The Milroy Lectures

ON

INDUSTRIAL ANTHRAX.

Delivered before the Royal College of Physicians of London.

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LECTURE I.

[ABSTRACT.]

UNDER the Factory and Workshop Act all cases of anthrax contracted in connexion with various industries have to be reported to the Home Office, and I intend to deal with the cases—261 in number—which were thus notified during the six years 1899-1904 inclusive. These are classified in the following table:

Industry.	Males.	Females.	Total.	Fatal.	Per Cent.
Worsted and wool	70	13	83	23	26.1
Horsehair and bristles	53	17	70	17	24.3
Hides and skins	86	—	86	21	24.4
Other industries	15	2	17	6	35.3
	224	37	261	67	25.6

The bulk of the wool cases occurred in the processes of wool sorting, wool combing, and spinning; those in the horsehair trade principally among hair curlers and brush makers. In the hide and skin industry they occurred at the docks, in warehouses, and tanyards, isolated cases having also been noted in the making of leather articles. The cases included under other industries are interesting. This heading includes isolated cases among workers of horn and persons employed in rag sorting, portage, etc.

The total number of persons employed in wool, worsted and shoddy manufacture in the United Kingdom in the year 1901 is stated to have been 259,909. Of these, however, only 4,264 were engaged in combing or sorting the classes of wool recognized to be specially dangerous.

Of the total cases 64 at least occurred among such persons, and this gives attack-rate of 1.3 per cent., or 0.21 per cent. per annum.

In horsehair, in all processes, the total number employed in the year 1901 was 2,206, and the number of cases at least 40, even when from this figure cases occurring in brush factories are excluded. The attack-rate is thus 1.8 per cent., or 0.3 per cent. per annum, or greater than in wool, even when the figures for the latter are limited to those manipulating the scheduled dangerous classes of wool. For particular factories, both of wool and horsehair, a very much higher attack-rate could be given.

Incidence of anthrax on persons employed in wool is centred almost entirely round the Bradford district of the West Riding (66 cases among 187,204 persons) and in Worcestershire (12 cases among 7,263 persons). This is explained by the fact that the use of the dangerous classes of wool is practically confined to these counties; elsewhere colonial wools are handled. The distribution of horsehair cases is more regular, and suggests that the dangerous classes of hair from China, Russia, and Siberia are more generally used. In the hide trade the incidence is mainly confined to the ports of London and Liverpool, and thus is comparable to that in the wool industry.

The mortality among the reported cases—25.6 per cent.—is probably higher than would be expected by medical men having knowledge only of cases treated in hospital, and less than that expected by the general lay public, which believes it hardly possible for recovery from anthrax to take place. It seems, however, to be that which is to be anticipated in anthrax when all cases are included, and when the type is mainly external. Thus, in Italy,¹ where anthrax is notifiable, in the eleven years 1880 to 1890 there were recorded 34,052 cases with 5,812, or 24.1 per cent., deaths. In 1,473 cases collected by Wilhelm Koch the rate was 32 per cent. He added, however, that these figures appeared to him to cover many cases where diagnosis was not made until late; treatment, therefore, deferred.

In the 261 cases now under consideration, the situation of the pustule was reported in 248, and these are here tabulated.

Six other cases, all from Bradford, appear to have been of the internal variety; they were all fatal.

Situation.	Number.	Per Cent.
Head and face	100	43.5
Neck	103	41.5
Upper extremity	31	12.5
Lower extremity	3	1.2
Trunk	3	1.2

The situation of the pustule appears to vary in a measure with the occupation of the patient, and is certainly of considerable moment in determining the severity of the disease. Thus, in the cases under review, of 13 on the upper eyelid 6, or 46.0 per cent., were fatal; of 103 on the neck, 31, or 30.0 per cent.; of 19 on the forehead, 2, or 10.5 per cent.; and of 31 on the upper extremity (including the shoulder), 4, or 12.9 per cent.

The figures which I have given for this country exclude the cases which have occurred to the numerous class of persons who come into contact with animals infected with anthrax during life, or have taken part in their slaughter and disposal of the carcasses. Unfortunately in no country can more than a guess be made at the number thus engaged who suffer. In Great Britain, however, the annual returns of the causes of death published by the Registrar-General are of material help.

The following table shows the number of registered deaths from anthrax since 1882, and since 1899 the large share of them borne by those due to factory and workshop conditions:

Registered Deaths from Anthrax since 1882.

