Jl S.Afr. vet. Ass. 46(2) 185-189 1975

HAEMOGLOBIN TYPES IN AFRICAN CATTLE

D.R. OSTERHOFF*

SUMMARY

The migration of domesticated animals in Africa is of particular interest to the anthropologist and ethnologist in that it may provide valuable information concerning the migration of human tribes that accompanied these animals.

Haemoglobin C is only found to be present in indigenous breeds of African cattle and can therefore be used as one of the best genetic markers of these animals.

Haemoglobin B has been established in many breeds in Africa and India. It seems that the further away the animals migrated from India, the lower is the frequency of HbB.

Breed comparisons from numerous breeds in Africa are made, including the results of the present investigations on breeds of different countries in Southern Africa.

INTRODUCTION

The migration of different cattle types into the African continent and the relationship between these animals has always been of great interest to human biologists and scientists[4]. The choice of yardsticks in the evaluation of these relationships has been changed from body measurements and photographs to genetical markers such as blood groups and genetical polymorphisms in protein and enzyme types[10].

Since most of the studies have been performed on the haemoglobin types in African cattle[1 8 11 14 16] it was felt that the first survey of cattle breeds and types in Africa could best be performed by studying the haemoglobin types of these animals. The study is by no means complete and it is necessary to collect blood samples from additional breeds and types of cattle to determine not only the haemoglobin types but also study the biochemical polymorphism in the other protein and enzyme types.

Haemoglobin, the oxygen-carrying component of the blood, consists of complex molecules consisting of a protein part, the globin and the effective haeme part. The haeme part comprising only 4% of the haemoglobin molecule contains four iron atoms which are able to bind loosely with four molecules of oxygen. While the haeme part of the haemoglobin is relatively constant, the globin part, a combination of two sets of polypeptide chains and comprising 96% of the haemoglobin molecule varies considerably from species to species and also within a species.

In cattle, Cabannes & Serain[5] were the first to report two electrophoretically distinct components in Algerian cattle. It was pointed out by these workers that the presence of the second haemoglobin was not associated with disease. After the initiation of the starch gel electrophoresis, a third component, called haemoglobin C and a fourth component, haemoglobin D were found[3 6 9 12].

In the investigations before 1964/65 the Allele HbC was not identified because different techniques were used and even in the first starch electropherograms the C band was overlooked. In these investigations, however, the haemoglobin B was always established as correct, while haemoglobin C formed part of haemoglobin A. This could also be confirmed in a study of the Malagasy Zebu[13].

MATERIAL AND METHODS

Blood samples were collected from different types of breeds of animals in Southern Africa: from Rhodesia samples were obtained from the Nkone, Tuli and Mashona, and from Mozambique samples were obtained from the "Landim", a native name for unimproved, indigenous cattle of mixed origin. In Angola cattle were bled in three different regions, Cafa Cunene, Malanje and Quilenques; from the Veterinary Department in South West Africa samples were obtained from Ovambo, Sango and Caprivi cattle. Lesotho, Malawi and Malagasy Zebu cattle could be included, while in South Africa samples were obtained from the Nguni and imported Brahman, the latter for reasons of comparison.

All blood specimens were collected from adult animals to avoid misclassification due to foetal haemoglobin[10]. Starch gel electrophoresis was used throughout, the techniques being described in earlier papers[11 15]. Clearcut separation of the different migration bands was always obtained.

RESULTS

In Table 1 the haemoglobin gene frequencies are presented from the material investigated in this study together with the gene frequencies from earlier investigations[11 12] of blood of cattle of the Afrikaner, Drakensberger, Bonsmara and Ankole breeds.

For the first time haemoglobin D with the slowest migrating molecular structure was found in cattle from Malawi, expressed in heterozygous form as HbA/HbD in two animals and as HbC/HbD in one animal.

DISCUSSION AND CONCLUSIONS

In an attempts to compare the results obtained with those of other authors one has to clarify the problem of correct determination of the haemoglobin types. In

* Dept. of Zootechnology, Faculty of Veterinary Science, University of Pretoria, Onderstepoort.

