The Importance, Cause and Effect of Bushmeat Hunting in the Udzungwa Mountains, Tanzania: Implications for Community Based Wildlife Management

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Abstract: *Community Based Wildlife Management (CBWM) has been suggested as a conservation strategy in response to bushmeat hunting in the Udzungwa Mountains of the globally important Eastern Arc biodiversity hotspot. The feasibility of CBWM based on meat cropping was therefore evaluated in New Dabaga/Ulangambi Forest Reserve (NDUFR), which is known to be under pressure. Comparison of relative wildlife densities with an area subject to only low hunting pressure indicate that most relevant populations are severely depleted (Cephalophus monticola, harveyi and spadix, Potamochoerus larvatus) and hence that there is no resource basis for sustainable harvesting in NDUFR. Records of catch from hunters in the villages surrounding NDUFR reveal that bushmeat is of relatively little importance in terms of frequency of consumption and recommended daily amount of protein to a low proportion of the population. Variations between villages furthermore indicate that proximity to NDUFR and secondarily population size is positively correlated with hunting intensity and depletion of wildlife. A comparison of hunters and non-hunters in various measures of wealth suggest that the causes of hunting are connected with poverty and low dietary standards. An estimation of maximum sustainable harvest in NDUFR, however, reveal that CBWM has a very low capacity to alleviate the cause of hunting, maintain the communities interest and offset the opportunity costs of conservation. The results therefore suggest that conservation efforts in NDUFR should focus on protecting wildlife against exploitation instead of encouraging use and dependence through CBWM. Supporting efforts should attempt to facilitate a complete shift to domestic sources of meat, by increasing the number of domestic animals in the poorest part of the population.*

Introduction

Hunting of wildlife for food (i.e. bushmeat hunting) is today considered a significant threat to conservation of wildlife diversity in tropical forest (Robinson et al. 1999; Milner-Gulland & Bennett 2003). Particularly in Africa the available information indicates that hunting is often not sustainable and wildlife populations have shown consistent declines or become locally extirpated (see Robinson & Bennett 2000).

Tropical forests have traditionally been an essential source of protein in Africa (Asibey 1974). In Tanzania, bushmeat is becoming increasingly important for maintaining standards of living, as a source of protein and cash income (Barnet 2000). Illegal bushmeat trade is therefore developing fast in urban areas and is beginning to drive demand (Milledge & Barnet 2000). Hence, unless bushmeat hunting becomes managed within sustainable limits, it will be an increasing threat to conservation of wildlife as human populations continue to grow[1]. Ultimately it may lead to the empty forest described by Redford (1992) with adverse consequences to the livelihood of rural households dependent on these resources. Furthermore, because many of the species targeted by bushmeat hunting are highly frugivorous, depletion of these populations may have adverse effects on forest regeneration and long-term development (Redford 1992).

Much current conservation planning in response to this problem rests on the philosophy of Integrated Conservation-Development Projects (ICDPs), referred to as Community Based Wildlife Management (CBWM) in the case of wildlife. The concept originates from the idea that the long-term survival of wildlife depends on the goodwill and cooperation of the people who live adjacent to wildlife areas (Brandon & Wells 1992). CBWM therefore aims to provide incentives for conservation by ensuring that adjacent communities receive tangible economic benefits from the continued future presence or exploitation of wildlife (Gibson & Marks 1995; Barrett & Arcese 1995; Songorwa 1999). The legal basis is attained

[1] Harvesting of a population is sustainable when the rate of extraction does not exceed the population's rate of increase. This definition is, however, irrespective of population density and it is therefore suggested to include considerations to ensure that the population is not reduced by hunting to levels at which the species is vulnerable to local extinction or where ecosystem function is affected (Robinson & Redford 1991; Bennett & Robinson 2000).

through devolving of property rights to the communities, which is often described as essential for successful conservation (Songorwa 1999). Development efforts and economic activities that provide alternatives to unsustainable resource exploitation are furthermore often financially supported in order to encourage local support (Brandon & Wells 1992). CBWM thereby aspires to stop illegal hunting by providing development and economic opportunities that are linked to wildlife, and by empowering the communities to manage and protect this resource (Gibson & Marks 1995). In many locations and particularly tropical forests, the demand and feasibility of tourism and trophy hunting are low (Wilkie & Carpenter 1999 a & b) and the only benefit available from wildlife will therefore be through meat cropping.

Numerous CBWM programs are currently under way in tropical African forests and the new wildlife policy of Tanzania (MNRT 1998) also favors the CBWM approach for conservation of wildlife outside the limited area of parks. The Danish funded MEMA project has therefore been supporting the appropriate authorities in developing and testing participatory management approaches in the forest reserves of the Udzungwa Mts. The Udzungwa Mts are a component of the globally important Eastern Arc biodiversity hotspot, which is unique in having the highest ratio of endemic plant and animal species to area of any of the 25 hotspots worldwide (Myers et al. 2000).

