A Rapid Survey of Primates from the Atewa Range Forest Reserve, Ghana

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Chapter 13

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SUMMARY

During a RAP survey of the Atewa Range Forest Reserve, we recorded six primate species belonging to four families including two families of nocturnal prosimian represented by the potto, *Perodicticus potto* and Demidoff's galago, *Galagoides demidovii.* Four diurnal simians belonging to two families were identified, including two Red-Listed colobus monkeys (the olive colobus, *Procolobus verus* and Geoffroy's pied colobus, *Colobus vellerosus*) and two cercopithecus monkeys (the lesser spot-nosed monkey, *Cercopithecus petaurista buettikoferi* and Lowe's monkey, *Cercopithecus campbelli lowei*). Based on our results, Sites 2 and 3 appear to be the most important for primates in Atewa and particularly slopes and plateaux, at least during this season in which our survey was conducted. Additionally, observations of leftover fruits suggest that gallery forest found in valleys constitutes an important habitat in terms of primate diet. Taken together, our results suggest that the primate populations of the Atewa Range require the integrity of this mountainous biotope to survive.

INTRODUCTION

The taxonomy of the primate order is liable to frequent modifications resulting from identification of new taxa, extinction or systematic revisions (Oates et al. 2000, McGraw and Oates 2002, Grubb et al. 2003, Jones et al. 2005, Davenport et al. 2006). To date, almost 300 primate species have been identified worldwide, including approximately 60 in the African continent (Gautier-Hion et al. 1999). It is estimated that 85% of African primate taxa are living exclusively in tropical rainforests and have consequently developed specific ecological and behavioral adaptations (Oates 1994). Based on available data, the monitoring of certain key primate populations is becoming a powerful tool allowing indirect and continuous follow-up on the status of targeted habitats. Temporal variations in the relative abundance of particular monkey species can be a very good indicator of habitat disturbance that might otherwise go undetected using remote sensing tools.

Primates play an important role in the ecology of tropical rainforest and especially in the reproductive biology of flowering plants. They are highly frugivorous mammals with expansive habitat ranges, making them particularly efficient seed-dispersers (Chapman 1995). The digestion and consequent dispersal of seeds promotes seedling establishment and survival, influencing the regeneration of the consumed plant species (Dominy and Duncan 2005). Chapman and Onderdonk (1998) suggest that the extinction of primates, and to a lesser extent their increasing rarity, could cause a prominent threat to the structure, composition and diversity of tropical forests. Furthermore, primates represent an important component of the forest food web. In addition to fruits, their omnivorous diets include numerous species of insects, rodents, hyraxes, duikers, and even monkeys in the case of chimpanzees (Clutton-Brock 1977, Sugiyama and Koman 1987, Yamakoshi 2004). In return, they are prey for species such as the crowned eagle *Stephanoaetus coronatus*, the leopard *Panthera pardus* and snakes (Cowlishaw 1994, Mitani et al. 2001, Zuberbülher and Jenny 2002).

Besides, probably because of their fascinating similarity to human beings, monkeys and apes are amongst the most important tourist attractions of the African intertropical zone (Weber 1993). The Republic of Ghana, with its sixteen inventoried primate species (Gartlan 1982) and ecotourism projects such as the Kakum National Park (Central region) and the Boabeng-Fiema monkey sanctuary (Brong-Ahafo region), is no exception. In this context, primate conservation and the preservation of primates' natural habitat are ecologically essential, but also become an economic challenge for local authorities and communities. In terms of politics as well, the charismatic images of simians can be used to influence conservation decisions and environmental policies in general.

Despite all this, since the early 1980's over 50% of primate diversity faces some form of threat (Chapman and Peres 2001). Primates and their natural habitat are increasingly threatened globally by hunting and other human activities including logging, slash-and-burn agriculture and mining (Mittermeier et al. 2005). Such activities, leading to destruction and fragmentation of the forest, not only affect primate species' abundance and ranging patterns, but also their group size and composition (Dominy and Duncan 2005). Given this tenuous conservation context, any area hosting threatened primate populations deserves attention and in particular those areas representing rare ecosystems or remnant habitats benefiting from protected status.

