INDIVIDUAL IDENTIFICATION OF THE BLACK RHINOCEROS *Diceros bicornis* AND THE USE OF PHOTOGRAPHS

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Individual identification of the black rhinoceros and the use of photographs

TABLE OF CONTENTS Page

1. Report Outline

Between June 2001 and May 2005, a study was undertaken with the aim of examining the use of photographs for the recognition of individual black rhinos. Fieldwork was carried out at Port Lympne Wild Animal Park, UK, and Sweetwaters Game Reserve and Aberdare National Park, Kenya.

The specific objectives were to:

i) identify the features which can be potentially used to distinguish individual rhinos and to confirm that these can be successfully photographed under field conditions;

ii) identify the consistency of rhino identification features and review the speed and frequency of changes to these features which would lead to misidentification of individuals;

iii) identify the usefulness of each identification feature in differing habitats

iv) identify the likely sources of error in using photo identification

Following a review of the literature on the features that determine the identification of individual black rhinos, initial field work was carried out on a captive population of black rhinos at Port Lympne Wild Animal Park in the UK. As a captive population is readily available, easily accessed and used to humans, it offered the best opportunity to obtain the highest quality identification feature photographs and on more than one occasion.

The next stage was to take identification photographs of a wild population in an enclosed sanctuary, the Sweetwaters Game Reserve in Kenya.

Having successfully carried out identification research on a well known population in a habitat that could be described as ‘open bush’ allowing for relatively easy access to individual rhinos, the techniques learned were tested in the Aberdare National Park, Kenya - a more challenging ‘closed bush’ environment where photographing rhinos was much more difficult.

All the research was based on the premise. Published work on other species showed that judges differed markedly in their ability to accurately identify individual rhinos from photographs and errors could occur with all judges. A series of tests were carried out to determine if the same or different errors arose when identifying black rhinos from photographs.

2. Summary of Key Conclusions

This study demonstrates:-

i) the features used for the identification of individual black rhinos are sex, age, horn shape and length, ear notches and deformities, body scars and corrugations, tail shape and size, nose and eye wrinkles, mother and calf association and calf development.

ii) the essential value of photographs in accurately identifying individuals in a population of black rhinoceros

iii) the need to obtain and use good quality identification photographs, especially for those individuals with less distinct identification features, in order to make accurate identifications

iv) that there are photographic and computer techniques that can be used to obtain and improve the quality of the identification photographs

v) that changes may occur in the importance of each feature used to identify a rhino depending on the habitat type and behaviour of the rhinos in a specific population

vi) that while large differences can arise in the aptitude and the level of ability of judges to identify individual rhinos from photographs, the skill can be learned

vii) that the correct identification of individuals is essential in order to provide accurate information on a population and so manage it for maximum output.

3. **Recommendations**

i) A good quality (6+ million megapixel) single lens reflex digital camera with 400mm lens is ideal for identification photography especially where time available in the field is limited. Where time is not limiting, a 3+ million megapixel digital camera with x10 optical zoom can give excellent results. Digital photographs are easier to handle and give better quality than medium quality scanned print film. A digital video camera with x20/25 zoom is useful in low light conditions or for identifying the sex of individuals especially calves.

ii) Where a vehicle is available, one which is small sized and dark green coloured which blends into the bush habitat is preferred to those which are larger and bright coloured (often white) which rhinos become aware of from a distance and usually run off.

iii) The results obtained show that using photographs to identify individual rhinos is not without error but that such errors can, in part, be reduced in practice. It is recommended that, where possible:

a) several photographs of the same rhino showing as many different identification features should be reviewed so that as much identification information is available on which to make a judgement.

b) the quality of the photographs should be as high as possible although in practice this may be limited by the location of the rhino at the time the photographs are taken. If there is sufficient time, it will benefit the accuracy of identification for either the photographer to move, and/or to wait for the rhino to move, in to positions where good, clear identification photographs are taken of different views of the rhino from different angles.

c) photo-identification databases should be continuously updated to take account of changes in the identification features of an individual eg broken horn, torn ear while calf and sub-adult identification features develop as the animals mature. Populations will need to be re-photographed and new photo-identification booklets distributed about every two years

d) while nothing can be done to improve the distinctness of a rhinos natural identification features, ear notching - cutting shapes in the ear of a rhino while anaesthetised - makes an individual more distinctive. As this process is invasive, costly and may affect the rhinos' future behaviour, it should not be considered as a general recommendation to improve identification accuracy but rather to overcome specific problems where two similar featured rhinos are hard to distinguish.

e) before a person is chosen to make identification judgements from photographs, they should receive appropriate training and be tested to show they have an aptitude for the task. It should not be assumed that someone good at identifying individuals in the field will be equally as good at doing so from photographs.

f) training ranger teams tasked with identifying individual rhinos, normally as part of a monitoring programme, should be undertaken regularly, probably every 6 months, to point out any changes in identification features and to avoid 'slippage' where the identity of two rhinos may be swapped due to human error. This can be carried out using photographs in a 'classroom' situation. Verification of identifications made by each patrol should be carried out regularly in the field.

4. General Introduction to Identification

4.1. Background

Over the period 1970 to 2003, the world population of the African black rhinoceros (*Diceros bicornis* L.) has declined from ca. 65,000 to ca. 3,600 (Emslie 2004). Kenya, with 18,000, held approximately 28% of the population in 1970 but this had reduced to 1500 in 1980 and only 400 in 1990 - some 12% of the remaining population (Brett 1993). This represents the only substantial wild population of the eastern race or subspecies of the black rhinoceros *(Diceros bicornis michaeli)*; in 2005 Kenya held 87% of the world population of this subspecies.

The reason for the decline was that throughout the 1970's and early 1980's, Kenya's black rhinos were poached in all areas, inside and outside of National Parks and Reserves, with few controls and little law enforcement. It was eventually recognised that the only hope for protecting the remaining black rhino in Kenya was to place them in smaller areas which were fenced and intensively protected (Brett 1993). Kenyan rhino sanctuaries were established on both government-owned land such as Lake Nakuru National Park and privately owned land such as Solio Ranch although the rhinos located on this land remained the property of the Kenyan state.

From 1984 onwards in Kenya, an active conservation programme devoted to the recovery of the black rhino population was developed and from 1988 this became known as the Kenya Rhino Project (Brett 1993). The policy was relatively successful and from 1986, black rhinos in sanctuaries suffered negligible poaching and showed an annual increase in numbers of approximately 5% to ca. 430 in 2003. Where rhino populations exceeded estimated carrying capacity, surplus individuals, initially bred in privately-owned sanctuaries, particularly from Solio Ranch, were used to stock new sanctuaries in National Parks (Kenya Wildlife Service 2003).

In March 2003, the Kenya Wildlife Service (KWS) adopted a new management plan for black rhino conservation in Kenya (KWS 2003). Surplus rhinos from both private land and National Parks and Reserves were to continue to be used to complete the stocking of new sanctuaries in both sectors. KWS reported that there was an urgent need to maintain a sustainable and high annual growth rate in population in order to develop and conserve a genetically viable population of black rhinos of the East African race/subspecies (*Diceros bicornis michaeli*) in their natural habitats in Kenya. This was to be accomplished through increased attention to biological management and law enforcement. Active biological management should entail maintenance of appropriate stocking rates, movement of animals to 'improve' age and sex structure and minimisation of competition from other browsing species (KWS 2003).

The specific goal of the KWS strategy was to increase the black rhino numbers by at least 5% per annum and reach a confirmed total of 500 rhinos by 2005, 650 rhinos by 2010 and 1000 by 2020. The strategy also stated that without reliable monitoring data, informed biological management decisions could not be made, and progress towards meeting the overall goal could not be assessed. A standardised integrated monitoring system was therefore introduced to monitor rhino populations so as to ensure that performance targets were being reached (KWS 2003). The basic information on population performance such as birth rate, mortality, sex ratios and calving index would be provided by regular monitoring (Walpole 2002) requiring, importantly, individual identification techniques.

Individual recognition is essential for rhino management. If, for example, the density of rhinos exceeds that ‘required’ for the optimal growth rate, translocation may be necessary and to select appropriate individuals for relocation requires a detailed understanding of the relationships between rhinos within the population. Even where a population may be well below its density maximum, the need for accurate individual identification can be important. An imbalance of the sexes can create potential problems, for example an excessive proportion of males leading to fighting resulting in death (Emslie & Brooks 1999).

4.2. Identifying Individuals

Detecting variation in natural markings has been the basis for the recognition of individual animals in many studies. For mountain gorillas (*Gorilla gorilla beringei*), Schaller (1963) used wrinkle patterns on noses in combination with the shape of nostrils. Goodall (1968) used differences in facial structures for identifying chimpanzees (*Pan troglodytes*), as did MacKinnon (1974) for orang-utans (*Pongo pygmaeus*). Elephants (*Loxodonta africana*) were distinguished by differences in ear outline, vein patterns on the ears and natural ear tears, holes and nicks (Douglas-Hamilton & Douglas-Hamilton 1975). Peterson (1972) used the position and shape of stripes to produce a simple coding system to identify individual zebra (*Equus burchelli*) while the patterns on the neck were used by Foster (1966) for giraffe (*Giraffa camelopardalis*). Geertsema (1985) identified servals (*Felis serval*) by stripe and spot pattern variation but with lions (*Panthera leo*) Pennycuick & Rudnai (1972) devised a method of identification based on variation in mystacial vibrissae spots, a method which was used and extended for use with leopards (*Panthera pardus*) by Miththapala *et al.* (1989). Natural markings are relatively easy to use as they have been found to be sufficiently varied to distinguish individuals and to be unchanged over the life of the animal particularly once it has reached maturity.

Rhinos rarely possess long term natural markings but individual rhinos can be identified from a number of features including the size and shape of the anterior and posterior horns, peculiarities of the ears, the pattern of wrinkle contours on the snout, prominent scars and sores on the body, the state of the tail, body size including the size of a calf in relation to the mother and skin folds (Klingel & Klingel 1966; Goddard 1966, 1967; Hamilton & King 1969; Hitchins 1969; Schenkel & Schenkel-Hulliger 1969; Hitchins & Keep 1970). In Javan rhinos (*Rhinoceros sondaicus* L.) eye wrinkle patterns have been used to separate individuals (Polet *et al.* 1999).

4.3. Identifying Individual Black Rhinos from Physical Features.

This section is presented in chronological order to illustrate how the identification features used in current monitoring systems were first identified and developed.

Much of the recent research on the black rhinoceros, where the identification of individual animals was necessary, quote Goddard (1967) as their key reference. However it was Klingel and Klingel (1966) who first set out the criteria for identification. In characterising the relatively small (61) population of black rhinos in the floor of the Ngorongoro Crater, Tanzania, they found that the shape of the horns, deformations of the ears, prominent scars on the body, the state of the tail and the sex of the animal provided sufficient details for the recognition of all the individuals. Close-up photographs of the left and right head profile were taken using a 400mm lens.

Goddard continued this work and extended it to the surrounds of the Crater, eventually identifying 78 individuals. He used the same features but found that nose wrinkles, the pattern of wrinkle contours on the snout, was also helpful which was particularly important where horn shapes became uncertain due to tip breakages. Goddard found that identification by horns alone could be misleading, especially among rhinoceroses with relatively small horns.

The methods developed by Klingel and Goddard were used to monitor the black rhinoceros population of Nairobi National Park by Hamilton and King (1969) and this is one of the few references containing illustrations of rhino identification features. They used frontal photographs with five main features selected – sex, horns, ears, sores and scars and size. Nose wrinkles were found to be of no value as they could only be seen on very placid animals in the open. Considerable variation was found in ear hair tufts, tears and notches. Sex differences were considered to be readily distinguishable by the appearance of the external genitalia - in the male, the prepuce shows between the hind legs while in the female, the vulva is visible below the anus with the udder occupying the same position as the prepuce but less pendulous.

Mature animals varied markedly in size, from 770kg to 1270kg, and this was not related to sex. With horn size, they found that in the male the anterior horn was usually much longer than the posterior whereas with females both horns tended to be of similar length. Habitat was found to affect horn structure with individuals that had been translocated from rocky areas with short, stout horns developing longer and sharper horns in more open habitat. While sores were not present on the rhinos in Nairobi National Park, healed areas sometimes lacked pigmentation or had formed obvious cicatrices. This meant that the photographic record cards needed to be regularly updated.

In identifying individual black rhinos in the Hluhluwe Game Reserve, Zululand (now Natal), Hitchins (1969) recorded presence or absence of ears – a few animals were seen with one or both ears missing (considered to be either a genetic variation or due to predators or both) - patterns of tears in the ears, the presence or absence of the tail (absence being attributed to predators), tail abnormalities, the sex and horn confirmation and length relative to each other.

Schenkel and Schenkel-Hulliger (1969) added some additional information on individual rhino recognition from their experience in Tsavo, Kenya. Skin folds are mentioned as a feature. They also suggest it is possible to recognise the sex of the rhino from the way it urinates – whether as a horizontal shower as with bulls, or in a typically female manner, which they do not specify. They note that external features such as body size, shape and size of the horns or shape of the neck are not reliable indicators of the sex of the rhino. Males are reported to be easier to sex than females particularly in immature animals.

As a general point, it was stated that recognition of individual rhinos using the basic features of horn shape, wounds, scars and skin folds was often impossible at a distance. The association of mother and offspring was found to be useful. Mother and calf formed a stable group up until the time when the mother was ready to breed again when the calf was chased off until it was no longer in the physical presence of its mother.

The first attempt to categorise immature black rhinos into age classes was also made by Schenkel and Schenkel-Hulliger (1969). Very small rhinos were named Babies; rhinos ¼ to ⅔ of the size of their mother were named Calves; rhinos ¾ to 4/5 of the size of their mother were named Subadults. A diagram illustrating the sizes was given but there was no attempt to relate size to age.

Assigning chronological age to the size and horn growth of immature black rhinos was undertaken by Hitchins (1970) working in the Hluhluwe Game Reserve, Natal, South Africa. Five size categories were used, illustrated with diagrams and photographs:

A - Size = level with inguinal region of adult female
Horns = absent

B - Size = top of shoulder level with ventral part of vulva
Horns = anterior horn small and knob like (approx. 3" in length).
posterior horn not noticeable

C - Size = shoulder level with base of tail
Horns = anterior horn approx. 6"-8" in length. Posterior horn noticeable.

D - Size = shoulder height at a level between base of tail and sacral region
Horns = anterior horn approx. 8"-12" in length, posterior horn approx. 2"-4"

E - Size = slightly smaller than adult
Horns = anterior horn approx. 10"-12" in length, posterior horn approx. 2"-4"

Based on known age animals, Hitchins suggested age ranges of up to 6 months for A, 6 months to 1 year for B, 1 year to 2 years for C, 2 years to 3 years for D, over 3 years until age at leaving mother for E.

Black rhinos are commonly seen with skin lesions caused by filarial infestations of the parasite *Stephanofilaria dinniki*. Hitchens and Keep (1970) found that there were nine sites on a rhinos body where these lesions could be present. There was seasonal variation with lesions being redder and more prominent in the summer and receding in the winter. Lesions may heal completely making them an unreliable long term identification feature but useful in the short term.

A further refinement to rhino identification was undertaken by Joubert and Eloff (1971). They recorded the approximate size of the horns in relation to the ears and incorporated the size of the calf in relation to the female.

To age black rhinos in the Masai Mara Game Reserve in Kenya, Mukinya (1973) developed a set of categories based on four individuals whose dates of birth were known. Their pictures were taken and their body size compared with full grown individuals. Using this method, rhinos were classified into four age groups: Group I whose age was under 1 year, Group II whose age was over 1 year but under 2 years, Group III whose age was over 2 years but under 4 years and Group IV whose age was over 4 years. The method was acknowledged to be similar to that of Schenkel and Schenkel-Hulliger (1969) and was considered to be most useful for rhinos accompanied by their mothers and those which had just left their mothers.

Mukinya (1976) observed and photographed the main identification features highlighted by Goddard, Klingel and Klingel and Hamilton and King on 108 individuals found in the Masai Mara Game Reserve, Kenya and found the length and shape of horns varied with sex and age. Mature females had horns of similar length, the posterior horn being erect, the anterior horn curved from the second quarter. Mature males usually had a shorter posterior horn than anterior. With both sexes, the sub-adult had a short anterior horn which was curved half-way while the posterior horn was very small. In calves the anterior horn was very small and there was no posterior horn, only a swelling where the horn would grow later. Hair tufts and cuts on the ears varied considerably. In this rhino population, the wrinkle joining the two nostrils was continuous and straight. The total number of nose wrinkles varied between five and eleven. Wrinkles got progressively longer, the nearer to the base of the anterior horn. Considerable variation was observed in wrinkle pattern.

Mukinya created a classification scheme from his identification photographs using designated marks to classify ears, horns and nose wrinkles. The edge of the ears was divided into four equal parts and numbered I, II, III and IV starting from the median edge. The horns were divided into four equal vertical parts and numbered 1, 2, 3 and 4 from the base of each horn. By assuming an imaginary line running vertically from the base of the anterior horn to the mid-point of the upper lip and another line horizontally from one nostril to the other (actually a true nose wrinkle), the front of the face was divided into four quarters. Working clockwise and starting with the right lower quarter, they are lettered A, B, C and D. The sex of the individuals was classified in the field. This system enabled a classification key to be created from which an individual rhino could be described by a formula. The key used was:

M, male; F, female; R, right ear; L, left ear; N, normal ear; V, V-cut present on the ear; U, U-cut present on the ear; W, finger-like cuts on the ear; T, long hair tufts on the ear; S, posterior horn short; K, erect horn; Z, curved horn; Q, anterior and posterior horns are of similar lengths; P, posterior horn; O, anterior horn; X, cross-over wrinkle; I, wrinkle is discontinuous before reaching vertical mid-line; Y, wrinkle is branched.

An example formula is given as M; RUIV; IB, IC, YB, YC to represent a male rhino with U-cut, branched and discontinuous wrinkles. Mukinya claimed that applying the keys made it easier for the observer to identify the individuals quickly. However there are no examples in the literature that show that the system was ever taken up by others, probably as, in practice, it is overcomplicated and difficult to learn.

Frame (1980) noted that a sexually mature female could be distinguished by the large, dry white stain on the hind legs and vulva caused by a female in oestrus dribbling urine every few minutes. This observation was used in formulating an age categorisation of the individuals found on the Serengeti Plains in northern Tanzania. It was based on three categories: adult, immature and calf defined as - “Adult was considered to be sexually mature, but necessarily full grown (about 4 years old and older); Immature was considered to be not sexually mature, but had left its mother and is nearly fully grown (about 2¼-4 years old). The anterior horn is less than ear-length; Calf was considered to be one still with its mother”.

Frame used the standards for identification set in the 1960’s and found that none of the rhinos observed matched those of Goddard’s studies in the Oldupai Gorge. He concluded that while a third of the rhinos could be considered to have died in the intervening period, the natural physical features of the survivors had probably changed significantly. This illustrates the need for regular monitoring and updating of identification indices.

In undertaking a study of the reproductive performance of a population of 47 black rhinos on Ol Ari Nyiro ranch, Laikipia, Kenya (Brett, Hodges and Wanjohi 1989), visual sightings were found to be impaired by the thick bush. To overcome this problem, individual rhinos were identified from the measurements and features of their footprints. The main characters were found to be the width of the hind feet between the two side toes and the patterns of wrinkles in the base of the footpad. Such detail could be captured in fine, dry soil and were found to be unique to each animal. This is a technique which had been mostly used for Sumatran rhinos (*Dicerorhinus sumatrensis)*, the most detailed and extensive published work being that of Van Strien (1985). None of the studies were able to verify the accuracy of the estimates of population by relating footprints to actual animals.

A hind foot spoor measurement was taken for the identification files for the black rhinos of Damaraland, Namibia where a complete record of almost every individual with photographs and relevant statistics was completed by 1986 (Britz and Loutit, 1989). The authors reported that regular monitoring was carried out with teams of three – a tracker who notes ear notches, a ranger who notes tail deformities and sex and a photographer who attempts to capture a side, front and back view of the animal. Left and right hind feet spoor measurements were recorded by Cilliers (1989) in Etosha National Park, Namibia.

Digital photography and image analysis by computer were used by Jewell, Alibhai and Law (2001) to identify individual black rhinos from their spoor. Photographs were taken with an Agfa e-photo 1280 digital camera at medium resolution (1024 x 768 pixels). Adobe Photoshop software was used to optimise image quality and discard colour information. Thirteen landmark points were placed on the image which was then exported into customised NiSAS software which positions a further thirteen derived points. Using all these points, 47 length and 30 angle measurements are obtained for statistical analysis. By using tracks, a series of 15 photographs for each footprint was recommended in order to obtain an identification accuracy of over 90%.

The essence of rhino spoor identification is the availability of good spoor quality. This is influenced by the age of the spoor, the substrate, wind strength, light quality, pace of the animal, slope of the terrain and the presence of other animals. It would seem, therefore, not without limitation in its application to individual rhino identification.

It can be concluded from the literature reviewed that the statement 'not without limitation in its application to individual rhino identification', can be applied to any of the features mentioned for individual identification. It has been stated that horn size and shape varies with different habitats and that breakages can make identifications uncertain. To determine nose wrinkle patterns, tail differences and skin fold differences and scars/sores, the observer has to be close to the animal and scars/sores may heal or change in appearance due to the season.

More useful were sex differences as they could usually be determined as genitalia are external and readily discernible while the sex can also be determined by observing the way a rhino urinates but sex alone is insufficient to identify an individual rhino. Ear deformations through tears and notches or tufting was also found to be useful but were not always present and could be obscured by the habitat, as was the association between a mother and calf. Given the limitations expressed, it can be seen that identification based on a single feature is unlikely to be reliable and the more identification features that can be recorded at a sighting, the more reliable an identification is likely to be.

In every case, the scientific literature referred to previously, fails to illustrate in any detail, or show examples of, the sort of differences that the observer is looking for in rhino identification. The best source, particularly for the inexperienced, is the Rhino Monitoring Training Programme Trainee's Manual by Milledge (1998) and Adcock & Emslie (2000), updated 2003. Sections 1.3 Sexing, 1.4 Aging and 1.5 Identification show clearly the features that should be observed while other sections cover the various aspects of rhino monitoring.

