Przewalski horse) has already been described (Buckland *et al.*, 1976). Studies of the chromosomes of the domestic horse have also revealed polymorphisms of chromosome no. 1 with variants corresponding to the medium and large bands reported here, together with an additional variant with a very large block of heterochromatin (see Plate 40 f).

Further investigations into C-band polymorphism on chromosomes which are less readily identifiable than chromosome 1 require further study, preferably using sequential Q and C-banding to identify each chromosome.

From these results there is no evidence of hybrid origin for any of the 21 Przewalski horses studied. The translocated chromosome presumably transmitted by the known Mongolian domestic ancestor has not been transmitted to any member of the present generation included in this study. We have so far not been successful in karyotyping any present day Mongolian domestic horses, but it is likely that their karyotype is the same as that of other domestic horses. When we have completed our investigations on the chromosomes of these Przewalski horses, including following the other C-band polymorphisms, it is possible that by combining these results with those for gene markers some information may be obtained regarding linkage of genes with particular chromosomes.

The biochemical gene markers studied by our colleagues (Fisher *et al.*, pp. 228–235) provide the best method of distinguishing each individual animal. So far, we have not enough information on the chromosome polymorphisms to be able to identify individuals. However, since the gene markers in *Equus przewalskii* and *Equus caballus* are so similar in nature and distribution, it is impossible to be sure from which species a given sample is derived. Since the chromosomes of the two species show a clear distinction, that of number, karyotyping remains the crucial test for distinguishing these closely related species.

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GLOSSARY OF TERMS

Acrocentric chromosome: chromosome with the centromere very close to one end. The short arms are then frequently genetically inactive.
Alleles: alternative forms of the same gene, any one of which can occupy the locus for that gene.
C-bands: units of chromatin which represent constitutive heterochromatin, produced by hot alkali treatment followed by Giemsa staining.
Constitutive heterochromatin: heterochromatin that is always present in the cell as opposed to facultative heterochromatin, e.g. the second X of ♀ mammals, which becomes heterochromatic during development.
Fibroblast: undifferentiated connective tissue cell, in this case derived from the dermis.
G-bands: pattern of bands on the chromosomes produced by pre-treatment with trypsin and/or a saline solution followed by Giemsa staining.
Gene: segment of a chromosome which determines an inherited characteristic.
Genotype: the hypothetical constitution of an individual.
Heterochromatin: chromosome material which, unlike euchromatin, normally remains condensed and shows maximal staining in the interphase nucleus. It is generally thought to be genetically inactive as far as structural genes are concerned but may have regulatory functions.
Heterozygous: having different alleles at a given locus on a pair of chromosomes.
Homozygous: having identical alleles at a given locus on a pair of chromosomes.
Karyotype: the somatic chromosome complement of an individual or species.
Linkage group: a group of genes having their loci close together on the same chromosome.
Locus: position on a chromosome occupied by a gene.
Marker chromosome: a chromosome which has a distinctive feature which allows the pattern of inheritance to be followed from generation to generation,

Metacentric chromosome: chromosome with the centromere in a central position.
Monomorphic: showing no inherited variation, i.e. all individuals are homozygous.
Phenotype: the observed characteristics of an individual.
Polymorphic: showing inherited variation due to the presence of more than one allele. A locus may be defined as polymorphic when heterozygotes occur with a frequency of more than 1 in 50.
Segregation: the separation into different gametes of the two members of each pair of chromosomes.
Silent allele: an allele with no detectable product.
Sub-metacentric chromosome: chromosome with the centromere nearer one end than the other.
Translocation: a chromosomal rearrangement involving exchange between non-homologous chromosomes. In a Robertsonian translocation the breaks are at or near the centromere in acrocentric chromosomes. The short arm material is lost and the result is a reduction in the chromosome number by one with no loss of active genetic material.

The husbandry and veterinary care of captive rhinoceroses

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INTRODUCTION

The five species of rhinoceros are amongst the world's most endangered mammals. Only the southern race of the Square-lipped or White rhinoceros *Ceratotherium simum* is not threatened at the present time. Following rigorous conservation measures over the last 50 years in Natal, the population in the Umfolozi and Hluhluwe reserves has reached the maximum consistent with sound ecological management, and from there a large number have been introduced to other parts of their former range – in particular the Transvaal and Rhodesia. It is probable that the total wild population of this race is now approaching 3000. Although the International Union for the Conservation of Nature and Natural Resources (IUCN, 1978 a) gives a figure of less than 200 for the northern race, this is probably an underestimate. Savidge *et al.* (1976) recently conducted a survey of the Garamba Park in Northern Zaire and concluded that there were over 400 there including a large number of calves. Chipperfield (pers. comm.) came across the species in the Southern Sudan adjacent to the Uganda border and there are thought to be about 100 in Northern Uganda itself. The total numbers of this race probably approach 1000, but it remains vulnerable while the degree of protection given to it throughout its range is minimal.

Although the total numbers of the Black rhinoceros *Diceros bicornis* are greater than for any other rhinoceros species, poaching and habitat destruction have eliminated it from most of its former range. As it prefers dense thornbush, an accurate estimate of its numbers is difficult to achieve. The figure for the whole of Africa probably lies between 12,000 and 20,000 with the major populations in Kenya, Tanzania, Zambia and Rhodesia. Smaller populations (in the low hundreds) are thought to survive in Uganda, Sudan, Mozambique, Angola, South Africa, Zaire and the Central African Empire (Ansell, 1975; IUCN, 1978b).

The Asiatic species are in a much more precarious situation. Laurie (pers. comm.) working on the ecology of the Great Indian rhinoceros *Rhinoceros unicornis* estimates a total wild population of around 1200 animals. This is probably a fairly accurate figure as the species is now very localised, and under close observation in and adjacent to a number of reserves in Southern Nepal, West Bengal and Assam, notably Chitawan and Kaziranga.

Both the Sumatran rhinoceros *Didermocerus sumatrensis* and the Javan rhinoceros *Rhinoceros sondaicus* are highly endangered. It is probable that no more than 300 Sumatran rhinoceroses survive, but an accurate estimate is impossible due both to the politics and to the dense forests

of its range. The most important population (about 30–50 animals) inhabits the Leuser reserve in Sumatra. Elsewhere it is known to exist in small scattered populations in Burma, Thailand, Sabah and West Malaysia. Its status in other South-east Asian countries where is was formerly found is unknown at the present time. The Javan rhinoceros is only known with certainty from the Udjung Kulon reserve in West Java and along the border between Laos and Democratic Kampuchea. It is unlikely that more than 100 animals survive, half of them in the Udjung Kulon where, with strict protection, they have doubled their numbers during the last decade (IUCN, 1976a, 1976b).