The Republic of Ghana, located in the Guinean Forests of West Africa, is one of the 34 global Hotspots for biodiversity conservation, and probably the most important one in terms of primate diversity (Bakarr et al. 2004). The Atewa Range Forest Reserve (Atewa), located in the Eastern Region of Ghana (see Map), is part of the eastern sub-region of this biodiversity hotspot, which is known to contain severely fragmented forests of high conservation value. Atewa consists of a 23,660 ha range of hills oriented approximately north-south, and is characterized by steep-sided slopes topped by flat plateaux. The reserve lies within the moist semi-deciduous forest zone, and three-quarters of it is composed of healthy Upland Evergreen Forest. Atewa is one of only two reserves in Ghana representing this forest type, and those two reserves together hold 95% of the Upland Evergreen Forest of Ghana (BirdLife International 2005). The very ancient soils of the Atewa Range, which are reputed to be bauxite laden, contain the headwaters of several of Ghana's major watercourses including the Birim, Densu and Ayensu rivers. This area has been legally protected for over eighty years, and was more recently declared a Globally Significant Biodiversity Area (GSBA). Despite these measures, Atewa is still threatened by illegal logging and hunting, and has recently been granted by the Ghanaian government on concession to ALCOA for bauxite mineral exploration.

METHODS

A survey of primate diversity, abundance and distribution was conducted in Atewa from 7-22 June 2006. The RAP survey focused on three study sites with campsites located on the top of the large plateaus dominating the reserve at an altitude of 800 m. Atiwiredu (Site 1) still contains relatively healthy forest although it is the zone most impacted by mineral prospecting activities and a number of roads and large trenches have increased access to the top of the Atiwiredu plateau. Asiakwa South (Site 2), located at an intermediate latitude between Sites 1 and 3, shows evidence of disturbance, with moderate scars resulting from drilling activities and other human disturbance (mainly hunting and clearing of forest for wood). Asiakwa North (Site 3) presents the healthiest forest of the three sites, but it is also the site where the highest hunting pressure was recorded.

Five to six days were spent in each of the three sampling sites to get an overall picture of Atewa's primate diversity (see Map for site locations). Sixteen days were spent surveying the forest, using a combination of field methods complemented by interviews with local villagers. Primates and evidence of their presence were recorded both from line transects and "reconnaissance surveys" during thirteen days (a total of 93 hours). One full day was devoted to interviews with local hunters and cultivators in villages surrounding the reserve.

Table 13.1. Starting location, bearing, length and survey time of four line transects employed during the 2006 RAP survey of the Atewa Range Forest Reserve, Ghana.

Transect	Start location	Bearing	Length (km)	Number of visits	Time spent surveying (h)
T1 (Site 1)	N 06°11'26.9" W 00°34'48.3"	N 30°	0.880	3	3h20
T2 (Site 2)	N 06°15'14.5" W 00°33'14.4"	N 30°	1.210	2	4h05
T3 (Site 3)	N 06°16'09.4" W 00°33'56.5"	N 30°	0.850	2	2h50
T4 (Site 3)	N 06°15'52.0" W 00°33'51.6"	N 30°	0.430	1	0h55
Total			**7.19 km**		**11 h 10 min**

Line Transect (T)

The line transect count method allows an estimation of animal population density in a sampled area. To calculate such a density, critical parameters have to be measured at the time of each contact with the targeted species (Buckland et al. 1993, White and Edwards 2000). We established four parallel line transects, randomly located within the three sampled sites. To undertake our survey, one to three observers walked transects very silently at an average speed of between 0.5 and 1 km/h, scanning and listening for primates and recording evidence of their presence. Table 13.1 presents general characteristics of the four transects.

One transect was employed per site and walked two or three times at different hours of the day. Transect 1 (T1) was walked once at night to look for nocturnal primates. A fourth short transect (T4) was set up at Site 3 and walked only once. The total time spent walking transects was 11h 10min, surveying a total of 7,190 m.

Reconnaissance surveys (R)

Reconnaissance surveys were conducted following pre-established itineraries that were adapted with respect to the reality of field conditions. Itineraries consisted of loops radiating from campsites and following pre-existing paths or low resistance routes in the forest. One to four observers recording clues of primate presence walked each of these once, silently and slowly. Compared to line transects, reconnaissance surveys are less time and effort consuming, they have the least impact on surrounding vegetation and allow the survey of greater distances while giving a picture of the spatial distribution of primate populations (Walsh and White 1999). Nevertheless, this method does not permit access to a population density estimate, but to a Kilometrical Index of Abundance (KIA) of a selected item. KIA refers to the ratio between the number of contacts with the selected item and the walked distance (White and Edwards 2000, Maillard et al. 2001). Table 13.2 describes distance covered and time spent on reconnaissance surveys per site.

During thirteen days (a total of 82h 30min), 64 km were walked including reconnaissance surveys in all studied areas. This included one nocturnal survey, made at Site 2 where almost 3 km were walked in two hours.

