BRITISH INDUSTRIAL ANTHRAX.

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Part I.

(1 Figure.)

CONTENTS.

Since anthrax is a disease exceedingly fatal to man and beast, and an important factor in several industries, further and more complete records of the circumstances of the outbreaks, and a better knowledge concerning the history and antecedents of the material conveying the infection, and of the natural condition and resistance of anthrax spores, should greatly facilitate preventive measures.

Anthrax is not only formidable from its severity, and the frequency of a fatal issue, but also because of the insidious nature of the attack.

The bacillus of anthrax is comparatively easily destructible, but it has the power of producing highly resistant spores, which gives the clue to the power of raw animal products to transmit the infection; and since the environment of grease, dirt and animal discharges increases the natural resistance of the spores, efficient disinfection is the more difficult.

Notification of cases of anthrax occurring in workshops and factories in Great Britain became compulsory in 1895[1], from that date to 1907, a period of 13 years, 514 cases were notified.

Human anthrax as it occurs in this country may be divided into non-Industrial, and Industrial or notifiable.

The "*non-Industrial cases*" include (*a*) those which occur amongst the numerous class of persons who come into contact with animals infected with anthrax during life, as shepherds, farmers, veterinary surgeons, etc., or have taken part in their slaughter, and subsequent disposal, as knackers, butchers, etc.; (*b*) rarer cases of transmission of anthrax from person to person by accidental contact, or of infection either during post-mortem examinations of a patient or animal that has died of anthrax, or during bacteriological research, or of infection by flies that have fed on infected carcases; (*c*) lastly, a number of people who become infected through contact or association with persons working under one or other of the industrial conditions to be mentioned. Several of these cases have been from time to time notified under the mistaken impression that they were industrial.

"*Industrial Anthrax*" includes cases arising from the manipulation (1) of wool (sheep or lambs' wool, goats' wool or hair [mohair], camels' wool or hair, alpaca and other allied textile fibres); (2) animal hair and bristles (pigs' bristles, horsehair, and less commonly the hair of other animals); (3) hides and skins; and lastly (4) cases arising in various other industries as harness, furniture, cutlery, boot, manure, rag-sorting and horn trades, grain porterage, etc.

This paper is confined to the problem of anthrax arising during the manipulation of horsehair and bristles.

Historical.

In the latter half of the 18th century anthrax in the human subject came to be associated with the industrial manipulation of hides and fleeces.

In 1769 Fournier of Dijon drew attention to the occurrence of the disease in men who were handling raw hair and wool. Lawrence in 1847 described anthrax as it occurred in a hair factory in England, and in 1878 Dr J. B. Russell drew attention to the danger of anthrax in hair manufacture. He described nine cases occurring in connection with a horsehair factory in Glasgow. Seven of the cases were fatal,

[1] Factory and Workshops Act 1895, Sect. 29.

and seven of the internal type. Infection arose from Russian mane hair, and in his report he cites numerous accounts dating from 1777 published in France, of workmen having been attacked with anthrax and boils in opening and sorting bales imported from Russia.

Since 1878 no case of anthrax was known to have occurred in Glasgow until 1899, when three were reported, and in 1900, two were reported. The particular factory in which the early cases had occurred escaped, having, since 1878, discarded Siberian hair altogether.

In 1879 Dr J. H. Bell of Bradford definitely established the association of wool sorters' disease with anthrax by injecting blood from a case of the former into a rabbit, a guinea-pig, and a mouse. All the animals died within 60 hours, and the blood of each showed the presence of anthrax bacilli.

Frisch in Germany in 1887 proved that a case of rag sorters' disease was due to the anthrax bacillus. The *Annual Reports of the Medical Officers of Health of London* show that between 1873 and 1896 148 cases of anthrax were recognised in the metropolis and its neighbourhood. Of these 18 occurred in the manipulation of horsehair and bristles.

Statistics.

Anthrax due to industrial conditions became notifiable in 1895. From 1896 to 1898 (three years) 64 cases were notified, and of these three only, all occurring in 1898, were due to horsehair. That these three cases were all that occurred is improbable, the statistics being very likely incomplete owing to ignorance of the necessity of notification. Since 1898 the number of cases due to horsehair has varied from seven in 1903 and in 1905 to 19 in 1899 and the year 1898 may therefore fairly be taken as a starting point for compiling statistics.

The total number of cases of anthrax due to horsehair and bristles from 1899–1907 (nine years) was 106, making an average of nearly 12 cases in each year. Of the 106 cases 25 proved fatal giving a mortality of 23·5 %. The highest percentage of mortality, 40 %, was in 1906 when there were 10 cases and four deaths, and the lowest, 11 %, in 1901 when there were nine cases and one death.

In Dr Legge's *Report to the Chief Inspector of Factories* for 1904 the following statistics for the six years 1899–1904 are given:

Anthrax due to the manipulation of:

(1) Worsted and wool, 88 cases, 23 fatal, 26·1 % mortality.

(2) Horsehair and bristles, 70 cases, 17 fatal, 24·3 mortality.
(3) Hides and skins, 86 cases, 21 fatal, 24·4 mortality.
Anthrax arising in other industrial conditions:
17 cases, 6 fatal, 35·3 mortality.

Completing these figures for the period 1905–1907 (three years) we find:

(1) Worsted and wool, 87 cases, 24 fatal, 27·5 % mortality.
(2) Horsehair and bristles, 34 cases, 9 fatal, 26·5 mortality.
(3) Hides and skins, 45 cases, 13 fatal, 28·8 mortality.
And in other industries, 20 cases, 7 fatal, 35·0 mortality.

These figures disclose several interesting points (1) the increase in the number of cases in the worsted and woollen industries in recent years, notwithstanding the introduction of special rules and regulations for the manipulations of raw animal products likely to be contaminated with anthrax spores. This increase of cases is probably due to the increased quantities of dangerous wools handled as there was a demand for a particular class of yarn which could only be supplied (without dyeing) by using certain Central Asian wools, and with the demand broke out the attacks of human anthrax in the trades which used them. Scotch houses used none of this wool and were free from the disease. There may also have been an increase of the disease among animals in Central Asia but statistics are untrustworthy. (2) The higher mortality, despite the use of better methods of treatment. (3) Cases arising in the manipulation of horsehair and bristles are slightly less fatal than in the other industries. (4) The high mortality in the group of unnamed industries; this may be explained by the very varied nature of the industries in which no doubt anthrax not being expected is not watched for, the result being the diagnosis is too late for successful treatment.

The total cases of industrial anthrax from 1899–1907 from all causes was 452. Of these 114 died giving a percentage mortality of 25·2. The proportion of cases in each industry was wool, 4; bristles and horsehair, 2; hides and skins, 3. Other industries 1. (Table I.)

Cases of "non-Industrial anthrax," not being notifiable, can only be traced when a fatal result ensues. Table II shows the total number of deaths, 58, due to anthrax during the three years 1902–1904, of these deaths 32 were due to industrial conditions, the difference 26, is therefore the number of deaths occurring in non-industrial occupations. The average mortality of anthrax being about 25 % we may therefore estimate that during the three years above mentioned the non-industrial

TABLE I.

Year	All cases of Industrial Anthrax	Deaths	Percentage fatal	Cases due to the manipulation of Horse-hair and Bristles	Deaths	Percentage fatal
1899	55	14	25·4	19	4	21·0
1900	37	7	18·9	15	4	16·0
1901	39	10	25·6	9	1	11·0
1902	38	9	23·6	10	2	20·0
1903	47	12	25·5	7	1	14·3
1904	50	11	22·0	12	4	33·3
1905	51	18	30·5	7	1	14·3
1906	67	22	32·8	10	4	40·0
1907	58	11	19·0	17	4	23·5
Total	452	114	25·2	106	25	23·5

cases amounted to about 104; this gives an average of over 34 cases per annum, as against 50 cases per annum due to industrial conditions. Also "industrial anthrax" accounting for 32 out of 58 deaths gives a percentage of industrial deaths of 55, and seven of the 58 deaths were ascribed to the manipulation of horsehair and bristles, hence 12% of the total deaths from anthrax occurred in the latter industries (Table II.)

TABLE II.

Deaths from Anthrax 1902–1904 (3 *years*).

	(1) Returns of Registrar General												(2)			(3)			(4)		
	a England and Wales			*b* Scotland			*c* Ireland			*d* Total for United Kingdom			Fatal cases notified under Sec. 29 Factories and Workshops Act, 1895			Fatal cases of non-Industrial Anthrax — difference between (2) and (1) *d*			Fatal cases due to manipulation of Horsehair and Bristles		
Year	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total	M	F	Total
1902	12	1	13	0	1	1	1	0	1	13	2	15	8	1	9	5	1	6	1	1	2
1903	17	1	18	0	0	0	0	1	1	17	2	19	11	1	12	6	1	7	1	0	1
1904	18	2	20	3	0	3	1	0	1	22	2	24	9	2	11	13	0	13	2	2	4
Totals	47	4	51	3	1	4	2	1	3	52	6	58	28	4	32	24	2	26	4	3	7

M = Males. F = Females.

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An analysis of the sex and numbers of persons employed in relation to the cases of anthrax in horsehair and bristle manipulations is instructive showing:

(1) that anthrax is more fatal to women than men;

(2) that the occupational risk is greater for men than for women, both in horsehair and bristle industries, the explanation being that men are employed more in the earlier and more dangerous manipulations;

(3) that the occupational risk is greater and the mortality among the workers higher in the manipulation of horsehair than in brush-making;

(4) that the risk of infection from horsehair is very much greater than from bristles.