Substantial criticism has, however, been directed against the anthropogenic assumptions underlying the CBWM approach (Gibson & Marks 1995; Noss 1997; Oates 1999; Hackle 1999; Songorwa 1999) and against the inherent concept of sustainable use (Robinson 1993; Ludwig et al. 1993; Kremen et al. 1994; Barrett & Arcese 1995; Struhsaker 1998). There is thus reason for skepticism about the approach and particularly about its performance in relation to tropical forests in densely populated fertile highlands.

This paper therefore aims to evaluate the feasibility of CBWM as a strategy to conservation of wildlife in the Udzungwa Mts of Tanzania. The paper is based on a case study in the New Dabaga/Ulangambi Forest Reserve (NDUFR), which is known to be under pressure from exploitation (Topp-Jørgensen & Pedersen unpubl). The evaluation will specifically consider whether CBWM based on meat cropping in NDUFR can provide tangible benefits to the surrounding communities in consideration of relevant biological constraints. An assessment of the status of animal populations in NDUFR is therefore conducted through a comparison with the West Kilombero Scarp Forest Reserve (WKSFR), which is subject to only low hunting pressure. An assessment of the importance and causes of the illegal bushmeat hunting is furthermore conducted to support the evaluation of the feasibility of CBWM in NDUFR.

Study area

NDUFR and WKSFR are situated at approximately 40-60 km's distance in the Udzungwa Mts and were presumably connected in recent historical time (Dinesen et al. 2001). The two forest reserves are located in the same general habitat of montane and upper montane forest (Lovett

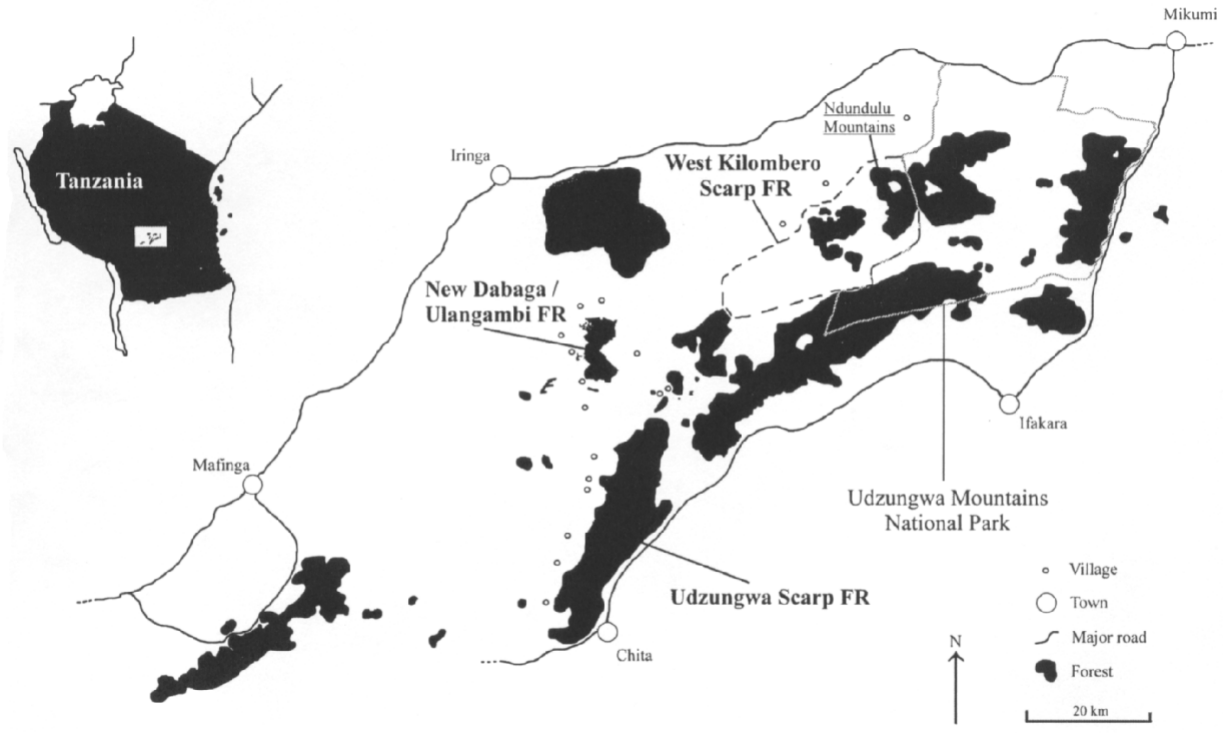

Fig. 1. Distribution of forest reserves in the Udzungwa Mountains. Adapted from Moyer (1993).