All five species have been kept in captivity although only nine positively identified Javan rhinos have been exhibited (Reynolds, 1961a). The last died in Adelaide in 1907. Fifty-five Sumatran rhinos are known to have been exhibited (Reynolds, 1961a). Most were captured at around the turn of the century and the last died in Copenhagen in 1972. The same author (1961a, 1961b, 1962) lists the individuals of all five species kept in captivity up to these dates. The *Yearbook* gives up to date information on the numbers of the three species currently being kept, together with details of any births.

GENERAL HUSBANDRY

The shipment of captive rhinoceroses is usually restricted by the laws of their countries of origin and by the Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora. All rhinoceroses are listed on appendix I of the convention; an indication of their endangered status. Rhinoceroses have not yet been shown with certainty to carry diseases which might pose a problem to human or animal health, and for this reason there are usually no restrictions on their importation on grounds of health, but this will vary from one country to another.

A considerable amount of fieldwork has now been carried out on the African members of this family in the wild, and much of the information obtained is relevant to their successful management in captivity. Very little is known about the Asian species. Van Strien (1975) has summarised the literature on the Sumatran rhinoceros and Borner (1975) gives a concise account of the present work being directed to conserve it. Schenkel & Schenkel-Hulliger (1969a) and Schenkel (1971) describe the ecology and behaviour of the Javan species. Laurie (pers. comm.) is completing his preliminary work on the Indian rhinoceros in Chitawan and Kaziranga, the first detailed study of this animal.

All the Asian rhinoceroses are basically solitary animals, only coming together for mating or for brief periods into areas containing favoured food plants. It has been impossible to study the behaviour of the Sumatran and Javan species to date but some preliminary work has been carried out on the Indian. It is probable that the adult ♂♂ are territorial and will therefore be aggressive to other mature ♂♂. The Sumatran rhinoceros is almost certainly a browser, the Javan probably takes both browse and grasses, while the Indian takes mainly grasses but at certain times of the year will eat shrubs, trees and, if given the opportunity, agricultural crops.

Much more is known of the African species. Schenkel & Schenkel-Hulliger (1969b) have summarised much of the ecological and behavioural work carried out on the Black rhinoceros, including their own studies and those of Goddard (1967) in East Africa. A popular and more readily available summary of this work is also given by Moss (1975). In East Africa this species does not appear to exhibit territoriality although they have a 'home range,' but further south there is some evidence of ♂ territories (IUCN, 1978b). Groups of up to six Black rhinoceroses may occasionally be seen together, but like the Indian rhinoceros, these probably consist of cows and calves near a watering point, a wallow, or in bush clearings where the animals' pathways cross each other. Groups of adult ♀ White rhinoceroses and their calves of up to three years old are more stable. In this species, the ♂♂ maintain territories and will drive off mature ♂ intruders (Owen-Smith, 1971). The Black rhinoceros is almost exclusively a browser, mainly of *Acacia* species. During the daytime this animal prefers to rest in thick cover and often spends some hours every day in mud and shallow water, coming out to feed as the daylight fades. The White rhinoceros is almost exclusively a grazer preferring open grassland or sparse woodland. Short grasses are favoured, and both feeding and drinking take place mainly at night.

The three species now kept in captivity all experience an ambient temperature variation in the wild of between 0°C and 45°C at certain times of the year in parts of their range. Even temperatures below 0°C are tolerated for short periods providing humidity and wind velocity are low. Rhinoceroses prefer warmed housing during the winter in temperate climates but there is no substantial evidence that this is necessary as long as a dry and draught-proof shelter is provided and that the temperature does not fall below 5°C for long periods.

Rhinoceroses are not animals that habitually tend to destroy the perimeter of their enclosures, neither are they capable of jumping. Despite this, their potential power together with the unpredictability of some individuals, especially amongst the Black and Indian species, necessitates the building of substantial boundaries. Dry or water-filled moats are probably the best method of enclosing the exhibit although strong steel or wooden vertical posts placed a maximum of 0·5 m apart are suitable if somewhat unsightly. Occasionally, the latter have the disadvantage that young animals force their way between the bars and may become stuck. A 2m high barrier is adequate but visitors should be kept back from it using a second lower fence. At Whipsnade an experiment where White rhinoceroses have been enclosed by a fence consisting of horizontal cables maintained under tension and supported by heavy wooden posts sunk into concrete has proved to be successful (Toovey, pp. 270–274; Wears, p. 276 this volume).

The relatively soft sole of the rhinoceros foot is easily damaged by highly abrasive surfaces. If concrete yards are used, they should be as smooth as possible and an alternative exercise area with a softer surface provided in addition. Grass paddocks on which rhinoceroses are kept deteriorate very rapidly unless a sufficient area is provided. In wet conditions this can become a serious problem, especially adjacent to the animals' housing.

NUTRITION

All the rhinoceroses are monogastric herbivores and the anatomy of their digestive systems is similar to that of the equines. Microbial fermentation takes place in the relatively very large caecum. An adult White rhinoceros of 1800 kg can cope with a daily intake of some 25–35 kg of dry matter. The high moisture content of fresh foods would mean that in the wild state some four times this weight would probably be consumed in a 24-hour period. All the rhinos are used to taking a diet with a high fibre content for at least part of the year and their protein intake would also vary, probably from as low as 5% of dry matter in the case of the grass-eating White rhinoceros towards the end of the dry season to 20% plus in the fresh growth of grass following rains. The browsing rhinoceros can be more selective throughout the year and the range of protein in this case is probably nearer 10–25% of the dry weight of the diet, allowing for seasonal differences. This is not likely to mean that browsing rhinoceroses have a higher requirement for protein. It is probable that, as with some of the browsing ruminants, the daily capacity of these animals is not as great as their grazing relatives and that as a result the total uptake of usable nitrogen over a 24-hour period may be similar. There is a tendency in zoological collections to feed browsers on a diet containing more protein than that given to grazing herbivores. This may be detrimental to the animal unless it can be shown that an individual's total daily intake of food is lower than that of a grazing relative with a similar metabolic weight. Captive rhinoceroses are frequently subject to laminitis and, as in the case of equines, this can often be related to high levels of protein in the diet.

