A SEGREGATION METHOD FOR ELIMINATING TUBERCULOSIS FROM CATTLE.

By C. R. W. ADEANE and J. F. GASKELL.

The elimination of tuberculosis is a problem which has become within the bounds of possibility with the increase of knowledge of the infecting organisms and the sources from which fresh infections arise.

Infection by the bovine type of tuberculosis has been proved by Griffiths and others to form a very serious proportion of the infections of childhood.

Present evidence supports the view that such infections are almost always due to the ingestion of infected milk, so that the elimination of this type of infection resolves itself into the supply of milk which is free from tubercle bacilli. Although the percentage of reacting cattle which give milk containing tubercle bacilli is usually small, one cow is sufficient to contaminate the whole milk supply; in addition it is impossible to be certain when a reacting cow may begin to give milk containing tubercle bacilli. Complete elimination of tuberculosis from the milking herd is therefore essential.

The tuberculin test properly applied is of the greatest value, but the elimination of all tuberculin reacting cows by slaughter is not within the bounds of practical politics; for not only would the cost of compensation be enormous but an impossible shortage of milk supply would immediately occur. Other methods of elimination are therefore to be sought for, and this paper gives a brief record of a method which has been successfully applied at Babraham in Cambridgeshire.

When the experiments were first started in 1909 a valuable herd of shorthorns had been built up. The first tests gave a very high percentage of positive reactions (see Table I) so that immediate slaughter would have caused great financial loss and serious diminution of the herd.

The first form of experiment was an attempt to render the calves of the herd immune by vaccination with living human tubercle bacilli. The results were, as many others have found, extremely disappointing. It was therefore determined to attempt some method of segregation on the lines suggested by Bang.

The early experiments which followed during the next three years were most unsatisfactory because rigid isolation of the reactors from the non-reactors was not carried out. Attempts were made to isolate in a single farm with intercommunication of drainage and of feeding arrangements, both groups being attended by the same staff. Rigid isolation was only begun in 1911.

The reactors and non-reactors were then placed in separate farms and treated by separate staffs, each farm having a complete outfit kept rigidly

apart from that of the other. The bulk of the non-reacting herd remained negative to tuberculin and the reacting herd became gradually eliminated in course of time. Both herds were used freely for breeding. The calves of reacting mothers were removed at birth to isolated roughly built sheds and there brought up on sterilized milk, with the result that they grew up tuberculin negative. It was found to be absolutely necessary to remove the calf at birth.

Table I.

Year	Total herd	Mortality	%	Total number animals tested	Total number passed	Total number reacted
1909	100	16	16·0	20	10	10
1910	98	20	20·4	63	39	24
1911	99	29	29·3	79	50	29
1912	102	19	18·6	69	42	27
1913	100	24	24·0	67	58	9
1914	98	18	18·1	66	64	2
1915	107	9	8·4	70	70	—
1916	92	6	6·5	87	87	—
1917	94	9	9·6	66	66	—
1918	104	4	3·8	73	73	—
1919	103	7	6·8	70	70	—
1920	105	9	8·6	78	78	—
1921	104	6	5·8	72	72	—
1922 to Oct.	98	2	2·0	66	65	1
Oct. 1922 to Oct. 1923	94	6	6·4	60	58	2
Oct. 1923 to Oct. 1924	79	4	5·0	36	36	—
Oct. 1924 to Oct. 1925	25	1	4·0	25	25	—

Note. The high mortality of the earlier years was in part due, either directly or indirectly, to the attempts then being made by vaccination etc. to render the herd negative to tuberculin.

Table I shows that by 1914 a herd completely negative to the tuberculin test had been obtained. The herd remained free up to the end of 1925 with the exception of two reactors in 1922.

Table I also shows a great diminution in general mortality when the herd had been freed, an average percentage of 21 falling to 6·5. As the method is one which can be applied by a very great many dairy farmers, if not all, at comparatively little cost, a detailed description will be given of the method employed.

The experiments are also of interest in that they confirm the view that a direct hereditary transmission of tuberculosis *in utero* does not take place; though the earlier experience proved that extra uterine infection could take place within a very few hours of birth.

