THE
BLOOD OF THE OSTRICH

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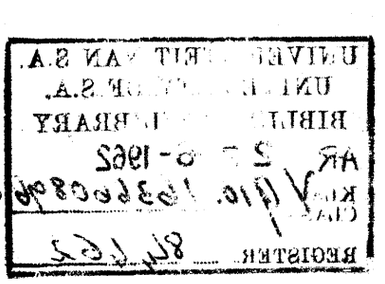

THE BLOOD OF THE OSTRICH.

Introduction.

Blood is subject to many diseases and the study of haematology not only yields information concerning these diseases but often also furnishes valuable information for use in the interpretation of disorders which primarily affect other parts of the body. However, all knowledge about the state of the blood during disease is useless without comparative data for healthy blood.

The purpose of this treatise is to present haematological data for use in the study of diseases of the ostrich, and to render possible a comparison of the data on ostrich blood with those on the blood of other animals.

In order to avoid repetition, the technique, results and discussions of each phase of the investigation are grouped together, whenever possible, and the work is presented under the following headings:-

1. Subjects used for determinations ;
2. Marking of ostriches ;
3. Collecting the blood ;
4. Preventing the coagulation of the blood ;
5. Preparation of smears ;
6. Staining of smears ;
7. Cell measurements ;
8. Morphology of the blood;
9. Erythrocyte counts ;
10. Relative volume of corpuscles and of plasma ;
11. Minimum and maximum resistance of red cells ;
12. Osmotic pressure on the red cells ;
13. Haemoglobin content ;
14. Leucocyte counts ;
15. Differential counts ;
16. Thrombocyte counts ;
17. Viscosity ;
18. Specific gravity ;
19. Phosphorus, calcium, sodium, magnesium and potassium content of the blood;
20. Total blood volume;
21. General discussion;
22. Summary.

The blood of birds has been little investigated compared with that of domesticated mammals, and literature referring to the blood of the ostrich is very meagre indeed. Table 1 comprises all the records (relating to the blood of this bird) revealed by an exhaustive search carried

carried out with the assistance of the Staff of the Imperial Bureau of Animal Health, Weybridge, Surrey, England. None of the six investigators mentioned in table 1 indicated the technique employed for collecting the blood neither was there any mention of the number of birds from which blood was collected, nor the number of blood samples examined.

It would appear therefore that the data were obtained incidentally in the course of other studies; and it will be observed that although the erythrocyte counts given by Malassez (1872) and Hayem (1879 and 1889) are in fairly close agreement, they differ considerably from that of Venzlaff (1911). The cell lengths recorded by Malassez and Venzlaff also differ appreciably from those given by Gulliver (1875) and Hayem. But in any case, great accuracy can scarcely be expected in the cell counts and cell measurements by the early investigators, considering that in those days the apparatus was not so accurately calibrated as it is to-day.

The ostrich is a domesticated bird with a very ancient history and the following information given by Wormser (1930) may prove of interest : A specimen of the bird was found in a sepulchral chamber of the 18th dynasty which is supposed to be contemporary with Moses and frequent mention of the feather is made in Egyptian hieroglyphics. Arsenoe, an Egyptian queen before Cleopatra, caused to be erected a statue of herself seated on an ostrich, and in Roman public functions the feather was much worn and the bird was ridden by ladies of noble birth. The beauty of the feather has been praised in all ages and from time immemorial the plumes have been sought for personal adornment. Warriors wore them as early as 1350 - 1100 B.C. and ostrich eggs were greatly prized and used for ornamental and religious purposes. The plumes

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TABLE 1.

SUMMARY OF OSTRICH BLOOD EXAMINATIONS CARRIED OUT BY DIFFERENT INVESTIGATORS.

