RESEARCH

Determining the suitability of using eye wrinkle patterns for the accurate identification of individual black rhinos

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Abstract

Photograhic identification is used to identify individual black rhinos (*Diceros bicornis*) with the distinguishing features of sex, 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. Eye wrinkle patterns have received little attention but were found to be useful when separating a large number of photographs of 19 captive rhinos particularly for distinguishing individual sub-adults where other features such as horn length and shape were very similar. Each rhino was found to have unique eye wrinkle patterns which remained consistent when the eyes were open or closed. By developing and applying a series of tests, judgement errors that occur when reviewing eye wrinkle photographs were determined and are reported. Results show that individual black rhinos can be accurately identified from suitable photographs but, even for the best of the judges, using eye wrinkles alone to identify individual rhinos was not completely reliable.

Key words: photo-identification, photographs, black rhinos

Résumé

L'identification photographique est utilisée à identifier différents rhinocéros noirs (*Diceros bicornis*) ayant des traits distinctifs de sexe, de taille et de la forme des cornes antérieure et postérieure, les particularités des oreilles, la configuration des contours des rides sur le museau, les cicatrices et les blessures sur le corps, l'état de la queue, la taille du corps - y compris celui d'un veau par rapport à sa mère - et les plis de la peau. Les configurations des rides oculaires ont suscité peu d'attention mais se sont avérés utiles quand on a organisé un grand nombre de photographies de dix-neuf rhinocéros captifs, surtout pour distinguer les différents sous-adultes alors que d'autres traits, comme la longueur et la forme de la corne, étaient semblables. Chaque rhinocéros s'est avéré avoir des configurations de rides oculaires qui restaient conformes que les yeux soient ouverts ou fermés. En développant et en appliquant une série de tests, les erreurs d'appréciation qui se produisent lorsqu'on examine les photographies des configurations des rides oculaires ont été déterminées et rapportées. Les résultats montrent qu'on peut correctement identifier les différents rhinocéros noirs à partir des photographies appropriées mais, même pour le meilleur des juges, les rides oculaires seules n'étaient pas complètement fiables pour identifier les individus.

Introduction

The natural features used for the identification of individual black rhinos are sex, 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 and Klingel 1966; Goddard 1966, 1967; Hamilton and King 1969; Hitchins 1969; Schenkel and Schenkel-Hulliger 1969; Hitchins and Keep 1970). Polet et al. (1999) used eye wrinkle patterns to distinguish photographs of individual Javan rhinos (*Rhinoceros sondaicus*). This technique has not so far been used for black