Of the 106 cases of anthrax due to horsehair and bristles between 1899 and 1907, 73, of which 15 were fatal occurred in males, and 33, of which 10 were fatal occurred among females. There was therefore a higher mortality in the cases among females, *i.e.* 30·3 % to 20·5 % among males.

Of these 106 cases, 60 with 13 deaths occurred in adult males, 24 with eight deaths in adult females, 12 with one death in young male persons, eight with two deaths in young female persons, and the remaining two cases were children, one, age 11, who recovered, and the other, age eight, who died.

For every 100 males attacked about 45 females contract anthrax.

In 1900 there were employed in horsehair manufactures 1412 work-people; in 1901, 2206, and in 1906, 2535, taking the average, 1900–1906, the number was 2076. Of these about 690 were employed in spinning and the incidental processes, 1035 in weaving, and its incidental processes, and 350 in dressing, finishing and miscellaneous processes. In 1901 out of 2206 workers—724 were males and 1482 females.

The total number of cases of anthrax that occurred in horsehair factories or workshops during the years 1901–1906 (six years) was 37 (seven fatal) of these 26 (five fatal) were males and 11 (two fatal) were females.

From these figures we may deduce the risk to, and the mortality among, the work people manipulating horsehair thus:

Average No. of people employed 1900–1906 = 2080.

Average No. of cases per ann. of anthrax $= \frac{37}{6} = 6{\cdot}16,$

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then the occupational risk expressed in percentages would be

$$\frac{6{\cdot}16 \times 100}{2080} = {\cdot}296\,\%.$$

In a similar manner we may estimate the risk for male workers only, *i.e.* ·593 % and for female workers ·123 %.

Also the mortality per 100 workers:

Male and female	·168.
Male	·115.
Female	·022.

In other words for every 1000 workers, male and female, there are on the average nearly three cases of anthrax each year, and for every 1000 male workers six cases, and for a similar number of female workers just over one case. Hence the risk for men is more than five times that for women.

It is impossible to estimate accurately the number of people employed on bristles. The brushmaking industry includes practically all bristle workers, as well as a small unknown number of horsehair workers. Some of the cases of anthrax under the head of brushmaking are due to horsehair, making the occupational risk for brushmakers higher than it would be for bristle workers only; but as many brushmakers work on materials that have no connection with anthrax, it is possible to make a rough comparison as to the risks in manipulation of horsehair and bristles. In 1900 there were 5365 people employed in brushmaking—in 1901—7026 and in 1906 the number had risen to 11,753. Therefore the average number employed from 1900–1906 was 8048. In 1901 out of 7026 workers 4138 were males and 2888 were females.

The total number of cases of anthrax in brushmaking factories and workshops during 1900–1906 was 14 (four fatal). Of these 10 (three fatal) were in males and four (one fatal) in females; hence the occupational risk to brushworkers expressed in percentages was ·029 and mortality per 100 workers ·008.

Risk to male workers only ·04 % mortality ·012 %.

Risk to female workers ·022 % mortality ·005 %.

Therefore for every 10,000 workers of bristles we have nearly three cases of anthrax compared with the same number of cases in 1000 workers of horsehair, hence roughly the chances of infection from horsehair are 10 times as great as for bristles.

For every 10,000 male workers in bristles we have four cases of anthrax and among the same number of female workers just over two,

the risk for men then is almost double that for women as compared with horsehair in which the risk for men is five times as great as for women.

Dr Legge put the occupational risk during the five years 1899–1903 at 1·5 % or ·3 % per annum in horsehair industries, and compared it with the woollen industry; estimating the risk (as in the case of horsehair) on the total number of persons employed. The risk worked out at ·0028 % or ·00056 % per annum. In horsehair industries practically all the employees are exposed to risk of infection; in the case of the woollen industries, as Dr Legge points out, the number employed is above half-a-million, males to females being roughly as two to three. Of this half million only 1171 (1164 males, seven females) are classed as being engaged in sorting, and 3093 (1882 males and 1211 females) in combing dangerous wools; making in all 4264 persons incurring special risk.

Estimated on this number of workers Dr Legge states that the occupational risk is 1·3 % for five years, *i.e.* ·26 % per annum.

This figure is below the occupational risk in horsehair as worked out by Dr Legge, *i.e.* ·3 and myself, *i.e.* ·296.

The premises in which 77 of the 106 cases due to the manipulation of horsehair and bristles occurred were as follows:

Central horsehair warehouses	3		
Horsehair factories ...	39	... ...	54
[1] Hair dressing workshops	12		
[1] Brushmaking factories and workshops			15
Other industries as upholstering, mattress making, stuffing boxing gloves, and making knife cleaning machines ...			4
Infection conveyed to outside persons by workers ...			4
			77

These figures again indicate the much greater risk in the manipulation of horsehair, more especially, as previously shown, the horsehair industry is a much smaller one than brushmaking.

Of the 106 cases of anthrax due to the manipulation of horsehair and bristles only one was internal. There are no details of this case which occurred in 1900 and was fatal.

One fatal case in 1904 was of the erysipeloid type, there being no true pustule but a cellulitis of the neck. In one fatal case in 1906 intestinal anthrax developed secondarily to a pustule on the thigh.

[1] Six of the cases under these two heads occurred in domestic workshops or among homeworkers.

Out of 215 cases of anthrax arising from all industrial causes during four years, 1903–1906, 12, and one doubtful case, were of the pulmonary type, all in the woollen industry, and all were fatal except one in 1906. There was one fatal primary intestinal case probably from ingestion of spores with food. This patient was employed in some paint works. A very doubtful and non-fatal case of intestinal anthrax occurred in hide and skin industries in 1906. A fatal case of anthrax septicaemia (Anthracaemia) occurred in the woollen industry in 1905, there being no external lesion, and four cases of the erysipeloid form, of which only one was fatal.

These figures prove that the nature of the lesion varies considerably with the industry; inhalation of the spores being uncommon in any but the woollen industry. This is a little remarkable, as many of the processes in the horsehair and woollen trades are very similar. There is however undoubtedly a great reluctance among men whose trade requires them to handle dangerous materials to state the true facts. A horsehair manufacturer, who has had considerable experience of anthrax, mentions two cases, both fatal, which were highly suspicious of pulmonary anthrax, and states that he is much more afraid of the internal than the external form. Pulmonary anthrax due to the manipulation of hides and skins one would *not* expect and does not find.

Table III shows the exact position of the pustule in 100 cases of anthrax due to the manipulation of horsehair and bristles from 1899–1907. From this it will at once be seen, that the pustule occurs most frequently on the neck, 34·2 %, then on the cheek, 20 %, then the forearm, 11 %, none of the other positions at all approach these in frequency.

It will be noticed too, that the vast majority of the cases (93 out of 100) occur on the exposed parts, and that of the exposed parts the neck and cheek (57 out of 93) are the most frequent sites. This may be explained in two ways: (1) the forearms and hands though more in contact with raw material are more frequently washed; (2) the nails harbour dirt containing spores, the worker scratching his face or neck is then very liable to infect these parts. This is well illustrated by a case in which a worker on horsehair went home and accidentally scratched his niece's neck, with the result that she developed an anthrax pustule.

For the purposes of comparison, Table IV has been drawn up, showing that to some extent the situation of the pustule varies with the occupation.

TABLE III.

Situation of the Lesion in 105 *cases of malignant pustule due to manipulation of Bristles and Horsehair.*

Situation of pustule	Cases	Deaths	Percentage fatal	Position percentage
Head	3	0	0	2·8
Forehead	7	1	14·3	6·6
Eyebrow	2	1	50·0	1·9
Eyelids	2	0	0	1·9
Face	5	1	20·0	4·7
Chin	5	3	60·0	4·7
Cheek	21	2	9·5	20·0
Neck	36[1]	12	33·3	34·2
Arm and shoulder ...	4	1	25·0	3·8
Forearm	12	1	8·3	11·4
Hand	0	0	0	0
Fingers	0	0	0	0
Trunk	2	0	0	1·9
Lower extremity ...	1	1	100·0	0·9
Not stated ...	5	1	20·0	—
Totals	105	24	22·8	—

It will be noticed that pustules on the head, face and neck, are the most common in the English cases, while in the foreign cases, lesions on the upper extremity are next in frequency to the head and face, and lesions on the neck come third. In all the lesions on the trunk and legs (covered parts) are uncommon. The statistics of Debray and Cavaillé refer to industrial cases while many of Koch's are agricultural (connected with disposal of carcases).

The statistics for wool and horsehair are much alike, but in hides the pustule was situated on the neck most frequently (60 %), possibly due to the frequent carrying of hides on the shoulder.

In Koch's cases the majority of the pustules, under the title of upper extremity, were on the hands and fingers, while in malignant pustule arising in all industries in England 1903–1906, only three were on the hands and one on the finger.

In horsehair and bristle industries in England 1899–1907 there were none on hands or fingers.

The mortality of cases of malignant pustule varies with the situation; thus in the English and French statistics the neck would appear to be a much more fatal situation than head and face or other parts (Table V),

[1] Including one erysipeloid form without true pustule (fatal).

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TABLE IV.

Position of the Pustule in different Industries and Countries.

