Determining minimum population size and demographics of black rhinos in the Salient of Aberdare National Park, Kenya

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Abstract

Photographic identification techniques were applied in the Salient of Aberdare National Park, an area known to be one of the most difficult in Kenya for sighting and identifying black rhinos (*Diceros bicornis*). A method of assessing photographs visually was used to identify individuals. Individual identification features were recorded and an identification description written for each rhino. Descriptions were reduced to 'descriptors' and combined with appropriate photographs in a searchable Access database; a simple sighting recording system that could be used in conjunction with the database was developed. The database and a standard method of describing the identification features of each of the rhinos enabled details of individuals to be disseminated, patrol rangers trained to identify individuals accurately, minimum population demography to be described and changes in minimum population size, from potentially 23 in 2003 down to possibly only 7 individuals in 2005, to be observed. Resighting some of the rhinos was a problem, and there was concern that the significant reduction in the number of previously identified individuals may have been due to poaching.

Résumé

On a appliqué des techniques d'identification photographique dans le *Salient* du Parc National des Aberdares, une zone connue pour être une des plus difficiles du Kenya pour l'observation et l'identification des rhinos noirs (*Diceros bicornis*). On a utilisé une méthode d'évaluation visuelle sur photos pour identifier les individus. Les caractéristiques de chaque individu et une description permettant de l'identifier ont été rapportées pour tous les rhinos. Les descriptions ont été réduites à des « descripteurs » et combinées aux photographies appropriées dans une base de données Access ; on a mis au point un système simple de compte-rendu des observations qui peut être utilisé en conjonction avec la base de données. La base de données et une méthode standardisée pour décrire les caractéristiques d'identification de chacun des rhinos ont permis de faire connaÓtre les détails concernant les individus, de former les gardes en patrouille à l'identification précise des animaux, de décrire la démographie minimale de la population et d'observer les changements de la taille minimale de la population qui est passée de 23 animaux potentiels en 2003 à seulement sept en 2005. Il a été problématique de revoir certains des rhinos, et la réduction significative du nombre des individus identifiés auparavant pourrait être due au braconnage.

Introduction

The Aberdare Mountains support the largest indigenous forest in Kenya. They run along the edge of the Rift Valley for some 60 km in the central part of the country. In 2004 the ecosystem, which covers 2185 km^2, received international recognition as a 'tropical wilderness hotspot' (an area of crucial importance to climate regulation and watershed protection) by the Global Conservation Fund in partnership with Conservation International. Aberdare National Park covers some 767 km^2. The area in the east known as the Salient extends from Treetops Lodge to the 2600-m contour and covers 100 km^2. It receives up to 1000 mm of rainfall per year with peaks in March–May and October–November.

The altitude exceeds 3000 m with Dongo Lesatimma in the north reaching 3999 m and Kinangop

in the south 3905 m. There are five main habitat zones: 1) salient shrub characterized by *Ocimum suave*, *Hypoestes verticillaris* and *Toddelia asiatica*, with swampy glades rich in mineral salts; 2) bamboo forest with closed canopy and little undergrowth; 3) moorlands of tussocky grassland; 4) north and south montane forests on the lower slopes; and 5) north and south hagenia forests on the upper slopes.

In the 1940s and 1950s, the Aberdares forest was known to hold one of the highest densities of black rhinos in Kenya with estimated densities of at least one rhino per square kilometre (Sillero-Zubiri and Gotelli 1991). There were thought to be 450 black rhinos in the park in the early 1970s but a census in 1982 recorded only 132, and by 1987, the population was estimated at 50, 30 of which were in the Salient (Sillero-Zubiri and Gotelli 1991). The Salient was identified by the Kenya Wildlife Conservation Department (now known as the Kenya Wildlife Service, KWS) as a priority area for developing a rhino sanctuary. It was upgraded from a priority area to rhinos sanctuary status in 1988. An electric fence was constructed along the part of its boundary that abutted land settlement and this was completed in 1990 (Brett 1993). During June–July 1991, 31 different rhinos were identified at the Ark and Treetops lodges (Brett 1993), the two tourist lodges located in the Salient. A photography-based monitoring programme in July 2000, based mainly at night at these two lodges, resulted in photographs of 17 individual rhinos being placed on record.