The three species of rhinoceroses being discussed in these paragraphs are kept by the Zoological Society of London. Their basic diets are calculated from the known data established for the domestic horse. The White rhinoceros is given an equal mixture of meadow hay with either clover or lucerne together with commercial horse cubes containing 10% crude protein and 20% fibre. During the summer animals with adequate grazing receive only meadow hay. During the winter, approximately 5 kg of cubes are given to each animal per day, but this will vary with the quality of the hay. Heavily pregnant and lactating ♀♀ receive up to twice this quantity. The Black and Indian rhinoceroses are given a similar concentrate diet in smaller quantities but the crude protein levels are increased to about 13% by the addition of cubes with an 18% crude protein content. These

	WHITE RHINO			BLACK RHINO			INDIAN RHINO		
	AVERAGE VALUE	NO. OF SAMPLES	NO. OF INDIVIDUALS	AVERAGE VALUE	NO. OF SAMPLES	NO. OF INDIVIDUALS	AVERAGE VALUE	NO. OF SAMPLES	NO. OF INDIVIDUALS
VITAMIN A									
Blood iu/ 100 ml	53 (12–120)	21	16	56 (52–60)	2	2	27 (0–55)	6	3
Liver iu/g	70	1	1	—	—	—	—	—	—
COPPER									
Blood mg/ 100 ml	0·14 (0·10–0·21)	24	19	0·17 (0·16–0·17)	2	2	0·17 (0·10–0·22)	7	3
Liver ppm/ DM	24·0 (14–32)	4	4	33	1	1	—	—	—
Kidney ppm/ DM	25·0 (15–39)	4	4	20	1	1	—	—	—

Table 1. Vitamin A and copper levels in clinically normal rhinoceroses at Whipsnade Zoo.

species are given clover or lucerne almost exclusively, browse when it is available in the summer, and grass or 4 kg of vegetables with a high carotene content every day, as they have no access to growing herbage.

The plasma levels of vitamin A in Perissodactyl ungulates (Table 1) appear to be substantially lower than those noted in Artiodactyls. In the absence of figures from free-living wild members of the group, it is not possible to establish whether these are normal. The plasma of captive rhinoceroses often contains moderate levels of carotene but almost no vitamin A. Administration of large doses of vitamin A (2-4 million units intramuscularly) appears to produce some improvement in a number of the cases involving skin disease which are described in a later section. As a result, there is some doubt as to whether captive members of this group generally receive sufficient vitamin A and whether they are unable to utilise the usual commercial forms of the vitamin. Clinical cases have also arisen where other nutritional causes were suspected and these are described later.

BREEDING

Rhinoceroses are probably not as difficult to breed in captivity as has been popularly suggested. Adequate nutrition and housing together with rational management based on a sound knowledge of their reproductive behaviour usually produces results. Although Black rhinoceroses have bred relatively regularly in some collections for a number of years, it is only in the last decade that there have been enough mature White and Indian rhinoceroses in zoos to establish for certain whether these species would reproduce as successfully in captivity. Most adult rhinoceroses will be aggressive to another strange adult if placed together in a small enclosure. Introductions should be made as slowly as possible with animals initially being separated by bars or a fence. As much space as possible should be allowed when they are finally put together as premating behaviour, especially in the Indian, often consists of a great deal of chasing and mock fighting.

Depending on their rate of growth and nutritional status, ♀ Black, White and Indian rhinoceroses first begin to cycle at about four years of age, though they rarely conceive before the age of five. Freiheit (pers. comm.) describes a Black rhino calf born to a ♀ of four-and-a-half years and a ♂ of three-and-a-half years, both captive-bred, but this is exceptional. Greed (1967) described a 17-day oestrous cycle in a ♀ Black rhinoceros of four-and-a-half years of age. This period became more irregular and cycle lengths of from 14–49 days were recorded. She first became pregnant when about six-and-a-half years old. Dittrich (1967) reports a ♀ of the same species cycling at 26–30 day intervals when six-and-a-half years old. The duration of oestrus was given as 3–4 days. A short (one-and-a-half) day post-partum oestrus occurred 20 days after birth. The duration of matings is given by Dittrich as approximately 30 minutes and by Greed as 2–55 minutes with most taking 15–30 minutes. Hallstrom (1967) gives similar information on this species. Yamamoto (1967) records oestrus lengths of 28–30 days and Krishne Gowda (1967) gives 30–35 days. Young (1967) has described a manipulative technique for obtaining semen from a quiet Black rhinoceros.

The stages of labour are similar to those described for the horse (Arthur, 1964), the second stage usually taking less than half an hour. Dittrich gives birth weights for three ♂ calves of between 30 and 45 kg and for two ♀ calves as 27 and 38 kg. He describes calves suckling for 5–6 minutes at a time, nibbling hay at nine days and eating solids well at five weeks. During the first four months the average daily weight gain was approximately 1 kg. Dittrich (1971) also gives details of the birth and development of a White rhino calf.

Tong (1961), Krishne Gowda (1969), Lang (1975) and Bhatia & Desai (1975) give data for the Indian rhinoceros similar to that given above for the Black rhinoceros although Lang reports conception in one captive-born ♀ at four-and-a-half years. The data in the Zoological Society of London's records also give similar figures for these two species and for the White rhinoceros (Rawlins, 1977). More data are needed before it will be possible to say whether there are any significant differences in the reproductive physiology of these species. Analysis of a milk sample from the Black rhinoceros is given by Gregory *et al.* (1965), and data from two Whipsnade White rhinoceroses are given in Table 2. As with any other mammal the composition of milk will vary during lactation and this factor must be borne in mind when considering these very limited data. Data on the hand-rearing of rhinoceroses have been published by Hagenbeck (1969) for the Indian species and Wallach (1969) for the White rhinoceros. Table 3 lists the published data on gestation periods for the three species.

	STAGE OF LACTATION 3 DAYS	8 WEEKS
Packed fat volume %	0·6	2·4
Packed protein volume %	—	—
Packed cell volume %	—	—
Total nitrogen mg%	250·0	415·0
Non-casein protein N mg%	64·0	76·0
Protein g%	2·2	4·1
Calculated % non-casein P	0·408	0·484
Na mM	5·5	9·0
K mM	14·0	15·0
Cl mM	15·5	18·0
Lactose	200·0	182·0
Citrate mM mg%	1725·0	1550·0
Inorganic phosphate mg%	—	37·5

Table 2. Composition of milk samples from two White rhinoceroses *Ceratotherium simum* at Whipsnade Zoo.

SPECIES	AVERAGE AND RANGE IN DAYS	REFERENCE
White rhinoceros *Ceratotherium simum*	514 (480–548)	548 days—Morris & Jarvis, 1960 480 days—Smith, 1968
Black rhinoceros *Diceros bicornis*	452 (419–469)	438, 419, 438 days—Greed, 1967 469 days—Dittrich, 1967 465, 462 days—Yamamoto, 1967 458 days—Krishne Gowda, 1967 463, 454, 457 days—Hays, 1967
Indian rhinoceros *Rhinoceros unicornis*	492 (464–530)	530 days—Morris & Jarvis, 1960 488 days—Tong, 1961 464 days—Hagenbeck, 1969 486 days—Krishne Gowda, 1969

Table 3. Gestation periods of three species of rhinoceros.