4.4. Kenya Wildlife Service Monitoring

In 2001, KWS introduced a standardised integrated monitoring system to monitor rhino populations so as to ensure that performance targets were being reached. KWS stated that the monitoring of populations should be undertaken using recognised, individual identification techniques (as outlined in the training manual mentioned above). Each rhino sanctuary received a computer loaded with a purpose built KWS Black Rhino database for storing information on individual rhinos collected by monitoring patrols. Patrol monitoring was to be based on observing rhinos through binoculars and recording, including drawing, identification features in order to establish the identity of the individual. KWS provided a standardised sighting record form on which details of the left and right body profile, the left and right head profile, a front view of the head, the left and right ear, nose wrinkles and rear view could be recorded on outline drawings.

Also provided was a Sony Mavica FD-95 digital camera to enable identification photographs to be taken and stored in the database.

Kenya Wildlife Service (KWS), and others (Adcock & Emslie 2003), also acknowledged that, as rhino numbers increased, the problems of identifying individual rhinos would also increase. There is a particular problem with 'clean' animals where ear notches or tears, a significant identification feature, are absent. As a result, a programme of ear notching 'clean' rhinos to aid in individual identification is in operation in Kenya. This entails immobilising the rhino by anaesthetic and cutting the skin of the ear to create a shaped area of the outer margin that is readily identifiable.

There are, however, a range of problems associated with ear notching and these can be summarized as follows:

- i) immobilising black rhinos may cause reduced fertility (Alhibai *et al.* 2001) which is contrary to the objective of optimising population growth rates;
- ii) inherent, albeit small, risks of death during and following immobilisation;
- iii) there are some, densely bushed, areas where darting rhinos may be risky as if the animal is not found and revived within a short time period it will die;
- iv) the procedure requires skilled veterinarian and capture team members which makes the process expensive;
- v) notched animals may need to be translocated which would require a repeated immobilisation with greater risks of infertility and death;
- vi) dead animals which have had their ears eaten by hyenas cannot be identified;
- vii) disfigured ears may not be considered acceptable to tourists.

There is an obvious need, therefore, for alternative and non-invasive methods of individual recognition. Using photography could enable the capturing of many identification features at a single sighting with time for close analysis at a later occasion.

4.5. Individual Identification Using Photographs

Photographic identification of naturally identifiable individuals is now a standard research method in studies of whales and dolphins (Hammond *et al.* 1990). It is considered particularly useful for studies of free ranging populations of marine mammals, especially in those cases where artificial marking could potentially harm animals or bias behavioural data collected (Wells *et al.* 1999).

Photo identification has been integral to the collection of information on -
associations between individuals (Wursig 1977, Shane 1990); associations between individuals at different spatial and temporal scales (Whitehead 1997); migrations (Stone *et al.* 1990); survival rate (Slooten, Dawson, Lad 1992); key population parameters such as reproductive rates, survival rates and population size (Bigg 1982, Hammond 1986, Buckland 1990) and the measurement of social groupings, movements, residency, abundance and life history (summarised in Mann 2000).

An advantage of using photographs to confirm identity is that whatever features are actually being used to identify individuals, they can be carefully scrutinised without time limit. This is important for the black rhino as they are very nervous of humans and a field sighting of a rhino may be over in seconds. The problem is exacerbated where observations are being made in heavy bush or at long range.

Photographs of rhinos can be obtained by camera trapping using an infrared transmitter, an infrared receiver and a modified compact camera. Whenever the infrared beam is interrupted, the receiver gives a signal to the camera, which is then triggered. While not all pictures have the targeted species on them - big raindrops, insects, falling leaves and so on can trigger the mechanism - this has proven to be an excellent technique to use to capture evidence of rhinos in dense forested areas.

Polet *et al.* (1999) report work with Javan rhinos (*Rhinoceros sondaicus* L.) in the Ujong Kulon National Park, Java, Indonesia where, due to the small population and very dense forest, rhinos have not been seen for several decades. From the photographs taken, eye wrinkles were among a list of eight parameters with which individual rhinos could be recognised. Polet used the technique with the rhinos in the Cat Tien National Park, Vietnam (Polet *et al.* 1999) finding eye wrinkles on three pictures appeared to be more oval than the other four pictures supporting previous evidence that there had been two different rhinos photographed.

A technique for using enhanced photographs to ensure individual rhino recognition in the Masai Mara National Reserve, Kenya has been reported by Morgan Davis (1996). The author suggested that the larger the population under study, the greater the problem of recognising individual physical characteristics and the greater the need for photography. Morgan Davis stated that photography, to a great extent, clarified the exact shape and size of the horns of each individual animal, thus providing a useful method of identifying one animal from another. He suggested that photographic information rendered individual rhino identification and monitoring records more reliable, helping to provide a dependable and on-going record of subtle horn changes.

Morgan Davis recommended taking either the left or right profile in a silhouette against the background of the sky or at least with a blurred background and, where possible, such that the head fills the picture. Working on the understanding that the distance between the nostril and the eye of a mature rhino is around 260mm, the negative of the profile of an individual rhino was placed into an enlarger and the image adjusted for size over a head profile template. When the right size and position was obtained, the template was replaced by photographic paper and a new image exposed. From this, it was possible, with reasonable accuracy, to determine the length and shape of each of the horns and their forward and/or backward tilt. When compared to a field sketch, a much more accurate portrayal of the shape and size of the horns was obtained. A tracing of the revised image was transferred to an individual identification card. It was recommended that each animal in a population should be re-photographed at least every two years and more frequently where possible.

Using a photographic enlarger is a relatively cumbersome and expensive procedure and not very practical in field conditions. However, with the recent development of computer hardware and software, including photographic scanning, the potential to digitally enhance the identification features of a photograph should be significantly increased. This allows for even relatively poor photographs to be used for more positive individual identification.

While the use of close-up photography is considered fundamental to rhino identification and record keeping, it may not be possible to get very close to rhinos in the field and, even with the use of a zoom lens, the best obtained photograph may not show identification features clearly. In the literature, little or no detail is given, or attention paid, to recommending techniques for obtaining best photographs or the problems encountered with taking identification photographs.

Once suitable photographs are available, the next stage is to select the features which can actually be used for the individual identification and with as little potential error as possible. Mistakes in identification, whilst rarely documented (Berger *et al.* 1994), are generally accepted to occur regularly (F. Patton personal observation). Using the current systems, there may be changes in the identification features during the life of the individual rhino due to horn breakage, horn rubbing, ear tears on thorns, healing of sores and so on which can contribute to mistakes.

5. Capturing individual identification features of the black rhinoceros on photographs

5.1. A Captive Situation

The largest black rhino herd in captivity, located at Port Lympne Wild Animal Park, Kent, UK was used to obtain high quality identification photographs in conditions considered to be near ideal. In 2001 there were 19 individuals mostly kept in large paddocks, all of which were made accessible for photographs to be taken.

The aim of this part of the study was to confirm that the features which can be potentially used to distinguish individual rhinos can be successfully photographed under field conditions and identify the consistency of rhino identification features and review the speed and frequency of changes to these features which would lead to misidentification of individuals.

5.1.1. The Study Area

Port Lympne Wild Animal Park is situated in the county of Kent, close to the coast in the south of England. It was established in 1973 with the objective of breeding endangered species in captivity for re-introduction to their natural habitat. Black rhinos and Gorillas were, and remain, the key species at Port Lympne. In August 2001 at the start of the study, the Park held 19 black rhinos and this was claimed to be the largest herd of black rhinos outside of Africa. At Port Lympne, the rhinos are released during the day into grass paddocks surrounded by a one metre high, two bar metal fence. The paddocks are bordered by concrete roads or holding areas allowing zoo keepers easy access to the rhinos. Photographs were taken from the roadways and holding areas enabling clear sighting of the rhinos which were often within ten metres of the camera.

The rhinos were originally obtained from zoos in the United Kingdom, Italy, Ireland and the Czech Republic and from wild populations in Kenya and South Africa. During the study period there were several births, deaths and translocations (including two sub-adults returned to South Africa in 2004). At the end of 2004 and the beginning of 2005, five of the rhinos were transferred to a new facility at Howletts Wild Animal Park but remained accessible. There were also three introductions, the males Joss and Mwaniki and the female Salome. Only 12 of the original 19 were still available at the end of the study in August 2005.

Rhino matings had been managed to maximise genetic diversity. For example, the four calves of the female Rukwa were all sired by different males – Baringo, Bwana Mkuba, Parky and Addo. With a widely sourced founder group and managed matings, despite the relatively small population of 19, it was expected that there would be a wide range of variability within identification features.

5.1.2. Methods and Materials

Appropriate photographs were taken of each individual (if available) from many angles and distances depending on the position of the rhino in its paddock in order to extract the identification features. Photography was carried out in August 2001, August 2003 and August 2005 in order to identify the changes in these features over time.

Appropriate photographs were considered to be high quality pictures akin to the outline drawings used to identify individual rhinos on the KWS standarised sighting record form. These drawings are of the left and right body profile, the left and right head profile, a front view of the head, the left and right ear, nose wrinkles and rear view but also including, where possible, left and right eye wrinkles as these were found by Polet (1999) to be useful in identifying individual rhinos from photographs. Therefore, eleven photographs of each individual were required for a full 'set' to show all the features used for identification.

Photographs were also taken of mothers and calves in close association to produce an example age key for the Port Lympe rhino population for comparison with the standard system (Adcock & Emslie 2003).

5.1.2.1. Equipment and Processing

In August 2001, photographs were taken with a Minolta 35mm SLR camera with a fixed 400mm lens using low cost ASA400 colour film. These were processed by a standard C41 automatic processing unit in a low cost outlet. Matt finished prints measuring 5" by 7" were produced on Kodak paper. These photographs provided the base set of identification features for each rhino.

In August 2003 and August 2005, the fixed 400mm lens was replaced with a more versatile Tokina 80-400mm zoom lens with film and processing as in 2001.

In August 2005, photographs were taken using a 6 million megapixel digital camera, Minolta Dimage 7D, with the setting ISO 400, picture quality FINE and a 512MB memory card. Digital images were downloaded directly from the camera via USB to the computer using Dimage Viewer software.

5.1.2.2. 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 where features were readily discernible e.g. head profile, at 900 dpi where features were more difficult to discern and at 1200 dpi for small features such as eye wrinkles where detail was very 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. In 2005, digital images were downloaded directly from the digital camera with no effect on quality 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. Where the file size was large, over 500KB, this was done by reducing the dpi but where it was small, under 500KB, this was done by adjusting the print size to the required height. Scans were adjusted for brightness and contrast using the Paint Shop Pro software as and where necessary.

5.1.2.3. Visual Analysis of Identification Photographs

Having obtained a 'set' of identification photographs for each rhino in August 2001 and having each rhino identified by name by the senior rhino keeper, a visual inspection was undertaken to review which features discriminated each rhino from the population. In the case of the rhino population at Port Lympne, it was possible to tell each individual apart by the visual analysis of photographs.

5.1.2.4. Changes in Identification Features between 2001 and 2005

Identification photographs taken over the study period were compared to determine whether individual identification features had changed and, if they had, whether any changes could lead to mis-identification. Photographs of the face, right and left profiles and right and left eye wrinkles taken in mid-2001 were compared to those taken in mid-2005 for the 11 rhinos present in both years. These were independently given a rating 1 to 3 by three judges – two rhino researchers and a senior zoo keeper. Where the photographs could be mistaken for different rhinos it was rated 1, where they were seen to be of a similar rhino but could be of different one it was rated 2, and where the photographs were clearly of the same rhino it was rated 3. Identification photographs of six rhino calves/sub-adults were taken at intervals between 2001 and 2005. These were, with age in months at mid 2005: Solio 48m, Limpopo 46m, Vungu 45m, Laikipia 41m, Manyara 35m, Zambezi II 31m. Photographs were reviewed for changes to/development of identification features.

5.1.3. Results

A full set of identification photographs (the left and right body profile, the left and right head profile, a front view of the head, the left and right ear, nose wrinkles, rear view, left and right eye wrinkles) for each of the available black rhinos was produced. Figure 5.1 shows an example for one rhino.

It can be seen that a face view photograph is needed to give the details of both ears and the nose wrinkles while a profile view photograph shows the horn shape and size, one eye wrinkle and sometimes (depending on the direction it is pointing) one ear marking.

5.1.3.1. Visual Inspection of Identification Photographs

Having had the identities of individual rhinos confirmed by the Senior Keeper in 2001 it was possible to highlight the key features that discriminated each rhino. These were clear to see or draw but difficult to adequately describe in words. Discriminators differed between rhinos but the most useful was ear variations - notches/cuts/margin shape/holes/hairiness (see figure 2.4 for example). Some rhinos had distinct horn shapes or lengths and distinct tail lengths, shapes and hairiness. All rhinos had different nose and eye wrinkle patterns.

When reviewing photographs taken after 2001, it was found that, in most cases, the discriminators previously determined would enable repeat positive identification. Where some individuals had similar horn shapes or where a horn had been severely rubbed to change its shape or broken off or where ear markings had changed or were obscured, eye wrinkle patterns were found to be a useful discriminator (see 6.2 for further details).

5.1.3.2. Comparison of Port Lympne Rhinos between 2001 and 2005.

Table 5.1 summarises the results of the ratings for changes in certain rhino identification features between 2001 and 2005 while Table 2.7 summarises the differences observed. It can be seen that overall the identification features change less as the rhino gets older. Changes were greatest with the rhinos of five years and under at the start of the period and could have led to the misidentification of all three such individuals – Ruaha, Magadi and Rufiji. Only one adult rhino, Kingo, might have been misidentified

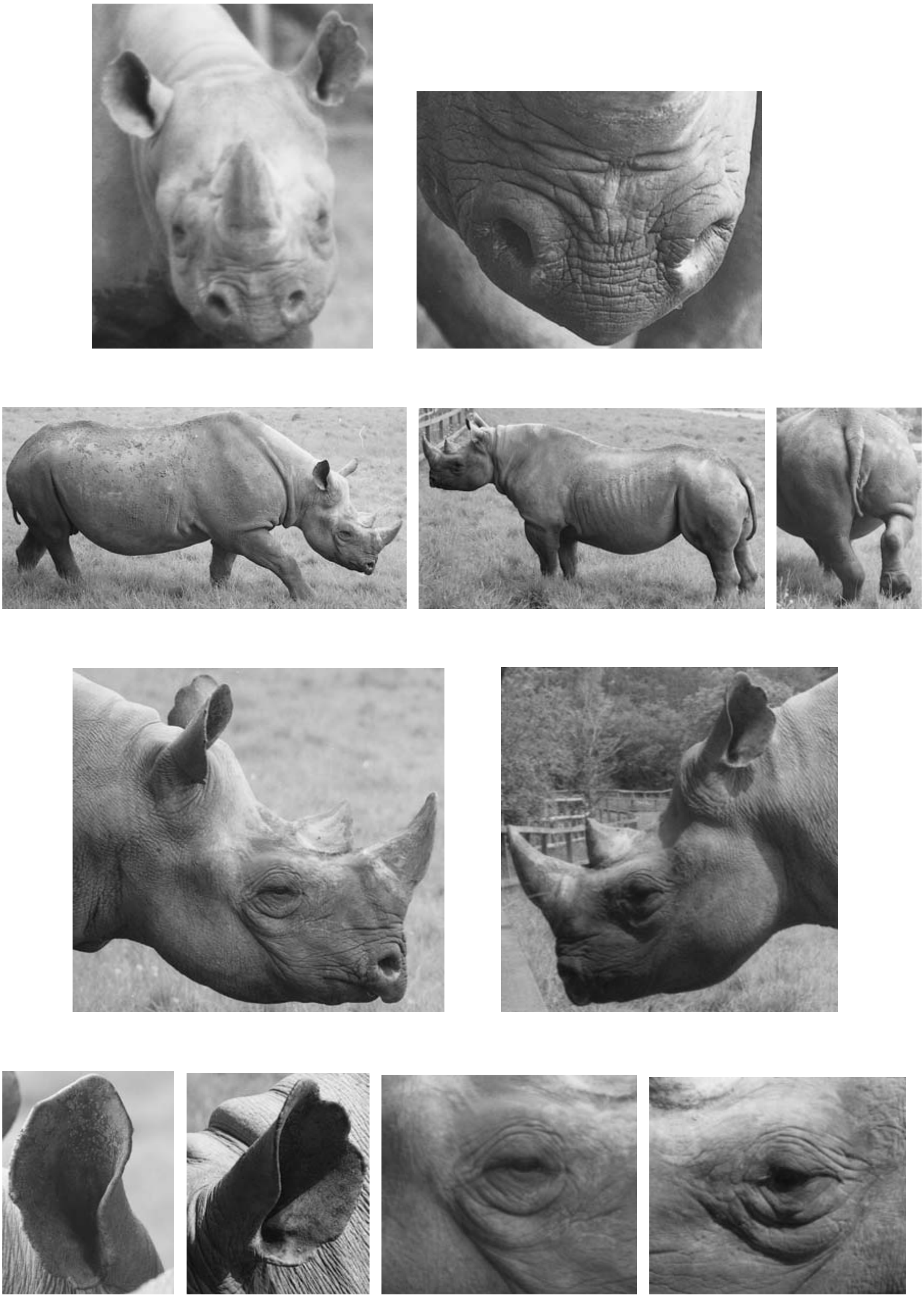


Figure 5.1. Example set of identification photographs for an individual black rhino taken at Port Lympne Wild Animal Park, UK

Of the individual features analysed, eye wrinkles showed little change and overall would not have led to mis-identifications while left and right profiles showed most change and could have led to mis-identifications. Of 22 eye wrinkle scores only 4 (18%) would have led to possible misidentification while 11 out of 20 (55%) scores for profiles could have led to misidentifications. Eye wrinkles are therefore shown to be a more reliable feature for identification over time. Changes in horn size and shape were most profound in the young rhinos moving from 2 to 6 years old while in the older rhinos the changes were due to the horns having been extensively rubbed. Table 5.2 shows that there is a significant difference between the median values with 'eyes' having the highest average rank and 'profile' the lowest.

Table 5.1. Summary of Judges Results

Rhino	Sex	Age '01	Age '05	face	rt profile	left profile	rt eye	left eye	Mean
Rukwa	f	31	35	n/a	3.0	3.0	3.0	3.0	3.00
Addo	m	26	30	3.0	2.0	2.3	3.0	3.0	2.70
Kingo	m	18	22	n/a	2.0	2.0	3.0	3.0	2.50
Nakuru	f	12	16	n/a	n/a	2.7	2.0	3.0	2.60
Vuyu	f	10	14	3.0	3.0	3.0	3.0	3.0	3.00
Jaga	f	9	13	n/a	2.7	2.7	3.0	3.0	2.85
Etna	f	8	12	2.3	2.7	2.3	3.0	2.3	2.52
Baringo	m	9	13	3.0	2.3	2.3	3.0	3.0	2.72
Ruaha	f	5	9	2.7	2.3	n/a	2.3	2.7	2.50
Magadi	m	2	6	1.7	1.3	1.7	2.7	3.0	2.08
Rufiji	f	2	6	2.0	2.3	2.0	3.0	2.3	2.32
Mean				2.53	2.36	2.40	2.82	2.84	

Rating 1 = looks like a different rhino Rating 2 = looks like the same rhino but could be different
Rating 3 = looks like the same rhino

Table 5.2. Kruskal Wallis test results on identification feature scores shown in table 5.1.

feature	number	median	ave rank	z
face	7	2.7	22.9	-0.41
profile	20	2.3	18.0	-2.84
eyes	22	3.0	32.0	3.10
overall	49		25.0	

H = 11.54 DF = 2 P = 0.003 adj for ties

Table 5.3 shows a further analysis of the results in table 5.1 by considering the effect of age with adults obtaining significantly better profile and eye wrinkles scores than those for sub-adults. Face data were limited, there being several missing scores.

Table 5.3. Mann Whitney test results on identification feature scores comparing adult and sub-adult rhinos

PROFILES	Adults		Sub-adults
n	15		5
		W = 183.5	
		P = 0.023 (adj for ties)	
EYE WRINKLES			
n	19		6
		W = 276.0	
		P = 0.015 (adj for ties)	

Table 5.4. Differences in photographs of Port Lympne rhinos between 2001 and 2005

RHINO	DIFFERENCE OBSERVED
Addo	2005 picture shows the bottom of the right ear more serated, smoother horns with the posterior horn split at the base
Kingo	posterior horn developed from triangular/pointed to thick cylindrical in shape
Nakuru	substantial rubbing disfigured horn shapes in 2001, poor 2005 right eye picture
Jaga	posterior horn grown longer and rounder
Etna	poor left eye picture in 2001, horns appear thinner and the posterior horn a bit shorter in 2005
Baringo	badly rubbed posterior horn in 2001 grown back to triangular/pointed shape
Ruaha	in 2005 the ear notches appear more rounded, anterior horn longer and sharper in the face and right profile pictures, right eye picture in 2001 poor
Magadi	2005 shows substantial horn growth especially the posterior horn
Rufiji	2005 shows substantial horn growth and the head appears wider, left eye picture in 2001 poor

Visual assessment was made of the development of identification features as seen in photographs taken of rhinos born at Port Lympne during the study period (see table 5.4). The adult face shape was established by around 15 months before which the face gave a rounder “baby” appearance. The profile shape, especially that of the horns, could be seen from around 15 months. The horns grew but maintained the general shape seen at 15 months. Key eye wrinkle lines were visible by 3 to 6 months with the skin generally smooth. By 9 to 12 months the wrinkle patterns were fully established and the skin wrinkled.

5.1.4. Discussion

Good quality identification photographs were readily obtained for the Port Lympne herd and the key features which discriminated each rhino were clear to see. The identification features changed less over time in adults compared to sub-adults and calves with the exception of the horn size and shape where excessive rubbing led to distinct changes. Eye wrinkle patterns were found to be a good discriminator of individuals from profile view photographs of rhinos.