	United Kingdom		United Kingdom		United Kingdom		United Kingdom		United Kingdom		United Kingdom		France		France		Germany		Italy		Italy	
	Industrial Anthrax all causes, 1903—1906		Industrial Anthrax, Wool, 1903—1906		Industrial Anthrax, Hides and Skins, 1903—1906		Industrial Anthrax, Horsehair and Bristles, 1903—1906		Industrial Anthrax, other industries, 1903—1906		Dr Legge, Industrial Anthrax all causes, 1899—1904		Dr Debray, chiefly casual labourers and leather dressers, 1897—1905		Statistique de Cavaillé, 1902—1905		Statistics of Koch		Statistics of Corradi		Statistics of Sclavo	
	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage	Cases	Percentage
Head and face ...	82	42·26	46	50·54	17	28·3	18	48·64	8	40	108	43·5	40	62·5	8	40	447	48·4	57	55·4	115	73·7
Neck ...	79	40·72	27	29·66	36	60·0	11	27·02	9	45	103	41·5	6	9·37	3	15	45	4·8				
Trunk ...	1	0·51	0	0	1	1·6	0	0	1	5	3	1·2	0	0	0	0	35	3·75				
Upper extremity	28	14·43	16	17·58	6	10·0	7	18·91	1	5	31	12·5	18	28·12	8	40	370*	40·8	46	44·66	41	26·21
Lower extremity	4	2·06	2	2·2	0	0	1	2·70	1	5	3	1·2	0	0	1	5	26	2·8				
Totals ...	194	—	91	—	60	—	37	—	20	—	248	—	64	—	20	—	923	—	103	—	156	—

* Fingers and hands chiefly.

while in the Italian observations the neck only comes third, lesions of the head and face and trunk being respectively more common.

Dr Legge states that out of 84 pustules on the neck, 26 were fatal, 30·9 %, of 12 cases on the upper eyelid five were fatal 41·6 %, of 31 on the cheek three were fatal 22·5 %, of 14 on the forehead two were fatal 14·3 %, and of 23 on the wrist and forearm only one was fatal 4·3 %. Difficulty of operation, frequent absence of diagnostic signs of local necrosis, looseness of the cellular tissues may help to account for the high mortality when the upper eyelid or eyebrow is affected.

TABLE V.

Mortality in relation to the situation of the pustule.

Situation	United Kingdom Industrial Anthrax all causes 1903—1906 (4 yrs.)		United Kingdom Industrial Anthrax Horsehair & Bristles 1899—1907 (9 yrs.)		France Statistique de Cavaillé (1902—1905)		? Italy Statistics of Nassarow quoted by Sclavo	
Head and Face	82 cases 14 deaths	17·07 % fatal	45 cases 8 deaths	17·7 % fatal	8 cases 3 deaths	37·5 % fatal	Out of 180 observations	26·3 % fatal
Neck	79 cases 26 deaths	32·91 % fatal	36 cases 12 deaths	33·3 % fatal	3 cases 3 deaths	100 % fatal		18·5 % fatal
Trunk	1 case 0 deaths	0 % fatal	2 cases 0 deaths	0 % fatal	0 cases 0 deaths	0 % fatal		22·7 % fatal
Upper Extremity	28 cases 5 deaths	17·85 % fatal	16 cases 2 deaths	12·5 % fatal	8 cases 0 deaths	0 % fatal		13·8 % fatal
Lower Extremity	4 cases 1 death	25 % fatal	1 case 1 death	100 % fatal	1 case 0 deaths	0 % fatal		5·1 % fatal
Total	194 cases 46 deaths	23·6 % fatal	100 cases 23 deaths	23 % fatal	20 cases 6 deaths	30 % fatal		

With the exception of Great Britain in probably all other countries in the world, anthrax in the human subject is derived more from contact with animals suffering from anthrax than from spores contained in wool, horsehair, hides and skins, and other raw animal products. Italy and Great Britain are the only countries whose governments require notification of anthrax cases in the human subject; and Great Britain, as has been shown, at present only requires industrial cases to be notified, while Italy makes no distinction between industrial and non-industrial anthrax, as far as notification is concerned; so that it is difficult to obtain reliable figures to compare with the English figures just given. Yet it is important to examine the prevalence of anthrax abroad, since all bristles and much of the horsehair used in this country are imported.

In Italy Prof. Monti says that anthrax in man is relatively more frequent than in any other European country. From 1890–1904 (15 years) there were no less than 36,426 cases with 7308 deaths. A percentage mortality of 20·6. The annual number of cases has increased but the death rate has decreased (Table VI).

TABLE VI.

Anthrax in the Human subject, Italian statistics.

Year	Cases of Anthrax notified in all Italy	Deaths from Anthrax in all Italy	Percentage fatal
1890	2047	526	25·6
1891	2241	645	24·31
1892	2077	650	31·3
1893	2461	598	24·3
1894	2400	635	26·46
1895	2179	621	28·5
1896	1985	453	22·82
1897	2123	460	21·66
1898	2327	433	18·6
1899	2672	461	17·25
1900	1867	330	17·67
1901	1992	341	17·11
1902	3528	403	11·42
1903	3423	397	11·6
1904	3104	355	11·43
Totals	36426	7308	20·6

Anthrax in Italy is generally of agricultural origin, there being in many districts, especially in the south, which is more agricultural, a close relation between the number of cases of animal and human anthrax. Sardinia, Calabria, and the Campania show the highest anthrax figures both animal and human.

The north of Italy is more industrial. Dr Corradi collected statistics, from 1877–1890, of 153 cases of malignant pustule in man, occurring in Genoa, one of the chief ports. Of these 117 were of industrial origin, and six of the 117 cases were among people employed on hair only, while 12 of the cases were in trades connected with skins and hair.

Bormans found, in studying an epidemic of anthrax in Turin, that the largest number of cases of malignant pustule occurred among tanners; next came workers employed in making hair pencils, painting and varnishing brushes, and lastly among the peasants who contracted the disease indirectly from the tanneries.

In France only 32 causes of death are entered; anthrax is not one of these, hence no official statistics are available.

Information communicated by Messrs Déséglise & Co., of Paris, and by Messrs Carlo Pacchetti & Co., of Milan, who also do business in Paris, shows that deaths from anthrax due to the manipulation of horsehair and bristles are exceedingly rare in France, but that a few cases have occurred especially from handling Russian horsehair.

Chauveau in 1893 gave particulars relating to seven cases of anthrax. These were due to the manipulation of horsehair, probably Chinese. The cases were spread over a period of four months, two were of the gastro-intestinal type and two erysipeloid (cutaneous anthrax). Six of the seven cases proved fatal.

TABLE VII.

Adapted from a similar Table by Prof. Langlois of Paris, and from details published by Dr Debray (*Le Charbon Industriel*, 1906).

Statistics	Numbers employed	Occupational risk expressed in percentages per annum	Mortality per 100 workers per annum	Percentages of cases fatal
English Wool sorters, 1899—1903	4264	·26	·05	27·7
English Horsehair Workers, 1901—1906	2080	·296	·056	18·9
Le Roy des Barres, 1875—1896 St Denis — Hair dressers	160	·42	·09	20
Le Roy des Barres, 1875—1896 St Denis — Leather dressers	760	·34	·04	12·3
Debray, 1897—1905, Ditto	1200	·5	·02	4·6
Cavaillé, 1902—1905, Wool sorters and Teasers	2168	·23	·07	30
St Jumien, Leather dressers ...	350	·4	·1	30

In Table VII French and English figures of industrial anthrax are compared. These figures are worked out from a series of 56 cases among English wool sorters, 37 in English horsehair industries, 15 in French horsehair industries and 57 among French leather dressers (Le Roy des Barres), 64 in French horsehair and leather industries (Debray), 20 among French wool sorters, etc. (Cavaillé).

These figures emphasize the greater risk both in England and France from horsehair (Debray's figures including horsehair) and further with the exception of Cavaillé's figures, only judged on 20 cases and none of these due to horsehair, the risk in the English industries of wool and horsehair is less than that in France, while the English mortality per 100 workers compares very favourably with the French mortality. The low percentage mortality in Debray's cases, 4·6, is remarkable and throws

some doubt on the genuineness of his cases of anthrax, more especially as he quotes 64 cases in nine years (1897–1905) to Le Roy des Barres' 72 cases in 22 years (1875–1896) in the same district (St Denis).

In Germany the horsehair and bristle industries are probably larger than in England. In 1895 Kübler estimated that 12,000 people were employed in the German empire in horsehair, brush and broom factories. Compare with this number the 6777 engaged in similar industries in England in 1900 (horsehair 1412 and brush-making industries 5365) and with 13,288 in 1906 (2535 horsehair and 11,753 brush industries), and there is not the least doubt that the German industries mentioned have increased as fast if not faster than the English ones.

In a paper published in 1886, W. Koch mentions 1473 cases of malignant pustule with 472 deaths, a percentage mortality of 32. From the Annual Report on diseases of animals in Germany we find that from 1894–1903 (10 years) there were 901 cases of human anthrax from all causes (anthrax not being notifiable throughout Germany the figures must necessarily be too low), *i.e.* just over 90 each year compared with my estimate of about 84 cases per annum in Great Britain. Of these 901 cases, 128 were fatal, a percentage mortality of 13·9, 26 of the 901 were ascribed to the manipulation of bristles and horsehair, while only 11 of the others were due to industrial conditions, that is only 4·1 % in Germany from 1894–1903 were industrial as compared with over 50 % in England (1902–1904) and 2·8 % were due to horsehair as compared with 11·5 % in England.