Author and Date	Species of ostrich	Red Cells per c. mm.	White Cells per c. mm.	Hemato-blasts[1] per c.mm.	Maximum measurements red cells		Minimum measurements red cells		Average measurements red cells			Average Nuclear measurements		Phosphorus content	Agglutination titer of anti-lepisepticus serum	Agglutination titer of anti-pigeon RBC. serum
					lgth.	bdth.	lgth.	bdth.	lgth.	bdth	Thickness	lgth.	bdth.			
Malassez, L.,1872	not stated	1,600,000							18u[2]	9u						
Gulliver, G.,1875	Struthio Camelus								1"/1649 (15.33u	1"/3000 8.47u	1"/9166 2.77u	1"/3200 7.94u	1"/9166 2.77u			
Hayem, G.,1879	Struthio Camelus	1,581,000	9,000	11,600					14.38u[2]	9.15u						
Hayem, G.,1889	Struthio Camelus	1,620,000	9,000	11,500					14.30u[2]	9.15u						
Venzlaff, W.,1911	Struthio Camelus	2,560,000			19u[2]	10u	15u	8u	18u	9u						
Malan, A.I.,1930	Not stated													Total Phosphorus 109.0 Lipoid P 11.3 Organic P 39.0 Inorganic P 5.5 Nucleoprotein 53.2		
Buchbinder, 1934	Struthio Camelus														0	40

1) These are evidently blood platelets: this is inferred from the authors discussion concerning the nature of the cells and the part which these cells take in the clotting of blood.

2) Moist preparations.

3) Not stated whether moist or dry preparations. Gulliver gave the measurements only in vulgar fractions of an inch.

formed part of the tribute imposed by Egyptians on conquered countries.

In the light of these facts and in view of the important role which the ostrich has already played in the economic history of South Africa it is surprising that the haematology of this bird has not received more attention, particularly from veterinarians in South Africa and that there is comparatively little scientific veterinary literature about the ostrich. This lack of information cannot be ascribed to the bird's immunity from disease, for, though the grown animal is very hardy, yet when young - particularly when under three months - it readily succumbs to disease.

That it is susceptible to a number of affections is well known, though to judge by the literature only a few of these have been scientifically investigated. This may be attributed partly to the fact that countries other than South Africa had little interest in the ostrich feather industry ; for during the years in which it flourished, it was almost entirely monopolised by South Africa, since the bird is indigenous to this country, and legislation prohibited the exportation of ostriches or even of fertilised eggs. Moreover at that time there were few veterinarians in South Africa and they were fully occupied with the many stock diseases then rampant, which owing to the havoc they were causing doubtless warranted more attention. Apparently no one qualified to do so had sufficient leisure to make a thorough study of the hygiene and diseases of the ostrich, and to present the information for the guidance of others. Besides, veterinary haematology and especially avian haematology was then much less advanced than it is at present.

For almost half a century the ostrich industry was of very great importance to South Africa and formed

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the most lucrative branch of farming. At one time ostrich feathers were second only to wool as an agricultural export. From the year 1860, when 2,361 lbs. of feathers valued at £19,726 were exported from South Africa (Wormser 1930), the exports steadily increased, except for minor fluctuations, till 1913, the peak year of the industry, when 1,023,307 lbs. valued at £2,953,587 were exported. At the end of 1913 there were 776,313 ostriches in South Africa, and before the collapse of the industry in 1914 as much as £1000 was paid for a good breeding pair, and the prices obtained for chicks varied from £5 to £50 (Official Year Book of the Union of South Africa 1910 -17). Feathers realised as much as £100 per lb. during the boom (Laite 1915).

The ostrich feather industry forms at present one of the lesser branches of South Africa's agricultural activities, and may be said to have been moribund for many years in so far as the value of the feather as an article of adornment is concerned. Still, it does not seem likely that ostrich feathers will ever pass quite out of favour, though the price may fluctuate in accordance with the vagaries of fashion. The ostrich is being exploited also in other ways - its skin is used for wallets, handbags, attache cases, tobacco pouches, shoes, etc. and the ~~eggs and the~~ meat, particularly when dried (biltong), and the eggs are relished by many people. The following paragraph recently appeared in the press :-

> "Having discovered that ostrich meat has d delicious flavour, the Moscow Zoological Park has begun breeding ostriches on a large scale, with the object of establishing large flocks in the Southern Steppes of the Soviet Union. Because of its thick layer of fat, which originally served as a

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protection from the Semi-tropical sun, the ostrich can endure the cold Russian winter, even at the latitude of Moscow."

The knowledge gained from veterinary research work in connection with the ostrich would, therefore, serve the interests not only of science but of trade, especially if there should be a revival in the feather industry. It is hoped that these studies will add a link to the chain of that knowledge.