In ideal conditions, as at Port Lympne, there were few problems encountered in obtaining good quality photographs of all of the main identification features of individual rhinos. It was possible to get close to the rhinos, in some cases within touching distance, and view them for long periods of over 30 minutes without them moving away. They could be followed by moving along the fence line enabling the angle at which the photograph could be taken to be altered. All features – sex, horns, ears, skin corrugations, tail, nose and eye wrinkle patterns and mother/calf association - were regularly and clearly visible. This situation is unlikely to be repeated with wild rhinos in bush habitat where sightings may be brief and movement of the photographer impossible without disturbing the rhino.

There was a wide variation within each identification feature which was probably due to the wide genetic diversity of the Port Lympne herd which had not only been sourced from many different areas but also had mate selection managed to ensure different males were used among the females. This situation is unlikely to occur in the wild. Many populations in enclosed reserves in Kenya have been introduced from limited sources, mostly from Solio Ranch. In addition, with black rhino males exhibiting exclusive access to several females within a given area, (ref ?.), paternity is likely to limit genetic diversity. If some identification features are inherited, a subject which has not been researched or at least reported, then individuals from the same parents may be more difficult to tell apart.

Access to the rhinos was not completely free and the time available was limited to the opening hours on the day of the visit. This meant that there were variations in the light – sometimes dull and overcast, other times bright and very sunny. The latter conditions resulted in heavy shadows which obscured some features like nose and eye wrinkles; the former conditions prevented photographs being taken with the conventional equipment. It was found that bright but not sunny conditions were best for getting good photographs of identification features especially those involving finer detail such as nose wrinkle patterns. With the digital camera, the ISO setting could be changed for each photograph - unlike film cameras where a single speed suited to the film being used has to be chosen - so low light problems could be overcome using 800 or 1600 speeds.

All identification features captured could be further enhanced by utilising simple image manipulation techniques either from scanned prints or from digital images. Scanning technology, as mostly utilised, was not available to previous researchers in the cheap-and easy form that is available today.

A full set of identification photographs for each of the available black rhinos covering the eleven identification features was produced on each occasion. The photographs were digitised, manipulated and then printed onto an A4 sheet and showed that it was possible to visually discern each rhino as a different individual. However the quality of the original photograph can affect the appearance of an identification feature and it is possible to make an error in identification if several, if not all, the features are not available to review.

Eye wrinkle patterns were found to be unique between the rhinos and consistent when photographed with the eyes open or closed unlike nose wrinkles which change in appearance depending on the position of the proboscis. An attempt was made to draw the key lines of the eye wrinkles from one photograph of the rhinos and use the data set to identify an individual from another picture. This was found to be very difficult but when comparing photographs with photographs (not the drawings) it was straightforward. However, in bush conditions, it may not be possible to get so close to the rhinos to get such clear eye wrinkle pattern photographs as was the case at Port Lympne.

The digital camera was introduced as a cost saving measure for the project. The tendency had been to take a number of shots of a particular feature from different angles at different light levels to be sure of getting a good result. There was a high wastage of the prints produced as only the best one might be used from half a dozen pictures leading to a high film and processing cost. The digital camera with large memory card enabled even more pictures to be taken but with only the cost of the time taken to sort out the best one to use. For photo-identification projects such as this, if funding can be found at the outset to purchase a good (6 million megapixel plus) single lens reflex digital camera with up to a 400mm zoom lens, it will be a significant cost saving over print processing in the longer term.

5.2. A Wild 'open bush' Situation

The experience gained in photo-identification from the captive herd of black rhinos at Port Lympne was applied to those of a wild herd in Sweetwaters Game Reserve, Kenya which was created on the Ol Pejeta Ranch as a fully enclosed rhino sanctuary in 1989. Over the next 5 years a founder population of 13 black rhinos was built up by introductions into the enclosed area where there were no indigenous rhinos. These were heavily protected in ideal rhino habitat with a consequent increase in population of 9.15% over the next 10 years.

Sighting data for each rhino are collected by patrols which look for rhino every day of the year. The aim was to see each rhino at least once a month to ensure they had not been poached and that they were healthy so did not need veterinary assistance. From the sighting data, breeding performance can be monitored to ensure that the sanctuary is meeting its growth targets. All this requires accurate identification of individuals. Some Sweetwaters rhino rangers had received training in the KWS monitoring system introduced in 2001 and inexperienced rangers work with experienced rangers to learn the visual assessment techniques. An independent assessment of the rhino monitoring at Sweetwaters (Demmers, 2002) recorded that "The rangers at Ol Pejeta appear to be good at identifying individual rhino.. I would recommend that the rangers at Ol Pejeta are used to train other RMG staff…" suggesting it to be among the best in Kenya.

The aim of this part of the study was to examine the potential to identify individuals from photographs taken in the less-than-ideal field conditions found in an enclosed rhino sanctuary in the wild by building up a dataset of computer software enhanced identification photographs of the individual black rhinos at Sweetwaters Game Reserve and then use visual analysis to identify their key identification features

5.2.1. Study area

The Sweetwaters Game Reserve is located within the 46,000 hectare Ol Pejeta Ranch in the Laikipia District of Kenya, between 0º00′N and 0º05′N, and between 36º53′E and 37º00′E. Altitude is between 1770 and 1820 metres. An electrified fence encloses the 93 km² Reserve. The main habitat frequented by the rhinos at Sweetwaters is principally characterised by *Acacia drepanolobium, Euclea divinorum* or a mix of both.

Water is readily available from rivers or man-made dams supplemented by many water pools formed after rains. In February 2002, the start of the research period in Kenya, 31 free- ranging black rhinos, including calves, inhabited the Reserve. At the end of the period, in October 2004, there were 38. Photographs were taken during two periods in each of 2002, 2003 and 2004: between January and March after the short rains and between August and October after the long rains.

5.2.2. Methods and Materials

Rhinos were located by, initially three, and latterly four, rhino monitoring teams who patrol the game reserve. Teams usually set out from 7am and completed their patrols by 1pm. The location of any rhinos found was radioed to the Research Centre so that myself and the Sweetwaters Head of Security or an armed ranger travelled to the position as soon as possible.

Having re-located the rhino, appropriate photographs, (the best quality pictures which matched the outline drawings used in the KWS standardised sighting record form - the left and right body profile, the left and right head profile, a front view of the head, the left and right ear, nose wrinkles and rear view but also including, where possible, left and right eye wrinkles), were taken from as close a distance as was safely possible. It was deemed essential that the rhino should not be disturbed by the monitoring activity so a conservative distance had to be maintained. This distance varied depending on wind direction (downwind, upwind or swirling), amount of cover (tree availability for refuge in case of attack), behaviour of the individual (asleep or moving) and disposition of the animal (calm or nervous).

From 2003, the research was also carried out at times before and after the normal patrols in order to obtain additional and/or improved identification photographs. It was found that, between 6.15 am and 7.15am certain rhinos crossed over a particular area of road probably moving from their night locations to their day resting sites and could usually be sighted clearly and at close range. Rhinos were also found moving to or at browsing sites in late afternoon/early evening usually between 5.15pm and 6.30pm. At these times, photographs were mostly taken from a vehicle which was manoeuvred as close to the rhino as possible.

5.2.2.1. Equipment and Processing

The camera used was a Minolta Dynax 5 with a Tokina 80 mm to 400 mm zoom lens. The single lens allowed for greater flexibility and versatility in the open ground conditions. Creating noise by changing lenses in the presence of a dangerous animal is not recommended and such disturbance could lead to an abrupt end to the photographic opportunity.

Films were processed regularly at the local town of Nanyuki on a Kodak C41 automatic processing machine. By having a set of prints to hand, it was possible to record which identification features had been successfully captured so that on a subsequent sighting, effort could be focused on attempting to obtain those that were missing.

Where photographs were taken early and late, in dawn and dusk light, the still camera was not able to capture photographs until the sun was high enough. A Sony TRV240 digital camcorder using High8/Digital8 tape and with x25 zoom and low light requirement was used and still pictures extracted from a video stream using PIXELA ImageMixer Version 1.0 for Sony software. Photography was mainly carried out from a vehicle. Following the successful application of the digital video to rhino identification photography, the equipment was taken to all daytime sightings and was used in tandem with the still camera.

5.2.2.2. Image Enhancement

The equipment and techniques employed were as outlined in 5.1.2.2. Where still pictures were extracted from a video stream individual frames were enhanced using Paint Shop Pro. The downloaded images are presented at 72 dpi. Resizing to 2.25 inches high, as with print scans, was undertaken, wherever possible, by upgrading the dpi quality to the enabled maximum (as the dpi is increased, the print image is reduced).

Playback of the video through the computer and still images extracted were often much darker than when played back through the video camera using its LCD screen. Still images, which do not contain full colour information when downloaded could be significantly improved for clarity by using the histogram function in the Colours drop down of Paint Shop Pro, selecting the histogram adjustment function, adjusting the low and high settings to 0.003% and the gamma to the best level for each image. Usable greyscale images were obtained where the original was unusable.

5.2.3. Results

A full set of identification photographs (the left and right body profile, the left and right head profile, a front view of the head, the left and right ear, nose wrinkles, rear view, left and right eye wrinkles) for each of the available black rhinos could not be produced within the study period. Some individuals remained elusive, others were difficult to approach such that a complete set of photographs were unobtainable. Only a limited number could be seen often enough and in the sufficiently open habitat to take all the required photographs.

For almost all rhinos, it was possible to obtain a face and a left and/or right profile view which could be analysed and an identification description for each individual produced (see below):

4002 RODNEY Male

Anterior:	medium long, thick and gently curved to a rounded tip
Posterior:	conical, thick with a round point, ½+ of anterior
Ears:	both ears notched, right: large notch in middle, left: in first quarter with small saucer shape below plus notch in fourth quarter, fringed tops

This description was condensed and the photographs were combined in a Microsoft Access database. An example page is shown in Figure 5.2. A Query Form (see figure 5.3) was developed which could be completed at the time of a rhino sighting and the information used to interrogate the database so that information on potential rhinos that the new sighting could be, was reported. From these descriptions and photographs, the rangers could then subjectively choose one of the rhinos shown or declare the sighting to be of a new rhino. This system has yet to be field tested.

A photo-identification booklet was produced with a page for each rhino including, where available, a face, left and right profile photograph, a photograph of the ears, and a drawing of notch patterns. An example of a page is shown in figure 5.4. Details of how to produce a photo-identification booklet are given in appendix 5.

5.2.3.1. Confusions in Identification

This section is included to illustrate that, however good the monitoring team is, there will be problems due to "human error" exascerbated by the type of habitat and individual rhino *behaviour encountered in each reserve. It also serves to illustrate the value of photographs in verifying identifications.*

Over three days in June 2002, an independent assessment of the Sweetwaters rhino monitoring team found the rangers to be good at identifying individual rhino. However, even in this short period there was some confusion over the identification of one rhino (Demmers 2002).

During the much longer periods of this research, several areas of confusion were identified. Two mothers with similar age but differing sex calves, sharing a similar range area, were confused. Two sub-adults of similar age, size and with the same rear horn character, bending forwards, were confused despite being of different sex. There was often confusion over the sex of calves that ran through to sub-adulthood. While horn changes were generally rare, there were two that occurred in the same week. Two adult female rhinos, despite clearly distinct horn shapes, ear notches and different age calves, and whose normal range areas were distinct, had their identities changed by a ranger who was so insistent it influenced his colleagues. The details of these confusions are:-

i) Two mothers Tamu and Ischerine with similar age but differing sex calves, sharing a similar range area, were confused. Although Tamu was older and therefore bigger than Ischerine, horn shapes at a glance were similar. Photographs obtained were able to clarify the difference. The sex of the calf was being used to identify the mother but some rangers confused which calf was of what sex. Again photographs were able to verify the sex of both calves and which belonged to which mother.

ii) Two sub-adults Roberto and Jama of similar age, size and with the same bending forwards rear horn character were confused despite being of different sex. Roberto had originally been sexed as male and named Robert, only for it to be changed later to female, with the subsequent name change. An additional reason for the confusion was caused by rangers using context (location) regularly to aid in identification. They expect to see certain individuals in certain areas of the Reserve. It was assumed that the female Roberto occupied one area while the male Jama another in a different area of the Reserve. When a rhino with a bent posterior horn was seen in a particular area it was assumed to be Roberto while in another area it was assumed to be Jama. Photographs were taken which illustrated the actual differences, apart from sex, between the two individuals and also showed that, while normally apart, the Roberto and Jama were using the same area at certain times of the day. They were in fact seen and photographed within 5 minutes of each other in the same location at 6.45am one morning.

iii) There was often confusion over the sex of calves that ran through to sub-adulthood. It is difficult to clearly see the sex organs of even a large calf moving in long grass. The ability of the video camera to run a stream of film proved invaluable in aiding in the accurate sexing of calves and the verification of the sex of sub-adults. The sub-adult Jama was reclassified as a male on the official database following photo-verification.

iv) While horn changes were generally rare, there were two that occurred in the same week. An adult female Carol and a sub-adult female Roberto both lost a significant part of their posterior horn. Such changes need to be identified early and rangers re-trained to avoid the potential for misidentification. This would be more likely to occur in a non-enclosed reserve where some rhinos may be transient inhabitants.

1	Rhino Sex		male	female	DK		
2	Rhino Age		adult	SA	calf	DK	
3	Calf	calf sex	male	female	DK	none	
4		calf age	<3m	3-12m	1-2yrs	2-3yrs	>3 yrs
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	DK		
Notes	Any other feature						

Date___________ Observer_____________________________________

Figure 5.3 Know-ID database sighting record and query form

v) Two adult female rhinos Shemsha and Chema, despite clearly distinct horn shapes, ear notches and different age calves, and whose normal range areas were distinct, had their identities changed by a ranger who was so insistent it influenced his colleagues. It is difficult to determine why this happened and it is put down to "human error" and the term 'slippage' coined for these occurrences. It required a review of photographs taken over an 18 month period and a discussion with all the rhino monitoring rangers to come to an agreement as to which rhino was which.

vi) Following the assessment of good quality identification photographs and digital video footage, one female rhino estimated to be around 7 to 9 years old, was newly identified. Prior to this, during the study period and in the same area of the reserve, there had been sightings and photographs of this rhino but they were mis-identified by the patrols as it was not considered possible that there could be a rhino in the enclosed reserve which was not known. Later, following the poaching (death) of an adult female, a mother and calf were similarly identified as 'new', there having found to have been two adult females with similar horn sizes and shapes and with similar age calves living in the same area of bush, the density of which had impaired the quality of the sightings. Again these two females had been identified by the patrols as one individual. Newly taken photographs confirmed the difference.

5.2.4. Discussion

The photography fieldwork was time consuming although this was partly been due to the work being run alongside the regular daily activity of the rhino monitoring patrols to minimise disruption as demanded by KWS. In addition to sighting the rhinos, for security reasons, rangers had to patrol specific areas looking for signs of poaching such as snares and unidentified human footprints. Some days this meant there were no rhino sightings to attend or that by the time a rhino was found it was settled on its bedding site and impossible to photograph. Even when found in a good position to photograph it was not often possible to get pictures of both left and right sides and face view at one sighting. Had it been possible to disrupt the daily monitoring programme then the rhinos could have been found over a shorter period. A previous verification project managed to find and identify, but not photograph, all the Sweetwaters rhinos within five days. However this meant all rangers working intensively as a single group leaving areas of the Reserve unpatrolled.

The number and length of photographic opportunities was reduced by the nervous disposition of many of the rhinos. On some occasions, the patrol team found a rhino but it fled immediately leaving no photographic opportunity. On other occasions the rhino had already fled before the patrol had reached it. Approaching the rhinos was especially difficult where the wind direction was particularly variable ie swirling. Some of the rhinos were aggressive and even a minor disturbance due to taking photographs caused the animal run off, but only twice did it first charge. However, as field experience was gained, there were only a few occasions that resulted in a rhino being accidentally disturbed and usually the photographs were taken without the rhino knowing there was a human presence close by.

The rhinos were mostly observed between 8 am and 11am and, at this time, were usually found in shaded areas dominated by Euclea. The underlying grass cover was relatively long. Rhinos laying down on bedding sites or moving with head bowed were often partly or wholly obscured by the grass as too were small calves. Tree branches often hid important details even where animals were standing. At most times the sun was bright and strong, which, coupled to the changeable wind direction and dense habitat, prevented photographs from being taken from ideal positions (ie with the sun behind the camera). Shadows were often cast on the animals obscuring some of the detail of an identification feature such as nose wrinkles. Where individuals were located laid down on bedding sites in dense Euclea bushes, no identification photographs could be taken. It had been suggested that rhinos in such a prostrate position stood up and moved around within a forty-minute period. On the occasions that the patrol team were prepared to wait, the animals usually moved after around 25 minutes allowing for photographs to be taken.

The video camera was particularly useful where rhinos were obscured by the bush or grass. By running a continuous stream of film, the odd occasions when an identification feature could be discerned, such as when an ear twitched to show up a notch, could be captured. It was usually possible to extract a single, in-focus, image of the feature. However, working on computer through a stream of film in the editing software, often frame by frame, to find a good quality identification feature was very time consuming. It was estimated that it took some four hours to carefully examine around 10 minutes of video. While this time cost may be acceptable for rhinos hard to find and identify, it is probably too time expensive in general. In practice it would probably be sufficient for a verifier simply to view the video on the camcorder LCD screen to agree to the identity of the sighting.

Rhinos were observed crossing areas of grass plains or browsing in the tree lines late in the afternoon, out of the heat of the day. They were mostly females with calves or sub-adult pairs. All were intolerant of foot patrols or vehicles and would run for cover if they were disturbed, usually between 50 and 100 metres away. With experience it was possible to slowly move closer to the rhinos, particularly in an appropriate vehicle, watching for changes in the rhinos behaviour, (head and body movements show agitation), that would suggest they were about to run off. Often rhinos that ran off could be found again by following quietly on foot. When browsing, rhinos make noise by breaking and chewing branches and twigs and appear very mentally focused on the operation such that they can be approached with care to within a few metres given adequate cover.

Taking good identification photographs requires intense concentration. Changes in the position of the animal, for example a slight turn of the head, may enable a good identification photographs to be taken but only for a fraction of a second. This is especially the case where only an ear is possible to photograph. A notched or marked ear may be the clearest identification feature. Rhinos constantly react to noise by adjusting their ear position or even move their ears to detect sounds. The identification marks on the ear may only be visible for a second, albeit repeatedly, as the ear keeps moving. It can take several attempts before a clear photograph is obtained. This requires the photographer to concentrate for extended periods with the equipment at the ready to take the picture the moment the necessary detail is in view. Because the photographer has to be clearly focused on getting good identification photographs, and because there may be only a short time when the animal is visible, it is not possible to expect the photographer to take on any other role. It is also difficult for the photographer to record which features for later identification had been photographed.

Animal movement, sun position and habitat interrelate such that it is necessary to take a number of photographs to ensure that one or two good identification pictures are obtained. It is not until the film is processed that the outcome is known. This significantly increases the cost per usable photograph.

The autofocus system of modern cameras is usually selected to obtain the sharpest images. Branches and leaves in front of the animal and rhino movement resulted in the system continually focusing on an area other than the identification feature. Selecting manual focus and diligently altering the focus ring to maintain feature sharpness was necessary to overcome the problem. With a good zoom lens, mostly set at the maximum 400 mm, acceptable identification photographs could be obtained even from a distance of over 100 metres. Identification features could be discerned following image enhancement. Different quality film was compared, from cheap supermarket brands to better, more expensive Fuji and Kodak brands. No difference in print or scan quality was observed between films. In order to preserve the detail of identification features, scanning from negatives was also tried using the most basic Epson film adapter. This resulted in the brown hue of the film affecting the colour of the scan that necessitated colour manipulation. The process was found to be complicated for the inexperienced operator and time consuming and did not give any discernible benefit. It was concluded that scanning a good quality print gave a better result. Recently a relatively inexpensive Minolta negative scanner has been released with reportedly excellent results. This may be worth testing.

In establishing the method to use for scanning identification features and resizing prints, little advice was readily available and much was contradictory. There may well be modifications that could be made to the techniques finally used that could make the process more efficient.

Experience at Sweetwaters with a Sony Mavica FD-95 digital camera (provided to all rhino reserves through KWS) was not a success. While initially the lack of opportunity for the operator to practice was a major factor, there were some recurring fundamental problems with the equipment, (for example use of 1.44MB floppy disks allowing for a limited number of good quality photographs to be stored), but these have been overcome by the latest generation of digital cameras. While this digital camera quality was not as good as that of similar images taken from scanned prints, it was perfectly acceptable for identification purposes. It served to illustrate that digital photography, as it improves, can be a useful support to rhino identification in the field. The main benefit is the ability to take a large number of photographs from which to select only the few of the very best that were needed but without the unused digital images incurring a cost as they do with unused but processed print images. As stated by Markowitz *et al.* (2003), when reporting on how digital photography had improved the efficiency of individual dolphin recognition, “as computer technology improves, the costs of digital photography are decreasing and the benefits to researchers increasing”. This was the case when using the new Minolta 7D digital camera where photographs were of excellent quality exceeding that of scanned prints.

When collecting a large number of photographs of individual rhino, it is important to try to record the film and frame number matched to a proposed identity of the animal at the time the photographs are being taken. Sorting through several hundred pictures, some of which may be difficult to identify, without this to refer to, would be impossible. Notes should be taken before leaving the location. It was found to be impractical to record which identification feature had been captured while concentrating on taking the photographs. Records should be transferred into a daily record book not taken into the field to ensure that the data are not lost. Films should be marked prior to going to a sighting as they may have to be changed during a sighting when time is of the essence.

5.3. A Wild ‘closed bush’ Situation

At the start of 2003, Kenya Wildlife Service (KWS) had no recent or accurate census of the genetically important rhinos, (they represent the only large indigenous population of the ‘highland’ ecotype in Kenya), in Aberdare National Park and therefore could not produce a management plan for the rhinos to ensure their safety and breeding performance.

The Aberdares forest was known to have held one of the highest densities of black rhino in Kenya in the 1940’s and 1950’s, with estimated densities of at least one rhino per km² (Sillero-Zubiri & Gotelli 1991). In the Aberdare National Park there were thought to be 450 black rhinos in the early 1970’s but a census in 1982 only recorded 132 and by 1987, the population was estimated at 50, 30 of which were in the Salient (Sillero-Zubiri & Gotelli 1991). Over 26 rhinos were individually identified and photographed at Ark Lodge during 1987 (Hardy & Aggett 1987) while during June-July 1991, 31 different rhinos were identified at the Ark and Treetops lodges (Brett 1993). A photography-based monitoring programme in July 2000, based mainly around the two lodges located in the Salient found and photographed only 17 rhinos.

