

TUBERCULOSIS IN CAPTIVE WILD ANIMALS.

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INTRODUCTION.

TUBERCULOSIS in warm-blooded animals living in the wild state is unknown; at least no authenticated example of such occurrence has been recorded. Herbert Fox (1923) mentions a few examples of tuberculous wild animals, among which were monkeys captured in the jungle for the experimental work of the Royal Commission on Tuberculosis, but in these the possibility that they had acquired the infection, directly or indirectly, through association with human beings and domesticated animals could not be excluded.

When however wild animals are kept in captivity, as in Zoological Gardens and other institutions, tuberculosis is very common among them and is one of the chief causes of mortality. This liability of captive animals to become infected with tubercle bacilli is a consequence of the conditions under which they are kept. Except in the most modern Zoological Gardens the animals are confined to restricted quarters and are often herded together in small cages. In these circumstances tuberculosis in one animal readily spreads to other occupants of the cage and may assume the character of an epidemic (Scott, 1927). The infection is transmitted from tuberculous members of the public or from tuberculous attendants by coughing, spitting, etc., or it may be conveyed in food contaminated with tubercle bacilli. Infection may also spread from one group of animals to another through the agency of animals, such as mice and sparrows, living free in the Gardens or Menagerie.

It is therefore important for those who have large numbers of animals

under their care to possess a knowledge not only of the susceptibility of the different species to different types of tubercle bacilli, but also of the sources of the infecting bacilli, the route by which the bacilli gain access to the body and the method of transmission from one individual in a group to another.

Through the kindness first of Dr Nathaniel Lucas and then of Dr H. H. Scott, Pathologists to the Zoological Society of London, I have been enabled to study the types of tuberculous infection, and to some extent the character and distribution of the tuberculous lesions, in many different species of animals.

During the period from January 1924 to April 1926 I received material from 33 mammals, ten birds and six cold-blooded animals. I am greatly indebted to Dr Lucas for 28 of these cases and to Dr Scott for the remainder, and also for the details of the post-mortem examinations. After the completion of the above series, Dr Scott in 1927 sent me tuberculous glands from a kangaroo; an account of the investigation of this case is appended.

METHODS OF INVESTIGATION.

Cultures of tubercle bacilli were obtained in each case either directly from the original material or through the guinea-pig, and were tested on various artificial media in order to ascertain their cultural characteristics. The virulence of the bacilli was tested by inoculation (1) of the original material into guinea-pigs and (2) of cultures (except a few eugonic strains) into rabbits.

As stated above the material was derived from mammals, birds and reptiles, and it will be convenient to consider the results in each of these groups separately.

MAMMALS.

Primates. This order, which has furnished the largest number of cases, includes three anthropoid apes and 12 monkeys of various species.

The three anthropoid apes, namely, an orang-utan and two chimpanzees, were all infected with tubercle bacilli of the human type. The orang-utan (*Simia satyrus*) was 25 years old at death and showed thoracic tuberculosis of a type similar to adult human phthisis, that is to say, there were breaking down caseous areas in the lungs and enlargement and congestion without caseation of the bronchial glands.

The two chimpanzees (*Anthropopithecus troglodytes*) died of general tuberculosis. In one case the post-mortem particulars did not enable any conclusion to be drawn regarding the portal of entry of the bacilli. In the other the bacilli appeared to have entered the body by way of the intestinal tract, since the mesenteric glands were enlarged, caseous and breaking down, and the bronchial glands were not caseous.

Of the 12 monkeys nine were infected with tubercle bacilli of human type and three with tubercle bacilli of bovine type.

One of the nine monkeys infected with human bacilli had been in the Gardens only 10 days when it died of general miliary tuberculosis, of uncertain origin. The remainder had been in the Gardens for some time and in five of these the oldest and most extensive lesions were in the thorax, indicating

that the infection was respiratory in origin. In the remaining three cases the anatomical evidence as to portal of entry was inconclusive, some mesenteric glands as well as the bronchial glands being enlarged and caseous.