Incidentally it may be mentioned that the literature discloses no data about the blood of any kind of South African bird - apart from the chemical analyses by Malan (1930) - and it will be seen from Table 2, which embraces most of the observations on the cellular elements of the normal blood of the domestic fowl, that the results show marked discrepancies, especially in respect of the total leucocyte and thrombocyte counts and the percentages of the types of leucocytes. Moreover, blood observations made overseas are not necessarily applicable to South African birds, for, as is well known, the blood picture varies more or less with breed, climate, geographical habitat, etc.[1)]

1) The writer is at present also studying ~~also~~ the blood of the South African domestic fowl.

TABLE 2.

SUMMARY OF EXAMINATIONS BY DIFFERENT INVESTIGATORS OF THE BLOOD OF NORMAL FOWLS.

Author and Date	Number of animals and sex		Number of counts	Haemoglobin per cent and gms. per 100 c.c.	Red cells per c.mm. (Millions)			White cells per c.mm. (Thousands)			Thrombocytes per c.mm. (thousands)	Percentages of varieties.					
					Max.	Min.	Av.	Max.	Min.	Av.		Lymphocytes	Monocytes	Polymorphonuclears with eosinophilic rods	Polymorphonuclears with eosinophilic granules.	Basophiles	Unclassified
Stolzing, 1856[1]							3.8										
Malassez, 1872[1]							3.1										
Hayem, 1889[1]							2.4			26.3							
Albertoni and Mazzoni, 1891[1]							2.5			32.3	45.5						
Moore, 1895-6[4]					3.7	3.5	3.6	21.2	18.9	20.0							
Heinz, 1901[4]					4.1	3.9	4.0										
Ward, 1904[4]					4.0	2.4	3.3	61.0	24.0	36.2							
Warthin, 1907					3.0	2.0		29.0	12.0	21.0		50(small,35.5) (large, 14.5)		21.5	10	2	16.5
Ellerman and Bang, 1905				50 - 65%(Sahli)			3.0			30.0	30.0	40	23		37		
Hirsfeld, 1909[4]							3.0			30.0							
Goodall, 1910[1]							3.2			19.0							
Hedfeld, 1911[3,4]	M.6 F.7	6 7			5.1	3.6	4.2 4.3			24.0		54.0		30.0	12.0	3.0	
Kleineberger and Carl, 1912	6	6		79%			3.12	60.8	35.0		22.9-130.0	63.8(Small,12.3) (large, 51.5)		29.5	4.5	2.2	
Burckhardt, 1912							3.3			23.8		61.3(small48.5 (large12.8		27.9	7.9	2.9	
Kozma, 1913					4.0	2.5											
Launoy and Levy-Bruhl, 1913[1]					3.16	2.18		35.0	20.0								
Schmeisser, 1915				60 - 70%(Sahli)	4.0	3.0		80.0	20.0			42.3	19.4	29.6	4.3	2.2	2.8
Pickens, 1915[5]					4.0	3.0	3.5			35.0							
Fatham, 1916[4]					5.8	3.6	4.7										
Taylor, 1916[1,4]								30.0	17.0	23.67		51(42-60)	9 (6-14)	33 (25-41)	3.6 (1.9-6.8)	3 (2.6-4.1)	
Burnett, 1917				76%			3.3				17.9	58	5.5	28.8	3.3	4.3	
Mack, ~~1908~~[1]				87.3%			3.0			33.77		54.9	6.2	32.7	2.7	3.3	
Kaupp, 1918[5]					4.0	3.0		35.0	28.0								
Salomon, 1919[3,4]	M.1 F.3				3.4	3.1	3.2	49.0 57.0	38.5 49.0	28.0 41.0		61.0 69.0	1.0 2.0	28 18	7 9	3 1	
Fritsch, 1920[2]	M.5	5		12.3gms			3.24				very few	40.0	2	49	5	3	
	F.5	5		9.6 "			2.77				do.	64.0	5	23	5	2	
Kleineberger and Carl, 1927	M.2	2		73-80%	3.91	3.44		32	23		25.3-28.0	24-27		60-71.5	1-2	0.5-14.0	
	F.5	5		67-80%	3.91	2.88		42.2	29.6		22.7-40.9	63.5-74		18.6-33.5	1.5-4.0	1.5-3.5	
Ellerman, 1921												53.0	12	29	4	2	
Romer, 1921				75%(Sahli)			2.62					64.6(small52.7 (large12.3	1.4	26.5	5.4	1.9	
Fink, 1924[2]					3.35	2.61	2.84										

continued.

