

THE PROPORTIONAL FREQUENCY OF THE HUMAN AND BOVINE TYPES OF TUBERCLE BACILLI IN HUMAN PULMONARY TUBERCULOSIS IN THE MIDDLE AND SOUTH OF SCOTLAND

BY A. STANLEY GRIFFITH, C.B.E., M.D., PH.D.
Member of the Scientific Staff, Medical Research Council

From the Field Laboratories, Cambridge

UNTIL recently, in all but specialized medical circles, ulcerative pulmonary tuberculosis was regarded as being due to the human type of tubercle bacillus and as being transmitted from man to man through the agency of human sputum. The possibility that the bovine tubercle bacillus might occasionally cause pulmonary disease and appear in the sputum was first revealed by the work of Griffith for the Royal Commission on Tuberculosis (1911) on material from the south of England, but later the occurrence of this form of tuberculosis was shown to be almost negligible in that region.

As a matter of historical interest, the first case of ulcerative pulmonary tuberculosis due to bovine bacilli was recorded by Cobbett working for the Commission (1907), though in this case the bacilli were not detected in the sputum during life but in the lung after death.

A male child (H. 59 "L. B."), aged 2½ years, died of general tuberculosis. The autopsy showed numerous tuberculous ulcers in the intestines, several enlarged and caseous mesenteric glands, caseous tubercles in the cervical glands, extensive tuberculous infiltration of the lungs with small cavities, small tubercles in the kidneys and small caseous abscesses in the brain. Fully virulent bovine strains were cultivated from the mesenteric and cervical glands, lungs and brain.

Following Koch's statement (1908) that adult phthisis had never been shown to be due to the bovine type of tubercle bacilli Griffith (1911), when working for the Royal Commission on Tuberculosis, examined twenty-nine cases of pulmonary tuberculosis and found tubercle bacilli of the bovine type alone, by repeated examination, in the sputum of two cases, males aged 21 and 31 years respectively. In 1914 he reported one case from Edinburgh, and in 1916 Wang reported a further case from the same city.

In 1922, that is to say 13 years after the first English cases had been discovered in 1909, only these four cases of pulmonary tuberculosis attributable to tubercle bacilli of the bovine type had been reported in Britain and a few doubtful cases of mixed infection with human and bovine bacilli on the Continent. Then in the years 1920–2 Munro isolated from sputum 100 strains of tubercle bacilli for serological purposes (reported by Munro & Cumming, 1926) and discovered among them two pure cultures of (slightly attenuated)

366 *Tubercle bacilli in human pulmonary tuberculosis*

bovine bacilli and one culture which was a mixture of standard human and bovine bacilli. This finding led to the continuance of the work in Scotland and to its wider extension in England.

It is not my purpose here to summarize the results of all the inquiries that have been made and reported in different parts of Great Britain, but merely those which I personally have conducted in the middle and south of Scotland. The inquiries of Munro have covered much the same ground, and it will be of interest later on in this paper to compare the percentages of bovine infections in the two series of cases.

DETAILS OF THE INVESTIGATION

I am greatly indebted to several Medical Superintendents of Sanatoriums and Medical Officers of Health for their kindness in providing me with specimens of sputum from cases of pulmonary tuberculosis. Dr G. W. Elder began to send me sputum in November 1931, and has continued to do so until the present year. Dr C. Cameron sent me specimens from December 1931 to August 1934. The remaining specimens were received in the years 1933-8.

During the period covered by this inquiry I have obtained cultures of tubercle bacilli from the sputum of 515 persons suffering from pulmonary tuberculosis living in the middle and south of Scotland.

The specimens from fifty-three cases were negative culturally. Of these forty-five showed no acid-fast bacilli on microscopical examination, repeat specimens being obtained in seven instances. In the remaining eight cases acid-fast elements were found microscopically, though in four they were found only after long search, but all attempts to grow them failed.