Another matter of interest has shown itself during the prolonged routine use of the tuberculin test, namely that certain cattle temporarily became tuberculin positive, though later they were again negative to repeated tests.

It is well known that nearly half the dwellers in our big cities show signs of healed tuberculosis on post-mortem examination. Similar temporary infections may well occur in cattle with little or no obvious illness followed later by complete recovery.

Tuberculin Tests.

As the tuberculin reaction is the criterion which has been used throughout, a few precautions which it was necessary to take in applying it may be first mentioned.

The temperatures of cattle go up and down considerably, sometimes quite unaccountably, at others on the least provocation. When testing first began great carelessness was shown in the way the animals were treated before the injection. To separate an animal from the herd and drive it into a yard there to remain by itself is quite enough to send up the temperature. The temperature of a cow has been observed to rise to 105° F. through being washed.

In the early experiments the beast was just driven into a field and tested on the spot. In this way many cattle were condemned which under proper conditions would never have reacted. It is therefore advisable always to take the temperature of an animal the day before it is tested under the same conditions and at the same hours at which it will be taken for the test. Unless the temperature is normal the test should not be applied. The temperature has been considered normal when lying between 101° and 103°, and a rise of 2° F. or over has been taken as positive. The test has often been delayed several days owing to the temperature being erratic. The temperature of calves is even more unstable than that of cows, and the earlier tests proved so inconstant and unsatisfactory that the practice was finally abandoned, and calves are not now tested before they are one year old. An example of this is the case of two calves, 472 and 485, that reacted at the ages of six months and four months respectively. Both were killed and post-mortems made by Dr Cobbett and Dr Griffiths. In the four months reactor No. 485 no sign of tuberculosis could be found, in the six months reactor No. 472 one small tuberculous gland was present.

The ignorance about temperature and the careless manner in which the test was made in the early days largely explains the distrust of the method which grew up in the minds of agriculturalists. Later experience at Babraham has all tended to show that the test properly applied is both reliable and satisfactory. The preliminary trial the day before is of the utmost importance. A few results which are at first sight unsatisfactory, reactions being inconstant, will be briefly discussed at the end of this paper.

The Method of Segregation.

The method that was successfully adopted was as follows: two farms, *A* and *B*, were used, which were at 150 yards distance from each other. The non-reactors were placed in farm *A*, the reactors in farm *B*. Besides the dangers of infection which arise from possible contact of feeding materials another fruitful source of infection is manure, which, if it comes from tuberculous cattle, is full of the germ; the disease can thus be carried to a distance on the boots of the farm hands. A separate staff was therefore kept for each herd; if the head cowman went over to farm *B* to see the reactors, he changed his

boots before returning to farm *A*. The two herds were never allowed to pasture in the same field or in any two fields which were side by side. As has already been mentioned, the implements, feeding utensils, etc., used in the two farms were kept rigidly apart.

In April 1911 two calf sheds were erected on an arable field on which no cattle had ever been: this field was distant about 160 yards from the nearest shed in which any reacting cattle were housed and about 260 yards from any grass land on which reacting cattle were pastured. The sheds were built of the cheapest possible materials, they were thatched with straw, and the backs were composed of faggots and cuttings from the hedges through which the air could percolate freely. The other side of the shed was open. Each shed was divided into small partitions separated from each other by large tin sheets so that the calves in the separate pens could not come into contact. In front was a screen made of brushwood to give shelter from the wind. From the roof hung sheets of rough canvas which could be lowered in boisterous weather. Each calf had a separate feeding trough and separate pail, numbered to correspond with the number on the calf pens. Each of the calves had a distinguishing number tattooed on the ear and its number, age, date of birth, etc., was posted up on the pen. One shed was kept for calves of the non-reacting dams from farm *A* and the other for calves of reactors from farm *B*. The calves from farm *A* were allowed to suck for a few days before being placed in the calf pens. Calves from the reactors in farm *B* were removed in sacks directly they were born, not being allowed to suck, and put in their appropriate pen. They were reared on milk heated to 200° F. and afterwards allowed to cool to 92°. For the first period of the experiment calves remained in pens until about ten months old. Farm *B* calves were then tested before they were placed in the open yard with the farm *A* calves. After it had been proved that calves from reactors were all right, they were put together and not tested until later.

