Section of Comparative Medicine

President—Thomas Dalling, M.A., M.R.C.V.S.

[*May* 24, 1939]

Infections of Wild Animals with Tubercle Bacilli and other Acid-fast Bacilli

By A. Stanley Griffith, C.B.E., M.D.

A few years ago this subject would not have attracted the interest that it does to-day because, apart from occasional instances of casual tuberculosis and the comparatively rare condition known as rat-leprosy, infections with acid-fast bacilli were not known to occur in wild animals living free.

This group of organisms is responsible for more widespread morbidity and mortality among human beings and animals, and causes greater economic loss than any other single group of bacteria.

Some species of wild animals living free, most species of wild animals in captivity and all the domesticated animals, including man, are liable to infections with acid-fast bacilli. Several members of the genus *Mycobacterium* can cause disease in animals, and the chief of these are the human, bovine, and avian types of tubercle bacilli which depend for their continued existence on human beings, cattle, and poultry respectively.

Each of these three types can under natural conditions infect other species of animals. Of the two mammalian types of tubercle bacilli the bovine has the wider range of pathogenicity and is responsible for most of the serious tuberculous disease in domesticated animals and for a not inconsiderable part of that which occurs in man. The human bacillus has been found as a cause of tuberculosis in the ox, the pig, and the horse, and several species of animals in captivity, but except in the primates its occurrence is rare. Neither the human nor the bovine type of bacillus is a cause of tuberculosis in poultry. The avian bacillus is exclusively responsible for tuberculosis in birds except in parrots and perhaps canaries. It can also infect the pig, the sheep, the goat, the ox, and the horse, the pig being the chief sufferer. Avian tubercle bacilli have not been found in human tuberculous lesions in this country.

It is clear from this brief review that the various types of *Mycobacterium tuberculosis* are not restricted to their special hosts, but can each infect many other species of animals. It is different with the other pathogens of the genus, namely *M. leprœ*, *M. leprœ murium*, *M. paratuberculosis*, and the newly discovered strain which is the cause of an epizootic disease in field voles in this country. These are highly specialized organisms and their transmission to other species of animals is rare or unknown. Only one of these, namely the vole strain, gives rise to disease which anatomically and macroscopically resembles tuberculosis.

The subject "Acid-fast Infections in Wild Animals" falls therefore into two parts, one concerning tuberculosis due to the recognized types of tubercle bacilli and the other dealing mainly with the disease in voles, due to an acid-fast organism whose taxonomic position has not yet been settled.

In considering tuberculosis in wild animals it will be advantageous to divide these animals into three categories :—

(*a*) Those living wholly in the wild state.

(*b*) Those living free but coming occasionally into contact, directly or indirectly, with civilized man and his domesticated animals.

(*c*) Those which are kept in captivity for exhibition, or as pets, or for their skins.

One can still maintain that tuberculosis among animals living entirely free from any contact with civilized man is unknown, though that statement had better be qualified for the moment by saying that tuberculosis in these animals due to the recognized types of tubercle bacilli is unknown. All the instances of casual tuberculosis in wild animals due to these bacilli which have so far been recorded can be relegated to the second category, namely, those in animals which come occasionally into contact with man and his domesticated animals.

The first examples of tuberculosis in wild animals coming under my own observation were in adult rhesus monkeys which had been captured in the jungle in India for the work of the Royal Commission on Tuberculosis. On arrival in this country some were in bad health and were killed and found to be extensively tuberculous. Their fellows were killed and nearly all were found to be similarly affected. In most of the animals some of the lesions were calcareous and it seemed highly probable that the disease had been contracted before their capture. The infection was likely to have been of human origin since rhesus monkeys in India visit the temples and shrines in search of food and are not molested ; one species of monkey—of the langur group—is indeed held sacred. There is support for the view of a human source rather than a natural epizootic because young rhesus monkeys captured in the same regions are usually free from the disease.

McCoy and Chapin (1911) recorded the occurrence of tuberculosis in 5 out of 225 ground squirrels captured in pastures in the neighbourhood of San Francisco. The disease was generalized and caused by tubercle bacilli of the bovine type. The infection was probably derived from the dejecta of cattle.

In S. Africa, Paine and Martinaglia (1929) observed tuberculosis in three antelopes (Kudu) and a Cape Duiker ewe in the Albany district of Cape Province. The disease was generalized and apparently of alimentary origin and due to bovine bacilli. The tubercle bacilli were probably from the water-holes and dams which during a record drought had become very low or dry and were visited by stock as well as game.

