones are regarded in most rural, sub-urban and even urban communities in Africa as gifts from nature whose utilization should not be regulated or should be under the most minimal control (Soewu et al., 2012; Soewu, 2013a, b; Simmonds, 1999). Based on this thinking, pangolins and other wild fauna are cropped for uses that the inhabitants desire; be it for food, traditional medicine or cultural ceremonies (Fa, 2000; Wallis, 2004; Wright and Priston, 2010). The exploitation is an "all-comers" affair and is fuelled by high level of unemployment and the attendant widespread poverty (Soewu, 2013b). Also, the skills required for cropping wild animals from the bush can be readily acquired in the community within a short period of time at little or no cost; and in most cases, the animals cropped require little or no further processing before they are disposed. The low production cost and high sales price translates to high profit margins.

For a trade that involves near-zero production cost outside that of cropping the animal from the wild, there are enough incentives to hunt this animal. Production cost ranges between NGN100.00 and NGN200.00 depending on the type of snare or trap used and can sometimes be at zero-cost on occasions when the animal is just picked incidentally in the bush while acquisition of skills needed to set up the snares and traps required training for just a couple of days at no cost. Market value of pangolin carcass presently ranges between NGN4500.00 and NGN7000.00 (Soewu pers. comm).

Ignorance about conservation status of local fauna and laws governing their use, absence of conservation education in the curriculum for formal education at most tiers of the education system; and non-enforcement of existing laws and regulations are further exacerbating factors. In a previous study describing conservation awareness, Soewu and Ayodele (2009), found that more than 90% of the respondents had no awareness about conservation status of pangolins. On their willingness to support conservation of pangolins, over 90% of respondents expressed that they would not support such effort.

The high level of illiteracy coupled with a total absence of conservation education in the curriculum for formal education creates a knowledge gap that adversely hinders biodiversity conservation efforts. People are left with no awareness about the essence of conserving natural resources, the objectives, benefits and the consequence of overexploiting any renewable resource.

Non-enforcement of existing regulatory policies and laws tacitly encourages continued exploitation and utilization of natural resources. It is common to see animals under various categories of threat displayed openly for sale in markets (Figure 5). Despite the fact that pangolins are protected in some form throughout most of their range states, they are offered for trade in these states: Botswana, Chad, Ethiopia, Ghana, Guinea, Malawi, Mozambique, Namibia, Niger, Nigeria, South Africa, Tanzania, Uganda and Zimbabwe (Brautigam et al., 1994).

Economic value and local trade

Legal and illegal trade in wildlife is pervasive and viable. Goodall (2000) observed that African species are getting closer to extinction as a result of the illegal trade in wildlife in Central and West Africa. On exploitation of wild fauna resources, Soewu (2006) observed that there is

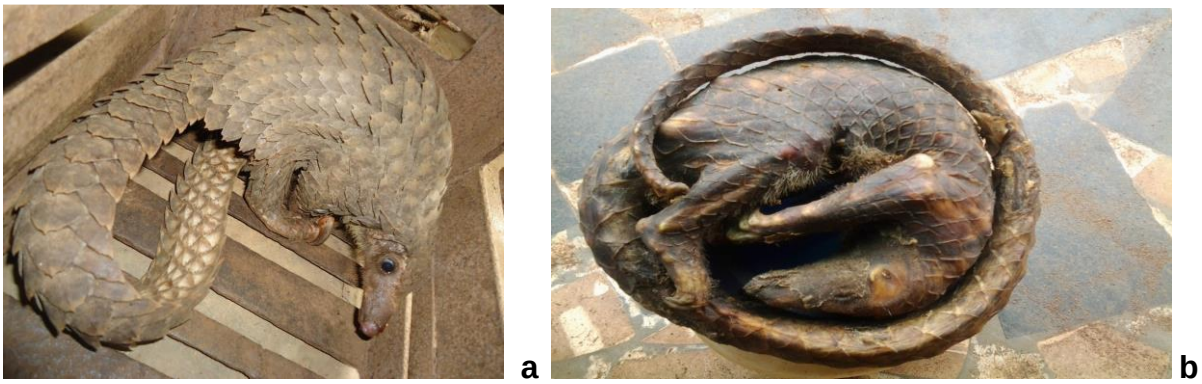

Figure 5. *P. tricuspis* (a: live; in captivity; b: processed) (Copyright Durojaye Soewu).

little concern for decimating wildlife in an area because profit maximization is the objective of exploitation. Traditional subsistence use of wild fauna which was sustainable has been changing as commercial factors have affected the socio-economies of communities that are dependent on forest resources for sustenance. Many of these pressures come from urbanization and associated market economies that are creating demand for a variety of products in ever-increasing unsustainable quantities (Bowen-Jones, 1998). Soewu et al. (2012) showed that local trade in mammalian species in Southwest Nigeria is lucrative, extensive and prevalent involving a broad spectrum of species including pangolins. At prices ranging from NGN 1,500-2500 (per carcass of whole pangolin depending on size) the trade as recorded (Soewu and Ayodele, 2009; Soewu et al., 2012) was worth NGN 267,000-356,000. This figure is for a survey that covered just a fraction of Nigeria over a period of six months.

Wildlife resources often change hands several times before reaching the market, allowing many individuals to profit from this trade. Hunters sell carcasses to intermediaries who supply retailers in the town (Fa, 2000; Ott el al., 2002). However, most of the trade is direct to vendors or consumers and therefore hard to quantify (Steel, 1994; Pearce, 1996; Bowen-Jones, 1998; Soewu, 2006; Chandeller and Hywood, 2012).

DIVERSITY OF USES

The very high market value ascribed to pangolin, whole or in parts is not accidental. It is a reflection of the benefits expected to be derived from its use (Sodeinde and Soewu, 1999; Soewu and Ayodele, 2009; Brautigam et al., 1994).

Food

Pangolin meat is not only a delicacy of choice but somewhat an exclusive preserve of the wealthy and influential in the society (Soewu, 2013a). A Nigerian adage states that “only the rich can request a meal with pangolin as an essential part of the ingredients”. This belief has actually turned pangolin into an article of ostentation, offered and purchased at a price well above its real value just because it is seen as a status symbol. This is in part responsible for the desperation of hunters and poachers to go all out in pursuit of pangolin. Sodeinde and Adedipe (1994) reported that the quality of pangolin meat in terms of taste rated higher than of other species such as cane rat, *Thryonomys swinderianus* and Maxwell’s duiker *Cephalophus maxwelli* that are also commonly hunted for food.

Ornament

Utilization of pangolin as ornament dwells primarily on the scales (Figure 6). Another Nigerian adage demonstrates the cultural value attached to pangolins; it states that “the only motivation or justification for a man to adorn a flowing gown made with pangolin scales is a flagrant, needless and oppressive display of opulence” (Soewu, 2013b).

Pangolin skins are also processed into leather used for making footwear, bags and belts; and the scales and claws are used in decorations and in or as ornaments.

Tradomedicine

The World Health Organisation (WHO) stated that traditional medicine refers to health practices, approaches, knowledge and beliefs incorporating animal and mineral based medicines, spiritual therapies, manual techniques and exercises, applied singularly or in combination to treat, diagnose and prevent illnesses or maintain well-being (WHO, 2000). Use of pangolins in traditional medicine is common in Africa: Nigeria (Soewu 2008; Soewu et al., 2012), Benin (Akpona et al., 2008), Cote D’Ivoire (Caspary, 1999), Tanzania (Walsh, 1996).

Figure 6. A coat of armor made of pangolin scales, an unusual object, was presented to George III in 1820. (Anonymous, 2014c)

The use for food and traditional medicine appears to exert more pressure on wild populations of animals than other uses (Bodasing, 1999, Ott et al., 2002; Soewu, 2006, 2013a). The demand created by traditional medicine has, however, been identified as one of the causes of the overexploitation of the wild population of numerous animal species (Soewu 2008). This indiscriminate use of wild animals, especially endangered species in all forms of traditional medicine is a cause of growing concern (Alves and Rosa, 2005; Soewu and Adekanola, 2011). Abdullahi (2011) reported an increase in the use of traditional medicine (TM) in Africa and the rest of the world.

TM, as observed, is being integrated into the mainstream of modern health care system in African countries including Ghana, Nigeria, Zambia, Mali and South Africa just as is the practice in China. Hunting and poaching animals for their medicinal values has brought many of the wild species closer to extinction and necessitated their listing in the red data book (Alves et al., 2011). Many African species, including pangolins now survive in fair numbers only in protected areas (Goodall, 2000). Pangolin rates very high on the list of species used for this purpose (Soewu and Adekanola, 2011; Seowu, 2013b).

The pressure on pangolin population from traditional African medicinal practices is premised on the belief that this animal has a reservoir of medicinal, magical or mystical properties. In southwestern Nigeria, pangolins are used to treat between 42 and 47 different ailments/conditions among the Ijebus and Aworis of the Yoruba tribe (Soewu and Ayodele, 2009; Soewu and Adekanola, 2011). The conditions treated range from therapeutic to psychological and even spiritual.

Soewu and Ayodele (2009) revealed some gender and age preferences for the use of pangolin in traditional African medicine. According to the report, some preparations specifically require juvenile and pregnant female animals. A pangolin seized in Zimbabwe in May 2012 had had most of its scales removed, which deviates from the local practice of *muti*, where the animal is kept alive and its scales removed as and when needed for medicinal purposes (Chandeller and Hywood, 2012)

Persons requiring pangolin-infused preparations for treatment of their peculiar conditions will always rate the exploitation as more important than conservation. Substituting other animals for pangolin in these preparations has been suggested as a means of alleviating the pressure on the species. Soewu and Adekanola (2011) reported that only 27.7% of pangolin-based preparations would accommodate use of substitute animals. However, some of the animals identified as possible substitutes for pangolin are themselves usually of greater conservation concern as indicated by their IUCN listings. For instance, gorilla, identified as a possible substitute in a particular case is actually listed on schedules I and 1 of CITES and Nigerian Decree No 11, respectively (Soewu and Adekanola, 2011).

Sustainability

An enormous number of meat in these instance pangolins, is being taken from some of the most bio-diverse forests in the world and this indicates the scale of seriousness of an ecological problem that will escalate if commercial trade goes unchecked (Bowen-Jones and Pendry, 1999; Caldecott et al., 1994; Fa et al., 2000, Soewu 2008). A huge number of animals are taken by subsistence hunters. Ott et al. (2002) reported that several regions of the world are experiencing massive defaunation, unregulated and unsustainable depletion of fauna resources, as a result of the bush meat crisis. Wilkie et al. (1998) stated that it is not habitat loss but defaunation that poses the greatest immediate threat to animal conservation in forests of west and central Africa.

Sodeinde and Adedipe (1994) estimated that an average of 24 pangolins was being supplied each month to the markets in Ogun State, Nigeria, with a total of 142 recorded between November 1988 and April 1989. In a more recent study, Soewu and Ayodele (2009) reported

Table 1. Extinction-susceptibilty rating of pangolins (*Manis*spp.) based on known attributes of extinction-prone species

Attributes	Extinction-prone species	Pangolins	Rating
Trophic level	Usually top of the food chain	Insect eater (Cansdale, 1947; Menzies, 1963)	2
Body size	Large to very large	Moderate, adults 43 cm head and body (Rahm, 1956)	2
Taxonomic uniqueness	Monotypic	Monotypic family and genus (Simpson, 1945; Emry, 1970)	4
Reproductive rate	Low, very low	One young per female, gestation period c. 6 months (Menzies, 1967; 1091); monogamous (Pages, 1972)	3
Breeding and longevity in captivity	Poor	No conception in captivity, do not survive long (usually <3 months) (Menzies, 1963)	5
Population distribution	Fragmented	Fragmented (Dorst and Dandelot, 1970; Happold, 1987; this study)	3
General habitat distribution	Fragmented surrounded by incompatible land use	Forests and savannah (Booth, 1960; Happold, 1987)	3
Habitat alteration	Continuous and high	Continuous; at high rate (Umeh, 1986)	5
Habitat requirements	Special or specific	Restricted in diet (Cansdale, 1947; Menzies,1963), found on trees infested with preferred prey (Pages, 1970)	
Insularity	Pronounced/high	Local populations discontinuous (Happold, 1987; this study)	3
Hunting pressure	High	Persistent (Walker, 1975; this study)	4
Economic/medicinal value	High or priceless	Flesh eaten, scales and other parts used for charms, ornaments and medicinal compounds (Hayman, 1954; Walker, 1975; this study)	4
Extinction risk index			0.68

Source: Sodeinde and Adedipe (1994).

that a higher figure:178 whole pangolins were sold into traditional African medicine during a period of three months amongst a population of people that represent less than 3% of the Nigerian population. Soewu and Adekanola performed another study in 2011, where the utilization of 64 pangolins were documented between 40 traditional medicinal practitioners within a month, giving a monthly average of 1.6 pangolins utilized per practitioner.

It has been suggested that the importance of pangolins as traditional medicines throughout Africa is likely to increase threats to their population (Anadu et al., 1988; Brautigam et al., 1994). The number of traditional medicinal practitioners in Africa cannot be ascertained but it has been estimated to be at least one practitioner to 2000 people (Soewu, 2013a). If we add the figures above that of the bushmeat markets spread all over the nook and crannies of the continent of Africa, the result would be devastating.

All these studies indicate a continuous decline in the size and number of the pangolin captured from the bush and a growing difficulty in encountering the animal. Sodeinde and Adedipe (1994) used an extinction-susceptibility rating to predict the long-term fate that would befall pangolins if the exploitation continues unabated. Extinction risk index for pangolins species was estimated to be 0.68 (Table 1).

Bowen-Jones (1998) observed that even the animals that could be hunted sustainably are often being exploited at probably unsustainable levels, and that controls need to be introduced in order to make sure that they are not added to the vulnerable category. However, Chardonnet et al. (2002) has established that excessive harvest of wildlife depletes the wildlife resource when the level of exploitation overtakes the recruitment rate. The level of exploitation for pangolins so far has clearly overtaken the recruitment rate. According to Challender et al. (2012) evidence suggests the conservation status of six pangolin species (all four African and two Asian species) is decreasing.

More importantly, pangolins sold and utilized in Africa today come directly from the wild as there are no records of successful captive breeding and ranching of this species yet (Soewu and Ayodele, 2009; Soewu and Adekanola, 2011). The situation in West and South Africa is suggesting that most pangolins found on the market have been taken from protected areas (Sodeinde and Adedipe, 1994; Brautigam et al., 1994). International trade in pangolins is undoubtedly having a detrimental effect on population levels (Chandeller, 2011)

Intercontinental trade

Due to the clandestine nature of illicit trade in wildlife, it is often difficult to estimate trade levels, hence minimum volumes can only be approximated/gauged based on data from media reports of seizures and the findings of research (Broad et al., 2003; Chandeller and Hywood, 2012). The exact proportion of the hunting and trade in pangolins in Africa intended for intercontinental trade,

international trade within Africa or for domestic use is not clear. However, the nature and circumstances surrounding seizures that have been made recently suggest links to intercontinental trade rather than to local use. Since 2008, a small number of seizures comprising African pangolins and derivatives have taken place in Asia and in Europe where the end destinations were reported to be China, Thailand and Hong Kong. This is undoubtedly a small fraction of actual trade levels based on the low detection rates associated with wildlife trade. Although the quantities of pangolins and scales seized are not known in all cases, some of these consignments included pangolin scales ranging in weight from between 1 and 115 kg; one comprised 100 African White-bellied pangolin skins (with scales attached) that had originated in Guinea and was bound for Thailand (Chandeller and Hywood, 2012). There is an evidence of a potentially growing intercontinental trade in African pangolins between Africa and Asia. Over the last two years, there have been a small number of pangolin-related seizures from Africa which have been destined for Asian markets. For example, in 2009, 100 kg of '*Manis* spp.' scales were seized in transit from Côte d'Ivoire to Hong Kong (Chandeller, 2011). Hong Kong Customs officials intercepted an illegal shipment of 2.6 tons of pangolin scales from Cameroon via Malaysia- the second haul from the African continent in less than a month. The 2,340 kg of scales were discovered on June 11, inside 115 bags on a shipment declared as timber. This follows the May 28 seizure of one ton of pangolin scales, initially reported by the Hong Kong Customs and Excise Department on May 28 as arriving from South Africa (however, later information suggests the illicit cargo arrived from Kenya or Uganda, via Malaysia). The seizure at the Kwai Chung Custom House examination compound, the largest seizure of pangolin at Hong Kong's port in five years, is estimated to be worth R5-million. This trade is having catastrophic effects on the populations of all of the remaining eight pangolin species world-wide, with the Asian pangolin populations showing dramatic declines in recent years. Illegal trade is rife in central and west Africa and was known to occur at low levels in southern Africa prior to this incident. This most recent seizure indicates that illegal trade is widespread in southern Africa as well, and is far from being sustainable (Anonymous, 2014d). In July 2012, 115 kg of pangolin scales were seized in Uganda; the trader claimed that he had many suppliers and that he always exported the pangolin scales to China. He said that he received deliveries from various locations within the country and from the Democratic Republic of Congo. According to a spokesperson from the Ugandan Wildlife Authority, wealthy Chinese were encouraging the illegal trade. This supports the concern that intercontinental trade, if not the case already, is set to be a major threat to Africa's pangolins, especially if this practice is occurring elsewhere in Africa, facilitated by a growing Chinese presence on the continent as a result of increasing trade and economic links. The larger volumes suggest this trade is commercial in nature but operating in parallel with smaller volumes (Chandeller and Hywood, 2012).

Conservation awareness

As reported earlier, there is a general lack of awareness of conservation laws and protection status of wild animals in Africa. In Soewu and Ayodele (2009), well above 90% of the respondents had no awareness about conservation status of, or any threat to the survival of pangolins. On their willingness to support conservation of pangolins, less than 10% expressed varying degrees of interest in any conservation programme for pangolins while others expressed total apathy towards such projects.

Recommendations

The first step towards saving our darling species is to determine the sizes of isolated populations of pangolins across their ranges in the region and on the continent of Africa. Such a study requires concerted, coordinated and harmonized surveys throughout Africa. This is no doubt a daunting task, but it is attainable. Population studies should also incorporate evaluation of immediate and remote threats to the supporting ecosystem.

There is a need to quantify the number of pangolins sold and utilized within a specific time frame in the region and on the continent of Africa for all the identified uses. The sales figure should include domestic, cross-border and intercontinental trade. This will give an insight into the exploitation pressure on resources in the wild. According to Chandeller and Hywood (2012), research needs to be undertaken on inter-continental trade, given the potential magnitude of the threat and the suspected precipitous decline in Asian pangolin populations driven by demand in the region, inparticular China and the growing economic ties between Africa and China. Such a study should be supplemented with research into the status and ecology of African pangolins in order that an informed assessment can be undertaken into the impact of trade on pangolin populations. A critical examination of these uses as an index of pressure on resources in the wild is a prerequisite for any conservation programme to be meaningful and effective (Chardonnet et al., 2002; Soewu, 2006).

Lastly, the twin approach of increasing yield and reducing demand for pangolins should be adopted.

Yield boosting measures

The following in situ and ex situ approaches to increasing yield are suggested.

In situ

Pangolin sanctuaries: Establishment of sanctuaries around identified populations of pangolins will be a good starting point. It gives room for regulation and monitoring of exploitation. This will also raise the awareness about the conservation needs of the species among the populace in surrounding communities.

Involvement of host communities with incentives: Communities adjacent to conservation projects will more readily lend their support to such schemes if they are included as stakeholders and co-beneficiaries. Members of communities inhabited by pangolin population(s) should be engaged as much as possible in the projects. Offers of scholarship support to indigenes of such communities to pursue courses in conservation/ecology related courses will enable the engagement of such indigenes. This will prepare an army of conservationists among the indigene within a short time, thereby making the spread of the conservation message a lot easier.

Ex situ

There is a need to boost the yield of this animal by establishing pangolin husbandries across all regions of the world, most especially in Asia and Africa which had been regular suppliers over the years. Semi-captive breeding of pangolins for education, research and re-introduction purposes will greatly enhance the survival and continued existence of these species.

Reducing demand

Massive enlightenment campaigns on pangolin conservation should be mounted across all regions of the world. A drop in demand would impact on other dynamics of the trade and make it less rewarding to hunt pangolin. For this to be more effective, the manufacturing sector of the economy should be involved such that consumer products can begin to carry conservation-promoting inscriptions. It is also expedient we carry the pangolin gospel farther by participating in other fora and gatherings beyond the strictly conservation circles, for instance the World Social Forum. A point to emphasize to the world is that unsustainable depletion of wildlife resources not only embodies a challenge for conservation, but more importantly represents a serious threat to the health status and food security of human population (Soewu, 2006; Soewu 2008; Marshall, 1998).

Strengthening the legal machineries

With the recent re-evaluation and adjustments in the conservation status of pangolins by the IUCN Red Data List, and the on-going efforts by CITES to review the trade status of these species, there is a very urgent need to review the status of pangolin species across the continent as regards the African Convention on Nature and Natural Resources. It is also essential that all countries within the region review the status of these species accordingly and strengthen their legislation towards protecting pangolins and all other species identified as being under varying degrees of threats in their territories. Such legislations should be duly implemented to ensure its effectiveness.

The establishment of a joint-regional organ to monitor cross-border movement and trade in pangolins and all other vulnerable species would also go a very long way in enhancing the continued survival and availability of these species.

Conflict of interests

The author(s) have not declared any conflict of interests.

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Review

Considerations for additional tools in ecosystems management: Lessons from Zambia

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Formal institutional ecosystems management has been in existence since the creation of the Yellowstone National Park in the United States of America in 1872. Subsequently, many countries, including Zambia have evolved both legislative and policy frameworks for protecting various ecosystems. This move implied creating institutions to manage such areas accompanied by a statute to police the given area. Offenders are punished for breaking the law that protects the given resource. The results from such actions have been a growing conflict between the local communities and the ecosystem or resource management institution. In order to create harmony, ecosystems managements, in some sectors have evolved new strategies of sharing management responsibilities and benefits with local communities. This specific resource is in the wildlife sector in Zambia. The need to balance management costs and the benefits from the ecosystem services thus arises. However, in order to strike a reasonable balance, consideration should be given to adopting additional management tools for evaluating ecosystems so that one can place an economic value on any given resource. The major tool that has seen wide application in Zambia has been the Environmental Impact Assessment (EIA). However, methods for carrying out economic evaluation of ecosystems exist and have been developed over the years elsewhere. They include the Travel Cost Method (TCM). This method uses a surrogate market to estimate a consumer surplus and is site specific. The second common method is the Contingent Valuation Method (CVM) that solicits for a respondents willingness to pay (WTP) for an improvement to an environmental good or the willingness to accept (WTA) for a loss or partial loss of an environmental good using a hypothetical market. As a tool, the CVM can also be used in calculating a cost benefit analysis for a project in a given area and there by arriving at an economic decision. The method can also be used in a failed or derelict ecosystem reclamation and restoration efforts. Any conservation effort should consider the local community needs.