Calves were then kept in these sheds till they grew too large for the pens, when they were removed to an open yard. Here they remained till they were about six months old, they were then removed to another building also with open yards. As the bulk of the calves were born in the spring the second removal took place in the following autumn. In the following spring the calves were turned into the pasture and tested when one year old.

Every female in the herd was tested after calving; in this way every animal underwent the test once every year.

It will be seen from Table I that within three years of the system of rigid isolation, though the numbers of the herd had been fully maintained, the reacting herd, which had been reduced to one-tenth of its size, in the following year became completely eliminated. It should therefore be possible to clear a herd in three to four years.

The importance of the immediate removal of the newborn calf was incidentally proved in the earlier vaccination experiments. Although a

temporary negative reaction was obtained with certain vaccinated cows, quite a high percentage of their calves born after vaccination were tuberculin positive. These calves being from non-reacting mothers were not isolated at birth, but were allowed to suck for some days before removal to separate sheds. No less than four out of eleven gave a positive tuberculin reaction. They had therefore been infected by the dam, whose tuberculosis had been masked by the vaccination, during the few days they were allowed to suck. Thirteen calves removed immediately at birth from reacting dams were isolated at the same period as the eleven referred to above. Twelve of the thirteen gave negative tuberculin reactions. The thirteenth, which gave a positive reaction, was killed and examined post-mortem but was found by Dr Cobbett and Dr Griffiths to be free from tuberculosis. These two parallel experiments therefore show the efficiency of immediate removal at birth.

Rickets. Joint ill.

The hand rearing of calves with sterilised milk has similar dangers to those of the artificial feeding of infants, and heated milk needs to be supplemented by some form of special vitamine-containing food. This was strikingly illustrated in the first year or two of the experiments in complete isolation. It also showed that the tendency to the disease is much greater in bull calves than in heifers. The calves seem to do well till they are three to four months old, then they begin to get groggy on their legs and stand over at the knees. From this state they go from bad to worse and lose condition. Some of the heifers were slightly affected but never to the same extent as the bulls. The greater part of the bull calves had to be destroyed.

The occurrence of this serious condition was eliminated by feeding the animals with cod liver oil cake, which the calves ate with avidity. The delay in the appearance of the condition affords a striking parallel to that of the appearance of rickets in children. The two diseases thus appear to be essentially similar in nature, cause and time of occurrence.

Inconstant Tuberculin Reactions.

In the early years inconstant reactions were obtained in a number of animals tested. The report of the Royal Commission on Tuberculosis has proved that the tuberculin test remains constant in infected animals and that no masking of a second reaction by a previous positive one takes place; the second reaction is also positive, however soon after the first it is taken. Changes of reaction cannot therefore be due to any masking effect. Inconstant reactions can be considered in four groups:

A. Negative reactions which become positive.
B. Positive reactions which become negative.
C. Negative reactors which gave on one occasion a positive reaction.
D. Alternate negative and positive reactions.

One animal gave first a positive, then a negative, then a positive reaction, and will be included in the alternating group D.

Group A consisted of 17 animals in all. Seven became positive in 1911, six in 1912, three in 1913, one in 1914. The latter had been brought into the herd from elsewhere in 1912. The rest were clearly infected from other members of the herd mostly in 1910 and 1911 before proper isolation took place and need no further explanation.

Group B are given in Table II.

Table II.