The Salient, an area of prime rhino habitat with an abundance of natural water, was identified by the Kenya Wildlife Conservation Department (now known as the Kenya Wildlife Service) as a priority area for the development of a rhino sanctuary. It was upgraded from a priority area to rhino 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).

The fencing of the Salient represented phase 1 of a plan drawn up to fence the entire National Park, to include all the main areas of potential rhino habitat, funded and coordinated by the charity Rhino Ark (Kuhle 1989). In addition to the fence, funds were obtained to build guard posts, a sub-headquarters, bridges and other infrastructure. Vehicles and surveillance equipment were provided, together with funds for the operation and maintenance of necessary vehicles and plant (Brett 1993).

The population of rhinos in Aberdare National Park is particularly valuable as it is indigenous with only one rhino introduced from outside and that was from the neighbouring Solio Ranch. Elsewhere in Kenya, surplus rhinos, mostly initially bred in privately owned sanctuaries, and unsustainable remnant populations of rhinos were used to stock the new sanctuaries in National Parks. This means that nearly all the rhino populations in Kenya are of mixed origin. Not only is the Aberdares population believed to be genetically pure but it also represents the majority of what is referred to as the 'highland' ecotype as opposed to the 'lowland' ecotype.

The eastern race or subspecies of the black rhinoceros (*Diceros bicornis michaeli*) can be divided into lowland and highland ecotypes. Rhinos originating from low altitude areas where several species of tsetse fly (*Glossina* spp) and the species of trypanosome they carry) are present seem to have or adapted resistance along with adapting to associated differences in habitat, diet, altitude, temperature and rainfall. Rhinos from highland areas (e.g. Aberdare NP) have not been subject to the same selection pressure as the tsetse is absent (Brett 1993).

At the start of 2003, changes to the KWS Aberdare rhino unit personnel meant that a largely new team of rangers were given the task of estimating the number, recording the individual identity and regularly monitoring the rhinos in the Salient area of the Park. Prior to this, most of the information on the Salient rhino population had been derived from sighting records at the Ark and Treetops tourist lodges. Foot patrols were mounted in the Salient by two man ranger teams from up to four 'outcamps'. Each patrol was equipped with a small camera and charged with photographing rhinos wherever possible.

The Rhino Unit Warden also had a Sony Mavica FD95 digital camera. Limited training in the use of the camera had been carried out some months before. The camera stored images as jpeg files on a standard 1.44MB 3.5 inch floppy disk. There was almost no success in obtaining identification photographs with this camera in the conditions experienced in Aberdares.

Preliminary discussions with, and the observations of, KWS staff at Aberdares suggested there was much confusion over the rhino population size and structure. Some 70 individuals had previously been listed and named although there were no confirmed sightings of many of them. Between 50 and 60 rhinos were thought to be ranging mostly in an area of the Park known as the Salient but most sightings were recorded as 'unidentified' as new staff did not know how to distinguish individuals and often could not get close enough to see identification features.

Daytime rhino sightings were rare, often of only a few minutes duration and from a distance that made identification photography impossible. Also many sightings were early in the morning or late in the evening when the light levels were too low for the equipment to work. At the end of 2004, only a handful of usable identification photographs had been acquired by foot patrols. Two tourist lodges in the Salient, the Ark and Treetops, provide a water and mineral salts resource for visiting animals including rhinos. At the Ark Lodge, the layout of the waterhole and viewing area was such that rhinos came within 10 metres so were clearly visible. Even then, individual rangers recorded different names for the same rhino. It was essential for the identification and monitoring system to be completely overhauled and a clear need to develop different techniques to obtain identification photographs.

The forested habitat of the Aberdare National Park offered a special challenges in both finding, photographing and identifying individual rhinos in the Park with a view to making a 'best estimate' of the current rhino population on which future management decisions could be based.

The aim of this part of the study was to use techniques learned at Port Lympne and Sweetwaters in taking and enhancing photographs to identify individual rhinos in the extremely difficult field conditions experienced in Aberdares with the objective of proposing changes to current techniques and/or additional techniques in order to capture information on the individual identification of the black rhino population in the park.

5.3.1. Study Area

The Aberdare Mountains represent the largest indigenous forest in Kenya. It runs along the edge of the Rift Valley for some 60 km in the central part of the country. The whole ecosystem covers 2185 km². The National Park covers some 767 km². The area of the Park in the east known as the Salient is delineated as being the area from Treetops Lodge to the 2600m contour and covers 100 km². The area receives up to 1000mm of rainfall per year with peaks in March to May and October/November. The altitude of the Park 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 (characterised by *Ocimum suave*, *Hypoestes verticillaris* and *Toddelia asiatica.*) with swampy glades rich in mineral salts 2. Bamboo forest (closed canopy, little undergrowth) 3. Moorlands of tussocky grassland 4. North and South forests - lower slopes of montane 5. North and South forests - upper slopes of hagenia

The main species found in abundance in the Park include 3000+ elephants and many thousands of buffalo. Rare species include the Giant Forest Hog and the Bongo.

5.3.2. Methods and Materials

From the research carried out in Port Lympne Wild Animal Park and Sweetwaters Game Reserve, reported earlier, techniques for obtaining, enhancing and analysing appropriate identification photographs - the left and right body profile, the left and right head profile, a front view of the head, the left and right ear, nose wrinkles and rear view – were known. In addition, rhinos visit the waterholes at the Ark and Treetops Lodges mostly at night to take water and lick the mineral salt provided. A pilot research study was carried out in February 2002 to consider, from the equipment available, what was best suited to taking night photographs under the low light conditions provided by the Lodges' floodlighting systems. Identification research was undertaken during March, June and September of 2003 and 2004 and March and June 2005.

5.3.2.1. Equipment and Processing

After much trial and error, it was found that a 400mm K lens attached to a Minolta Dynax 5 camera body gave adequate results. It required placing the camera on a bean bag and the use of an external shutter switch to avoid any camera shake. The film used was ASA 1600 or ASA 800 with the camera stopped to ISO1600, the latter representing an acceptable but cheaper option than using ASA 1600 film. With these materials, there was still the need for the shutter to remain open for several seconds to allow in sufficient light, and it was important to try and capture the rhino when it was completely still during this period to avoid blurring. Several attempts were often needed to obtain this.

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

The layout of the Ark waterhole meant rhinos came as close as 10 metres 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 the still and video cameras gave good results. At Treetops, the lighting was less bright. The layout of the waterhole was such that rhinos that only took water remained more than 50 metres from the vantage point on the terrace of the Lodge. This was outside the capability of the video camera. 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 the rhino through binoculars until it was still and then opening the shutter. Due to the poor quality light, up to 10 seconds was required for sufficient light for a photograph. Where rhinos wished to lick salt, they had to come right up to the building. Those that did could be photographed with both cameras and a ground level photohide allowed direct photography with the video camera, the slits in the walls being too narrow to balance the still camera.

Extra photographs were taken from a vehicle on daytime patrols in the Salient. Rhinos were found at certain locations early in the morning and late in the afternoon when only the video could successfully capture images in the low light levels. A few daytime sightings were made in good light and photographs were taken with a Minolta Dynax 5 single lens reflex camera with a Tokina 80 mm to 400 mm zoom lens. This lens allowed for greater flexibility and versatility in the open ground conditions.

Film was processed in the local town of Nyeri through a standard Kodak C41 processor on to 6”x 4” Kodak paper with gloss finish. Individual rhino features were obtained by scanning the prints with a Mustek 1200 UB Plus scanner using a Toshiba Satellite Pro 4600 laptop computer. Scanning was carried out at 600 dpi where features were readily discernible eg head profile, at 900 dpi where features were more difficult to discern and at 1200 dpi for small features such as eye wrinkles where detail was very difficult to capture.

5.3.2.2. Image enhancement

Scans were saved, images enhanced and still pictures extracted from video following the methods outlined in 5.1.2.2 and 5.2.2.2.

5.3.3. Results

Despite the difficult conditions, with the experience gained from Port Lympne and Sweetwaters, identification photographs were obtained both at the Lodges at night and in the bush during the day. 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. 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 equal length, long horns and a small ear notch, the third female had a prominent body scar.

During the 2003 and 2004 study periods in Aberdares, 159 rhino sightings were made of which 84 were at the ARK waterhole, 47 at the TREETOPS waterhole and 28 (17.6%) in the open bush. Opinions were sought from several of the more knowledgeable rangers as to which rhino had been photographed and names derived for individuals not already known by name. Seven rhinos were already named and individually identifiable and included Ark, Ruinu, Ann and calf Lucy, Siankikki and calf Daniel and Nyalou. Sixteen rhinos were named after good identification photographs were obtained. For nine further rhinos, the identity was uncertain and they were ascribed the title Tofauti and a letter A to Z, see table 5.5.

Based on the noted features from direct observations and photographs, a standard identification description was made for each rhino and an example is given in figure 5.5 for the rhino Ann, one of the regularly seen individuals visiting the Ark waterhole at night.

The descriptions and photographs were combined in a Microsoft Access Database (Figure 5.6, an example page) with the Query Form (see figure 5.3) used to interrogate the database so that information on potential rhinos that the new sighting could be reported. From these descriptions and photographs, the rangers could then subjectively choose one of the rhinos shown or declare the sighting to be of a new rhino. This system has yet to be field tested.

Table 5.5. Aberdare National Park, Black Rhino Population, (estimate by author)

MALE	FEMALE	CALF		SUB ADULT	UNKNOWN
Ark	Ann	Lucy	f	Daniel - male	Tofauti A (kw) ?
Ezekiel	Kilema	-		Hurricane - male	Tofauti B (0304tt) f
Ndirangu	Malaika	Hadija	f	male like Nyalou	Tofauti C (0303kw) f
Ngiriini(d)	Nyaruii	?			Tofauti D (0303kw) f
Ngiriini(w)	Pembemoja	Kelele	m		Tofauti E (04) ?
Nyalou	Siankikki	Aberdare	m		Tofauti F (03tt) ?
Nywele	Treetops	?	m		Tofauti G (0303kd) sam
Ruinu	Wanjiko				Tofauti H (0303tt) f+calf
	Warimu	Mwangi	m		Tofauti J5 (0304j5) ?
	?	?V small	?		
8	10	8		3	9

Notes: Any rhino given a name including Tofauti has been photographed. Any rhino marked as ? 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.

1026 ANN Female, 16 years old, with calf Lucy,

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, ½ of anterior
Ears: clean, hairy fringed
Other: ring marking on stomach

Figure 5.5. Example rhino identification description with sample photographs produced for Aberdare rhinos

5.3.3.1. Application of the Results

There were no new sightings made during 18 days of monitoring in 2005 (see figure) prompting an investigation of the patrol daily sighting records to determine when the rhinos identified in table 4.1 were last seen.

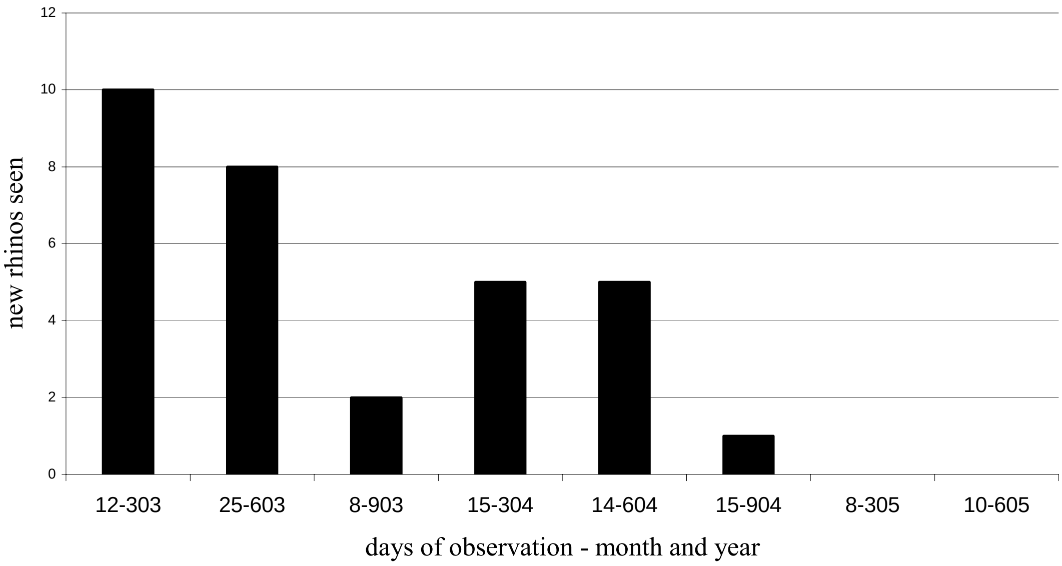


Figure 5.6. Number of newly identified rhinos at each study period in Aberdare National Park

At the Ark waterhole, the male Ark was last reported on 10/3/03, the male Ruini on 14/5/03 and the male Musyoka on 29/8/03. Thereafter the male Nyalou was seen regularly from September 2003 until the end of July 2004. The sub-adult 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/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, was seen in its normal area around Treetops waterhole on 16/11/04 but was then seen for the first time at the ARK waterhole on 22/1/05. It was fighting with the female Siankikki, whose calf Aberdares was poached on 21st November 2004 and would have been a candidate for mating. Since February 2005, the two have been seen together.

At the Treetops waterhole, the female Malaika and her calf Hadija were last observed at the waterhole on 8/10/04 while the female Kilemma, a regular visitor, was last observed on 3/11/04. The female Pembemoja and her calf Kelele were last observed on 18/02/05 but were positively identified at Ngiriini Dam on 27/2/05. These were the only rhinos visiting Treetops regularly at the end of 2004/beginning of 2005.

Only 7 individuals could be found and photographed in June 2005 over a 10 day period and no others were sighted by patrols. It is only since the rhinos were individually identified and named as a result of the study that this analysis has been possible.

5.3.5. Discussion

The quality and quantity of the images obtained, even after enhancement, was much poorer than those obtained in the better conditions at Port Lympne and Sweetwaters. The most important identification features used to disseminate the Aberdares rhinos were sex, ear markings, horn size and shape, body markings and tail size. Photographs from both the still and video camera were essential to obtaining 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 could be seen and described.

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 overcome the inaccuracies. At Treetops, where sightings were all being recorded as unidentified, names and descriptions enabled all sightings to be assigned to a particular rhino. One ranger was stationed at Treetops on a full time basis so was able to acquire, with the help of the photographs, experience in recognising the individuals visiting the waterhole ensuring accurate identification.

Visual assessment using photographs was used to determine different rhinos. As the individual sighting frequency was low, a combination of identification features was 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, experience from Sweetwaters where the rhino Roberto had her rear horn torn off in a fight, suggested that 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.

The development of the photographic identification database for Aberdares 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 to be described and changes in population size to be observed.

The KWS standardised monitoring system requires rangers, at the time of sighting, to make drawings of a rhinos' identification features on to a special form. For the drawings to be an accurate representation needs time to be taken to observe the features and record them correctly. It is less appropriate where sightings last for a relatively short period. The KNOW I/D form acts as a prompt for rangers to look quickly for key features. Even after a brief sighting, on immediate prompting, rangers can remember more than would be expected. While they may not be able to state which rhino they saw, they might be able to recognise it if they saw a picture of it. By interrogating the database with the details collected at the sighting, photographs of potential individuals that match their description are selected from the whole population for review.

With most individuals identifiable and most sightings:resightings recorded by name rather than as 'unidentified' as had been the case, it might now be possible to make an estimate of the rhino population using mark-recapture analysis. However, an 'unidentified' sighting did not mean a clean individual, that is, one which is not identifiable by most observers. A sighting recorded as unidentified in Aberdares usually meant that the rhino was seen from a distance, in the bush, and could not be seen well enough for a positive identification. Most daytime, bush based sightings that were photographed were found to be of known, named rhinos.

6. The Usefulness of the Key Features used for Individual Rhino Identification in three different habitats

6.1. Background

Visual assessment, with and without photographs, is the approach used most often for individual identification but in researching black rhino identification features, none of the papers reviewed (see section 4) discussed the usefulness and drawbacks of the features used for individual identification.

Rhino populations at three locations were studied:

i)	Port Lympne Wild Animal Park – ex situ, captive situation	see section 5.1
ii)	Sweetwaters Game Reserve – in situ, open bush	see section 5.2
iii)	Aberdare National Park – in situ, closed bush and forest	see section 5.3

The key features used most often for individual identification in black rhinos are:-

- i) sex
- ii) horns – shape and length
- iii) ears – notches and deformities
- iv) body – scars and corrugations
- v) tail – shape and size
- vi) wrinkles – nose and eyes
- vii) mother/calf association and calf development

6.2. Outcome of visual assessment of photographs

The key features used for identifying individual rhinos varied in their usefulness depending on the habitat in which the animals were found. This is summarised in table 6.1 and reported in detail below. Some features can change significantly over time, for example horns may be rubbed or broken and ears may get torn. Where individuals are not seen with sufficient frequency to observe these changes, the feature should be considered as unreliable for accurate identification. Eye wrinkles, once established, do not change over time and are a reliable discriminator of individuals but obtaining suitable photographs can be difficult in field conditions.

6.2.1 Sex

The number of potential rhinos that an individual could be in a population is reduced, normally by around half, by determining its sex. In the captive situation, the sex organs of the rhinos were clearly visible in both adults and very young. In some paddocks there was long grass on occasions which temporarily obscured visibility but over time the rhinos came close to the fence and it was easy to determine their sex.

In open bush, while the differences in sex organs were easily distinguished, there were many occasions when it was not possible to see them clearly. Long grass and bush obscured the organs especially with calves and small sub-adults. The rhino holds its tail down when walking which can cover the organs but will often flick the tail at flies which enables identification although this may only be for a split second and can be missed in the field unless the feature is being focused on. Reviewing a digital video stream and selecting individual frames can often show the sex which could otherwise not be determined.

Table 6.1 Summary of the usefulness of the main identification features in three different locations

Feature	Port Lympne	Sweetwaters	Aberdares
Sex	U	U/L1	U
Horn shape	U/L2	U	U
Length	U/L3	U/L3	U/L4
Ear notches	n/a	U/L1	N1
Deformities	U/L5	U	U
Body scars	N2	U	U
corrugations	U	U/L6	N3
Wrinkles eyes	U	N4	N4
Nose	U	N5	N5
Mother/calf	U/L7	U/L8	U/L9

U = useful N = not useful U/L = useful with limitations

Limitations:

L1 can be obscured by habitat

L2 can change with excessive rubbing

L3 can change by breakage

L4 sightings may be infrequent

L5 can change due to frost bite

L6 can be obscured by wallowing

L7 other i/d features easier to use

L8 similarity can cause confusions

L9 as L7 and few cow/calf combinations

Not Useful:

N1 mostly clean animals

N2 no filarial parasites

N3 none observed

N4 limited opportunity to see

N5 as N4, and inconsistent

At Aberdares, sex differences were visible for those individuals visiting the Ark and Treetops waterholes. Even where the organs could not be seen, the sex could be determined by the way in which the rhino urinated (downward stream for females, outward spray for males). It was rare for a rhino drinking water after licking the salt not to also urinate. Sightings in the bush were often at a distance but the sex organs could be readily observed unless obscured by the habitat.

In summary, determining the sex of an adult or sub-adult was relatively easy in most situations and made easier by using a digital video camera where even calf sex determination was possible.

6.2.2. Horns – shape and length

Horn shape and length are useful identification features in situations where changes – due to rubbing or breakage - either do not occur or can be readily detected. In the captive herd, some rhinos had distinct and unique horn shapes such as Naivasha whose anterior horn was sharply curved backwards in the top third while Jaga had a medium length, thick anterior horn which pointed forwards. Horn rubbing was especially prevalent at Port Lympne. This mostly occurred after rain with the rhinos rubbing their horns against the rectangular metal bar fencing, often quite vigorously. Rubbing made significant changes to the horn shape, particularly to the posterior horn as the rhinos would put the horn gap either side of the fence. The green colour of the fence paint was clearly visible on the horns. Horn breakage occurred with the anterior horn of two rhino calves breaking off at the base where they had been caught between the bars of the pens. Over time the horns started to grow back. There were no cases of adult horn breakage and rubbing tended not to alter horn length. The diverse background to the population and changes in the males used for mating meant that there were clear differences between rhinos who displayed various combinations of long, medium and short anterior and posterior horns.

At Sweetwaters, there was no discernible change to the shape of the horns of any rhino during the study period. Some shapes were very distinct eg the forward curving posterior horn of Jama and the strong curvature of the last third of the anterior horn of Kurkura and Millenium while some rhinos eg Cathy, had a marked ridged ring at the base of the anterior horn. Some rhinos, eg Manchester and Solo, had a distinct pattern of hair on the base of the anterior horn and this could be used as one of its identification features.

Horn length was an important identification feature. Three females (Saba, Tulivu and Kilo) had equal length horns while male Loita broke the tip of its front horn to render the horns of equal length. Of the males, Kurkura had a very small triangular posterior horn compared to Rodney who had a longer thick conical posterior horn. The females Chema and Shemsha had long, thin, curved and pointed anterior horns.

During the study period three rhinos broke their horns: Roberto lost nearly all its posterior horn, Carol lost half the posterior horn and Loita lost the tip of the anterior horn. As these three rhinos were among those which were seen most regularly and were easy to identify (all are notched), the changes were noticed immediately.

When looking face on the rhino most of the rhinos had the posterior horn obscured by the anterior horn. Sometimes the posterior horn curved to one side and could be seen e.g. Shemsha where the horn curved out to the right. The relative length of the horns can be misjudged due to the angle of the head where the more downward tilting the head is, the more the horns appear of equal length. Observation must be studious to record horn length accurately. Also there were times when reviewing photographs that a branch of a tree was superimposed on a horn making the horn appear longer so it is important that photographs are studied carefully to avoid mis-identification.