Table 1. *Source of material*

No. of cases	Sender	County	Human		Bovine	Bovine %
			Eugonic	Dysgonic		
317	Dr G. W. Elder	Lochmaben Sanatorium, S.W. Scotland	290	4	23	7.2
144	Dr C. Cameron	East Fortune Sanatorium	137	2	5	3.5*
3	Dr C. C. Finlator	Clackmannan	1	—	2	—
2	Dr McWhan	Berwickshire	1	—	1	—
21	Drs Grant & H. Scott	Ayrshire	20	1	—	—
26	Dr H. F. Cameron	Perthshire	25	1	—	—
2	Dr R. A. Hunter	Renfrewshire	2	—	—	—
515			476	8	31	6.0

* If the eighteen cases with one bovine infection from this Sanatorium examined by Munro during the same period are included the percentage is 3.7.

Table 1 shows that thirty-one (or 6.0%) of the 515 cases examined were bovine infections and 484 were human infections, of which 476 were eugonic and eight were dysgonic. The essential clinical particulars of the cases yielding bovine tubercle bacilli are given in Table 2. Some have already been published in full (Griffith & Munro, 1933).

BACTERIOLOGICAL OBSERVATIONS

All the strains were isolated directly from the sputum with the aid of potassium hydrate. Equal parts of sputum and 5% KOH were thoroughly mixed and incubated for $\frac{1}{2}$ – $\frac{3}{4}$ hr. at 37° C. At the end of this period a small drop of the mixture, without neutralization, was spread over each of two or three egg tubes and one 5% glycerin egg tube. The strains were grouped culturally according to their appearances in primary culture on egg and glycerin egg and in subculture on glycerin egg and glycerinated potato. They were thus divided into three groups: 476 cases yielded eugonic human, eight cases yielded dysgonic human and thirty-one cases yielded dysgonic bovine strains. In all except three of the last cases more than one strain of tubercle bacilli was obtained. Altogether seventy-two strains were isolated from the thirty-one cases, sixty-two from sputum, the intervals between the specimens ranging from 14 days to 3½ years, and ten from post-mortem material (four cases).

In one instance only the different strains differed in cultural characters and in virulence. In this instance a bovine and a human strain were obtained from the same patient on different occasions. The case was case 5 from which five specimens of sputum were received. The first specimen gave negative results microscopically and culturally. From the second specimen cultures of bovine tubercle bacilli were obtained directly, four typical colonies growing on two egg tubes. The third, fourth and fifth specimens were negative microscopically and culturally but the last produced tuberculosis in a guinea-pig from which a culture of human type of low virulence for the rabbit was raised. The sputum has not since proved positive microscopically.

I have considered this case to be primarily a bovine infection because bovine tubercle bacilli were isolated in pure culture directly from the sputum on the first occasion. I explain the presence of the human bacilli as a chance infection of the sputum in the Sanatorium through air-borne bacilli in the inspired air. However that may be, it is impossible to be certain whether or not both types are concerned in the production of the pulmonary tuberculosis in this case until further strains have been examined.

Virulence tests. Of the eugonic strains three were tested on the rabbit and proved slightly virulent for this species. Of the eight dysgonic human strains seven were tested on the rabbit and two were tested on the guinea-pig; they exhibited the virulence of the eugonic human type, that is to say, they were slightly virulent for the rabbit and highly virulent for the guinea-pig. The culturally bovine bacilli from thirty cases proved fully virulent for the rabbit, all the strains producing typical general tuberculosis, the disease with few exceptions being of maximum severity. With the strains from these thirty cases eighty-three rabbits were inoculated, twenty-five intravenously with doses ranging from one-millionth of a primary egg tube to 0.01 mg. and fifty-eight subcutaneously with doses which varied from about 1.0 to 10.0 mg. Of the twenty-five rabbits inoculated intravenously nineteen, doses 0.01 and 0.001 mg., died of general miliary tuberculosis in from 13 to 52 days and six of severe general tuberculosis in 47, 105, 128, 77, 85 and 113 days respectively. The last six rabbits received small doses, three about a ten thousandth, one a hundred thousandth and two each a millionth of a primary culture, the whole amount of such a culture being equivalent to 1.0 mg. or less. Eleven rabbits

inoculated intravenously with a thousandth of a primary culture died of severe general tuberculosis in from 19 to 58 days (average 35·7 days).

Of the fifty-eight rabbits inoculated subcutaneously three died prematurely in from 20 to 34 days and showed general tuberculosis not sufficient to account for death; four died of chronic moderately severe general tuberculosis in 100, 102, 113 and 116 days respectively, and fifty-one died of typical general tuberculosis in from 21 to 94 days, average 57·3 days.