Table 13.2. Distance covered and time spent on Reconnaissance surveys per site during the 2006 RAP survey of the Atewa Range Forest Reserve, Ghana.

Study sites	Reconnaissance survey	Length (km)	Time spent (h)
Site 1 - Atiwiredu	R1	24	28
Site 2 – Asiakwa South	R2	17	24.5
Site 3 – Asiakwa North	R3	23	30
Total		**64**	**82.5**

Interviews

The interview methodology permits a precise assessment of human knowledge on studied species with minimum time and effort requirements. Combined with field survey techniques, interviews increase and diversify data sources, allowing further data comparison and reliability checks. On 19 June, we visited villages surrounding Atewa to question local hunters and farmers about primates that can potentially be found in the reserve. Interviews were conducted in a standard manner (Boyd and Stanfield 1998): plates showing both photos and drawings of 11 forest primates known to occur in Ghana (Oates et al. 1997) were presented to interviewees. They were asked to point toward items identified as being present in Atewa, and to specify whether any other species not depicted on the plates would also be present or not. Interviews were conducted in English, and when necessary Vincent Pratt, field assistant from the University of Ghana (Accra), translated into the local dialect (Twi). However, primates' local names in Twi were systematically asked. We used the variability recorded in each primate local name as a reliability-check index (RI), defined as the ratio of interviewees who have given the same local name to a given primate, to the total number of interviewees. Thirty-eight villagers (12 hunters, 20 farmers and 6 local guides who were working with the RAP team) were individually contacted in nine communities surrounding the Reserve.

RESULTS

Overall, six primate species belonging to four families were identified in the Atewa forest (Table 13.3). We recorded the presence of two families of nocturnal prosimian represented by the potto, *Perodicticus potto* and Demidoff's galago, *Galagoides demidovii*. Four diurnal simians belonging to two families were also identified, including two Red-Listed colobus (IUCN 2006) (the olive colobus, *Procolobus verus* and Geoffroy's pied colobus, *Colobus vellerosus*) and two cercopithecus monkeys (the lesser spot-nosed monkey, *Cercopithecus petaurista buettikoferi* and Lowe's monkey, *Cercopithecus campbelli lowei* (Grubb et al. 2003)).

During surveys, three kinds of observation related to primate presence were recorded: 1) direct visual observation, 2) direct observation of vocalizations, and 3) indirect observation of alimentary leftovers, which were exclusively fruit leftovers. Sixty percent of the recorded observations (n = 58) were feeding remains, which cannot be easily attributed to one specific primate. Consequently, species' identification was based on visual and vocal observations, which have enabled the unequivocal identification of five primate species. The sixth species' presence was deduced from interviews, observations of the habitat and bibliography. Table 13.4 describes the results obtained from both surveys and interviews.

The presence of *Perodicticus potto* was reported in 72% of interviews with a Reliability Index (RI) of 0.97, which means that all interviewees except one have attributed the same local name ("aposso") to its illustration. Despite the

Table 13.3. Primate species identified in the three sampled sites of the Atewa Range Forest Reserve, Ghana, during the 2006 RAP survey.

Species	Vernacular name	Local name	Site (see methods)	IUCN Status (IUCN 2006)
Perodicticus potto	Potto	Aposso	Atewa	LC
Galagoïdes demidovii	Demidoff's galago	Aprékéssima	1, 2, 3	LC
Procolobus verus	Olive colobus	Assébé	2	NT
Colobus vellerosus	Geoffroy's pied colobus	Afuo	1, 2, 3	VU
Cercopithecus petaurista buettikoferi	Lesser spot-nosed monkey	Ahwéhéma	1, 2, 3	LC
Cercopithecus campbelli loweï	Lowe's monkey	Okokuo	3	LC

fact that we did not observe this species during the two nocturnal surveys carried out, we believe the potto actually occurs in Atewa because it is a common and widespread nocturnal prosimian found in a large variety of habitats across equatorial Africa (Kingdon 1997, Pimley et al. 2005).

G*alagoides demidovii*, quoted as present in 74% of interviews with 95% of reliability, was abundantly heard all over the three study sites. Different members of the RAP team observed it three times in Atewa and a nest was seen on reconnaissance survey R3. Based on these observations, we are reporting galago's presence mainly on the tops of plateaux.