At Aberdares, due to the rarity of sighting some of the rhinos, using horn shape to identify individuals had to be treated with caution. Those rhinos seen regularly at Lodge waterholes showed no changes in horn shape i.e. there were no instances of horn breakage or excessive rubbing noted. Three rhinos in the Treetops area had long, thin, strongly curved anterior horns which could easily be confused and it was necessary to compare the horn angle shown in photographs to confirm their identity. Some rhinos had distinctive horns due to their length e.g. Siankikki had two long equal length horns while Kilemma had two short almost equal length horns. Two rhinos visiting the Ark waterhole, Nyalou and Hurricane, could be confused as they had similar horn shapes and sizes although Nyalou was a full grown male and Hurricane a maturing sub-adult male. Other features showed they were different animals. The female Pembemoja was distinct having no posterior horn, not apparently due a breakage but more likely a genetic mutation, and a very long gently curved front horn.

In summary, few horn changes were observed in the two bush environments while large changes were seen in the captive herd. The changes observed in the frequently sighted Sweetwater rhinos, had they happened with less frequently observed rhinos, could have led to incorrect identification.

6.2.3 Ears – notches and deformities

Ear notches and deformities, such as tears, are normally unique to individual animals and ears are usually visible even in relatively thick bush. This makes them especially useful as identification features. However, in some environments they are rare and of little use.

At Port Lympne, parts of ears were lost due to frost bite caused by the often strong cold winds coming off the nearby sea (a similar situation was seen in the desert rhinos in Namibia where night temperatures are very cold). This also caused the loss of hair on the ear fringes. While this created clear identification marks, it also meant that some rhinos ear shape changed over time and care had to be taken not to confuse the new shape with another rhinos ear. A small number of the rhinos who had come from the wild had notches made on translocation. Jaga had a small hole in the left ear. There were no sharp objects around on which a rhino could tear an ear.

At Sweetwaters, 18 of the 27 adult and older sub-adult rhinos had been or were ear notched and this made them much easier to identify correctly. Notches were not always clearly visible in field conditions depending on the ear position, the amount and angle of sunlight, movement of the animal, distinctness of the notches and their concealment due to habitat. For example, at one sighting in April 2005 a rhino around 30 metres distance first appeared to have no notches, then after further observation appeared to have notches in its left ear and then as it came even closer and turned head on, was seen to have notches in both ears. The individual, Maendeleo, was inadequately notched, the notches having not been cut deeply enough. This illustrates the importance of ensuring that notches are clearly cut for accurate identification to be made.

No rhinos had markings from tears in their ears but two rhinos had enlarged a notch by tearing, probably on acacia thorn. Rhinos maintained their ear tufting in the bush and sometimes gaps in the tufts of hair could be mistaken for a notch. On the other hand, distinctive tufting could also be used as an additional identification feature.

In Aberdares, in order to maintain the integrity of the forest rhino ecotype found there, translocation of the bush rhino ecotype found in other reserves was discounted apart from one male, Solio. This rhino was introduced with notches and the only other notched rhinos were those that had to be caught to be treated for some ailment or injury. Darting is a high risk operation in the thick bush of Aberdare so notching as a regular practice was not an option. Occasionally a rhino might have a tear in its ear but most Aberdare rhinos were clean eared and this rendered ears less useful for identifying individuals. Despite this, confusions did arise when a male rhino was found with ear marks as it was assumed to be Solio. Photographs showed this was not the case and in the study period Solio, as previously described by former observers, was not seen.

In summary, ear notches and tears can offer a useful indication of the identity of a rhino. Ears are often the only part of a rhino clearly visible when it is in thick bush or lying down at rest in long grass. Even when sleeping, the rhinos ears will move to detect sound so ear markings can be seen.

However care has to be shown to observe and record ear markings carefully to ensure they are accurate and then to compare them with a database of photographs or drawings to ensure the right individual is identified. Photographs of ear markings can also be misleading where a branch or leaf obscuring part of the ear makes it look like a mark.

6.2.4. Body – scars and corrugations

Where two rhinos appear similar, a distinctive scar or heavily corrugated skin can be used to separate individuals. While scars often heal so are transitory identification features, skin corrugation is life long and can be a very prominent feature. In the captive situation, the filarial parasite that causes lesions on the rhinos body were not present and all rhinos had clean bodies with good skin condition. Some rhinos had distinctively darker "leather look" skin. Vuyu had particularly marked skin folds highlighting the ribs and which could be used as an additional identification feature.

At Sweetwaters, filarial lesions or other wounds were not generally prevalent on the rhinos in the reserve and were therefore rarely useful as an identification feature. However, in June 2005 there were 4 sub-adult females whose identity was being confused especially from a distance. Two of the four had distinct body scars which could be used to confirm their identity at the time. Manchester had a long reddish lesion at the top of and just behind the front leg while Solo had a smaller dark lesion on the right midriff. These were discernible in the field and on photographs and were used in addition to other features. A few individuals had marked skin corrugations highlighting the ribs eg Jama and the sub-adult Jasho had such pronounced corrugations that one or two of them could be mistaken for long scars. However skin folds could be completely obscured after wallowing in mud.

Although scars can disappear over time and some rhinos were seen infrequently, some scars were useful in identifying individuals in the difficult habitat of Aberdares. One female, Kilemma, had a white ring scar behind the shoulders and right around the belly, the result of having been caught in a snare. This scar was even visible at night through binoculars under the poor light conditions at Treetops waterhole. At the Ark waterhole, Hurricane could be distinguished from Nyalou by a scar on its right shoulder.

In summary, scars and body marks may be help in confirming the identity of an individual but only as a secondary character. These scars and marks usually disappear over time and cannot therefore be considered a reliable, long term identification feature.

6.2.5 Tail – shape and size

In most bush situations it is not possible to get a good view of the tail of a rhino. However in some circumstances, such as visits to a waterhole, tails can be seen and differences in size and shape may be distinct. Tails were easily visible in captive conditions in both the short grass paddocks and concrete exercise areas. Differences between individuals were readily discernible in length, thickness, hair tufts, shape (straight or kinked) and could have been used alone to identify almost all individuals, certainly adults. Tails were subject to damage by frost bite (as with ears) rendering the rhino with a much shortened tail and changing the identification feature.

In the bush habitat of Sweetwaters, tail differences were not found to be a useful identification feature. It was not possible to photograph all the tails of all the rhinos with those especially secretive individuals never seen in sufficiently open conditions. Some tails were seen when rhinos were running away having been disturbed by the human presence but these animals typically held their tails erect. At other times, the long grass and bushy environment prevented much of the tail from being seen. None of the rhino monitoring teams reported any of the rhinos as having a distinctive tail and no rhino had a shortened tail – there being very few hyenas, the main cause of rhino tail shortening in the wild, in the reserve.

However at Aberdares the situation was different. Good views of the tail of rhinos were possible with those individuals that came and licked salt at the Ark and Treetops waterholes. Attacks on rhinos by the high number of hyenas found in Aberdares, had led to several individuals having shortened tails.

In summary, in cases where tails can be observed, tail deformities can be a useful secondary identification feature.

6.2.6 Wrinkles – nose and eyes

Wrinkle patterns, whether eye or nose, requires close examination of the rhino which limits their use in bush conditions. While nose wrinkle patterns change with the movement of the mouth, eye wrinkle patterns were found to be very consistent and unique to each rhino and can play a secondary role as an identification feature. Rhinos in captivity were very easily accessible and would come close to the fence so very clear nose and eye wrinkle photographs were obtained. Some rhinos had very distinctive nose wrinkles which, while changing pattern when the proboscis was moved, did not alter in essence. For example a few rhinos had vertical as opposed to the more regular horizontal wrinkles.

Eye wrinkle patterns also showed clear differences between individuals and eye movements such as opening and closing did not affect the pattern. The patterns were also consistent over time. This feature was found to be very useful in identifying individuals when sorting through a large number of photographs particularly separating the sub-adults where other features such as horn length and shape are very similar.

At Sweetwaters, it was occasionally possible to get close enough to a rhino to obtain a clear sighting and photograph of the nose wrinkles. However these were never considered distinct and consistent enough to be useful in identification. Images of eye wrinkles could be obtained from the best photographs but it took considerable time to obtain sufficiently good photographs. In practice eye wrinkles were not found useful in identifying individuals as other features were more distinct and easier to see.

Similarly at Aberdares, where nose and eye wrinkles could be seen and photographed, the rhinos were at close proximity enabling other more easily discernible, distinctive characters to be used for identification.

In summary, it was found that nose wrinkle patterns change with the rhinos facial expression making it unacceptable for identification but eye wrinkle patterns remain consistent even when the eye moves. However getting good eye wrinkle photographs in bush conditions was difficult.

One suggestion for the use of eye wrinkle patterns for individual rhino identification is when a rhino has been killed by poachers, the horns have been taken away and hyena or other carnivores have eaten the ears. The skull is often the last part to be destroyed and eye wrinkle patterns may be discernible. A good time to capture the patterns on photographs is when a rhino has been anaesthetised for translocation, notching or treatment.

6.2.7 Mother/calf association and calf development

For at least two years after calving, a female rhino will normally be seen with its new calf. As such the identity of the calf can assist in the identification of the mother. Calves may be of different sexes and, while ageing, develop in body size and horn size and shape such that, for example, a 3 month old calf and a 12 month old calf are clearly different.

At Port Lympne, several births occurred over the study period and calf development photographs were taken at 6 month, and sometimes three month, intervals. Calf development (body size compared to mother) largely followed the age classification of Hitchins (1970) although some of the captive calves appear to develop quicker reaching nearly full size by 24-27 months as compared to Hitchins 3+ years. Horn growth development/age could not be compared due to the horn breakages and effects of rubbing experienced.

At Sweetwaters, calf height compared to the mother (as a prediction of calf age) and calf sex were helpful in the identification of females especially where the horns of the mothers were obscured or where the pair were viewed from the rear or where several pairs were located in the same range. However one of the key confusions came where two similar females sharing much of the same range had calves within a month of each other. While the calves were of different sexes, their identities were switched round in the minds of some of the rangers who then confused the identities of the mothers. Relative calf height related to age generally conformed to that of Hitchins (1970). Although the sample size was relatively small (n = 3), the indication was that calf horn size relative to age did not conform to Hitchins (1970) in that the posterior horn in particular developed faster and had some shape within a year. This was carried through and by 30 months, as opposed to 36 months, the calves had distinct and distinguishable posterior horns.

At Aberdares there were relatively few mother/calf combinations and these were further separated between the Ark and Treetops areas. Three of the mothers, Siankikki, Malaika and Pembemoja, were distinct due to their horn shape and size so mother/calf association as an identification feature was of limited use and served only as added confirmation of the identity of the mother and/or calf. Hitchins (1970) age classification was assigned to calves as their birth dates, and therefore actual ages, were not known.

In summary, mother calf associations were of limited value for identification purposes and at best should be used a secondary, confirming feature in support of other identification features.

6.2.8 Overview

Different identification features were found to be of more or less use depending on the constraints imposed by the specific conditions encountered. Accuracy of identification was improved when several features were discernible and can be likened to a jigsaw where the more pieces of information are available, the clearer the picture.

7. Errors that occur when identifying individual rhinos from photographs

7.1. Introduction

Problems can occur when identifying individual rhinos from photographs which vary in quality. Also good quality identification photographs may be difficult to obtain and sightings of some individuals infrequent such that poor quality photographs are all that may be available for assessment. If photographs are to be used to individually identify rhinos, the potential causes of error (misidentification) need to be addressed. The supposition is that a person will be able to regularly and accurately identify individuals from the photographs, a subject which psychologists have studied since the 1950's (Zhao *et al.* 2000). The basic problem is that 3D objects have to be recognised from 2D images.

7.1.1. Identifying individuals from photographs

The results of research on human face recognition using photographs suggest areas that need to be investigated when considering the recognition of individual rhinos. Bruce and Young (1986) stated that humans derive structural codes for faces which capture those aspects of the structure of a face essential to distinguish it from other faces. Some areas of the face provide more information about a person's identity than other areas which has led to the view that face recognition is dependent on the arrangement of the features with respect to each other (their configuration), as much as the features themselves. This suggests that photographs which do not contain all the important features or which obscure important areas of the face could lead to misidentification. In many situations, contextual knowledge is also applied e.g. the surroundings play an important role in recognising faces in relation to where they are supposed to be located (Zhao *et al.* 2000). However, it was found that, with rhinos, context can also lead to misidentification as an observer 'expects' to find a certain rhino in a certain place. Independent verification could involve using judges with no experience of the area the rhinos inhabit so have no contextual knowledge.

Some identification features on individual animals may be particularly distinct. A single distinctive feature may be sufficient to extract an accurate identity while a face with no particular distinctive features may be recognised by the whole set of features together (Zhao *et al.* 2000). However, Vokey and Read (1992) found that faces which are highly distinct in appearance are not necessarily highly memorable although they usually are (Zhao *et al.* 2000). It is therefore important to consider distinctness of identification features as well as the quality of the photographic image obtained of the feature.

Rangers identifying rhinos would usually see the individual animals as they move about their habitat and not motionless as captured in a photograph. Knight and Johnston (1997) found that famous human faces were easier to recognise when seen in moving sequences than in still photographs. It is possible therefore, that those used to seeing movement could misidentify individuals they know well when reviewing photographs. This may impact on the choice of person to be an identification verifier.

7.1.2. Identifying individual animals from photographs

Bateson (1977) tested an observer's ability to recognise individuals from photographs. He was working with Dafila K Scott who claimed she could individually identify some 450 wild Bewick's swans. With good photos, she scored 29 out of 30, with poor, 23 out of 30. She acknowledged that in the field she used behavioural characters as well as identification markings to recognise individuals.

Photo-identification is now a standard research method in studies of whales and dolphins (Hammond *et al.* 1990). In photo-identification work, the usefulness of a feature is not based on its stability alone. It is also important to consider the individual distinctiveness of a feature and the ease with which that feature can be photographed. Researchers have found that as the quality of a photograph decreases, the information in the natural markings becomes obscured and it becomes increasingly difficult to recognise the represented individual. As less distinctive individuals are more difficult to recognise than more distinctive ones, poor quality photographs will exacerbate this problem (Hammond *et al.* 1990). With bottlenose dolphins *(Tursiops truncates)*, acceptable quality photographs had to be sharply focused and provide a clear view of identification marks. Only good to excellent rated photographs were considered acceptable for identification (Defran *et al.* 1990). In a similar vein, Agler (1992b) found that fewer errors were made in photographic matches of fin whales (*Balaenoptera physalus*) where individuals were distinctive and/or photographs were of high quality.

Bottlenosed whales *(Hyperoodon ampullatus)* are well marked with some 14 to 15 different marks found in a typical photograph. However the marks in a population were not equally distributed such that some animals were unmarked or "clean" even in high quality photographs while others had very large markings, like notches, and could be identified even in the poorest photographs. In general, poor quality photographs did not contain sufficient information to consistently identify individuals (Gowans & Whitehead 2001).

Problems were encountered while examining photographs of Bowhead Whales *(Balaena mysticetus)* (Rugh *et al.* 1992) including 1) recognition of marks could be prevented by poor photographic quality – motion blur, incorrect exposure, image partly off frame 2) reflected light may appear as a mark or disguise a mark 3) submerged or partially submerged whales may result in marks being missed or distorted 4) ice or splashing water may distort or conceal a mark and 5) sloughing skin or other ephemeral interferences (algae, mud) may be confused with or conceal natural white markings. Inexperienced judges obtained 60% correct classification while experienced judges obtained 85%. The main difference was the relative success in subjective comparisons – judging if a mark was larger or smaller than standard. It was recommended that clear photographs of high resolution and standard image size were best to use. Judges should be experienced and used to the photographs and changes in markings over time (Rugh *et al.* 1992).

However with humpback whales *(Megaptera novaeangliae)* most judges were able to agree when evaluating specific and overall aspects of photographic quality and individual distinctiveness and it was found that they need not be experienced in photographic identification. Nevertheless it was stated that some individuals may be less suited as judges for evaluation (Friday *et al.* 2000).

7.1.3. Types of Errors associated with Photo-Identification

Incorrect identification may involve falsely identifying two sightings of different individuals as the same – a false positive – or two sightings of the same individual as different – a false negative error. In practice the likelihood of a false positive error is a function of the similarity of the markings of the individuals compared. Thus, if the information content on which the identification is based is high, the number of comparisons at risk for false positive errors is correspondingly low. False negative errors are well known to occur in animals with natural markings. Both photographic quality and distinctiveness appear to be related to error rate and are difficult to determine independently (Stevick *et al.* 2001).

Stevick *et al.* (2001) undertook the first large scale investigation of errors in individual identification by natural markings for any species. Working with humpback whales *(Megaptera noraeangliae)* they used photographs which showed the pigmentation pattern and scars on the ventral side and contours in the trailing edge of the tail flukes. Because the quality of the photograph may influence recognition of individual whales, all photographs were given a quality designation based on the clarity and contrast of the image and the angle of the fluke to the camera. An additional rating was designated to half flukes or images showing less than 20% of the fluke area, designated as partial flukes, irrespective of other photographic quality considerations. This rating reflected the difficulty in re-identifying animals based on only part of the tail being visible. Since distinctiveness of the individual markings may also influence recognition, each nominal individual was given a distinctiveness rating based on the colour pattern, scarring and serrations of the trailing edge.

Five photographic matching errors were identified as due to half or partial fluke photographs and four errors were considered to be due to problems with the photographic angle, contrast, clarity or portion of fluke visible. Error rates increased steadily with decreasing image quality. When identification was made by an experienced individual, using restrictive criteria and/or confirmed by at least two others, the probability of errors was substantially reduced.

7.2. Methods and Materials

The aim of this part of the study was to examine whether the types of problem and error found in the photo-identification of sea mammals are reflected in photo-identification of black rhinos. This was achieved by carrying out a series of tests as outlined below.

Photographs were selected from the dataset produced in 2002 and 2003 for individual identification of black rhinos at Sweetwaters Game Reserve. Photographs of adults and older sub-adults were used as young sub-adults and calves have limited and under- developed identification features. Three types of identification photograph for each rhino were chosen – face view, left profile and right profile. Of the photographs of the rhino population at Sweetwaters, there were 12 individuals for which all three types of identification photograph were available i.e. 36 pictures.

A second set of identification pictures was also made where a similar but not the same identification photograph was available. This was only possible for 7 of the 12 individuals, giving an additional 21 pictures. Prints were made at a standard 2.5” height in greyscale on HP premium quality paper on a portable Hewlett Packard hp deskjet 450 printer.

All 57 individual pictures were cut out and pasted separately on to 15cm x 10cm card. Each card was identified by a number written on the reverse which corresponded to a particular rhino. All photographs were subjectively graded independently by three assessors (experienced in reviewing rhino photographs) for their clarity of exhibiting features used for black rhino identification using a rating scale 1-5 with 1 = poor, 2 = fair, 3 = average, 4 = good and 5 = excellent.

A cross section of people, 33 in all and including the three assessors, were selected as judges but all had at least a minimum knowledge of black rhino identification features. They were graded 1 – 3, with 7 judges graded 1 = very experienced with black rhinos, 6 graded 2 = moderately experienced with black rhinos, and 21 graded 3 = limited experience with black rhinos

There were three levels on which an identification judgement was made. Firstly there was the individual animal and how distinct it was within a population. Secondly, there was the photograph and if it was of sufficient quality for accurate identification. Thirdly, there was the amount of information available on which to make the judgement eg whether there was one, two or three different views available. Three tests were developed which would provide information for each of the three levels.

7.2.1. Name Test

This test was devised to examine the importance of the quality of the photograph, the distinctness of the identification features and the aptitude of a judge to observe differences in identification features – the three key factors found to influence the ability of judges to correctly differentiate individual animals in sea mammal populations.

Very few judges know how to identify all the rhinos at Sweetwaters and so had the competence to attempt to name the individual rhinos from the photographs. A test was run with 4 judges – the author, the Head of Security, the Head of Rhino Patrols and a senior ranger.

The judges were given identification photographs in the following order and asked to give a name to the individual rhino:

1 – face 2 – left profile 3 – right profile 4- face and left profile together
5 – face and right profile together 6 – left and right profiles together
7 – all three types together

For the Name Test analysis, in order to standardise the quality assessment for the number (one, two or three) of types of photograph used for the identification, a quality rating was calculated by dividing the total quality score given by the three judges by the total available quality i.e. by 15 for one photograph, by 30 for two and 45 for three.

The identification features are such that some rhinos are more distinct than others. Each of the 12 individuals were placed into one of three distinctness categories with 1 = least distinct, 2 = moderately distinct and 3 = most distinct

7.2.2. Matching Test

A second test, the Matching Test, was devised to examine the ability of a range of judges with different levels of knowledge of rhinos to correctly match an identification photograph of an individual rhino with a similar photograph of the same rhino from within a set of identification photographs. The set of 12 photographs of the same identification type was laid on a table in front of each of 17 judges. Each judge was individually handed one of seven identification photographs and asked to select which one of the 12 photographs was of the same individual. The judges were informed that there was definitely one that corresponded to the one in hand and were allowed to move the 12 photographs in any way they liked.

This was repeated for each identification view in the following order:

1 – face view 2 – left profile 3 – right profile 4- all three types together

7.2.3. Pairs Test

A third test, the Pairs Test, was devised to examine the ability of a range of judges with different levels of knowledge of rhinos to correctly decide if two similar identification photographs were of the same individual or different individuals. A pair of photographs of the same type was given separately to 22 judges who were asked to record on a simple slip of paper a tick if they thought the photographs were of the same individual or a cross if they thought they were different individuals. The pairs test was repeated on 5 separate occasions with 3 of the judges to determine how consistent their judgements of the photographs were. For the Pairs Test, each pair was rated from 1 (most difficult) to 5 (easiest) in terms of the quality of one or both photographs and therefore the difficulty of obtaining a correct result.