1993) and previous research supports the comparability in terms of habitat quality (Topp-Jørgensen & Pedersen unpubl). They are furthermore exposed to similar rainfall (1500-2000 mm per year) and temperature regimes (10-27°C) (Lovett & Pócs 1993). Elevation ranges vary from 1740-2100 and 1420-2570 m. and size of forested area is 37 and 305 km^2 in NDUFR and WKSFR respectively.

NDUFR (35º54'-35º57'E; 8º01'-8º06'S) is situated 45 km southeast of the regional capital, Iringa. Six villages surround the forest reserve connected by a well-established infrastructure on the western side. Agriculture and plantations occur right up to the edge of the forest. Subsistence agriculture is the main economic activity in the area. Other economic activities include timber harvesting, small-scale cash crop and livestock production and trade. Logging took place in the forest reserve in the 1970's and 1980's but has now ceased (Dinesen et al. 2001). The predominant threats to the reserve therefore now originate from the large surrounding human population. Particularly a high level of hunting intensity inside the forest reserve (32.6 traps/km^2) has been emphasized in explaining the low species diversity and abundance of mammals (Topp-Jørgensen & Pedersen unpubl). NDUFR has, despite these circumstances been categorized as a forest reserve of second priority for conservation of threatened species in the Udzungwa Mts, because of the presence of the IUCN vulnerable listed Udzungwa red colobus (*Procolobus gordonorum*) and Abbot's duiker (*Cephalophus spadix*) (Dinesen et al. 2001).

WKSFR (36º05'-36º33'E; 7º38'-8º17'S) is located 80 km east of Iringa. Road access is rudimentary and the area is remote and sparsely populated with only three villages at some distance from the forest reserve. WKSFR consists of three forest fragments, one of which is continuous with a large fragment in the Udzungwa Mts National Park. Only very low levels of logging have occurred and there is little evidence of human disturbance (Topp-Jørgensen et al. 2001). WKSFR contains a large mammal assemblage rich in species and has been assigned first priority in conservation of biodiversity in the Udzungwa Mts, due to the largest overlap of threatened and endemic species (Dinesen et al. 2001).

Conceptual Framework

The use of WKSFR was necessary in the absence of a suitable completely hunting free place in the Udzungwa Mts. No signs of past or present use of traps or snares have, however, been observed inside the forests (Topp-Jørgensen et al. 2001; this study). Hunting small forest ungulates and other small terrestrial forest mammals with traditional weapons and firearms is furthermore difficult (Bodmer et al. 1988). The hunting intensity is therefore assumed to be low and restricted to forest edges and preferred large species that are not present in NDUFR. Selecting survey areas deep inside the forests and as far from human settlements as possible furthermore reduced the potential effect on wildlife populations of hunting in proximity of the villages. It is therefore assumed that there is no adverse effect of hunting on populations of smaller species in WKSFR relevant to the comparison in the objective of this study and that these populations consequently are at carrying capacity (*K*). It is also assumed that population densities in WKSFR are representative of potential densities in NDUFR through equal habitat quality and that hunting therefore is the main reason for observed differences. These assumptions may not be entirely justifiable due to differences between locations in size and logging history and the implications will be considered in the discussion.

This study concentrate on terrestrial animals which presumably are most exposed to hunting in NDUFR considering the wide use of snares and traps. Spoors were used as measures of densities and by counting burrows and scats it is assumed that the observed relative densities are proportional to the actual densities. Compared species include: Giant pouched rat (*Cricetomys gambianus*), hyraxes (*Hyracoidea spp.*), Suni (*Neotragus moschatus*), Blue duiker (*Cephalophus monticola*), Harvey's duiker (*C. harveyi*), Abbot's duiker and Bush pig (*Potamochoerus larvatus*).

Methods

Line transect sampling (Burnham et al. 1980) was used to estimate relative densities. The surveys were conducted in the dry season from July to late October 2001. Procedures and assumptions relevant to the estimation of densities of immotile objects (Buckland et al. 1993) were observed by moving slowly (70-175 m/hour) along transect lines, measuring the perpendicular distance to observed objects with a measure tape and by optimizing search effort to the detection of objects in the vicinity of the line.

Duikers usually deposit pellets in discrete groups, and Blue, Harvey's and Abbot's duiker pellets were easily distinguishable by size and shape and thus categorized (see Bowland & Perrin 1994). No attempts were made to distinguish between pellets of Blue duiker and Suni that hereafter are referred to collectively as Blue duikers. Only active Giant pouched rat burrows characterized by uncovered trails and entrance holes, was included and the distance from the estimated center of the burrow to the transect line was recorded. Observations from individual transects in the same location were combined, truncated at 5% and histograms of perpendicular distance frequency classes were constructed to determine the relative density of relevant species using the method of Whiteside et al. (1988).