Of the three "bovine" cases, one, a woolly monkey (*Lagothrix lagotricha*), showed ulcers in the intestines, enlarged caseous mesenteric glands and general tuberculosis; it was clearly infected by bacilli which had been ingested, probably in cows' milk. In the other two, both capuchins (*Cebus fatuellus*), the lungs were severely affected and in a condition of caseous pneumonia.

In addition to the cases from the Zoo I have examined tuberculous material from three rhesus monkeys (*Macacus rhesus*), of which one was a pet and two were purchased from a dealer for experimental purposes. The details of the autopsies and the results of the bacteriological investigations of these cases are appended. All these monkeys were infected with tubercle bacilli of human type.

It will be convenient at this point to refer briefly to other investigations which were undertaken to ascertain the type of infection in tuberculosis of apes, monkeys and lemurs. F. Griffith (1911), when working for the Royal Commission on Tuberculosis, obtained cultures of human type from a chimpanzee with general tuberculosis of alimentary origin and from a rhesus monkey with chronic pulmonary and slight disseminated tuberculosis. Cobbett (1917) reported that he had obtained human tubercle bacilli from two tuberculous lemurs.

A. S. Griffith (1917) recorded the results of investigating the tubercle bacilli from ten cases of tuberculosis in monkeys, some of which had died in the Gardens of the Zoological Society. Five of the ten monkeys were infected with bovine tubercle bacilli and five with human tubercle bacilli (four eugonic and one dysgonic). [To these ten cases might be added three others which had been used for subcutaneous inoculation experiments after having passed the tuberculin test. When these monkeys were examined post-mortem the distribution of the lesions was such as to suggest that they were infected before inoculation, and the bacteriological evidence supported this conclusion since the tubercle bacilli—fully virulent bovine bacilli—from the lesions were different from those inoculated. These animals probably acquired the infection from spontaneously infected monkeys with which they had been in contact.]

The proportion of bovine infections in the above series of cases is much higher than in the series examined by Rabinowitsch (1906). She obtained cultures from 33 monkeys which had died in the Zoological Gardens in Berlin. The strains from 27 of these monkeys were tested culturally and on animals with the following result. Of the 27 monkeys

	19	yielded human t.b. ¹ ,
	3	„ bovine t.b.,
	1	„ human t.b. from the lung, bovine t.b. from the spleen,
	1	„ avian t.b.,
and	3	„ strains with intermediate characters.

¹ Tubercle bacilli.

The strains from the remaining six monkeys were investigated culturally only and all proved to be of human type.

In my series one strain only was atypical, and this exhibited the characters which I have termed dysgonic human. No strain was obtained with avian characteristics.

The results of the above investigations show that spontaneous tuberculosis in the monkey may be caused either by human or by bovine tubercle bacilli. To these two types of bacilli monkeys of all species are equally highly susceptible, and infection with either type, whether natural or experimental, is always followed by generalisation of the disease and progression to a fatal termination. There are no features of the disease which differentiate one infection from the other.

Tuberculosis in the spontaneously affected monkey generally takes one or other of two forms. In one the bacilli entering the body by way of the alimentary tract produce ulcers in the intestines, enlargement and caseation of the mesenteric and other abdominal lymph glands and general miliary tuberculosis; in this type the bronchial glands show lesions which are less extensive and in an earlier stage than those in the mesenteric glands. The resemblance of this form of tuberculosis to that in children resulting from alimentary infection is very close.

In the other form the primary lesions are intrathoracic and the bronchial glands are greatly enlarged and caseous; the mesenteric glands may show lesions but they are less extensive than in the bronchial glands. It is usual to find one or more lobes of the lung in a condition of caseous consolidation, with cavitation in long-standing cases. This form of disease I consider to be due to air-borne infection. In monkeys, as in human beings, it is usually caused by human tubercle bacilli. It is of great interest therefore that in my series of cases no fewer than four monkeys with this form of tuberculosis were infected with bovine tubercle bacilli.

