are distributed as I imagine them to be, the farmers owning them do not take much interest in them - their dairy herds take most of their attention. It is the man who owns a large number of one type of pig who is likely to do something about improving them. Would that explain the decline?

MR. SMITH: I think the keeping of pigs is fairly general. Many dairy-farmers of necessity must keep some for dealing with their skimmed-milk. As for the number kept, this is generally related to the size of the dairy herd.

THE PRESIDENT: Could you give us any idea as to the number of special lay-outs there are for pigs throughout the various areas today? Have you the figures for all the Pig Clubs? I know that in the Waikato and Manawatu Districts the arrangements for pigs have improved out of sight as a result of the work of Pig Clubs during the last ten or fifteen years.

MR. SMITH: There are no figures in regard to housing, etc., at all at the moment. Some areas have definitely improved - considerably and rapidly - over the last few years, but there are no figures available to indicate what percentage of farms have erected decent accommodation.

DR. McMAHON: What is the reason for the very marked drop in productivity in 1944 - in regard to "Litter Weight at 3 weeks" in particular?

MR. SMITH: I am afraid, from the records available, that I cannot explain that in any way whatever. I felt myself to be exceedingly lucky in being able to obtain even those figures.

DR. McMAHON: Cannot anyone make an educated guess?

MR. SMITH: When one is dealing with only two or three sows, I do not think an educated guess would help much.

DR. McMEEKAN: The numbers on which they are based for the last three years are insufficient to give those figures any meaning at all.

INHERITABLE CELLULAR ANTIGENS IN CATTLE BLOOD

by

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The observations by Landsteiner, over forty years ago, on individual differences in the blood of humans, prompted the subsequent investigations which have revealed that individuality in man and animals can be demonstrated serologically by the existence of numerous genetically determined antigens in the red blood cells.

The methods adopted to demonstrate individual differences in the blood of animals have been basically similar to those used for human blood. Thus, for the identification of individual differences in the blood of animals of the same species normal or immune antibodies (agglutinins and haemolysins) and normal or immune hetero-antibodies have been successfully utilised. A number of investigators have observed strong iso-agglutination reactions with normal iso-agglutinins in cattle blood but it was found difficult to make a definite classification into groups on that basis.

The investigations of Todd and White in 1910 using iso-immune sera gave the first indication of the complex antigenic structure of the red cells of cattle.

Of recent years, the Wisconsin investigators, Ferguson, Irwin, Stormont, Cumley and Owen, in a series of intensive studies have reported the identification of thirty unit factors in cattle erythrocytes, which would make possible the classification of cattle into over a billion distinct blood types.

The iso-immune sera utilised in this work were usually procured by four transfusions of a litre of whole blood each at weekly intervals. Hetero-immune sera were also utilised and these were produced by tri-weekly intravenous injections of washed cattle erythrocytes into rabbits for periods of three weeks. The specific lysins in these immune sera were fractionated by absorption techniques to produce mono-specific re-agents to identify the individual unit characters in the red cells of cattle.

In heredity studies, Ferguson, Stormont and Irwin have proved from a large series of matings that each of the 30 cellular antigens are inherited as simple mendelian dominants. It was observed without exception that an antigen was not found in any calves from matings in which both parents lacked the antigen. From this observation it was apparent that none of the characters resulted from the complementary action of genes as had been observed in other species.

More recent work by the American investigators on the genetic relationships between the different antigens have indicated that many of them are produced either by genes in multiple allelic series or by series of very closely linked genes. It is suggested further that a single allele or complex may govern the production of two or more immunologically distinct antigens, thus discounting the possibility of independent inheritance of all the antigens.

Owen, Stormont and Irwin have reported their observations on the frequency of each of the thirty cellular antigens in a sample of 1,305 Guernsey cattle as compared with that of 875 Holstein Friesians. It was observed that no antigen served by itself to distinguish one breed from the other, since each of the thirty antigens occurred in both breeds. Seventeen of the antigens were significantly more frequent in Guernseys than in Holsteins, eight more frequent in Holsteins and five were not significantly different in frequency in the two breeds. These observations are based on the antigens reported up to that time and it is possible that a number of antigens more frequent in Holsteins than in Guernseys may yet be discovered.