The remaining bovine case, case 28, yielded two strains at an interval of 83 days. The first strain was injected in a dose of 5·0 mg. subcutaneously into a rabbit, which was killed 140 days later. The autopsy showed, besides a local lesion and caseous adjacent glands, about a third of the lungs replaced by caseous masses, a few small tubercles in the kidneys and one tiny tubercle in a lachrymal gland. This strain was also injected into two guinea-pigs subcutaneously, the dose for each being about 0·1 mg., a little of the culture in each case, as was later found, going into the peritoneal cavity. The guinea-pigs died in 77 and 97 days of general tuberculosis, which, however, was not of full bovine severity, and as the injection was partly intraperitoneal—the omentum being affected—the duration of life in each instance was longer than it would have been had the bacilli been fully virulent. The second strain of case 28 was injected intravenously in a dose of 0·001 mg. into a rabbit which died in 101 days of general tuberculosis of moderate severity. It may be noted that the average duration of life of rabbits injected intravenously with 0·001 mg. was 35·7 days.

Both in the rabbit and the guinea-pig the results indicated that the strain fell a little in virulence below that of standard bovine strains. It was, however, impracticable by further experiments to confirm this conclusion.

Bovine strains from cases of phthisis pulmonalis rarely show any alteration in pathogenicity as a result of residence in the human subject. In Munro's series there were five instances of attenuated bovine strains from sputum, and in one of these patients the vertebral column, as in my case (case 28), was tuberculous long before the lungs were affected. Attenuated bovine strains have been occasionally obtained from bone and joint lesions and also from one case of peritoneal tuberculosis. The rare occurrence of attenuated bovine strains in lung, bone and joint and peritoneal tuberculosis is in striking contrast to the frequency with which they are found in the skin tubercloses, particularly in lupus.

ANALYSIS OF THE BOVINE CASES

Of the thirty-one persons with bovine tubercle bacilli in the sputum fifteen were males and sixteen were females.

The ages of the patients when bovine strains were obtained from them varied from 17 to 61 years. Five of the patients were 17–18 years, fifteen were 20–29 years, eight were 30–37 years and three were 48, 58 and 61 years of age respectively. More than two-thirds of the patients, therefore, began to

discharge bovine tubercle bacilli in the sputum before they were 30 years of age.

The occupations were various but chiefly those associated with country life. Thirteen persons were employed in household duties. Three were workers on farms (two having to milk the cows) and two were farmers, one being a cattle dealer also. Five patients were brought up on farms and pursued other avocations in later life. Most of the other patients drank a good deal of raw milk daily in childhood and later life. Among the 476 persons with human tubercle bacilli in the sputum twenty-four were farmers or worked on farms.

The duration of clinical pulmonary tuberculosis, i.e. from the first sign of pulmonary disease to the finding of tubercle bacilli in the sputum, varied in 25 instances from about 3 months to 5 years. There is little doubt that in most of the cases the ulcerative pulmonary tuberculosis had lasted longer than stated and could have been detected at a much earlier stage. In six instances the period was not determined but was of long duration.

The distribution of the thoracic tuberculosis varied from affection of one lobe to gross infiltration of the lungs on both sides with profound systemic disturbance. In general a cavity system was found by clinical or X-ray examination in one or both upper lobes with infiltration of other lobes due to aspiration pneumonia.

The pulmonary tuberculosis was associated with other obvious tuberculous lesions in ten cases. They occurred in the cervical glands in eight patients, once (case 8) subsequent to the clinical pulmonary disease and seven times antecedently. The intervals between the enlargement of the glands and the development of clinical thoracic tuberculosis ranged from 2 years or so to about 26 years.

In case 5 tuberculous cervical glands were incised about 2½ years before the patient was notified. In cases 10, 23, 29, 11 and 19 the intervals were about 4, 7, 11, 14 to 16 and 26 years respectively. In case 6 the interval could not be determined but was long, the woman having had neck glands in early childhood; she also had tuberculosis of the larynx and an old spinal lesion. In each of three cases (7, 14 and 24) autopsy showed a calcareous mesenteric gland or caseo-calcareous mesenteric glands which were free from living tubercle bacilli. Cases 7 and 28 both had spinal tuberculosis of old-standing; one of these (case 7) died and caseous and calcareous mesenteric glands were found at autopsy.