Information regarding hunting was obtained directly from cooperating hunters in the villages surrounding NDUFR. Hunters were approached through the aid of a local assistant and their confidence and cooperation were gradually attained. A sequence of three questionnaires in Kiswahili was applied to obtain the relevant information through a combination of fixed-response and open-ended

questions. Questions obtained information regarding size of household, size of shamba, number of domestic animals, typical frequency of meals containing meat of various types, methods of hunting, species and number of animals caught etc. More precise records of catch were obtained through short weekly interviews in all villages except Isele from late August 2001 to late January 2002. The interviews recorded caught and sold animals and number of traps used on a weekly basis, which is assumed to allow precise recall due to the low catch. Only animals caught inside or on the edge of the forest were recorded. Comparison of the number of animals caught according to the interviews and the questionnaires enable an evaluation of the consistency of individual hunters' statements. This aspect is considered a measure of reliability in view of the illegal nature of hunting in NDUFR. The total number of people hunting in NDUFR, cooperating or otherwise, was determined through the local knowledge of the cooperating hunters in the surrounding villages.

A comparison of the economic status of hunters and non-hunters was conducted in Kidabaga, which is the second largest of the villages surrounding NDUFR. A random sample of 60 non-hunting male villagers was drawn from the public register. Hunters were removed from the sample through the knowledge about their identity. The non-hunters were presented with a questionnaire in Kiswahili matching information obtained from the hunters. Wealth ranking (IIED 1989) was applied to assess the affluence of hunters in comparison to non-hunters in the opinion of their fellow villagers. A random sample of 67 males was drawn for this purpose following the described procedure. Their names and the names of the hunters (n=33) were written on slips of paper without distinction between the two groups and the cooperating non-hunters were instructed to individually sort people into the three consecutive categories: wealthy, poor and very poor. The category poor was defined as normal or neutral based on conversations with participants. The frequency of which hunters and non-hunters were ranked in the three categories was compared. In all comparisons the hypothesis of no significant difference were tested.

A standardized census of the population was conducted through the cooperation of the village boards. Measures of distance from the villages to NDUFR were obtained from maps in scale 1:50,000. Statistical tests were performed with the Systat 10.2 statistical software, applying the parametric Pearson product moment in correlation test.

Results

A total of 19.40 and 11.05 km were surveyed, divided on 5 and 4 transects in NDUFR and WKSFR respectively. Comparison of relative densities (Tab. 1) between the two locations indicate that populations of Blue and Harvey's duikers in NDUFR are reduced to densities of less than 10% of hunting free densities. Bush pig and Abbot's duiker in NDUFR appear to be severely depleted and potentially extirpated respectively, compared to the densities observed in WKSFR. No hyrax latrines were observes in NDUFR. Potential differences in species composition (*Heterohyrax brucei* vs. *Dendrohyrax validus*) (Topp-Jørgensen et al. 2001), however, confound comparison between locations and hyrax was therefore excluded from further considerations. The density of Giant pouched rat in NDUFR appears to exceed that in WKSFR.

A total of 180 active hunters were identified and 135 of them choose to cooperate (Tab. 2). 97 hunters replied all questionnaires and were interviewed consistently every week to obtain records of catch. All these key informers hunted continuously during the recording period. The hunting intensity of the remaining cooperating and the non-cooperating hunters cannot be quantified. Only unselective snares and traps permanently set and checked at intervals of 1-2 days were used for hunting in NDUFR. On average 10% (95% CI ±9) of the animals caught (n=901) by the hunters (n=64) were sold and those that did trade bushmeat (n=23) on average sold 20% (95% CI ±14) of their catch. The proportions sold in terms of biomass are on average 19% (95% CI ±18) and 33% (95% CI ±25) respectively, indicating that primarily larger animals were sold. The average price obtained from sale of bushmeat of 0.46$ per kg (95% CI ±114) (n=95 calculated

Tab. 1. Estimation of density of duiker and Bush pig scat, hyrax toilets and Giant pouched rat burrows in NDUFR and WKSFR through the method of Whiteside et al. (1988). 19.4 and 11.05 km transect were surveyed in NDUFR and WKSFR respectively.