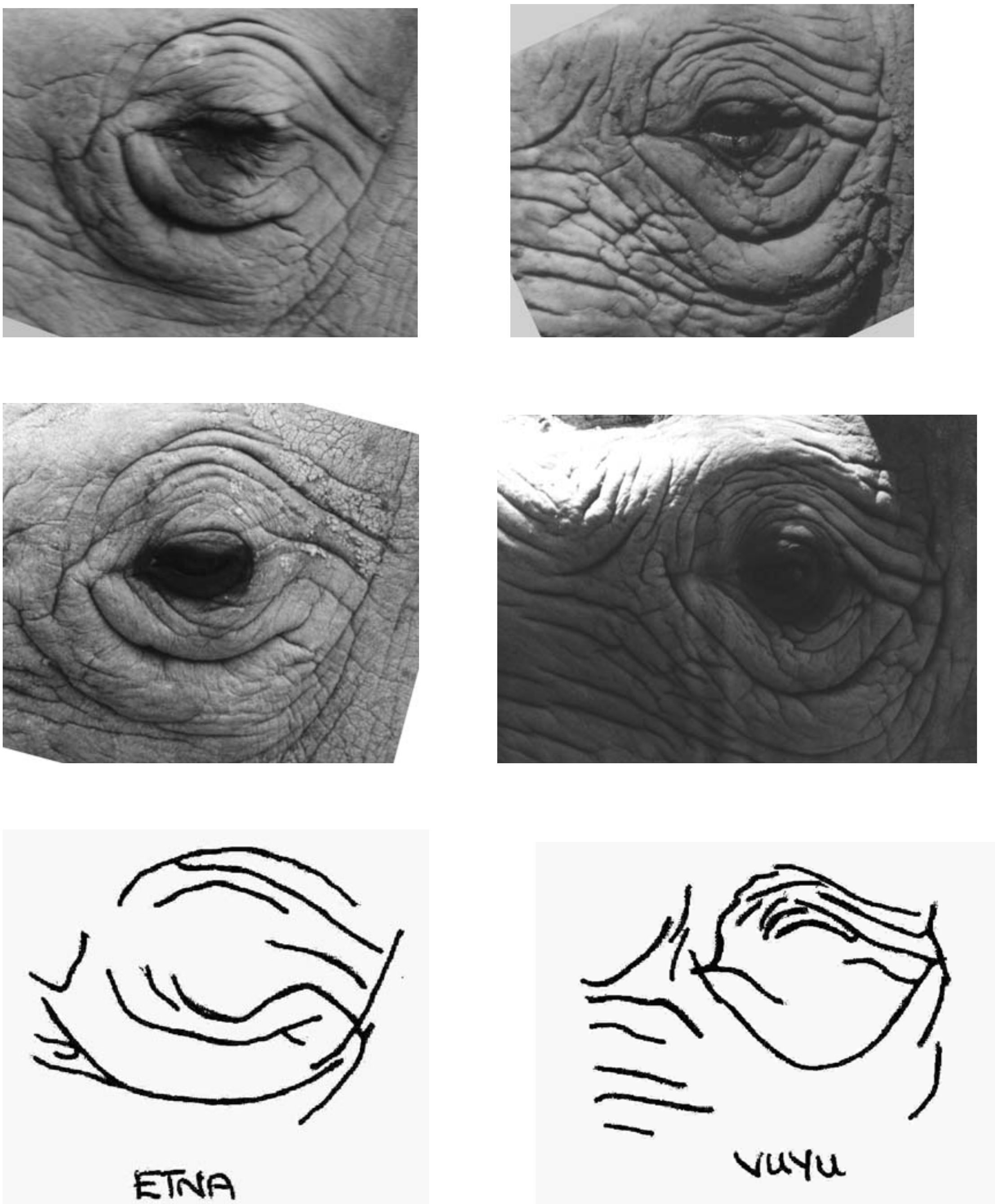
7.2.4. Eye Wrinkle Tests

In order to specifically test whether eye wrinkles were a robust identification feature to distinguish individual rhinos from photographs as was suggested in 7.7, a Couples (pairs) test and a Twinning (matching) test were devised, similar to those described. Ten new judges were selected, five who had little or no knowledge of rhinos and five rhino keepers from Chester Zoo, UK.

For the Couples Test, eighteen pairs of good quality photographs from the Port Lympne photo-identification database were prepared with one of the pair being of a profile of a rhino where the eye wrinkle pattern was discernible and the other photograph being a close up view of an eye wrinkle pattern. Ten of the pairs were matches of the same individual and eight were incorrectly matched. The pairs of photographs were given separately to the 10 judges who were asked to record if they thought the photographs were of the same individual or if they thought they were different individuals.

For the Twinning Test, using the set of 10 photographs where the pairs matched, the profile photographs were laid on a table in front of each of 10 judges who were handed separately one of the eye wrinkle photographs and asked to select which one of the 10 photographs was of the same individual. The judges were informed that there was definitely one that corresponded to the one in hand and were allowed to move the 10 photographs in any way they liked.

Figure 7.1 shows an example of eye wrinkle patterns for two rhinos illustrating their clear difference, the effect of eye movement, open or closed, and how the key lines can be selected out. Appendix figures A7.1a & 1b illustrates the main left and the right eye wrinkles of rhinos at Port Lympne Wild Animal Park with figure A7.2 showing them in pairs



Top photographs show the eyes nearly closed, middle photographs show the eyes open, bottom drawings are of key wrinkles.

Figure 7.1. Examples of left eye wrinkle patterns for two black rhinos from Port Lympne Wild Animal Park, UK

7.3. Results

The quality of the photograph, the distinctness of the rhinos identification features and the ability of a judge to determine differences between individuals were all found to be important factors in correctly identifying rhinos from photographs.

7.3.1. Name Test Results

The more distinct the rhino, the more likely it will be correctly identified. Table 7.1 shows that half of the total correct identifications, 60/119, were from the rhinos independently rated as having the most distinct features.

Table 7.1. The number of correct identifications of individual rhinos from photographs

Distinctness*	1	2	3	ALL
View				
Face	2	4	10	16
right profile	2	6	6	14
left profile	4	5	5	14
face & right profile	1	5	10	16
face & left profile	5	5	10	20
right & left profiles	3	7	7	17
all views	4	6	12	22
Total	21	38	60	119
median	3	5	10	
	n=112	n=112	n=112	n=336

*1 = least distinct, 2 = moderately distinct and 3 = most distinct

The more identification information available, the more likely there will be a correct identification. A single view photograph, be it of the face or either profile, contains less identification information than two photographs of different views which contain less information than three photographs each of a different view.

Rather than modelling eight levels of factor information, Table 7.2 presents the data in Table 7.1 in three groups depending on the level of information available from which the judgement is made. It can be seen that the mean number of correct identifications, calculated by dividing the number of correct identifications by the number of views, increased with the amount of information available i.e. it is lower (14.7) when only a single photograph is available, increases (17.7) when two photographs are available and the highest (22.0) where all three photographs were viewed. The probability of getting a correct identification was significantly increased with increasing distinctness and increasing the level of information (χ^2 = 34.74, df=4, p= <<0.001).

When modelled using logistic regression, as shown in Table 7.2a, the observed and fitted probabilities are similar. It can be seen that a probability in column D3 is about three times greater than a probability in column D1 while a probability in row G3 is only about half times as great as a probability in row G1. This shows that getting a correct identification was mostly due to increasing the level of distinctness and while there was an information level effect it was not as significant.

Table 7.2. The number of correct identifications of individual rhinos from three levels of information derived from identification photographs

Distinctness/ Information	D1	n	D2	n	D3	n	ALL	Mean Score
G1	8	48	15	48	21	48	44	14.7
G2	9	48	17	48	27	48	53	17.7
G3	4	16	6	16	12	16	22	22.0
ALL	21		38		60		119	17.0
n		112		112		112	336	

D1 = least distinct, D2 = moderately distinct and D3 = most distinct
G1 = information from one view of an individual
G2 = information from two views of an individual
G3 = information from three views of an individual

Table 7.2a. Observed and fitted probabilities of obtaining a correct identification

Distinctness/ information	D1	D2	D3
G1 P OBS	0.17	0.31	0.44
P	0.15	0.29	0.48
G2 P OBS	0.19	0.35	0.56
P	0.20	0.35	0.55
G3 P OBS	0.25	0.38	0.75
P	0.27	0.45	0.65

The better the quality of the photograph in bringing out the identification features, the more likely there will be a correct identification. Figure 7.2a shows that there is an increasing trend to obtaining correct identifications with increasing photographic quality. This was especially the case when it was also linked to the distinctness of the rhinos' features with Figure 7.2b showing the trend for the least distinct group, where the ability to obtain a correct identification was increased markedly with improving photo quality.

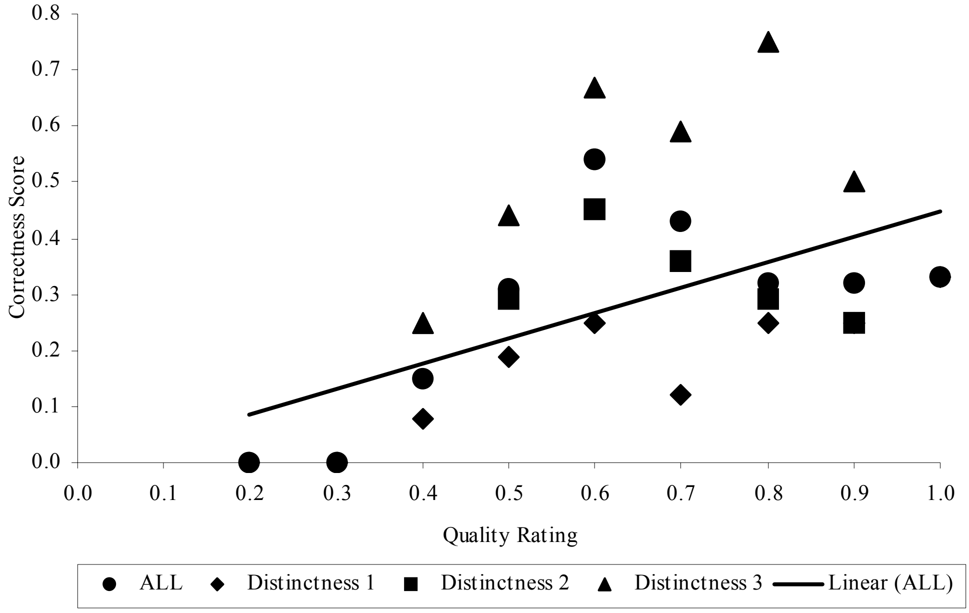


Figure 7.2a. Relationship between correct identification and the quality of photographs used for different levels of feature distinctness of individual rhinos

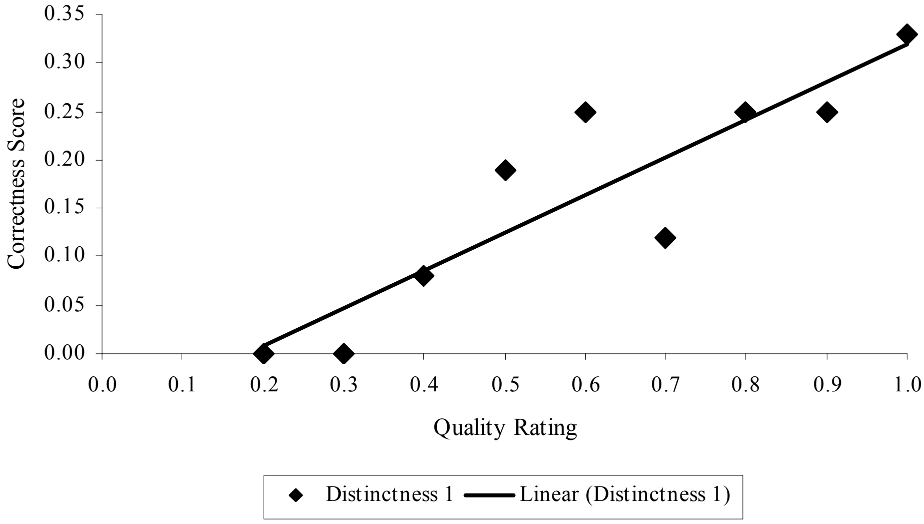


Figure 7.2b. Relationship between correct identification and the quality of photographs used for least distinct individual rhinos

Given that all the four judges that took part in the Name Test were experienced in the identification of the Sweetwaters rhinos, it would be reasonable to have assumed that there would have been a similarity of performance when judging the photographs. Experience with sea mammal photo-identification suggested that judges, however experienced, differed in their aptitude to make judgements from photographs.

This difference was also apparent in the results with rhinos as is shown in Table 7.3 with the poorest judge only getting 12% correct identifications while the best achieved 68%.

Of the 84 pictures to identify, judge 2 was only able to get 10 correct while judge 4 got 57 correct. However, this also shows that even the best judge failed to identify 27 (32%) of the photographs correctly.

Table 7.3. Judging Ability from Name Test

View	Judge 1	Judge 2	Judge 3	Judge 4
Face	6	0	4	6
Right profile	2	3	2	7
Left profile	5	1	0	8
Face & right	4	1	2	9
Face & left	7	1	3	9
Right & left	5	2	1	9
All views	7	2	4	9
Total	36	10	16	57
% total correct	43%	12%	19%	68%

7.3.2. Matching Test Results

The level of a judges' experience of rhinos was not found to be a factor in obtaining correct identification from photographs. Table 7.4 showed that, where judges are all highly experienced in field identification, there was a wide variation in a judges' ability to identify individual rhinos from photographs. This is reflected in Table 7.4a which shows that where judges have a wide variation in their experience of field identification there is also a wide variation in a judges' ability to match pictures of individual rhinos.

Table 7.4. Judging Ability from Matching Test

Category of Judge	A	B	C
Number of Judges	7	5	12
Average correct	17.29	16.60	18.83
Range	14 - 23	12 - 22	13 – 23
% in top third	29	20	42
% in bottom third	42	40	25

Table 7.4a. Kruskal Wallis test on the 3 judging groups

Group	number	median	Ave. rank	Z
A	7	17.0	11.1	-0.64
B	5	18.0	10.4	-0.75
C	12	18.5	14.2	1.18
overall	24		12.5	

H = 1.44 DF = 2 P = 0.487 (adjusted for ties)

The results show that 42% of the least experienced group of judges (group C) were in the top third of all judges (those who scored the most correct pairings) while only 29% of the most experienced group (group A) were in the top third. Judges in the least experienced group got a higher average number of correct pairings (18.83) than those in the most experienced group (17.29) although table 3.4a shows that there is not a significant difference between any of the groups (P = 0.487).

7.3.3. Pairs Test Results

Out of 441 potential pairings, 154 (35%) were incorrect of which 90 (58%) were different rhinos rated the same and 64 (42%) were the same rhinos rated as different. This is shown in Table 7.5 which demonstrates that there were more false positive errors than false negatives with those judges getting the most number incorrect more likely to give false positive errors.

Table 7.5. Types of errors arising from comparing pairs of photographs of individual rhinos

Type of Error	ALL SCORES			Top 3			Bottom 5		
	incorrect	total	%	incorrect	total	%	incorrect	total	%
Different rated same	90	154	58	7	12	58	29	45	64
Same rated different	64	154	42	5	12	42	16	45	36
Total	154	441	35	12	63	19	45	105	43

The best 3 of the 21 judges made errors in 19% of cases compared to 43% with the worst five judges. There was an increase in the proportion of false positive errors (58% to 64%) with poorer judges.

It would be expected that more errors would occur with pairs where the quality of the photographs made a judgement more difficult. This was found to be the case and is shown in Figure 7.3 where the number of correct judgements increased with a corresponding increase in the adjudged quality of the photograph.

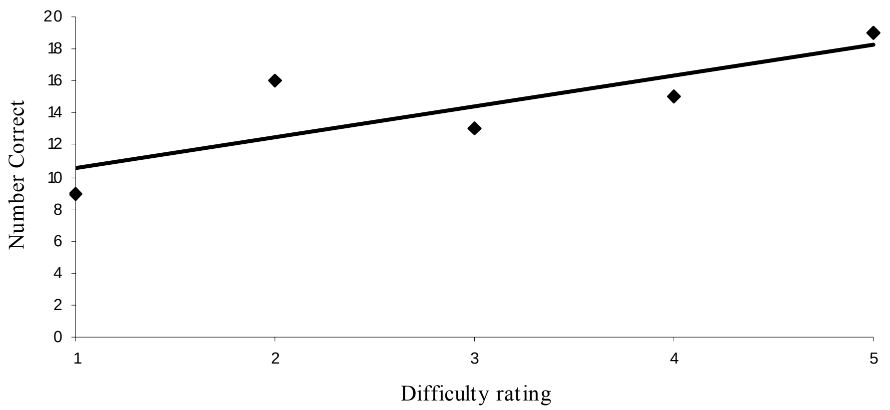


Figure 7.3. Effect of the degree of difficulty in correctly identifying pairs of photographs

It would also be expected that where the photographs of the pairs were rated as easier to correctly identify as the same or different, the level of accuracy obtained would be repeatable. Table 7.6 shows how consistent judges ratings of the pairs were with, in this test, three judges consistently rating, rightly or wrongly, those pairs which were most easy (class 5) or most difficult (class 1).

Table 7.6. Difficulty ratings for 21 pairs of rhino photographs sub-divided into four consistency rating

DEGREE OF CONSISTENCY			
0	**1**	**2**	**3**
2,3	3,3,2	1,1,3	5,4,4,5,
1,4	2,1,4		3,4,1,5

This consistency is also shown by the increase in number of correct identifications with the increase in adjudged quality of the photograph (figure 7.4)

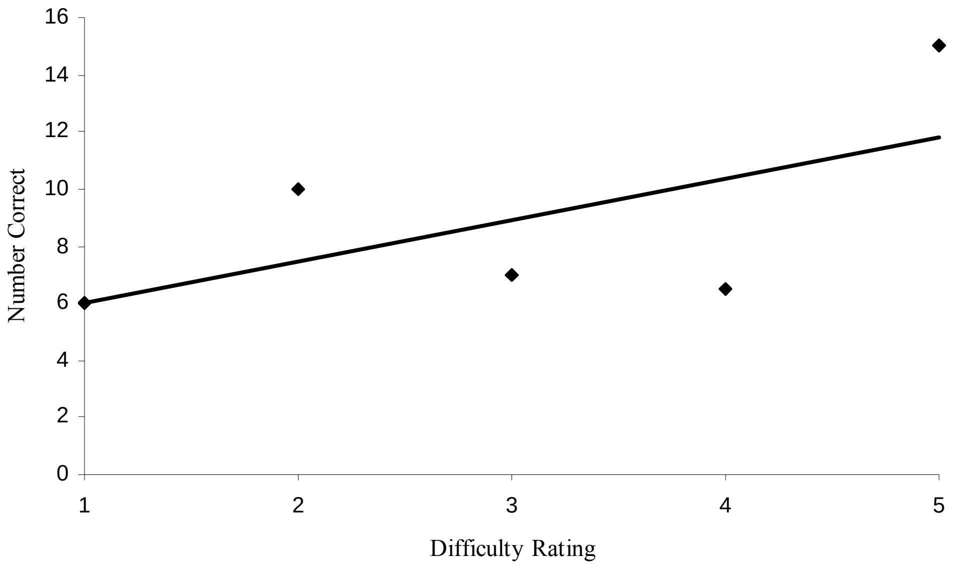


Figure 7.4. Number of correct pair identifications compared to their difficulty rating from the results of 3 judges tested 5 times with 21 pairs of photographs

In a test of two proportions there was no significant difference (P = 0.689) detected in the level of consistency in obtaining correct identifications from either a same pair or a different pair of photographs with both options achieving 60% and 62.2% correct identifications respectively as can be seen in table 7.7. There was also no significant difference detected in the level of consistency in obtaining correct identifications from either a same pair or a different pair of photographs with decreasing the difficulty of identification improving the consistency of obtaining a correct result as shown in table 7.8.

Table 7.7. Comparison of the proportion of correct identifications from pairs of photographs of either the same or different rhinos

	Different Rhinos	Same Rhinos
Correct	81	112
All possible	135	180
% correct	60.0	62.2

Test of two proportions: Z = 0.40; P = 0.689; 95%CI for difference (-0.13, 0.087)

Table 7.8. Comparison of the mean consistency results from pairs of photographs of either the same or different rhinos

Difficulty Rating	1	2	3	4	5
different rhinos	5.7	n/a	4.7	10.0	15.0
same rhinos	6.5	9.7	9.7	9.0	15.0

It was possible that judges could get better at observing the details in the photographs as they got used to the test and at what they were looking for to determine similarity or difference in features, that is, as their experience in judging increased. This was analysed by comparing the number of correct scores achieved for the first 7 of the 21 pairs with that for the last 7 as shown in table 7.9. The level of difficulty ratings for each third was 21 for the first third and 17 for the last meaning the difficulty in getting the last third correct was a little harder than for the first third with three of the seven pairs rated as level 1 (most difficult) while there were only two in the first third.

Table 7.9 shows that, whatever the level of experience with rhinos, all judges improved their scores between the first and last thirds with overall the first third pairings being judged correctly in 48% of times rising to 73% for the last third. When modelled using logistic regression, there was strong evidence of an 'order' effect which was found to be highly significant (χ^2 = 19.85, df=1, P = <<0.001)

Table 7.9. The effect of order on the Judges ability to make correct decisions at different levels of experience with rhinos

Judge Level	A	%	B	%	C	%	ALL	%
	correct		correct		correct			
first 3rd pairs	21	50	12	34	41	53	74	48
last 3rd pairs	30	71	26	74	56	73	112	73
no of judges	6		5		11		22	
total pairs in 3rd	42		35		77		154	

A = very experienced B = some experience C = no experience

Since it has already been shown that experience with rhinos was not a factor in obtaining correct identification, the data were re-analysed to compare the performance of the best and worst judges, see table 7.10. While only a sample of three, the performance of the best judges improved to 100% correct for the last seven pairs from 67% for the first seven. The worst judges also improved their performance from 40% correct to 66%.

Table 7.10. The effect of order on the best and worst judges ability to make correct decisions

Judges	Top 3	%	Bottom 5	%
	correct		correct	
first 3rd pairs	14	67	14	40
last 3rd pairs	21	100	23	66
no of judges	3		5	
total pairs in third	21		35	

7.3.4. Eye Wrinkle Test Results

The tests showed that judges differed in their ability to correctly identify individuals from eye wrinkle photographs and that ability was not dependent on the experience of the judge with rhinos. All photographs used for the eye wrinkle test were of good quality and no wrinkle pattern was considered more or less distinct than another and all patterns were unique.