Two cercopithecus monkeys were identified in Atewa as well (Table 13.3). The lesser spot-nosed monkey or *Cercopithecus petaurista buettikoferi* was directly observed on two occasions and heard three times across the three sites: on plateaux, slopes and down in the valleys. Its presence was reported in 74% of the interviews with good reliability (RI=0.84). The second identified guenon, Lowe's monkey or *Cercopithecus campbelli loweï,* belongs to the West African group of mona guenons, and was cited in 63% of the interviews (RI=0.81). On one occasion, characteristic alarm calls were heard and subsequent agitation in trees was seen in the higher part of the east slope of Asiakwa North plateau (Site 3). Evidence of an individual kept in captivity was also reported in an interview.

Finally, we are reporting the presence of two colobus monkeys, both classified as threatened on the IUCN Red List (IUCN 2006). The West African endemic olive colobus, or *Procolobus verus*, was heard once on reconnaissance R2, in the higher part of the northwestern slope leading to Asiakwa South plateau (Site 2), and was indicated as present in 72% of interviews (RI=0.81). The second species, a regional subspecies of black-and-white colobus named Geoffroy's pied colobus or *Colobus vellerosus*, was selected in 79 % of interviews (RI=0.87), directly observed twice and heard on plateaux, slopes and valleys in the three study sites.

Three primate species that were quoted as present by less than half of the interviewees and never observed during surveys are presumed absent from Atewa. *Procolobus badius waldroni* (quoted as present in 55% of interviews with 0.39 of reliability) and *Cercocebus atys lunulatus*, (presence quotation=42%; RI=0.52) exhibit low indexes of reliability, reflecting interviewees' difficulty in identifying these species properly. By contrast, the chimpanzee *Pan troglodytes verus* (presence quotation of 24%) shows a very high reliability index (RI=0.97), probably because of the fame attached to this well-known ape. We believe that the interviewees have good capacities for distinguishing primates from pictures and/or drawings since they were able to recognize all the species we identified during surveys.

A fourth monkey, the Roloway guenon or *Cercopithecus diana roloway* was cited as present in 66% of interviews and exhibits the highest index of reliability (RI=1). The Diana monkey is listed as Threatened on the IUCN Red List (IUCN 2006) and the Roloway subspecies is particularly in danger of extinction (Magnuson 2003). Nevertheless, this guenon was not added to the list of Atewa's primates because so far the species has only been described in the western part of Ghana and Côte d'Ivoire (Oates 1988), and we did not see any evidence of its presence. The high index of reliability recorded for this beautiful and characteristic species probably results from a similar "fame effect" as described for the chimpanzee.

Polyspecific associations between Geoffroy's pied colobus and lesser spot-nosed guenons were observed on two consecutive days in the higher part of the northeastern slope leading to the top of Asiakwa North plateau (Site 3). In both cases, we heard one species and visually identified the other.

We compared the results of monkeys' presence between sites, as shown in Figure 13.1. At Site 2, the presence of two Red-Listed species of colobus was recorded. Furthermore Sites 2 and 3 show the highest primate diversity, with four species recorded from each. Therefore, it appears that Asiakwa South and Asiakwa North are the most important in terms of primates.

We then compared the nature and number of observations made in each of the physical environment types present in Atewa: plateaux, slopes and valleys (Figure 13.2). Approximately the same surveying distance was walked in each of these environments. The most evidence of primates was recorded on slopes and plateaux (respectively n=22 and n=15), which suggests these constitute the most important habitat types for the primates of Atewa.

Table 13.4. Primate observations made during transects and Reconnaissance Surveys (Recon): Voc = vocalization heard; Obs = visual observation made; Al = Feeding remains observed. Interview results: Present = Percentage of interviewees affirming the presence of the species; RI = Reliability index.

Species	Surveys (71 km)		Interviews (n=38)	
	Transect	Recon	Present (%)	RI
Perodicticus potto			72	0.97
Galagoides demidovii	1 Voc	4 Voc, 1 Obs	74	0.95
Procolobus verus		1 Voc	72	0.81
Procolobus badius waldroni			55	0.39
Colobus vellerosus	5 Voc	2 Obs, 3 Voc	79	0.87
Cercocebus atys lunulatus			42	0.52
Cercopithecus diana roloway			66	1
Cercopithecus campbelli lowei	1 Voc		63	0.81
Cercopithecus petaurista buettikoferi	3 Voc	2 Obs, 1 Voc	74	0.84
Pan troglodytes verus			24	0.97
Unknown Species	11 Al	23 Al		