	OCCASIONS	NO. OF INDIVIDUALS	ESTIMATED WEIGHT (kg)	DOSE ETORPHINE (mg total dose)	DOSE ACP (mg total dose)	ANTAGONISTS I/V DIPRENORPHINE (mg total dose)	ANTAGONISTS I/V NALORPHINE (mg total dose)
White rhinoceros *Ceratotherium simum*	74	23	100–1800	0·3–4·0	2·0–18·0	0·6–6·0	30–100
Black rhinoceros *Diceros bicornis*	43	5	350–1400	0·6–3·3	3·0–15·0	1·0–4·5	70–200
Indian rhinoceros *Rhinoceros unicornis*	18	3	500–1900	2·3–6·0	16·0–50·0	3·5–9·0	100–250

Table 4. Suggested dose rates of etorphine, acepromazine and etorphine antagonists for use in rhinoceroses (based on the author's work).

HANDLING AND TRANSPORTATION

Although many rhinoceroses become tractable in captivity, it is rarely possible to conduct more than a superficial examination of these animals without resorting to chemical immobilisation. This group responds particularly well to a mixture of the potent narcotic etorphine hydrochloride and the sedative acepromazine. Although etorphine can be replaced by fentanyl citrate, no other drug has been found to be effective. Hofmeyr *et al.* (1975) preferred azaperone to acepromazine for wild Black rhinoceroses as it had a more rapid effect. Dose rates for the three species based on the use of these drugs at Whipsnade are given in Table 4. The addition of hyoscine and atropine to the mixture has been reported (Keep, pers. comm.). These drugs produce distortion of vision which is useful in the wild, where they were originally used to capture White and Black rhinoceroses (King & Carter, 1965; Keep, 1973). It is rarely necessary in captivity.

Very little work has ever been carried out on the Indian rhinoceros. The injection site of choice for rhinoceroses is the neck, where the subcutaneous fibrous layer is not as deep as elsewhere on the body. In White and Black rhinoceroses the shoulder and hind quarters are reasonable alternatives but there is more risk of incomplete penetration of the dart needle or of the dart rebounding. In Indian rhinoceroses, the much more dense subdermal plates over the shoulder and hind quarters makes the neck the only practical site for such injections, but even there, the folds of skin sometimes prevent deep penetration of the needle. Both the manufacturers, Palmer Chemical Co. and 'Dist-Inject', market heavy duty plain and cuffed 6–8 cm needles for use in rhinoceroses and these should always be used. It is advisable to use a dart barrel of at least 4 ml capacity with these needles as the smaller barrels combined with a heavy needle lead to instability in flight. Hand injection is sometimes possible in quiet animals and the same injection sites should be used. In designing housing for these species it is always advisable to include a trapping area where an animal can be injected safely. The new house for White rhinoceroses at Whipsnade incorporates a number of narrow feeding stalls where a gate can be lowered behind the animal by remote control.

Immobilised rhinoceroses should always be kept sitting in an upright position. If it is necessary to turn them on to their sides, respiration should be monitored very carefully and they should not be kept in this position for more than ten minutes. Occasionally, in some individuals, mild excitatory muscular tremors are seen but these are of no clinical significance. It is possible to keep rhinoceroses recumbent by this method for up to four hours, but the sooner an animal of this weight is on its feet the less likely is the risk of damage to superficial blood vessels or nerves.

The specific antidote to etorphine, diprenorphine hydrochloride, is usually given intravenously using an auricular vein. Black and Indian rhinoceroses invariably rise within ten minutes, but the White rhinoceros may remain recumbent and under light narcosis for a further two hours. Keep (1971) reports that nalorphine is a more effective antagonist in this species, but no significant difference has been noted between the efficacy of the two antagonists in the Whipsnade herd. It is often useful to control the rate of