Key words: Contingent valuation method (CVM), travel cost method (TCM), willingness to pay (WTP), willingness to accept (WTA), environmental impact assessment (EIA).

INTRODUCTION

Ecosystems are specialized depending on the goods and services that they offer. These goods and services are not uniform and can therefore not be found everywhere. This specialization suggests an economic value on an

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ecosystem of any given locality. There is however an invisible gradient of value that follows this specialization as no ecosystem is the same. Even ecosystems that do not seem to have economic resources still provide natural goods and services that include life support systems to the beneficiaries. These include clean air water resources, fire wood and a host of natural materials.

Economic resources require an institutional arrangement to be in place for both management and conservation measures as the demand arises. Management arrangements will therefore require a legislative frame work in order to operate and create a working structure for the institution. In this way, a sustainable utilization of resources and the structures that guide sharing of the benefits that accrue from the ecosystem management and conservation will coincide. If this is not done, then the famous "tragedy of the commons" economic theory metaphor put by Garrett Hardin (1968) comes into play. The theory states that "individuals, acting independently and rationally according to each one's self interest behave contrary to the whole groups' long term best interests by depleting some common resource". This trend can however be limited by a government intervention that would limit the amount of a common good that is available for use by any individual through permits for extractive economic activities such as mining, fishing, hunting livestock, grazing and timber harvesting. The second alternative, that is difficult to achieve, is for resource users to cooperate and conserve the resource for their own mutual benefit.

The economic value of an ecosystem would diminish at a faster rate if there are no institutional arrangements in place. Resources that an 'economic' ecosystem provides directly or indirectly to the public or the benefits that accrue are the subject of this discussion. Coupled with this is the conservation and management of such resources.

Roe et al. (2013) observe that conservation of biodiversity is critical, in that The Convention on Biodiversity (CBD) acknowledges that; "economic and social development and poverty eradication are the first and overriding priorities of developing countries". In their new strategic plan for biodiversity 2011-2020 mission is to halt the loss of biodiversity thereby contributing to human well-being and poverty eradication. Global players believe biodiversity can indeed help alleviate hunger and poverty and promote good human health.

The challenge of institutions that manage ecosystems is in developing tools that will help not only in the management but will take on board the perceptions and views of respective local communities that live near a given resource. In doing so they could be working out reasonable economic benefits to the recipients. The Community Based Natural Resources Management (CBNRM) for example, is a new paradigm in natural resource management that has been generally been accepted as a working structure for both conservation of natural resources and the sharing of benefits that accrue from the resource. The expectation from its use is that it will assist in the alleviation of rural poverty by empowering communities to manage resources for the long term social and economic benefits

This discussion raises issues for debate primarily on the invisible gradient of benefits that range from local benefits with an impact either in monetary terms or otherwise, to those that benefit people remotely placed from the local resident in the given resource area by way of using examples. Observations also raise issues on ecosystems and suggest an invisible gradient on their value apart from discussing the available structures for sharing of benefits with concerned local communities and the public at large. This discussion is not in any way based on empirical data research but is a commentary on the best practice for conservation and wise use of natural resources in Zambia given the current practice trends and how these can be harmonized. In order to enrich the arguments, examples from both past and current practices in Zambia are used and how these relate to the global trends of ecosystems management.

The use of the EIA in Zambia is as a result of a legal framework that has been put in place by the Zambian government as a way of protecting and enhancing the conservation of ecosystems in the country. The EIA is imposed on development projects. The valuation methods suggested are research based and are not part of the broader legal framework for Zambia. They however constitute an alternative approach to ecosystem management and can be adopted as management tools by various ecosystems and natural resource management institution in the country.

Ecosystems

Researchers in resource economics spend little time discussing ecosystems in their ecological context as these, one would argue, vary from each other despite carrying the same ecological definition. As a result there seems to be not only a variation of the ecosystems constitution but there is a silent economic gradient in their values that lacks detailed discussion. This silent economic gradient of ecosystems suggests that each ecosystem has a value that is tied to the goods and services that it provides to the end users (Figure 1). Some values can be attached to the monetary benefits that come out of a given natural ecosystem seen mainly from direct use of a given natural resource.

Wastelands, for example, would in the context of value, have a lower scale of units because of the use they provide to society. This use lies mainly in being dumping sites for industrial and domestic waste (especially where there is no waste recycling industries available) closed factories, quarries and brick pits constitute other forms of wastelands ecosystems. Wastelands can however be

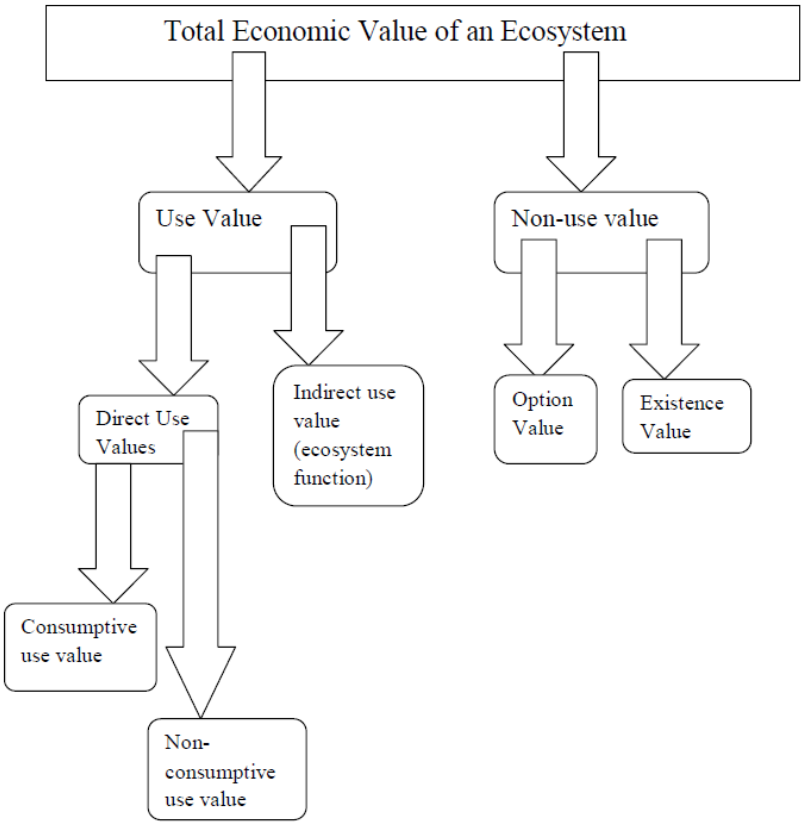

Figure 1. The ecosystem goods and services value relationship.

restored through land restoration and reclamation efforts by relevant institutions and become useful ecosystems again.

Urban ecosystems, are part of a broader ecological system, but affected by their surrounding environment. In both cases there is an element of the human activities impact on natural ecosystem in order to provide both urban and contemporary use of natural ecosystems through modification of such habitats.

Other ecosystems consist of natural ecological systems that are partially or totally undisturbed and thereby providing a pristine environment that provides both direct and indirect benefits to society. These include national parks, natural sites, water courses and forest reserves. The grading of ecosystems is a major subject of research and it would not be possible to deal with it without raw data.

Parallel to the economic gradient is the variations in the respective institutional legal frameworks that the management structures are based on for ecosystem management. In short there is no common legal frame work for ecosystem management, as the case in Zambia. Each case of breaking the law that protects an ecosystem has its own penalties and punishment. This suggests that the law makers do not see the common ground in offences as one would see them in the criminal sense. Acts against ecosystems legal protection are seen just as offences against a particular section of a respective act of the laws of Zambia that stipulates the offence or the fine. The prosecution will therefore use that given provision when presenting their case before court in seeking for a conviction. The resulting conviction will either pass a custodial sentence or a fine depending on what is prescribed by the respective law.

Placing value on an ecosystem

Most researchers in environmental economics agree that the total value of an ecosystem is quantified by taking both use and non-use values. The use value constitutes both direct and indirect use in addition to the option value, while the non-use value captures those elements that are unrelated to current, future and potential use. These include the existence and bequest value of a given ecosystem. However, placing a value on a variety of ecosystems can be a challenging task. The reasons being that there are diverse schools of thought driven primarily by an equal variety of disciplines. For example, Dziegielewska (2013) observes that there seems to be no consensus among environmental economists as to the exact placement of the option value among use and non-

use components because while some consider it as a use function others consider it as a non-use function because it is not related to any current use of the good.

In the utilitarian concept for example, the value of an ecosystem is based mainly on the services that the system provides to society based mainly on the utility that people derive from their use either directly or indirectly (use value) (MEA, 2005). Most of the ecosystems valuation can be obtained by the common methods that have been developed over time, namely, the contingent valuation method (CVM) and the Travel Cost Method (TCM). Their use is closely related to the users or the beneficiaries of a given resource and a given locality.

The Millennium Ecosystem Assessment (MEA, 2005) so far has been the most comprehensive survey on the state of the planet. The assessment conceptual framework looked at the interactions between biodiversity, ecosystem services, human well-being and drivers of change. The premise of the assessment was that changes that directly affect biodiversity such as population, technology and life style can lead to changes in drivers directly affecting biodiversity. These in turn result in changes to ecosystems and the services that they provide and there by affecting the human well-being.

The survey revealed that over the past 50 years humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, primarily to meet the growing demands for food, fresh water, timber and fuel. This has led to a substantial loss in biodiversity on earth. Secondly, changes to ecosystems structures have contributed to substantial net gains in human well-being and economic development at a cost in form of degradation of many ecosystems services. Thirdly, the degradation of ecosystem services could grow significantly worse and could be a barrier in achieving millennium goals. The fourth finding was that the challenge for reversing the degradation of ecosystems while meeting increasing demands for their services can be partially met but these involve significant changes in policies, institutions and practices. The issues the survey raises are the valuation of ecosystem services (Daily, 1977). However, Arrow et al. (2000) argue that the value of an ecosystem as a whole may be more than the value of the sum of its parts owing perhaps to the complex ecological interactions. The development of valuation methods or their choice should therefore be seen in the suitability to aid a decision making process.

The current use of an Environmental Impact Assessment (EIA), in the Zambian context looks inadequate as the EIA looks at the possible impact a particular activity or development is likely to have on a particular ecosystem by giving the pros and cons of particular impacts. It also analyses the ecosystem legal frameworks that may be contravened in the course of a particular impact. Unfortunately, this tool has not been used to determine the benefits for local communities who may be beneficiaries of returns from a natural resource in their respective areas neither is there adequate research that is usually put in place to investigate biodiversity loss from economic impacts.

THE METHODS

The evolution of the EIA, in Zambia, as a tool for assessment of impacts that any given activity will have on a specific ecological zone is a product of the global agenda driven by the World Conservation Union who published the World Conservation Strategy in 1980 (WCS, 1980). Respective countries adopted their national strategic plans in the years that followed. Zambia developed a national conservation strategy in 1985 (National Conservation Strategy, 1985). As a result of this strategy, a legal framework was initiated that led to the creation of environmental protection agency initially known as the Environmental Council of Zambia (ECZ) created under the Environmental Protection and Pollution Control Act of 1990 and now known as the Zambia Environmental Management Agency (ZEMA) under the Environmental Management Act Number 12 of 2011. The new act repealed and replaced the former act as an all-inclusive act on environmental issues. It has now become a legal practice and requirement that any project before it is undertaken passes the EIA provisions that are approved by ZEMA. The EIA however does not assist one to evaluate a given ecosystem and it comes with its own costs that come as a way of sustaining the institution, that is, the investor has to pay a certain percentage of the total investment cost to ZEMA for them to carry out the assessment and give their comments and consent for the project to go ahead or not.

In this discussion, the argument is to improve our valuation methods of ecosystems from just having an EIA, as the case at the moment, and to use additional tools for making assessment of a project before it is undertaken given the diversity of ecosystems in any given part of the country. Such assessments would reveal a broader perception by those affected by any impact on their respective ecosystem.

Environmental goods, in general, do not have a formal market and as such there is an economic failure because the market price that people pay to use natural resources is lower than the value society as a whole would be willing to pay for them. This results in a market failure and there is always a need for government intervention in the market to promote specific environmental goods and services.

In order to place value on environmental goods and services, one has to simulate a market in order to base their valuation of that particular ecosystem. McNally et al. (2003) suggest five basic approaches, namely market based, surrogate market based, hypothetical market based, cost based and benefits transfer. Each of these

valuation techniques employs specific approaches to the market. This discussion is limited only to the surrogate market or travel cost method (TCM) and hypothetical market Contingent Valuation Method (CVM) approaches. The two methods are discussed because they deal with consumer behaviour that exhibits both revealed and stated preferences. Data from both methods may be combined and can be used in joint estimation of parameters associated with attributes (Atkinson and Mourato, 2008). The stated preference is the umbrella term under which a number of survey methods are found. They construct a hypothetical market or a contingent market that elicits for preferences of specified policy changes (Bateman et al., 2002). The common survey method in this area is the CVM.

The contingent valuation method

The CVM technique was first used by Davis (1964) and has since been widely used for over 40 years. The technique relies on a well prepared and designed structured questionnaire, which is presented directly to a sample of relevant individuals about a well-defined public good such as a particular ecosystem and asks for their willingness to pay (WTP) for the improvement of such an ecosystem or environmental good in one scenario. The second scenario, the questionnaire will ask for the respondents willingness to accept (WTA) the loss or a decrease in the services of the same environmental good or services.

All individuals respond to the same situation. The assumption is that people have true but hidden economic values for environmental goods that can be revealed through the creation of hypothetical markets and that the value of any good depends on its utility to individuals (Hoevenagel, 1994). The sample size for administering the questionnaire will vary depending on the area one is dealing with. Users of the CVM do not suggest the number of respondents to be interviewed.

The ultimate aim of the CVM survey is to obtain an accurate estimate of benefits and sometimes costs of a change in the level of provisions of some public good. The results of such an estimate can then be further used in a cost-benefit analysis. However, in order to achieve the desired results, the survey must meet two criteria namely, the methodological imperative and the requirements of economic theory. The methodological imperative requires that the environmental scenario at hand be understandable and meaningful to the respondents. It should also be free of incentives that may bias the results (Mitchell and Carson, 1989).

The CVM has been extensively used in both developed and developing countries. It addresses a wide range on environmental issues that include among others water quality, outdoor recreation, species preservation, forest protection, air quality, biodiversity health impacts and natural resource damage.

The premise behind this is that goods and services provided by biological resources do not have a market neither is there a surrogate market from which to derive their value. So one has to construct a hypothetical market by asking the respondents their WTP for an environmental benefit or how much they would be WTA a loss or partial loss of an environmental good or services The WTP elicited values are contingent upon the particular hypothetical market hence the term contingent valuation (Knetsch and Robert, 1966).

The success of the method is contingent upon successful simulation of the market. It is the only valuation method that is a true measure of welfare changes based on the Hicksian demand curve. It is also the only technique that is able to capture existence and option values and also allows researchers to capture any environmental value as long as respondents are able to understand the question and answer truthfully (Atkinson and Mourato, 2008).

The method has its pitfalls and draw backs. These have to do mainly with sample and response biases. They include hypothetical, strategic, information and sample bias. In the hypothetical bias respondents will not be making real transactions, while in strategic bias respondents will make bids that are not a true reflection of the value because there is an opportunity of free ride. In order to eliminate these potential biases, one has to experiment with survey design and use different payment vehicles and careful sampling.

Other pitfalls include the choice one makes between WTP and WTA because the hidden issues of property rights may arise. This will give, in some instances, a higher WTA value than the WTP because of the property rights framework that may prevail.

Venkatachalan (2004) observes that the maximum WTP represents the amount of money income that has to be given up by the consumer to attain an increased level of utility. Similarly, the minimum WTA represents the amount compensation required to be provided to the individual so that they can attain an improved utility level in case the provision of the public good does not take place.

The travel cost method (TCM)

The revealed preference method or TCM relies on the consumer behaviour that leaves a foot print associated with the actual travel market. This allows the quantification of this behaviour pattern to create a surrogate market. Like in the CVM approach, the investigations here rely on a well-structured questionnaire that asks the consumer or the visitor to a recreational site, a series of questions related to their expenses for their visit. The questions may be extended to their income and other personal variables. However, such questions are

relevant only to adults who have to make decisions on expenditure and not to the accompanying children.

The advantage is that this is based on actual behaviour of the consumer. Knetsch and Roberts (1966) both recommend the TCM as an ideal method for valuing recreational activities. The method relies on variations in travel costs of site visitors in order to make a demand curve so as to estimate the consumer surplus (or the net willingness to pay) for the continued existence of the site. Habb and McConnell (2002) gave a further and elaborate overview of the travel cost method. It has been widely used to value non-market goods such as outdoor locations and recreational sites.

In both methods one would be paying attention to relations ships between variables that speak to each other and those that have significant P-values (P<.05) from the statistical analysis. These results can then later be considered when making or incorporating them in policy formulations and management decisions on respective public goods.

Benefits and sharing of benefits

The methods discussed so far strongly suggest that there are some information on benefits that can be obtained from their use in the evaluation of ecosystems. The CVM results for example, can be used in the computation of a cost-benefit analysis on policy decision on whether an intended project should go ahead or not. Similarly, in the TCM benefits of a particular site will be seen from the consumer surplus that will be equated to the net willingness to pay for the conservation of that particular site.

Benefits may also be seen from a conservation point of view under some institutional arrangement that is operating under a given legal framework. Direct benefits may be a direct appropriation of known resources such as timber products, fisheries and a host of natural products because the beneficiaries have direct access to an ecosystem without a regulatory framework. Not all natural resources will be based in a protected area and not all ecosystems will enjoy a legislative protection because of the variations in the land use arrangements. However, there is always a government intervention to avoid the “tragedy of commons” scenario in most cases. It is this intervention that should balance the benefit sharing with people living close to the resources as they would if there was no intervention from a government.

The benefits gradient advocated above may also be viewed from the formal structures that may be available under the various legal frameworks and institutional arrangements as seen for example in the wildlife management sector. Benefits may have local impact and they may also have a spin off that gives a benefit avenue for non-local populations. Good examples may be seen from mining and hydro-power generation in Zambia.

Lumwana mine development

One of such investment in recent years is the Lumwana mine in the North-western part of Zambia (Figure 2) in the early 2002. Copper deposits had been known to exist since the 1930 explorations but they were seen to be of low grade ore. The site of the mine was once a forest reserve but was de-gazetted to pave way for an open pit mine. An EIA was conducted as a requirement by law. Upon passing the EIA, the mine operations commenced in earnest. Now Lumwana mine is one of the largest open pit mine in Zambia and in the world. At the time of its inception, it was said to be the largest mine venture in the world. The mine is located on traditional land and had to be surveyed and demarcated for the purpose of mining.

Benefits accruing to the local people have been seen mainly in the spin off from the infrastructure development, employment opportunities and trade. Government on the other hand has accumulated benefits in the form of taxes both employment and corporate accruals. There was no CVM survey, for example, to assess whether the local community was willing to accept the change in their protected forest status or indeed how much they were willing to pay to maintain the forestry reserve.

Information from such a survey would have been used in a cost-benefit analysis to assess the merits and demerits of the project. If these had been done maybe mining would have been a better form of land use because of the benefits that have been brought by the venture to the area. However, the benefits above do not follow a formal established structure but they are negotiated as and when the need arises for the local residents.

Kafue hydro-power development

Hydro-power generation has been a major investment in the last 50 years or so in Zambia, starting with the Kariba dam hydro-power located on the Zambezi River in southern Zambia where the river forms the border with Zimbabwe. The project was started and completed in the late 1950s to provide electricity for the growing industry in the country.

The Kafue gorge power station development followed in the late 1970s on the Kafue River. However, in order to establish the Kafue gorge power station, the Kafue River (Figure 3) had to be dammed at a place called Itezhi-tezhi mid-way, the river course in 1978. The reasons advanced were that, the dam would be used as a strategic reservoir to regulate the water flow in case of drought. The power station gorge is much further downstream from the dam wall where the water course is narrow and is bordered by a hilly escarpment, making it ideal for hydro-power generation.