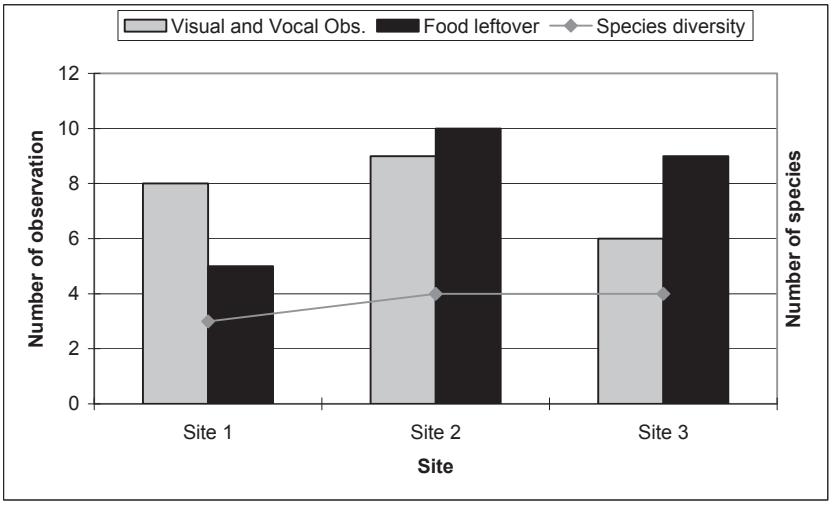


Figure 13.1. Amount of primate evidence and number of species recorded per site during the 2006 RAP survey of the Atewa Range Forest Reserve, Ghana.

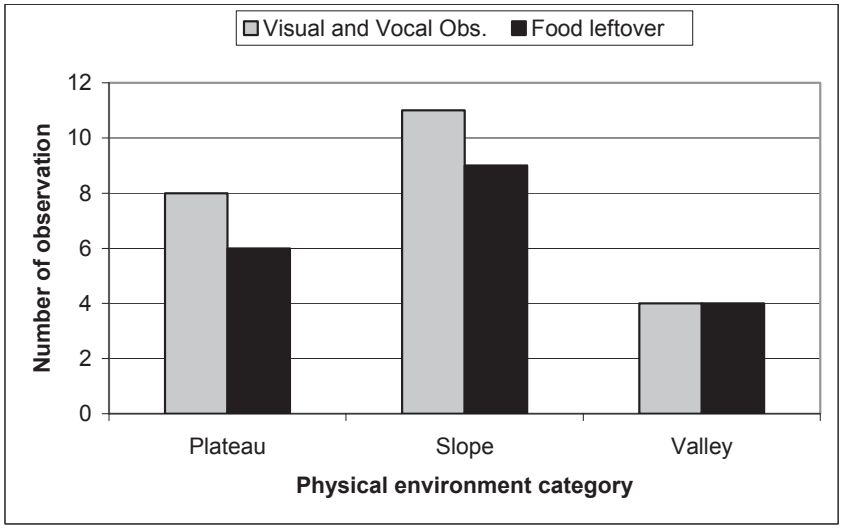
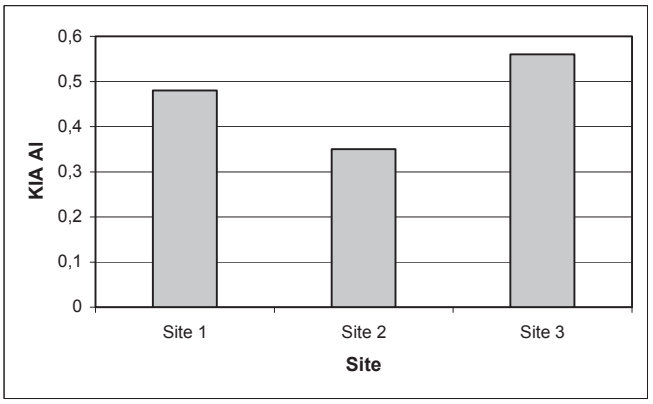


Figure 13.2. Primate evidence recorded per type of environment during the 2006 RAP survey of the Atewa Range Forest Reserve, Ghana.



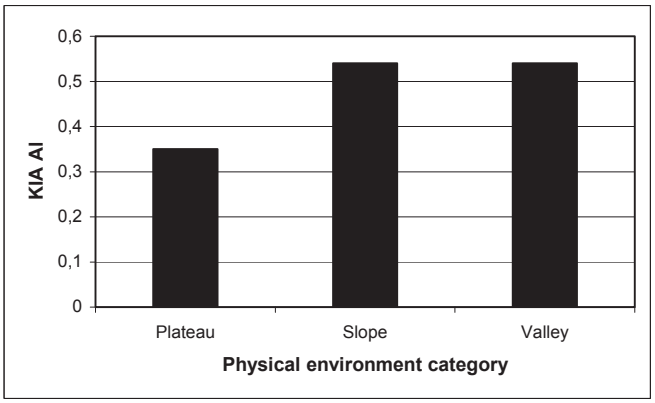


Figure 13.3. KIA of Alimentary leftovers (KIA AI) per site (i) and per environment type (ii).