	INDIAN RHINO MEAN (RANGE)	INDIAN RHINO SAMPLES*	WHITE RHINO MEAN (RANGE)	WHITE RHINO SAMPLES*	BLACK RHINO MEAN (RANGE)	BLACK RHINO SAMPLES*
HAEMATOLOGY						
RBC	6·5 (5·7–7·5)	7 (3)	7·0 (5·8–8·4)	35 (26)	4·3 (3·5–5·4)	5 (4)
WBC	7·2 (4·3–9·9)	7 (3)	9·1 (4·9–12·4)	35 (26)	7·6 (3·7–14·4)	5 (4)
Hb	14·1 (11·5–15·5)	7 (3)	17·3 (15·3–19·3)	35 (26)	13·9 (13·3–16·7)	5 (4)
PCV	39·4 (37·0–42·0)	7 (3)	46·9 (39·0–54·5)	35 (26)	38·6 (32·5–45·0)	5 (4)
Platelets	165·5 (75·0–244·0)	7 (3)	469·5 (146–848)	33 (24)	361·8 (196–520)	5 (4)
Reticulocytes	0 (—)	6 (3)	0 (—)	24 (15)	0 (—)	5 (4)
Neutrophils	72·5 (65·0–82·0)	8 (3)	61·1 (39·0–82·0)	35 (26)	57·6 (47–74)	5 (4)
Lymphocytes	22·7 (15·0–28·0)	8 (3)	29·4 (14·0–44·0)	35 (26)	37·0 (23–49)	5 (4)
Monocytes	3·0 (2·0–4·0)	8 (3)	3·5 (0·0–8·0)	35 (26)	3·4 (0–8)	5 (4)
Eosinophils	2·1 (0·0–5·0)	7 (3)	4·3 (0·0–11·0)	34 (24)	1·4 (0–5)	5 (4)
Basophils	0 (—)	3 (2)	0·3 (0·0–2·5)	28 (19)	0·6 (0–3)	5 (4)
MCV	60·3 (54·7–66·0)	7 (3)	67·2 (54·6–74·0)	34 (25)	90·5 (83·6–95·4)	5 (4)
MCH	23·4 (20·0–36·4)	7 (3)	24·7 (19·9–28·9)	35 (26)	32·3 (30·3–35·4)	5 (4)
MCHC	35·2 (33·6–37·6)	7 (3)	36·6 (34·8–40·0)	35 (26)	35·8 (33·2–27·1)	5 (4)
ESR	32·0 (13·0–55·0)	6 (3)	15·6 (4·0–33·0)	32 (23)	33·6 (14–54)	5 (4)
BIOCHEMISTRY						
Urea	4·5 (4·3–4·8)	3 (2)	7·9 (6·7–10·0)	14 (11)	3·8 (3·6–4·2)	3 (2)
Bicarbonate	29·5 (29·0–30·0)	2 (2)	29·7 (22·0–34·0)	13 (11)	24·3 (21·0–28·0)	3 (2)
Cl	88·0 (86·0–90·0)	2 (2)	88·8 (86·0–94·0)	13 (11)	94·0 (93·0–96·0)	3 (2)
Na	134·5 (134·0–135·0)	2 (2)	135·1 (133·0–138·0)	13 (11)	132·0 (132·0)	3 (2)
K	3·7 (3·6–3·8)	2 (2)	4·5 (3·6–5·5)	13 (11)	5·0 (4·0–6·2)	3 (2)
Creatine	97·2 (88·4–106·1)	2 (2)	86·6 (70·7–119·0)	6 (6)	93·5 (88·0–99·0)	2 (2)
Uric acid	42·0 (30·0–60·0)	3 (2)	25·8 (18·0–30·0)	6 (6)	51·5 (51·0–52·0)	2 (2)
Aspartate transaminase	25·7 (19·0–32·0)	3 (2)	40·2 (21·0–55·0)	9 (9)	60·5 (49·0 72·0)	2 (2)
Alkaline phosphotase	83·0 (60·0–110·0)	3 (2)	118·0 (30·0–290·0)	9 (9)	124·5 (62·0–187·0)	2 (2)
Total protein	80·0 (76·0–82·0)	3 (2)	96·0 (89·0–105·0)	10 (9)	77·0 (68·0–88·0)	3 (2)
Albumin	33·0 (28·0–38·0)	3 (2)	36·0 (29·0–42·0)	11 (10)	36·0 (19·0–30·0)	3 (2)
Globulin	47·0 (38·0–54·0)	3 (2)	60·0 (50·0–67·0)	10 (9)	51·0 (45–60)	3 (2)
Ca	2·8 (2·7–2·9)	3 (2)	3·1 (2·9–3·3)	11 (11)	3·1 (3·1)	2 (2)
PO_4	1·4 (1·2–1·8)	3 (2)	1·3 (0·9–1·7)	11 (11)	1·3 (1·0–1·7)	2 (2)
Mg	0·7 (—)	2 (2)	0·8 (—)	2 (2)	0·8 (0·8)	2 (2)
Total bilirubin	2·2 (0·0–5·1)	3 (2)	2·6 (1·7–3·4)	8 (8)	3·5 (2·0–5·0)	2 (2)
Conjugated bilirubin	0 (—)	1 (1)	0 (—)	9 (9)	0 (—)	2 (2)
Fe (plasma)	23·8 (23·8)	1 (1)	27·7 (27·7)	1 (1)	42·4 (23·2–61·6)	2 (2)
Specific gravity	1028·0 (1027–1030)	3 (2)	1031·5 (1031–1032)	8 (8)	— (—)	(—)

* No of individuals from which samples were taken is shown in brackets.

Table 5. Routine haematology and serum biochemistry (in standard international units) in clinically normal rhinoceroses at Whipsnade and Regent's Park Zoos.

recovery in order to give time after the animal rises to walk it into a travelling crate. This is best carried out by giving the antidote intramuscularly in the Black and Indian rhinoceroses. In the White species, because a residual narcotic effect is usually seen anyway, the antidote can still be given intravenously.

The Indian rhinoceros appears to require about 50% more acepromazine and etorphine per unit body weight than the African species, but this estimate is based on only three individuals. Normal resting respiration rates vary from about 7–12 per minute. Although this rate may be somewhat depressed soon after the animal becomes recumbent, it should return to the lower rates of the normal range within 10–15 minutes of immobilisation. Any irregularity of breathing should be treated with suspicion and the antidote

should always be ready for rapid administration if necessary, The rectal temperature of rhinoceroses usually lies in the range of 36·5°–37·5°C. This may rise during immobilisation particularly if the animal has been excited. As rhinoceroses are very sensitive to heat stress, the animal should be cooled with water if the temperature exceeds 38°C. It is always advisable to keep the head covered with a clean sack or towel during the period of immobilisation; apart from improving the general relaxation of the animal, the eyes are protected from strong light, dust and desiccation. A bland antiseptic ophthalmic ointment should be introduced on to the corneal surface of both eyes soon after the animal becomes recumbent.

The best crate design for these species is that used by the Natal Parks Board. It consists of heavy duty wooden boards on a steel frame with a wood floor supported by steel girders which also act as 'skids.' Two hinged doors, the lower a small one for feeding, are incorporated at either end of the crate with inside these a row of removable vertical steel poles. Towing hooks are built in at both ends and the frame is constructed to take steel hawsers for lifting the crate with a crane.

CLINICAL PATHOLOGY

Table 5 summarises some haematological and biochemical parameters from normal animals examined in the collections of the Zoological Society of London over the last ten years. These animals were all immobilised with a mixture of etorphine and acepromazine. Figures for normal White rhinoceroses have also been published by Seal *et al.* (1976) and to a more limited extent by Keep (1976). These values are broadly similar to those for the equines (Jones, 1976), although the transaminase levels of normal rhinoceroses tend to be lower. More transaminase figures for Black rhinoceroses can be found in Hofmeyr *et al.* (1975). The platelet counts in the White rhinoceroses were higher than for the other two species, and Heinz bodies are frequently encountered although their significance in this species is unknown. It is not possible to assess the significance of other differences between the three species as comparatively little data are available from normal Black or Indian rhinoceroses at the present time. Further comments on their haematology have been made by Hawkey (1975) and Seal *et al.* (1976).

	BODY WEIGHT		
DRUG	300 kg	800 kg	1500 kg
Thiabendazole	15 g	35 g	70 g
Mebendazole	15 g	35 g	70 g
Niclosamide	15 g	35 g	70 g
Dichlorvos	10 g	25 g	50 g

Table 6. Anthelmintics for rhinoceroses.