In this country authenticated examples of tuberculosis among wild animals are extremely few and confined almost exclusively to birds.

The only case of tuberculosis seen by me in a mammal living free was in a hedgehog caught in Regent's Park. The animal was taken to the Zoo where it died of pneumonia with grey hepatization, and acid-fast bacilli in great numbers were found and proved to be fully virulent bovine bacilli. Col. Hamerton is not convinced that hedgehogs can be included among the indigenous fauna of inner London, but it is not unlikely that discarded pet hedgehogs may be found there. The infection in this case may have been through tuberculous cows' milk taken as food.

Tuberculosis has been reported by M. Koch and Rabinowitsch (1907) in rats and mice caught in infected poultry yards. In some instances cultures were obtained and proved to be of the avian type. The possibility exists, therefore, of avian tubercle bacilli being conveyed from one poultry run to another by rats and mice. Wild rats may also become carriers of bovine bacilli, as indicated by results communicated personally to me by Mr. Bosworth. When searching for *Br. abortus* in rats by guinea-pig inoculation, he found that some of the guinea-pigs injected with emulsions of rat-organs from two farms had developed tuberculosis. He obtained a culture from one which was a fully virulent bovine strain.

Instances of naturally occurring tuberculosis among wild birds are more numerous than among free-living mammals. Many different species of birds have furnished examples, but in each species only one or two instances have as yet been put on record. This indicates that the cases are casual and not part of an epizootic among birds. The birds acquire the tuberculous infection, which is always due to avian bacilli, on visits to poultry runs, or through eating garbage or dead tuberculous fowls. Our first experience of infection in a wild bird with avian bacilli was in 1907 in a sparrow which, seen to be flying rather unsteadily on one of the Commission's farms, was followed

and shot with an air-gun. The autopsy showed general tuberculosis. I have shown experimentally that the sparrow is highly susceptible to infection with avian bacilli and there is little doubt that this bird may sometimes convey infection from diseased to healthy poultry.

Other wild birds which frequently visit poultry runs are starlings, jackdaws, rooks, crows and, in winter, sea-gulls. Rooks, jackdaws, crows and gulls have been found tuberculous, but not starlings so far as I am aware. I have myself obtained cultures of avian bacilli from tuberculous lesions in two gulls and a jackdaw. The gulls became infected apparently as a result of eating garbage from a poulterer's dump. As all the birds mentioned may travel great distances, it is obviously important for poultry farmers to prevent wild birds from visiting poultry runs and feeding with the fowls. (For further observations on this subject see review by Feldmann, 1938.)

Other instances on record of casual tuberculosis in wild birds are in a lapwing, a kestrel, and a partridge. A few weeks ago Mr. Dunkin mentioned to me that a thrush had been found affected with tuberculosis. Tuberculosis in wild pigeons seems never to have been observed, although hundreds have been examined. This immunity from attack is in harmony with the fact that tame pigeons, though susceptible to infection with avian bacilli, are much less so than fowls.

Although it is likely that in regions thickly populated with farm animals casual tuberculosis occurs in wild animals more frequently than the recorded examples indicate, there can nevertheless be little doubt that such infections are comparatively rare.

When, on the other hand, wild animals are held in captivity, tuberculosis is of common occurrence among them and in crowded conditions may assume the character of an epidemic.

Of the different orders of mammals, that of the primates—which includes apes, monkeys, and lemurs—is the most prone to infection with tubercle bacilli, followed closely by that of the ungulates. Tuberculosis in captive wild mammals may be caused by any of the three types of tubercle bacilli, human, bovine, or avian. In the primates, which experimentally are highly susceptible and in equal degree to bovine and human tubercle bacilli, natural tuberculosis may result from infection with either type. As might be expected from their frequent contacts with human beings, monkeys are more often attacked by human than by bovine bacilli. The human type of bacillus is usually found in cases where the oldest and most extensive lesions are in the thorax, and bacilli of bovine type where the primary complex is abdominal, but several instances of the reverse association have been recorded for each type. The occurrence in monkeys of primary thoracic tuberculosis due to bovine bacilli suggests that this type of bacillus may be transmitted from monkey to monkey by inhalation, as is the case also in man. Respiratory infection is more frequent than alimentary infection and more rapidly fatal.

It is very interesting to note that the anatomical-pathological picture of tuberculosis in the monkey is very similar to that in the child, and the younger the child the closer the resemblance.