Table 1: HAEMOGLOBIN GENE FREQUENCIES IN INDIGENOUS CATTLE BREEDS IN SOUTHERN AFRICA.

Breed	No. of samples	Gene frequencies			
		Hb^A	Hb^B	Hb^C	Hb^D
Malagasy Zebu	199	,354	,623	,023	
Brahman	155	,577	,400	,023	
Tuli	199	,580	,399	,021	
Ankole	70	,721	,279	,000*	
Malawi-Zebu (North)	57	,623	,255	,096	,026
Angola-Malanje	134	,682	,235	,083	
Angola – Quilenques	90	,738	,184	,078	
Ovambo	200	,748	,150	,102	
Malawi -Zebu (Central)	55	,700	,140	,160	
Sango	248	,732	,141	,127	
"Landim"	172	,756	,130	,114	
Angola-Cunene	140	,801	,119	,080	
Mashona	124	,866	,117	,017	
Caprivi-Sanga	97	,876	,114	,010	
Nguni	300	,883	,064	,053	
Afrikaner	1 428	,819	,064	,117	
Lesotho-Nguni	100	,910	,060	,030	
Nkone	156	,929	,049	,022	
Drakensberger	27	,833	,037	,130	
Bonsmara	78	,962	,013	,025	

* Investigated before 1965, see text.

the earlier investigations paper electrophoresis or the cellulose acetate technique was used which could not give clear separation of the slow migrating A- and the somewhat faster moving C-band. All results given in Table 1 except those of the Ankole cattle were obtained with the improved starch gel electrophoresis technique[12]. Two examples of these typing difficulties will be given to illustrate the fact that haemoglobin C was typed incorrectly as haemoglcbin A in the earlier investigations.

Different haemoglobin investigations performed on Afrikaner cattle are compared in Table 2.

Table 2: COMPARISON OF SEVERAL STUDIES ON AFRIKANER CATTLE.

No. of samples	Gene frequencies			Author — Year
	Hb^A	Hb^C	Hb^B	
165	,852	,084	,064	Osterhoff & van Heerden 1965[12]
100	,840	,145	,015	Osterhoff & van Heerden 1965[12]
122	,828	,155	,057	Osterhoff & van Heerden 1965[12]
1041	,810	,120	,070	Bouquet et al, 1970[4]
100	,985		,015	Osterhoff & van Heerden 1965[11]
99	,909		,091	Singer & Lehmann, 1963[16]
200	,915		,085	Singer & Lehmann, 1963[16]

The first four groups of animals are regarded as correctly typed, and are included in Table 1, while in the other three groups the frequencies of HbA and HbC were given combined as HbA for the reasons mentioned.

These observations were followed up by a comparison on Malagasy Zebu. In 1968 a study was completed by Petit using the cellulose acetate technique and samples of the same herd were investigated 4 years later with the starch gel technique.

These examples provided evidence for the statement that earlier and present studies can best be compared on the basis of the HbB — frequencies. Table 4 presents the haemoglobin gene frequencies obtained in all studies of African cattle breeds from North to South.

The survey of African cattle is by no means complete, because of all breeds or types of cattle shown in Table 4 very little additional genetic information is available at this stage, except for the South African cattle breeds[10]. In spite of this fact one is inclined after plotting these results on a map of Africa to hypothesise in the following way: Haemoglobin B has been established correctly in the investigations of 39 breeds or types of cattle. Therefore it is believed that

Table 3: COMPARISON OF TWO STUDIES ON MALAGASY ZEBU

No. fo samples	Gene frequencies			Author
	Hb^A	Hb^B	Hb^C	
226	,378	,622		Petit, 1968[13]
199	,354	,623	,023	Present study

this haemoglobin type can be used as a reliable marker in breed comparisons. Haemoglobin B indicates an Asiatic rather than an African ancestry for most of the cattle breeds, considering the high fre-