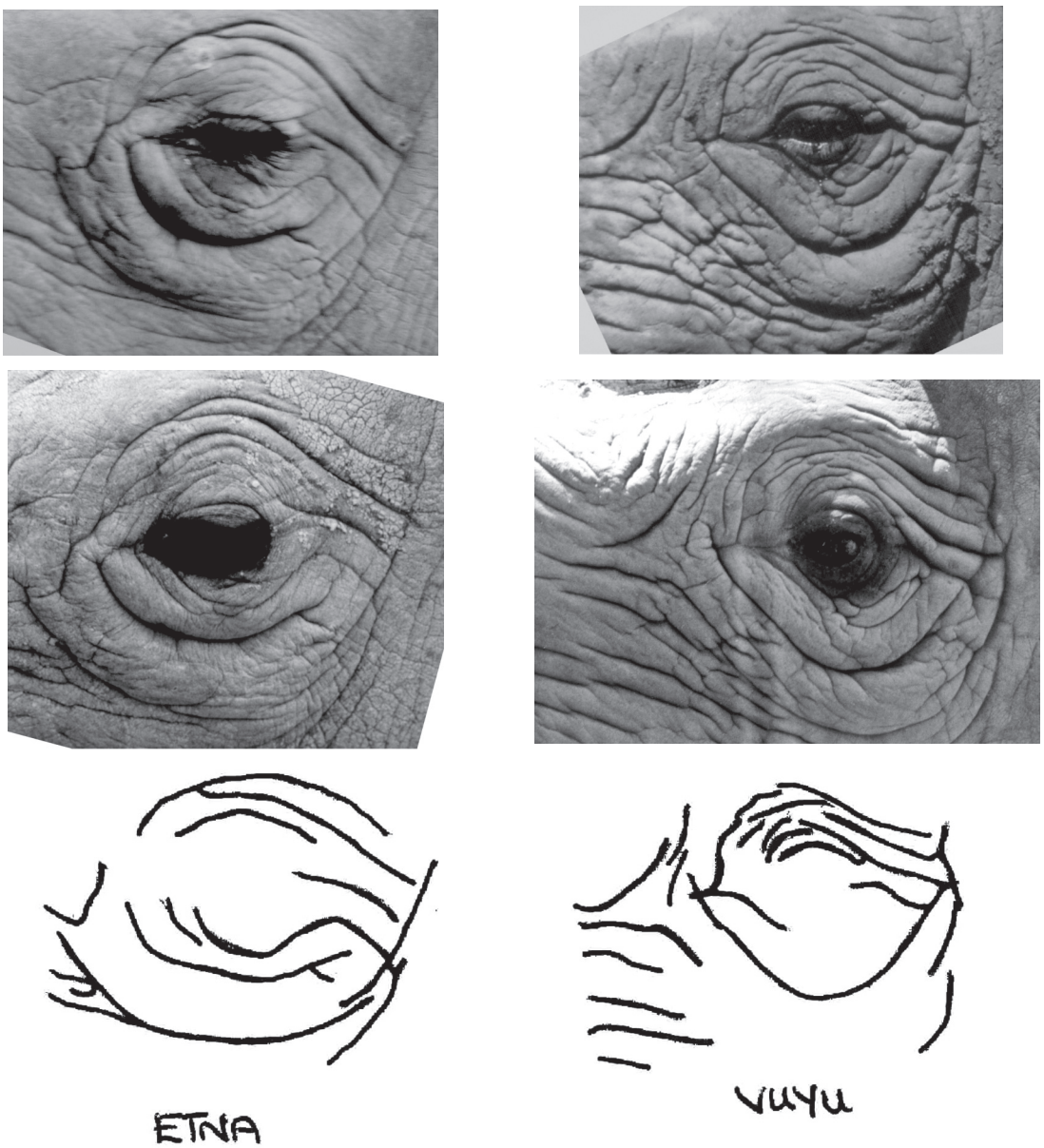

Figure 1. Examples of left eye wrinkle patterns for two black rhinos from Port Lympne Wild Animal Park, UK. Top photographs show the eyes nearly closed, middle photographs show the eyes open, bottom drawings are of the key wrinkles.

rhinos (*Diceros bicornis*)—nose wrinkle patterns have but our observation was that these proved to be inconsistent as a result of differing facial expression. Therefore, in this study we test the use of eye wrinkles for the individual identification of black rhinos from photographs and assess the consistency of the feature in comparison to other key features used similarly. Examples of left eye wrinkle patterns for two black rhinos are shown in Figure 1.

Methods and materials

Port Lympne Wild Animal Park is situated in the county of Kent in the south of England. In August 2001 at the start of the study, the Park held 19 black rhinos. 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 and three introductions.

Rhino matings are managed to maximize genetic diversity. For example, the four calves of the female Rukwa were all sired by different males. 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 such as the eye wrinkle patterns.

Photography

Photographs appropriate for individual identification were considered to be those akin to the outline drawings used to identify individual rhinos in the Kenya Wildlife Service 'Black Rhino Sighting Form Booklet'. 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. Therefore, 11 photographs of each individual were required for a full 'set' to show all the features used for identification as mentioned previously. Photography was carried out in August 2001, August 2003 and August 2005 in order to identify the changes in these features over time. Photographs were taken from the roadways and holding areas enabling clear sighting of the rhinos which were often within 10 m of the camera.

Equipment and processing

In August 2001, photographs were taken with an SLR camera with a 400 mm lens using ASA 400 colour film. In August 2003 and August 2005, the fixed 400mm lens was replaced with a more versatile Tokina 80-400 mm zoom lens with film and processing as in 2001. In August 2005, photographs were taken using a Minolta Dimage 7D digital camera.

Image enhancement

Individual rhino features were initially obtained by scanning prints. In 2005, digital images were downloaded directly from the digital camera. The scans and images were saved using JASC Paint Shop Pro 7 software as 'JPG' files in greyscale as this gave the most observable contrast.