TABLE 2 Continued.

Author and Date	Number of animals and sex	Number of counts	Haemoglobin per cent and gms. per 100 c.c.	Red cells per c.mm. (Millions).			White cells per c.mm. (Thousands).			Thrombocytes per c.mm. (thousands)	Percentages of varieties					
				Max.	Min.	Av.	Max.	Min.	Av.		Lymphocytes	Monocytes	Polymorphonuclears with eosinophilic rods	Polymorphonuclears with eosinophilic granules	Basophiles	Unclassified
Niggermaier, 1925[2]				2.83	2.16	2.68	40	19	29		52.5 (40.4-64.7)	7.5 (4.3-10.6)	32.1 (24-41)	6 (3.7-10)	1.9 (0-3.4)	
Kennett, 1926[5]						2.9			33.0							
Chaudhuri, 1926[5]				M.5.2 F.3.1	3.9 3.8	4.6 2.0										
Blacher, 1926[5]				M.4.4 F.3.7	3.0 2.1	3.8 2.9										
Hayden, 1927			74%	3.7	2.28	2.83	48	22	38.9		81	1.5	5.17	10	1.6	
Breusch, 1928						3.47			33.3		66.5	9.2	17.7	4.1	2.5	
Blain, 1928	6	75					29.5	10.1	18.6	None	32.8	5.7	49.4	8.7	3.6	
Gohs, 1928									17	50-100						
Kyes, 1929							13.0	8.0								
Forkner, 1929	11	29	62.9% (Newcomer)	4.6	2.3	3.27	74.0	6.8	24.6	35.0	41.8	17.1	34.7	1.8	4.2	
Kaupp, 1929						3.5	30.0	25.0		50.0	45.0	18.0	30.0	6.0	1.0	
Thomsen and Engelbreth-Holm, 1931[3]			50%			3.0			30.0		65.0	5-10	25.0	2-4	1-2	
Wirth, 1931			50-65 (Sahli) 10.2-10.6 gms.	4.0	3.0						60.0 (small 40-60 (large 5-15	2 (1-4)	30 (20-50)	5 (2-8)	3 (1-5)	
Fenstermacher, 1932				2.8	2.2	2.6	29.3	19.8	24.0							
Seagar, 1933						2.9			27.0							
Landauer and David, 1933[4]				M.4.6 F.3.7	4.0 3.4	4.3 3.2										
Cook and Dearstyne, 1934	M.5 F.75	80	10.8 gms	4.2	1.8	2.84	47.0	3.0	16.36		12 (small 8-54 58 (intermediate 0-18 (large 0-5	4-33	22-78	0-18	0-18	0-3
Gibbs, 1934	15	20	85.3 (Wong)			3.2			24.0							
Blakemore, 1934	19	19				2.8	36.0	13.3	25.1		69.4	7.5	21.5			1.6
Palmer and Biely, 1935	50	50		3.3	1.0	2.5	77.5	15.8	38.5							
Morgan and Chichester, 1935						2.9										
Biely and Palmer, 1935.	F.100 47[7]	100 47		3.84 3.18	1.80 1.80	2.78 2.48	49.00 28.30	18.33 15.00	32.15 20.60							

1. Listed by S.H. Burnett (1917).
2. " " D. Wirth (1931).
3. " " T.B. Magath and G.M. Higgins (1934).
4. " " J. Palmer and E.I. Biely (1935) citing Scarborough (1931).
5. " " J. Palmer and E.I. Biely (1935).
6. Gibbs records the differential counts as follows: Eosinophilic leucocytes with rods 10.3 per cent. Eosinophilic leucocytes with granules 23.0 per cent. Polynuclear leucocytes 10.6 per cent. Neutrophilic leucocytes and mast cells 4.2 per cent. Small lymphocytes 40.3 per cent. Large lymphocytes and mononuclears 11.8 per cent.

7. One- to two-day-old chicks

SUBJECTS USED FOR DETERMINATIONS.

As the primary object of this work was to obtain information about the blood of normal ostriches, the intention was to utilise, for the purpose of research, birds hatched either in an incubator or naturally and removed immediately to an area where there was no risk of worm infection - to which the ostrich is very susceptible - and where they could be so attended to as to remain in perfect health. But incubator-hatched birds were unobtainable and the writer had to content himself with six chicks which had been hatched by a semi-wild ostrich, and which were already about two weeks old when they were caught. Luckily they proved later to be three hens and three cocks and consequently the blood of the sexes could be compared.