Location	Species	Fall-off distance (m)	Total number of obs. (N_t)	Obs. within fall-off (Nt)	Effective sighting distance (m)	Area surveyed (km^2)	Density of objects (No/km^2)
NDUFR	Blue duiker	7	196	180	7.62	0.2957	663
	Harvey's duiker	7	187	170	7.70	0.2988	626
	Abbot's duiker		0				(a)
	Bush pig		5				(a)
	Hyrax		0				(a)
	Giant pouched rat	4	119	85	5.60	0.2173	548
WKSFR	Blue duiker	7	1640	1524	7.53	0.1665	9851
	Harvey's duiker	9	1412	1369	9.28	0.2051	6883
	Abbot's duiker	8	243	242	8.03	0.1775	1369
	Bush pig	12	176	176	12.00	0.2652	664
	Hyrax	4	48	41	4.68	0.1035	464
	Giant pouched rat	4	23	18	5.11	0.1130	204

(a): Inadequate sample size prevents estimation of density.

Tab. 2. Number of hunters and key informers in the villages surrounding NDUFR. Presented are also the combined number of days that recording of catch were obtained from the key informers and the accumulated number of trap nights defined as the number of active snares and traps per day.

Village	Total hunter	Key informers	Recording days	Trap nights
Magome	32	19	2075	51596
Kidabaga	48	23	3406	56345
Ilamba	31	18	2303	41263
Lusinga	21	18	2083	66963
Lulanzi	24	19	2049	83485
Isele	24	(a)	(a)	(a)

(a): There are per definition no key informers in Isele because no records of catch were obtained.

Tab. 3. Estimated total annual harvest by the key informers in the villages surrounding NDUFR based on extrapolation of the average catch. Presented are also species average weight obtained from the litterature (see references in Nielsen 2004).

Species	Common name	Weight (kg)	Magome	Kidabaga	Ilamba	Lusinga	Lulanzi
Cercopithecus mitis	Syke's monkey	5	0	2	6	0	156
Cercopithecus aethiops	Vervet monkey	5.75	3	0	0	38	88
Galagoides spp.	Galago spp.	1.1	3	5	23	0	0
Rhynchocyon spp.	Elephant Shrew spp.	0.4	33	39	97	580	254
Protoxerini spp.	Squirrel spp.	0.3	3	7	29	0	0
Cricetomys gambianus	Giant pouched rat	1.2	207	57	208	312	305
Thryonomys spp.	Cane rat spp.	6.6	7	0	9	0	298
Mustelidae spp.	Weasel spp.	0.29	0	5	0	0	7
Genetta spp.	Genet spp.	2.75	0	2	14	0	74
Hyracoidea spp.	Hyrax spp.	2.75	237	49	154	1009	250
Potamochoerus larvatus	Bush pig	61	7	0	0	3	20
Cephalophus monticola	Blue duiker	5	37	22	26	0	58
Cephalophus harveyi	Harvey's duiker	14.5	50	0	0	35	44
Aves spp.	Birds spp.	0.23	3	0	157	0	464

from species average weights Tab. 3) furthermore appears to be low compared to the standard price of 1$ per kg beef (1000 TSH was in 2001 equal to approximately 1$.).

Bushmeat was on average consumed in 22% (95% CI ±3.1) of the meat-containing meals of the cooperating hunters (n=125). The annual catch (Tab. 3) was estimated by extrapolation from the average annual harvest of the key informers. The average annual harvest of a key informer was estimated by dividing the combined catch of the key informers in the recording period, with the accumulated recording days in the sample and converting to one year (Tab. 2). The amount of meat available for consumption was calculated from species average weights (Tab. 3) after subtracting the inedible proportion. Only approximately 65% of the live weight of animals is edible meat (Hill & Hawkes 1983) and 17% of all animals caught (n=641), estimated to 11% of the biomass, were rotten or scavenged upon and hence inedible. The amount of meat available per capita in key informers' households and to non-hunters through purchase was determined from information on household size and the population count respectively (Tab. 4). Sales rates were assumed to be similar to the key informers in the recording period. The contribution of bushmeat to the diet was hereafter estimated assuming a recommended daily amount (RDA) of protein of 53g per capita (Khan & Al-Kanhal 1998) and that meat consists of 29.4% (95% CI ±12.7) protein (Ajayi 1978; Asibey 1987). The results indicate that bushmeat provides on average 16.1% (95% CI ±13) of the RDA of protein in the key informers households. The amount available to non-hunters through purchase is equivalent to 0.3% (95% CI ±0.3) of the RDA of protein per capita.

Variation in the importance of bushmeat between villages in terms of frequency of consumption was positively correlated with the size of the average annual catch per key informer in number (r_5=0.945 P<0.05) and biomass (r_5=0.940 P<0.05). The average annual catch was negatively correlated with the number of hunters in the village (r_5=-0.894, P<0.05). This indicates that profits become dissipated where a large number of hunters are present. Moreover, the extrapolated annual catch of all the hunters in a village combined was also negatively correlated with the number of hunters in the village (r_5=-0.913, P<0.05). Average catch per unit effort, in terms of number of animals per trap-night (Tab. 2 and 3), was furthermore negatively correlated with the number of hunters in the village (r_5=-0.957, P<0.05). It is, however, not possible to test for village-level differences in wildlife availability. Hence, although variation in effort, hunter skills and trap efficiency cannot be excluded, the results indicate that wildlife populations in NDUFR have become depleted through time in the vicinity of villages where there are many hunters.