In 1929 I had the opportunity of studying the distribution of the lesions in nine monkeys, all of which had been infected through the respiratory tract from one source, a monkey with two discharging tuberculous ulcers on a forearm. In eight of the monkeys there was a single primary focus, and in one there were two primary foci in the lungs with enlargement and caseation of the tracheo-bronchial glands on the same side. In children also, it may be mentioned, single foci are more frequent than two or more. The lobe containing the focus was consolidated in whole or in part and showed on section a softened caseous mass, in some instances containing a cavity, surrounded by grey tuberculous tissue undergoing caseous degeneration. The tuberculosis in all the monkeys was generalized, the crepitant parts of the lungs,

the liver, the spleen and, in some cases, the kidneys showing caseous tubercles and nodules. All the monkeys yielded cultures of the human type.

This series illustrates the great susceptibility of the rhesus monkey to tuberculous infection.

In more advanced cases the whole of one or more lobes may be uniformly caseated and softened in parts or converted into bags of pus.

In alimentary cases also the post-mortem appearances in man and monkey are very similar. In the monkey, however, the disease appears always to be progressive, whereas in children, particularly as age advances, it may extend no further than the adjacent glands and there become arrested. The avian tubercle bacillus is not virulent for apes or monkeys, and when inoculated or fed has left either no trace of infection or a few trivial lesions.

This type of bacillus has not been found in any spontaneously infected monkey examined in this country, but one or two alleged examples are given in continental literature.

In the English series of 30 examinations human bacilli were found in 22 and bovine in 8 cases.

In Paris the tubercle bacilli from 30 cases were typed ; 25 were said to be infected by human, 4 with bovine, and 1 with avian bacilli.

In Germany Rabinowitsch (1906) tested cultures from 27 monkeys ; 19 were classed as human, 3 as bovine, 1 as avian, and 3 as transitional ; from the remaining case human and bovine bacilli were cultivated.

The proportion of bovine infections was therefore much higher in England than on the Continent, the percentages being 27 and 12 respectively.

Monkeys kept as pets frequently become tuberculous. I have examined two or three of these and have cultivated human tubercle bacilli from the lesions.

In ungulates also tuberculosis may be the result of infection with either the human or the bovine type of bacillus, the latter occurring much more frequently. Infection in this order appears to be predominantly respiratory since in the majority of cases the thoracic organs and glands have shown more severe and more advanced lesions than the abdominal ; in several instances the tuberculous disease was limited to the thorax.

All the families in this large order are susceptible to infection with tubercle bacilli but the incidence is less and the disease progresses more slowly than in the primates. The lesions are generally of the fibro-caseo-calcareous variety characteristically seen in domestic cattle. The pulmonary lesions of deer, antelopes and sheep, like those in the domestic goat, are very liable to break down with the formation of cavities.

In a series of 18 cases from the London Zoo—namely 3 in gnus, 9 in deer and antelopes, 2 in the sheep, and 2 in the pig families, 1 in a tapir and 1 in a rhinoceros—bovine bacilli were responsible for the tuberculosis in 14 and human in 4 instances. The human bacilli were obtained from a gnu, an antelope, a blesbok, and a peccary.

The gnu died of generalized tuberculosis, the lungs, liver, and the thoracic, portal, and gastric glands containing dense caseo-calcareous nodules ; portions of the lungs were quite solid with nodules embedded in a matrix of fibrous tissue. The antelope (*Oryx beisa*) died of extensive tuberculosis of the lungs, the greater part being riddled with intercommunicating cavities. In the blesbok the lungs were closely beset with miliary tubercles singly and in aggregations. In the peccary the lungs showed numerous caseous tubercles and irregular caseous areas and the bronchial glands were caseous.

The human type of bacillus has also been obtained, on the Continent, from the elephant, and three instances have been recorded. In two the disease was apparently restricted to the lungs, which in one case showed extensive cavitation on one side ; the third was affected not only in the lungs but also in several vertebræ. Elephants

in Zoological Gardens come very little into contact with other animals, but they have very close contacts with human beings.

It is a very interesting fact that human tubercle bacillus can cause in wild species of ruminants and pigs progressive tuberculosis equal in severity to that produced by the bovine type of bacillus. In this connexion I would mention the case of tuberculosis in a native ram from Western Uganda reported by Carmichael. The animal was a fat-tailed sheep which died ten days after purchase from a native in Ankole. The autopsy revealed tuberculosis of both lungs which were full of tubercles and also contained large caseous abscesses; the thoracic glands were enlarged and caseous and there were tubercles in the spleen. The type of bacillus was eugonic human, as I was able, through Dr. Carmichael's kindness, to confirm. The sheep, as is the custom with the Bahima tribe, in which pulmonary tuberculosis is rife, had lived in the same hut with its owner, whose medical history, however, was unobtainable.