There was tuberculosis in other members of the families in six cases:

Case 1. The father died of bronchitis, aged 60, and two sisters and a brother of acute pulmonary tuberculosis. This may have been an example of familial tuberculosis with the bovine tubercle bacillus.

Case 5. The paternal aunt died of pulmonary tuberculosis, aged 21, and a nephew developed tuberculosis of the spine at the age of 10. The family lived together at a farm where a cow died of tuberculosis when the patient (case 5) was 10 years old.

Case 17. The maternal uncle died of tuberculous hip.

Case 18. Of five brothers and sisters one, aged 10, has had pleurisy.

Case 24. Of two sisters one, aged 19, died of pulmonary tuberculosis and one, aged 31, suffers from asthma.

Case 28. One sister died of tuberculous meningitis in 1912.

370 *Tubercle bacilli in human pulmonary tuberculosis*

From none of these relatives was it possible to obtain material for determining the type of tubercle bacillus.

Inquiries among the ten married persons, two or three years ago, elicited that there were twenty-nine children, 10 years of age and under. All were then reported to be in good health.

Most of the patients are recorded as having drunk raw milk daily and, as already stated, several lived or were brought up on farms.

AUTOPSIES

Of the thirty-one patients infected with bovine tubercle bacilli seven died during the period of observation and autopsies were made on five, two of which have been fully reported (Griffith & Munro, 1933 and 1935).

Case 3. Autopsy. The right lung was free from adhesions and showed fibro-caseous disease with cavities affecting about two-thirds of the lung and spreading outwards mainly from the root. The left lung was firmly adherent to the diaphragm at the base where it enclosed thick pus; the lung itself was in a similar condition to the right but the disease was not so extensive in the upper lobes; there was however more cavitation and at the base there were some large subpleural caseous nodules.

The bronchial glands were anthracotic but there was caseation of the intertracheo-bronchial glands only, the right being 3-5 cm. in length and more than half of it caseous; three others on the left side showed slight caseation. The abdominal lymphatic glands were free from lesions. The appendix was fibrosed and bound down by adhesions.

Case 7. Autopsy (abstract from notes by Dr Agnes R. Macgregor, Pathologist, Royal Hospital for Sick Children, Edinburgh). Spinal deformity in lower lumbar region with kyphosis; no evidence of active tuberculous disease in affected vertebrae or in spinal canal. Both pleural sacs obliterated by very dense fibrous adhesions over posterior aspect of each upper lobe, more extensive and dense on left than right side. The lungs were the seat of a very extensive tuberculous process, most advanced in posterior parts of upper lobes. These parts contained almost no functional lung substance and were largely obliterated by fibrosis and riddled with small ramifying cavities. The cavities were larger in both lobes of the left lung, especially in the lower part of the upper lobe where they were about 1.5 cm. in diameter; these had caseous contents and fibrous walls. Most of the cavities were smaller and bronchiectatic in distribution. There had been a recent haemorrhage and several cavities contained blood clot, but the bleeding point was not found. All the remaining parts of both lungs contained numerous hard tubercles, mostly in clusters, some calcified. Tracheo-bronchial glands, slightly enlarged and pigmented, contained small discrete tubercles, none caseous or calcified. Some mesenteric glands were greatly enlarged, caseous and softened and one was calcified. No other tuberculous lesions in thorax or abdomen. Brain: a small hard tuberculous nodule was found in the grey matter of the left parietal lobe and two firm tubercles were seen on the surface of the same lobe. Dr C. A. Green isolated tubercle bacilli of the bovine type from a tracheo-bronchial gland. The results with the cerebro-spinal fluid were negative.

Case 9. Autopsy. The right lung was generally adherent and completely fixed at the apex, which tore on attempting to remove the lung, exposing a large cavity filled with several ounces of dark green fluid. The left lung could not be separated; a portion sent to Cambridge was dense, anthracotic and infiltrated with caseous softened areas, 3-4 mm. in diameter. The bronchial glands were intensely anthracotic but free from caseation or calcification; one gland below and behind the bifurcation was greyish in the cortex for about 1 cm., the area under 8 × resembling aggregated tubercles. In the abdomen the only glands detectable were the ileo-caecal, which were very hard and fibrosed.