Down in the valleys, we observed feeding remains left by six primates and heard vocalizations by four different species.

No direct observation of primates was recorded on transects, preventing any density estimation of monkey populations. Therefore, to get an idea of primate abundance in Atewa we grouped observations of feeding remains recorded on both transects and reconnaissance surveys to calculate the Kilometrical Index of Abundance (KIA) of primates' alimentary leftovers. KIAs of alimentary leftovers were compared between sites and environment types, as shown in Figure 13.3.

Site 2 shows the smallest KIA of all sites, but is also the site where survey time and distance were the shortest (see Tables 13.1 and 13.2). Site 3 exhibits the highest KIA of primate alimentary leftovers, with 0.56 items seen per kilometer. Taking all sites into account, primates seem to rely mostly on slopes and valleys for feeding on fruits (0.54 alimentary leftovers observed per kilometer in both).

DISCUSSION

The Kilometrical Index of Abundance of alimentary leftovers (KIA AI) does not directly reflect primate abundance, but rather the relative abundance and distribution of places where they have fed on fruits. Thus, fruits represent only a fraction of the omnivorous and seasonally changing diet of primates, and each of the six described species has different alimentary requirements. Consequently, the KIA of feeding remains gives an indirect and global picture of all primate species populating the Atewa forest. This practical monitoring tool is easy to set up and to carry out, and allows for the assessment of general changes in primate demographics as well as the comparison of overall population dynamics across habitats and time (White and Edwards 2000, Thibault et al. 2001) and indirect analysis of the impacts of development activities or other alterations to the habitat.

Based on the RAP results, Sites 2 and 3 appear to be the most important for primates in Atewa, particularly slopes and plateaux, at least during the season of our survey. The least evidence of primates per environmental category was recorded in valleys (as shown in Figure 13.2), nevertheless, observations of primate feeding remains here suggest that the gallery forest found in valleys definitely constitutes an important habitat in terms of primate diet. It emerges that the primate populations of the Atewa Range, taken as a whole, require the integrity of this mountainous biotope to survive. Moreover, the numerous observations of other large mammals' tracks in valleys lead to the conclusion that this particular type of environment is important for large fauna in general.

Habitat disturbance resulting from human activities in Atewa appeared to be characterized by two opposite gradients: the mining impact, which decreases when going north, and activities of local communities, which decrease when going south. In addition to these gradients, the topography also influences the spatial distribution of human disturbances: mining activities focus on the top of the plateaux whereas local community activities mainly target slopes and valleys, as well as Atewa's peripheral areas. This explains how, up to now, mineral exploration has spared the forest cover of slopes, which remain outwardly nearly unsullied in the three sampled sites.

Species of general interest

The potto (*Perodicticus potto*) is a solitary animal living in secondary and lower mountain forests. It has a relatively large home range (from 5 to 40 ha) and exhibits seasonal variations in its diet, mainly composed of gum, insects, and fruits (Rowe 1996). In this nocturnal species, days are spent in trees (Pimley et al. 2005). The galago (*Galagoides demidovii*) is common and widely distributed throughout tropical Africa's secondary forests, populating mainly open areas such as forest and road margins. Individuals live in groups of about ten but forage at night on their own. The high canopy forest in the top of Atewa's plateaus seems to be a suitable habitat for the species.

Primates of the *Cercopithecus cephus* group inhabit the Central African forest block, but the "*petaurista*" sub-group is exclusively found in the Guinean Forest ecosystem in West Africa (Gautier-Hion et al. 1999). The lesser spot-nosed monkey (*Cercopithecus petaurista buettikoferi*) is a common

species highly adaptable to a large spectrum of disruptive factors, known to live in a wide range of forested habitats ranging from primary lowland and medium-altitude forests or galleries, to secondary regeneration and coastal bushes. It feeds mainly on fruits and buds but also on leaves, stems and insects. Lowe's monkey (*Cercopithecus campbelli lowei*) is distributed only between the Sassandra and Volta rivers, where it is a recognized target for hunters but nevertheless is still relatively common. This arboreal subspecies of mona monkey is also adapted to most tropical forest types, relying on trees where fruits (like cola and figs) and flowers essential to its diet can be found (Rowe 1996).