Kübler says that from 1880–1896 there were more than 141 cases of anthrax due to bristles and horsehair, of which 44 were fatal, mortality 31·2 %, and that these figures are too low because anthrax is not notifiable all over the Empire and because of errors of diagnosis. He strongly holds the opinion that bristles as well as horsehair are a source of infection and quotes cases to prove this assertion.

Monti in a paper on the infections of work people, states that in Prussia from official data from 1898–1902 (five years) there were 378 cases of anthrax with 44 deaths, a percentage mortality of 10·6, but gives no details as to the nature of employment of the cases.

Sclavo in a paper published in 1903 mentions 91 cases of anthrax due to horsehair in Germany of which 29 were fatal, per cent. fatal 31·6.

Debray gives the following for Germany:

	Cases	Deaths	Per cent. fatal
Spinning of Horsehair	11	6	54·5
Brushmaking	2	2	100
Tanneries	25	4	16
Manufacture of hides and skins ...	11	0	0
Wool combing	1	0	0
Knackers	2	0	0
	52	12	23·0

This excludes cases in the Palatinate where the mortality is above 23 %.

TABLE VIII.

Nature of trade, Country, Dates	Numbers employed	Cases of Anthrax	Occupational risk expressed in percentages per annum	Mortality per 100 workers per annum	Percentages of fatal cases
English Horsehair Workers, 1901—1906	2080	37	·296	·056	18·9
German Empire Horsehair Factory at Schleswig, 1873—1881	35	25	8·7	3·9	44
German Empire. Three Horsehair Factories in Eschwege, 1884—1888 ...	30	16	10·6	4·0	37·5
German Empire. Three Horsehair Factories at Kitzingen, 1890—1894 ...	150	19	2·5	·8	31·6
English Brush manufacturers, 1901—1906	8048	14	·029	·008	28·5
German Empire. Brush makers in Nuremberg, 1890—1894	1700	19	·22	·034	15·8

Table VIII shows the occupational risk and mortality per 100 workers in certain horsehair and brush manufacturing towns in Germany and the figures are tabulated with similar English figures for comparison.

The higher occupational risk and mortality per workers in Germany is remarkable, though allowance must be made for the smaller numbers employed in the particular instances given.

Moreover, the mortality of cases varies considerably from 10·6 of Monti to the 32 % of Koch, yet the average would not be far from the English mortality. The mortality in horsehair seems somewhat higher than the English figures.

Eppinger records many internal cases previous to 1886 with a mortality of 88 %, and more recently in Vienna there were six cases (four fatal) among brushworkers due to Russian horsehair.

Munch and Albrecht have recorded cases of the gastro-intestinal form among horsehair workers in Russia.

Reports as to anthrax in China are very contradictory. At the

Catholic Hospital, Hankow (from which port several thousands of pounds' worth of bristles are annually exported) 15,000 natives are seen each year, but only three or four cases have occurred in the past seven years. (Report of Medical Officer to the Consulate, Hankow.)

In Tientsin, through which city passes large quantities of bristles, no cases of anthrax have been heard of. Several medical men in various parts report that they have not seen any anthrax cases, though in several of these places hides and bristles are prepared.

Boils and swellings are said to be common after sorting horsehair, but are never fatal. There is, however, no registration of births or deaths in China, and the Chinese, except Christians, do not go to the foreign doctors, which perhaps may partly account for the supposed absence of anthrax.

On the other hand a doctor, who had spent several years in China, reports that he was seldom without a case. Anthrax was constant, but in all probability the well-known symptoms lead to the men attacked immediately recognising the disease and seeking surgical assistance without delay.

In the hospitals of Montevideo, South America, about 20 cases of anthrax are treated annually, and in the central produce market of the Argentine it is stated that no case of human anthrax has been known, though millions of hides and skins, and about 150,000 tons of wool, pass through it. This statement must be accepted with caution, since dry hides from South America have certainly given rise to cases of anthrax in Antwerp and Liverpool.

In Buenos Ayres "grano malo," a pustular swelling like anthrax, is said to be well known.

Variations in the prevalence and mortality of anthrax among human beings may possibly to some extent be accounted for by natural constitution, inhabitants of colder climates being probably more resistant than those of warmer, such as Italy.

The more sluggish temperament of the Englishman may tend to reduce the number of cases, but renders him, as will be shown later, less susceptible to the serum treatment than the Italian, *i.e.*, it takes a more virulent form of the disease to affect an Englishman than an Italian and therefore it takes more serum and earlier injection to obtain a favourable termination.

Also in the case of the Chinese it is possible that, their diet being largely vegetarian, a condition of body is created which makes the disease less fatal, but it is certain it largely exists.

History of bristles and horsehair in relation to anthrax.

The danger of infection from anthrax in the manipulations of animal hair and bristles depends on the origin, kind, and cleanliness of the materials, and the processes they have to undergo.

Bristles. Bristles are obtained entirely from the hog, and those worked in this country are all foreign. The English pig is useless as a producer of bristles, because by intermixing and crossing, swine have lost in the value of their clothing what they have gained in the delicacy of their flesh.

In the more northerly parts of Europe and Asia the hogs have longer and thicker coats. The larger and older the hog, and the more nearly he approaches to the wild boar, the better his bristles. A long, spare and thin pig will produce long and stiff bristles; the best are taken from along the dorsal spine, each pig yielding about ½ lb. of bristles. Bristles are taken from both live and dead animals. Most bristles are imported into Great Britain partially prepared, that is, roughly combed by drawing through graduated steel combs fixed upright on a bench and then bundled according to length, quality and colour. A small quantity comes in bleached or dyed and well cleaned, bundled and packed. Up to within the last 25 years Russia, Siberia and Poland held the monopoly of supply; but with the opening up of new ports the bristle trade in China has increased enormously, until at the present time Great Britain imports more bristles from China than from any other country. Germany also largely supplies the English brushmaking industries, and smaller quantities come from Hungary and Austria, the Balkans, France, India, Japan, and North and South America.

Through the vast forests of Northern Europe, where trees bearing berries, acorns and other fruit drop endless supplies of food, wander large droves of swine, attended only by a rude swineherd. In Russia at certain seasons of the year those animals likely to produce the best bristles are fattened on tallow waste for a short time and then plucked alive. The swine protected from the rigours of the climate by the short thick tufts, known as pig's wool, which grow at the root of the bristles, wander northward again until a fresh crop of hair has grown. As the swine roam through the forests they rub themselves against trees at the foot of which fall quantities of hair. These are collected by the swineherds, sewn up into skins, and sold to collectors who carry

them to the bristle markets; from these they pass to the two great distributing centres, Moscow and Leipzig.

From the dead pig the bristles are scraped off after scalding, or dragged off after softening by wood ashes.

Bristles come from all parts of Russia and Siberia, but Polish bristles, whether from natural deterioration or careless dressing, are now of small value. Bristles from France, Germany, and Southern Europe vary greatly, some German States supplying hair of good length and quality, but others with France and Southern Europe yield either too long a bristle, or else too short and rigid a one.

From France too is imported a very highly esteemed white bleached bristle, but this is probably largely manufactured Russian. American bristles are wanting in flexibility and are not used now to any great extent.

Bristles from China and India have only been in use about 25 years, and the more valuable bristles come from Northern China. There the pig, having been "stuck," is scalded and the bristles scraped off; these are washed in hot water, air dried, roughly bundled in the interior, and sold to bristle merchants or dressers at Tientsin, Hankow, etc., who open the bundles, comb and straighten the bristles, sometimes by steam. They are then resorted and bundled according to length and quality, care being taken to get the "bend" (the natural curve of the bristle) all the same way in each bundle. Some dressers use a dry powder (naphthalene) in packing. The better class bristles are packed in rice paper stamped with the dresser's name or mark.

The waste that falls to the ground is roughly bundled and sold as riflings; it is exceedingly dirty, but as bristles are sold on gross weight, the more dirt the better, so far as the Chinaman is concerned. Much of the dirt in bristles is doubtless gathered in the drying in the open, and in dressing before exportation bristles pass on an average through 10 pairs of hands, and the washing and combing largely remove the original animal fat and dirt.

Bristles from Japan, like the best Chinese, are well cleansed and packed.

The cleanliness of the bristles when they reach the manufacturer varies widely, some being extremely dirty, as Russian, Siberian, and the Chinese riflings; the dirt consists of dust of all kinds, including the irritating naphthalene, animal dirt, skin and scurf, nits, etc., others, as the better class Chinese, French and Japanese, are very clean. Bristles differ immensely in substance, colour and length, varying from jet black

TABLE IX.