Case 14. Autopsy. The parietal and visceral pleurae were largely adherent. The left lung was almost completely destroyed and converted into a sac filled with purulent fluid; the lower part was friable. Right lung, upper part destroyed and converted into a bag of pus; the lower lobe showed caseating pneumonic patches and cavities; some parts were crepitant. The tracheo-bronchial glands—very anthracotic—showed no caseation or calcification. The mesenteric glands contained three completely calcified nodules.

Case 24. Autopsy. The lungs, which filled the thoracic cavity, were firmly adherent to the upper halves of the chest wall and to the diaphragm and were removed with difficulty. They were severely affected, more than two-thirds of the upper parts of the lungs showing old cavities and caseous pneumonic areas, very little crepitant lung tissue remaining.

In the left upper lobe there were two irregular cavities, one about 2 cm. or more in diameter, situated posteriorly about midway between the apex and the hilus and one, 5 cm. in diameter, in the lower part of the lobe, its wall being intimately adherent to the lower lobe. The apex of the right upper lobe, which was fibrosed and shrunken, was ragged and torn and contained a large anfractuous cavity, 5 cm. in greatest diameter. On the posterior aspect of this lobe there was a depressed puckered area, a section through which showed a thick fibrous wall and a collection of what seemed to be old caseous substance, 1.5 cm. in depth and 0.5 cm. in width. In the apex of the right lower lobe there was a cavity, about 5 cm. in diameter; it was crossed by a fibrous trabeculum and its wall posteriorly seemed to be merely thickened pleura, which was adherent to the chest wall.

The upper (apart from the cavities) and right middle lobes were composed for the most part of caseous pneumonic areas—some firm, some softened—which in places projected from the surface as bosses; the softened areas showed small cavities here and there.

The lower lobes, excluding the cavity already described and some caseous pneumonic areas in the margins and upper parts, were crepitant and contained scattered dark pigmented tubercles. Besides these there were three abscesses, two subpleural, about 0.5 cm. in diameter, and one in the depth of the lobe; the last was 2 cm. in diameter and had a thick capsule with a pea-sized hernial protrusion into the parenchyma, apparently a recent rupture. The mucous membrane of the bronchi was congested and some of the bronchi to the upper lobes were occluded with caseo-pus.

The tracheo-bronchial glands were fairly large, congested, oedematous and anthracotic; there was no sign of caseation or calcification. One mesenteric gland contained a bean-shaped stony-hard calcareous nodule, 1 cm. in greatest diameter. Dr Elder sent me the tissues of this case for description.

Microscopical examination. Lungs: t.b. + + +; they varied in length and, except the shortest, were beaded; they seemed rather stouter than human bacilli usually are.

In three of the five autopsies the mesenteric glands contained from one to three nodules, calcareous in two and calcareo-caseous in one, and there is little doubt that in each of these instances the bovine bacillus gained access to the body through the mucous membrane of the intestinal tract. It may be noted that in each of these cases the tracheo-bronchial glands were not macroscopically tuberculous. In the other two cases none of the glands bordering the alimentary tract showed macroscopic tuberculous lesions, but the ileo-caecal glands in one were hard and fibrosed and may originally have been infected with bovine tubercle bacilli. The bronchial glands in this case showed no signs of caseation or calcification. In the fifth case the intertracheo-bronchial glands showed some caseation but this was not sufficient to say that the primary infection was respiratory in origin.

Table 2. *The clinical particulars of the 31 cases of pulmonary tuberculosis with bovine tubercle bacilli in the sputum*