The population of rhinos in Aberdare National Park is particularly valuable as it is indigenous with only one rhino introduced from outside from the neighbouring Solio Ranch. The Aberdares population was believed to be genetically pure and represents the only large, indigenous population of the 'highland' ecotype in Kenya (Brett 1993).

At the start of 2003, KWS had no accurate census of the rhinos in Aberdare National Park and therefore could not evaluate whether the management plan for the rhinos was the most effective to ensure their safety and successful breeding performance. Changes in the KWS Aberdare rhino unit personnel meant that a largely new team of rangers was given the task of estimating the number, recording individual identity by photographs or drawings, and regularly monitoring the rhinos in the Salient. Daytime rhino sightings were rare, often of only a few minutes duration and from a distance that made identification photography or drawing impossible. Also many sightings were either early in the morning or late in the evening when light levels were too low for the equipment to work. Preliminary discussions with and observations by KWS staff at Aberdares suggested there was much confusion over the rhino population size and structure. Between 50 and 60 rhinos were thought to be ranging mostly in the Salient, but most sightings were recorded as 'unidentified' because new staff did not know how to distinguish individuals and often could not get close enough to recognize identification features. The shrub habitat of the Salient is very dense and offers a special challenge first to finding and then to observing rhinos for a time sufficient to make reliable identification.

The aims of the study were to photograph and positively identify individual rhinos in the Salient, use the photographs to make a 'best estimate' of the minimum current rhino population, and use the photographs to assist in training local staff to identify individual rhinos as part of the KWS rhino-monitoring programme.

Materials and methods

The work was carried out by vehicle-based monitoring throughout the Salient during the day and at the Ark and Treetops lodges, where rhinos visit the waterholes and salt licks, mostly at night. Daytime patrols were between one and five and a half hours long. Daylight techniques for obtaining, enhancing and analysing appropriate identification photographs (left and right body profile, left and right head profile, a front view of the head, left and right ear, nose wrinkles and rear view) were known from previous research (Patton 2007). A pilot research study was carried out in February 2002 to consider, from the equipment available, what was best suited to taking photographs at night under lodge floodlighting systems. Identification research was undertaken during March, June and September of 2003 and 2004 and March and June 2005. Monitoring was carried out on 112 days, which included 209 daytime patrols throughout the Salient, 66 nights at the Ark and 42 nights at Treetops.

Equipment and processing

Daytime photographs were taken from a vehicle during patrols in the Salient. Those made in good light were taken with a Minolta Dynax 5 single-lens reflex camera with Tokina 80–400 mm zoom lens. This

lens allowed good flexibility and versatility in open-ground conditions. Low-cost ASA 400 colour film was used. Rhinos were found in the open at certain locations early in the morning and late in the afternoon when only a Sony TRV240 digital camcorder (video camera) could successfully capture images in the low light levels.

For night photography at the artificially lit waterholes, it was found that a 400 mm K lens attached to a Minolta Dynax 5 camera body gave adequate results. It required placing the camera on a bean bag and using an external shutter switch to avoid any camera shake. The film used was ASA 1600, or ASA 800 with the camera stopped to ISO 1600, which was cheaper than using ASA 1600 film and gave acceptable results. With these materials, it was necessary to leave the shutter open for several seconds to bring in sufficient light. It was important to capture the rhino when it was completely still to avoid blurring. Several attempts were often needed to do this.

To overcome the problem of animal movement, we also used a Sony TRV240 digital camcorder and Digital8/High8 tape. With a x25 zoom it was possible to get close-up images of identification features.

The layout of the Ark waterhole meant that rhinos came as close as 10 m to the building where a ground-level concrete photohide allowed direct photography rather than through the glass windows of other observation points, which reflected light and gave poor results. The area was brightly lit and both still and video cameras gave good results.