This case, and the four others which I have mentioned, of progressive tuberculosis in ungulates due to the human type of tubercle bacillus, show that native wild races of this order which, it may be supposed, have not acquired an inborn or racial immunity through long exposure to infection with tubercle bacilli, are as susceptible to human as to bovine bacilli.

Among carnivorous animals in captivity tuberculosis is not rare, and has been described in the lion, tiger, and other species of Felidæ and also in the bear, jackal, fox, genet, civet, and coati. The disease is generally of the fibro-ulcerous type with tendency to calcification of pulmonary and extrapulmonary lesions, and often affects with greatest severity the lungs, particularly of lions and bears, which become riddled with cavities. The types of tubercle bacilli have been determined in only eight instances. Bovine bacilli have been obtained from a lion, a bear, a genet, and a coati, and human bacilli from a lion, a bear, a civet, and a coati. It is interesting that the lion is susceptible to infection with both types of bacilli. In the domestic cat naturally acquired tuberculosis appears always to be caused by bovine bacilli, at any rate in this country, where of 36 cases all could be attributed to that type. The findings in natural tuberculosis in the domestic cat are in harmony with the experimental evidence which showed that the cat is highly susceptible to infection with bovine bacilli and very resistant to human bacilli, in fact completely insusceptible when the organisms are given with the food.

In bats, i.e. members of the order Chiroptera, tuberculosis is extremely rare, and there are only two recorded instances, both of which I investigated bacteriologically. The animals were fruit-bats and both died in the Zoo of severe pulmonary tuberculosis caused by bovine bacilli. The source of the infection in these cases was not ascertained. Fruit-bats are never given fresh milk though occasionally they may be given condensed milk.

Among marsupial animals tuberculosis is not of frequent occurrence. Herbert Fox (1923) found only two cases, both in pet opossums, among 324 autopsies on marsupial animals. H. H. Scott (1928) examined the records of the Zoological Society of London from the beginning of the present century down to 1927 and found only 16 cases recorded as exhibiting tuberculous lesions. The diagnosis was supported in only four instances by finding acid-fast bacilli though it is probable that eight others were instances of tuberculosis. The remainder were doubtful. To these must be added another kangaroo, which died in the Zoo in 1931 from tuberculosis of the pancreas, and a wallaby. Bacteriological investigations have been made in five of these cases of marsupial tuberculosis, two in kangaroo-rats, one in a wallaby and two in kangaroos, and in four instances the disease was due to avian tubercle bacilli; the remaining case—a kangaroo-rat with extensive tuberculous pneumonia—yielded bovine tubercle bacilli. The avian bacilli were found in a kangaroo-rat with a suppurating mesenteric gland and tubercles in the liver (Lucas, 1925), in the wallaby

which died of general tuberculosis of alimentary origin (Stableforth, 1929), and in the two kangaroos by me. One of the latter, as just stated, had tuberculosis of the pancreas to which organ the disease was practically limited. The other had wide-spread glandular tuberculosis, miliary tubercles in the lungs, and tuberculosis of one shoulder-joint and both sterno-clavicular joints (Scott, loc. cit.).

Animals that are bred for fur also may contract tuberculosis. I have obtained cultures from the lesions of a mink and several rabbits. The cultures all proved to be of the bovine type.

Among birds living in zoological gardens tuberculosis is generally very prevalent and may attack every avian species, including birds of prey and ducks and geese. I mention the latter because these birds, when living under ordinary domestic conditions, are rarely found tuberculous.

Parrots may contract tuberculosis in zoological gardens, though instances are rare, and the disease is then due, as in all other avian species, to the avian type of bacillus. When kept as pets, on the other hand, parrots are frequently affected with a peculiar form of cutaneous tuberculosis occurring most commonly in the skin of the head (eyelids, root of beak, ears, &c.). The lesion at first is a nodule which extends and ulcerates, the ulcer becoming covered with a warty or horn-like excrescence. In the single case—sent to me by Dr. Hare—which I have investigated bacteriologically, the lesion was a disc-shaped ulcerated nodule on the right mandible. Stableforth has described a case where the lesion was in an eyelid. In the cutaneous forms of parrot tuberculosis the type of bacillus concerned is the human, the infection being the result of intimate contact with a tuberculous owner. Attempts to produce cutaneous tuberculosis experimentally with human bacilli failed. Two parrots were infected by scarifying the skin at the root of the beak with a scalpel which had previously been dipped into a turbid suspension of culture of human bacilli. One parrot died of general miliary tuberculosis in 250 days, the other was killed 522 days after infection with an attenuated lupus strain and showed a mild form of general tuberculosis. In neither case was there any sign of disease in the skin. It is of interest to note that the parrot is susceptible to all three types of bacilli injected parenterally, the bovine being the most, and the avian the least, virulent.