Table 7.11 shows that the overall error made in the Twinning test was 12% with the inexperienced judges making half the number of errors (8%) compared to those with experience (16%) although a test of two proportions showed that the difference was not significant (Z = 1.24; P = 0.215).

Table 7.11. Analysis of errors made in the Twinning Test

	ALL	Inexperienced	Experienced
No. Judges	10	5	5
Matches	100	50	50
Errors	12	4	8
Errors %	12	8	16

Table 7.12 shows that overall a similar level of error (13.3% compared to 12%) was made in the Couples test as in the Twinning test but in this test inexperienced judges performed similarly to experienced judges. There were less false negative errors, (pairs described as different when they were the same), than false positive (10/14), (pairs described as the same when they were different) although a test of two proportions showed that the difference was not significant (P = 0.149). While inexperienced judges made the same number of errors as experienced judges (12/12), the inexperienced judges made more false negative errors (7/10) and the experienced more false positive (9/14).

Table 7.12. Analysis of errors made in Couples Test

ERROR	TOTAL	Actual	%	Inexperienced		Experienced	
maximum possible	180	24	13.3	12	50%	12	50%
error:same rated different	100	10	10.0	7	70%	3	30%
error:different rated same	80	14	17.5	5	36%	9	64%

The proportion of false positive errors at 58% (10/24) of all errors is the same as that found in the Pairs test (90/154) as shown in table 3.5.

Table 7.13 shows the effect of presenting the results not by experienced/inexperienced judges but by best five judges compared to worst five judges. The results show that the worst five judges made five times more errors (30v6) than the best five judges in using eye wrinkles for rhino identification so selection of judges is important.

Table 7.13. Analysis of errors made in both eye wrinkle tests by best and worst judges

ERROR	TOTAL	Actual	%	Best 5 Judges		Worst 5 Judges	
maximum possible	280	36	12.9	6	17%	30	83%
error: Couples test	180	24	13.3	5	21%	19	79%
error: Twinning test	100	12	12.0	1	8%	11	92%

It can be concluded that eye wrinkles are a robust feature to discern individuals from photographs with the best five judges achieving an overall accuracy of 95%+ (6 errors in 280) when comparing a single eye wrinkle picture against a limited database of ten potentials.

7.4. Discussion

Even for the best of the judges, using photographs to identify individual rhinos was not completely reliable. There were four key factors which improved the accuracy and consistency of identification: the amount of identification information available, the quality of the photograph, the distinctness of the rhino and the aptitude of the judge for reviewing photographs.

The number of correct identifications increased with the amount of information available and the quality of the photograph. This suggests that there are certain important aspects of the structure of the rhinos face that distinguishes it from others and where some or all are missing it can lead to misidentification. This is similar to what was reported with human face recognition (Bruce and Young 1986).

Overall there was an increasing trend to obtaining correct identifications with increasing photographic quality while half of the correct identifications were from the rhinos rated as having the most distinct features such as a unique horn structure or ear marking. Again the relationship of quality and distinctness was found to be the same by Zhao *et al.* (2000) with human face recognition.

The importance of distinctness was further evidenced by the results showing that errors were more often made with pairs which were rated most difficult to match and least often with pairs rated most easy, the degree of difficulty being related to the distinctiveness of features. Easier pairs to identify were also more consistently identified correctly by judges. However part of the difficulty was related to the obscuring of a feature by a poor quality photograph or by the habitat as was found by Rugh *et al.* (1992) in examining photographs of bowhead whales

The need for good quality photographs to be used in ensuring correct identification was found to be the same with rhinos as that found by researchers in sea mammals (Hammod *et al.* 1990, Defran *et al.* 1990, Agler 1992b, Gowans and Whitehead 2001).

The judges with a high level of field experience with the rhinos showed a wide variation in their ability to identify rhinos from the photographs. The judges with a wide variation in their experience of field identification also showed a wide variation in their ability to identify individual rhinos from photographs. This illustrates that a high level of field experience is not a prerequisite for having a high level of ability to identify rhinos from photographs and the selection of a judge should be undertaken with care. Friday *et al.* (2000) reported similar experiences with photographic judging of humpback whales.

The improvement in the performance of judges between the first third and last third of the pairs test suggests that judging the identification of rhinos from photographs can be a skill which can be learned or at least improved on with practice. The best judges were those with some knowledge of rhinos, not from working in the field as rangers, but from having been involved in some level of rhino research. They were also used to looking at photographs in general which the rhino ranger is normally not accustomed to. Among the worst judges of photographs were the rangers who were considered the most skilful at identifying rhinos in the field. This should be borne in mind when selecting a judge to verify the identification of a rhino from a photograph.

While errors in identification of animals with natural markings are more likely to be false negatives, with the rhinos, where structural characteristics are the main source for identification, there were more false positive errors than false negatives particularly with the judges getting the most incorrect ratings.

Although the dataset was limited to 19 rhinos considered to be widely genetically diverse, eye wrinkle patterns appear to offer a robust feature for identifying individual rhinos from photographs. Should this be an inherited feature, for which there was no evidence from the photographs, it may be a less robust identification feature in enclosed, reserve populations where genetic diversity is more restricted.

7.5. Recommendations

The results obtained show that using photographs to identify individual rhinos is not without error but that such errors can, in part, be reduced in practice. It is recommended that, where possible:

g) several photographs of the same rhino showing as many different identification features should be reviewed so that as much identification information is available on which to make a judgement.

h) the quality of the photographs should be as high as possible although in practice this may be limited by the location of the rhino at the time the photographs are taken. If there is sufficient time, it will benefit the accuracy of identification for either the photographer to move, and/or to wait for the rhino to move, in to positions where good, clear identification photographs are taken of different views of the rhino from different angles.

i) while nothing can be done to improve the distinctness of a rhinos natural identification features, ear notching - cutting shapes in the ear of a rhino while anaesthetised - makes an individual more distinctive. As this process is invasive, costly and may affect the rhinos' future behaviour, it should not be considered as a general recommendation to improve identification accuracy but rather to overcome specific problems where two similar featured rhinos are hard to distinguish.

j) before a person is chosen to make identification judgements from photographs, they should receive appropriate training and be tested to show they have an aptitude for the task. It should not be assumed that someone good at identifying individuals in the field will be equally as good at doing so from photographs.

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APPENDIX

A5 A Guide to Producing Photo-Identification Booklets – one rhino/page

This guide assumes that photographs are taken with a digital camera

A. CREATING A SUITABLE PHOTO

1. Take photographs on the highest quality setting or if a lot of photographs are expected to be taken before downloading, set to the highest quality that allows for sufficient number to be taken or use a second memory disk.

2. Download the photographs to the computer into a newly named folder – use the download wizard on the screen where shown.

3. Close all programmes and then open Paint Shop Pro 9.1 – select drop down menu FILE, choose BROWSE. Open your saved folder and thumbnails of your photographs will be displayed.

4. Select a suitable photograph, double click on the thumbnail to open it. Select CROP TOOL icon (third down) on TOOLS toolbar (drop down menu VIEW, select toolbars, select TOOLS).

5. Drag the icon over the area of the photograph you wish to have eg the head profile from a full side view of a rhino. When sized as required, double click on the middle of the selection and the photo will be cut down to size.

6. Select drop down menu IMAGE, choose RESIZE. In PRINT SIZE box HEIGHT type in 2.25 inches (width will automatically scale). In RESOLUTION type in 200. Click OK. (Don't worry if the picture expands and looks out of focus, the size you are using is small and can be checked by selecting drop down menu VIEW, choose Zoom, select ZOOM OUT MORE. Now it will look OK.

7. If the photograph is too dark or too light then select drop down menu ADJUST, choose BRIGHTNESS and CONTRAST, select top line Brightness and Contrast and then increase % for lighter or decrease % for darker. Put contrast on +2.

8. When happy, select drop down menu FILE, choose SAVE AS, type in suitable description usually rhino number, name, age/sex, date, type of photo. Check SAVE AS TYPE is on JPG, check OPTIONS is on COMPRESSION FACTOR 1 Always start with the number as this is important in sorting photos in order.

9. If all the above is OK select SAVE. Now you have the original photograph AND the new photograph so if something is wrong then you can go back to the original and try again.

10. For the books, the photographs are printed in greyscale. Open the photograph, select the drop down menu IMAGE and choose GREYSCALE. The photo will turn to shades of grey. Select drop down menu FILE, choose SAVE AS, put a G at the end of the description and select SAVE. Now you have the colour photograph and a grey photograph.

11. For each rhino there should be 4 greyscale photos – face, left, right, and ears (in some cases this may be two separate photos of each ear). These should be moved into a folder RESERVE

DATABASE (date). Move the greyscale photos into the appropriate folder. In addition move all notch drawings into the folder. Sort all thumbnails into rhino number order as they will appear in the book.

B. CREATING A PRINT LAYOUT TEMPLATE

12. In Paint Shop Pro, – select drop down menu FILE, choose BROWSE. Open your saved RESERVE DATABASE folder and thumbnails of your photographs will be displayed

The way the booklets are produced means that 4 different rhinos can be printed on one A4 page so:

13. Click on all 5 thumbnails of the photographs of the required sequence of 4 rhinos if all are available. If not click on the thumbnails of the photographs of the 4 rhinos and no more. With these selected, go to drop down menu FILE, choose PRINT LAYOUT. The selected thumbnails will appear down the left side and a white page on the right. If it is landscape format and you want portrait go to drop down menu FILE, choose PRINT SET UP, click on the PORTRAIT icon and the page shape will change. For the books we design the layout in LANDSCAPE.

14. If no grid is showing, select drop down menu VIEW, choose SHOW GRID. Select drop down menu VIEW, choose OPTIONS and ensure the unit is inches and the horizontal and vertical spacing is set at 0.5

15. To move a photo on to the layout – only ONE AT A TIME, click on the desired photo and drag it on to the page. Drag it so one corner is on the corner of a square and resize to 2½ squares high except for the ears photo which will be about 1½ squares high (size to fit available space).

There are 22 grid boxes horizontally. The face, right and left photos of one rhino go on the top and must not take up more than 10 boxes then leave two blank boxes and start another rhino in the next 10 grids. Don't go over the 10 boxes, make each photo a little smaller to get them to fit with just a tiny space between each photo. This should leave two free boxes between the end of the left side photos and the beginning of the right side photos. This is important when coming to do the laminating.

There are 16 grid boxes vertically. You need two box gap between the top rhino and the bottom but you only need to leave half a box at the top of the page and the bottom and only half a box between rhino 1 top and bottom photos and between rhino 2 top and bottom photos.

To add the text, go to the toolbar and select **A** (create a text field). Put the text field next to the notch diagram. Select Times New Roman, 12pt, bold. Type number, enter/enter, type NAME in capitals, enter/enter, type sex, male or female, in lower case. Make sure the text in the box does not extend wider than the photograph above it. (use previous book layout as a guide)

16. When there are all 16 photos and text sized and positioned correctly and all lined up select drop down menu FILE, choose SAVE TEMPLATE, click WITH IMAGES box, write a short name, a page number and a date and list the rhino numbers in the description. Press OK. Your template is saved. Close.

C. TO PRINT A TEMPLATE.

17. Open Paint Shop Pro, select drop down menu FILE, choose PRINT LAYOUT. A white page is shown If it has the grid on it switch this off by selecting drop down menu VIEW, choose SHOW GRID and the grid will disappear.

18. Whatever the format (landscape or portrait) of the template, at this stage the white page must be PORTRAIT. To alter this from landscape, select drop down menu FILE, choose PRINT SET UP and click on PORTRAIT.

19. Select drop down menu FILE, choose OPEN TEMPLATE choose USER DEFINED and locate the required template Click on it and click OK. The template will be formed on the screen

20. Select drop down menu FILE, choose PRINT SET UP. Under PRINTER select appropriate printer series Select as appropriate for the printer and make changes – Paper Quality/ More/Inkjet Papers/HP PREMIUM PAPER; Print Quality/FAST NORMAL; Size/A4. Select COLOUR, click GREYSCALE/High Quality

Note: greyscale high quality uses the colour cartridge to make grey and gives the best result. However by using the black cartridge a greyscale image can be printed. If there is not sufficient colour ink and an image is essential then select BLACK PRINT CARTRIDGE ONLY.

21. Click OK, then next screen OK until the PRINT SET UP window appears. Under PRINT OUTPUT select GREYSCALE and under NUMBER OF COPIES select number required. Check the print preview to see that the template fits

Note: If printing many copies – say 10, just select number 1 and print to ensure it is all set up correctly. If OK, print say 4 more copies of the whole booklet then repeat the process for another 5 copies. This ensures that paper is not wasted if a) the set up is wrong especially as the text often does not appear where it looks as if it should or b) the ink cartridge runs out before all copies are made.

22. Click CLOSE. Load paper into printer. Most premium inkjet paper has one good (bright white) side and one poor (dull grey). Ensure paper is loaded the correct way.

23. Select drop down menu FILE, choose PRINT and hope it all goes well!

Note: if it does not print correctly, the text box can be moved on the template and then resaved and try 1 copy again. For no obvious reason it may never work with the text and this then has to be deleted and written in by hand

D. PREPARING THE PAGES FOR LAMINATING

24. The A4 sheets need to be cut up into 4 separate pages whereby each photopage is 13.5/14 cms wide, 10 cms high. There should be roughly 1cm white margin above the top of the top photos and 1 cm margin below the bottom of the bottom photos. This allows for the binding.

25. The front cover with the number and names of the rhinos is made up and printed in Excel. Just modify the previous spreadsheet and print on plain paper. This can be pasted onto a piece of correctly sized premium paper.

26. The latest book is set up in number order. Arrange the pages into the appropriate order using a previous book for guidance.

27. The pages are loaded back to back into the laminating pouches. One of the two pages should be upside down. The couple must be kept together so a small amount of paper glue PRITT STICK is used. At this stage it is clear which edge of each page will be bound and if there is not sufficient area the pages can be put together in such a way to give more space and the top should be trimmed to make sure the whole area is no more than 10 cm high.

E. LAMINATING THE PAGES

28. Place the laminating machine on a large flat surface and ensure there is space in front of and behind it. Get some books such as telephone directories which are the same height as the input and output of the machine and place in front and behind. Turn on the laminating machine. Wait for the light READY to start.

Note: it is recommended to use A5 laminating pouches of 2x75 microns=150 total. Any bigger ie the 125 micron pouches = 250 total produces less good booklets. Experience shows thatA5 makes for easier finishing than cutting up A4.

29. Take the laminating pouch and open. Place a page up to the top edge of the pouch and in the middle so that there is about an equal amount of laminate each side of the page. Take a second page and place close to the bottom of the pouch but with a few mm of laminate at the bottom. Ensure the top edge of the bottom page is parallel to the bottom edge of the top page and that they are lined up one below the other. Ensure the gap between the two photos is large enough for lamination to occur effectively when cut in half.

30. Put laminate pouch with top end going into the machine first laying the bottom end carefully on the supporting books making sure the line up of the bottom page in the pouch has not been disturbed. If all OK push the pouch into the machine until it is gripped and is pulled through automatically. Make sure as the pouch come out it is on a flat surface or it will bend.

31. Prepare the next pouch as the previous one is laminating.

32. When the pouch has been laminated, take away from machine and let cool for 30 seconds. Then take a pair of small sharp scissors and cut the pages apart as near to the centre of the gap between the top and bottom pages as this means the two will be the same size and will require no further work.

Note: to prevent overheating, after laminating say three books worth of pages, turn off the machine and let cool down for 30 minutes or more. Then turn back on and when light READY is on start again

F. MAKING UP THE BOOKLETS

33. Get all the pages of the book in the right order.

34. Make sure the comb binding machine is set so that the first hole is fully cut into the laminate – use a piece of paper to adjust the set up holding the edge of the paper against the left side guide bar. Make holes. Move guide bar accordingly and check until right.

35. Take each laminated page <u>one at a time</u> and place carefully in the binder so that the left edge is against the guide bar and the front edge is fully into the machine. If this is not done carefully the holes will not be put fully on the page and the binding will be poor.

36. Place binder into machine and open. Ensure booklet pages are all in the correct order. Shuffle so all holes visible and put into binder ensuring all rings have gone through all pages. Release binder and trim off excess so that there is no part of the binding outside the width of the page – if there is this will get caught and can tear the binding off.

Note: if the binding comes partly away, it is possible to put the rings back one at a time by hand with a little patience.

YOU NOW HAVE A NEW IDENTIFICATION BOOKLET!

A Guide to Producing Photo-Identification Booklets – two rhinos/page

This guide assumes that photographs are taken with a digital camera

A. CREATING A SUITABLE PHOTO

1. Take photographs on the highest quality setting or if a lot of photographs are expected to be taken before downloading, set to the highest quality that allows for sufficient number to be taken or use a second memory disk.

2. Download the photographs to the computer into a newly named folder – use the download wizard on the screen where shown.

3. Close all programmes and then open Paint Shop Pro 9.1 – select drop down menu FILE, choose BROWSE. Open your saved folder and thumbnails of your photographs will be displayed.

4. Select a suitable photograph, double click on the thumbnail to open it. Select CROP TOOL icon (third down) on TOOLS toolbar (drop down menu VIEW, select toolbars, select TOOLS).

5. Drag the icon over the area of the photograph you wish to have eg the head profile from a full side view of a rhino. When sized as required, double click on the middle of the selection and the photo will be cut down to size.

6. Select drop down menu IMAGE, choose RESIZE. In PRINT SIZE box HEIGHT type in 2.25 inches (width will automatically scale). In RESOLUTION type in 200. Click OK. (Don't worry if the picture expands and looks out of focus, the size you are using is small and can be checked by selecting drop down menu VIEW, choose Zoom, select ZOOM OUT MORE. Now it will look OK.

7. If the photograph is too dark or too light then select drop down menu ADJUST, choose BRIGHTNESS and CONTRAST, select top line Brightness and Contrast and then increase % for lighter or decrease % for darker. Put contrast on +2.

8. When happy, select drop down menu FILE, choose SAVE AS, type in suitable description usually rhino number, name, age/sex, date, type of photo. Check SAVE AS TYPE is on JPG, check OPTIONS is on COMPRESSION FACTOR 1 Always start with the number as this is important in sorting photos in order.

9. If all the above is OK select SAVE. Now you have the original photograph AND the new photograph so if something is wrong then you can go back to the original and try again.

10. For the books, the photographs are printed in greyscale. Open the photograph, select the drop down menu IMAGE and choose GREYSCALE. The photo will turn to shades of grey. Select drop down menu FILE, choose SAVE AS, put a G at the end of the description and select SAVE. Now you have the colour photograph and a grey photograph.

11. For each rhino there should be 3 greyscale photos – face, left, right. These should be moved into a folder RESERVE DATABASE (date). Move the greyscale photos into the appropriate folder – one for males and one for females with sub-adults and calves at the end of the adult females. Sort all thumbnails into rhino number order as they will appear in the book.

B. CREATING A PRINT LAYOUT TEMPLATE FOR SOLIO

12. In Paint Shop Pro, – select drop down menu FILE, choose BROWSE. Open your saved RESERVE DATABASE folder and thumbnails of your photographs will be displayed
The booklets are produced with 8 different rhinos printed on one A4 page so:

13. Click on all 24 thumbnails of the photographs of the required sequence of 8 rhinos if all photos are available. If not click on what photos there are of the 8 rhinos but no more. With these selected, go to drop down menu FILE, choose PRINT LAYOUT. The selected thumbnails will appear down the left side and a white page on the right. If it is landscape format and you want portrait go to drop down menu FILE, choose PRINT SET UP, click on the PORTRAIT icon and the page shape will change. For the books we design the layout in LANDSCAPE.

14. If no grid is showing, select drop down menu VIEW, choose SHOW GRID. Select drop down menu VIEW, choose OPTIONS and ensure and the unit is inches and the horizontal and vertical spacing is set at 0.5.

15. To move a photo on to the layout – only ONE AT A TIME, click on the desired photo and drag it on to the page so one corner is on the corner of a square and resize to 3 squares high.

There are 22 grid boxes horizontally. The face, right and left photos of one rhino go on the top and must not take up more than 10 boxes then leave half a blank box and start another rhino below. Don't go over the 10 boxes, make each photo a little smaller to get them to fit with just a tiny space between each photo. This should leave two free boxes between the end of the left side photos and the beginning of the right side photos. This will be important when laminating.

There are 16 grid boxes vertically. You need a two box gap between the top two rhinos and the bottom two but you only need to leave half a box at the top of the page and the bottom of the page and only half a box between rhino 1&2 top and 3&4 bottom.

16. When all 24 photos are positioned correctly and all lined up select drop down menu FILE, choose SAVE TEMPLATE, click WITH IMAGES box, write a short name, a page number and a date and list the rhino numbers in the description. Press OK. Your template is saved. Close.

C. TO PRINT A TEMPLATE.

17. Open Paint Shop Pro, select drop down menu FILE, choose PRINT LAYOUT. A white page is shown. If it has the grid on it switch this off by selecting drop down menu VIEW, choose SHOW GRID and the grid will disappear.

18. Whatever the format (landscape or portrait) of the template, at this stage the white page must be PORTRAIT. To alter this from landscape, select drop down menu FILE, choose PRINT SET UP and click on PORTRAIT.

19. Select drop down menu FILE, choose OPEN TEMPLATE choose USER DEFINED and locate the required template. Click on it and click OK. The template will be formed on the screen.

20. Select drop down menu FILE, choose PRINT SET UP. Under PRINTER select appropriate printer series. Select PROPERTIES, FEATURES and make changes – Paper Quality/ More/Inkjet Papers/HP PREMIUM PAPER; Print Quality/FAST NORMAL; Size/A4. Select COLOUR, click GREYSCALE/High Quality

Note: greyscale high quality uses the colour cartridge to make grey and gives the best result. However by using the black cartridge a greyscale image can be printed. If there is not sufficient colour ink and an image is essential then select BLACK PRINT CARTRIDGE ONLY.

21. Click OK, then next screen OK until the PRINT SET UP window appears. Under PRINT OUTPUT select GREYSCALE and under NUMBER OF COPIES select number required. Check the print preview to see that the template fits.

Note: If printing many copies – say 10, just select number 1 and print to ensure set up is correct. If OK, print say 4 more copies of the whole booklet then repeat the process for another 5 copies. This ensures that paper is not wasted if a) the set up is wrong especially as the text often does not appear where it looks as if it should or b) the ink cartridge runs out before all copies are made.