Year.	Males.	Females.	Total.	Year.	Males.	Females.	Total.	Deaths Due to Factory or Workshop Conditions.
1882	10	5	15	1893	6	1	7	—
1883	5	3	8	1894	7	3	10	—
1884	13	5	18	1895	11	2	13	—
1885	7	4	11	1896	8	1	9	—
1886	8	3	11	1897	16	2	18	—
1887	10	1	11	1898	16	2	18	—
1888	11	1	12	1899	16	5	21	17
1889	6	1	7	1900	10	—	10	7
1890	3	1	4	1901	11	1	12	10
1891	1	2	3	1902	12	1	13	9
1892	5	1	6	1903	15	1	16	12

In 1901 deaths not due to factory conditions were those of a butcher and a fireman in the merchant service; in 1902 of two farmers, a shepherd, and an auctioneer and valuer (the latter had assisted in dressing a dead carcass); and in 1903 of a grocer's assistant, a farm labourer (contracted from bone manure), a butcher, and a gamekeeper.

The figures show a marked increase in the decade 1894-1903 (140 deaths) as compared with the previous one (90 cases).

Complete comparison with other countries is not possible, but from such information as is obtainable it would appear that in other countries anthrax in the human subject is derived much more from contact with the carcass of a dead animal than from the spores contained in the wool, horsehair, hides and skins of animals imported from afar. This being the case, it is of all the greater interest to consider the source and comparative value and quantity of the material which gave origin to the 261 cases now under review. No single case has with certainty been traced in the six years to wool from Australia and New Zealand, which in the year 1902 was valued at £13,537,457. On the other hand, at least 30 cases with certainty, and possibly 40, have occurred from use of Persian wool, valued in 1902 at £13,159. At least 21 cases, again, have occurred from use of mohair and van mohair imported from European and Asiatic Turkey, the value of which in the same year was £746,818.

In horsehair at least 22 cases are traceable to material from China valued in the year in question at £40,758, or, if bristles be added, at £188,650, and several cases also to Russian material valued at £266,497, whereas suspicion only attached to £421,235 worth of material imported from all the other countries in 1902.

To hides and skins imported in the wet condition (mainly from Italy and South America through the ports of

Germany, France, Holland, and Belgium) only 2 cases could with any certainty be traced, although the value of such material in 1902 was valued at £1,595,109. To dry hides, on the other hand, 19 cases were due during manipulation of material from China valued in 1902 at £87,989, and a similar number to Bombay and East Indian raw dry hides valued at £265,422.

The part played by the introduction of raw foreign material having thus been shown, the conditions which favour the occurrence of anthrax amongst the animals in the countries whence these materials come may be considered, especially in Asia. These appear to be conditions of soil, and of climate, and the primitive nomadic life of many of the inhabitants which takes no thought of rational preventive measures. Anthrax in animals is common in all parts of the world. Official figures² showing the gross number attacked in a few countries are set down in the following table for the years 1901 to 1903:

Country.	Cases of Anthrax in Animals.		
	1903.	1902.	1901.
Great Britain	1,143	1,032	971
Germany	4,626	4,852	5,843
Italy	3,959	6,099	2,604
European Russia and the Caucasus	47,300	42,423	54,731
Asiatic Russia	4,200	6,802	6,888

For one country in Asia statistics of the prevalence of cattle diseases may given, namely, India:

India.	1899.	1900.	1901.	1902.	1903.
All animal diseases ...	343,906	304,931	249,691	228,666	258,419
Anthrax	33,667	36,070	25,997	28,081	30,715

Whether these Indian figures be regarded as absolutely accurate or otherwise, the statement remains in the report³ from which they have been derived that rinderpest and anthrax are the "two most prevalent fatal diseases of Indian cattle"; while it is to be noted that in the recent Thibetan mission⁴ it is stated that it was chiefly anthrax which reduced the number of yaks which accompanied the force from 3,000 to 1,450.

Too much stress must not be laid on the greater number attacked in one country over another, in the absence of knowledge of the number of animals in each country. The actual incidence of the disease in proportion to the number of animals I can only give for Germany and Great Britain:

Incidence of Anthrax per 10,000 of Each Class of Animal.