Species of particular interest

Two colobus monkeys, both classified as threatened on the IUCN Red List (IUCN 2006) were identified in Atewa. African colobus, or thumbless monkeys, are arboreal primates populating the forest tropical zone and are highly dependent on good quality forest comprised of several levels of closed canopy. Chapman et al. (2004) have shown that the presence and abundance of colobus monkeys was influenced by very subtle ecological factors linked to forest structure and composition. They have a highly specialized digestive system allowing them to process difficult or "uncommon" plant materials: the most important part of their diet consists of leguminous plants, whose fruits and leaves are protected by chemicals. Thus, in comparison to many other primate species, colobus monkeys aid in dispersal of "uncommon" vegetal species.

To date, the olive colobus (*Procolobus verus*) was not known to occur in this part of Ghana. This colobus is classified as Near Threatened on the Red List (IUCN 2006). In 2000, this relict species confined to the forested zone of West Africa was classified as Endangered, showing a recent and significant improvement of its conservation status. However, it is still a fragile monkey, which is difficult to observe because it is very shy and communicates infrequently by quietly chirping. It is the smallest of all colobus, very light and exclusively arboreal; the olive colobus usually groups in units of five to twenty animals that exploit the highest part of the forest canopy in the secondary growth of high forests, margins of forested zones as well as swamps. They easily associate with other monkey species foraging in lower layers of the canopy without any inter-specific food competition (McGraw 1998).

Geoffroy's pied colobus (*Colobus vellerosus*), classified as Vulnerable on the IUCN Red List (IUCN 2006), is more widely distributed than the olive colobus. Nevertheless, this subspecies of black-and-white colobus is likely to soon become Endangered if the present rate of hunting and habitat destruction continues in its ecological range. This monkey ranges in restricted lowland rainforest and galleries of Côte d'Ivoire, Ghana and Togo, relying on food items mainly consisting of leaves (Wong and Sicotte 2006). It usually forages in the shaded middle layer of the canopy. In Atewa, we frequently observed this species on the slopes and, less often, on plateaux. Geoffroy's pied colobus groups can be composed of up to 50 individuals and in Boabeng-Fiema monkey sanctuary (Ghana), particularly high densities have been recorded, such as 119 indiv/km^2 (Wong and Sicotte 2006).

Primates living in tropical rainforest often form large mixed-species associations, which can include up to eight species (Zuberbühler and Jenny 2002). Here we report the association of two species: the Geoffroy's pied colobus and lesser spot-nosed monkey, which can stay together for several days. Actually, the lesser spot-nosed monkeys are known to be highly visually oriented, and to warn other species of danger (mainly linked to predation) in such polyspecific associations (Rowe 1996).

CONSERVATION RECOMMENDATIONS

Ghana has a long history of forest exploitation. It is estimated that the forest cover has been reduced to nearly one-sixth of its original size during the past century, leaving only 1,500,000 ha of undisturbed forest (IUCN 1996). Struhsaker and Oates (1995) have long warned the Ghanaian authorities and the scientific community of this critical situation and its potentially tragic consequences for the high and original primate diversity of the country. Amongst the ten forest species of monkeys occurring in Ghana, three species, all endemic to southwestern Ghana and eastern Côte d'Ivoire, are highly threatened by extinction (Oates et al. 1997): Miss Waldron's red colobus (*Procolobus badius waldroni)*, white-naped mangabey (*Cercocebus atys lunulatus)*, and the Roloway subspecies of Diana monkey (*Cercopithecus diana roloway*). We strongly believe that an essential prerequisite to protect primates is to take conservation action and promote the sustainable use of natural ecosystems so as to avoid irreversible extinction of species. Given the particular context and history of Ghana, each forest fragment presently populated by primates, regardless of size, should be actively protected from further destruction and fragmentation. The rich upland ecosystem of Atewa Reserve is a relatively large and isolated forest fragment, which constitutes one of Ghana's last refuges for six primate species including two Red-Listed species of colobus monkeys.

For these reasons, our overall recommendation is that Atewa should receive full protection and no development activities should proceed in the area. Clearing plateaus would undeniably affect headwaters of major rivers and have long-term destructive consequences on the environment, principally by increasing soil erosion on surrounding slopes and disturbing the hydrographical net of the entire sub-region. Habitat loss would put several primate species under serious threat of local extinction. The galago would probably be the most impacted species, but colobus and guenons would also suffer from the opening up of their habitat and subsequent disruption. However, it would be very difficult and hazardous to give an opinion on the future of Atewa's primates if development were to happen because data are largely unavailable on the adaptive capacities of the different species.

Specific conservation recommendations

If, against our strong recommendation, development activities within Atewa are to proceed, exposing Atewa to a high risk of biodiversity loss, we submit some important recommendations related to the conservation of primates populating the area.