22. Click CLOSE. Load paper into printer. Most premium inkjet paper has one good (bright white) side and one poor (dull grey). Ensure paper is loaded the correct way with, for the D2300, the grey side facing upwards.

23. Select drop down menu FILE, choose PRINT and hope it all goes well! Write on clearly but small the names in CAPITALS and numbers using a black fine tip biro.

D. PREPARING THE PAGES FOR LAMINATING

24. The A4 sheets need to be cut up into 4 separate pages whereby each photopage is 14 cms wide, 10 cms high. There should be roughly 1cm white margin above the top of the top photos and 1 cm margin below the bottom of the bottom photos. This allows for the binding.

25. The front cover with the number and names of the rhinos is made up and printed in Excel. Just modify the previous booklet cover spreadsheet and print on plain paper. Cut same size page size.

26. The latest book is set up in number order. Arrange the pages into the appropriate order using a previous book for guidance.

27. The pages are loaded back to back into the laminating pouches. One of the two pages should be upside down. The couple must be kept together so a small amount of paper glue PRITT STICK is used. At this stage it is clear which edge of each page will be bound and if there is not sufficient area the pages can be put together in such a way to give more space and the top should be trimmed to make sure the whole area is no more than 10 cm high.

E. LAMINATING THE PAGES

28. Place the laminating machine on a large flat surface and ensure there is space in front of and behind it. Get some books such as telephone directories which are the same height as the input and output of the machine and place in front and behind. Turn on the laminating machine. Wait for the green light to be fully on to start.

Note: it is recommended to use A5 laminating pouches of 2x75 microns=150 total. Any bigger ie 125 micron pouches = 250 total will not go through the laminator and will produce less useful booklets. Experience shows thatA5 makes for easier finishing than A4.

29. Take the laminating pouch and open. Place a page up to the top edge of the pouch and in the middle so that there is about an equal amount of laminate each side of the page. Take a second page and place close to the bottom of the pouch but with a few mm of laminate at the bottom. Ensure the top edge of the bottom page is parallel to the bottom edge of the top page and that they are lined up one below the other. Ensure the gap between the two photos is large enough for lamination to occur effectively when cut in half.

30. Put laminate pouch with top end going into the machine first laying the bottom end carefully on the supporting books making sure the line up of the bottom page in the pouch has not been disturbed. If all OK push the pouch into the machine until it is gripped and is pulled through automatically. Make sure as the pouch come out it is on a flat surface or it will bend.

31. Prepare the next pouch as the previous one is laminating.

32. When the pouch has been laminated, take away from machine and let cool for 30 seconds. Then take a pair of small sharp scissors and cut the pages apart as near to the centre of the gap between the top and bottom pages as this means the two will be the same size and will require no further work.

Note: to prevent overheating, after laminating say three books worth of pages, turn off the machine and let cool down for 30 minutes or more. Then turn back on and when green light is on start again

F. MAKING UP THE BOOKLETS

33. Get all the pages of the book in the right order.

34. Make sure the comb binding machine is set so that the first hole is fully cut into the laminate – use a piece of paper to adjust the set up holding the edge of the paper against the left side guide bar. Make holes. Move guide bar accordingly and check until right.

35. Take each laminated page one at a time and place carefully in the binder so that the left edge is against the guide bar and the front edge is fully into the machine. If this is not done carefully the holes will not be put fully on the page and the binding will be poor.

36. Place binder into machine and open. Ensure booklet pages are all in the correct order. Shuffle so all holes visible and put into binder ensuring all rings have gone through all pages. Release binder and trim off excess so that there is no part of the binding outside the width of the page – if there is this will get caught and can tear the binding off.

YOU NOW HAVE A NEW IDENTIFICATION BOOKLET!

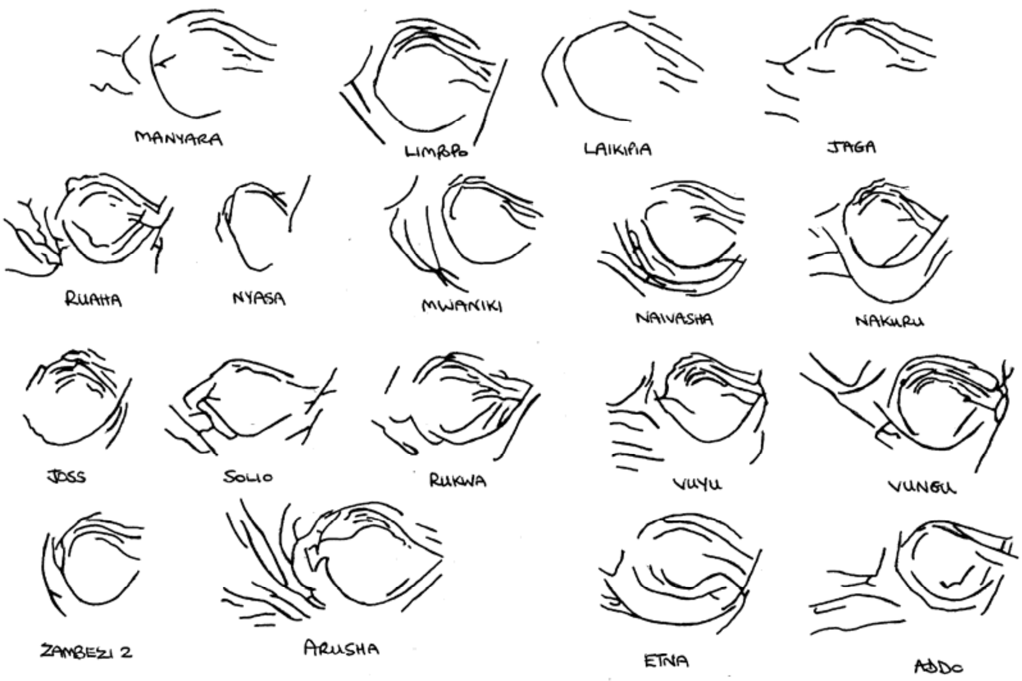


Figure A7.1a Left eye wrinkles of black rhinos at Port Lympne Wild Animal Park

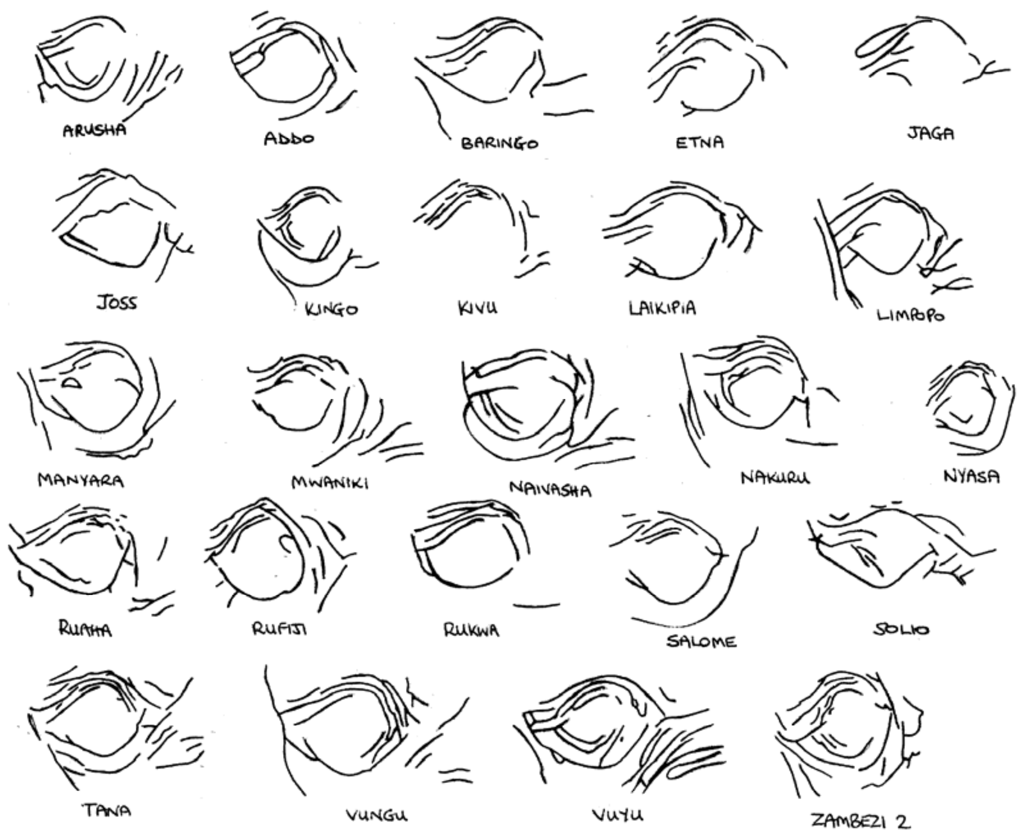


Figure A7.1b Right eye wrinkles of black rhinos at Port Lympne Wild Animal Park

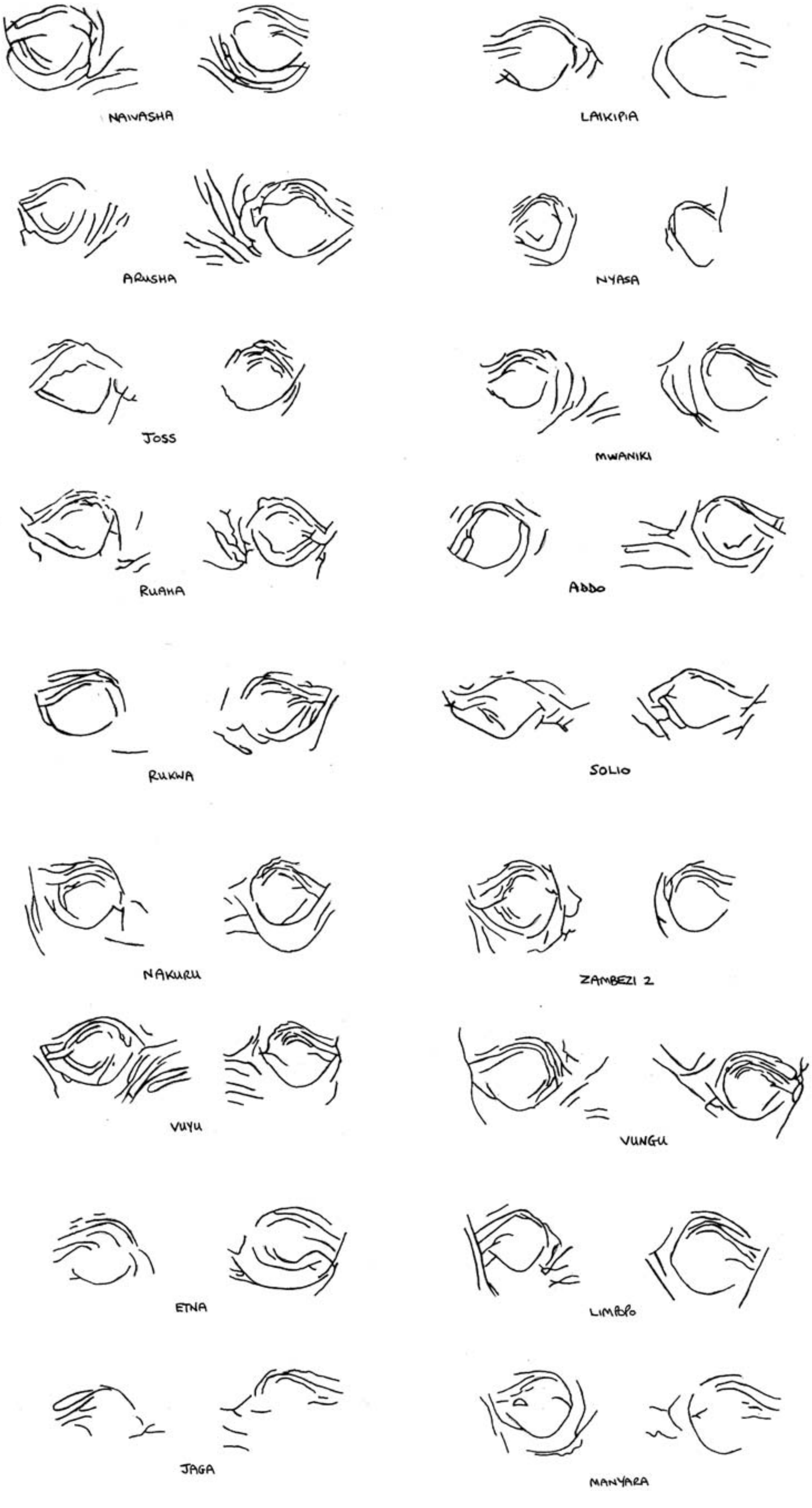
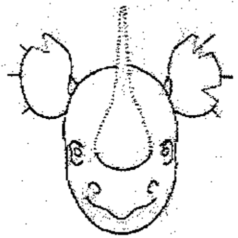
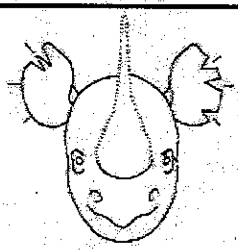


Figure A7.2 Pairs of eye wrinkles of the black rhinos at Port Lympne Wild Animal Park, UK

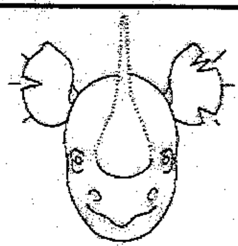


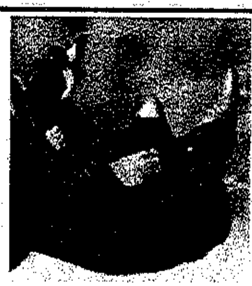


Rhino	Number	Sex	Age	Horn Size Front/Rear	Rear Horn Shape	Rear Horn Length	Notches Right	Notches Left	Calf Sex	Calf Age
Baraka	4017	M	A	>	conical	shorter	1	3	-	



Rhino	Number	Sex	Age	Horn Size Front/Rear	Rear Horn Shape	Rear Horn Length	Notches Right	Notches Left	Calf Sex	Calf Age
Batian	4032	F	DSA	>	triangular	short	2	3	-	



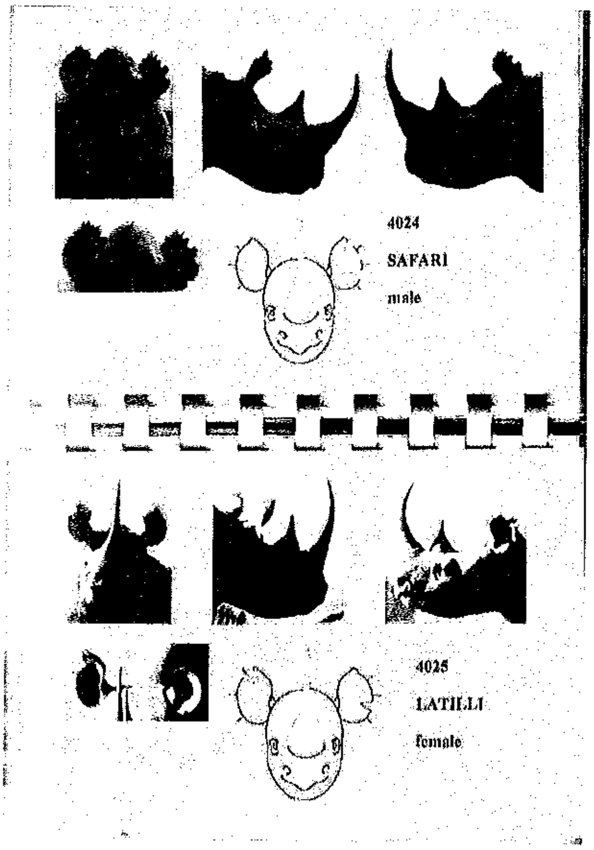


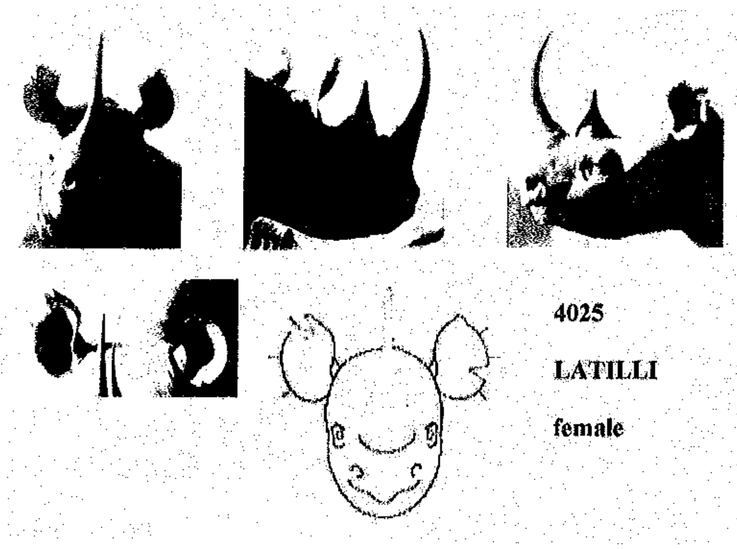
Rhino	Number	Sex	Age	Horn Size Front/Rear	Rear Horn Shape	Rear Horn Length	Notches Right	Notches Left	Calf Sex	Calf Age
Benja	4037	M	SA	>	triangular	short	1	3	-	

Date printed 17.01.2006

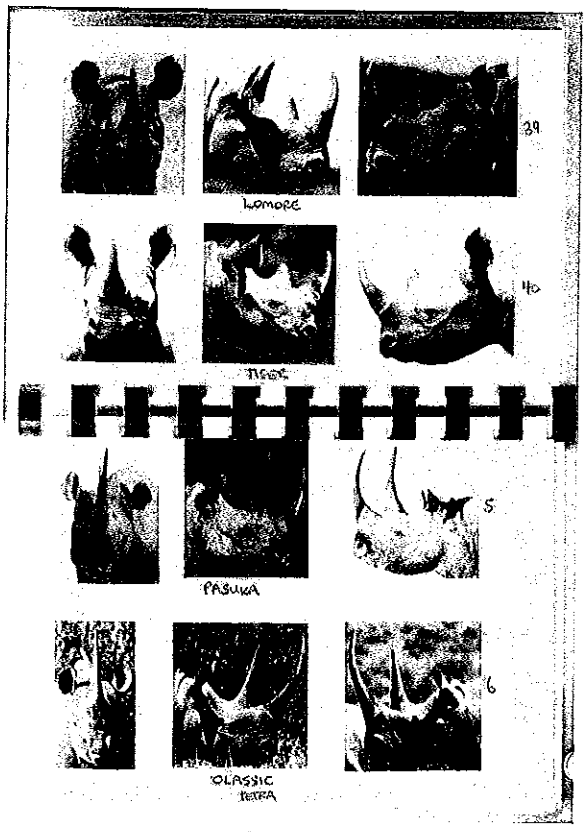
Database created 03.01.2006

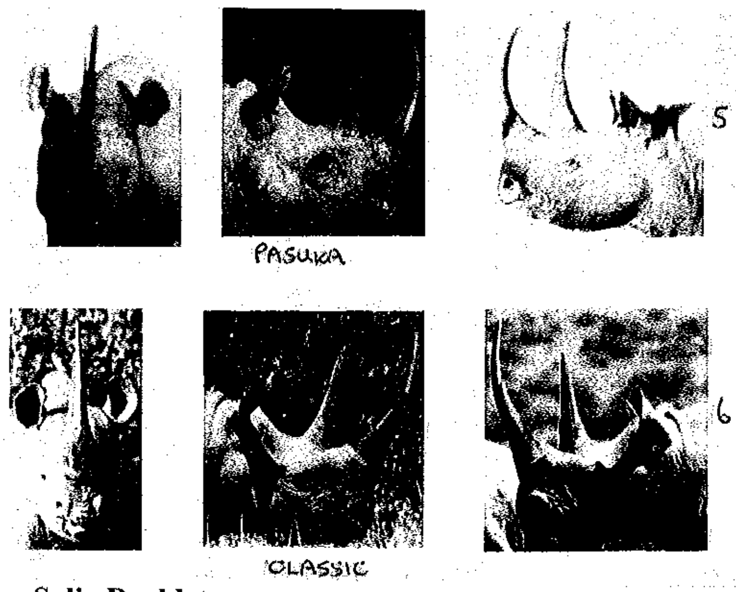
FIG 5.2 SWEETWATERS ACCESS DATABASE EXAMPLE





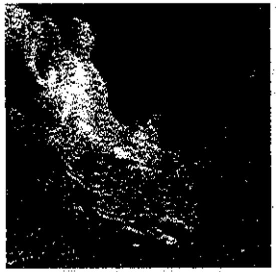
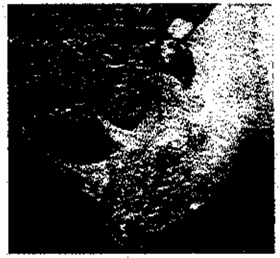
Sweetwaters Booklet
One rhino per page





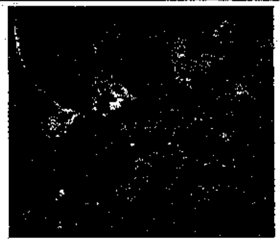
Solio Booklet
two rhinos per page

Fig 5.4 **Example Pages from Photo-Identification Booklets**


Old

Rhino				Notches		Horn Size	Rear Horn		Calf		
Name	Number	Sex	Age	Right	Left	Front/Rear	Shape	Length	Number	Sex	Age
Ann	1026	F	A	0	0	>	triangular	short	1079	F	>3 yrs


Old

Rhino				Notches		Horn Size	Rear Horn		Calf		
Name	Number	Sex	Age	Right	Left	Front/Rear	Shape	Length	Number	Sex	Age
Ark	1024	M	A	0	0	>	conical	m long		-	-



Old

Rhino				Notches		Horn Size	Rear Horn		Calf		
Name	Number	Sex	Age	Right	Left	Front/Rear	Shape	Length	Number	Sex	Age
Daniel	1080	M	SA	0	0	>	triangular	v small		-	-

Date printed 17.01.2006

Database created 03.01.2006

Fig 56 ABERDARES ACCESS EXAMPLE PAGE