Name	Date of test	Initial temp. at time of injection	12th hour after injection	15th hour after injection	18th hour after injection	Remarks
"Dodo"	1910 Nov. 1	102·6	105·0	105·2	104·0	Reacted
	1911 Apr. 17	102·4	102·6	102·4	103·4	Passed
	Oct. 17	102·0	102·0	102·0	102·2	,,
	1912 Mar. 25	101·6	101·8	101·6	103·2	,,
"Babraham Mist"	1912 Jan. 29	102·0	103·4	105·0	105·4	Reacted
	Feb. 21	102·2	102·0	102·0	103·4	Passed
	Apr. 12	101·6	102·4	102·2	103·0	,,
	1913 Mar. 13	102·0	101·8	102·2	102·8	,,
"Babraham Ethelred"	1912 Jan. 29	101·4	101·8	103·6	103·8	Reacted
	Feb. 21	102·4	102·2	102·6	102·8	Passed
	Apr. 12	101·8	102·2	102·4	103·0	,,
"Babraham Lady Falka"	1920 Jan. 16	102·1	102·4	103·1	106·1	Reacted
	Mar. 10	102·0	102·1	102·4	103·4	Passed
	Apr. 28	101·3	101·3	102·0	102·0	,,
	1921 May 14	102·0	101·0	101·0	101·2	,,
	1922 Sept. 1	101·4	101·0	101·0	101·2	,,
	1923 Aug. 15	102·1	101·1	101·2	101·2	,,
"Babraham Princess Pippin"	1910 Nov. 1	101·6	103·8	104·2	103·6	Reacted
	1911 Sept. 13	100·6	101·6	103·0	103·8	,,
	1912 Aug. 24	102·0	102·2	102·4	102·8	Passed. Passed 7 more tests
"Babraham Claribel"	1911 July 10	102·0	103·6	104·8	105·4	Reacted
	Oct. 18	102·0	104·8	104·6	104·4	,,
	1913 Mar. 29	102·2	101·8	102·2	102·4	Passed. Not tested again
"Babraham Chieftain"	1912 Jan. 29	102·4	102·2	102·8	104·8	Reacted
	Feb. 21	102·8	102·8	103·4	104·6	Reacted?
	Apr. 12	102·0	102·0	102·2	103·4	Passed
"Babraham Lady Chance II"	1923 Jan. 9	101·4	103·3	103·3	104·3	Reacted
	Apr. 4	101·3	104·2	106·0	105·2	,,
	July 12	102·4	102·0	102·0	102·3	Passed

All, with the exception of "Babraham Lady Falka" and "Babraham Lady Chance II," showed the change of reaction in the early years; four became negative after two positive reactions and the remainder after one positive reaction only. It is arguable in the case of the four latter that the single positive reaction was due to lack of the precautions which have already been discussed, but the other four can hardly be explained in this way. They thus afford evidence that a cure of tuberculous infection can take place in cattle. As has already been pointed out, such a cure is common in human tuberculosis.

The details of group C are given in Table III. Out of the 17 animals in

Table III.