PREVENTATIVE AND CLINICAL MEDICINE

Parasites—Helminths: Almost all newly imported, wild-caught rhinoceroses will carry heavy nematode burdens unless an anthelmintic has been administered soon after capture. Strongyles are most frequently seen and on occasions, if the animals are kept on grass, the egg counts may rise to 8000 per gram of faeces. This need not necessarily be of any clinical significance but must be assessed against the general condition of the animals and the stocking rate of the pasture. Under extensive management where animals are kept on large areas of pasture, regular use of anthelmintics may be impracticable. All the more recently available anthelmintics for horses have been used with safety in rhinoceroses. Thiabendazole and mebendazole have been regularly used at Whipsnade, and organophosphate anthelmintics have also been used occasionally when other agents are having little effect. In all instances doses are based on those recommended by the manufacturers for horses, allowances being made for the greater body weight of rhinoceroses (Table 6). With the organophosphates in particular, it is essential to give the drug individually and not to a group of animals where the exact intake cannot be assessed. Where rhinoceroses are kept permanently on solid, easily cleaned yards, helminth parasites usually disappear after two to three years of captivity as the animals are not readily reingesting the eggs or larvae. Nevertheless, it is good husbandry to carry out regular faecal checks (at least twice a year) to assess the status of helminth parasites in the host. The microfilarial nematode *Stephanofilaria dinniki* associated with necrotic skin ulcers in wild Black rhinoceroses in South and East Africa does not recur in captive animals. Although newly imported Black rhinoceroses may still have the lesions (Zukowsky, 1966; Messow, 1967), these heal with careful management and reinfection is unlikely because the nematode is believed to be transmitted only by certain species of biting flies. Schulz & Kluge (1960), Tremlett (1964), Round (1964) and Hitchins & Keep (1970) all discuss the pathology of these lesions in their areas of Africa. Perhaps the most intriguing feature of this parasite is its species specificity in that lesions have never been reported from White rhinoceroses inhabiting the same areas as affected Black rhinoceroses. Such is the case in the Natal parks.

Larvae of the ascaroid *Probstmayria vivipara* have been found in the faeces of Indian and White rhinoceroses at Whipsnade. Schenkel & Schenkel-Hulliger (1969b) and McCulloch & Achard (1969) have found the trichoneminid *Kililuma* in Black rhinoceroses, and the former report the presence of a thelaziid in the conjunctival sac of one bull of this species. The pathological significance of these is probably minimal.

Cestodes of the genus *Anoplocephala* are also occasionally encountered in the wild and in captivity. These can usually be cleared with a single treatment of niclosamide although they probably do little harm.

Parasites—Arthropods: Larvae of the bot fly *Gyrostigma* are frequently found attached to the gastric mucosa in Black (Schenkel & Schenkel-Hulliger, 1969b) and White rhinoceroses and are often voided in the faeces of newly imported animals. Organophosphate anthelmintics kill these larvae and dichlorvos is the most frequently used (Table 6) (Condy *et al.*, 1963).

Ticks are regularly encountered on wild African rhinoceroses. Schenkel & Schenkel-Hulliger (1969b) list the genera *Rhipicephalus, Amblyomma, Dermacentor* and *Hyalomma* as those identified from Black rhinoceroses in Tsavo, Kenya. A different species of *Amblyomma* (*A. crenatum*) was found on a Javan rhinoceros in the Udjung Kulon reserve (Kraneveld & Keidel, 1956).

Parsons & Sheldrick (1964) identified four genera of biting flies which were commonly found on Black rhinoceroses in the wild. Although flies frequently irritate rhinoceroses in captivity in temperate climates, they are not known to be parasitic. Hubback (1939) describes the significance of ticks and biting flies to the Sumatran rhinoceros.

Parasites—Protozoa: Large *Babesia* have been reported in the blood of White and Black rhinoceroses (Brocklesby, 1967; Bigalke *et al.*, 1970). The same authors also describe a smaller piroplasm from both species, probably of the genus *Theileria* or *Nuttalia*. Their clinical significance is unknown. McCulloch & Achard (1969) described trypanosomes from a group of 59 Black rhinoceroses which they caught on the Serengeti and attributed their heavy losses to a flare up of this latent infection. They also attributed two deaths to babesiosis. Coccidial oocysts have been seen in the faeces of Indian and White rhinoceroses at Whipsnade but in the absence of clinical signs, their significance is not known. The trophozoites of a protozoan resembling *Entamoeba* were found in large numbers in the wall of the ileum of a young Black rhinoceros (Michelmore, pers. comm.) and were thought to have contributed to its death.

Bacteria, viruses and fungi: The only confirmed viral infection of a rhinoceros was of a pox virus isolated from skin ulcers in a Black rhinoceros (Mayr & Mahnel, 1970). The virus was similar to that of fowlpox and grew readily in chicken eggs. The animal was believed to have died of a mycotic pneumonia and was already in poor condition when the viral infection occurred.

Haemolytic streptococci and staphylococci are frequently isolated from ulcers on the skin and mucous membranes but these are probably secondary invaders. Haemolytic and non-haemolytic *Escherichia coli* have been associated with gastrointestinal ulcers in young rhinoceroses and have also caused haemorrhagic enteritis in unweaned animals. *Yersinia pseudotuberculosis* and *Klebsiella* sp have been isolated from the mesenteric lymph nodes or intestinal mucosa of three young rhinoceroses in Britain in recent years. The animal infected with *Yersinia* had a rectal prolapse after straining for two days and it is thought that the infection and enlarged lymph nodes may have produced this reaction. Treatment with oxytetracycline by daily injection was successful. Schmidt & Hartfiel (1976) describe a haemorrhagic enteritis in an infant

White rhinoceros where *Klebsiella* and *Pseudomonas* were involved. Salmonellae have been isolated on a number of occasions. Williamson *et al.* (1973) describe a non-fatal *Salmonella* infection in young rhinoceroses and *S. typhimurium* was also found in freshly captured adults by Windsor & Ashford (1972). Keep & Basson (1973) describe acid fast organisms thought to be mycobacteria from a number of pulmonary and pleural abscesses in a debilitated Black rhinoceros.

Fungi are frequently isolated from skin and mucosal lesions, but contrary to some opinions (Fox, 1925) it is unlikely that these are primary invaders. The most commonly encountered genera are *Fusarium, Alternaria, Absidia* and *Pityrosporum.*

SYSTEMIC MEDICINE

Three systems figure prominently in the clinical problems of rhinoceroses – the integument, digestive and respiratory. The author has reviewed some of the diseases of rhinoceros skin (Jones & Thomsett, 1972). The lesions encountered so far are of three main types: generalised exfoliation of the epidermis, affecting most of the dorsal half of the body surface; discrete deep ulcers eroding the dermis and epidermis; and slightly raised vesicles and pustules. The vesicles and pustules are also occasionally seen at mucocutaneous junctions and they have been reported on the mucosa of the mouth, nostrils and external nares in Black rhinoceroses. At a later stage, these lesions may become ulcers. Animals may show one type of lesion or a combination of them. Bacteria and fungi have been isolated from the lesions as described previously, but these are almost certainly secondary invaders. Another type of lesion, a raised, vegetative, haemorrhagic node of 3–6 cm diameter has also been seen on the mucosa of the lips, but only in Black rhinoceroses. Where cases involving pathology of the skin have come to post-mortem, gastric ulcers are also frequently encountered.