Name by which bristles are known in the Trade	Country of origin	Qualities	Length	Colours	Condition when imported	How imported	Remarks
Russian	Russia	1. Firsts	3″ rising by $\frac{1}{4}$″ & $\frac{1}{2}$″ sizes to $5\frac{3}{4}$″	White, yellow, black & grey	Combed and bundled to sizes & qualities	In casks	Very dirty, full of dust.
		2. Suchoys	5″ & $5\frac{1}{2}$″	,,	,,	,,	,, ,,
		3. Seconds or Donskoi's	$3\frac{1}{4}$″ rising by $\frac{1}{4}$″ & $\frac{1}{2}$″ sizes to $4\frac{1}{2}$″	,,	,,	,,	,, ,,
Siberian	Siberia	1. O'Katka	$5\frac{1}{2}$″, 6″, $6\frac{1}{2}$″, 7″	,,	,,	,,	,, ,,
		2. Firsts	$3\frac{1}{2}$″, 4″, $4\frac{3}{4}$″, $5\frac{1}{4}$	,,	,,	,,	,, ,,
		3. Suchoys	$4\frac{3}{4}$″	,,	,,	,,	,, ,,
		4. Seconds	3″, $3\frac{1}{2}$″, 4″	,,	,,	,,	,, ,,
Polish	Poland	Abfall	$3\frac{1}{2}$″	Yellow, white and grey	,,	,,	Dirty and dusty.
		Spitz-Spitz	4″, $4\frac{1}{2}$″	,,	,,	,,	Rather dirty and dusty.
Auszug	Bohemia	One only known as Auszug	$4\frac{3}{4}$″ rising by $\frac{1}{4}$″ & $\frac{1}{2}$″ sizes to 7″	,,	,,	,,	,, ,,
German-Polish	? Austria	Leck	5″ rising by $\frac{1}{4}$″ & $\frac{1}{2}$″ to 7″	White, yellow, black & grey	,,	,,	,, ,,
	The Balkans	Bukharest	$4\frac{1}{2}$″		,,	,,	,, ,,
Indian	India	Indians, Calcuttas Border-Indians	2″ rising by $\frac{1}{4}$″ sizes to 8″	,, ,,	,,	In casks of various sizes	Nits eggs and nits very occasionally alive, common.
German	Germany	All qualities, known as German unprepared	$3\frac{1}{2}$″ rising by $\frac{1}{4}$″ & $\frac{1}{2}$″ sizes to 7″	,,	,,	Casks	Rather dirty and dusty.
		German prepared and bleached	3″ rising by $\frac{1}{4}$″ & $\frac{1}{2}$″ sizes to 7″	White	Bundles bleached and fully prepared	,,	Well prepared, cleaned and packed.
French	France and possibly Russia	Known by colour as Beau Blanc, Blanc, Demi-blanc, Gris, "Lily White" the best	50 mm. to 120 mm.	Lily white, light yellow, grey	,,	Cases	Whatever the origin the dressing is done in France. Very clean.
Chinese	China	Hankow	2″ rising by $\frac{1}{4}$″ up to 7″. Riflings (waste) 2″ or less	Black	Except riflings Very well bundled and prepared	,,	Riflings very dirty, others very clean.
		Tientsin	Ditto ditto	,,	,,	,,	,, ,, ,,
		Hong-Kong	A. Long B. Medium C. Short	,,	,,	,,	,, ,, ,,
Japanese	Japan	?	?	? Black	Bundled and fully prepared	?	Very clean not much used.
American	North and South America	?	?	?	?	?	Very little used.

through dark or light grey to yellowish buff or white. The length varies from two to 14 inches. The bundles weigh from a few ounces to two or three lbs., and vary according to length, quality and colour.

Table IX is a classification of bristles as imported into England.

Horsehair. Horsehair is derived from the manes and tails of English, Russian, Siberian, Australian, South American and Chinese horses. In all countries it is taken from both live and dead animals, and a bale may contain both "live and dead" hair.

English horsehair is largely derived from combings from living horses. In China 50% of the hair exported comes from Koolan in Mongolia, where the hair is taken mainly from dead horses; most of the other 50% is "live hair" and comes from around Mukden in Manchuria. In Russia, Siberia and China many of the horses are wild, but a few are farmed for the hair. Whatever its origin, the hair may be either directly made into bales of various sizes for export, or may undergo some preliminary processes before export. In this case the hair is washed in cold water, and manes are roughly separated from tails. The long tail hair is more valuable, and therefore is often well washed and beaten, and sometimes dyed. Chinese horsehair is roughly combed, the waste, corresponding to bristle riflings, is exported as "combings." Hair is sold by gross weight and therefore the measures to get rid of the dirt are not so energetic as they ought to be. From South America the majority comes from the Argentine Republic and Uruguay and is often mixed with cow tail hair. Smaller quantities are occasionally imported from Hungary, Japan and Morocco.

Russian and Siberian tail hair arrives in loosely packed bales of about 4 cwt. each, roughly bundled and all colours packed together. Mane hair in loosely packed bales of $2\frac{1}{2}$—5 cwt. each, all colours together, but a little cow hair is mixed in.

Chinese and Manchurian tail hair comes in cases of about $1\frac{1}{2}$ cwt. The hair is wholly or partially drawn into lengths, and colours separated. Mane hair arrives in cases of about $1\frac{1}{2}$ cwt. treated in the same way as the tail hair, combings in bales of 5 cwt.

South American tail hair arrives in press packed bales of 8—9 cwt. sometimes wholly on the dock but more often free. Mane and tail hair also arrives, all qualities and colours mixed. Cowhair is often mixed with the horsehair.

Mode of importation. All bristles and horsehair are imported into England by brokers, arriving in casks, cases or bales. Practically all of it enters at the Port of London, and for a time is centred in two ware-

houses close to one another. Here certain cases are opened for the purpose of collecting samples, and the consignments are sold by auctions, which are generally held once a fortnight. The raw materials then pass directly to the manufacturers. None of the cases are ear-marked by any sanitary authority as are consignments of tinned goods, so that there is no restriction on the distribution of any infected material.

From this brief survey of the antecedents of bristles and horsehair it is evident (1) that bristles enter Great Britain in a far more prepared state than horsehair, (2) that tail hair is better cleansed than mane hair.

Manipulation of bristles and horsehair.

Bristles are mainly used for making brushes, a very small quantity is used in the same way as short horsehair. Long horsehair above 18 inches is used for weaving, seating, and for making crinolines, below 18 inches chiefly for brushmaking. The short tail hair is used for upholstery and mattress work, and the short mane hair for horsehair carpets, oil press cloth, etc.

The processes to which hair is subjected vary with the nature and origin of the hair. Russian tail hair is first sorted for colours, then wet hackled, *i.e.* drawn while damp by hand through upright steel combs, afterwards drawn into lengths and bundled. Russian mane hair is sorted for colours, then carded (a carding machine consists of rollers with metal teeth revolving against each other) for spinning or curling. Chinese tail hair if not completely drawn, must have the process completed; the mane hair if in cases must have strings removed from bundles before carding.

South American tail hair is cut off docks when necessary, wet hackled and drawn into lengths. The mixed hair is first sorted for colour, quality and length, and the long and short hair is then treated in the same way as the Russian.

For curling, the raw materials are taken in the required proportions and placed in a willeying machine which consists of a cylinder with several teeth on it; in this the material is further cleansed, the dust extracted, and thoroughly mixed; the machine is usually covered and connected with a fan. The mixed material is then spun, and the curl set by steam or by baking in a fire-heated oven.

Brushmaking. Most brushmakers buy horsehair already prepared from the horsehair manufacturer; a few of the larger firms prepare their own, selling all that is of no use for brushes for other purposes; some

bristles are used as imported, and made directly into brushes without any further processes, but for other brushes it is necessary to blend and dress the bristles to the required length and stiffness. Sorting for stiffness is accomplished by drawing the bristles through a series of graduated steel combs. In sorting into lengths a handful of mixed bristles is stood up against an inch measure, marked to the eighth parts of an inch; then the bundles are held in the left hand, and with the right finger and thumb bristles above the indicated length are removed. This is repeated until the residue is as solid as requisite. Each bundle is now so accurately arranged that the flag ends of the bundle are almost solid and perfectly level, while the base of the bundle is smooth. It is quite common during the above operation for the sorter before pulling the bristles to wet his finger and thumb from his lips, a most dangerous practice as the following case illustrates. In 1900, a girl died from anthrax; she had a pustule on the cheek, and large pustules were found in the stomach and intestines, but nowhere else, hence the lesion in the latter positions was probably due to a separate infection. This girl was in the habit of constantly chewing hair.

Table X outlines the processes of brushmaking. Washing and bleaching are done in some cases before and in others after the brush is made; in either case the process is the same, though it varies in different factories. In the washing, soap and boiling water or washes made of oleic acid 1 in 8 and ·880 ammonia 1 in 20 at 190° F. are used, and the bristles or brushes rubbed by hand on corrugated beech blocks or stone. Bleaching is done by sulphur. Many of the processes both in horsehair and brush-manufacturing are extremely dusty, and it is remarkable there have been so few cases of internal anthrax recorded.

Dangerous processes and materials.

Table XI shows the occupation of cases of anthrax ascribed to infection from horsehair and bristles from 1899–1907 (nine years).

From this will be seen that cases have occurred in practically all the processes to which hair is subjected; in the warehouses where the hair is stored after arrival, in the course of distribution, and in most of the subsequent processes even from finished products. Further, it will be seen that the incidence is greater (1) among workers in short hair, as brushmakers; and (2) in the earlier processes, as drawing.

Lastly, seven of the cases, of which two were fatal, were due to infection carried to outside persons by workers in horsehair. Kübler quotes

TABLE X.