Country.	Year.	Horses.	Cattle.	Sheep.	Goats.	Swine.
Germany	1902	0.32	2.11	0.64	0.02	0.05
"	1903	0.36	2.11	0.35	0.03	0.08
Great Britain	1904	Not stated	1.2	0.02	Not stated	0.8

Although this is the average for the whole of the countries named, incidence in particular districts is far greater. Thus among cattle in the district of Düsseldorf it was 11.15 per 10,000, in Zwickau in Saxony 8.8, in Chemnitz, also in Germany, 8.5, and in Anhalt 6.6. In this country in 1903 in Haddington it was 15.4 per 10,000, and in Aberdeenshire 4.9. Interest for us centres round the large figures obtained from Russia. Their importance in establishing the law underlying the whole question of the incidence of anthrax among animals in Asia and in man in this country is brought out by distributing the cases month by month over a period of years as has been done in the following table.

Until March of each year there is practically no change in the incidence; there is then an enormous development of the disease, reaching its maximum in July and August, followed by a rapid fall in September and October; in November and December is reached the same figure as that for the early months of the year.

In contrast to this, figures taken quarterly in Great Britain show least incidence of anthrax in the third quarter of the

year. Thus, of a total of 4,250 outbreaks in the six years 1899-1904, there occurred in the first quarter 1,114, in the second 1,166, in the third 850, and in the fourth 1,120.

Monthly Return of the Total Number of Animals attacked by Anthrax in European Russia, Asiatic Russia, the North Caucasus, and Transcaucasia from January, 1899, to September 1904.

	1899.	1900.	1901.	1902.	1903.	1904.
January	554	669	522	853	784	907
February	1,348	653	542	800	748	952
March	1,032	690	994	881	1,089	982
April	811	1,191	1,240	1,212	1,287	1,387
May	1,165	3,109	4,738	3,657	3,249	2,467
June	3,852	5,891	10,665	9,647	11,405	5,469
July	6,403	10,892	17,194	14,014	17,681	5,940
August	12,996	8,521	11,300	10,556	7,433	5,377
September	6,395	2,341	2,913	2,799	4,203	2,473
October	3,861	1,210	1,328	1,640	2,278	—
November	1,292	747	1,091	971	1,640	—
December	952	663	651	795	1,075	—

The simplest explanation of the facts stated is seasonal variation in temperature and all that this means in changes in the soil and vegetation. Greatest development of the anthrax bacillus takes place at a temperature of 35° C.; multiplication is arrested below 12° C. and above 45° C.; and cooling below the freezing point does not kill it. Spores are most readily produced at a temperature of 32° C. Below 18° C. and above 42° C. the capacity for sporulation ceases. In studying the possible saprophytic growth of the bacillus, Koch⁵ found that excellent media for its growth could be obtained from emulsions of seeds rich in starch, such as barley, wheat, pease, and grass, and from the fresh juice of potatoes, turnips, etc. Living plant cells did not form a suitable soil, but water in which hay and straw had been allowed to decay, if neutralized and made slightly alkaline, became a suitable medium.

The characteristic of anthrax specially to infect certain districts has been known for centuries. Long before the bacillus anthracis was discovered as the *causa causans*, the epidemiology of anthrax had been studied in many different countries by Hevsinger,⁶ especially in Siberia and Germany, with results which led him to the conclusion that the conditions of climate and soil which favoured the development of anthrax in animals were the same as those which favoured the development of malaria in man. In Siberia it was most commonly met with on the salt grass steppes, in the river valleys, and round the bitter lakes. Wilhelm Koch,⁷ from consideration of the principal anthrax districts in France, Germany, and Russia, concluded that the favouring conditions of soil for the development of the disease as an epizootic were:

1. Fairly impervious soils of chalk, marl, clay.

2. Sandy soil, but only when the sand lies in a thin layer on impervious ground and when it is intimately mixed with decomposing animal and vegetable matter.

3. Peaty soils, rich in organic and mineral substances such as prairies, steppes, moor, and marsh land.

Height above the level of the sea matters little, but a definite temperature must be reached at which the growth of the bacillus and formation of spores can take place—that is, between 18° and 40° C. For a typical anthrax district is required only, in addition to the bacillus, a degree of moisture in the soil greater than that of the surrounding country, periodical high temperatures, and profuse vegetation.

In the Bavarian Alps, in Switzerland, Billings says: "The people know almost to a day how long they dare let cattle graze on the anthrax districts before they must remove them."