Downstream, immediately from the dam wall, the water course passes through a unique wetland ecosystem called the Kafue flats that is an open flood plain and

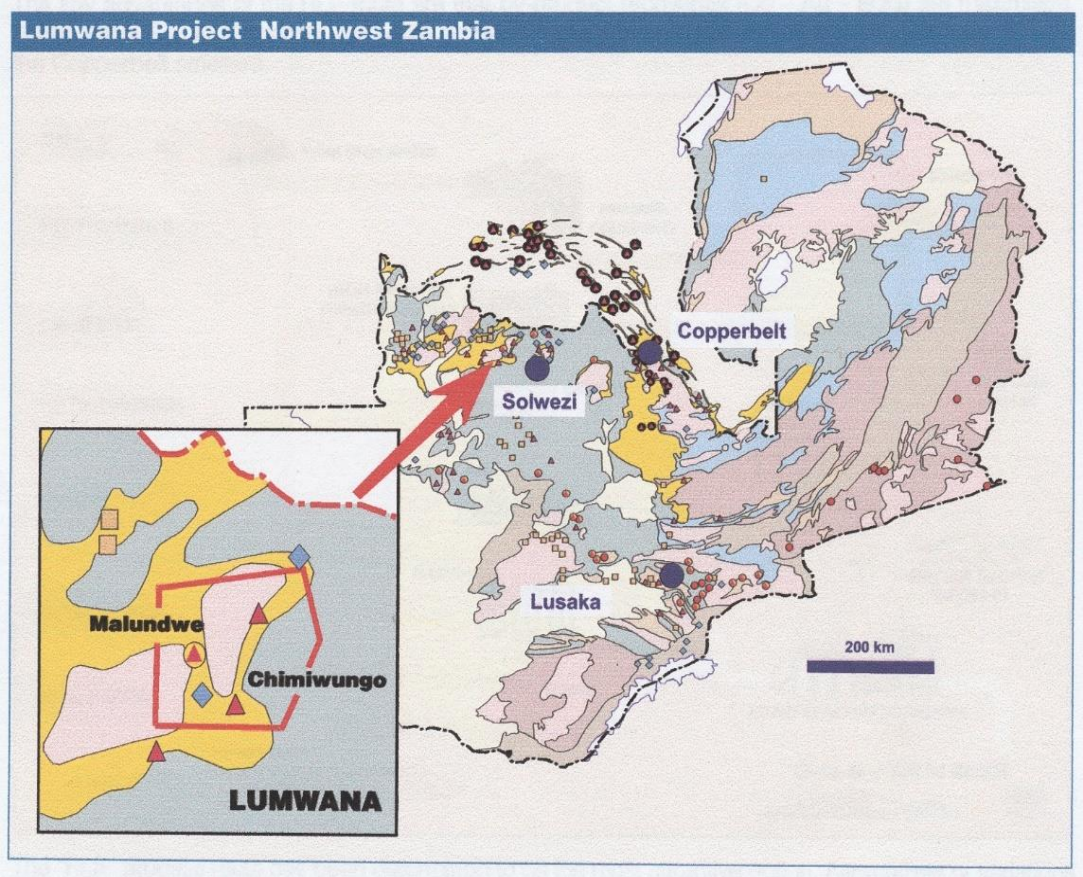

Figure 2. Lumwana project, northwest, Zambia. Source: Lumwana mine images.

covers 6,500 km^2. The wetland supports both domestic and wildlife populations, especially the Kafue lechwe antelope (*Kobus leche kafuensis)* that is unique to the area in that it is a wetland antelope feeding mainly on grass that is inundated annually. In addition to this, the river course supports the irrigation of a 17,000 hectare sugar cane plantation on its way down. Added to this demand is the water supply for the city of Lusaka that is drawn directly from river and pumped over 50 km to Lusaka by the water utility company for their urban clients.

The concern, prior to the dam construction, was the effect the regulation of water would have on the ecosystem and the support it gives to various life forms in the area. A research group, The Kafue Basin Research, was formed as a result of this plan to carryout studies in both scientific and social sciences, but very little was done on perceptions of the respective local communities that are along the water course up to the hydro-power station on the impact the project would have on their ecosystem using methods discussed above. During this time, there was no EIA mechanism in place (Howard and Williams, 1982). In addition to this, there are no structured benefits or any legislative frameworks available. The World Wide Fund for Nature (WWF) has since established local community conservation participation in critical areas such as wildlife and fisheries management and how the domestic livestock grazing can be accommodated in the ecosystem.

Wildlife, as a resource, especially the mega-fauna, occupies a variety of ecosystems in Zambia and is probably the most complex of the resources to manage. The management interaction also cuts across multiple ethnic communities with varied customs and traditions including land use patterns. Zambia has 73 different ethnic groups around the country. A benefit sharing scheme has evolved over time as a way of mitigating excessive poaching of wildlife in different parts of the country.

Wildlife management sharing arrangements with the local communities in Zambia

Lewis et al. (1990) account for the genesis of the sharing of wildlife based benefits with local communities in Zambia as a tool to reduce illegal hunting of wildlife species and thereby engaging the local community in a shared resource management scheme. This was as a

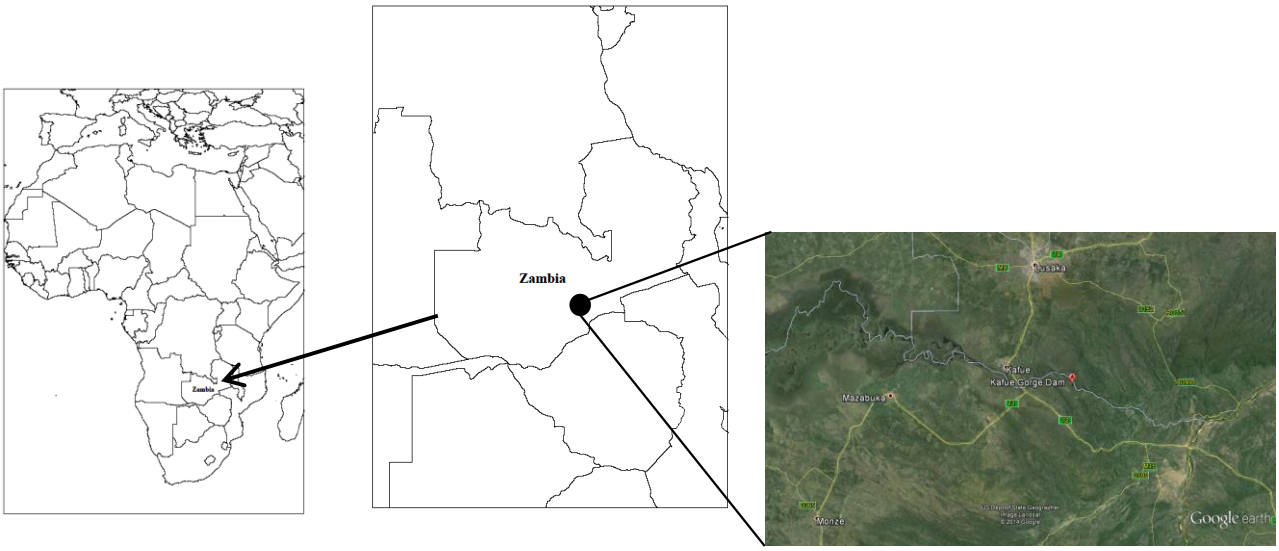

Figure 3. Africa, Zambia and the Kafue River system.

result of a successful experiment in the Lupande GMA in South Luangwa that was initiated in 1985-1987. The experiment was based on the premise that the wildlife department be allowed to retain some funds from the revenues that were at that time all retained by the central treasury in order to support management needs of the department and the local community benefits. Secondly, that the department employ and train local staff from the experiment base area above the normal staff strength. Lastly, those issues of wildlife management are dealt with in collaboration with the local community of the area.

The main reason for the experiment was to reduce the illegal off take (poaching) of a number of wildlife species in the area and in Zambia in general especially that of the black rhino and the elephant. The law enforcement measures were failing to contain the rate at which wildlife was being lost. The attention was turned on the attitudes of the local people on wildlife conservation given their participation in revenue sharing with the department of national parks and wildlife.

The success of this experiment in one locality led to the formulation of a general policy on wildlife management in Zambia on all the 35 GMAs. The policy was called the Administrative Management Design (ADMADE) adopted as a tool for wildlife management in Zambia. Its application had its own challenges because each locality had its own perception of the new policy. For example, Siachoono (1995) while carrying out a CVM assessment of the ADMADE policy in Mumbwa GMA with the local community found that the responses on WTP (44%) had lower monetary value while the responses on WTA (28%) had a higher monetary value. Mitchell and Carson (1989) propose four reasons for this phenomenon in contingent valuations surveys, namely: (a) rejection of WTA property rights, because people are motivated to give a higher WTA value as a way of rejecting the property rights implied by the WTA, (b) that the respondents are cautious consumers in a CVM survey, (c) the value function is steeper for losses than gains. The function predicts a higher amount of compensation because WTA implies giving up a good and (d) that the WTP and WTA in contingent valuation surveys have unresolved implications for the possible differences in their values.

The dilemma for wildlife management in Zambia has been that GMAs and the national parks they support are actually sitting on traditional land that is controlled by traditional leaders. The dual land tenure in Zambia creates this dilemma. While the land may be said to be in the hands of the traditional leadership, the wildlife belong to the state just like in the minerals and oils below the land surface. This is what fuels the human–wildlife conflict in most of the GMAs. The ADMADE policy was seen as the solution to the perceived conflict for wildlife management.

The ADMADE policy has since been converted into a legal framework with the same meaning. The implication here is that it has provided a long time solution for wildlife management in Zambia. Section 5 of the current Zambia Wildlife Act of 1998 states that: the functions of the Zambia wildlife authority are to (a) control, manage, conserve, protect and administer national parks, bird sanctuaries, wildlife sanctuaries and GMAs, (b) share responsibilities of management of GMAs with local communities and (c) pay out such money into a fund established by community resources board from revenues payable (Zambia Wildlife Act, 1998).

Community based natural resources management (CBNRM)

ADMADE in Zambia has since evolved into a CBNRM

that has been supported by a legal framework. It is now a working paradigm for natural resources management designed to mitigate rural poverty and share both benefits and management responsibilities of wildlife with the local communities. CBRNM has now a wider application in sub-Saharan Africa and has also become a subject of debate by scholars.

Critics however, argue that the intended beneficiaries in the CBNRM model are treated as passive recipients of project activities (Pimbert and Pretty, 1995) and that as a result it has failed to deliver expected and predicted benefits. Improvements of the CBNRM model practice should therefore focus on creating a relationship between management institutions and the beneficiaries as they both relate to the environment. Established institutions should further play more of a mediating role between the resources and the beneficiaries. The complication arises however because such institutions are usually fragmented and do not function as one unit. There are varying legislative frameworks for each natural resource.

Communities on the other hand also vary from a homogeneous ethnic group in a rural area under one traditional leadership to a mixed population with a broad cultural and social divergence in more metropolitan areas. Blaikie (2006) sees a community as a spatial unit with a distinct social structure and a set of shared norms. In general, community members have an extended set of entitlements for different actors who command a bundle of user rights for environmental goods and services for their own well-being.

The wildlife management in Zambia, especially as it regards the mega fauna, has been active in engaging the respective local community in wildlife based areas in as far as the resource management is concerned. These efforts have been successful in an attempt to reduce, but not eradicate illegal hunting. However, there is still a need to employ methods that will give local perceptions as opposed to a country wide strategy on wildlife management. These perceptions would greatly assist in building a national policy framework or even lead to better legislative instruments for wildlife management.

Other resource management institutions such as fisheries, forestry, water and the respective land use management authorities have attempted to have similar arrangements with local communities, but these lack the harmony expected from joint resource management arrangements with local communities with well recorded and documented perceptions.

Conclusion

The CVM surveys have a broader application in environmental assessments in general as they can be used to value both use and non-use values. The TCM on the other hand is limited to direct use value as it relies mainly on consumer expenditure behaviour to find the value of a resource. The two are however not the ultimate methods, but decisions on environmental policy issues and assessment of ecosystems in general would benefit from the employment of such methods at any given time.

There are challenges in using the methods and they include the educational level of the respondents and the vehicle one uses to put value on the environmental good being assessed. Monetary value may not be the best as most rural communities do not have disposable income. The strategy should include a pilot survey to seek for the best vehicle to use in the survey and select the best tool for use.

Land tenure in Zambia is still dual and traditional leaders (chiefs) still have a say in the land distribution. Such land is not surveyed and does not carry title but is seen as communal land for that particular ethnic group. This outcome has its implications on the property rights that the respondents may assume in a survey.

The current use of the EIA as a standard tool falls short of putting value on the ecosystem and raises concerns on the effect of the impact that may be affected with a particular project going ahead. This includes also the effect on the environment. EIAs are open to the public at large with various interests as a procedure before the implementation of a project and are not restricted to the local community. The EIAs often suffer from limitations and are sometimes prone to government control if the project is seen to be an economic life line for the country. Additional methods argued here can be used not only to put value on respective ecosystems but to cushion some of the limitations of the EIAs.

Conflict of Interests

The author did not declare any conflict of interest.

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Species diversity and regeneration of Tilonj Oak (*Quercus floribunda* Lindl.) dominated forests of Nainital in Kumaun Himalaya

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The present study deals with species diversity, and regeneration of *Quercus floribunda* Lindl forest lies in moist temperate sites in Nainital of Kumaun Himalaya. Tree, sapling and seedling density was 490-1190, 260-1280 and 100-670 ind.ha^{-1}, respectively. The species diversity of trees and shrubs density ranged from 0.421 to 1.177 and 310 to 1540 ind.ha^{-1}. The regeneration of *Q. floribunda* was J-shaped in forest site-1 and 2 while I-shaped (no regeneration) was reported for the forest site-3. The regeneration status of species in the studied forest sites indicates the impact of disturbances caused by anthropogenic activities. Thus, the presence of either seedlings or saplings and or also occurrence of new plant species in forest site-1 and site-2 predict the possible change in forest species composition in coming years while there was a very alarming condition in forest site-3 as new recruitments of tree species is evidenced by their absence. Thus, the above findings of *Q. floribunda* have shown that there is an urgent need to provide judicious inputs of management and conservation for sustaining the oak species in such forest sites of the region.

Key words: *Quercus floribunda*, species diversity, trees, saplings, seedlings, regeneration, moist temperate.

INTRODUCTION

Himalaya is one of the biodiversity hot spots in the world but the recent change in biodiversity and climate has been seen in every part of the globe which is caused by disturbances and faulty development activities. The variation in endemism species along the altitudinal gradient have shown that the changes in species diversity and microclimate of forest site in mountain region, also result to the integrated impacts of disturbance, poor conservation, faulty development and lack of appropriate management strategies. However, in the past, a lot of research works were done by many scientists focusing simply on their quantitative information but assessing the integrated effects of various factors was still not explored for the region. The various species of oaks are dominated in the forest communities throughout the mountain region of northern India (Stephenson and Saxena, 1984). There are five oak species viz., *Quercus leucotrichophora* A. Camus,

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Quercus floribunda Lindl., *Quercus lanuginosa* (Linn) Thuill, *Quercus semecarpifolia* Smith and *Quercus glauca* Thumb, which grow naturally between 1500 and 3300 m elevation in the Western Himalayan region and are regarded as climax species (Champion and Seth, 1968). The oak forest not only provides numerous ecosystem services but also serves as a lifeline for the local communities (Singh et al., 1984). Presence of oaks has been related with quality and quantity of spring water and considered best for water and soil conservation (Saxena and Singh, 1982). In Central Himalaya, oak forests support the subsistence agriculture and fulfill the need of agriculture implements, fire wood and leaf fodder of villagers in the region. Therefore, Oak forest acts as an important key in subsistence agricultural economy of hill people (Singh et al., 1984). Forest is the main source of livelihood for the local people in Uttarakhand, the human settlements practices in oak forests, lopping and felling as well as fire spreading in pine forests which reduced the area under oak forests (Champion and Seth, 1968). Biodiversity of forests is under great anthropogenic pressure and most of the species have become threatened and on the verge of extinction (Ram et al., 2004). In the Himalayan forest, various changes in structure, density, composition and regeneration due to biotic pressure have been reported in the Himalayan forest, that is, lopping, felling, collection of fuel wood, fodder and uncontrolled grazing (Kumar et al., 2004). Among the human influences, the commercial exploitation, agricultural requirements, forest fire and grazing pressure are the important sources of disturbance (Singh and Singh, 1992).

Population structure of a species in the forest conveys the regeneration behavior (Saxena and Singh, 1984). The presence of sufficient number of seedlings, saplings and young trees in a given population indicates the successful regeneration and tree regeneration can be predicted by the structure of their populations (Khan et al., 1987). According to Shanker (2001), regeneration status of individual tree gives the quantitative potential life-form at different stages and based on phyto-sociological reasons regeneration can be categorized into: (a) good, (b) fair, (c) poor, (d) no regeneration (Shankar, 2001). Theoretical population models predict that the shape of population size distributions results from the interaction between size-specific survival, growth and fecundity (Condit et al., 1998; Case, 2000; Caswell, 2001). If two populations differed in fecundity only, having equal growth and survival rates across size classes, then a larger population growth rate would produce a steeper negative size distribution (Condit et al., 1998). Population size distribution carries a wealth of demographic information and is frequently the most unequivocal and accessible attribute available for a population (Souza, 2007). The size distribution of a population is synthesis of the demographic events of recruitment, mortality and individual growth rates over time (Kelly et al., 2001).

The objective of the present study was to determine the vegetation analysis and regeneration status of Tilonj oak (*Q. floribunda*) dominated forests of Nainital in Kumaun Himalaya.

MATERIALS AND METHODS

The present study was conducted in moist temperate forests of Nainital in Kumaun region, Uttarakhand. The forest sites were located between 29°21' - 29°24' N latitude and 79°25' -79°29'E longitude. The three forest sites studied were site- 1, University Administrative Blocknear Sleepy hollow side, site-2, situated at University Administrative Block towards Tiffin top upper side and site-3, near Zoo forest between 2000 to 2500 m altitude. The sites aspects were NE and SW with a 26.5°, 12.5° and 50.55° slopes, respectively. Vegetation analysis of forest in each site was carried out by using quadrat method. The quadrat 10 x 10 m size was used for trees, 5 x 5m for shrubs and 1 x 1 m for herbs, placed randomly in each forest site. The sampling size and number of quadrat was determined as using Saxena and Singh (1982, 1984). Density was determined following Misra (1968) and Curtis and McIntosh (1950). In each quadrat, sampled tree species were categorized into: Trees (with >30 cm Cbh circumference at breast height, 1.37 m from ground level) and sapling with 10-30 cm above 1 m from ground and seedling <10 cm Cbh at 50 cm ground level placed randomly in each forest site were measured. Regeneration status of tree species was assessed following Shankar (2001). For the assessment of population structure of tree species based on seedling and sapling available in different tree, girth classes, that is, 30-60, 60-90, 90.0-120,120-150, >150cm were arbitrarily established based on Good and Good (1972).

Species diversity of trees in each forest site was determined by using Shannon-Weiner Index (Shannon and Weiner, 1963) and Concentration of dominance (Cd) was determined by Simpson's Index (Simpson, 1949).

$$H' = -\sum_{i=1}^{s} \left(\frac{Ni}{N}\right) 3.322 \log_2\left(\frac{Ni}{N}\right)$$

Where, H' = species diversity, Ni = total number of individuals species and N is total number of individuals of all tree species.

$$Cd = \sum_{i=1}^{s} (Ni/N)2$$

Where, Cd = concentration of dominance, Ni = total number of individuals of tree species and N = total number of individuals of all tree species.

RESULTS

Tree layer analysis

In forest site- 1, the total seven tree species *Q. floribanda* Lindl. exRehder, *Litsea umbrosa* Nees*, Asculus indica* Colebr. exCamb.Hook *Ilex dipyrena* Wall.*, Cedrus deodara* (Roxb. ex D. Don) G. Don*, Fraxinus micrantha* Lingelsh, *Rhamnus virgatus* Roxb were present. Total tree density of the forest site was 490 indha^{-1} of which *Q. floribunda* showed maximum density (300 indha^{-1}). Total

Table 1. Density (ind. ha^{-1}) of tree species in each forest site.

Species	Forest site-1			Forest site-2			Forest site-3		
	Tree	Sapling	Seedling	Tree	Sapling	Seedling	Tree	Sapling	Seedling
Quercus floribunda	300	670	340	740	960	340	960	260	70
Litseaumbrosa	90	20	90	10	80	-		-	-
Fraxinus micrantha	10	60	80	-	70	20		-	-
Aesculus indica	10	20	-	-	20	10		-	-
Ilex dipyrena	40	40	30	-	30	60		-	-
Cedrus deodara	10	-	-	-	50	10		-	-
Rhamnus virgatus	30	-	-	-	-	-		-	-
Acer oblangum	-	-	110	10	-	-		-	-
Prunus ceresoides	-	-	10	10	30	20		-	-
Pyruspashia	-	30	-	-	10	--		-	-
Grevillia robusta	-	-	10	-	-	-		-	-
Quercus leucotrichophora	-	10	-	-	20	10	220	-	30
Rhododendron arboreum	-	-	-	20	-	-	10	-	-
Cupressus torulosa	-	-	-	10	10	-	-	-	-
Total	490	850	670	800	1280	470	1190	260	100

Table 2. Diversity (H') and concentration of dominance (Cd) of tree species in each forest site.

Tree layer	Forest site-1		Forest site-2		Forest site-3	
	H	Cd	H	Cd	H	Cd
Trees	1.769	0.423	0.553	0.861	0.421	0.686
Saplings	1.234	0.632	1.518	0.577	0	1
Seedlings	1.947	0.319	1.455	0.530	0.881	0.580

seven sapling species, that is, *Q. floribunda, L. umbrosa, A. indica, I. dipyrena, F. micrantha, Pyrus pashia* Buch.*,Q. leucotrichophora* A. Camus were present. The total density of saplings was 850 indha^{-1}, of which *Q. floribunda* showed maximum density, that is, 670 indha^{-1}. Total seven seedling species, that is, *Q. floribunda, L. umbrosa, A. oblongum, I. dipyrena, Prunus ceresoides* D. Don*, F. micrantha, Grevillia robusta* A. Cunn. were present. Total density of seedlings was 670 indha^{-1} of which *Q. floribunda* showed maximum density (340 indha^{-1}) (Table 1). The species diversity and concentration of dominance for trees, saplings and seedlings was 1.769, 1.234, 1.947 and 0.423, 0.632, 0.319, respectively (Table 2).

In forest site- 2, the total six tree species, that is, *Q. floribunda, A. oblongum, L. umbrosa, Rhododendron arboretum* Smith.*, P. cerasoides* and*C. sustorulosa* D.Don were present. The tree density of forest site was 800 indha^{-1}, of which *Q. floribunda* showed maximum density (740 indha^{-1}). The total 10 sapling species, that is, *Q. floribunda, Q. leucotrichophora, C. deodara, I. dipyrena, A. indica, L. umbrosa, F. micrantha, P. cerasoides, C.torulosa and P. pashia* were found.

The total saplings density was 1280 indha^{-1}, of which *Q. floribunda* showed maximum density (960 indha^{-1}). The seedlings of seven species viz., *Q. floribunda, Q. leucotrichophora, C. deodara, I. dipyrena, A. indica and F. micrantha* were reported in the forest site (Figure 2). The seedling density was 470 indha^{-1}, of which *Q. floribunda* showed maximum density, that is, 340 indha^{-1} (Table 1). Species diversity and concentration of dominance of trees, saplings and seedlings was 0.553, 1.518, 1.455 and 0.861, 0.577 and 0.530, respectively (Table 2).

In forest site-3, total three tree species viz., *Q. floribunda, Q. leucotrichophora* and *R. arboreum* were reported. The total tree density was 1,190 indha^{-1}, of which *Q. floribunda* showed maximum density (960 indha^{-1}). Only *Q. floribunda was* reported in sapling stage with density of 260 indha^{-1}.