Before capture these birds had the run of a big farm on which there were few other ostriches and it was therefore considered that little, if any, worm infection could have occurred within so short a period. They were then reared in a camp on the Stellenbosch-Elsenburg Agricultural College farm, Mariendahl, Stellenbosch district, where they had considerable freedom and where there had been no ostriches for many years (perhaps never), not even within a radius of many miles. Furthermore, as the four species of worms known to be harboured by the ostrich, viz., the tape-worm, Houttuynia struthionis, and the nematodes, Codiostomum struthionis, Ornithostrongylus douglassii and Contortospiculum spicularia (Monnig 1929 and 1934), are not known to occur in any other species of animal, little, if any, worm infestation was anticipated. This expectation was fortunately realised, for faeces examinations made - by the centrifugal flotation method described by Monnig (1934) - during the course of the research work proved

/negative.....

negative and also on post-mortem no worms were found. The administration of vermicides was therefore unnecessary, and possible blood changes due to such treatment was accordingly eliminated. Care was taken also to ensure that the birds remained entirely free from ectoparasites. Five of the birds - numbers 1 to 5 - showed no trace of disease, either during life or on post-mortem examination, and their blood may therefore be considered to have been normal.

The remaining bird, number 6, when about six months old, dislocated a metacarpo-phalangeal joint and the dislocation could not be remedied. In consequence the bird had a club-foot, and as the joint always came in contact with the ground a large tumour-like formation developed over the part exposed to the ground. Otherwise the bird was perfectly healthy, for on post-mortem examination it showed no internal evidence of disease. As it could not be considered perfectly normal, the results of the examinations of its blood are not included with those from the normal birds, but they are nevertheless recorded for the purpose of comparison.

It would, of course, have been better to have had a larger number of absolutely healthy birds for these blood observations, but sufficient lucerne-grazing, so essential to the well-being of ostriches kept in a limited area, was not available. Their other food consisted of a plentiful supply of chopped bones, oats, mangolds, etc. Some of the observations, such as cell-counts, etc., were repeated at intervals from the time when the birds were about seven months until they were about two years and eight months, viz., until they were fully mature.

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The blood of sixteen other ostriches was also examined. Eleven of these - numbers 7 to 17 - were semi-wild full-grown birds caught on the farm "Nagwag", Bredasdorp district. They appeared healthy, but the writer was unfortunately not given an apportunity of conducting post-mortem examinations on them. Faeces from only a few of these birds could be examined and these contained many worm eggs. As none of the birds had ever received vermicidal treatment, it is most likely that all of them were worm-infested.

The remaining five birds, 18 to 22, were semi-wild ostrich chicks sent to the writer from the farm "van der Stelskraal", Bredasdorp District. These birds showed marked unthriftiness, and on post-mortem examination they were all found to be severely infested with worm parasites, particularly tapeworms. As it is impossible to judge of normality from external appearance alone, only the results from birds 1 to 5 will be considered as results from normal birds, and those from numbers 7 to 17 and from numbers 18 to 22 will be classed respectively as from clinically healthy ostriches and from unthrifty ostrich chicks which on post-mortem examination showed marked verminosis.

It was difficult to make observations as the nearest farm - other than Mariendahl - on which ostriches were kept was over a hundred miles distant from the laboratory.

CLASSIFICATION OF THE OSTRICH.

There are different opinions regarding the classification of the ostrich. Cronwright-Schreiner (1898) gives the following classification:-

1. North African bird - Struthio camelus.
2. South African bird - Struthio australis.
3. Somali Ostrich - Struthio molybdophanus.

In South Africa the industry was started with the

/Struthio .....

Struthio australis, but as the feather of the North African bird, Struthio camelus, proved superior, a number of these birds were introduced at different times to improve the stock. Cross-breeding was successful and, as the hybrids are fertile, a certain percentage of the birds in South Africa are crosses between the two species, Struthio camelus and Struthio australis. The birds used in this work, however, had the characteristics of the true South African bird, namely, the Struthio australis.

THE MARKING OF OSTRICHES.