Table showing materials and processes in brushmaking

Raw materials	Preparation of raw material	Actual brushmaking		The finished brush
Handles and backs of brushes consist of Various woods, Silver, pearl, Tortoise-shell, Ivory, bone, quill, and Composition.	Cutting, Weathering, Planing, Shaping, Boring, and Drilling.	Drawn work, filling by hand and trepanning using wire, making scrubbing, nail, cloth, tooth, hair and other brushes.	Grinding Pointing	Household, trade, and machinery brushes.
Brush consists of Hair of Horse, Cow, Bear, Squirrel, Kolinsky, Badger, etc. Bristles of Hog, Various vegetable fibres, Whalebone.	May be rough dressed (abroad), Dressing, Sorting, Drawing, Mixing, Washing, Bleaching.	Machine work, filling by machinery nearly all varieties of brushes.	Trimming	Fancy brushes, as toilet, hair, nail and shaving brushes.
		Set work—Pan department, filling brooms by hand, using string and pitch.	Washing Bleaching Finishing	Bone brushes—tooth and nail. Brushes for painters and whitewashers.
Accessories Steel and other wire, Pitch, Wax, etc.	—	Painters', Artists', and Decorators' brushes filled by hand and machinery.	Polishing	Artists' Brushes.

TABLE XI.

Showing occupation of cases (Horsehair and Bristles).

c = cases, d = deaths.

Occupation	1899 c—d	1900 c—d	1901 c—d	1902 c—d	1903 c—d	1904 c—d	1905 c—d	1906 c—d	1907 c—d	Total c—d
Making boxing gloves	—	1—0	—	—	—	—	—	—	—	1—0
Brushmaking	—	3—2	2—1	2—1	3—0	2—0	—	1—1	—	13—5
Carding	4—1	3—1	—	—	—	—	—	—	—	7—2
Carrying	1—0	—	—	—	—	1—0	—	—	2—0	4—0
Clerk	—	—	—	1—0	—	—	—	—	—	1—0
Curling	5—1	—	—	—	—	1—0	—	2—0	—	8—1
Drawing	2—1	—	1—0	1—0	—	1—1	2—1	2—1	2—0	11—4
Dressing	—	1—0	—	—	1—0	1—0	1—0	—	1—0	5—0
Fibre drawing & dressing	—	1—0	—	—	—	—	—	1—0	—	2—0
Hackling (3 of the cases were wet hackling)	—	—	—	—	—	1—0	1—0	—	2—0	4—0
Making hair cloth	—	—	—	—	—	—	—	1—0	—	1—0
Labourer	1—0	1—1	—	2—0	—	1—0	—	—	—	5—1
Making mattresses	—	—	—	1—0	—	—	—	—	—	1—0
Mixing	1—0	—	—	—	—	—	—	—	—	1—0
Not stated	—	—	1—0	—	—	—	—	3—2	1—1	5—3
Plasterer	—	—	—	—	—	—	—	—	1—0	1—0
Sorting	2—1	—	—	—	—	—	1—0	—	2—2	5—3
Spinning	—	—	—	—	—	—	—	—	1—0	1—0
Teasing	—	—	1—0	—	—	—	—	—	—	1—0
Twisting	—	—	1—0	—	—	—	—	—	1—1	2—1
Vanman	—	1—0	—	—	—	—	—	—	1—0	2—0
Warehouseman	—	1—0	1—0	1—0	1—1	—	—	—	—	4—1
Washer	—	—	—	—	—	—	1—0	—	1—0	2—0
Weigher	1—0	1—0	—	—	1—0	—	—	—	—	3—0
Willeyer	—	—	1—0	—	—	—	—	—	—	1—0
Willowing	—	—	—	1—0	—	1—1	—	—	—	2—1
Yarn winding	—	1—0	—	—	—	—	—	—	—	1—0
Outside cases	2—0	—	1—0	—	1—0	2—2	—	—	1—0	7—2
Drawing & sorting	—	1—0	—	—	—	—	—	—	—	1—0
Warehouseman & brushmaker	—	—	—	1—1	—	—	—	—	—	1—1
Hackler & brushmaker	—	—	—	—	—	1—0	—	—	—	1—0
Drawer & brushmaker	—	—	—	—	—	—	1—0	—	—	1—0
Drawer & wet hackler	—	—	—	—	—	—	—	—	1—0	1—0
Totals	19—4	15—4	9—1	10—2	7—1	12—4	7—1	10—4	17—4	106—25

many similar cases in Germany, as does Debray among French workers.

The case in mattress making is an excellent example of the vitality of anthrax spores. A hair mattress was being renovated after twenty

TABLE XII.

Nature of material giving rise to infection in 106 *cases.* (*Horsehair and Bristle*

Material	1899 c—d	1900 c—d	1901 c—d	1902 c—d	1903 c—d	1904 c—d	1905 c—d	1906 c—d	1907 c—d	T
Not stated	6—1	3—0	4—0	b2—0	—	1—0	1—0	2—0	3—0	2
Australian hair	—	1—0	—	—	—	—	—	—	—	
Siberian hair	—	—	—	—	—	2—0	—	1—1	1—0	
Chinese manes and short hair ...	7—2	—	2—1	4—2	1—0	—	—	—	1—1	1
English cow hair	1—0	—	—	—	—	—	—	—	1—1	
Chinese hair	1—1	2—0	—	—	—	1—0	2—1	1—1	1—0	
American hog hair	—	—	—	—	—	—	—	—	1—0	
South American hair	2—0	—	—	—	—	—	—	—	—	
English horsehair	—	1—0	—	—	—	—	—	—	1—0	
Chinese, Russian & American hair	—	3—2	—	—	—	—	—	—	—	
Russian tail hair	—	—	—	—	—	—	—	—	1—0	1
Russian bristles	—	—	—	—	—	—	—	—	1—0	1
Russian hair	—	—	—	—	—	—	—	1—0	3—1	4
Bristles ? Origin	—	1—1	—	—	—	—	—	—	—	1
British cow hair and horsehair. American hog hair	—	—	—	—	—	—	—	—	1—1	1
Chinese, Siberian and Russian hair	—	—	—	—	—	—	—	—	a1—0	1
Chinese and South American hair	—	1—0	—	—	—	—	—	—	—	1
American hog hair, English cow tails all dyed and boiled	—	—	—	—	—	—	—	—	1—0	1
Chinese horse tails	—	—	2—0	—	—	—	—	—	—	2
Chinese and Siberian bristles ...	—	—	—	—	—	—	—	1—1	—	1
Russian and South American hair	—	1—0	—	—	—	—	—	—	—	1
Chinese and Siberian hair ...	—	—	—	—	1—0	2—2	—	1—0	—	4
Siberian tails	2—0	1—1	—	—	—	—	—	—	—	3
Argentine and Russian hair ...	—	—	—	—	—	—	—	1—0	—	1
English, S.American and Russian hair	—	—	—	—	—	—	—	1—1	—	1
Russian and Siberian hair ...	—	—	—	—	1—0	1—1	—	1—0	—	3
Chinese hair and bristles	—	—	—	—	1—0	—	1—0	—	—	2
Yak hair, Chinese, Siberian, and Australian hair	—	—	—	—	—	—	3—0	—	—	3
Russian and Chinese hair or bristles	—	—	—	—	—	1—0	—	—	—	1
Russian and Chinese hair ...	—	1—0	—	—	—	2—1	—	—	—	3
South American horse and cow hair (tan yards)	—	—	—	—	—	1—0	—	—	—	1
Siberian and Chinese horsetails ...	—	—	—	—	—	1—0	—	—	—	1
Chinese horsehair, Indian and other bristles	—	—	—	—	1—1	—	—	—	—	1
Native	—	—	—	—	1—0	—	—	—	—	1
Chinese and Russian bristles ...	—	—	—	—	1—0	—	—	—	—	1
All hair except Chinese	—	—	—	4—0	—	—	—	—	—	4
S. American, Chinese & Siberian hair	—	—	1—0	—	—	—	—	—	—	1

N.B. Unless otherwise stated hair means horsehair.

a = The Chinese had been disinfected.
b = In one of these cases the material was said to have been dyed and boiled for more than 30 mins.
c = cases, d = deaths.

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Summary of Table XII.

Bristles alone were suspected in	3	11	Bristle.
Bristles mixed with other raw materials do.	8		
Horsehair alone was suspected in	40	73	Horsehair.
Horsehair mixed with other raw materials do.	33		
Chinese material alone was suspected in manes 15^6, tails 2^0, hair 8^3, and bristle 2^0	27^9	48^{16}	Chinese raw material.
Chinese material mixed with other raw materials ditto, hair 13^5, Yak 3^0, horsetails 1^0, bristles 2^1, hair and bristle 2^1 ...	21^7		
Siberian material was suspected alone in hair 4^1, tails 3^1	7^2	41^{12}	Raw material from Russian Empire
Siberian material mixed with other raw materials ditto, bristles 1^1, hair 8^3, tails 1^0, Yak 3^0	13^4	20^6	
Russian material alone was suspected in tail 1^0, bristle 1^0, hair 4^1	6^1		
Russian material mixed with other raw materials ditto, hair 13^5, hair and bristle 1^0, bristles 1^0	15^5	21^6	
Australian material alone was suspected in hair 1^0 ...	1^0	4^0	Australian raw material.
Australian material mixed with other raw materials ditto, Yak etc. 3^0	3^0		
English material alone was suspected in cow 2^1, horsehair 2^0	4^1	7^2	English raw material.
English material mixed with other raw materials ditto, cow and horsehair 1^0, cow hair 1^0, hair 1^1	3^1		
American material alone was suspected in bristle 1^0, hair 2^0, horsehair and cow hair 1^0	4^0	14^3	American raw material.
American material mixed with other raw materials ditto, bristle 2^1, hair 8^2	10^3		
Indian material mixed with other raw material was suspected in bristles 1^1 (Indian)	1^1	1^1	Indian raw material.
Native hair alone was suspected in	1^0	1^0	
Not stated	22^1	22^1	

The smaller figures indicate the fatal cases.

years' use, and the material was being put through a hand teasing machine, when the workman scratched the back of his hand, and a malignant pustule developed in that position.