As might be expected, animals in poor condition or those which have sustained injuries from others in a group appear to be particularly susceptible to these problems, and the lesions are most frequently seen in the winter. Local surgical debridement of the lesions together with applications of a vegetable oil blend containing 2% oxytetracycline and 0·5% thiabendazole appears to produce a clinical improvement. Parenteral antibiotics are given in the more severe cases. Massive intramuscular doses of vitamin A (four million units per week) and oral doses of vitamin C (1000 units per day) for three weeks have also appeared to induce an improvement in the three cases in which it has been tried. If the mucosal membranes are involved the outlook is more serious. In view of the failure to find a living agent in any of these lesions which could have convincingly caused them, it is possible that they are produced by a metabolic effect, such as a low uptake of fat soluble vitamins. The low serum levels of vitamin A found in some of these animals may not be normal, as was originally thought, but similar levels are found in animals with no clinical history (Table 1). It is also possible that rhinoceroses, like guinea pigs and some primates, are unable to make their own vitamin C.

Apart from the consideration of dietary factors in the maintenance of the integrity of the skin, the facility to bathe and wallow may also be important. The epidermis of rhinoceros skin dries and cracks very readily if it is not soaked regularly. In temperate climates, where access to water in the winter might lead to other problems, the regular application of a vegetable oil or lanolin on to the skin is recommended.

Abrasive floor surfaces have been mentioned as a potential danger to the animals' relatively soft soles. In addition, foreign bodies, such as fragments of metal wire, glass and sharp stones, may become lodged in the feet. Deep interdigital and solar fissures can result from physical damage and from necrosis caused by continuously damp, urine-soaked floors. Almost always these fissures become infected and are difficult to treat because the cavities have to be cleaned and opened to allow air flow and the daily application of an adsorbent antiseptic powder. Interdigital granulomas and papillomas are not uncommon in all three species of rhinoceros kept in captivity. They have been encountered regularly at Whipsnade and Boever (1976) has described the surgery and care of such a case. Their main significance is that they cause physical discomfort and at that stage have to be removed. They often recur. Laminitis, sometimes affecting all four feet, is not infrequently seen; the first signs being lameness and pus at the coronary band of one or more digits. The aetiology of this problem is not clear although it may be related on occasions to excessive feeding of concentrates. The most severe case of laminitis seen by the author involved an adult Indian rhinoceros with terminal chronic renal failure.

Under-running infections of the horns often result from fighting or regular rubbing and wear of the horn against walls and bars. Deep fissures sometimes appear in the base of the horn and on occasions necrotic fragments of nasal bone have been found underneath it. A closed abscess forms under the horn and the only effective treatment is to remove the horn, drain and clean the infected area and allow it to dry. In captivity under good management, new horn will grow at the rate of 10–15 cm a year. Nandi & Kumar Deb (1972) describe a squamous cell carcinoma of the base of the horn of a senile Indian rhinoceros. Surface abscesses often result from fights, and injuries from this cause constitute the most frequent clinical problem where rhinoceroses are kept in groups. Spinal injuries, one involving a young ♀ being mated by a much heavier ♂, have contributed to two fatalities at Whipsnade. Recently a case of mandibular osteitis has been seen in a Black rhinoceros where the presenting sign was a chronically discharging sinus which had to be opened and the source of infection rigorously cleaned out.

Most of the digestive problems encountered in rhinoceroses affect animals of under one year of age. Those caused by bacteria have already been described. Apart from specific antibiotic therapy, in cases of bacterial diarrhoea it is most important that replacement fluids, electrolytes and intestinal spasmolytics are given as soon as signs are seen because these species become dehydrated very rapidly. Apart from the ulcers seen on the oral and gastric mucosa, oedema, particularly of the stomach, lower ileum, caecum and colon, is occasionally seen.

Diarrhoea is often encountered in newly captured rhinoceroses which have been transported into captivity without adequate acclimatisation. Environmental stress and change of diet are the major contributory factors; the supportive treatment remains the same.

Bile duct proliferation and focal necrosis and fibrosis of the liver (particularly affecting the periportal areas) have been noted in a number of post-mortem examinations on rhinoceroses, but the significance of these lesions remains unclear. The presence of lipofuscin and haemosiderin pigments in the liver, intestine and spleen of some adult rhinoceroses in Britain is of doubtful clinical significance, but at present there is no histological material from normal animals available for comparison.

Prolapse of the rectum has already been mentioned as occurring in young rhinoceroses. Apart from the case seen at Whipsnade, Ensley & Bush (1976) describe a case in an Indian rhinoceros. There is also one report in the literature of intestinal torsion (de Vos, 1975). A similar case has been seen at Whipsnade where colonic impaction had also occurred.

Earlier research of post-mortem examinations suggests that respiratory diseases, mostly tuberculosis and bronchitis, were once frequently encountered in rhinoceroses (Garrod, 1878; Mitra, 1893; Coenraad-Uhlig, 1932). Lang (1966) and Ruedi & Muller (1975) describe cases of interstitial pneumonia in an Indian rhinoceros.

A small quantity of serous nasal discharge appears to be a frequent occurrence in captive rhinoceroses in temperate climates, especially in the winter. No significant lesions were found in the nasal passages or pharynx on examination with a fibrelight endoscope. Recently, ulceration of the mucosa of the nasal passages had been reported in Black rhinoceroses from Whipsnade and the Bristol collection (Greed, pers. comm.). Skin lesions as previously described were also noted on these animals. Invading bacteria and yeasts in the lesions were assumed to be secondary, the primary cause being unknown.

Severe muscular necrosis and degeneration contributed to the death of an adult Indian rhinoceros at Whipsnade which was also suffering from renal failure caused by periglomerular fibrosis. Myocardial degeneration was also evident in this animal, and a complex vitamin A and vitamin E deficiency was suspected. Lyon (1976) recorded a case of muscular dystrophy in a two-year-old Black rhinoceros but did not comment on the aetiology. Murray (1967) described an arteritis affecting the small distributing arteries of lymph nodes and the intestines in a Black rhinoceros; the pathology was very similar to equine viral arteritis. Lymphadenitis and lymphangitis affecting principally the

lymphatics of the head and neck of a young adult White rhinoceros has been seen at Whipsnade. Mitra (1893) records a single case of tetanus in a rhinoceros. Dittrich (pers. comm.) describes benign sarcomas in the muscles of the hind legs of a Black rhinoceros. A large number of 2–15 cm diameter firm nodes in the uterine and vaginal wall of a ♀ Indian rhinoceros at Whipsnade were found to be leiomyomas. Five years after their initial discovery there had been no increase in their size or number and the animal remained in good health but showed no signs of oestrous behaviour.