Cold-blooded animals also are liable to spontaneous affections associated with acid-fast bacilli which are present in the lesions in great abundance. These affections have been described in fresh- and salt-water fish, amphibians, and reptiles. Among cold-blooded animals living free, tuberculous lesions are extremely rare and have been reported in three or four fish, three frogs, and a reptile or two. One of the latter —an iguana caught in its native habitat—died three months after its capture, during which period it had never fed. The autopsy, made by Col. Hamerton (1933), showed advanced pulmonary disease and extensive caseating foci in the fat-body. In the London Zoo instances of tuberculous disease among amphibians and reptiles crop up from time to time, but they are by no means of frequent occurrence. Although in the years 1931 to 1933 there was an average of 3,400 reptiles and amphibians in the Zoo only 11 instances were found among the hundreds that died. H. H. Scott saw only nine cases in two and three-quarter years (1924–27). I have obtained cultures of acid-fast bacilli from 28 cases of the disease—including the iguana just mentioned—the material having been supplied by Dr. N. Lucas, Dr. H. H. Scott, and Col. Hamerton.

The acid-fast bacilli of cold-blooded animals do not form a homogeneous group and can be divided into types. The type occurring most frequently in my series—namely in 20 out of 28 cases—grows abundantly on all media at 20° C. or less and forms soft slimy readily-emulsifiable layers, which on glycerine media have a deep canary-yellow colour. This type is serologically identical with Aronson's *Mycobacterium marinum*.

Then there are three or four strains which produce a soft white growth serologically

identical with the well-known carp strain—the group to which Friedmann's turtle strain belongs.

A third group forms a pinkish, rather dry type of growth apparently identical with Aronson's *Mycobacterium thamnopheos*.

There remains a heterogeneous group of at least three strains—one from a frog, one from a halibut, and one from a terrapin (the latter obtained by Wilson)—which differ from each other and from other acid-fast strains in cultural characters and in serological reactions.

I have tested the virulence of most of the strains on toads, frogs, or grass-snakes, and found some to be pathogenic when relatively large doses of culture have been given. The disease as it occurs naturally has, however, not been reproduced.

I have now to mention two diseases which occur in wild animals belonging to the family Muridæ produced by acid-fast organisms of the second group.

The first is rat-leprosy due to an acid-fast bacillus which cannot yet be cultivated with certainty on artificial media. The natural disease in its typical form is characterized by the deposition in the subcutaneous tissues of greyish-white granular material composed largely of acid-fast bacilli which by pressure eventually causes atrophy of the underlying muscles and of the skin, leading to the formation of indolent discharging ulcers. Lesions of the internal organs are said to be rare. The examination of large numbers of rats has revealed that the disease is world-wide, the frequency generally varying from about 0·1 to 0·2% up to 4 or 5%. The organism is apparently not transmitted under natural conditions to other species of animals and experimentally is not pathogenic to guinea-pigs, rabbits and the monkey, though it has been reported that Japanese dancing mice are susceptible.

The second is the epizootic disease of field-voles discovered by Wells in 1937.

In 1928 I stated that tuberculosis among animals living wholly in the wild state was unknown, meaning of course tuberculosis due to one or other of the three classical types of tubercle bacilli. Just two years ago Wells (1937) reported the widespread occurrence of a disease among field-voles which was due to an acid-fast bacillus and resembled tuberculosis in macroscopic features. The organism was cultivated by Wells on an egg medium and a culture was sent to me. The organism differs both in cultural characteristics and in virulence from any of the three established types of tubercle bacilli. A report is being prepared.