The number of hunters in a village was negatively correlated with the distance from the center of the village to the boundary of NDUFR after reciprocal transformation (r_6=0.873 P<0.05) (Tab. 4). The distance to the forest thus reduces the intensity of exploitation in terms of number of hunters in a village. The number of

Tab. 4. Relevant population meassures from the 2001 population census. Presented in brackets are also the distance from the centre of villages to the border of NDUFR.

Village	Distance from NDUFR (km)	Number of families	Total population	Male adults (>18)
Magome	14	383	1671	368
Kidabaga	1.5	509	2562	525
Illamba	4.5	209	1061	257
Illusinga	7.5	275	1376	284
Lulanzi	9	542	2566	574
Isele	11	493	1996	482

Tab. 5. Significant differences between hunter and non-hunter households in number of adults, children, pigs, combined amount of meat from domestic animals (kg), frequency of consuming pig (times per month) and frequency of ranks in the categories wealthy and very poor. T and U referres to two-tailed T-test and Mann-Whitney U-test respectively.

Parameters	Test statistics	Average (hunters vs. non-hunters)	True mean difference
Adults	$T_{59.24}$=3.84, P<0.01	3.54 vs. 2.56	0.98±0.53
Childre	$T_{59.24}$=2.73, P<0.01	5.42 vs. 3.68	1.74±1.22
Pigs	$T_{59.24}$=2.84, P<0.01	0.25 vs. 1	0.82±0.39
Available meat (a)	$U_{59.24}$=480.5, P<0.05	62 vs. 106	44.3±74.2
Pork consumption	$U_{59.31}$=660.5, P<0.05	3.83 vs. 5.94	2.10±1.66
Wealthy	$U_{67.33}$=807.5, P<0.05	0.06 vs. 0.16	0.09±0.01
Very poor	$U_{67.33}$=1494, P<0.01	0.19 vs. 0.14	0.05±0.01

(a): Species average weights of 250, 60, 20, 30, 1.5, 2.5 and 0.5 kg were assumed for cows, pigs, goats, sheep, chickens, ducks, and guinea pigs respectively in accordance with LEAD.

hunters in a village was also positively correlated with the size of the village in terms of population (r_{27}=0.457, P<0.05) and number of adult males (>18 years) (r_{27}=0.443, P<0.05) on the subvillage level after excluding one outlier (Tab. 4). Finally the proportion of the adult males that hunt was negatively correlated with the size of the village in terms of population (r_6=-0.814 P<0.05) and number of adult males (r_6=-0.830 P<0.05) again after excluding the same outlier. Hence, the number of hunters in a village increases with increasing village size but the proportion of the population that hunts simultaneously decrease.

Comparison between hunter and non-hunter households revealed significant differences in: number of adults, children, pigs, estimated amount of meat available from domestic animals, frequency of consuming pork and in frequencies of ranks in the categories wealthy and very poor (Tab. 5).

Discussion

Status of Populations in NDUFR

Assessment of the status of populations in NDUFR rests on the assumption that relevant populations in WKSFR are at *K* and representative of potential densities in NDUFR through similar habitat quality. Previous studies support the comparability of habitat quality in terms of large overlap in tree species composition and similar tree densities (Topp-Jørgensen & Pedersen unpubl). A subjective description of vegetation cover at 50 m intervals along the transects furthermore revealed no significant difference in bush and canopy cover (Nielsen 2004). Difference in habitat quality therefore does not explain the results. The difference in size of the forest reserves should similarly have no influence on densities of the relevant small species.

Information obtained concurrently with this study from hunters in WKSFR, however, revealed that low levels of hunting of relevant species do occur (Nielsen 2004). Populations in WKSFR are in addition subject to predation by carnivores that are not present in NDUFR. Populations in NDUFR are therefore more severely depleted than the comparison of the two locations indicate and thus at high risk of extirpation from hunting and environmental and demographic stochasticity (Lande 1993).

The density of Giant pouched rat as an exception appears to be higher in NDUFR. This can be the result of low predation and competition from depleted populations of relevant species. Alternatively it means that *K* is higher in NDUFR for this species through some difference in habitat quality presumably related to past logging. Many duiker species in this respect have a wide tolerance for logging with the direct effect of habitat alteration having only negligible and in several cases positive effects on densities (see Davies et al. 2001). This possibility therefore supports the results of the comparison. Minor variations within the same general habitat do furthermore not explain the very large differences in relative densities between locations or the potential extirpation of one species. The Giant pouched rat population in NDUFR appears to be unaffected and this species is presumably capable of sustaining high levels of harvest. Continued harvest would, however, because of the unselective methods, result in incidental by-catch and thereby potentially extirpate vulnerable species (Noss 1998).