Test of consistency of eye wrinkle patterns

Identification photographs taken over the study period were compared to determine whether eye wrinkle patterns had changed, if they had changed whether these could lead to mis-identification and whether eye wrinkle pattern photographs were more or less robust for identification than other feature photographs.

Face, right and left profiles and right and left eye wrinkle pattern photographs taken in mid-2001 were compared to those taken in mid-2005 for the 11 rhinos present in both years by three judges (two rhino researchers and a senior zookeeper unfamiliar with the Port Lympne rhinos) who independently provided a rating of 1 to 3: 1 = where the photographs could be mistaken for different rhinos; 2 = where they were seen to be of a similar rhino but could be of a different one; 3 = where the photographs were clearly of the same rhino.

Identification feature scores were tested using the Kruskal-Wallis non parametric statistical test with further analysis of the effect of age using the Mann-Whitney test (Corder and Foreman 2009).

Test of reliability of eye wrinkle patterns

'Couples' and 'twinning' tests were devised in order to test specifically whether eye wrinkles were a robust identification feature to distinguish individual rhinos from photographs. Ten judges were selected, five postgraduate degree students who had little or no knowledge of rhinos and five rhino keepers from Chester Zoo, UK.

For the couples test, 18 pairs of good quality pho-

Table 1. Summary of average judges scores

Rhino	Sex	Age '01	Age '05	Face	Rt profile	Lft profile	Rt eye	Lft 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

tographs 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.

Results

Table 1 summarizes the results of the ratings for changes in certain rhino identification features, including eye wrinkles, between 2001 and 2005. Of the individual features analysed, eye wrinkles showed least change (most consistency) and in only 4 out of 22 cases was it deemed likely that a misidentification could take place while the figures were 11 out of 20 for profiles.

Table 2 shows that there is a significant difference

Table 2. Test between identification feature scores shown in Table 1, using the Kruskal-Wallis test

Feature	Number	Median	Av. 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 3. Comparisons of identification feature scores between adult and sub-adult black rhinos, using a Mann-Whitney U test

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 4. Analysis of errors made in the twinning test

	ALL	Inexperienced	Experienced
No. Judges	10	5	5
Matches	100	50	50
Matching errors	12	4	8

Table 5. Analysis of errors made in couples test

Error	Total	%	Actual	Inexperienced		Experienced	
Maximum possible	180	24	13.3	12	50%	12	50%
Error: false negative	100	10	10.0	7	70%	3	30%
Error: false positive	80	14	17.5	5	36%	9	64%

between the median values with 'eyes' having the highest average rank and 'profile' the lowest. Eye wrinkles are therefore shown to be a more reliable feature for identification over time.

Table 3 shows a further analysis of the results in Table 1 by considering the effect of age with adults obtaining significantly better profile, (left and right profile scores combined), and eye wrinkles scores than those for sub-adults. Face data were limited, there being several missing scores.

Twinning and couples test results

The 10 judges considered that 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 4 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 5 shows that overall a similar level of error (13.3% compared to 12%) was made in the couples test as in the twinning test and that 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 (pairs described as the same when they were different)- (10/14) - 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 6 shows the effect of presenting the results not by experienced/inexperienced judges but by the best five judges compared to worst five judges. The results show that the worst five judges made five times more errors (30 verses 6) than the best five judges in using eye wrinkles for rhino identification so selection of judges is important.

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 10 potentials.

Table 6. 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%

Discussion

Eye wrinkle patterns, fully established by 9 to 12 months of age, 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. The 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.

The tests showed that judges differed in their ability to identify correctly individuals from eye wrinkle photographs and that ability was not

dependent on the experience of the judge. This suggests that the aptitiude to judge eye wrinkles from photographs is more important than experience with rhinos as was found to be the case when testing the general use of photographs in identifying individual black rhinos (Patton and Jones 2008).

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.

One suggestion for the use of eye wrinkle patterns for individual rhino identification would be 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 would be when a rhino has been anaesthetized for translocation, notching or treatment.

It may be possible to obtain the eye wrinkle patterns of individual rhinos photographed in close up using camera traps. These may be used to assist in determining the structure of a rhino population in dense habitat where visual observation of individuals is difficult or impossible (Polet et al. 1999).

Although the data set 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.

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