At Treetops, the lighting was less bright. The layout of the waterhole was such that rhinos that took only water remained more than 50 m from the vantage point on the terrace of the lodge. This was outside the capability of the camcorder. While it was nearly impossible to see the rhinos through the viewfinder of the still camera at such a distance, it was found that acceptable identification pictures could be obtained by watching one through binoculars until it was still and then opening the camera shutter. Because of the poor light quality, a photograph required up to 10 seconds. Rhinos using the salt lick had to come right up to the building. Those that did could be photographed with both cameras. A ground-level photohide also allowed direct photography with the video camera, the slits in the walls being too narrow to balance the still camera.

Film was processed in the nearby town of Nyeri through a standard Kodak C41 processor onto 4″ x 6″ Kodak paper with gloss finish.

Image enhancement

Individual rhino features were obtained by scanning the prints with an Epson Perfection 1240U scanner using a Toshiba Satellite Pro 4600 laptop computer. After much trial and error, scanning was carried out at 600 dpi when features such as a head profile were readily discernible, at 900 dpi when features were more difficult to discern, and at 1200 dpi for small features such as eye wrinkles where detail was difficult to capture. In 2003, the Epson scanner was replaced with a Mustek 1200 UB Plus scanner, an inexpensive model, but no effect on scan quality was observed.

The scans were saved using JASC Paint Shop Pro 7 software as jpeg files in greyscale as this gave the most observable contrast. Features were cropped out and resized to a height standard of 2.25 inches (572 mm). When the file size was large (over 500 kb) this was done by reducing the dpi, but when it was small, less than 500 kb, this was done by adjusting the print size to the required height. Scans were adjusted for brightness and contrast using Paint Shop Pro software as and when necessary.

From photographs taken with the Sony TRV240 digital camcorder, still pictures were extracted from a video stream using PIXELA ImageMixer Version 1.0 for Sony™ software.

The most important identification features used to distinguish the Aberdares rhinos were sex, ear markings, horn size and shape, body markings and tail size. Three evaluators—the rhino warden, an experienced ranger who had been formally trained in rhino identification and had been with the rhino-monitoring team in the Aberdares for five years, and the first author—visually studied the photographs to identify individual rhinos. While all three of us exhibited strong aptitude, visual assessment cannot be considered completely reliable (Patton 2007).

Based on the photographs, a standard identification description was made for each rhino identified. Descriptions were given to the key features of sex, age, horn size and shape, and ear markings and any additional ‘special’ feature such as prominent scars. The full description was then reduced into a number of key descriptors as shown in table 1.

The description of each rhino, in the form of the appropriate descriptors, name and code number plus identification photographs, was entered in a Microsoft Access™ database. For Aberdares rhinos,

Table 1. Key descriptors used for identifying individuals

Category	Descriptor	Description
Sex	M	male
	F	female
Age	A	adult
	SA	subadult
	calf	calf
Horn size	>	front longer than rear
Front : rear	><	front and rear equal length
	<	rear longer than front
Rear horn shape	triangular	as descriptor
	conical	
Rear horn length	shorter	as descriptor
	medium	
	longer	
Notches right	0	no notch
	1	one notch
	2	two notches
	3	three notches
Notches left	0	no notch
	1	one notch
	2	two notches
	3	three notches
Calf sex	M	male
	F	female
	UID	unidentified
Calf age	250605	date of birth if known
	> 3 yr	as descriptor
	2–3 yr	
	1–2 yr	
	3 m–1 yr	
	< 3 m	
	none	

many rarely seen, the photographs were of the most recent face, left and right profile views and, where appropriate, former pictures. The database could be interrogated and a query form was included in its setup to enable this.

As new photographs were obtained, the descriptions were tested against the database. Where a match was found, the new pictures were compared with previous photographs of the individual to visually confirm the match. Where no match was found the new pictures were compared with all previous photographs to confirm there was no match by visual assessment and therefore a new rhino had been identified. In this way the database was built from the bottom up and a minimum population demography for Aberdares rhinos was determined.

Results

Despite the difficult 'closed bush' conditions throughout the Salient, identification photographs were obtained both in the bush during the day (from over 600 hours of monitoring time) and at the lodges at night (from 108 nights monitored), which could be used to visually assess individuals and enable a minimum population estimate to be made. During the study periods in the Aberdares, 170 rhino sightings were made, of which 31 (18.2%) were in the open bush during vehicle-based patrols, 84 (53.5%) were at the Ark waterhole and 55 (28.3%) at the Treetops waterhole. Based on the noted features of each rhino, a standard identification description was made. An example is given in figure 1 for the rhino Ann, one of the regularly seen individuals visiting the Ark waterhole at night.