Name	Date of test	Initial temp. at time of injection	12th hour after injection	15th hour after injection	18th hour after injection	Remarks
"Babraham Fortune"	1913 Aug. 8	102·0	101·6	101·8	101·8	Passed
	1914 June 3	102·4	104·0	105·0	106·0	Reacted
	Aug. 5	101·8	101·8	102·0	102·4	Passed
"Babraham Evelyn Bates"	1913 Aug.	102·4	102·4	102·0	102·2	Passed
	1914 June	101·6	102·6	101·8	104·8	Reacted
	Aug.	101·8	102·0	101·0	101·4	Passed. Passed in 1915 and 1916
"Babraham Radiance"	1915 July	102·0	101·8	101·6	101·8	Passed
	1916 Sept.	101·4	102·0	102·3	104·0	Reacted
	Nov.	101·8	101·8	100·8	101·6	Passed
"Babraham Empress"	1916 Aug. 4	102·1	101·0	101·3	101·2	Passed
	1917 June	102·0	104·3	104·4	103·3	Reacted
	July	101·1	101·0	101·0	102·0	Passed
"Shard Isabella Burton VI"	—	—	—	—	—	Passed 8 tests, 1913–1920
	1921 Apr. 21	102·2	101·4	101·3	101·4	Passed
	1922 Apr. 19	102·2	101·1	101·4	105·4	Reacted
	June 6	101·3	101·3	101·3	101·2	Passed
"Babraham Bella Burton"	—	—	—	—	—	Passed 1917 and 1919
	1921 Jan. 15	101·2	101·1	101·2	101·1	Passed
	1922 Mar. 2	102·1	103·0	104·3	106·0	Reacted
	Apr. 15	101·3	101·0	101·0	101·1	Passed
"Sunrise"	—	—	—	—	—	Passed 7 tests, 1913–1918
	1919 Nov. 10	101·3	101·1	101·2	103·0	Passed
	1920 Nov. 26	101·3	103·0	105·0	103·3	Reacted
	1921 Jan. 21	101·4	101·0	101·2	101·2	Passed
	1922 May 19	102·0	102·0	103·3	102·4	„
"Babraham Columbine"	—	—	—	—	—	Passed 6 tests, 1913–1918
	1919 Sept. 22	102·0	101·3	101·3	101·1	Passed
	1920 Sept. 13	102·1	102·0	104·3	104·3	Reacted
	Nov. 9	101·2	100·2	100·3	101·2	Passed
"Babraham Chance"	—	—	—	—	—	Passed 5 tests, 1913–1917
	1918 Feb. 1	101·4	101·3	102·0	101·3	Passed
	1919 Jan. 25	101·4	103·0	102·3	102·3	„
	1920 Mar. 10	102·0	106·0	105·0	104·3	Reacted
	Apr. 28	101·3	101·4	102·0	103·0	Passed
	1921 Feb. 27	101·3	101·0	101·2	101·2	Passed. Also passed 1922
"Babraham Coronet"	1914 June 26	101·8	101·8	101·6	101·8	Passed
	1916 Sept. 1	101·4	103·4	105·0	102·0	Reacted
	1917 Jan. 11	101·4	101·4	102·1	102·4	Passed
	Apr. 4	101·4	101·2	101·2	101·4	„
"Babraham Christobelle"	—	—	—	—	—	Passed 8 tests, 1909–1917
	1918 May 21	102·2	102·0	102·2	102·0	Passed
	1919 May 2	101·4	101·4	104·1	104·3	Reacted
	June 6	101·0	101·3	102·3	101·3	Passed
"Babraham Louise X"	1910 July 12	101·8	103·0	103·0	101·2	Passed
	1911 Aug. 3	102·0	104·6	105·8	105·8	Reacted
	1912 July 19	102·2	102·6	102·0	102·4	Passed
	1913 June 2	101·8	101·8	102·2	102·0	„
"Babraham Beatrice"	1911 May 25	102·0	102·0	102·0	102·2	Passed
	1912 June 18	101·6	102·6	104·4	104·8	Reacted
	1913 Apr. 10	102·0	102·6	102·0	101·8	Passed. Passed 8 more times

https://doi.org/10.1017/S0022172400031983 Published online by Cambridge University Press

Table III (*continued*).

Name	Date of test	Initial temp. at time of injection	12th hour after injection	15th hour after injection	18th hour after injection	Remarks
"Freemason's Fortune"	1910 Nov. 15	101·6	101·4	101·8	102·4	Passed
	1911 July 10	102·0	102·2	102·4	102·6	,,
	1912 July 6	102·4	102·2	103·6	104·0	Reacted?
	1915 May 26	102·4	102·6	102·2	102·0	Passed
"Babraham Beryl"	1911 Oct. 31	102·2	101·2	102·4	103·2	Passed
	1912 Mar. 27	101·0	102·6	104·6	105·4	Reacted
	Oct. 13	102·0	101·0	101·8	101·6	Passed
"Babraham Mischief"	1914 June	102·0	101·6	101·8	101·8	Passed
	1915 May	101·8	103·2	103·8	102·4	Reacted?
	1916 Mar.	102·0	101·6	101·8	102·4	Passed. Passed 4 tests, 1917–1920
"Babraham Lady Myrtle II"	1921 Apr. 13	102·1	101·2	101·1	101·1	Passed
	1922 Sept. 6	101·4	102·2	103·4	105·1	Reacted
	Nov. 11	102·1	104·1	104·0	103·1	,,
	1923 Apr. 8	101·3	103·0	103·0	104·3	,,
	July 12	101·4	102·0	101·4	102·0	Passed

this group, 11 were tested again within one to two months of their positive test and were negative both then and to subsequent tests. It is allowable to explain these positive reactions as due to insufficient precautions being taken in testing or to some coincident temporary malady. They are therefore taken as having passed in Table I.