Importance of Bushmeat

Bushmeat on average appears to contribute relatively little to the hunters' livelihoods in terms of frequency of consumption and RDA of protein although most of the catch was retained for own consumption. Seasonal variation may, however, lead to underestimation of the importance of bushmeat. The hunters can furthermore be suspected of understating their catch because of the illegal nature of hunting in NDUFR. An evaluation of the sustainability of the estimated annual catch using Robinson & Redford's method (1991), however, indicates that they are unlikely to catch substantially more because of the depleted status of wildlife populations in NDUFR (Nielsen 2004). Excluding five outliers or 33 hunters above a medium inconsistency in statements as a measure of reliability furthermore had no appreciable influence on the results (Nielsen 2004). Finally, although the possibility cannot be excluded, there was no indication of malnutrition or diseases related to protein deficiency, which would increase the relative importance of bushmeat.

None of the non-hunters declared eating bushmeat, and only little is available through purchase. The catch of the remaining cooperating and non-cooperating hunters was not considered in this estimate. Their catch is, however, likely to be lower than that of the key informers due to occasional absence and illness and will therefore not increase the importance considerably. Considering furthermore that all hunters households only constitute 7.5% of the population all evidence indicate that bushmeat hunting is of little importance to the general population.

The correlations indicate that increasing village proximity and population size lead to depletion of wildlife resources in NDUFR through a higher number of hunters and thereby reduce the importance of bushmeat. This implies that people have been able to shift to alternative sources of protein as the contribution of bushmeat has declined progressively with increasing human population until the current situation where bushmeat appears to be of little importance to a low proportion of the population.

Determinants of the Intensity of Exploitation

The number of hunters in a village is presumably also influenced by the opportunity costs of hunting through the economic equilibrium (see Milner-Gulland 2001). Large villages in the area are characterized by good infrastructure and markets, which provide employment and hence increase the opportunity costs of hunting. The

decreasing proportion of the population that hunts with increasing: size of the village, number of hunters, dissipation and reduction of profits thereby illustrate the importance of the opportunity costs in determining the intensity of exploitation and hence the position of the open-access equilibrium. The importance of the distance in determining the intensity of exploitation further emphasizes the opportunity costs in terms of the time required to perform regular checks of traps. The results in all circumstances indicate that the economic equilibrium point to hunting in NDUFR is far below the MSY of most relevant populations.

Cause of Hunting

The comparison of hunters and non-hunters reveal that hunters' households contain more adults and children and therefore require more meat, which they are less able to supply because they have less meat available from domestic animals and because they are relatively poorer than their fellow villagers. The results thus suggest that low dietary standards and poverty provide the incentives for hunting in NDUFR. The generally low sales rates in the villages and the low price obtained for bushmeat furthermore suggest that it is not a luxury commodity with high profit margins and that these causes of hunting therefore also may apply in the remaining villages.

Implications for CBWM

The status of populations in NDUFR indicates that an immediate stop to hunting is required to prevent further depletion and extirpation of species. This implies that there is no resource basis in NDUFR for sustainable harvesting as envisioned in CBWM until wildlife populations have recovered to densities safely above MSY. It is therefore also not possible to establish the direct link between improving the communities' livelihoods and sustainable use of natural resources that has been emphasized for ICDPs to succeed (Salafsky & Wollenberg 2000).

The results, however, initially support devolving property rights to the communities surrounding NDUFR to avoid the open-access situation. This should lead to a profit maximizing equilibrium at higher wildlife densities because proprietors can be certain that future yields will benefit themselves (see Milner-Gulland 2001). A critical aspect of the feasibility of CBWM in NDUFR is, however, to what extend sustainable harvesting can provide tangible benefits and alleviate the causes of illegal hunting, assuming that the required recovery of wildlife populations was facilitated.

Robinson & Bennett (2000) derived a theoretical estimate of wildlife production in tropical forest suggesting that maximum sustainable harvest rarely exceed 200 kg/km^2 annually. Applying this estimate suggests that maximum sustainable harvest can provide 0.65% of the RDA of protein in the communities surrounding NDUFR. The actual sustainable harvest is, however, probably less because the estimate is based on Robinson & Redford's (1991) method that does not consider stochastic variation and involves overly optimistic assumptions (see Milner-Gulland 2001).