Factors which must not be left out of consideration, as they form important links in the chain of the creation of anthrax districts, are the insect, bird, and animal life, and the occurrence of dust storms. Marchoux and Salimbeni,⁸ for example, have shown the part played by vultures in South America in the spread of anthrax—first, by observing them devouring the carcass of an animal which had died of anthrax and subsequently by finding the bacilli in their excreta.

The number of recorded instances in which the presence of anthrax bacilli has been demonstrated in imported material is not large, but only because search has not often been made. Andrewes⁹ has cultivated bacilli from the dust shaken from a few strands taken at random out of a hydraulically-packed bale weighing 5 cwt. Andrewes,¹⁰ again, found them in Siberian hair used for brushmaking in a blind asylum in Glasgow, and Balfour Stewart¹¹ in a piece of Kurachi hide in Liverpool. Other in-

stances are given by Silberschmidt,¹² Gruber,¹³ Frank,¹⁴ and Burka¹⁵ in horsehair, and by Heim¹⁶ in goat hair. The most important, however, of such experiments are those of Webb and Duncan made at the factory of the former in Worcester. Of eight cases of China mane hair four contained anthrax, of four bales of the same material all were infected, as were also both of two samples of dust taken from large bulk quantities. From these experiments they drew the conclusion that all bales of China mane hair must be regarded as infected. Whether further development of bacilli occurs inside a bale after it has been packed has never been determined. Since the conditions of soil, temperature, moisture, and decomposing vegetable matter play so prominent a part in the development of outbreaks of anthrax among animals, any theory of direct contagion from animal to animal and dead animal to man may be readily abandoned. Dirt and sand adhering to the fleeces of healthy Bagdad sheep and mohair goats may contain spores picked up in anthrax districts. In many outbreaks from manipulation of wool, horsehair and hides, no evidence of a fallen fleece or of damaged material is forthcoming. The view expressed is, too, further supported by the fact, well known in the trade, that mane hair is considered much more likely to be infected than tail hair, inasmuch as the mane hair comes most in contact with the earth. It explains also most readily the remarkable conclusion of Webb and Duncan that it would be unsafe to assume that a single bale of horsehair from China was free from risk.

Several outbreaks of anthrax in animals have been directly traced to spores which have escaped from factories in which raw animal products are dealt with, either through pollution of streams or through refuse dust used as manure on fields. Sometimes, however, infection is even more direct. Thus, two horses at grass in a field, on to which dust from Persian wool used in the manufacture of blankets was blown, died of the disease in 1901 in Yorkshire. In a series of outbreaks near Zurich¹⁷ eight out of twenty-two animals were infected by dust blown from the chimney of a horsehair factory, and at least 7 other cases were due in one way or another to conditions in this factory. Almost the first recorded outbreak (1858) of splenic apoplexy in cattle,¹⁸ as the disease was then called, occurred in the valley of the Yeo in Somerset. The existence of a considerable glove industry at Yeovil suggests that the outbreak had relationship with factory conditions. I mention this outbreak because recently Houston¹⁹ has demonstrated the presence of anthrax (1) in the general effluent from the final catchpit in a hide factory in Yeovil, (2) in the septic tank liquor, the sludge, and the washings of coke from primary and second coke beds, and (3) in mud from the banks of the river Yeo and Yeo brook.

On the corporation sewage farm at Kidderminster, where incidence on the workers from the use of Persian wool during the same period has been high, there have been eleven outbreaks since 1897. An outbreak on the sewage farm at Market Harborough in October, 1904, synchronized with the occurrence of 3 cases of malignant pustule in men employed at a tannery, where previously no case had been known to have occurred. Illustrative outbreaks of a similar nature have been described by Mr. Spear,²⁰ and are reported from Germany²¹ and the United States.

While, however, in some cases the association of outbreaks of anthrax in animals with factory and workshop conditions is clear, the evidence, when closely examined in this country, fails to show that incidence of outbreaks of anthrax in cattle is greatest in counties where industries connected with wool, or with raw animal products, are mostly carried on. This point has been treated by me elsewhere.²² Indeed, incidence on animals appears to be greatest in counties where danger from factory conditions appears most remote; for instance, incidence of anthrax on animals is twice as great in Scotland as it is in England; yet incidence on the human subject from wool is negligible in Scotland as compared with England. No doubt the direct influence of a particular factory in causing anthrax in animals operates over an extremely limited area, but the use made of refuse dust from wool and horsehair factories as manure is an unknown quantity, and may be the cause of many outbreaks the origin of which cannot be traced. Most cases are rightly attributed to the consumption by cattle of infected fodder, either from direct grazing on fields where previously cattle had died from the disease, or from grass which has been cut from places where animals have died, or where the carcasses have been buried at an insufficient depth.