To facilitate investigations in New Zealand on the cellular antigens in cattle blood paralleling those being conducted in America, Professor Irwin in November, 1943, graciously supplied small quantities of mono-specific re-agents which identified the thirty then known unit characters. Utilising these re-agents the antigenic pattern of the red cells of the cattle in the Wallaceville Jersey Herd was determined and transfusions were arranged which would possibly produce iso-lysins against the known antigens and other hitherto unidentified unit characters. The investigations in New Zealand have been directed towards the production of adequate quantities of the re-agents to identify the cellular immunologically distinct characters, to permit the conduction of intensive studies in the field at a later date.

In a consideration of the application of this work to particular problems, the unique nature of the utilisation of blood testing for the identification of identical twins is apparent. Evidence is available that indicates the existence of further antigens in addition to the thirty hitherto reported in cattle

red cells, which increases the phenotypic combinations possible to an infinite number. In large scale surveys in America utilising the majority of the factors, no two animals were ever observed to possess the same combination of antigenic characters apart from identical twins. In preliminary investigations in New Zealand in which re-agents to detect the thirty identified antigens were utilised, quite characteristic differences were observed in the antigenic pattern of the blood from each member of pairs of fraternal twins. The value of the test is further enhanced by the reliability of its application as early as in the first week of the life of a calf when other tests at present available are less exact in nature.

Another most valuable practical application of blood testing is in cases of disputed parentage in cattle. The presence of any of the known antigens in the blood of an individual implies the presence of these antigens in the blood of one or both parents. If a cow had been mated to two bulls at a particular heat period it would be impossible to exclude one of these bulls as the sire of the calf on the basis of any known test. The exclusion of a particular bull as the sire of a calf is rendered possible by a comparison of the antigens present in the blood of the calf with those of its dam and reputed sires. If a calf possesses a number of cellular antigens which are not present in the blood of its dam, these characters must have been inherited from its sire. The absence of these characters in the blood of the reputed sire would immediately exclude that bull as the true sire of the calf. On the basis of this test, it cannot be positively asserted that a particular bull is the sire - only that it could be the sire. Paternity cannot be proved by virtue of the blood tests, only non-paternity. It is apparent that the application of the test would prove of considerable value in the settlement of cases of disputed paternity which might arise in the registration of cattle.

In reporting the identification of the thirty antigens, the American investigators did not infer that there was now a "marker" on at least one member of each pair of chromosomes. Although the genetic relationships of each of these antigens have not been completely elucidated, sufficient is known to preclude a statement that these thirty characters are independently inherited. However, the suggestion has been ventured that should one or more "markers" be found on each of the chromosomes of cattle, it is not entirely improbable that correlations could be established between different combinations of these antigenic characters and physiological characters. It has not been possible as yet for the American investigators to test for any possible correlation between characters of the blood and production, as activities have been largely directed towards the identification of antigens and the determination of their genetic relationships. However, the implications of these investigations to the genetics of milk and butterfat production are considerable. Should a strong correlation be established between the presence of particular combinations of antigens and high producing qualities in cattle, the selection of stock of outstanding quality at an early age becomes a possibility. For instance, it might assist in indicating which sons of a proven sire were most likely to be of outstanding merit.

A great deal of work remains to be conducted on the isolation of immunologically distinct unit characters from the erythrocytes of cattle and the determination of their genetic relationships before it is possible to proceed to observations on possible correlations between combinations of antigens and physiological characters of economic importance in dairy cattle. The possible manifold application of blood tests in the field of dairy cattle genetics may well be the subject for considerable speculation but in addition to the interest the subject presents to the immunologist several practical applications of the test are already apparent.

DISCUSSION ON MR. BUDDLE'S PAPER:

DR. DRY: May we have the details about the identical twins, as to whether they concurred or not - whether there were any exceptions of agreement between members of the same sex; and also whether anything has been done with sheep. I would dearly like to be able to test the paternity of a ram. It is so easy for accidents to happen while hand-serving a ram and your attention is distracted for a moment.

COL. MATSON: As a layman, I was very much interested in this address. I was very closely concerned with the immunisation of cattle in a cattle plague in India about 1904. The virus-serum simultaneous method had been experimented with for many years, and about the year I mentioned it was decided to embark on full-scale operations, and herds of cattle of which I was in control were selected for the purpose. The point that has interested me since, is that the serum had been developed not from the cow, but from the water-buffalo, and the water-buffalo does not cross with the cow. Perhaps Mr. Buddle would be good enough to remark on that aspect. The curious thing about the buffalo in that regard is that, as far as we can determine in 30 years' study, the buffalo was immune from contagious abortion, and the cow was not.