Of the remaining six three were tested in the early days when proper precautions were not taken; one "Babraham Mischief" gave a very doubtful positive reaction, the temperature only just rising 2° and the animal being negative in five subsequent tests. This has also been taken as a negative reaction in Table I. The final case, "Babraham Lady Myrtle II" will be discussed later.

This group therefore emphasises the importance of proper precautions in taking the test, and except in the one case to be discussed does not afford definite evidence of any temporary brief infection.

The final group D consists of four animals only, all tested in the early years; these are shown in Table IV.

The first case, "Babraham Countess Clara," shows an extremely doubtful negative between the two positives; the second case, "Babraham Charlotte," shows only doubtful positive reactions; this also applies to the first positive reaction in the third case "Babraham Evangeline." The fourth case is more difficult of explanation, a negative reaction occurring between two positives: for practical purposes such an animal should be treated as positive. The first three cases of this group therefore tend to merge into the previous group.

It will be seen in Table I that two positive reactions occurred in the year 1922. The details of the two animals affected, namely "Babraham Lady Chance II" and "Babraham Lady Myrtle II," are given in Table II and Table III. Two other animals were bought at a sale in October 1921, one of which proved positive when tested after the sale, the other negative; the

Table IV.

Name	Date of test	Initial temp. at time of injection	12th hour after injection	15th hour after injection	18th hour after injection	Remarks
"Babraham Countess Clara"	1909 Apr. 2	102·4	101·6	101·8	101·8	Passed
	1910 Aug. 23	101·2	104·2	104·8	105·0	Reacted
	Oct. 18	102·4	103·0	103·2	103·0	Passed
	1911 July 10	101·8	102·4	103·2	104·0	Reacted
	1912 July 26	101·6	102·6	102·8	102·8	Passed. Passed in each year 1913–1919
"Babraham Charlotte"	1911 Apr. 12	101·8	102·2	101·6	102·2	Passed
	Oct. 13	102·0	103·0	104·0	103·2	Reacted?
	1912 July 9	102·0	101·4	101·6	101·8	Passed
	1913 July 14	102·0	103·0	103·0	103·8	Reacted?
"Babraham Evangeline"	1910 Nov. 15	102·6	102·8	103·8	102·8	Passed
	1911 Apr. 17	101·6	103·2	103·6	103·6	Reacted?
	1912 Aug. 11	102·2	103·0	103·2	103·6	Passed
	1913 Apr. 6	102·6	105·2	104·8	103·8	Reacted
"Babraham Royal Maiden"	1910 Nov. 1	101·8	105·0	105·4	104·4	Reacted
	1911 Apr. 17	101·6	101·0	101·6	101·8	Passed
	Oct. 13	102·0	104·8	103·6	103·8	Reacted

second animal, however, became positive in the following year. It is probable that the two Babraham animals, one of which was twice positive, the other three times, obtained a mild infection from the introduced cattle, and that they subsequently recovered from it. Confirmatory evidence of a possibility of such an occurrence is given by the reaction of "Babraham Countess Clara" and "Babraham Evangeline" in Table IV. The cases just discussed emphasise the necessity of strict precautions in the introduction into the herd of cattle from elsewhere.

Summary.

1. The tuberculin reaction properly applied is a reliable test of the presence of tuberculosis in cattle.

2. A method of segregation is described by which any herd can be rendered tuberculin negative in three to four years without diminution of the herd.

3. Evidence is given that recovery from a tuberculous infection can take place in cattle.

4. Calves can only be infected with tuberculosis after birth, such an infection may, however, take place extremely rapidly within the first few days of life.

5. Artificial feeding of calves with sterilised milk must be supplemented by some vitamine-containing food, otherwise "joint ill," corresponding to rickets in human beings, will develop at about the third or fourth month. Bull calves are more susceptible to "joint ill" than heifers.

(*MS. received for publication* 26. XI. 1927.—Ed.)