COOPERS® SCIENCE IN FARMING MEANS MORE PROFIT FOR YOU WITH 'GOLDEN FLEECE'®

Reg. No. G 65 Act 36/1947

'CONSTANT REPLENISHMENT'

TO ACHIEVE

UNIFORM DEPOSIT**

NEW D.F.F.* Sheep & Goat Dip

A FANTASTIC ONE-SHOT BROAD SPECTRUM DIP WHICH KILLS ● ITCH MITE. ● ALL TICKS. (INCLUDING KAROO PARALYSIS TICKS), ● LICE, ● KEDS, ● AND PROTECTS AGAINST BLOWFLY STRIKE.

ANOTHER **FIRST** FROM COOPERS RESEARCH!

WHAT IS 'CONSTANT REPLENISHMENT'?

'CONSTANT REPLENISHMENT' means exactly what it says. By means of a special replenishment tank placed next to the dipping tank, a constant and controlled amount of dip is added to the wash as each animal is dipped.

- allowing dipping to be undertaken at a lower 'comfortable' dipwash level, reducing the cost of the initial filling.
- ENSURING THAT EACH ANIMAL RECEIVES A UNIFORM AMOUNT OF EVENLY DISTRIBUTED ACTIVE INGREDIENT ON THE FLEECE.
- giving a consistently high biological efficacy without the danger of over or under dipping which occurs with other dipping procedures.
- facilitating non-stop dipping. No time wasted on routine replenishment.
- making it possible to adjust the dipwash concentration to suit the biological control required.
- enabling you, the farmer, to achieve better dipping with maximum efficiency at reduced cost with less effort.

and most important of all

IT MEANS THAT NOW FOR THE FIRST TIME THE HIGHLY SUCCESSFUL COOPERS INVENTION OF D.F.F. CAN BE USED FOR SHEEP AND GOAT DIPPING

SPECIAL REPLENISHMENT UNIT

To enable farmers to start using the 'CONSTANT REPLENISHMENT' method to achieve UNIFORM DEPOSIT** straight away, Coopers offer this easy-to-use unit at a very low cost.

FOR FULL DETAILS ASK YOUR LOCAL DEALER OR WRITE DIRECT TO:

COOPERS (SOUTH AFRICA) (PTY) LTD

68 RIGGER RD. SPARTAN TVL. P.O. BOX 677 KEMPTON PARK TEL: 975-1146

A Wellcome Company

® Registered Trade Mark

*Product patented. S.A. Patent No. 68/5864

Specially formulated for use in ** method of pending S.A. Patent No. 74/3864

International J11835

Table 4: HAEMOGLOBIN GENE FREQUENCIES IN AFRICAN CATTLE BREEDS.