DR. CAMPBELL: From this paper I would say that Mr. Buddle is working on a project that may give us an experiment of wonderful value. Could he give us any indication of the work involved in making one, or more, of these tests? Is it a process in which the bloods of different animals can be handled in large numbers?

MR. BUDDLE: In reply to Dr. Dry's question, Mr. Hancock who is responsible for the identification of the twin calves at Ruakura by the usual methods, could answer you more fully. Our investigations of the antigenic pattern of the red cells from suspected identical and fraternal twins confirmed Mr. Hancock's diagnosis in the majority of cases. Regarding the possible application of similar methods for testing for paternity in sheep, while little work has been conducted on cellular antigens in this species, it is quite possible that similar methods could be developed. I am not in a position to comment on Col. Matson's observations on the use of water-buffaloes for the production of hyper immune cattle-plague serum. In the experiments of Todd and White, cattle were hyper-immunised against cattle plague by the inoculation of large quantities of infected whole blood. These injections stimulated a complexity of specific isolysins which first suggested to these observers in 1910, the complex antigenic structure of the red cells of cattle. In reply to Dr. Campbell, one of the main objectives of our present work is the production of adequate quantities of mono-specific re-agents to permit large scale surveys in the field. Once sufficient re-agents are available in quantity it would be possible to test several thousand cattle a year. However, a great deal of work on the production of mon-specific re-agents to detect the numerous previously identified antigens still remains to be conducted before we can proceed to field investigations in New Zealand.

MR. HANCOCK: I would confirm Mr. Buddle's statement that in all those cases of identical twins which were tested, both members of the sets had the same make-up of blood cell factors. I would like to say a few words on the practical application of red cell factors in cattle blood in reference to selecting animals with a certain make-up of factors as high producers. If a certain pattern of factors has the indication of high production the animal will not be able to breed true for it if these are linked in the same chromosome; the crossing over which takes place in relation to the cells at the reduction stage will counteract the linkage.

DR. DRY: It is quite possible, as has been suggested, that the performance of an antigen as an antigen and its performance in affecting milk production may be a different expression of the same gene. That does seem to be the usual explanation of correlation when correlations are real. I think it is rather a long shot, and that the chances against that being true are very heavy; but the stakes are so high. We have spent a great deal of money in this country looking for oil, with little success, but it was considered worth while spending that money because if it had been successful it would have been enormously profitable. I think this question should be tackled in the same spirit. While I feel sure that progeny testing has great possibilities it is rather a clumsy method, and its place may be taken by such devices as those that have been suggested in relation to antigens. We might find a correlation between easily observable external characters and milk and butterfat production - rather a poor bet, I feel, but a risk very well worth taking. I would refer to some recent work at Passadena, following on work done about 20 years ago. It involved a textbook case of what looked like the inheritance of an acquired character. Anti-serum prepared from the lens of a rabbit's eye was injected into rabbits. The result was claimed to be defects in the eye of the rabbits so treated and similar defects in their descendants. That looked like inheritance of an acquired character. That work has been repeated by various workers with negative results, but more recently with positive results. In a report by Sturdee on the work of his colleague, Hardy, it was suggested that two different things had happened when the anti-serum was injected into the rabbit - an effect on the lens of the eye, damaging that lens, and also a change in gene so that the gene stood in the same relation to the serum as an antigen to an antibody, and then that antigen, or gene change in the descendants brought about the defect in the eye. That is not very constructive from a practical point of view, but it does point the way to inducing mutations of a particular kind determined in advance.

MR. McLEAN: If it were possible to associate with these genes controlling the antigenic nature of the blood, factors for high production, there would be a difficulty associated with the fact that they are inherited as simple dominants. In other words, it would lead again to the difficulty of breeding for dominant characters which we already have with certain of our other characteristics in stock. I wonder if Mr. Buddle would be able to find that these are actually inherited as wholly dominant, or whether the heterozygote would be the means of distinguishing between the pure breeding type and the other which transfers one half the character to its offspring. In other words, is the character absolutely and wholly dominant, or is it mainly so, and would it be possible, by an agglutination test, to find the degree of agglutination associated with degrees of dominance?

MR. BUDDLE: It is not possible by a quantitative haemolytic test to determine whether an animal is homozygous or heterozygous for a particular antigen. Although each of these characters studied in cattle appears to be a dominant, it is possible that some may have an allelomorph with independent expression comparable to the M & N antigens in humans. In the human, while all individuals possess either M or N or both, the phenotype MN denotes the heterozygote. No similar genetic relationship has been observed between any two of the thirty reported antigens in cattle.