No. of case and serial no. in brackets	Sex and age	Occupation and county	Duration of clinical P.T.	Distribution of pulmonary and other lesions
Date of sputum				
1 (18)	F. 32	Domestic servant, Kirkcubright	? 5 years	Left upper lobe infiltrated, fibrotic and breaking down. On right side, root shadow spreading into upper lobe, breaking down
December 1931				Whole left lung, dense perihilar consolidation, softening in centre. Right upper, small cavity
2 (23)	F. 25	Housewife, Linlithgow, Westlothian	1 year 9 months	Right lung infiltrated, mainly about root, spreading into upper and lower lobes, breaking down. Left lower, pleural thickening. (Died 1932, see p.m.)
December 1931				Root-spread infiltration into upper and lower lobes; cavitation in upper
3 (88)	F. 33	Farm work, Cumberland	Less than 1 year	Left upper lobe and root; root-spread type. Neck glands incised 2½ years ago
May 1932				Left lung, whole of; thick walled cavities in upper. Right lower, less extensive. Larynx affected. T. of lower spine. Neck glands in early childhood. (Died 1932.)
4 (92)	F. 27	Domestic service, Dumfries	More than 2 years	Whole left and upper right. T. of lower spine. Old mesenteric glands at autopsy
May 1932				Left upper half infiltrated; root shadows. Neck glands at 27. Perineal abscess at 20 (Died 1933, see p.m.)
5 (94)	F. 24	Domestic service, Dumfries	Notified Dec. 1931	Left upper half with vomica. Spread from right root. Suppurating neck glands at 13
December 1932				Right upper lobe, huge cavity; lower lobe infiltrated. Left central zone infiltrated, spreading into upper and lower lobes. Tonsillar gland at 41. Calcareous neck glands excised at 59
6 (106)	F. 28	Domestic service, Midlothian	?	No particulars except that it was an ordinary case of P.T.
June 1932				Gross infiltration whole right lung and involvement left root
7 (145)	M. 17	None, Westlothian	?	Whole left and upper right. Lower right caeating pneumonia. Mesenteric glands, 3 completely calcified nodules
September 1932				Both upper lobes infiltrated but no cavities; slight right base
8 (172)	F. 28	Housekeeper, Dumfries	More than 1 year	Left, large cavity upper third. General stippling both lungs
December 1932				
9 (183)	M. 30	Miner, Midlothian	Bronchitis from 5 years of age	
January 1933				
10 (238)	F. 17	Domestic service, Dumfries	"Influenza", May 1932	
June 1933				
11 (245)	M. 61	Miner, Linlithgow	Cough and slight breathlessness 4 years	
June 1933				
12 (299)	F. 29	Housewife, Berwick	No history	
December 1933				
13 (316)	M. 18	Farmer and cattle dealer, Dumfries	Night sweats, Aug. 1933. Cough and sputum, Dec. 1933	
April 1934				
14 (324)	F. 27	Housewife, Clackmannan	7 months	
May 1934				
15 (325)	M. 29	Labourer, Clackmannan	2½ years	
May 1934				
16 (375)	M. 58	Mason and granite worker, Kirkcubright	1 year	
May 1935				

Table 2 (continued)