REFERENCES

CARMICHAEL, J. (1938), *Vet. Rec.*, **50**, 1138.
DOBSON, N. (1930), *J. Comp. Path. & Therap.*, **43**, 310.
FOX, H. (1928), *J. Am. Vet. M. A.*, **72**, 792.
FELDMANN, W. H. (1938), Tuberculous Infections. London.
GRIFFITH, A. S. (1928), *J. Comp. Path. & Therap.*, **41**, 53, 109.
Id. (1928), *J. Hyg.*, **28**, 198.
Id. (1936), *ibid.*, **36**, 156.
HAMERTON, A. E. (1933), *Proc. Zool. Soc. London* (ii), 462.
KOCH, M., and RABINOWITSCH, L. (1907), *Virchows Arch. f. path. Anat., Beiheft zum Bande*, **190**, 363.
LOVELL, R. (1930), *J. Comp. Path. & Therap.*, **43**, 205.
LUCAS, N. (1925), *J. Path. & Bact.*, **28**, 123.
MCCOY, G. W., and CHAPIN, C. W. (1911), *J. Med. Research*, **25**, 189.
PAINE, R., and MARTINAGLIA, G. (1929), *J. Comp. Path. & Therap.*, **42**, 1.
RABINOWITSCH, L. (1906), *Deutsche med. Wchnschr.*, **32**, 866.
SCOTT, H. H. (1928), *Proc. Zool. Soc. London* (i), 249.
Id. (1930), "Tuberculosis in Man and Lower Animals", *Med. Res. Council, Spec. Rep. Ser.*, No. 149.
STABLEFORTH, A. W. (1929), *J. Comp. Path. & Therap.*, **42**, 163.
WELLS, A. Q. (1937), *Lancet* (i), 1221.

Discussion.—Mr. S. J. EDWARDS said the possible rôle of tuberculosis in wild animals and birds in the causation of tuberculosis in the pig was illustrated by the observations in a herd in which avian infection had been found in a small number of animals. Post-mortem examination

on 42 rooks which might have had access to the pasture land on which these pigs were kept revealed avian tuberculosis in one (2·5%).

A tentative suggestion is made that infection in the pigs was derived from rooks since there was no contact with domestic poultry and since no infection was found in other wild species examined, such as rats, starlings, pigeons, and various other wild fauna.

Dr. DAVID NABARRO said that he was interested in the possible relationship of the tubercle bacillus to the other acid-fast bacilli. More than thirty years ago he had examined samples of butter and margarine for tubercle bacilli, but instead of finding many instances of tubercle-infected butters, as was to be expected from the reports current at that time, he found no case of undoubted, and only 2 cases of possible, tuberculous infection. On the other hand, 23 of the 45 samples examined showed the presence of other acid-fast bacilli, which included not only the well-known Petri-Rabinowitsch bacillus, but also the various organisms previously described by Tobler, Korn, Grassberger, Moeller, and others.

Unlike the tubercle bacillus, the butter bacilli all grow readily in one to two days on ordinary media at room temperature, and most of them also at 37° C. On glycerine media the cultural appearances of certain of these acid-fast bacilli closely resemble those of the tubercle bacillus, while others produce marked pigmentation—yellow, orange, or a brilliant red. Morphologically they may be coccoid, bacillary, beaded, and even branched, some of them closely resembling the tubercle bacillus in appearance. As regards their acid-fastness, some are acid (25% H_2SO_4) and alcohol-fast; others will only withstand 5% or 1% H_2SO_4, and some of them lose this property after prolonged cultivation.

Pure cultures of these acid-fast bacilli are not ordinarily very pathogenic for the guinea-pig, but injected intraperitoneally, together with sterile melted butter or margarine, they give rise to varying degrees of proliferative, plastic peritonitis, with suppuration or caseation and matting together of the intestines—exactly like that seen after the injection of the infected butters of commerce.

The absence of proven tubercle bacilli from all the samples examined, their possible presence in two cases, and the isolation of so many different varieties of acid-fast bacilli, led him to agree with those earlier investigators who regarded these acid-fast bacilli as being closely allied to, if not actually derived from, the tubercle bacillus itself, or all of them as being derived from a common ancestor.

He accordingly adopted the name "paratubercle bacilli" for the acid-fast organisms, a name suggested for them by Potet in 1902. This and some other rather unorthodox views expressed in his report proved too big an obstacle to the publication of the report by the Local Government Board, who had given him a grant to carry out the investigation. It has remained unpublished to this day, but the theory of the mutability or variation of organisms which he advanced in 1909 in relation to the tubercle and other acid-fast bacilli, and later on (1923) in relation to the dysentery group of bacilli, has received considerable support in other directions, e.g. streptococci, pneumococci, &c., and is not so unacceptable or unlikely a theory as it was considered to be thirty years ago.