The seedlings of *Q. floribunda and Q. leucotrichophora* were present the total density of seedlings was 100 ind.ha^{-1}, of which *Q. floribunda* showed maximum density (70 indha^{-1}) (Table 1). Species diversity concentration of dominance for trees, saplings and seedlings was 0.421, 0.00, 0.881 and 0.686, 1.00, 0.580, respectively (Table 2).

Shrub layer analysis

In forest site-1, the total nine shrub species, that is, *Urtica parviflora* Roxb*, Hypericum oblongifolium* Choisy*, Rosa maschata* J. Herrm*, Urtica dioica* L.*, Berberis asiatica* Roxb.ex D. Don*, Arundinaria falcate* Nee*, Desmodium elegans* D.C*, Sarcococa saligna* Muell. Arg and *Senecio nudicaulis* Buch.-Ham. exD. Don were present. The total shrubs density was 1540 indha^{-1}, of which *S. saligna* showed maximum density (690 indha^{-1}).

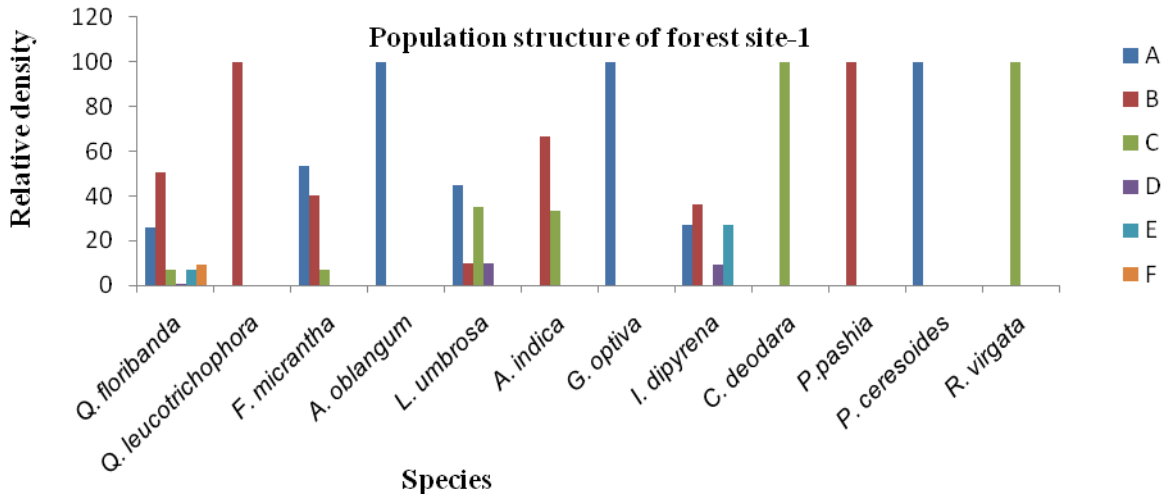

Figure 1. Population structure of all species (A- seedling, B- sapling, C- 30.1-60 cm, D- 60.1-90 cm, E- 90.1-120 cm and F-120< are different girth classes) in site 1.

Total species diversity and concentration of dominance was 2.518 and 0.260, respectively (Table 3).

In forest site-2, a total of eight shrub species, that is, *U. parviflora, Hypericum cernuum* Roxb*, Rosa micrantha* Lindll*, U. dioica, A. falcata, S. saligna, Daphane papirasea* Wall and *Indigofera heterantha* Wall. exBrandis were present. The total shrubs density was 1070 indha^{-1}, of which *S. salisena* showed maximum density (230 indha^{-1}). Species diversity and concentration of dominance of shrub was 2.82 and 0.223, respectively (Table 3).

In forest site-3, total five shrub species, that is, *C. coccinea, H. oblongifolium, Rubus ellipticus* Smith*, B. asiatica* and *Pyracantha crenulata* (D. Don) M. Roem were present. Total density of shrub was 310 indha^{-1}, of which *H. oblongifolium* showed maximum density (110 indha^{-1}). Species diversity and concentration of dominance of shrub was 2.126 and 0.249, respectively (Table 3).

Herb layer analysis

In forest site-1, total thirteen herb species were present, that is, *Strobillanthus atropurpurem* Nees*, Gallium aparina* L.*, Oxalis latifolia* BHK*, Achyranthes bidentata* Blume*, Argemone maxicana* L.*, Eulate amallis* (Griseb). O. Kuntze*, Justica simplex* D. Don*, Erigeron annua* (L). Pers.*, Carex condensate* Wahlenb.*, Viola canescens* Wall, *Ocimum sanctum* Linn*, Apludamutica* Linn. and *Arthraxon prionodes* Steud. Dandy. Total herbs density was 43.70 indm^{-2}, of which *A. mutica* showed maximum density (12.50 indm^{-2}). Species diversity and concentration of dominance was 3.05 and 0.161, respectively (Table 4).

In forest site-2, total seven herb species were present, that is, *S. atropurpurem, G. aparine, A. bidentata, V. canescens, A. prionodes, E. annua* and *Thalictrum foliolosum* DC. Total herb density was 14 ind m^{-2}, of which *A. bidentata* showed maximum density (5.7 indm^{-2}). Species diversity and concentration of dominance of herbs was 2.402 and 0.237, respectively (Table 4).

In forest site-3, total ten herbspecies such as *A. mutica, E. malis, C. condensate, G. aparine, A. bidentata, V. canescens, A. prionodes, E. annua, O. latifolia*and *T. foliolosum* were present in the forest site. Total herbs density was 49.10 indm^{-2}, of which *A. mutica* showed maximum density (25.10 indm^{-2}). Species diversity and concentration of dominance of herbs was 2.424 and 0.303, respectively (Table 4).

Population structure

In forest site-1, *Q. floribunda*, *I. dipyrena, P. pashia, Q. leucotrichophora* and *A. indica* showed the J-shaped (poor regeneration) because of lesser number of seedlings and trees than saplings. *F. micrantha* depicted reverse J-shape (good regeneration) and *L. ambrosa*has showed U shape (fair regeneration) with high number of seedlings but the conversion of seedlings into saplings was not adequate. *P. cerasoides, G. optiva* and *A. oblongum* were new invaders to the site as represented only by seedlings. *R. virgata* and *C. deodara* showed I-shape (noregeneration, only adult tree) in this forest site (Figure 1).

In forest site-2, *I. dipyrena,* indicates reverse J-shape (good regeneration), there was only presence of seedlings shown in the forest site. The *Q. floribunda*, *P. cerasoides, Q. leucotrichophora, C. deodara, F. micrantha, C. torulosa*, *L. umbrosa, A. indica* and *P. pashia* showed the bell shape or J-shape (poor

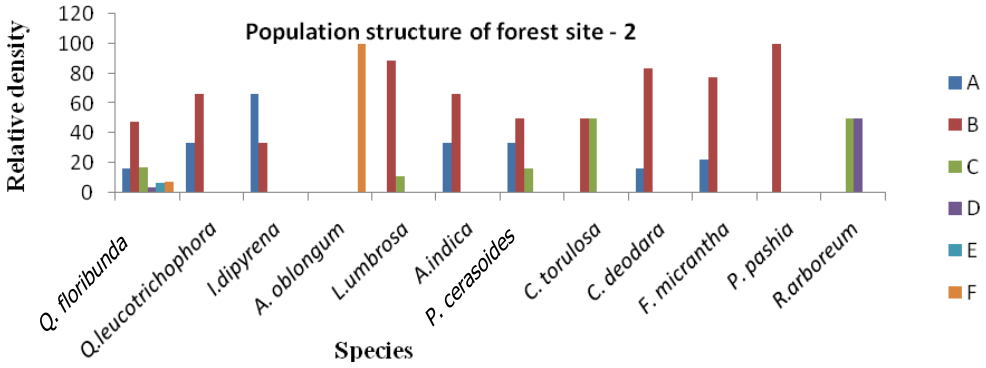

Figure 2. Population structure of all species (A- seedling, B- sapling, C- 30.1-60cm, D- 60.1-90 cm, E- 90.1-120cm and F-120< are different girth classes) in site 2.

Table 3. Density (ind ha^{-1}), species diversity and concentration of dominance of shrubs species in forest site.

Species	Forest site-1			Forest site-2			Forest site-3		
	D	H	Cd	D	H	Cd	D	H	Cd
Urtica parviflora	150	0.326	0.009	150	0.397	0.019	-		
Hypericum oblongifolium	180	0.362	0.014	-	-	-	110	0.529	0.126
Rosa maschata	40	0.136	0.001	-	-	-	-	-	-
Urtica dioica	60	0.182	0.001	70	0.256	0.004	-		
Berberis asiatica	150	0.326	0.009	-			40	0.381	0.016
Arundinaria falcate	120	0.287	0.006	50	0.208	0.002	-	-	-
Desmodium elegans	130	0.299	0.007	-			-	-	-
Sarcococas aligna	690	0.519	0.200	230	0.477	0.046	-	-	-
Senecio nudicaulis	20	0.081	0.013	-	-	-	-	-	-
Hypericum cernuum	-	-	-	80	0.280	0.075	-	-	-
Daphane papirasea	-	-	-	90	0.300	0.007	-	-	-
Indigofera heterantha	-	-	-	220	0.470	0.042	-	-	-
Rosa micrantha	-	-	-	180	0.432	0.028	-	-	-
Colquhounia coccinea	-	-	-	-	-	-	20	0.253	0.0042
Rubus ellipticus	-	-	-	-	-	-	60	0.459	0.037
Pyracantha crenulata	-	-	-	-	-	-	80	0.504	0.066
Total	1540	2.518	0.260	1070	2.82	0.223	310	2.126	0.249

regeneration). *A. oblongum* and *R. arboreum* represented no regeneration, only trees were present.

In forest site-3, the*Q. floribunda* and *Q. leucotrichophora* showed U-shape (fair regeneration, that is, seedlings>saplings<adult trees), these species is represented by young tree class while absence of saplings indicates that seedlings failed to attain the sapling stage due to climatic and anthropogenic pressure. *R. arboreum* was only represented by single adult tree class showing no regeneration (Figure 3).

DISCUSSION

The present study tree species density was 490 to 1190 ind ha^{-1}. These values are higher than 760 ind ha^{-1} reported for natural oak forest (Rawat and Singh, 1988), 349 ind ha^{-1} for Western Himalaya forest (Saxena and Singh, 1984), 930 indha^{-1} for *Q. floribunda* forest (Kumar and Ram, 2005) and 260-780 ind ha^{-1} for disturbed forest and 460-970 ind ha^{-1} for protected forests of Nainital catchment (Bargali et al., 2013). but present estimates are on the lower side than 1330 ind.ha-1 reported for Oak and Pine mixed forests(Lodhiyal and Lodhiyal, 2012) and 920-1345 ind ha^{-1} for natural Oak dominated forest (Lodhiyal et al., 2013). The *Q. floribunda* was the dominant tree species in the studied forest site which was 300-960 ind ha^{-1}, which accounted 61-92% of the total tree density.

Density of saplings in this forest site ranged from 260 to 1280 ind ha^{-1}, which was higher than 760 ind ha^{-1} reported for oak forest (Rawat and Singh, 1988). The

Table 4. Density (ind. m^{-2}), species diversity, concentration of dominance of herb species at forest site.

Species	Forest site-1			Forest site-2			Forest site-3		
	D	H	Cd	D	H	Cd	D	H	Cd
Strobillanthus atropurpurem	8.4	0.457	0.037	2.0	0.401	0.020	-	-	-
Oxalis latifolia	1.6	0.176	0.001	-	-	-	2.4	0.212	0.002
Gallium aparina	2.0	0.205	0.002	1.3	0.319	0.009	3.4	0.266	0.005
Achyranthes bidentata	0.8	0.106	0.001	5.7	0.528	0.166	2.1	0.194	0.002
Argemone maxicana	1.0	0.124	0.001	-	-	-			
Eulate amallis	3.8	0.306	0.008	-	-	-	1.6	0.176	0.001
Justica simplex	0.2	0.036	0.001	-	-	-			
Erigeron annua	0.6	0.085	0.001	1.1	0.286	0.006	1.4	0.146	0.001
Arthraxon prionodes	2.9	0.258	0.004	1.1	0.286	0.006	3.0	0.246	0.004
Carex condensate	5.4	0.371	0.015	-	-	-	7.5	0.415	0.024
Viola canescens	3.6	0.295	0.007	2.4	0.435	0.029	1.7	0.168	0.002
Ocimum sanctum	0.9	0.115	0.001	-	-	-			
Apluda mutica	12.5	0.516	0.082	-	-	-	25.10	0.495	0.261
Thalictrum foliolosum	-	-	-	0.4	0.147	0.001	0.9	0.106	0.001
Total	43.70	3.05	0.161	14	2.402	0.237	49.10	2.424	0.303

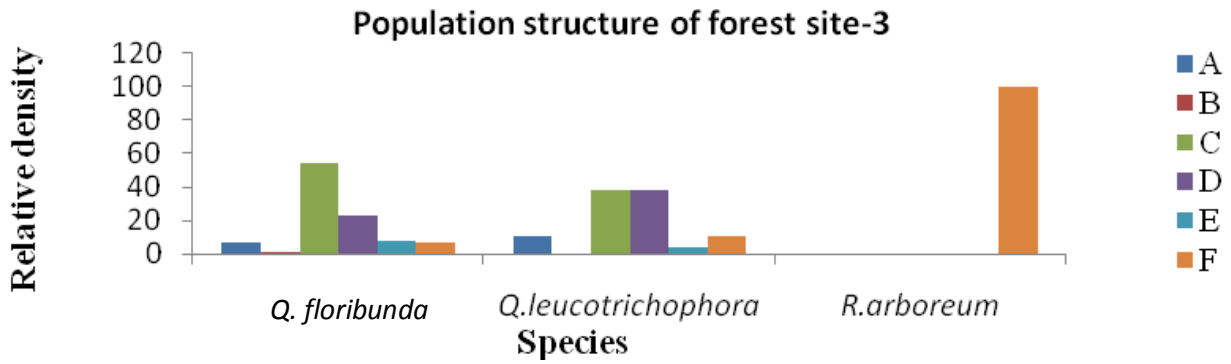

Figure 3. Population structure of all species (A- seedling, B- sapling, C- 30.1-60cm, D- 60.1-90 cm, E- 90.1-120cm and F-120< are different girth classes) in site 3.

sapling density was lower than 2061 ind ha^{-1} for *Q. floribunda* forest of Government House in Nainital (Saxena and Singh, 1984) and falls within the range 788-1718 ind ha^{-1} of Central Himalayan forest (Singh et al.,1987).

Seedling density was 100- 670 indha^{-1} in the forest site. These values are much lesser than 2030 ind ha^{-1} reported for Oak forest (Rawat and Singh, 1988),10899 ind ha^{-1} for *Q. floribunda* forest by Saxena and Singh (1984), 12750 ind ha^{-1} for *Q. floribunda* forest of Government House in Nainital (Singh et al., 1987). The present values indicate very poor regeneration of tree species in the forest sites.

Shrub density ranged from 310 to 1540 ind ha^{-1}. These values are on the lesser side than 1060 to 4250 ind ha^{-1} reported for oak forests of central Himalaya (Rawat and Singh, 1988). Herb density ranged from 14.0 to 49.0 ind m^{-2} (during winter season). The number of herbaceous species varied from 7 to 13.

Species diversity of trees in the studied forest sites ranged from 0.421 to 1.177 which falls within the range of 0.46 to 2.02 reported for oak forest in Nainital of Kumaun Himalaya (Ralhan et al., 1987), 1.2 to 2.7 for Central Himalayan forests (Kumar and Ram, 2005) and 0.78 to 3.45 for Garhwal Himalayan forests (Raturi, 2012) and 0.757-1.500 reported for natural oak mixed forests (Lodhiyal et al., 2013).

All the studied forest sites had shown J-shape (poor regeneration, that is, seedlings>saplings<adult trees) in sites-1 and 2, which indicates that forest sites has reproduced well in the immediate past but forest site need management and conservation. The forest site-3 showed very less number of seedlings and saplings and represented only by few tree classes with no regeneration. In forest site-1, only 8.33% species had shown reverse J-shape (good regeneration), 8.33% U, reverse bell shaped (fair), 16.7% no regeneration and

41.7% J-shape (poor regeneration), while 25% of species were new invaders to the forest site. In forest site-2, 8.3% showed reverse J-shape (good regene-ration), 75% species showed J-shape (poor) and 16.7% I-shape (no regeneration, only adult tree were found). At forest site-3, 66.7% species showed U shape or reverse bell shaped (fair regeneration, seedlings> saplings< adults trees) and 33.3% showed no regeneration.

Q. floribunda was dominant tree species in all the studied forest sites, which has shown J-shape (poor regeneration) at forest sites-1 and 2, and I-shaped (no regeneration) at forest site-3. The higher percent of J-shaped (poor regeneration) tree species in all the forest sites indicates heavy anthropogenic pressure on forest type species for fuel and fodder.

Oak forests are one of the important forests in Western Himalaya, as the oak tree provides various sustainable options to the village community residing in the region. Forest gives direct and indirect benefits to the community and also conserves the ecosystem landscape. Oak is most important precious gift of nature not only from the villager's point of view for their fuel and fodder and water resource needs but also designates specific living structure of ecosystem.

Wherever in the hills, the oaks are present, they depict the quality of organic soil fertility and the sign for community livelihood sustainability in the region. The present study shows that forests are in a very alarming situation as *Q. floribunda* forest has showing J-shape (poor or no regeneration) in the studied forest sites. Therefore, it is very essential to develop proper management and conservation strategies for maintenance of oak species and their sustainability in the forest of the region.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Attitudes and perceptions of the local people towards benefits and conflicts they get from conservation of the Bale Mountains National Park and Mountain Nyala (*Tragelaphus buxtoni*), Ethiopia

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A study to examine the attitudes and awareness of the local communities towards conservation values of the park, its flora and fauna with particular emphasis on mountain nyala was carried out in the Bale Mountains National Park in 2007. The study specifically investigated how attitudes vary with different groups of people involved in either recent or long term settlements; people with different livelihood strategies and among people that live at different distances away from the park. Questionnaire and interviews were directed to randomly selected households and key-informants in 7 villages located near the park. Out of the 136 people interviewed, 26% of the respondents felt that they benefited, while 55% experienced conflict by living near the park. The most important benefits were leasing of horses to tourists (62%), serving as tourist guide (44%), and use of the park's vehicles during the time of emergency (38%). A significant portion (83%) of the respondents agreed that there was lack of equity in benefit distribution. The main conflicts were fear of forceful relocation (84%), livestock grazing restrictions (74%) and restriction of firewood collection (54%). Perceived benefits and conflicts varied across livelihood strategy but not proximity to the park and duration of settlement. The majority of respondents (66%) believed that their presence in the area does not contribute to habitat degradation, an attitude more commonly held among recent settlers than long-term settlers. The overall attitude of the local people towards the park and the presence of mountain nyala were positive. 80% of the respondents would support the park's conservation activities suggesting that there is a room to enhance cooperation of the local people and improve the prospects for conservation of the mountain nyala and its habitat.

Key words: Attitude, benefit, conservation, conflict, encroachment, local people, mountain nyala.

INTRODUCTION

For wildlife conservation action to be effective, it is imperative to understand beyond the need of individual wildlife species in human cultural and economic aspects that profoundly affect conservation (Naughton-Treves

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and Weber, 2001; Baillie et al., 2004). It is increasingly recognized that biodiversity is ultimately lost or conserved at the local level, and it is therefore crucial that the perspective of the local people should be understood if wildlife management programmes are to be sustainable (Pratt et al., 2004).

Information on perceptions and attitudes of local communities living in and around protected areas is important to identify management programmes and strategies that best suit the protection of biodiversity alongside the development of local community livelihoods (Heinen, 1993; Infield and Namara, 2001; Allendorf, 2007; Kideghesho et al., 2007). Moreover, understanding of the attitudes of local communities, particularly where their rural livelihoods are dependent on agriculture is vital for resolving wildlife-human conflicts, which otherwise can threaten the success of any conservation activity (De Boer and Baquete 1998; Webber et al., 2007). Based on the fact that the attitudes are a strong predictor of a person or group's intentions to behave in a particular manner such as complying with wildlife protection regulations (Fulton et al., 1996), therefore, assessing attitudes and perceptions of humans toward wildlife provides insights on the degree to which people are willing to cohabit with wildlife (Carter et al., 2013).

Conflicts between the interest of wildlife conservation and local communities over the utilization of natural resources are well documented (Robert and Martin 2003; Warner, 2000). Human-wildlife conflict is more intense in developing countries where livestock holdings and agriculture are important parts of the rural livelihoods and income (Hackel, 1999). In these regions, competition between local communities and wild animals, for the use of natural resources, is particularly intense and direct (Messmer, 2000). Wildlife can negatively affect human livelihoods where they live in close proximity (Ogada et al., 2003; Woodroffe et al., 2005; Chardonnet et al., 2010), which in turn encourage people to kill wildlife (Woodroffe et al., 2005; Kissui, 2008), degrade wildlife habitat, or not comply with regulations designed to protect wildlife (Nyhus et al., 2005). Increased exposure to wildlife-related risks has been linked to negative attitudes of local people (Newmark et al., 1993; Arjunan et al., 2006). The nature and magnitude of the human wildlife conflicts are seldom uniform across space, and vary from country to country depending on a variety of factors including human population growth, culture, conservation methods and scarcity of critical natural resources especially land and water (Obunde et al., 2005; Sitati et al., 2003; Naughton-Treves and Treves, 2005). It is widely acknowledged that crop damage and livestock predation by wildlife are major sources of economic losses (Naughton-Treves, 1998). Encroachment into wildlife areas by humans has increased almost greatly over the past few decades and often resulted in the elimination of the larger species, particularly the large mammals, and such pressures hinder the success of species conservation programs in many regions around the world (Hackel, 1999; Woodroffe, 2001; Romanach et al., 2007; Milliken et al., 2009; Linderman et al., 2005; Lepczyk et al., 2008). Destruction of wildlife habitats has taken different forms, for example degradation, fragmentation, total loss of habitat due to the growing human activities prompted mainly by such factors such as human poverty, demographic increase, inadequate land tenure systems, lack of proper conservation and development policies and economic incentives (Kideghesho, 2007).