- **Integrally protect the northern part of the Atewa Range**

  Based on our results and analysis we strongly recommend to the concerned authorities that they safeguard an integrally protected area in Atewa. Actively protecting a large zone from development and all other human impacts is the only way to ensure the survival of the multiple species of primates present. The area of protection should have clear boundaries delimited and should be given a high protection status, with limits and regulations strictly enforced. The northern part of Atewa appears to be the most valuable in terms of primate presence and forest quality, and thus emerges as the obvious candidate. We propose Sites 2 and 3 to become an integrally protected reservoir zone for primates and general biodiversity. More precisely, the protected area should include plateaux, slopes and valleys of all the north part of Atewa, as far as the southern foothills of Asiakwa South plateau (Site 2). Findings that have motivated the choice of this zone are detailed below.

  Site 2, which contains the two Red-Listed species identified in this study, olive colobus and Geoffroy's pied colobus, is a priority site to protect for the conservation of Atewa's primates. Both of these species are reliant on good quality forest with several levels of closed canopy. We strongly believe that olive colobus is exploiting all described environment types of the northern part of Atewa. However that may be, the unsuccessful breeding of this monkey in captivity (Kingdon 1997) is an indicator of its fragility and low capacity for adaptation. The presence of Geoffroy's pied colobus was confirmed at Sites 2 and 3. We assume that both of these threatened species would drastically suffer from upland forest clearing and that the only option to ensure their survival consists in maintaining large intact areas of forest on the top of plateaux. Additionally, Sites 2 and 3, the most preserved in terms of forest quality, contain the highest primate diversity recorded during our survey. Excepting the two colobus, the other species recorded at these sites are not particularly threatened, but they are nevertheless fragile and isolated populations totally dependant on their habitat and its natural resources. In the case of a relatively large but isolated patch of forest like Atewa, destruction of the habitat would critically jeopardize all primate populations present (Mittermeier 2005). Their number and diversity would likely rapidly decline as a result of habitat fragmentation and loss (Tutin 1999).

- **Undertake a sensitization program targeting surrounding communities**

  In order to prevent local villagers from hunting and cutting the forest in the proposed integrally protected area, it is necessary to carry out a sensitization program involving all communities surrounding Atewa. Such a program should aim to inform local people of the importance of preserving their natural heritage and to help them organize to achieve this goal. The program would have greater impact and more sustainable effects if conducted over the long term. Furthermore, effort should be taken to employ villagers, who will be the real actors of local conservation, advised and supported by officers of the sensitization program.

- **Incorporate restoration plans into any proposed development**

  Any development of Atewa which would lead to the removal of vegetative cover and the upper stratum of soil from the plateaux would leave little chance for short- or medium-term natural regeneration of the forest. Forest primates cannot live in such a bare landscape, hence a restoration program favoring rapid regeneration of impacted sites has to be elaborated and implemented, as a matter of urgency, in respect to the specifics of Atewa.

  Linking patches of forest using corridors is one conservation alternative to address the problem of habitat fragmentation. This technique can also be used in the context of a restoration program to partially mitigate for any destruction, degradation or fragmentation inherent to development activities by enlarging natural habitat to new perspectives. Kwahu plateau forested zone, located about fifteen kilometers north from Atewa contains similar upland habitat and is consequently a good candidate for such a project. A feasibility study including assessment of primate diversity in Kwahu and landscape description should be carried out prior to take any action.

- **Publicize and enforce environmental protection guidelines for those working in Atewa**

  Any company that may become involved in development activities within Atewa should elaborate, in collaboration with scientists and conservationists, strict guidelines for the conservation of Atewa's biodiversity. This conservation plan should provide and explain a set of rules for employees concerning garbage management, chemical pollution prevention, hunting and bush-meat trade prohibition, and forest preservation. Defining these guidelines is an essential point considering that hundreds of people coming from various regions would possibly enter into the forest daily.

- **Undertake a longitudinal assessment program for primate populations**

  This RAP survey was the first primate assessment conducted in Atewa. A longer-term survey should be carried out to precisely estimate primate abundance and to monitor the different primate populations across time. This census should cover a larger area of the Atewa Range, during a longer time and over different seasons of the year. Considering the low rate of direct observations of primates, a statistically valid estimation of populations' density cannot be obtained without such a long-term work. Moreover, a specific survey is needed to settle the point of the Roloway guenon's hypothetical presence in the Atewa Range. If such an unexpected presence was reported by direct evidence, urgent research and conservation measures should rapidly be taken, due to the rarity and importance of this species, sadly emblematic of primate biodiversity decline.

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