Haemoglobinuria, almost certainly caused by excessive feeding of kale *Brassica oleracea* as a dietary supplement, has been noted in two Indian rhinoceroses at Whipsnade. Several collections have reported that rhinoceroses sometimes discharge a thick, white or cream-coloured urine. In the Society's collections this has been seen in all three species kept. Analysis of this material has shown it to consist mainly of ammonium urates and calcium carbonate. The pH of the urine varied from around 7·3 to 7·7. There were a few cellular elements in the samples with, on occasions, a trace of haemoglobin. No clinical signs were noted in association with the passing of this material, and it was considered to be a normal occurrence.

SUMMARY

With diminishing wild populations of rhinoceroses, the maintenance and breeding of these species in captivity becomes increasingly important. Because of the expensive facilities needed for their housing and management relatively few zoos will keep them and this, together with their slow reproductive rate, will ensure that the captive population will always be small. Information of relevance to sound management of this group is in short supply and more data are needed particularly on vitamin, mineral and protein requirements and on the detailed pathology especially of the skin and digestive tract. It is hoped that this paper as a synopsis of much of the available data will act as a stimulus for further work.

PRODUCTS MENTIONED IN THE TEXT

Acetylpromazine: acepromazine maleate, a sedative manufactured by Boots, Nottingham, Great Britain.
Astrobot: dichlorvos, an anthelmintic manufactured by Arnolds Veterinary Products Ltd, 14 Tessa Road, Richfield Avenue, Reading, Berkshire, Great Britain.
Atropine: atropine sulphate, a parasympatholytic central nervous system depressant manufactured by Evans Medical, Speke, Liverpool, Great Britain.
Darting needles: manufactured by Palmer Chemical & Equipment Co. Ltd, POB 867, Palmer Village, Douglasville, Georgia 30134, USA.
Diprenorphine hydrochloride: a narcotic antagonist manufactured by Reckitt and Coleman, Hull, Great Britain.
Dist-Inject: needles manufactured by Peter Ott AG, Postfach, CH-4007, Basel, Switzerland.
Equivurm plus: mebendazole, an anthelmintic manufactured by Crown Chemical Company Ltd, Lamberhurst, Kent, Great Britain.
Etorphine hydrochloride: a narcotic manufactured by Reckitt and Coleman, Hull, Great Britain.
Fentanyl citrate: a narcotic manufactured by Janssen, Beerse, Belgium.
Hyoscine: hyoscine hydrobromide, a parasympatholytic central nervous system depressant manufactured by Evans Medical, Speke, Liverpool, Great Britain.
Lethidrone: nalorphine, a narcotic antagonist manufactured by Wellcome Laboratories, Beckenham, Kent, Great Britain.
Suicalm: azaperone, a sedative manufactured by Janssen, Beerse, Belgium.
Terramycin: oxytetracycline, an antibiotic manufactured by Pfizer Ltd., Sandwich, Kent, Great Britain.
Thibenzole: thiabendazole, an anthelmintic manufactured by Merck, Sharp and Dohme Ltd, Hoddesdon, Hertfordshire, Great Britain.
Yomesan: niclosamide, an anthelmintic manufactured by Bayer UK Ltd, Bury St Edmunds, Suffolk, Great Britain.

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Notes on the Sumatran serow

Capricornis sumatraensis [Plates 48 & 49]

at Jakarta Zoo

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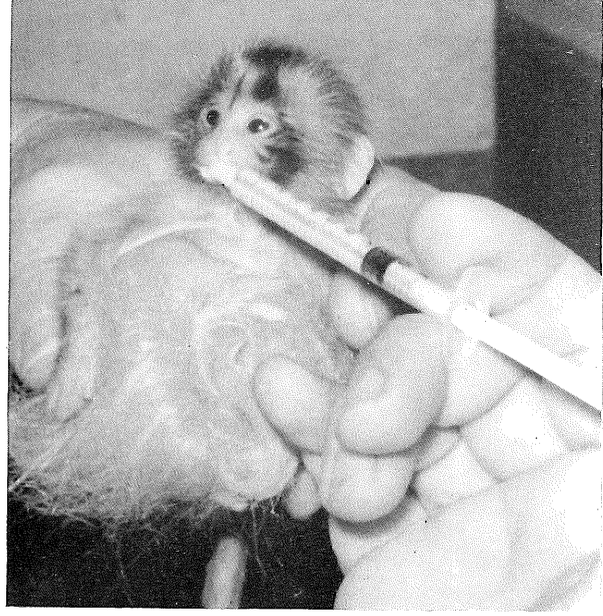
In October 1977 an adult ♀ and a juvenile ♂ Sumatran serow *Capricornis sumatraensis* were received at the Jakarta Zoo from the Wildlife and Nature Conservation Department in Aceh, North Sumatra. The animals, which had been illegally owned and were confiscated by the department, were too tame for release into the wild. Although efforts are made continually to educate the villagers not to hunt and trap protected animals, poaching still occurs. For the



47. *right.* An interesting experiment conducted at Monkey Jungle, Miami, involved hand-feeding twin male Golden lion tamarins *Leontopithecus r. rosalia* whose mother failed to suckle them without however requiring their permanent removal from the family group (see pp. 155–158). The picture shows how the syringe was placed, not directly into the mouth, but so as to deposit a small drop on the infant's lip. This was a precaution against inhalation, and both tamarins soon learned to lap from the tip of the syringe. After each feed the infants were returned, first to the mother and later, when the male was reunited with the group, to be carried and fed by both parents. Supplementary syringe feeding continued until the twins were eight weeks old. *Marilyn A. Norconk*

48, 49. This pair of Sumatran serows *Capricornis sumatraensis,* one of the 'goat-antelopes', was confiscated from illegal ownership by the Indonesian Department of Wildlife and Nature Conservation in Northern Sumatra and placed for safety in Jakarta Zoo. Although protected by law, these rare, shy animals are still hunted in their mountain retreats for hide and meat. Normally difficult to keep together, the juvenile male (*right*) and the older female (*below*) appear completely compatible and it is hoped eventually to breed from them (see pp. 252–254). Both sexes have well developed horns, and facial and interdigital glands which are used to mark territory. In the zoo it was the forelegs that were most often employed as weapons. *B. Galstaun*