In Ethiopia, human-wildlife conflict is often linked to crop damage by wild animals on farms adjacent to protected areas and also by negative attitude and/or stereotype held by the exclusion of local communities towards wildlife (Kidane, 1982; Hillman, 1993; Hundessa, 1997). Moreover, exclusion-protected area approach followed by the Ethiopian Wildlife Conservation Authority has contributed its share in nurturing of negative attitude by the local people towards wildlife conservation. Widespread destruction of wildlife in 1991, during change of the government, by local communities occurred in protected areas like the Bale Mountains National Park (BMNP), partly as an expression of resentment over the exclusionary approach followed by the Ethiopian Wildlife Conservation Authority (Tedla, 1995; Beltran, 2000). So far, no attempt has been made to diagnose what went wrong and what lessons can be learned to avoid such destruction from happening again in the future. Thus, the general aim of this study was to examine the attitudes/ perceptions and awareness of the local communities surrounding the northern boundary of the park towards conservation of the BMNP, its flora and fauna with particular emphasis on mountain nyala. The specific objectives were to: 1) determine and compare the types of benefits and conflicts that the local people are associated with the park's flora and fauna; 2) determine perceptions attitudes held among various groups of residents on land use/cover change, environmental/-ecological services, conservation values of the park and their willingness to support the park; 3) assess in particular, the attitudes and perceptions of residents' towards mountain nyala; and 4) assess how the type of villages, their proximity to the park headquarters, duration of settlements and livelihood sources have impacted the perceptions and attitudes of local communities towards conservation of the park and mountain nyala..

The study area

The study area is located within 6°20′ and 7°40′N latitude, and 39°30′ and 39°58′E longitude in the southeastern highlands of Ethiopia. The area supports more than 75% of the global population of mountain nyala.

The current conservation status of the mountain nyala, as designated by IUCN (2002), is endangered due to reduced populations and continued decline. The

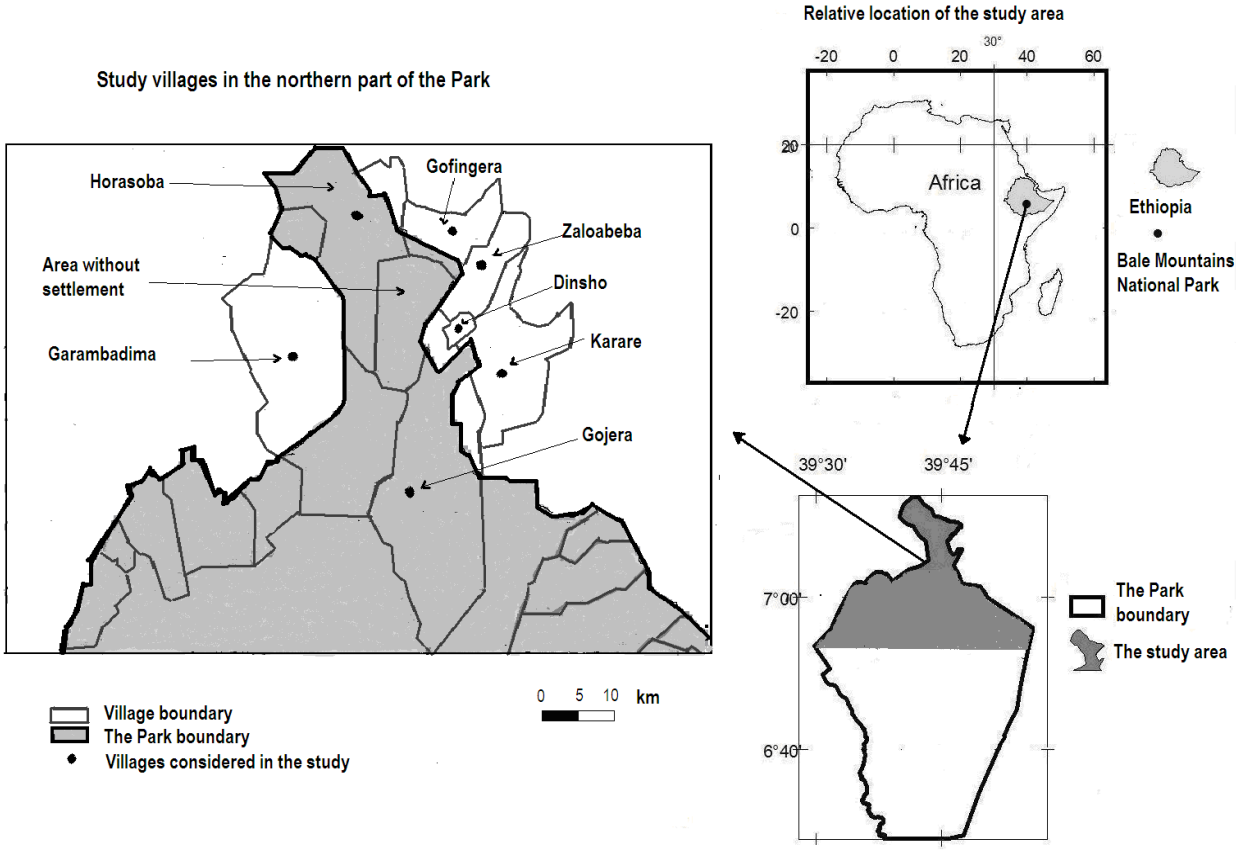

Figure 1. Map of the study area showing the different villages.

altitudinal range of the study area varies between 3000 - 3400 m asl. Seven villages or peasant associations (Dinsho, Zaloabeba, Karare, Gojera, Horasoba, Gofingera and Gerambadima) were selected that fall in and around the mountain nyala habitat range (Figure 1). Some of the villages were exclusively within the park. The focus animal, mountain nyala, was brought to the attention of science at the beginning of the 20th century (1908) by Major Ivor Buxton (Lydekker, 1911). The species is endemic to Ethiopia and under pressure due to encroachments by the local people and livestock (Hillman, 1986a).

The local people are mainly from Oromo ethnic group. They are subsistence farmers where their livelihood primarily dependent on crop cultivation and animal rearing.

The contribution of the natural resources particularly of natural forests of the area to their livelihood is crucial. More than 20,000 people settle and cultivate in and around the study area along with 50,500 heads of livestock and the trend is increasing from time to time (Tedla, 1995).

METHODS

Data were gathered using a cross-sectional survey of residents from seven villages located within or close to the northern part of the park. Using a combination of interviews with key informants and a questionnaire to household heads, quantitative and qualitative data were collected relevant to the research objectives. Seven villages were selected after discussion with the park staff, the Kebele (the lowest administrative unit in Ethiopia) administrators and the District Agricultural Development experts to identify which villages have direct access to the northern part of the park. Geographically, these seven villages encircle the northern part of the park. The number of households residing in the villages and their names were obtained. One of the villages was small town, which was the main administrative centre of the district. From these seven villages, 5% of the heads of household (HH) out of the total 2,720 were randomly selected as respondents (N = 136). Out of a total of 136 HH considered in the survey, 97 were males and 39 females. In addition key informants, generally elderly members of the communities and conversant with the happenings in the locality were identified with the help of Kebele administrators and villagers. Two key informants were interviewed for each village. A checklist of questions/issues was developed to guide the interview and discussion with the key informants.

A combination of closed and open-ended questions was developed and pre-tested before administering it to the intended household heads. The questionnaire was designed to query residents about a range of issues concerning their settlement history, benefits obtained and conflicts faced due to the PARK, views on land cover change, conservation values of the park and local knowledge and perceptions about mountain nyala. The questionnaire was translated into the local language and enumerators, with good knowledge of the local language (Oromifa), were selected to administer the questionnaire. Since the respon-

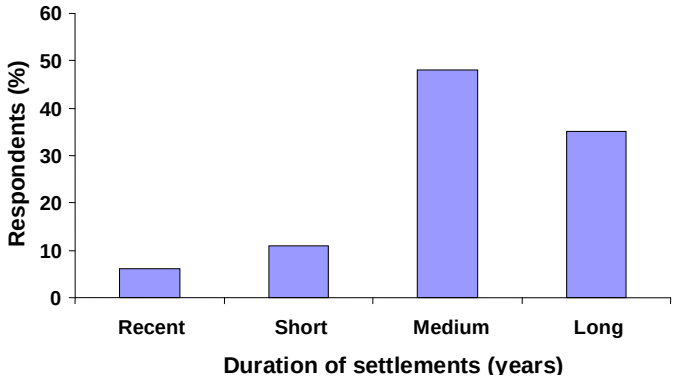

Figure 2. Proportion of residents settled in the area for different durations [Recent (<10 years), Short (10-20 years), Medium (21-40 years) and Long (>40 years)].

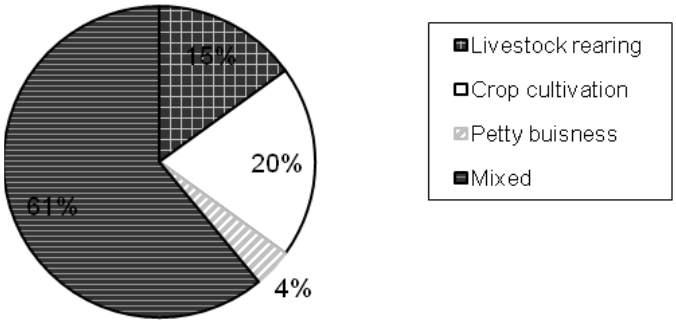

Figure 3. Livelihood sources of the local communities.

dents were illiterate, the enumerators read and explained each questions to the respondents and recorded their response in writing. The differentiation in the nature of the benefit types obtained by residents was made during the pre-test exercise of the questionnaire. Accordingly, two categories were identified: 1) Authorized or direct benefits; and 2) Unauthorized benefits. The data were summarized, analyzed using non-parametric tests by using SPSS version 14 statistical software.

RESULTS

The average family size of the respondents was 8.3 (95%CI = 7.6 – 9.0) and differed among villages (F = 2.062, df = 6, P = 0.062). The highest family size was observed in Dinsho and Zaloabeba with 9.8 and 9.6, respectively, while the lowest was in Gojera at 6.7. The average number of children per family was 6.4 and varied from 5.8 to 7.1 and was marginally different across villages (F = 2.073, df = 6, P = 0.061). Ages of the respondents varied between 18-90 years. Among the respondents, 61, 19, 17 and 3% were married, widowed, divorced and single respectively. On average, 67% of the respondents across the seven villages were permanent settlers, 25% were seasonal and the rest (8%) practice both (Figure 2). All the respondents in Dinsho were permanent settlers. The highest number of residents that use seasonal settlements and move between areas was recorded in Gofingera (60%) and Zaloabeba (52%). Duration of settlements is significantly different among the villages (x^2 = 12.668, df = 6, P<0.05). Recent and short term settlers were observed in villages that are very close to the park headquarters, of which Dinsho and Gofingera each supports 20% and Karare 12%, Gojera 6% and Garambadima 5%. Horasoba (57%) and Zaloabeba (57%) villages supported the highest number of settlers residing over 40 years (long term settlement).

A clear majority (72%) of the respondents preferred to stay in the area in the future and their views were not significantly different across villages (x^2 =12.801, df = 6, P>0.05). Respondents from Garambadima were different from the others with only 40% expressing the desire to stay. The majority of the respondents (58%) were against the idea of relocation and only about a third (32%) supported the idea, while the rest (10%) were unsure about its benefits. Their views were not significantly different across villages (x^2 =11.486, df = 6, P>0.05). The most important views against the idea of relocation were: they will become economically poor and dependent; difficulty in adapting to the new environment; their harmonious relationship with the mountain nyala and other animals will be affected; they fear enough land will not be available for re-settlers; and they wish to stay on the land of their ancestors. Subsistence agriculture was the dominant livelihood activity of the communities. The farming system involved complex linkages between crop production and livestock rearing. The majority of the households practice settled and mixed agriculture, producing crops and rearing livestock, followed by only crop cultivation (Figure 3).

The major types of livestock holdings were sheep and cattle. Each household on average has 10 heads of sheep and 8 cattle. The cattle (x^2=13.950, df=6, P<0.05) and sheep (x^2=20.751, df=6, P<0.01) holding size were significantly different across villages at 0.05 level. On average, 87, 78, 72, 71, 44 and 21% of the households were owners of cattle, horses, dogs, sheep, goats and donkeys, respectively. The highest number (15) of cattle per household was observed in Karare village, which was one of the closest villages to the park boundary.

58,000 heads of livestock and transport animals were roaming in and around the northern parts of BMNP. Nearly three quarter (74%) of the respondents wished to have more livestock than they have at present, although 78% of them experienced shortage of feed for their livestock. Their desire to have high number of livestock was significantly different across the villages (x^2 =17.986, df = 6, P <0.01), while their opinion on shortage of feed showed no significant difference (x^2=6.272, df = 6, P >0.05). About 73% of the respondents felt that they rear or keep livestock mainly for reason of insurance in time of crop failure rather than to signify their status, which was

Table 1. Perceived benefits and conflicts by the local communities (*n* =136) from the park.

Local communities	Perceived benefits	Perceived conflicts
Across villages (df = 6)	x^2 = 26.550; P = 0.000*	x^2 = 10.576; P = 0.102
Across distance (df = 2)	x^2 = 3.977; P = 0.134	x^2 = 6.030; P = 0.049
Settlement duration (df = 3)	x^2 = 1.443; P = 0.695	x^2 = 1.724; P = 0.632
Livelihood source (df = 3)	x^2 = 21.862; P = 0.000*	x^2 = 10.720; P = 0.013**

*Significant at 0.01, **Significant at 0.05 level.

about 4%. Their views were significantly different across villages (x^2=20.948, df = 6, P <0.01) with lowest number of respondents who rear livestock for insurance recorded in Dinsho villages (47%); while the highest in Karare (94%) and Garambadima (95%) villages. Those local communities relatively close to the Park boundary, mainly Karare (94%) and Zaloabeba (81%), desire to have and/or own relatively more cattle in the future than they have at present as compared to the rest of the villages. However, Garambadima, which is the farthest village with a similarly high percentage of the respondents (95%) indicated a desire for more livestock in the future. The dominant type of feed source for livestock was free range grazing on communal lands (79%), followed by seasonal grazing (35%) based on the availability of feed. However, the sources of feeds for livestock were different across villages except for free grazing. Cut and carry (x^2=59.419, df = 6, P<0.01) and seasonal grazing (x^2=20.392, df = 6, P<0.01) practices adopted by the communities were significantly different across villages.

Attitude of settlers towards dogs as shepherds of their livestock was evident from the number of dogs they own. More than 3,500 dogs have been estimated during the present study. On average, 2 dogs were owned by each household. Most of them were untamed and have been observed ranging freely in the wild and sometimes chasing mountain nyala calves. When they are in groups, they were also observed occasionally chasing adult mountain nyala. The local people also rarely associate dogs with the risk of disease transmission such as rabies to wild animals.

Perceived benefits were significantly influenced by the types of villages and livelihood sources than other group variables, that is, distance and duration of settlements (Table 1). Sources of livelihood appeared to be important group variables to have significant influence on perceived benefits and conflicts by the local people (Table 1). About a quarter (26%) of the respondents felt that they benefited while more than half (55%) experienced conflict by living near the park. The frequencies of conflicts by the local communities were similar across villages, proximity and settlement duration except for livelihood source; while perceived benefits were significantly different across villages and livelihood source (Table 1). With regard to livelihood strategy, those who principally depended on livestock rearing faced higher incidences (75%) of conflicts than mixed farming (57%) and crop cultivators (44%); and petty business with no reports of incidences of conflicts. The most beneficiaries from the park were those who depended on petty business (100%) and livestock rearing (35%), followed by mixed farming (27%) and crop cultivators (4%).

The majority of Dinsho village residents (68%) and the least (10%) in Garambadima felt that they have benefited a lot from the park. Large proportion of respondents (78%) from Gojera experienced more incidences of conflicts, while the least (47%) were reported from Karare villages. However, Karare village residents had more than double (15.2 cattle per HH) herds of cattle owned by residents such as in Zaloabeba (5.9). As distance increased from the park headquarters, perceived benefits and conflicts by the communities decreased. Recent (38%) and short-term (36%) settlers felt that they get more benefits than medium (26%) and long-term settlers (23%). Short-term settlers experienced more conflict (71%) than the recent settlers (50%). Views on conflicts (x^2= 1.724, df =3, P >0.05) and benefits (x^2= 1.443, df=3, P >0.05) across settlement duration were not different.

The most frequently mentioned benefits were horse lease (62%), tourism (44%) and use of the park vehicles during the time of emergency (38%). The least cited benefits were employment (15%) and infrastructure development (13%) (Table 2). Benefits obtained in terms of employment opportunity including the NGO's, leasing horses, serving as tourist guide and use of park vehicles during the time of emergency were different across the village and proximity to the park (Table 2). High proportion of respondents from Dinsho (45%) and Gofingera (21%) villages had employment opportunities as their benefits. More respondents residing very close to the park headquarters obtained more benefits than those residing faraway.

Village types and proximity of villages to the park headquarters influenced perceptions of the local communities towards authorized benefits as compared to other categories (Table 2). The perceptions of local communities were more variable and diverse towards authorized benefits than unauthorized ones (Tables 2 and 3).

From the customary benefit category, the most

Table 2. Perceived benefits (externally demanded benefits) by the local communities from the park.

Benefit type	Percentage that responded positively	Across Villages (df = 6)	Across proximity (df = 2)	Settlement duration (df = 3)	Livelihood source (df = 3)
Employment opportunities	15	X^2=22.780 P=0.001**	X^2=12.181 P=0.002**	X^2=1.523 P=0.677	X^2=2.389 P=0.496
Leasing horses	62	X^2=28.829 P=0.000*	X^2=21.591 P=0.000*	X^2=1.681 P=0.641	X^2=0.166 P=0.983
Tourist guide	44	X^2=18.792 P=0.005**	X^2=15.314 P=0.000*	X^2=11.014 P=0.012	X^2=2.428 P=0.489
Infrastructure development	13	X^2=6.035 P=0.419	X^2=3.403 P=0.182	X^2=2.156 P=0.541	X^2=19.113 P=0.000*
Employment by NGOs (EWCP)	37	X^2=17.496 P=0.008**	X^2=9.547 P=0.008**	X^2=1.234 P=0.745	X^2=1.653 P=0.648
Use of park vehicles	38	X^2=46.301 P=0.000*	X^2=41.092 P=0.000*	X^2=3.237 P=0.357	X^2=4.217 P=0.239

*Significant at 0.01 level, **Significant at 0.05 level

Table 3. Perceived benefits (customary benefits) by the local communities from wildlife of the park.

Benefit types	Percentage that responded positively	Across villages (df= 6)	Across proximity (df=2)	Settlement duration (df =3)	Livelihood Source (df =3)
Firewood collection	31	X^2=8.256 P=0.220	X^2=2.495 P=0.287	X^2=0.438 P=0.932	X^2=6.266 P=0.099
Construction materials extraction	15	X^2=8.643 P=0.195	X^2=0.930 P=0.628	X^2=1.234 P=0.745	X^2=5.540 P=0.136
Extraction of non-wood forest products	12	X^2=0.523 P=0.998	X^2=0.619 P=0.734	X^2=2.697 P=0.441	X^2=2.807 P=0.422
Grazing land	74	X^2=5.398 P=0.494	X^2=1.400 P=0.497	X^2=4.540 P=0.209	X^2=0.518 P=0.915
Cultivation land	4	X^2=13.362 P=0.038*	X^2=1.130 P=0.568	X^2=1.064 P=0.786	X^2=3.597 P=0.308
Extraction of fodder	15	X^2=7.180 P=0.305	X^2=0.337 P=0.845	X^2=2.107 P=0.550	X^2=0.488 P=0.921
Extraction of Bush meat	2	X^2=5.440 P=0.489	X^2=0.664 P=0.717	X^2=1.812 P=0.612	X^2=1.338 P=0.720

*Significant at 0.05 level.

frequently cited benefits were the source of grazing land (74%) and fuel wood collection (31%). While the least cited includes extraction of non-wood forest products (12%), land for cultivation (4%) and bush meat extraction (2%). The highest proportion of respondents who cited firewood as important benefit were from Dinsho (47%) and Gofingera (45%) villages, while the least was from Garambadima (15%). Most of the views of local communities on customary benefits were not variable across villages, proximity, settlement duration, and livelihood source, except for cultivation across villages.

Respondents from Zaloabeba, Karare and Gojera villages, which are partly within the park boundary, felt that they get no benefits concerning land for cultivation from the park area, while 11 and 15% of Dinsho and Gofingera residents acknowledged that local communities use land from the park area for cultivation. Dinsho had the highest proportion (32%) of respondents who cited construction material as source of benefit. 83% of the respondents thought that benefits were not fairly and equitably available to the local communities. The same view was held by key-informants that those settlers

Table 4. Perceived conflicts by the local communities.

Types of conflicts	Percentage that responded positively	Across villages (df=6)	Across proximity (df=2)	Settlement duration (df=3)	Livelihood strategy (df=3)
Competition with wild animals	32	X^2=7.604 P=0.269	X^2=2.491 P=0.288	X^2=4.202 P=0.240	X^2=2.708 P=0.439
Disease transmission	38	X^2=28.268 P=0.000*	X^2=3.422 P=0.181	X^2=6.166 P=0.104	X^2=5.639 P=0.131
Predation (depredation)	47	X^2=7.834 P=0.250	X^2=4.580 P=0.101	X^2=2.950 P=0.399	X^2=2.977 P=0.395
Crop damage	71	X^2=8.994 P=0.174	X^2=10.115 P=0.028**	X^2=1.386 P=0.709	X^2=1.273 P=0.736
Resentment due to forceful relocation in the past	84	X^2=31.906 P=0.000*	X^2=12.889 P=0.002**	X^2=1.146 P=0.766	X^2=2.653 P=0.448
Firewood collection restrictions	54	X^2=35.397 P=0.000*	X^2=19.081 P=0.000*	X^2=2.503 P=0.475	X^2=1.389 P=0.708
Construction wood collection restrictions	53	X^2=26.268 P=0.000*	X^2=7.857 P=0.020**	X^2=1.880 P=0.598	X^2=0.374 P=0.946
Restrictions to access roads	39	X^2=20.371 P=0.002*	X^2=9.365 P=0.009**	X^2=0.750 P=0.861	X^2=3.512 P=0.319
Livestock or grazing restrictions	74	X^2=15.645 P=0.016**	X^2=5.236 P=0.073	X^2=1.205 P=0.752	X^2=1.865 P=0.601

*Significant at 0.01 level, **Significant at 0.05 level.

from Dinsho town were more privileged than residents in other villages when it comes to benefits such as employment, leasing horses and serving as tourist guide.