From 1899–1907 bristles alone were said to be the source of infection in only three cases, bristles mixed with hair in eight cases, making 11 cases in which bristles were suspected against 73 in which horsehair was suspected. (Table XII and Summary.)

Horsehair alone was suspected in 40 cases, and mixed with bristles and other hair in 33 cases. Chinese and Russian (including Siberian) material was the most dangerous giving rise respectively to 48 and 41

cases. America is third with 14 cases. These figures are of little value unless we examine them in relation to the amount imported.

TABLE XIII.

Relation between the weight and value of imports and cases of Anthrax 1899—1907.

Material	Imports in 1902, tons weight	Imports in 1902, value in thousands of pounds	Average number of cases of anthrax per annum	No. of tons of material to each case of anthrax	Value of material in thousands of pounds for each case of anthrax
Horsehair and Bristles	3708·75	876·5	9·3	398·79	94·25
Bristles	2046	626·5	1·2	1705	522
Horsehair	1662·75	249·75	8·1	205·2	30·8
Chinese raw material	1076	189	3	358·6	63
Russian & Siberian raw material	891·5	266·5	1·4	636·75	193
American raw material	129·5	17	·44	294·3	38·6
Australian raw material	101	17·5	·11	1010	175

Table XIII shows that (1) horsehair is more than eight times as dangerous as bristles; (2) that taking into consideration the quantities imported the risk of infection is greatest from Chinese and Russian raw materials.

Errors in the last table arise because it is impossible to estimate the amount of material of any particular country that passes through Great Britain without being manufactured. The exports of bristles are large, most going to the United States of America. In 1901 the value of imports of bristles from all countries was £527,691 of which £232,283 worth were re-exported. In the case of horsehair also the export trade is large, though in this case the exports contain probably a little English hair as well as re-exported foreign hair. In 1901 the imports of horsehair were valued at £165,702 and exports £82,211. A large proportion of the latter went to the U.S.A. Also raw material from one country is often shipped from a port in another country, and the material is then entered under the country to which the port belongs. Practical experience in this country, however, bears out my conclusions. Hair from China, Russia, and Siberia, and more rarely from America, being considered by English manufacturers the most dangerous. Similarly in France, Italy and Germany, raw materials from China, Russia, and Siberia are all considered more dangerous than other kinds.

Debray from observations at St Denis states that hair from China, Russia, Australia, and Siberia, are the most frequent sources of infection.

In some English factories and workshops isolated cases have occurred, in others repeated attacks follow one another. Incidence is not limited to any particular district, and an examination of the locality shows that cases of anthrax due to the manipulation of horsehair are distributed evenly with the number of people employed, the dangerous classes of hair being used very generally. In the woollen industries it is otherwise. Anthrax is common among workers in wool in the West Riding of Yorkshire especially in Bradford and Worcestershire. There dangerous classes of wool are commonly used. In the south of England and Scotland, anthrax is conspicuously absent from the woollen districts, as in these places only colonial and home-grown wools are manipulated. In the hide and skin industries most of the cases occur in Liverpool and London; and the Liverpool Urban Sanitary Authority have made anthrax notifiable for three years from 1907. For the three years ending 1906, 21 cases of anthrax, mostly among dock labourers, occurred in Liverpool, of these 20 were external and 14 died.

Anthrax among animals.

The accuracy of statistics of anthrax among animals must be doubted, as any animals that die suddenly are often said to have died of anthrax.

TABLE XIV.

Gross number of animals attacked with Anthrax in various countries.

Country	1902	1903	1904	1905	1906	Averages
United Kingdom	1032	1142	1589	1317	1233	1263
Germany	4852	4626	5959	6133	6226	5559
Italy	6099	4059	3946	3783	5039	4585
British India	28081	30715	?	?	?	29398
Russia:						
European Russia, Finland and North Caucasus ...	42423	47300	?	?	48783	46169
Asiatic Russia and Trans-Caucasus	6802	4200	?	?	2906	4636

TABLE XV.

Number of premises in which cases of Anthrax occurred among animals.

Country	1901	1902	1903	1906	Averages 1901—1903
France	416	395	491	416	434
Hungary	1974	2158	2754	—	2295
Sweden	224	218	179	—	207

From the figures given in Tables XIV and XV, it will be seen that anthrax occurs among animals practically all over Europe and Asia, and that in European countries it is most frequent (taking into consideration the area) in Italy and Hungary, and more frequent in Germany than in France, Sweden or England. Probably in France there are fewer cases among animals than in any other country, this may possibly be accounted for by the carrying out of vaccination under the Pasteur system.

In both the Russian and Indian Empires, anthrax is extremely common among animals.

In China anthrax among animals is said to be a rare disease, at any rate it is probable that it does not occur to the extent one would expect. Trustworthy information is entirely lacking, but two events indicate that anthrax does occur. In the Thibetan mission a few years ago, anthrax among the Yaks reduced the number from 3000 to 1450. Also some Australian cattle imported into China all died of anthrax at Wuchow.

In Australia the incidence of anthrax is small, precautions are taken to prevent the spread of the disease and to secure proper disposal of the carcase.

In the United States of America, in the Argentine and Uruguay, consular reports mention scattered outbreaks of anthrax from time to time, but no definite figures are obtainable. Similar precautions are taken as in the case of Australia.

From 1903–1905, 92,113 bovines were reported to have died of anthrax in India and Burma.

Tables XVI and XVII give the class of animal attacked and the incidence.

Among cattle the incidence is highest in Italy and Germany and low in England and France.

Among horses the incidence is much the highest in Italy, England again being low; but among swine the English and Italian figures closely approximate, while the German figures are so low as to make one suspect that many cases pass unreported, considering the half wild condition of many German swine this is not improbable.

In certain countries the incidence is greatest in the hot summer months; this is well shown by the curve in the diagram on page 310 which shows that in Russia in 1906, there was no change in the incidence of anthrax until March, when the number of cases rapidly increased, reaching a maximum in July; after which there was a fall until in November and December the figures reached the level of the

early months of the year. An examination of the statistics in any recent year will show a similar result, and Dr Legge states that the same seasonal variation may be observed in Germany. On the other hand in Great Britain we have fewer cases in the warmer months of

TABLE XVI.

Cases of Anthrax among animals.

Country	Animal	1902	1903	1904	1905	1906	Average no. affected per annum
United Kingdom	Cattle	746	807	1115	1001	937	921
	Horses	44	51	47	53	?	49
	Sheep & Goats	50	48	62	53	83	59
	Swine	192	234	365	210	213	243
	Total	1032	1142	1589	1317	1233	1272
Germany	Cattle	4003	3990	4571	5308	5390	4652
	Horses	134	150	177	172	183	163
	Sheep	620	339	1111	509	502	616
	Goats	8	11	12	13	14	12
	Swine	87	136	88	131	137	116
	Total	4852	4626	5959	6133	6226	5559
Italy	Cattle	?	1294	1311	1195	1444	1311
	Horses	?	111	67	32	97	77
	Sheep	?	2275	2317	1339	3357	2453
	Goats	?	262	140	124		
	Swine	?	117	111	93	141	115
	Total	?	4059	3946	2783	5039	3956

TABLE XVII.

Incidence of Anthrax per 100,000 *of cattle, horses and swine.*

Country	Number of cattle in country indicated	Average number of cattle affected with anthrax	Incidence of anthrax per 100,000 cattle	Number of horses in country indicated	Average number of horses affected with anthrax	Incidence of anthrax per 100,000 horses	Number of swine in country indicated	Average number of swine affected with anthrax	Incidence of anthrax per 100,000 swine
United Kingdom	11,961,955 (1907)	921	7·6	2,110,024 (1907)	49	2·3	3,580,740 (1907)	243	6·7
Germany	18,939,692 (1900)	4652	24·5	4,195,361 (1900)	163	3·9	16,807,014 (1900)	116	·69
Italy	5,000,000 (1900)	1311	26·2	741,739 (1900)	77	10·3	1,800,000 (1900)	115	6·4
France	14,673,810 (1901)	804 (1892)	5 4	2,926,382 (1901)	?	?	6,758,198 (1901)	?	?