As ostriches look so much alike - even the sexes being difficult to distinguish until the birds are about a year old - it was necessary to mark the birds on which repeated observations were being made, so that they could be readily identified. They were therefore branded, for branding is a simple and most effective way of marking an ostrich. Clips in the wing were considered undesirable, as they sometimes cause inflammation and possibly leucocytosis.

A piece of wire, about 7mm. in diameter and 18 inches long, was bent at right angles, so that the short arm of the wire was two and a half inches long. The six birds kept at Mariendahl were each branded on the right thigh in Roman letters, viz., I to VI, when they were four months old and the letters were placed sufficiently low and were big enough to be seen readily from a distance ; thus any unnecessary handling of a bird was avoided. The wire, heated to a dull red, was applied just long enough to burn through

through the epidermis. Excessive burning, particularly when a small brand with ordinary lettering is used, sometimes results in so much scar tissue formation that the actual lettering is obliterated. If chicks under three months have to be branded, it is best to brand them on the side of the abdomen, for the thighs are then still covered with down. A fine wire should then be used. Healing is usually complete after five weeks and the mark probably remains for life. Determinations recorded were made only about two months after the wounds had completely healed.

COLLECTING THE BLOOD.

From ostriches up to the age of about four months small amounts of blood, such as for cell counts, were most easily obtained by puncturing the brachial vein just above the shoulder joint. The bird is laid on its side on a table or box of convenient height, and is suitably controlled by one or two assistants. It is much easier to restrain troublesome birds if the hock joints are flexed and then immobilised by means of cords, or preferably soft linen bands, as the skin is easily chafed. The uppermost wing is held extended and the site is cleansed with a pledget of cotton wool moistened with alcohol. The vein, which is easily seen when the wing is extended, is then slightly compressed opposite the shoulder joint with the thumb of the left hand and when the site is quite dry the vessel is punctured, an ordinary hypodermic needle being quite suitable for the purpose. The needle should be held in a position vertical to the course of the vein; if the puncture is made obliquely, the skin stretches slightly, with / the result that when the needle is withdrawn, the skin retracts, preventing the free/.....

free flow of blood . The blood then collects on the fold of skin which fills the angle between the humerus and the ribs, and the required amount of blood can then be correctly drawn up in a blood cell count or other kind of pipette. Blood cell count pipettes (Thoma-Zeiss and Trenner) were always used for diluting the blood in the case of young chicks, as much blood could not easily be obtained, nor was it desirable to extract much blood. Haemorrhage may be arrested by pressing a finger on the wound for about one minute, but after release of the bird bleeding generally stops quite soon.

When a fair quantity of blood was needed, as for the purpose of determining percentage volume, etc., it was drawn from the brachial vein by inserting into it a hypodermic needle with a bore of about 0.5 mm. and drawing off the required amount of blood with a syringe. As a needle of such fine bore has to be used the blood seldom flows satisfactorily of its own accord even when the vein is well compressed. (Differences between counts made of blood drawn off with a syringe and of blood which flowed out spontaneously were negligible). Very young chicks should be handled carefully as they readily succumb to injury.

In older birds, sufficient blood for ordinary haematological determinations can be obtained from either the right jugular or brachial vein, for these veins are well developed. The blood was usually collected from the right brachial vein, which is easily accessible; the birds usually resent handling of their necks. They persist in swaying them about and they usually struggle if attempts are made to control the neck. The needle therefore easily becomes dislodged. The procedure adopted here was based on the method of Neser (1923) and is as follows :

The birds are driven into a small enclosure and by

/means .....

means of a stick - about six feet long, to one end of which a thick piece of hard wire bent in the shape of a hook is attached - the bird is gripped at the back of its neck just below the head. The bird immediately rears and with the right hand it is then caught at the back of the neck. Very tame birds may be caught without the aid of a stick. A black stocking or some other type of blinker porous enough to admit sufficient air but too dense for the bird to see through is pulled over the head. When once the head has been caught there is little danger of being kicked, and it is surprising how helpless and docile an ostrich becomes when it cannot see. The bird is then manoeuvred into a V shaped crush just long and wide enough to accommodate it. The back of the ostrich is on a level with the top of the crush. (Fig. 1).

Fig. 1

It is not desirable to use galvanised iron for making the crush, for noise caused by the kicking of the birds frightens them and they become very restless. Neither should the crush be built close to trees for their rustling on a windy day also excites them. Flooring boards were found very suitable. Their surfaces should be planed smooth, otherwise the ostrich can get a hold on

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