Key informants recommended the benefit types that they thought as direct and would serve common interest of all their members. Their main recommendations were: 1) Free distribution of food grains in times of drought: 2) Financially assist the local communities when they are constructing and restoring religious sites such as mosques; and 3) Subsides, if possible, provide first-aid drugs free of charge to local communities from existing human and vet clinics.

The most frequent cited source of conflict was fear due to forceful relocation experience in the past (84%) from the park area although grazing restrictions (74%) and crop damage (71%) were also commonly cited by residents experiencing conflicts. Those villages very close to the park have significantly felt fear of relocation as the major source of resentment towards the park, particularly all in Gojera and Horasoba villages. The least cited conflicts were grazing competition between wild animals with the domestic stock (32%) and disease transmission from wild animals to domestic stocks (38%). Villages closer to the park area, as revealed from key informants, frequently cited crop damage and livestock depredation as the main conflicts. Warthog and baboons were the main causes of crop damage. Crop damage also occurred by mountain nyala during the evening, especially when the crops, mainly barley, ripened (Table 4).

Village types and proximity to the park headquarters appeared to have influenced more the perceptions of local communities towards most conflict encounters than other group variables (Table 4). On average, 70 and 40% of the respondents felt that forest cover had decreased and land covered by agriculture increased over the past 5 to 10 years, respectively. However, a clear majority (66%) did not believe that their livelihood activities were contributing to decrease in forest cover. This view was more common among recent settlers than medium and long-term settlers (Figure 2). Almost all (98%) the respondents agreed that if the park was left open access, the park's resources (forests and wild animals) would be severely affected.

Views about trends of land size covered by crops differed significantly among different villages (X^2 = 29.061, df = 6, P <0.01) and across proximity (X^2 =15.315, df = 2, & P <0.01). The proportion of respondents that felt big game population have increased over the past 5-10years ranged from 15 (Garambadima-the farthest village) to 74% (in Dinsho town), with the average being 54%. The views were different across villages (x^2 = 15.182, df = 6, P <0.05) and proximity (x^2 = 8.186, df = 2, P <0.05). Similarly, views of respondents on changes of land cover (forests) in the past five to ten years were highly different across proximity (x^2 =15.315, df = 2, P <0.001).

Awareness of local communities on the relationship

between park protection or conservation and continuous flow of streams and rivers were significantly variable across villages (x^2 =13.853, df = 6, P <0.05). The highest number of respondents, who differed on the association of continuous water flow with park protection was recorded from Zaloabeba (57%) followed by Gojera (28%), while the lowest number from Garambadima and Horasoba was 10% each. Garambadima and Horasoba villages have suffered from recurrent drought in recent history more than the other villages. The majority (61%) of the respondents agreed that conservation efforts of the park influenced the amount and quality of water for drinking (both livestock and humans) and irrigation. The highest number (81%) was recorded in Horasoba village while the lowest in Zaloabeba, which is very close to the park. Respondents' perception concerning rainfall, soil productivity and forest cover change were not different. On average, 56 and 61% of the respondents felt that the rainfall and soil productivity decreased in the last five to ten years, respectively.

94% of the respondents felt that BMNP is a heritage site for all Ethiopians and their views were significantly different across villages (x^2 = 16.678, df = 6, P<0.05). All respondents in Dinsho town agreed with the idea that they were beneficiaries of hospitality services to a range of visitors. 79% of the respondents held an inspiration to support the park conservation activities if given the chance. However, almost comparable number (78%) felt that they were alienated or were never consulted on issues that matter to the park development. Views of willingness to support the park were highly significantly different across the villages (x^2 = 48.036, df = 6, P <0.001) and proximity (x^2 = 9.792, df = 2, P<0.01). High proportion (95%) was recorded in Garambadima village agreeing to support while 82% of respondents in Karare disagreed on the idea of supporting the park.

Three quarter (75%) of the respondents across the villages agree with the idea that tourism is good for the regional economy although their views were significantly different across proximity (x^2 = 6.106, df = 2, P<0.05). 83% of respondents from villages relatively closer to the park and 55% from villages far away from the park headquarters agreed with this idea. Positive behavior was observed from the local communities concerning the importance of the park as a centre of recreation.

Nearly three quarter (73%) of the respondents felt that the mountain nyala population size has increased in the past ten years, while 6% stable and 15% have no idea about its trend. Their views were similar across villages, proximity and duration of settlements. The proportion of respondents in livelihood category, felt the increase of the mountain nyala was from small businesses holder (100%), farming/crop cultivation (89%), mixed farming (71%) and livestock rearing (50%). Out of the total respondents, 75% felt that poaching was a common practice, although they did not think it is a threat to the mountain nyala, while 17% considered it as a minor threat and 8% a major threat. 18% of the respondents have encountered dead mountain nyala in their lifetime, and the highest number was recorded in Karare Village (65%), which was very close to the park headquarters, and the lowest in Horasoba (5%). Most respondents assumed that the cause of death was predator. On average, 60% of respondents encountered live mountain nyala on their farmlands and the encounter rates were highly significantly different across villages (x^2 =30.841, df = 6, P <0.05) and proximity (x^2 =11.399, df = 2, P < 0.01). About 64% of the respondents thought that mountain nyala follow daily regular paths while moving and their knowledge were highly significantly different across villages (x^2 = 37.138, df = 6, P <0.001) and proximity (x^2 = 22.554, df = 2, P<0.001). Clear majority (64%) of the respondents recognize daily pattern of movements of mountain nyala in the area.

The proportion of respondents in favor of having high number of mountain nyala in the area ranged from 81 to 94%. Their views were not statistically different across villages (x^2 =3.654, df = 6, P >0.05), proximity (x^2 =0.896, df = 6, P >0.05), duration of settlements (x^2 =2.252, df = 6, P >0.05) and livelihood source (x^2 =0.901, df = 6, P >0.05). However, group discussion with key informants revealed that numbers of mountain nyala were growing and they were concerned about its impact on their agricultural crops.

Traditional and cultural uses of the mountain nyala products such as horns and hides were rarely practiced in the area with only 2% of the respondents having knowledge of such uses. Their knowledge were significantly different across villages (x^2 =55.642, df =6, P <0.05), with the highest number of respondents in Zaloabeba (10%) and Gofingera (5%); and with no record in other villages. About three quarter (77%) of the respondents had views that livestock has no impact on the mountain nyala although their views were significantly different across the villages at 0.01 level (x^2 = 21.418, df = 6, P <0.05) and proximity (x^2 = 8.049, df =2, P >0.05). Almost equal proportion (76%) of them felt that there were no common diseases affecting both the mountain nyala and their livestock, although these were significantly different across villages (x^2=13.987, df = 6, P <0.05) and duration of settlements (x^2 = 9.104, df = 3, P <0.05). However, 61% the respondents acknowledged that mountain nyala were seldom observed feeding on areas overgrazed and often frequented by livestock.

DISCUSSION

Local people negative influences on the park and the mountain nyala that include crop cultivation, deforestation, illegal settlement and livestock grazing were common in the study area. Similar finding was reported in other National Park of Ethiopia (Tewodros and Afework, 2014). Land use practices in the area have

changed considerably in the past 40 years. Expansion of agriculture and subsequent loss of forest cover (mainly *Juniperus/Hagenia* woodlands) in the area have been enormous. The contrast of forest cover change was obvious to a casual observer between scattered trees of *Juniperus* and *Hagenia* in some of the villages, for example Gojera farmlands; and the Sanctuary, which was covered relatively by dense trees of these two species (Hillman, 1988). Unlike the early 1970's, when the local people were predominantly pastoral, at present, the majority of households practice settled agriculture as well as keeping livestock. Principal sources of feed for livestock were from communal land, which includes the park area; hence the park's authority was faced with a challenging task to implement the required measures to conserve wildlife of the park vis-à-vis the prevailing high grazing pressure. The land which otherwise was used for grazing was put under cultivation and this has led to a shortage of grazing land. This was especially the case during the wet season when crops mature in the farmers land and the pressure often mounted on 'unused' land from the park area.

The park was not legally gazetted and accordingly with no clear boundary that makes applying law enforcement a difficult task (BMNP, 2007), and hence these uncertainties seemed to have affected the relationship between the park authority and the local communities. Legitimacy are largely based on the degree of accord with a person's values and beliefs, it may also be expected that personal evaluations of benefits and disadvantages associated with a given management system may be linked to views of legitimacy (Stern, 2008). Such rational evaluations may form a strong basis for individuals' perceptions and attitudes toward the protected areas (Fiallo and Jacobson, 1995; Ajzen, 2001). This basic view of legitimacy, which is largely based on acknowledging of protected areas authorities for reasons of self-interest, has been termed 'pragmatic legitimacy' by Suchman (1995).

Perceptions of legitimacy around protected areas, and therefore voluntary compliance, may also be related to local perceptions of the benefits and disadvantages associated with the existence of the protected area (Stern, 2008). Similarly, this study revealed that conservation in the park heavily relied on voluntary compliance of the local community due to their perceived benefits from the park. Similar finding was noted by (Nielsen, 2003) that if the risk is perceived by local community to be too high in relation to the potential benefits of violating protected areas regulations, then compliance is likely to be enhanced. Ways of achieving voluntary compliance with protected areas regulations have been widely debated (Stern, 2008). There have been many argument for more people-oriented approaches, including stronger emphases on environmental education strategies, integrated conservation and development projects (ICDPs) and community-based natural resource management (CBNRM) (Stern, 2008). Such arguments often advocate the participation and empowerment of local residents in natural resource-based decisions and management processes (Gurung, 1995; Wells and McShane, 2004; Moorman, 2006; Baral et al., 2007). Meanwhile, others have cited failures in such approaches to call for a continued reliance upon more traditional coercive measures, suggesting that relying on voluntary compliance, even in exchange for some benefits, fails to account for people's desires to maximize their take of common resources (Rabinowitz, 1999; Terborgh, 1999.).

The majority of the respondents rear or keep livestock mainly for insurance in time of crop failure. This was a change in attitude of the local communities towards livestock ownership from the widely held attitude in which high numbers of livestock irrespective of quality are mainly kept to signify social status in rural areas than household food security in Ethiopia (Misginaw, 2013). The change in attitude might be influenced by a deteriorating natural environment. For example, the overwhelming majority of Garambadima residents have experienced recurrent droughts in recent years due to poor agricultural practices and insufficient rainfall. They acknowledged that livestock ownership for prestige is something of the past.

Hence, there is good reason for optimism for an intervention related to animal husbandry that focuses on promoting ownership of few quality animals rather than quantity. Nevertheless, the study revealed that the local people still own a lot of animals, which might suggest the need for awareness education that can lead to behavioral change (Tedla, 1995). The local people that were relatively close to the park have higher desire to own more cattle in the future than they have at present. The proximity to grazing lands within the park may partly explain this attitude of having more cattle. The majority of the local communities were dependent on free range grazing as sources of feed for their livestock, and they have also experienced animal feed shortage. The grazing pressure on grassland habitat of the park was undoubtedly clear because virtually no open grazing land was kept aside by the farmer especially during cropping season.

Land use practices in the area have changed considerably in the past 40 years. Expansion of agriculture and subsequent loss of forest cover (mainly *Juniperus/Hagenia* woodlands) in the area have been enormous. The contrast of forest cover change was obvious to a casual observer between scattered trees of *Juniperus* and *Hagenia* in some of the villages, for example Gojera and the Sanctuary, which were used to be covered relatively by dense trees of these two species (Hillman, 1988). Unlike the early 1970's, when the local people were predominantly pastoral, at present, the majority of households practice settled agriculture as well as keeping livestock. Principal sources of feed for live-stock were from communal land, which includes the park

park area; hence the park's authority was faced with a challenging task to implement the required measures to conserve wildlife of the park vis-à-vis the prevailing high livestock grazing pressure. The land which otherwise was used for grazing was put under cultivation and this has led to a shortage of grazing land. This was especially the case during wet season when crops mature in the farm land and the pressure often mounted on 'unused' land from the park area.

The study reveals that the local communities did not consider the park, as it stands, as a source of substantial benefit. Denying people benefits and access from natural resources, people opt to develop negative attitudes and engage in activities that are detrimental to conservation (Ebua et al., 2011). However, they acknowledged the eco-tourism potential of the park because the legal benefits they were getting from the park such as horse lease, employment as tour guide are tourism related. Hence, the local people have a strong belief and hope that the future development of tourism sector of the park could bring them sustained benefits. Kruger (2005) highlighted the importance of ecotourism as a means of generating much needed foreign currency, both locally and nationally, while at the same time providing a strong incentive to manage nature's strongholds in a way that would conserve them. Irrespective of the consent of the park's authority, the study revealed that, the local people were able to extract what they call 'their customary right' such as fuel wood and construction materials from the park area in their day-to-day activities. This customary use was not considered as benefit.

Provisions of tangible benefits and alternative sources of livelihoods to the local communities should be considered as the central theme. Previous studies have shown that socioeconomic benefits affect attitudes of local people toward wildlife (Kellert and Berry, 1987; Gadd, 2005; Naughton-Treves and Treves, 2005; Romanach et al., 2007; Morzillo et al., 2010). Part of the revenue generated from the tourism sector should be available for common needs of the local community. A system should be sought on how to share benefits generated from trophy hunting of mountain nyalain nearby controlled hunting area. In addition, some of the revenue should go to the efforts on the conservation of mountain nyala on the site. The hunting affair was owned by private entrepreneurship with no financial input for the park management. To maximize the tangible benefit that the people are getting, allowing low-impact sustainable use of resources from the park area such as bee keeping and collection of dry fuel wood could be an option. Realizations of tangible benefits to local communities living around protected areas in Africa are curtailed by political and economic regimes that are not accommodative of such provisions (Emerton, 2001). The case of BMNP was not different, since all revenue generated at the park level goes to regional or central government, with nothing left for the park authority to augment such provisions. Equity of benefit distribution that accrued from the park also remained a problem and the overwhelming majority of respondents in this study clearly indicated that benefit access to the park's resources was unfair and unbalanced. Such unfairness must change since some authors like Robinson (2006) argue that conservation of wildlife can only be achieved through proper resource management and by establishing effective governance by allocating resources fairly and equitably.

The utilization of certain resources within a protected area on a sustainable basis could decrease conflicts and nurture positive attitudes of the local people towards wildlife conservation and ultimately encourage them to reduce poaching, timber felling and other consumptive land uses (De Boer and Baquete, 1998; Kruger, 2005). The local people will start to appreciate the significance of the protected area if income from tourism and employment would be made available to them (Nepal, 2002). Studies showed that the attitudes of people towards protected areas are positively influenced by the benefits, which they acquire from the protected areas (Lewis et al., 1990; Saberwal et al., 1994; Fiallo and Jacobson, 1995; Studsrod and Wegge, 1995; Emerton, 2001; Kruger, 2005; Allendorf, 2007). However, if benefits are perceived as small in relation to losses or inequitably distributed, they may not achieve the required positive effect (Homewood et al., 1997). Unfortunately, realization of tangible benefit to the local communities living around protected areas in Africa is curtailed by political will and economic regimes that were not accommodative of such provisions (Emerton, 2001). The case of BMNP was not different.

With regard to conflict, 40 years ago, the memory of infamous relocation, carried out by the then regime, of the people living in Gojera village appeared to be fresh and alive in the minds of the local people. Most residents still fear that one day they will be displaced. Relocation with very limited consultation with the people, has negatively affected the relationship of the park authority with the local people.

Relocation of the local community should not be forceful, as it had been done in the past, which could be counterproductive and would aggravate the existing conflict between the park authority and the local communities. Reducing conflicts between wildlife and people is likely to reduce the negative attitude that many communities have towards wildlife and conservation (Emerton, 2001; Muruthi, 2005; Kideghesho et al., 2007). Relocation should be based on consent of the local communities. Rigorous conservation awareness education and communication coupled with compensation schemes are mandatory before attempting any relocation activities of the local communities from the park area.

The traditional knowledge of the local people concerning change in their surrounding environment such as forest cover, soil and wild animals were enormous. The

majority of them felt that rainfall and soil productivity have decreased in the last five to ten years. However, there seemed to be a gap in awareness on some ecological issues. The majority of these people predominantly from recent settlers did not associate their livelihood activities with dwindling forest cover and also most believe that big game animals were increasing in the park. This could indicate that there would be a need for targeted and concerted environmental awareness education in order to achieve positive change in the perception of the local people. Particular emphasis on awareness education should be given to recent and short-term settlers within the park. The existing awareness education, which was mainly undertaken by the Ethiopian Wolf Conservation Project, was narrow in scope targeting only on the conservation of the Ethiopian Wolf (*Canissimensis*). The park authority should apply such awareness education to target wider issues of wildlife conservation in the Park. Most of the local people were positive to support the conservation activities in the park if they are given the chance, even though they were alienated or never consulted before on issues of the park management and matters that would ultimately affects them. Moreover, the overwhelming majority of the respondents have supported the idea of BMNP as a national heritage for all Ethiopians, which is probably a good indicator of how the local people perceive the importance of the park beyond their immediate use.

The knowledge of the local people about the mountain nyala was diverse. Most were not antagonistic towards having mountain nyala in their vicinity, even though some were concerned about their impact on agricultural crops. Wildlife crop damage was often the major cause of human-wildlife conflict, particularly in situations where the site of farming community border protected areas (Gillingham and Lee, 2003). Malcolm and Evangelista (2002) have noted that mountain nyala are peaceful and do not appear to infringe directly on the lives of many people; and therefore, the antelope is not seen as a competitor. Group discussions revealed that the existence of mountain nyala was tied up to their existence and livestock as well. Surprisingly, some argued that mountain nyala are attracted to the smoke and household rubbish coming out of their house and accordingly they thought that if they are displaced, the same would happen to the animals. Part of their assertion was because mountain nyala often spend the night roaming around the farmers' field. However, the cause of the movement was not related to loving of smoke or people but presumably for search of habitat requirement from the area that were taken by the local communities. The local communities were also concerned about the apparent high population number of mountain nyala. Particularly, they were concerned about crop damage and disease transmission to their livestock. As a measure against these, some suggested culling the mountain nyala population and if possible fencing out the area. Traditional hunting of wild animals for their skins, horns and meat were practiced to a limited extent (Hillman, 1986b).

Conclusions and recommendations

Proximity of settlements to the park and types of villages appeared to have influenced perceptions held by the local people more than the duration of settlements and livelihood sources. The views on perceived benefits and conflicts, forest cover change and ecological variables and local knowledge about the mountain nyala to some extent were diverse across the livelihood source. The overall attitude of the local people towards the park and the mountain nyala conservation seemed positive. However, having positive attitude does not guarantee positive behavior because majority of the local people carry out unchecked exploitation of the park's natural resources.

The results were indicative of the attitudes of the local people. Awareness education to bring positive required behavioural changes among the local communities would be indispensable. Arguably, even if the local communities were allowed to have free access to the park by abolishing restrictions, the sustainability of their livelihood could not be guaranteed in the longer term Hurni and Ludi, (2000).

Settlement and its associated problems could remain as formidable challenge facing the park authority. Re-demarcation of the park boundary is paramount. Particularly, relocation of settlements out of Gojera village should be carried out as a matter of urgency. Resettling the remaining bordering villages like Karare, Horasoba and Zaloabeba at least at 5 km radius away from the park border should also be considered if conservation of the mountain nyala is anticipated. Establishment of a liaison committee including representative from the park staff, local communities and Dinsho town that would serve as a link between the park authority and the local people is paramount. Such committee would oversee issues like natural resources use including benefit sharing, control or regulation of settlements and immigration, control of illegal use of the park's resources and would also assist law enforcement concerning wildlife.

Conflict of interest

The author has not declared any conflict of interest.

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Distribution study of some species of spontaneous Flora in two Saharan Regions of the North-East of Algeria (Ouargla and Ghardaïa)

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The botanical and edaphic inventory investigations of the spontaneous flora distribution in the regions of Ouargla and Ghardaïa revealed the presence of 56 taxa of which 32 were ephemeral and 24 vivacious. The sweeping operation of 6 stations over these two regions showed an abundant richness estimated to 39 species localized mainly in the beds of Wadis and distributed as follows: Reg (19), Sebkha (7), Erg (6) and Hamada (5). The average richness of species was about 4, 83 in the beds of Wadis and 0, 83 in Hamadas. The abundance and dominance of plants varied within the same species from one station to another. In fact, severe climato-edaphic conditions gave rise to isolated life. For example, Chamephytes dominate in dry and moderately humid environments as in the Reg of Hassi Ben Abdellah and Wadi N'sa. However, in humid zones such as the Wadi M'zab, it was therophytes that dominated. In these dry zones, the spontaneous plants were distributed according to their ecological affinities. The position of each species depended on different ecological factors such as dryness, soil and humidity.

Key words: Distribution, spontaneous flora, richness, soil, Sahara.

INTRODUCTION

Knowledge, classification, characterization and conservation of different taxa is a global scientific priority for the assessment and management of biodiversity and conservation (Cotterill, 1995). Efforts to study the flora are very important in the understanding of the great biological traits of plants and their biogeographical distribution (Lavergne et al., 2005). However, biological, taxonomic and ecological aspects of a considerable number of plant species remain unknown (Grubb, 1977; Pyšek et al., 2008).

For those who have not had the opportunity to explore

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the desert bar by hearsay, the idea of the existence of spontaneous flora in the Sahara nevertheless would be strange. A short sojourn is sufficient to catch sight of the arid soil, which nourishes many plants decorated by flowers, sometimes curious sometimes with real beauty (Gubb, 1913). This testimony of such an eminent naturalist is a powerful motivation towards more discoveries of the Saharan flora secrets. The Sahara is the largest desert covering nearly eight million km^2, but also the most expressive and typical regarding its extreme aridity. Otherwise, the desert conditions reach their greatest harshness. The ground sheet vegetation is discontinuous and remarkably irregular. Plants mainly use places where water supply is slightly less unfavorable than elsewhere (Ozenda, 1983). Vegetation in arid areas, particularly that of the Sahara is very sparse, in appearance generally naked and bleak. The trees are rare as they are scattered and herbs are evident for a very short period of the year when conditions become favourable. This Saharan flora is adapted to dry climate and salty soil (Trabut and Mares, 1906). It appears poor if we compare the small number of species that live in this desert to the enormity of the surface that is covers. It includes only 1200 species.