Visual assessment of the identification features of the rhinos photographed suggested there were at least 23 individuals. Seven of these had been individually identified from previous records and already had names—Ark, Ruinu, Ann and calf Lucy, Siankikki and calf Daniel, and Nyalou. The remaining 16 rhinos for which good identification photographs had been obtained were assessed as new individuals and named during the research period. The identities of another 9 rhinos were considered uncertain as, while they appeared to be different from the 23 named rhinos, their identification photographs were of insufficient quality to ascertain identification reliably. These rhinos were ascribed the title Tofauti plus a letter A to J (see table 2). In some cases a rhino was photographed on only one occasion and it was not possible to verify the consistency of its identification features, especially horn size and shape.

With the importance of the Ark and Treetops waterholes as sources of sightings (81.8%), some further analysis was undertaken using data collected daily by staff at the two lodges at each of the waterholes. It may contain some bias because the consistency of recorder effort is not known. The results, shown in table 3 and figures 2 and 3, clearly demonstrate a major decline in the number of sightings at both sites over the period. In both cases, the monthly pattern of sightings is

Horn anterior: medium long, gently curved, narrow rounded tip
Posterior: short, narrow and triangular, rounded tip, back face indented in top third with front face straight, $^1/_2$ of anterior
Ears: clean, hairy fringed
Other: ring marking on stomach

Figure 1. Example rhino identification description and photographs produced for Aberdare rhinos.

Table 2. Aberdare National Park, black rhino demography 2004 (estimate by first author)

Male	Female	Calf	Subadult	Unknown
Ark	Ann	Lucy f	Daniel – male	Tofauti A ?
Ezekiel	Kilema	—	Hurricane – male	Tofauti B f
Ndirangu	Malaika	Hadija f	male like Nyalou	Tofauti C f
Ngiriini D	Nyaruii	?		Tofauti D f
Ngiriini W	Pembemoja	Kelele m		Tofauti E ?
Nyalou	Siankikki	Aberdare m		Tofauti F ?
Nywele	Treetops	? m		Tofauti G sam
Ruinu	Wanjiko			Tofauti H f + calf
	Warimu	Mwangi m		Tofauti J ?
	?	?V small ?		
8	10	8	3	9

Any rhino given a name including Tofauti has been photographed. Any rhino marked ? has not been photographed but has been recorded by a ranger. It is possible that Tofauti rhinos are actually ones named but the photographs are not conclusive.

f – female; m – male; sam – subadult male

generally the same for all years, suggesting the drop is real and not a seasonal effect. Figure 4 illustrates the reduction in total visits per year.

After the rangers had been trained in identifying the named individuals, more recent daily sighting records of the rhino-monitoring patrols were reviewed to determine when the rhinos identified in table 2 had been last seen.

At the Ark waterhole, the male Ark was last reported on 10 March 2003, the male Ruinu on 14 May 2003. The male Nyalou was seen regularly from September 2003 until the end of July 2004. The subadult male Hurricane visited the waterhole between September 2004 and the end of November 2004. The adult female Ann was seen with her calf Lucy until the end of April or early May 2004, when Lucy started to appear alone. Ann had a male calf in June 2004 but it was killed. Lucy reunited with Ann from August 2004 and they were always seen together from then on. The male Ngiriini W was seen in its normal area

Table 3. Rhino sightings made at the Ark and Treetops waterholes, 1999, 2002 and 2004

	ARK			TREETOPS		
Month	1999	2002	2004	1999	2002	2004
January	81	88	41	51	31	46
February	46	74	36	38	18	29
March	67	53	26	52	33	31
April	70	44	24	26	45	48
May	79	56	37	66	31	55
June	96	61	31	47	37	15
July	67	42	40	36	23	14
August	76	29	39	85	34	16
September	81	36	62	27	17	14
October	63	45	46	42	16	15
November	42	23	26	69	26	26
December	60	18	16	69	43	24
Annual	828	569	424	608	354	333