No. of case and serial no. in brackets.	Sex and age	Occupation and county	Duration of clinical P.T.	Distribution of pulmonary and other lesions
Date of sputum				
17 (380)	M. 25	Barber and Bookie's clerk, Kirkcudbright	About 4 months	Left upper two-thirds infiltrated, spreading to right root
18 (406)	F. 18	Farm worker for 4 years, Dumfries	Began with pleurisy, April 1935. Septic tonsils excised 1933	X-ray picture shows fine mottling in lower half of right lung and enlargement of both root shadows
19 (453)	M. 31	Electrician, Dumfries (Burgh)	About 2 years	Both upper two-thirds infiltrated with cavities. Neck glands enlarged at 3
20 (467)	F. 20	Domestic service, Wigtown	A few months, since 1 Jan. 1937	Both roots and left lower lobe, latter fibro-caseous
21 (473)	M. 34	Farmer, Dumfries	Very longstanding from X-ray picture. Haemoptysis Nov. 1936 and April 1937	Fibro-caseous disease of both upper lobes. Throughout rest of lungs "heated" tubercles (X-ray). (Died 2 days after sputum sent for examination)
22 (498)	M. 48	Joiner, Dumfries	Pleurisy right side, Feb. 1937, then night sweats, cough and sputum	Enlargement of root and apical shadows and two calcifying lesions in left subclavicular area. Thickened pleura at right apex
23 (503)	M. 29	Book-keeper, Dumfries	Haemoptysis, Dec. 1933 (4 years)	Left upper lobe infiltrated. Cervical glands excised at 18
24 (516)	F. 34	Housewife, formerly domestic servant and nurse, Dumfries	Had cough in 1930 when she married. Dry pleurisy left side in 1935. Diagnosed P.T. in 1937	Gross infiltration of both lungs. Calcareous mesenteric gland at autopsy
25 (530)	F. 27	At home (unmarried), Dumfries	Acute illness about 3 months ago. Never been "well"	Dense caseating disease of upper two-thirds of both lungs. (Died 4 December 1938, autopsy refused)
26 (531)	F. 36	Housewife, Kirkcudbright	Cough and sputum, 1936 (after birth 2nd child). Diagnosed P.T. Oct. 1938	Gross disseminated tuberculosis of both lungs. Left lung breaking down
27 (537)	M. 24	Labourer, Wigtown	Cough, Mar. 1938. Sputum, June 1938. Gastritis for 6 months at 16	Infiltration of middle third of left lung and of upper third of right lung
28 (540)	M. 29	Timekeeper, Dumfries	Cough and sputum, May 1938	Acute dorsal kyphosis and narrowing of rib spaces preventing accurate examination of lungs. Lower dorsal spine, 1919
29 (543)	M. 37	Electrician, Dumfries (Burgh)	Cough at 36. Diagnosed as P.T. at 37	Infiltration upper half left lung. Fan-like spread from upper half left root. Gland over apex right lung. Right cervical glands at 25. Right axillary gland excised at 33
30 (544)	M. 25	Lorry-driver, Dumfries (Burgh)	Cough and sputum, Oct. 1938. Diagnosed P.T. Jan. 1939	Central lesions in both lungs. Acute febrile case. Prognosis bad. Appendicitis operation, December 1938
31 (562)	F. 17	Farm outworker, Wigtown	Jan. 1939, developed a cold but was not diagnosed till May	On admission gross infiltration both lungs with cavitation at apices. Disease said to have begun at roots of lungs. (Died, 28 September 1939, no autopsy)

DISCUSSION

I have stated briefly the results I have obtained in the examination of the sputum from 515 cases of pulmonary tuberculosis derived from the middle and south of Scotland and one from Cumberland. Of these, 476 were attributable to eugonic human, eight to dysgonic human and thirty-one to dysgonic bovine tubercle bacilli. Of the last, one only was less virulent than standard bovine bacilli. Including the Cumberland case, the percentage of bovine infections in my series is 6.0.

Munro (1940), Medical Superintendent, Glenlomond Sanatorium (Fife and Kinross), reported that he had found tubercle bacilli of the bovine type in the sputum of fifty-nine out of 1170 cases of pulmonary tuberculosis. All, except six, of the fifty-nine strains were typically bovine, alike in cultural characters and in virulence for rabbits. Of the excepted strains one was a mixture of bovine and human tubercle bacilli and five were attenuated.

Table 3 gives the counties from which the 1170 cases were derived (personal communication). This figure includes five cases from Caithness which appear in the north-east of Scotland figures.

Table 3

County	No. of cases	Human	Bovine	Mixed	% bovine
Glenlomond Sanatorium, resident patients, mainly from Fifeshire	976	925	50	1	5.2
Ayrshire	100	97	3	—	—
Perthshire	70	68	2	—	—
East Fortune Sanatorium (the Lothians)	18	17	1	—	—
Caithness	5	4	1	—	—
Edinburgh	1	—	1	—	—

Thus the joint percentage of bovine infections in the two series was 5.2 as compared with 9.1 for the rural districts of north-east Scotland (Griffith & Smith, 1938).

The results of investigating the bacteriology of pulmonary tuberculosis in Great Britain are impressive and show how greatly rural populations are endangered by tuberculosis among cattle. Nothing is done in the country districts to render milk safe for human use and, in Scotland particularly, milk is, or was, invariably taken raw both as a beverage and with porridge. Since milk is given on farms in Scotland in part payment of work done (Munro, 1939) the consumption of milk in the country places is relatively high. The Department of Health for Scotland (Leighton & McKinlay, 1934) found that the average daily consumption of milk was higher in the counties than in the large burghs, the corrected figures being 0.550 and 0.417 pint per head respectively.