Representing more than two thirds of the Algerian territory, arid and semi-arid regions are natural resources deserving great attention. The preservation of these ecosystems depends on increased knowledge and on the conservation of the biological diversity, especially of wild plants, which have developed specific qualities and adaptations in harmony with the extreme environmental conditions over thousands of years. Taking into account the fact that little information on the biodiversity of native flora in these arid regions of the northern Sahara is available, special attention is paid to the study of the distribution of its natural vegetation. The aim of the present survey was to establish the correlation between vegetation and arid soil and the delimitation of the wild plant distribution. In this region, vegetation has been seriously degraded as a consequence of a long history of desertification, resulting from a combination of factors such as drought, overgrazing and overcutting, such information is crucial for developing strategies, programs or technical guidelines for the conservation and sustainable utilization of natural resources.

MATERIALS AND METHODS

Area presentation

The investigated surface area covers 163.230 km^2. It is located at an average altitude of 157 m, at latitude 32° 45' / 31° 45' North/South and at longitude 5 ° 20 '/ 5 ° 45' East /West. It is a low altitude area lying from 30 to 200 m (Rouvillois – Brigol, 1975; Dubost, 1991). Ouargla and Ghardaia soils are derived from non-gypsum miopliocene clay- quartz sandstone. They consist of quartz sands. The sandy skeleton of the soils studied is very abundant, consisting almost entirely of quartz. The colour becomes less red and the film thickness decreases in high altitudes and especially in dunes. Despite its relative septentrional latitude, the climate is typically hot arid. Average temperatures are high, with absolute maxima in July–August exceeding 50°C, and minima in January ranging from 2 to 9°C (Le Houerou, 1990). However, the temperature rapidly deceases with depth. Because of low cloudiness, the sunlight in the Sahara Desert is relatively strong and has a drying effect by raising the temperature (Ozenda, 2004). Practically, precipitation always occurs as rain characterized by its slight importance; torrential rains are rare. Rains are related to Sudano-Saharan and Saharan meteorological disturbances (Dubief, 1963). Such insufficient Saharan rains are associated with a significant irregularity of rainfall patterns and a considerable interannual variability, which induce more or less lengthy severe droughts (Ozenda, 2004).

Selected stations

According to the Gounot method (1969), six representative area studies were selected. The selection criteria were based on the most distinguishing ecological factors of vegetation, especially the geomorphology and soil. Since that is the case, for salty soils, we chose the Sebkha of Bemendil (05°17'E.; 31°56'N) and the Reg of Hassi Ben Abdellah (05° 27′ E.; 31° 59′ N). The stony soils were represented by Hamada El Atchanne (32° 08' N.; 004°33'E) and finaly sandy soils were represented by Erg Sidi Khouiled (31° 58′ N, 5° 24′ E), Oued M'Zab (32° 23′ N, 4° 12′E) and Oued N'Sa (32° 27′ N, 5° 20′ E) (Figure 1).

Floristic data

Phyto-ecological surveys were conducted on the entire range of the spontaneous flora in the regions of Ouargla and Ghardaia. The sampling procedure took into account the vegetation structure and the floristico-ecological homogeneity criterion was privileged. The samples were collected using the subjective sampling method using and minimum area field technique (Gounot, 1969). This is a method of establishing a list of new species appearing in successive doubling of the surface. It is assumed to reach a surface (n) on which no new species appear. Some authors such as Gounot (1969) and Djebaili (1984) agree that the minimum area of 60 to 100 m2 is sufficiently representative in Mediterranean formations. For arid regions as is the case in the region of Ouargla, largely to offset the absence of certain plant species, we can sample over very large areas, for example from 50 to 1000 m square (Voisin, 1980). The determination of the observed species richness was calculated according to the Ramade method (1984). The total richness (S) is equal to N were n is the total number of species in biota. It is expressed as follows: S = sp1 +sp2+ sp3 + sp4 ..... spn, S: is the total number of species observed, and sp1 +sp2+ sp3+ sp4 ..... + spn: are the species observed.

The Average richness (Sm) is the average number of species recorded at each survey. It is obtained by the following formula: Sm = Σ S / N or S Σ = s_1, s_2, s_3, s_n .....: Sm is the sum of the number of species found for the N reported. N is the total number identified. Furthermore life forms of the recorded species were determined following the Raunkiær classification (Ellenberg and Mueller-Dombois, 1967). The spring season corresponds to the maximum development of floristic diversity especially for annual species; we chose this period to ensure a significant sampling. Also, by choosing a time when perennial species flower, we facilitated their identification (Ozenda, 1983).

Soil data

The floristic survey was systematically accompanied by soil

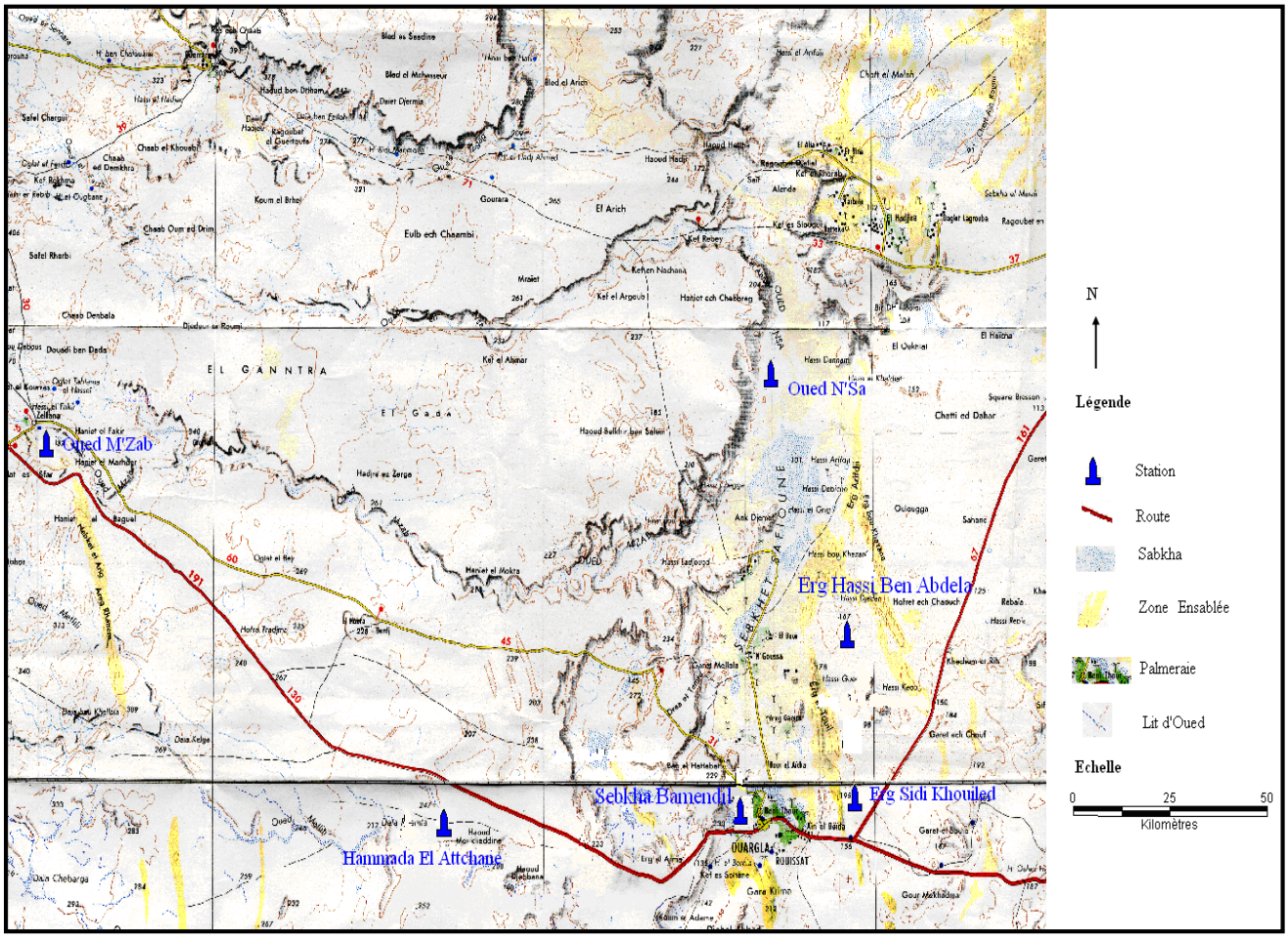

Figure 1. Localization of study in the region of Ouargla and Ghardaia stations. (INCT 1956, modify BAAMEUR, 2012).

profiling. The characterization of soils in biological and physico-chemical terms allowed us to aspects of soil to elucidate the distribution of spontaneous flora in arid environments. Morphological and analytical studies of profiles at each station can give a general idea about the edaphic soil requirements of vegetation in its proper habitat. Six soil sample (0-25 cm) were collected from each site, air dried, thoroughly mixed, and passed through a 2 mm sieve to get rid of gravel. Particle size analysis was carried out using the pipette method, after the destruction of organic matter and the carbonates, and then the particles were dispersed with sodium hexametaphosphate and mechanical agitation (Aubert, 1978), The portion finer than 2 mm was kept for physical and chemical analysis according to Aubert (1978). Electrical conductivity (EC) and soil reaction (pH) were evaluated in 1 :5 soil-water extract using an electric a conductivity meter and a glass electrode pH-metre, respectively. A Bernard calcimetre was used to determine the $CaCo_3$ content, and the atomic - absorption spectrophotometer method for the estimation of the organic matter content. The gypsum was determined according to the method suggested by Coutinet (1965), whose principle is the precipitation of SO^{2-}_4 ions after pretreatment with ammonium carbonates and barium chloride, and the total nitrogen by the Kjeldahl method. This method transforms organic nitrogen into ammonia compounds by concentrated sulfuric acid in the presence of a catalyst. This technique takes place in three stages, the mineralization of organic compounds, distillation and dosage (AFNOR, 1999).

We also prepared a saturation extract from each sample at 25°C to determine its soluble ions (meq/l). Calcium and magnesium were determined by atomic-absorption spectroscopy, and potassium and sodium by flame photometry. The anions were determined by liquid chromatography using DR 2000 equipements. However, the remaining ecological criteria of the stations were slope, altitude, exposure, state of the soil surface and micro-relief.

RESULTS AND DISCUSSION

The identification, classification and the inventory of the spontaneous species of Ouargla and Ghardaia region, using flora Ozenda (1983), have been confirmed in accordance with the Department of Botany of the Graduate School of Agriculture of Algiers. This inventory showed a floristic richness of 56 species belonging to 28 families. It appears that 21 families were represented by only one species (37.5 %) (Table 1). The largest families were Amaranthaceae with 7 species (12.5%), followed by Poaceae, Brassicaceae and Asteraceae (10.71%). However, Zygophyllaceae and Fabaceae represent 5.36%. Euphorbiaceous and Geraniaceae were

Table 1. Distribution of the inventoried spontaneous species according to biotops.

Classes	Families	Species	Biotope									
			Sebkha		Reg		Ham.		Erg		Lit w.	
			V.	A.	V.	A.	V.	A.	V.	A.	V.	A.
Monocotyledons	Poaceae	*Cynodon dactylon*	-	+	-	-	-	-	-	-	-	-
		Danthonia forskahalii	-	-	-	-	-	-	-	-	-	+
		Phragmites communis	+	-	-	-	-	-	-	-	-	-
		Stipagrostis obtusa	-	-	-	+	-	+	-	-	-	+
		Stipagrostis plumosa	-	-	-	-	-	-	-	-	-	+
		Stipagrostis pungens	-	-	+	-	-	-	+	-	+	-
	Liliaceae	*Androcymbium punctatum*	-	-	-	+	-	-	-	-	-	-
	Apocynaceae	*Nerium oleander*	-	-	-	-	-	-	-	-	+	-
	Asclepiadaceae	*Pergularia tomentosa*	-	-	-	-	-	-	-	-	+	-
	Asteraceae	*Bubonium graveolens*	-	-	-	-	-	-	-	-	-	+
		Echinops spinosus	-	-	-	-	-	-	-	-	-	+
		Perralderia coronopifolia	-	-	-	-	-	-	-	-	-	+
		Pulicaria crispa	-	-	-	-	-	-	-	-	+	-
		Rhanterium adpressum	-	-	-	-	-	-	-	-	-	+
		Launaea resedifolia	-	-	-	+	-	-	-	-	-	-
	Brassicaceae	*Farsetia hamiltonii*	-	-	-	-	-	-	-	-	-	+
		Moltkopsis ciliata	-	-	-	+	-	-	-	-	-	-
		Moricandia arvensis	-	-	-	-	-	-	-	-	-	+
		Oudneya africana	-	-	+	-	-	-	-	-	+	-
		Zilla macroptera	-	-	+	-	-	-	-	-	+	-
		Zilla spinosa	-	-	-	-	-	-	-	-	+	-
	Borraginaceae	*Echium pycnanthum*	-	-	-	+	-	-	-	-	-	+
	Capparidaceae	*Cleome amblyocarpa*	-	-	-	-	-	-	-	-	-	+
	Caryophyllaceae	*Paronychia Arabica*	-	-	-	-	-	-	-	-	-	+
Dicotyledons	Amaranthaceae	*Anabasis articulata*	-	-	-	-	-	-	-	-	+	-
		Carduncellus eriocephalus	-	-	-	+	-	-	-	-	-	-
		Cornulaca monacantha	-	-	+	-	-	-	+	-	-	-
		Halocnemum strobilaceum	+	-	-	-	-	-	-	-	-	-
		Salsola vermiculata	-	-	-	-	-	-	-	-	-	+
		Suaeda fruticosa	+	-	-	-	-	-	-	-	-	-
		Traganum nudatum	-	-	-	-	+	-	-	-	-	-
	Cistaceae	*Helianthemum lippii*.	-	-	-	-	-	+	-	-	-	+
	Convolvulaceae	*Convolvulus supinus*	-	-	-	-	-	-	-	-	-	+
	Cucurbitaceae	*Colocynthis vulgaris*	-	-	-	-	-	-	-	-	-	+
	Euphorbiaceae	*Euphorbia guyoniana*	-	-	+	-	-	-	+	-	+	-
		Euphorbia calyptrata	-	-	-	-	-	-	-	-	-	+
	Fabaceae	*Astragalus gombo*	-	-	-	-	-	-	-	-	+	-
		Argyrolobium uniflorum	-	-	-	-	-	-	-	-	-	+
		Retama retam	-	-	+	-	-	-	-	-	-	-
	Frankeniaceae	*Frankenia pluverulenta*	-	-	-	-	-	-	-	-	-	+
	Geraniaceae	*Erodium glaucophyllum*	-	-	-	+	-	+	-	-	-	+
		Monsonia *heliotropioides*	-	-	-	-	-	-	-	-	-	+
	Joncaceae	*Juncus maritimus*	+	-	-	-	-	-	-	-	-	-
	Plantaginaceae	*Plantago ciliata*	-	-	-	+	-	-	-	-	-	+
	Plombaginaceae	*Limonaistrum guyonianum*	-	-	-	-	-	-	-	-	+	-

Ham., Hamada; W, Wadi; V, Vivacious; A, Annual; +, Present; -, Absent.

Table 1. Contd.

Classes	Families	Species	Biotope									
			Sebkha		Reg		Ham.		Erg		Lit w.	
			V.	A.	V.	A.	V.	A.	V.	A.	V.	A.
Dicotyledons	Polygonaceae	*Calligonum comosum*	-	-	+	-	-	-	-	-	+	-
	Resedaceae	*Randonia africana*	-	-	+	-	-	-	+	-	-	-
	Rhamnaceae	*Zizyphus lotus*	-	-	-	-	-	-	-	-	-	-
	Rosaceae	*Neurada procumbens*	-	-	-	-	-	-	-	-	-	-
	Solanaceae	*Datura stramonium*	-	-	-	-	-	-	-	-	-	+
	Tamaricaceae	*Tamarix aphylla*	-	-	-	-	-	-	-	-	-	+
	Thymeliaceae	*Thymelea microphylla*	-	-	-	-	-	-	-	-	-	+
		Fagonia glutinosa	-	-	-	+	-	+	-	-	-	+
	Zygophyllaceae	*Peganum harmala*	-	-	-	-	-	-	-	-	-	+
		Zygophyllum album	+	-	+	-	-	-	+	-	-	-
Saccovulees	Ephedraceae	*Ephedra alata*	-	-	-	-	-	-	-	-	+	-
Total	28	56	6	1	9	10	1	4	6	0	16	23
			7		19		5		6		39	
Frequency		100%	12.5		33.9		8.9		10.7		69.6	

Ham., Hamada; W, Wadi; V, Vivacious; A, Annual; +, Present; -, Absent.

represented by two species per family (3.57%) (Figure 2). OZENDA (1983) noted that Poaceae, Fabaceae and Asteraceae are everywhere dominant families, even in the southern part. Le Houerou (1995) noted 2630 spontaneous species in the arid North African's area; In the Sahara, 1200 species of which only 500 were inventoried by Ozenda (1983) in the Northern Sahara. It should be noted that in the studied area, the natural environment is undergoing degradation due mainly to climate change, overgrazing and poor management of plant genetic resources. Furthermore, for Boumlik (1995) class Saccovulees represented by Ephedra alata is an endangered group.

Concerning the temporal distribution of the spontaneous flora, we distinguish 57.14% were ephemeral and 42.86 % vivacious. The Ephemeral plants, also called "purchases" appear only after the period of rain and execute all their growth cycle before the soil is dry. For Permanent or perennial plants, adaptation puts into Play as-well-as poorly understood physiological phenomena, an assemblage of morphological and anatomical adaptation which mainly give rise to an absorbent system and a reduction in the evaporation surface. The importance of the ephemeral is primarily due to the selected sampling period, which is favourable to their development. However, the unequal distribution between the ephemeral and perennial is also due to the adaptation to drought (Ozenda, 1983). According to UNESCO (1960), herbs appear only for a short period of the year when conditions are favorable, and exhibit permanent morphological changes that enable them to withstand the lack of moisture and long periods of drought.

The different biotopes of the present study, which contain spontaneous species, are classified according to their importance as follows: Wadi beds, Regs, Sebkhas, Ergs and Hamadas (Table 1). These ecologies contain a different floristic richness (Figure 3). The Wadi beds marked by the presence of water contained 39 species which was equivalent to 69.64 % of the total flora in the of different studied biotopes (56 plants)**.** The total richness for the regions Ouargla and Ghardaia was 56 species. 29 species among which 19 are ephemeral and 10 vivacious were located in the Wadi M'zab station. Similarly the maximum values of the average richness with 4.83 species. The total richness of a biocenosis is all the component species (Ramade, 1985). The lowest richness was found in the Hamada el Atchane station with 0.83 (Table 2). Huetz (1970) reported that drought is causing certain poverty in species of spontaneous flora in arid regions, especially in dry areas. Ground cover discontinues because of result either insufficient water in the soil. Low total rainfall prevents water withdrawal by plants in the soil (Mainguet, 1995).

The life-form spectrum of these species was as follows: Chamaephytes are the best-represented species with 22 (39.28%). In the second position came the Therophytes with 19 species (33.92%), the Hemi-cryptophytes (10.71%) and Cryptophyta with six species (10.71%) for each group. Phanerophytes were represented only by three species (5.35%) (Figure 4). The abundance of Théropytes in Wadi M'Zab can be explained by the strong presence of water favourable to the development of annual plants. The different biological forms provide information on growth forms and therefore the response

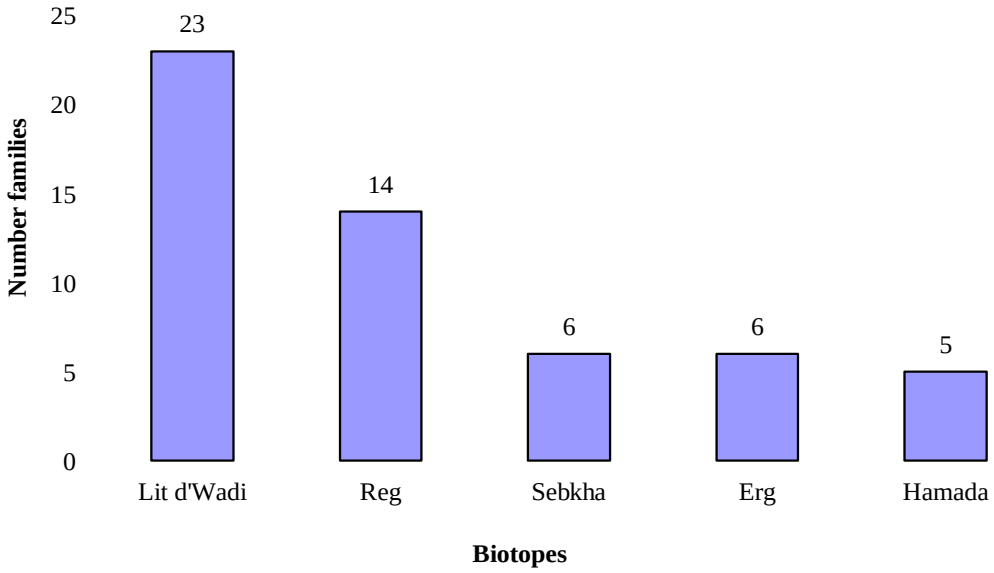

Figure 2. Number of botanical families by biotope.

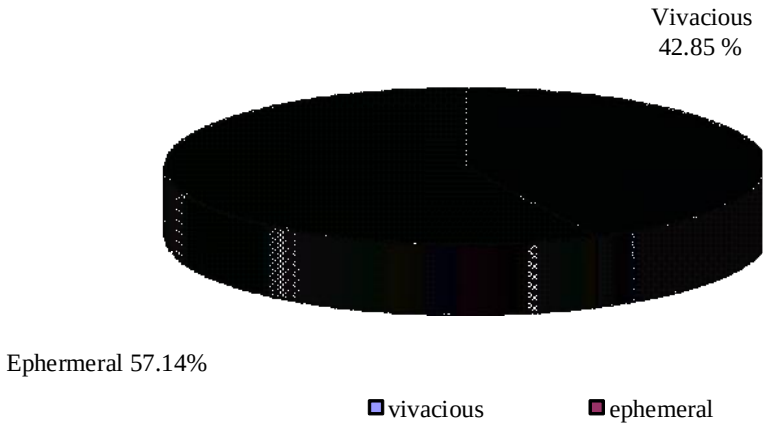

Figure 3. Distribution by category of species in the studied area.