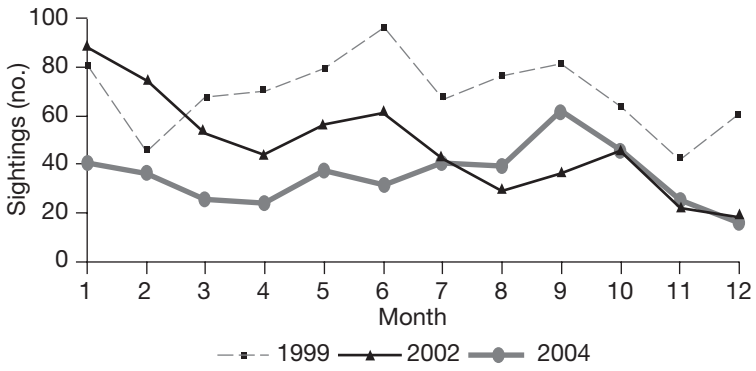

Figure 2. Monthly rhino sightings made at the Ark waterhole, 1999, 2002 and 2004.

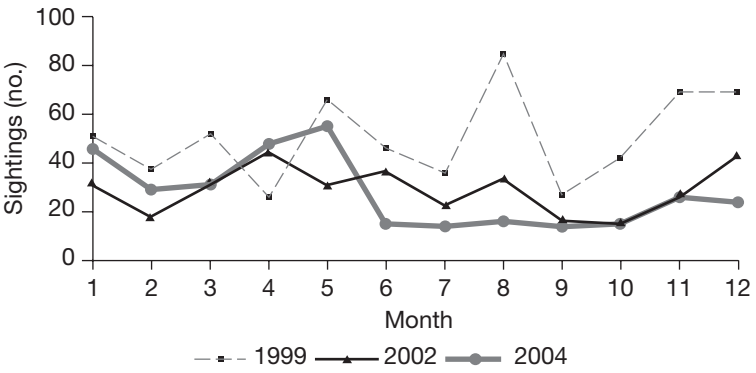

Figure 3. Monthly rhino sightings made at the Treetops waterhole, 1999, 2002 and 2004.

around the Treetops waterhole on 16 November 2004 then was later seen for the first time at the Ark waterhole on 22 January 2005. It was fighting with the female Siankikki, who would have been a candidate for mating as her calf Aberdare had beens poached on 21 November 2004. Since February 2005, Ngiriini and Siankikki have been seen together.

The female Malaika and her calf Hadija were last observed at the Treetops waterhole on 8 October 2004; the female Kilema, a regular visitor, was last observed there on 3 November 2004. The female Pembemoja and her calf Kelele were last observed at the waterhole on 18 February 2005 but were positively identified nine days later at Ngiriini Dam, on 27 February. These were the only rhinos visiting Treetops regularly at the end of 2004 and the beginning of 2005.

The number of newly identified rhinos found during each of the study periods in Aberdares is shown in figure 5. New sightings tailed off from June 2004 and no new sightings were made during 18 days of monitoring in 2005.

A reconsideration of the demographics of the rhino population was made based on the date of the last sightings and resightings in the first half of 2005 (table 4). The names shown in bold are of the only seven individuals that could be found and photographed in June 2005 over 10 days and nights; patrols sighted no others. Only four adult rhinos were seen regularly during the study periods and these were all easily distinguished—the only male was notched in the left ear, one female had no rear horn, another female had long horns of equal length and a small ear notch, the third female had a prominent body scar.

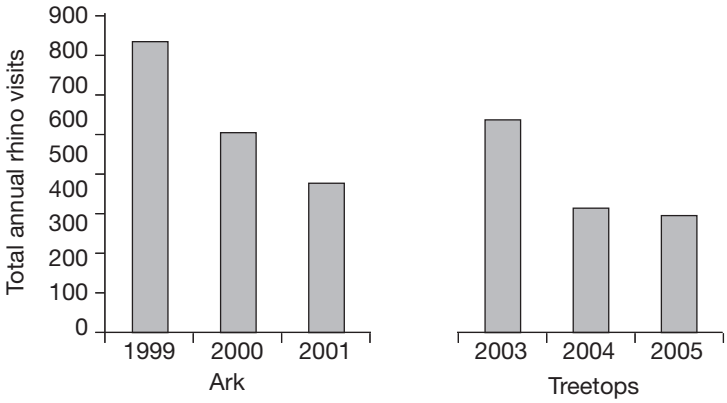

Figure 4. Total number of rhino sightings at the Ark and at Treetops waterholes.