The risk of becoming infected with bovine tuberculosis is relatively great at the present time because so many children and adults, evacuated from cities and large towns with a milk supply which is largely pasteurized, have been sent to rural areas where milk is generally consumed raw. Precautions

which might be taken in normal times are apt to be omitted when, as at present, there is stress. Nevertheless, all those in a position to do so—Medical Officers of Health, Medical Attendants, nurses, etc.—should never cease to insist that all milk from the accredited standard downward should undergo some form of adequate heat treatment before use for human or animal consumption.

SUMMARY

1. The types of tubercle bacilli have been determined in the sputum of 515 cases of pulmonary tuberculosis occurring in the middle and south of Scotland.

2. Of the 515 cases 484 were human (476 eugonic and eight dysgonic) and thirty-one were bovine infections.

3. With the exception of the strains from one case (case 28) all the bovine strains, seventy in number, were typical culturally and fully virulent for rabbits.

4. The attenuated strains, two in number, from case 28 were slightly less virulent than typical bovine strains for rabbits and (one strain) for guinea-pigs.

5. The percentage of bovine infections found in this series, including the Cumberland case, during the years 1931–9 was 6·0, but excluding that case it was 5·8.

6. The percentage of bovine infections found by Munro during about the same period and covering the same regions was 5·0%.

7. In Munro's series strains of bovine tubercle bacilli were obtained from fifty-eight out of 1165 persons (5·0%). Five of his cases yielded attenuated bovine strains and in one of these the pulmonary tuberculosis was preceded by tuberculosis of the thoracic spine.

8. In my series the attenuated tubercle bacilli came from a case (case 28) of pulmonary tuberculosis which was preceded nearly 20 years previously by tuberculosis of the lower dorsal spine.

Dr Munro and others have made post-mortem examinations on cases of phthisis pulmonalis due to bovine bacilli, but I wish to defer reference to these until we can review them altogether.

In this series there are seven instances of cervical gland enlargement and one instance (case 28) of spinal tuberculosis¹ occurring previous to the development of phthisis pulmonalis. These, I think, are examples of alimentary infection with the bovine tubercle bacillus. Thus, with the three autopsies previously mentioned, there are eleven cases, or about one-third, which are almost certainly alimentary in origin. As for the rest of the cases, 20 in number, no glandular enlargements in neck or abdomen were detected but the majority, if not all, were probably alimentary in origin, since all the persons drank a lot of raw milk and only five came into direct contact with cattle in their employment.

¹ Of the two other instances of spinal tuberculosis one (case 6) occurred after cervical gland, and one (case 7) after mesenteric gland tuberculosis.

REFERENCES

- COBBETT, L. (1907). The relations of human and animal tuberculosis. *Roy. Comm. on Tuberc. App. 2nd Int. Rep.*
- GRIFFITH, A. S. (1911). The relations of human and animal tuberculosis. *Roy. Comm. on Tuberc. App. Fin. Rep. 1.*
- (1914). Further investigations of the types of tubercle bacilli occurring in the sputum of phthisical persons. *Brit. med. J. 1*, 1171.
- GRIFFITH, A. S. & MUNRO, W. T. (1933). Phthisis pulmonalis due to the bovine type of tubercle bacillus. *Lancet, 1*, 399.
- — (1935). Family tuberculosis due to bovine tubercle bacilli. *Brit. med. J. 2*, 147.
- GRIFFITH, A. S. & SMITH, J. (1938). Bovine phthisis, its incidence in north-east Scotland. *Lancet, 1*, 739.
- KOCH, R. (1908). *The Relation of Human and Bovine Tuberculosis*. International Congress on Tuberculosis, Washington.
- LEIGHTON, G. & MCKINLAY, P. L. (1934). *Milk Consumption in Scotland*. Department of Health for Scotland.
- MUNRO, W. T. (1939). Epidemiological aspects of pulmonary tuberculosis due to bovine type tubercle bacilli. *Trans. Tuberc. Soc. Scot. 27*.
- (1940). *21st Ann. Rep. Fife and Kinross Joint Sanatorium Board*.
- MUNRO, W. T. & CUMMING, W. M. (1926). The virulence of tuberculous viruses. *Edin. med. J. 33*, 97.
- WANG, C. Y. (1916). Isolation of tubercle bacilli from sputum and determination of their type. *J. Path. Bact. 21*, 14.

(MS. received for publication 23. II. 40.—Ed.)