As showing the probable relation of the bacillus to the soil, I would cite as instructive the tracing of outbreaks in 1903

and 1902²³ to the feeding of cattle on turnips grown near the place where an animal had been slaughtered from anthrax, and of the death of six oxen out of a shed containing 100 animals from consumption of raw potato skins to which the spores of anthrax must have been attached, as only the six oxen thus fed succumbed.

But neither recital of such cases as these nor those resulting from insufficient disinfection in the disposal of the carcass, nor from industrial conditions, explains sufficiently all the outbreaks, especially the erratic ones which occur on farms where never before has an outbreak been known to have occurred. To account for these MacFadyen²⁴ suggests two possible sources: (1) artificial manure, and (2) imported feeding stuffs. Against the view that artificial manure can be the cause he cites "the erratic way in which outbreaks occur throughout the country apparently quite unconnected with the more or less liberal employment of artificial manure." In analysing 39 consecutive outbreaks, in 29 of which there was no previous history of anthrax having been known on the farm, he found that in 26 of the 39 outbreaks the animals were receiving a diet into which artificial food in different forms entered, he says:

The circumstances connected with the series of outbreaks deepens the suspicion which already existed that a considerable number of cases of the disease in this country have an extraneous source of infection, and that the vehicle of infection is not infrequently some artificial food-stuff of which the raw material is derived from a foreign country.

In one outbreak on cattle, causing the death of six valuable shorthorn cattle, he isolated the bacillus from linseed cake, and in this outbreak, as soon as the linseed meal was stopped, the outbreak ceased. In another outbreak among horses in London similarly the bacillus was isolated from the oats.

Of the outbreaks in Germany in 1903 Russian bran was believed to have been the cause in several instances. Five outbreaks from this cause have been cited in farms where anthrax had never occurred before. In 1902, fodder consisting either of bran, barley, or hay from Russia is cited as having been believed to be the cause of the outbreaks in seven instances. In 1901, in addition to fodder imported from Russia, reference is made to two farms believed to have been infected from fodder grown in the tropics.

In the light of these statements the explanation of the attack mentioned in the commencement of this paper of a man unloading corn, of a corn dealer, and of a person carrying sacks of potatoes is easy. If the soil under certain conditions is recognized as a suitable medium for the growth of the bacillus, it becomes no longer necessary always to seek for the material cause in raw animal products alone.

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- ³ Annual Administration Report of Civil Veterinary Department in India.
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- ⁶ *Die Milbrand Krankheiten der Thiere und des Menschen*. Erlangen, 1850.
- ⁷ Loc. cit., p. 91, et seq.
- ⁸ *Annales de l'Institut Pasteur*, 1903, p. 564.
- ⁹ Annual Report of Chief Inspector of Factories, 1899, p. 263.
- ¹⁰ *Ibid.*, 1900, p. 471.
- ¹¹ *Ibid.*, 1901, p. 239.
- ¹² *Zeitschrift für Hygiene*, vol. 20, p. 455.
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FEVERS IN INDIA.—A special report on the prevalence of fevers in the Dinapur district in Bengal has recently been published by the Government of India. The death-rate attributed to "fevers" having risen considerably, Captain Rogers, I.M.S., was specially sent to inquire into the matter. He found that chronic malaria—the chronic fever produced by Leishman's parasite—dysentery, pneumonia, phthisis, enteric, and other diseases were responsible for this large death-rate. The distribution and varieties of *Anopheles* in the district selected were also studied, and *A. fuliginosus*, *A. rossii*, and *A. listoni* were found to be the common species. The latter is probably the only one that spreads malaria in natives. and Rogers points out that, in dealing with the question of prophylaxis, it is important to direct attention to the destruction of the harmful species in particular. He further believes that great circumspection is required in recommending measures for destroying *Anopheles* in Lower Bengal, and looks more to the general distribution of quinine as the main factor in the reduction of malaria.