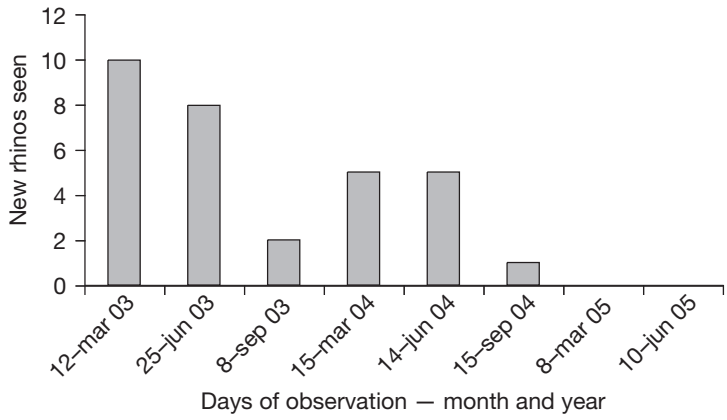

Figure 5. Number of newly identified rhinos at each study period in Aberdare National Park.

Discussion

Identification of individuals

Photographs from both still and video cameras were essential to obtain the identification description as some of the sightings were very brief. With the photographs available for extended analysis, identification features that were missed at the time of the sighting were seen and described.

Development of the photographic identification database for the Salient and a standard method of describing the identification features of each of the rhinos enabled details of individuals to be disseminated, patrol rangers trained to identify individuals accurately, the population demography described, and changes in minimum population size observed.

Photo identification enabled the sightings at the Ark, where names were being assigned to each individual seen, to be verified and, where inaccuracies were found, rangers trained to correct the inaccuracies. At Treetops, where all sightings were being recorded as unidentified, names and descriptions enabled all sightings to be assigned to particular rhinos. It had been decided to station one ranger at Treetops full time, whhich enabled him to acquire, with the help of the photographs, experience in recognizing rhinos visiting the waterhole and thus ensure accurate identification.

It also meant that even when individual sighting frequency was low, a combination of identification features could still be used to describe an individual rather than relying on a single feature, however distinct. For example, the rhino Pembemoja had no rear horn and was therefore distinct. However, another rhino could, at some time in the future, lose its rear horn and be mistaken for Pembemoja. Pembemoja was therefore fully described as a female, with a class D female calf, with clean but clearly tufted ears and no rear horn.

Table 4. Aberdare National Park, black rhino demography as at June 2005

Rhino	Last seen	Rhino	Last seen
MALE		SUBADULT	
Ark	March 03	Daniel	February 04
Ezekiel	March 03	Hurricane	November 04
Ndirangu	June 04	**? female**	**June 05**
Ngiriini D	June 04		
Ngiriini W	**June 05**	UNKNOWN	
Nyalou	July 04	Tofauti A ?	June 04
Nywele	October 03	Tofauti B f	March 04
Ruinu	May 03	Tofauti C f	March 03
FEMALE		Tofauti D f	March 03
Ann and Lucy	**June 05**	Tofauti E ?	June 04
Kilema	November 04	Tofauti F ?	March 03
Malaika and Hadija	October 04	Tofauti G sam	March 03
Nyaruii	June 03	Tofauti H f + calf	May 03
Pembemoja and Kelele	**June 05**	Tofauti J ?	March 04
Siankikki	**June 05**		
Treetops	June 03		
Wanjiko	June 04		
Warimu and Mwangi	January 04		

Names in bold are of rhinos photographed in June 2005; f – female, sam – subadult male, ? – sex unknown