Table 2. Total and average richness of the spontaneous species in the different inventoried sites

Parameter	Sebkha		Reg		Erg		Hamada		Wadi N'Sa		Wadi M'Zab	
	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.	V.	A.
Total richness	6	1	9	10	6	0	1	4	10	10	10	19
	7		19		6		5		20		29	
Average richness	1.16		3.16		1		0.83		3.33		4.83	

V, Vivacious; A, Annual.

of plants to local environmental conditions. The Chamaephytes have a good adaptation to drought (Aidoud, 2005). The same author adds that Therophytes persist while the Hemi- cryptophytes and Phanerophytes increase with rainfall, since this category of plants has low ecological requirements, they colonize various types of environments (Gomaa, 2012). Although the therophytic life form represents the ultimate stage of degradation in xeric habitats, it is often connected to environmental disturbances by grazing (Quezel, 2000). On the scarcity of phanerophytes, Ozenda (1964) reported that the tree layer of the arid zone is very scattered and dispersed in space. And Monod (1973), noted that the characteristic common to all deserts, is the scarcity of trees. This

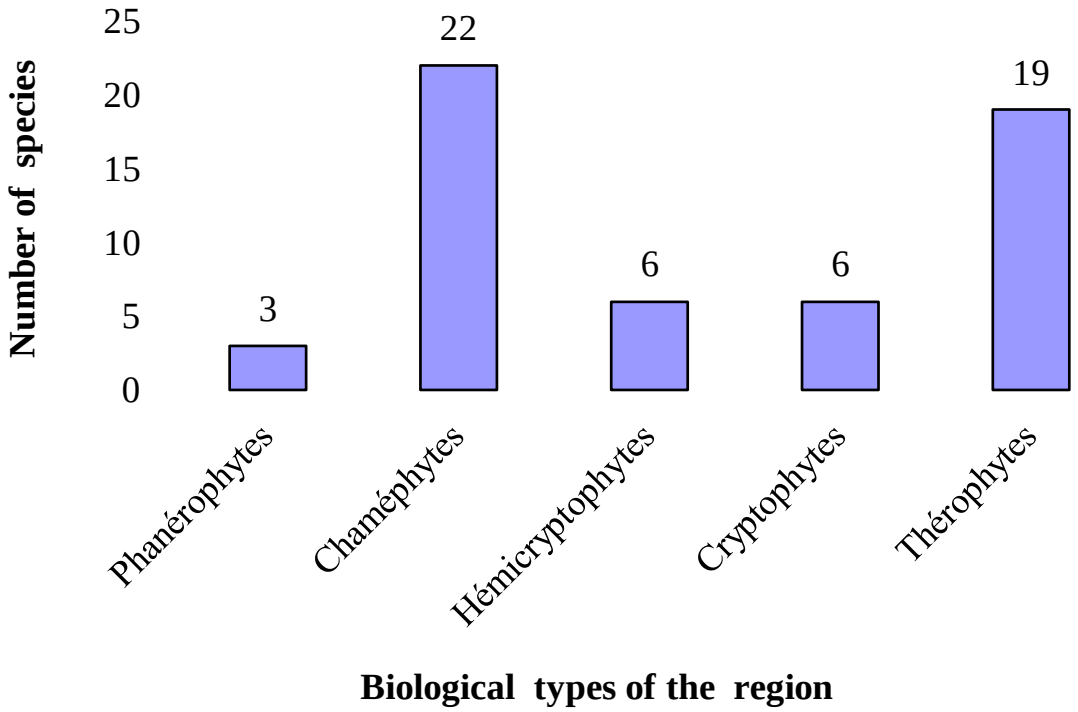

Figure 4. Biological spectrum of spontaneous flora in the studied area.

variation, however, was directly related to the plant cycle and the mode of adaptation of the desert species (Ozenda, 1991), which depends upon the climatic conditions (Gardi, 1973; Poupon, 1980).

The distribution of plant communities has been closely linked to all the physico-chemical characteristics of the soil; these factors appear to play a determing role in the implementation of certain types of plant communities (Lacoste and Salanon, 2001). In the present study the distrIbution of the species according to soil type reveals the presence of four associated sandy groups which are poor in organic matter and whose values ranged from 0.52 to 1.1%. These values reveal a high deficiency in organic matter in soil according to the scale of organic matter defined by Morond (2001), and the nitrogen ranged from 0 to 0.014%. In addition Rouvilois-Brigole (1975) noted that the Ouargla region is characterized by predominantly sandy light soils and particulate structure. It is also characterized by low levels of organic matter, alkaline pH, low biological activity and high salinity (HALILAT, 1993).

The first group represents the Wadi bed and Reg, and is characterized by soil that is endowed by gypsum between 17.3 to 23.3%. In addition the contents of $CaCo_3$ varied from 0.18 to 2.15 revealing that the sampled soils were moderately calcareous, with a notable presence of coarse particles. The Reg of Hassi Ben Abdellah are colonized by the psamophytic species like *Stipagrostis pungens*, *Danthonia forskahalii*, hygrophytic speices such as *Tamarix aphylla*, gypsophytic species like *Oudneya africana* and the Chasmophytic species such as *Zilla spinosa*. Ozenda (1983) indicates that the vegetation in Rreg is loose and poor but well diversified and has high contrast. The Vegetation of the wadi bed of M ‘Zab associated with this soil type is mainly composed of psamophytic speices such as *Stipagrostis pungens*, and gypsophytic speices such as *Randonia africana* but also of halopytic speices such as *Cornulaca monacantha*. Quezel (1965 and 1977) and Teofil Wojterski (1985) notes the presence of 77 species in Wadi M’Zab. Chehma et al. (2005) also demonstrated that the beds of Wadis are the richest and most diverse in species and plant families in the Northern Sahara habitats. Moreover, this area is well known for its richness of medicinal plants (Hadjaidji-Benseghier and Derridj, 2013).

The secend groups, Hamada and the Erg were characterized by soils having relatively neutral pH, whose values varied slightly beteween 7.05 to 7.08 and with average percentage of $CaCo_3$ between 0.67 to 5.23 %, colonized by Traganum nudatum, Stipagrostis obtusa and Fagonia glutinosa, for el Hamada station. These species are already recorded by Ozenda (1983) on the same type of habitat. Similarly Lacoste and Salanon (2001) note that gender Fagonia is particularly characteristic of the vegetation of the northern Sahara Hamada, and psamophytic species like Stipagrostis pungens, Cornulaca monacantha and Euphorbia guyoniana for Erg station . The same species and families obtained are mentioned by Ozenda (1983).

A third group is represented by the Sebkha of Bamendil

Table 3. Soil analysis of the different sites.

Horizons	Settings			Stations studies					
				Seb.	Reg	Erg	Haa.	Wn.	Wm.
Horizon 1	Depth (cm)			0-15	25-Jan	0-15	0-20	0-20	0-25
	Texture			S	S	S	S	S	S
	OM (%)			0.52	1.1	0.17	0.11	0.4	0.6
	Total limestone (%)			10.29	0.18	5.23	0.67	2.8	2.5
	Gypsum (%)			53.28	17.3	35.68	22.27	25.5	23.3
	Total nitrogen (%)			0.007	0.007	0	0.007	0.014	0.014
	$pHe_{1:5}$			6.83	6.81	7.05	7.08	7.08	6.9
	$ECe_{1:5}$ à 25°C (dS/m)			0.56	0.66	0.54	0.1	0.6	3.7
	Ionic balance (cmol / kg)	Anions	Cl^-	1	0.5	0.5	1.5	0.5	5
			SO_4^{--}	2.82	2.56	4.1	1.30	4.53	28.0
			HCO_3^-	0.5	1.5	1	0	0.5	0
			CO_3^{--}	0	0	0	0	0	0
		Cations	Na^+	0.63	0.75	0.84	0.38	0.59	10.46
			K^+	0.15	0.06	0.07	0.03	0.08	0.14
			Mg^{++}	1.5	1.4	1.1	0.2	0.5	6.6
			Ca^{++}	2	1.6	1.4	0.9	2.6	15
			Ca^{++}	0.8	2	0.9	-	13.6	14.5

Haa, Hamada; Wn, Wadi N'sa; Wm, Wadi M'zab; Seb, Sebkha.

whose soil has a sulfated tendency and counterbalanced cationic facies, and whose surface has a magnesium tendency with a conductivity of about 3.74 dS /cm, for Sebkha Hamdi-Aissa and Girard (2000) note that the soil is extremely salty. Reflects its salty aspect by hygrophtic speices such as Phragmites communis, Halocnemum strobilaceum, Sueada fruticosa, Juncus rigidus, and Tamarix aphylla. Khan (1990) indicated that the halophytic and hydro-halophytic plant communities characterize saline habitats, especially in the deserts. And Koull and Chehma (2014) indicated nine perennial species belonging to seven families in the saline wetlands in North East of Algerian Sahara.

Wadi N'Sa station, which forms the fourth group, constituted an intermediate station characterized by a homogeneous ground between the different groups dominated especially by *Ephedra alata*, *Tamarix aphylla* and *Calligonum Comosum* (Table 3). The richness and diversity of beds Wadis beds are mainly due to favourable and soil conditions conducive to the development and maintenance of spontaneous vegetation (Benhouhou et al., 2005). For Djili et al. (2005), there is a relationship between the ecological requirements of the species and medium conditions offered by the stations in the middle region of the Northern Sahara Guerrera East. Plant associations are not distributed randomly and are conditioned by soil, climatic and biotic (Guinochet, 1973). Morphological and analytical study of 6 stations surveyed in the region of Ouargla and Ghardaia, show that they have a texture ranging from sandy to sandy- loam (Table 3) but for Halitim (1980). Over 95% of Algerian arid soils are indeed either limestone or gypsum, or sal - sodium.

Conclusion

The spontaneous vegetation in this arid area, usually adopts a distribution according to edaphisme. No species have a uniform distribution due to the heterogeneity of the environment. Different life forms remain the plant's response to local habitat conditions. It seems that Chamaephytes dominate in dry and moderately humid environments, such as Reg Hassi Ben Abdellah and Wadi N'Sa. On the other hand, in wetlands such as Wadi M'zab, Therophytes dominate. A relationship may exist between a plant and the soil in these regions (Ghardaia and Ouargla) of Northern Sahara Eastern Algeria. Where the water is not a limiting factor, the spontaneous flora is divided into association ranging from Gypso neutrophil - looking for rocky soils to hygro - halophytic vegetation colonizing salty sandy soil. Therefore, this study is a relevant tool in conservation and rehabilitation actions.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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Short Communication

Livestock loss by the spotted hyena (*Crocuta crocuta*) in and around a waste dumping site in Northern Ethiopia

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Human-carnivore conflict is one of the leading constraints to biodiversity conservation efforts. We investigated livestock depredation in two sub districts (Debre-Genet and Debre Tsehay) that were located nearby a waste dump and in two sub districts (Worki-Amba and Dabanow) that were located far from the waste dump. We hypothesized that livestock depredation would be higher in villages located close to waste dumping place where hyenas are more abundant at night than in villages that are located at relatively far places. Structured interview was used for randomly selected 277 respondents from four sub-districts [Debre-Genet (n=30), Debre-Tsehay (n=31), Worki-Amba (n=140) and Dabanow (n=76). A total of 158 (57%) respondents claimed livestock depredation and a total of 535 livestock were lost over the years 2009-2013. In total, livestock depredation was higher in Worki-Amba and Dabanow sub-districts (67% n=360) than in Debre-Genet and Debre Tsehay sub-districts (33% n=175). However, in intensity livestock depredation was higher in the vicinity of waste dump than in sub-districts that were far from the waste dumping site. The findings demonstrate that livestock depredation was higher in the villages that were located close to the waste dumping site. This might be due to the availability of human organic waste in the waste dump.

Key words: Spotted hyena, livestock, depredation, waste dump.

INTRODUCTION

Livestock depredation (Thirgood et al., 2005; Nyahongo, 2007; Dickman, 2008; Kaswamila, 2009) and crop damages (Sitati et al., 2003; Nyahongo, 2007; Kaswamila, 2009) leads to human-carnivore conflict. Human-carnivore conflict is one of the leading constraints to biodiversity conservation efforts (Nyahongo, 2007; Kent, 2011; Lyamuya et al., 2013). Competition between wildlife and people for space and food resources leads to conflict (Thirgood et al., 2005; Dickman, 2008).

The spotted hyena is classified as Lower Risk and total

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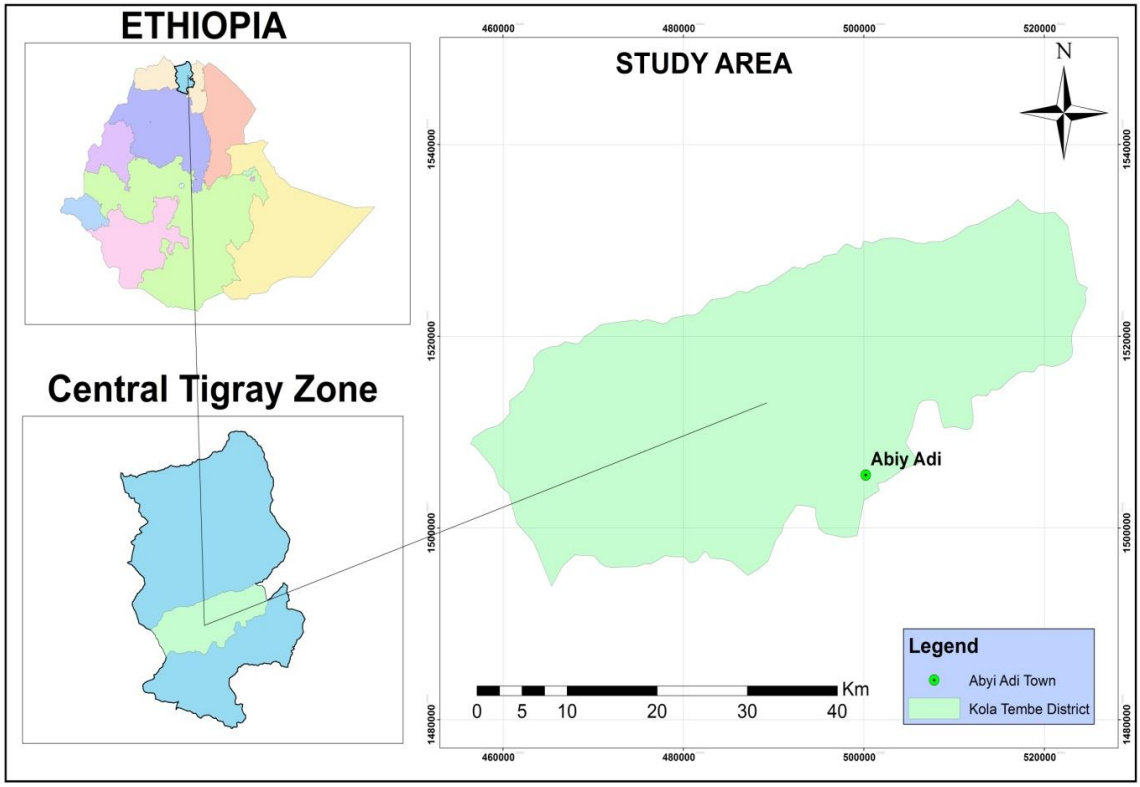

Figure 1. Map of Ethiopia showing Tigray regional state and map of Kola Temben district showing the location of Abyi Adi district.

world population size is estimated between 27,000 and 47,000 individuals (Mills and Hofer, 1998). Spotted hyenas are large (45-80 kg) carnivores that occur throughout sub-Saharan Africa (Mills, 1990; Frank et al., 1995*;* Mills and Harvey, 2001). They show many behaviors that help survive in proximity to humans (Woodroffe, 2000; Sunquist and Sunquist, 2001; Boydston et al., 2003). They breed at any time of the year (Van Meter et al., 2009) and inhabit very wide historical range with relatively stable populations (Kolowski and Holekamp, 2009). The nocturnal and opportunistic foraging behavior makes spotted hyena adaptable to anthropogenic environments (Mills and Hofer, 1998).

In Ethiopia spotted hyena depend largely on anthropogenic food (Gade, 2006; Abay et al., 2011; Yirga et al., 2012) due to the depletion of the natural prey base. Spotted hyenas are reported to be found near open refuse pit during times of food scarcity which might lead to increased livestock depredation in the nearby villages (Kolowski and Holekamp, 2006). We hypothesized that livestock depredation would be higher in villages located close to waste dumping place where hyenas are more abundant at night than in villages that are located at relatively far places. The aim of the study was to investigate livestock depredation at various distance from a waste dump.

Study area

The study was conducted in Kola Tembien district in four sub-districts. The first was Debre-Genet sub-district located approximately 5 km from the waste dumping site of Abyi-Adi town. Debre-Genet has a total of 409 households and 4867 livestock, respectively and is located at 1500 m.a.s.l. The second was Debre-Tsehay sub-district located approximately 6 km from the waste dumping site. Debre-Tsehay sub-district has 422 households and 16,561 livestock, respectively and is located at 1700 m.a.s.l. The third was Worki-Amba sub-district located approximately 18 km from the waste dumping site.

Worki-Amba sub-district has 1,907 households and 13,358 livestock, respectively and is located between 1500-1600 m.a.s.l. The last was Dabanow sub-district located approximately 22 km from the waste dumping site. Dabanow sub-district has 1,035 households and 18,164 livestock, respectively and is located at 1650 m.a.s.l (Figure 1). The rainfall is characterized by one main rainy season between June and September and small rain between March and May. The average annual rainfall is 532 mm and the mean minimum temperature ranges from 12.9 to 14.2°C, with the mean maximum being between 26.7 to 32.6°C. The vegetation of the

Table 1. Estimated economic loss over the last five years (n=277) caused by spotted hyena around waste dumping (Debre-Genet, and Debre-Tsehay) and locations away from the waste dumping site (Worki-Amba and Dabanow) districts in northern Ethiopia in 2013.

Species	Debre-Genet and Debre-Tsehay		Worki-Amba and Dabanow		Estimated economic loss	
	Stock	Depredation	Stock	Depredation	Debre-Genet and Debre-Tsehay	Worki-Amba band Dabanow
Sheep	359	54	1258	93	37,800	65,100
Goat	736	80	2166	154	64,000	123,200
Cattle	211	5	701	41	18,335	150,347
Donkey	68	30	198	64	38,010	81,088
Dog	55	6	142	8	0	0
Cat	28	0	95	0	0	0
Poultry	248	0	298	0	0	0
Total	1705	175	4855	360	158,145	419,735

study area is dominated by *Acacia abisynica* and *Acacia etbaica* trees (Bureau of Agricultural and Natural Resources development, unpublished data). Chronic food insecurity characterizes the study districts, and the farmers depend on subsistence agriculture. The main crops cultivated in the area are sorghum (*Sorghum halepense*), teff (*Eragrostis tef*), maize (*Zea mays*), finger millet (*Eleusine coracana*), wheat (*Triticum*) and legumes (*Fabaceae*). In addition livestock farming is also a common practice especially cattle and goats. Abyi Adi town has one waste dumping site which is located approximately 1 km south west of the town, and has an area of 150 x 100 m.

METHODOLOGY

A total of 277 respondents from four sub-districts (Debre-Genet (n=30), Debre-Tsehay (n=31), Worki-Amba (n=140) and Dabanow (n=76) were randomly selected for a structured interview. For random selection, households were listed and sample respondents were drawn from the list. Debre-Genet and Debre Tsehay sub-districts were located nearby the waste dumping site (< 6 km) whereas Worki-Amba and Dabanow were located relatively at far distance from the waste dumping site (>=18) and were selected with the help of extension workers of the area. Structured interview was used as data gathering instrument. And socio demographic characteristics of respondents, livestock owned, livestock lost, sex, age, depredation in time and palace was recorded. To estimate average costs of livestock lost, average current market price was collected from local livestock traders.

RESULTS AND DISCUSSION

Livestock and economic losses

A total of 158 (57%) respondents claimed livestock depredation and a total of 535 livestock were lost over the years 2009-2013. In total, livestock depredation was higher in Worki-Amba and Dabanow sub-districts (67% n=360) than in Debre-Genet and Debre Tsehay sub-districts (33 % n=175). However, in intensity livestock depredation was higher in the vicinity of waste dump than in sub-districts that were far from the waste dumping site (Table 1). The average annual livestock depredation in Debre-Genet and Debre Tsehay sub districts was 35 and in Worki-Amba and Dabanow sub-districts was 72. The average annual depredations per stock were approximately 2% and 1.5% in Debre-Genet and Debre -Tsehay as well as in Worki-Amba and Dabanow sub districts, respectively.

Approximately US$ 30,415 was lost: US$ 8323 in Debre-Genet and Debre –Tsehay sub districts and US$ 22,091 in Worki-Amba and Dabanow sub districts. The average annual livestock losses per households were approximately US$ 27 and US$ 21 in Debre-Genet and Debre-Tsehay as well as in Worki-Amba and Dabanow sub districts, respectively.

Livestock depredation by the spotted hyena was relatively high in intensity in the villages that were located close to waste dumping site. This might be linked with the presence of spotted hyena in the waste dumps attracted by human organic waste. Spotted hyenas are known to concentrate around urban waste dumps at night in northern Ethiopia due to the presence of human organic waste.

Spotted hyena abundance was significantly higher at the garbage dumps than in other open urban areas at night in northern Ethiopia (Yirga et al., unpublished data). The relative higher abundance of spotted hyena in around waste dumping areas might lead to relatively higher livestock depredation in the villages around. In human-dominated landscapes carrying capacity for predators is associated with abundance and availability of human organic waste (Boitani and Powell, 2012).

Human–spotted hyena conflict is a common problem across Africa (Ogada et al., 2003; Patterson et al., 2004; Kolowski and Holekamp, 2006; Holmern et al., 2007).

However, the problem is worse in other countries of Africa than Ethiopia where depredation of livestock by spotted hyenas is tolerable and is relatively low (Abay et al., 2011; Yirga et al., 2013). Livestock depredation is remarkably higher in other parts of Africa (Holmern et al., 2007; Kissui, 2008), however, even small livestock depredation in the study area could be considerable since food insecurity and poverty is severe in the area.

In conclusion livestock depredation was high in intensity in the villages that were located close to the waste dumps than in villages located further away from the waste dumps. This might be linked with the availability of scabengable food that attract spotted hyena to the waste dups.

Conflict of interests

The author(s) have not declared any conflict of interests.

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