Communities in CBWM furthermore usually sell the harvested meat in the villages to provide cash income. This implies that it will be less available to the hunters who need it most and are most likely to resume illegal exploitation. An average price of 0.5$ per kg was obtained from such sales of village hunting quotas in the Selous Conservation Project (SCP) (Hahn & Kaggi 2001). This is comparable to the price obtained from illegal trade by the key informers around NDUFR. Applying therefore this price indicates that the annual income from village hunting quotas in NDUFR would amount to 1.5 $ per household. The amount of meat and income currently obtained by the hunters thereby exceed the benefits that CBWM can provide and the benefits available per capita will furthermore decline as the human population continues to increase. The actual profits would also be lower after subtracting management expenses[2], which could fail to justify further investments in protecting the resource and thereby facilitate a resumption of unlicensed hunting.

This suggests that the meat and income generating potential of sustainable harvesting will be too low to maintain the communities' interest and offset the opportunity costs of conservation. The price attached to wildlife through CBWM may instead reveal that wildlife is an inferior asset and hence that conservation is not in the communities' economic self-interest compared to more intensive land use options. The highlands of Tanzania have a high potential for crop production and agriculture is likely to support more people (20-28 vs. 0.3 per km^2) at a higher material quality of life than the same area of tropical forest (Barnes & Lahm 1997). Land furthermore remains people's primary asset and social security and agriculture is strongly linked to rural peoples perceived long-term economic needs (Hackle 1999). Ultimately the communities may therefore, through democratic processes and the devolved property rights, decide to liquidate wildlife and timber resources, invest the proceeds elsewhere and convert NDUFR to agricultural production (Hackle 1999). Including other non-timber forest products (honey, medicine plants etc.) could increase the income generating potential of NDUFR. It is, however, doubtful that these enterprises will be able to compete with the actual or perceived benefits from the more intensive land use options particularly considering the generally high discount rate of rural people, which may cause them to prefer a smaller amount of benefits immediately rather than a larger amount in the long term (see Milner-Gulland 2001).

[2] Each village in the SCP typically employs equivalent to 3-4 fulltime scouts with payment ranging from 0.5-1$ per day in addition to food rations, medicine and uniforms (Hahn & Kaggi 2001).

Recommendations

Devolving of property rights over NDUFR to local communities as provided for in current Tanzanian legislation (Lund & Nielsen unpubl) can ultimately lead to loss of species and habitat and is therefore not recommended. Conservation efforts in NDUFR should focus on protecting wildlife against further exploitation instead of encouraging use and in addition connecting the communities' aspirations of development to the exploitation of this resource through CBWM. Efforts in support of law enforcement should address the reasons for hunting through initiatives to increase the number of domestic animals in the poorest part of the population (i.e. the hunters) and thereby facilitate a complete shift to this source of protein. Encouraging use and thereby dependence on wildlife through CBWM would instead counteract the shift that already has occurred. The incentives for illegal exploitation could be further reduced through more time requiring efforts directed at the hunters to increase their employment opportunities and thereby raise the opportunity costs of hunting. The correlations indicate that the largest effect of these initiatives would occur by concentrating limited funds in the villages nearest to NDUFR and secondarily in the largest villages. These results also suggest that maintaining a long-term effect of any initiative to reduce the pressure on wildlife resources will require measures to decrease the human population growth rate, which may be as high as 6.5% annually in the fertile highlands of Tanzania due to immigration (Lulandala 1998). Alternatively therefore, the results and the perils of bringing economic development to vulnerable areas (Barrett & Arcese 1995; Noss 1997; Struhsaker 1998; Oates 1999) support an approach suggested by Brandon & Wells (1992). This approach involves placing development programs (i.e. not CBWM) at suitable distances from vulnerable areas to absorb further immigration to these frontiers and to encourage emigration away from the proximity of these areas.

Conclusion

The results indicate that CBWM, based on meat cropping, is not a feasible approach to conservation of wildlife because of the constraints and realities in relation to NDUFR. The study also suggests reasons for skepticism about the appropriateness of CBWM in the Udzungwa Mts in general. Wildlife populations in other smaller forest fragments of the Udzungwa Mts in proximity of sizeable human populations are for instance, in consideration of the observed correlations, likely to be similarly threatened by exploitation and unable to contribute significantly to improving peoples' livelihoods. Also the aspects of encouraging the rapidly growing human population to use and depend on wildlife populations, which will not grow beyond the densities determined by the quality and amount of habitat available, appears to be an unsound approach in the long term (Barrett & Arcese 1995). Finally meat cropping cannot be recommended in general because of the particular importance of the Udzungwa Mts for the conservation of primates and duikers (Dinesen et al. 2001). Protecting wildlife therefore, for other reasons than its ability to produce income in CBWM will require continuous funding for management expenses that a developing country, in consideration of the global importance of this biodiversity hotspot, cannot be expected to finance alone.

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