No.	Breed	Country	Gene frequencies Hb^A	Hb^B	Hb^C	Hb^D	Author
1	Algerian	Algeria	,856	,144			Cabannes & Serain, 1955
2	Zebu Gobra	Senegal	,700	,300			Petit, 1968
3	Zebu Azeuoak	Nigeria	,677	,323			Schmid, 1965
4	N'Dama	Ivory Coast	,975	,025			Petit, 1968
5	White Fulani	Nigeria	,726	,274			Bangham & Blumberg,1958 Lehmann & Ross, 1959
6	Red Bororo	Nigeria	,540	,440	,020		Braend, 1972
7	Zebu Arabe	Chad	,578	,422			Queval et al, 1971
8	Sudan-Zebu	Sudan	,529	,471			Bangham & Blumberg, 1958
9	Mutura	Nigeria	,800			,200	Braend et al, 1965
10	N'Dama	Nigeria	1,000				Braend et al, 1965
11	Gudali	Nigeria	,600	,300	,100		Braend, 1972
12	Zebu Bororo	C.A. Rep.	,617	,383			Petit, 1968
13	Zebu Soudan	C.A. Rep.	,642	,358			Petit, 1968
14	N'Dama	Gabon	1,000				Petit, 1968
15	Ankole	Uganda	,764	,236			Lehman & Rollinson, 1958 Osterhoff & van Heerden, 1965 a
16	Shorth Zebu	Uganda	,678	,322			Lehmann & Rollinson, 1958
17	Barotse	Zambia	,738	,167	,095		Carr, 1964
18	Tonga	Zambia	,417	,417	,166		Carr, 1964
19	Angoni	Malawi	,436	,387	,177		Carr, 1964
20	C. Cunene	Angola	,801	,119	,080		Present study
21	Malanje	Angola	,682	,235	,083		Present study
22	Quilenques	Angola	,738	,183	,078		Present study
23	Malawi-Zebu (N)	Malawi	,623	,255	,096	,026	Present study
24	Malawi-Zebu (C)	Malawi	,700	,140	,160		Present study
25	Mashona	Rhodesia	,866	,117	,017		Present study
26	Tuli	Rhodesia	,580	,399	,021		Present study
27	Nkone	Rhodesia	,929	,049	,022		Present study
28	Caprivi-Sanga	S.W.A.	,876	,114	,010		Present study
29	Ovambo	S.W.A.	,748	,150	,102		Present study
30	Sango	S.W.A.	,732	,141	,127		Present study
31	"Landim"	Mozambique	,756	,130	,114		Present study
32	Rénitélo	Madagascar	,696	,304			Petit, 1968
33	Malag. Zebu	Madagascar	,354	,623	,023		Petit, 1968; Present study
34	Lesotho-Nguni	Lesotho	,910	,060	,030		Present study
35	Afrikaner	S.A.	,819	,064	,177		Present study
36	Brahman	S.A.	,577	,400	,023		Present study
37	Drakensberger	S.A.	,833	,037	,130		Osterhoff & van Heerden 1965 a
38	Nguni	S.A.	,883	,064	,053		Present study
39	Bonsmara	S.A.	,962	,013	,025		Present study

quency of the allele HbB in Indian breeds[9] and also the gene frequencies of the Brahman in South Africa and the Malagasy Zebu and the Rénitélo in Madagascar, both having an apparent close relationship to Indian cattle. With a few exceptions, one may state that the further the *Bos indicus* types migrated away from India to the West and South the lower is the frequency of the allele HbB. There are large "white" areas of the frequency-map of Africa and a study of cattle types of Egypt and cattle in the Horn of Africa would certainly provide more evidence for this hypothesis.

Haemoglobin C must still be studied biochemically, but it certainly is not an abnormal haemoglobin. It could be regarded as a typical "African" haemoglobin, because of its relatively high frequency in the breeds and types of Africa. The significance of haemoglobin D is not known. It is found only in the Muturu breed and in a few animals in Malawi. This haemoglobin variant is also of value in studying polymorphism as well as origin relationships and evolution of cattle breeds.

It is a challenge to the workers in the field of genetic markers and also to international organisations to

complete the survey of the possible genetical markers of the existing breeds and types of cattle in Africa. This survey may result in new theories of cattle relationship and migration and could also assist the colleagues from other faculties in their studies of human relationships.

ACKNOWLEDGEMENTS

The help of the persons and departments involved in the collection of blood samples of different breeds and types of cattle is acknowledged with thanks. Grateful thanks are also due to members of the staff of the Dept. of Zootechnology for their kind assistance in various phases of the investigation.