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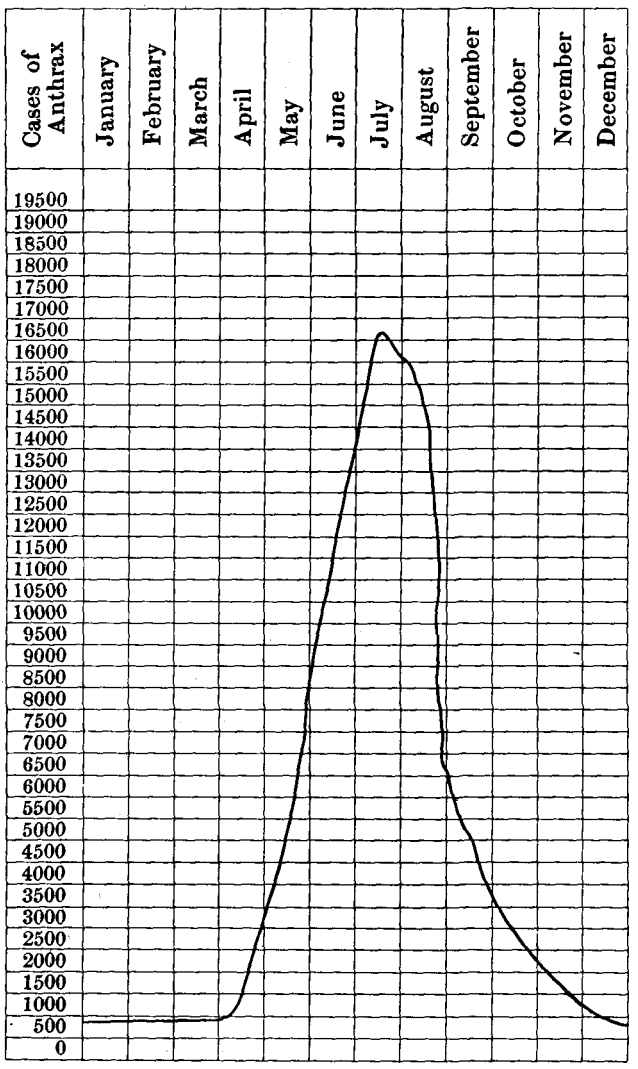
July, August, and September. From 1899–1904 (six years) there were 4250 cases of anthrax among animals in Great Britain. Of these 1114 occurred in the first quarter, 1166 in the second quarter, in the third 850 and the fourth 1120. In countries where cases of anthrax arise largely from actual contact with affected animals, and industrial conditions are not prominent, it will be found that incidence in man varies with the incidence in animals; thus in Italy from 1892 to 1896



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(five years) there were 11,102 cases of human anthrax. Of these 1482 occurred in the first quarter, 1398 in the second quarter, 5286 in the third, and 2936 in the fourth. In Italy as in Russia incidence in animals is greatest in the hot summer months. An explanation of this seasonal variation may be found in the changes in temperature, soil, and vegetation.

An animal affected with anthrax while still alive sheds into the air by the bloody discharges, and by the excretions from mouth, nose, and bowel, countless bacilli which readily spore. These spores, extremely resistant, may remain potent for long periods. Under suitable conditions of temperature which occur at certain seasons of the year, these spores develop as they can grow on organic matter in nature. Koch found that excellent media for growth could be obtained from seeds rich in starch, such as barley, wheat, grass, and potato and turnip juice; water in which hay has been allowed to decay, if neutralized and made slightly alkaline, is a suitable medium. Chalk in the soil would tend to make the medium alkaline.

Heusinger found that anthrax was most commonly met with on the salt grass steppes, river valleys, on round little lakes, and on lands rich in organic matter liable to putrefy.

Billing states that districts where anthrax is most prevalent contain profuse vegetation, are moist compared with surrounding districts, often liable to be flooded, but drying out considerably in the summer, often exposed to the full action of the sun, and protected from cooling winds.

In the Prairie States the most marked spots are the cups in the high prairie land more or less full of stagnant water, liable to flood in spring, while the surrounding country is parched and dry. In August and September green verdure grows around the cups where the water has overflowed, and the temperature is warm enough for the development of the bacillus among the roots of the grass.

Koch, from observation of the principal anthrax districts in France (banks of the Loire, Oise, Aisne, Saone, and the marshy low-lying country of the Gironde), in Germany (banks of the Danube, swampy sides of the Bavarian Alps, valleys of the Elbe, Mulde, Saale, Bude) districts all liable to floods, concludes that the favouring conditions of soil are (1) fairly impervious soils of chalk, marl or clay; (2) sandy soil but only where the sand lies in a thin layer on impervious ground, and where it is intricately mixed with the decomposing animal and vegetable matter; (3) peaty soils especially rich in organic matter and mineral

substances, such as prairies, steppes, moor, and marsh land. The essentials for any particular place to become a more or less permanent source of infection are (*a*) *Bacillus anthracis*, (*b*) a suitable soil, at times moist at others drying out, profuse vegetation and decay, (*c*) a suitable temperature. The *B. anthracis* develops best at 35° C. and multiplication may take place any where between 12° C. and 45° C., while cooling below freezing does not kill. Spores are best produced at 35° C. but sporulation may take place between the limits 18° C. and 42° C.

That such a district would remain a permanent source of infection is improbable since the bacilli would become attenuated and eventually die out; but from time to time a fresh supply is brought in by the discharges from animals infected from grazing on the place.

If anthrax bacilli are kept at 42° C. for eight days, they lose the power of sporulation and become less virulent, even when grown at a lower temperature, only regaining it after passage through the body of a susceptible animal.

The fact that in Great Britain there is no increased incidence of anthrax during July and August, as in most other countries, points to the absence of those special conditions which are necessary for the germination of the spores into bacilli and for the multiplication of these. However in most countries such districts as those above described do exist, and on them anthrax certainly flourishes; here too may occur the contamination of the hides and hair and wool, owing to the dirt and sand, containing the spores of anthrax, which become adherent to the long hair and fleeces, as these are trailed upon the ground.

Summary.

At the commencement of this paper it was pointed out that anthrax has been associated with the manipulation of hair and other raw animal materials for at least a century and a half, but that it has only been studied from an industrial point of view during the last 30 years, with the result that in 1895 cases of anthrax, occurring in workshops and factories, became notifiable. From that time to the end of 1907, over 500 cases have been brought to the notice of the Home Office. Beside these cases of industrial anthrax many others arise, chiefly from contact with animals or animal carcases affected with anthrax; these are not notifiable in this country.

The proportion of industrial to non-industrial cases of anthrax is about 4 to 3.

An analysis of cases of anthrax notified between 1898 and 1907 shows:

(1) A progressive increase in the number of cases in the woollen and worsted industries, probably due to the increased use of dangerous classes of wool.

(2) A progressive increase in the rate of mortality, due to the larger number of internal cases among manipulators of wool.

(3) A lower rate of mortality among workers on horsehair and bristles than in other industries.

(4) A high rate of mortality in the group of miscellaneous industries in which anthrax is not usually suspected, the diagnosis being then made too late for effective treatment.

In order to make an early diagnosis it is essential for anthrax to be suspected from the nature of the employment.

Among bristle and horsehair workers:

(1) Anthrax is more fatal to the women than to the men.

(2) The occupational risk is greater for the men than for the women, because the former are more often employed in the earlier, more dangerous manipulations.

(3) The occupational risk is greater and the mortality higher among the manipulators of horsehair than in brushmaking.

(4) Horsehair is from 8 to 10 times as likely to give rise to cases of anthrax as are bristles, and the risk of infection is greatest from Chinese, Russian and Siberian raw materials; this is confirmed by actual experience not only in this country but abroad.

(5) The risk to workers on horsehair is greater than the risk to workers on wool.

The nature of the lesion varies considerably with the industry, inhalation of spores being uncommon in any but the woollen industry, though internal cases undoubtedly occur among horsehair manipulators. This is not surprising as many of the processes in these industries are similar.

The position of the pustule varies slightly with the occupation; for example, pustules on the neck are most frequent among hide and skin workers, due to the frequent carrying of skins on the shoulder. Malignant pustule is most common on the exposed parts, and of the latter those less frequently washed, as the neck and face. The infection is in most cases by the nails, which harbour the dust containing anthrax spores.

In agricultural cases lesions on the upper extremity are most common.

The mortality varies with the situation. Difficulty of operation, frequent absence of the diagnostic signs of local necrosis, looseness of the cellular tissues increase the mortality.

In all countries except Great Britain agricultural anthrax is the most common, and consequently there is a close relation between the number of cases of human and animal anthrax.

Variations in the prevalence and mortality of anthrax among human beings occur in different countries, and may to some extent be accounted for by natural constitution and environment.

There has been a progressive increase of cases in Italy, but a decrease of the death-rate, roughly corresponding to the introduction of Sclavo's serum treatment.

French statistics, as do the English, emphasize the greater risk to horsehair workers, though the risk and mortality in Great Britain compare very favourably with those in France, and still more so with those in Germany.

The danger of infection from anthrax in the manipulations of animal hair and bristles depends on the origin, kind and cleanliness of the materials, and the processes they have to undergo.

Bristles as imported vary immensely, some being well cleansed and prepared, others in an extremely dirty state, but they are always in a far more prepared state than the horsehair.

The long tail horsehair, being more valuable, is better cleansed and less likely to cause infection than the shorter mane horsehair.

Cases of anthrax occur in practically all the processes to which hair is subjected from its time of arrival even to the finished products. Further, incidence is greatest among workers in short hair as brush-makers, and in the earlier processes, *i.e.* when the hair is in a less prepared state.

Infection may be carried in clothes or nails to people outside by workers.

Anthrax spores may retain their vitality for years on hair and other materials.

The dangerous classes of hair are very generally used. This is not so in the woollen and worsted trades.

Anthrax is common among animals all over Europe and Asia, and in most countries there is an increased incidence during the hot summer

months. It is probable that in certain districts special conditions exist which make them permanent centres of anthrax infection. Here too hides and hair from contact with the soil may possibly become infected without the animals actually contracting anthrax.

Note.

References to the Literature will be found at the conclusion of the second part of this paper which will appear in the next number of this *Journal.*