The KWS standardized monitoring system requires rangers, at the time of sighting, to make drawings of a rhino's identification features on a special form (Adcock and Emslie 2004). For drawings to be accurate, the observer needs time to see the features carefully and record them correctly—which many rangers find difficult. Drawings are less appropriate where sightings last for a relatively short period, as is the case in Aberdares. An alternative was developed—a sighting record form (fig. 6)—to act as a prompt for rangers to look quickly for key features. Even after a brief sighting and on immediate prompting, rangers can remember a lot of detail, which can be recorded. In dense habitats, like the Aberdares, where sightings are infrequent and where often nothing is currently being recorded from a brief sighting, the gathering of such additional information could be especially helpful in deciding if there were more rhinos to find. While rangers may not be able to state which rhino they saw, they may recognize it if they saw its picture. By interrogating the database with the details collected at the sighting, photographs of individuals that potentially match their description can be selected from those available for review with the possibility that a rhino that has not been seen before is identified. However, visual assessment of photographs is not without error (Patton 2007) and any selection a ranger makes would have to be treated with caution.

An additional problem is that the system would provide a 'result' even if the ranger may have wrongly described the rhino seen. For example, if an Aberdares adult male rhino was said to have one notch in its right ear instead of two, it would have been identified as Ezekiel and not Ngiriini D or Ngiriini W.

Or if it were described as having one notch in the left ear instead of the right, it would be identified as 'new'.

The 'simple to construct and interrogate' database approach is appropriate for use with any rhino population. The 'sighting record form' approach offers an easier alternative to that of drawing but the level of error arising from each would have to be determined and compared before deciding which one (or both together) might be appropriate for individual populations.

Sighting record

1	Rhino sex		male	female	DK		
2	Rhino age		adult	SA	calf	DK	
3	Calf	calf sex	male	female	DK	none	
4		calf age	< 3 m	3–12 m	1–2 yr	2–3 yr	> 3 yr
5	Ears	right notches	0	1	2	3	DK
6		left notches	0	1	2	3	DK
7	Horns	front : rear	longer	equal	shorter	DK	
8		rear shape	triangular	conical	DK		
9		rear length	longer	shorter	equal	DK	
notes			any other feature				

Date ..... Observer .....

Figure 6. Field sighting record form. DK – don't know

Previous to this study, most rhino sightings including those at the lodge waterholes (some of which were first class sightings) had to be classified by most rangers as 'unidentified' because there was no description or name or code for each rhino on which to base an identification. During the study, most daytime bush-based sightings that were photographed were found to be of known, subsequently named, rhinos. With most individuals now identifiable and most sightings and resightings recorded by name rather than as''unidentified', it should be possible to make an overall estimate of the rhino population using mark-recapture analysis.

Reasons for the apparent decline

Two possible reasons have been put forward for the decline in sightings (and consequently the population from potentially 30 to possibly just 7)—drought or poaching. It was reported in the press that February 2005 was the hottest in Kenya for 20 years. In the Aberdares this followed poor short rains with dried-up dams and shrivelled vegetation. It was thought likely that the rhinos no longer seen regularly in the Salient had moved to higher ground where habitat would have been 'fresher'. It was believed that they would return to visit their normal waterholes following rains. There was a normal rainy season recorded in March and April but no rhinos had returned by the end of June 2005 (table 3). It is possible that they found new home ranges but there was only one confirmed sighting of a rhino outside of the Salient during the study period and no spoor reported.

A far more plausible hypothesis is that the rhinos were being poached. It has been suggested that a professional poaching unit was operating in the area with some 30 rhinos killed in a five-year period on nearby Solio Ranch (E. Parfet, director and general manager of Solio Ranch, pers. comm. 2006). A poacher caught in Solio made a statement to the effect that elephants and rhinos were being poached in Aberdares (E. Parfet, pers comm. 2006). This is supported by the known loss to poaching of the rhino calf Aberdare in 2004, snare marks around the body of Kilema, snare marks on other large animals such as buffalo, and the many snares found in the park. Because the vegetation is dense and there is a high density of hyenas, finding a carcass is difficult, so the lack of such finding is understandable. Therefore, poaching offers a credible reason that so many rhinos were not resighted. However, more research is necessary before any firm conclusions can be made.

Whatever the cause of the decline in numbers is found to be, it is only since the rhinos have been individually identified and named, the result of this study, that this analysis has been possible.

Acknowledgements

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