REFERENCES

1. BANGHAM A.D. & BLUMBERG D.S. 1958 Distribution of electrophoretically different haemoglobins among some cattle breeds of Europe and Africa. *Nature* (Lond.) 181:1551
2. BRAEND M. 1972 Studies on the relationships between cattle breeds in Africa, Asia and Europe; Evidence obtained by studies of blood groups and protein polymorphisms. *World. Rev. Anim. Prod.* 8: 9
3. BRAEND M. EFREMOV G. & RAASTAD A. 1965 Genetics of bovine haemoglobin D. *Hereditas* 54: 255
4. BOUQUET Y., OSTERHOFF D.R. & VAN DE WEGHE A. 1970 The origin of Afrikaner cattle — The relationship of the Afrikaner with the Portugese Alentejo breed. *Proc. S. Afr. Soc. Anim. Prod.* 9: 203.
5. CABANNES R. & SERAIN C. 1955 Hétérogenéité de l'hémoglobine des Bovidés; identification électrophorétique de deux hémoglobines bovines. C.r. Seanc. Soc. Biol. Paris 149:7
6. CARR W.R. 1964 The haemoglobins of indigenous breeds of cattle in Central Africa. *Rhod. J. agric. Res.* 2:93.
7. LEHMANN H. & ROLLINSON D. 1958 The haemoglobins of 211 cattle in Uganda. *Man* 58:62
8. LEHMANN H. & ROSS J.G. 1959 Haemoglobin phenotypes in Nigerian cattle. *Man* 59:66
9. NAIK S.N., SUKUMARAN P.K. & SANGHAVI L.D. 1965 A note on blood groups and haemoglobin variants in Zebu cattle. *Anim. Prod.* 7: 275
10. OSTERHOFF D.R. 1968 Immunogenetical studies in South African cattle breeds. *Thesis D.Sc. (Agric)* University of Pretoria
11. OSTERHOFF D.R. & VAN HEERDEN J.A.H. 1965 Haemoglobin polymorphism in cattle. *Proc. S. Afr. Soc. Anim. Prod.* 4:274
12. OSTERHOFF D.R. & VAN HEERDEN J.A.H. 1965 Haemoglobin variation in Zebu-type cattle. *Immunogenetics Letter* 4: 89
13. PETIT J.P. 1968 Détermination de la nature des hémoglobines chez 982 bovins africains et malgaches (taurins et zébus) par électrophorése sur acétate de cellulose. *Rev. Elev. Méd. Vét. Pays trop.* 21: 405
14. QUEVAL R., PETIT J.P. & HASCOET M.C. 1971 Analyse des hémoglobines du sébu arabe (Bos indicus). *Rev. Elev. Méd. Vét. Pays trop.*, 24: 47
15. SCHMID, D.O. 1965 cited by BUSCHMANN H & SCHMID D.O. 1968 *Serumgruppen bei Tieren.* Berlin & Hamburg: Verlag Paul Parey
16. SINGER R. & LEHMANN H. 1963 The haemoglobins of Africander Cattle. *In Man and Cattle.* Eds Mourant A.E. & Zenner F.E. Royal Anthropological Inst., London

BOEKRESENSIE

BOOK REVIEW

FARM ANIMAL BEHAVIOUR

A.F. FRASER

Bailliére Tindall, London, First published 1974. Pp. 196, Figs 55. Price: £2.20.

Hierdie werk deur Andrew F. Fraser, senior lektor in die Departement van Veterinêre Obstetrie aan die Universiteit van Edenburgh, is 'n boek oor etologie (dieregedrag) soos van toepassing op perde, beeste, skape en varke. Die boek is geskrywe om as inleiding te dien vir die vak etologie by die plaasdiere.

Die boek is veral geskik as handboek vir studente in veeartsenykunde en die dierewetenskappe. Die boek behoort ook baie handig te wees vir diegene wat belangstel in plaasdier-etologie.

In die boek word etologie wetenskaplik uiteengesit en beskryf. Die beskrywings is ook pragtig geïllustreer met sketse om dieregedragspatrone sodoende makliker verstaanbaar te maak.

Die boek is beslis 'n konstruktiewe en baie belangrike bydrae tot die vak etologie as 'n toegepaste wetenskap in veeartsenykunde en as 'n vertakking van biologie. Die etologiese navorsing mag tot groot voordeel strek van die plaasdierindustrie en die metodes van produksie.

Die veearts en diereteler kan alleen baat deur kennis te dra van die vakrigting. Die boek kan beslis aanbeveel word, omdat dit maklik leesbaar is en 'n uitstekende inleiding tot die vak etologie gee.

H.P.v.N.