Ungulata. Thirteen animals belonged to the Order of Ungulates. The tuberculosis found in these animals varied in extent, but in all cases it was more severe in the lungs than in any other organ and in the great majority of instances appeared to be limited to the thorax. This distribution of the lesions points to the respiratory tract as being the usual channel of entry of the tubercle bacilli in this Order. Fox (1923) also concluded from a study of the distribution of the lesions in 33 cases of tuberculosis in Ungulates that infection in this Order is predominantly aerogenic. In some of the members (Z. 15, 21, 30, 38) various lesions showed fibroid and calcareous changes, indicating that these species of animals possess some considerable power of resisting the spread of the disease. In two sheep the pulmonary disease was very extensive and was characterised by the presence of cavities containing pus in which were numerous tubercle bacilli. In antelopes and deer the pulmonary lesions showed a similar tendency to break down to form cavities. It is interesting to recall that pulmonary lesions produced in the domestic

goat by inoculation of bovine tubercle have a strong tendency to soften and form cavities.

In the rhinoceros there were miliary tubercles in the lungs and nodules on the pleura and surface of the liver; tubercle bacilli were scanty in the lesions.

With regard to the type of tubercle bacilli responsible for the infection in the above animals, bovine tubercle bacilli were obtained from eleven and human tubercle bacilli from two. The animals in which bovine bacilli were found were three deer, three antelopes, a gnu, a rhinoceros, two sheep and a boar. The strains were typically bovine except the one from the boar; this was identical culturally with bovine (Class I) strains but was much less virulent than standard bovine viruses for rabbits and guinea-pigs.

The two animals infected with tubercle bacilli of human type were a blesbok (*Damaliscus albifrons*) and a collared peccary (*Tayassa tajacu*). In both of these animals the tuberculosis was apparently confined to the thorax.

The former case (blesbok) is the third example of tuberculosis of human origin in a ruminant animal to be discovered in the Gardens of the Zoological Society. When working for the Royal Commission on Tuberculosis, F. and A. S. Griffith (1911) obtained cultures of the human tubercle bacillus from a gnu and an antelope. The gnu (*Gorgon taurinus*) died of general tuberculosis, the disease being of great severity in the lungs which were very fibroid and packed with caseous nodules. The antelope (*Oryx beisa*) had been in the Gardens eight years and was killed when ill; the lungs of this animal were extensively diseased and riddled with communicating cavities containing soft caseous substance and caseo-pus in which were numerous tubercle bacilli.

These findings are of great interest, since they show that species of animals belonging to the Ruminantia which have always lived in the wild state are in captivity apparently as susceptible to the human as to the bovine type of tubercle bacillus. The domesticated species of ruminants—bovine animals and goats—on the other hand, while very susceptible to natural infection with bovine tubercle bacilli, are highly refractory to tubercle bacilli of the human type. This applies also to members of the family Suidae.

Carnivora. Two cases of tuberculosis in carnivorous animals have been investigated. One, a Pardine genet (*Genetta pardina*), showed tuberculosis of the chest wall with secondary empyema and tuberculous pericarditis. A smear from the empyema pus showed an enormous number of tubercle bacilli and resembled that from a pure culture. The tubercle bacilli were of the bovine type and highly virulent for rabbits and guinea-pigs.

The other animal was a coati (*Nasua narica*) with severe tuberculosis of the omentum, mesentery, diaphragm and pericardium; no tubercles were seen in the organs. A smear from the omentum showed extremely numerous slender beaded tubercle bacilli. A culture from the omentum was of the human type.

(An historical interest attaches to strains of tubercle bacilli obtained from

the coati, since it was from one of these animals that Theobald Smith (1896) cultivated the strain of human type which he used to demonstrate the difference in morphology, cultural characteristics and virulence for rabbits between tubercle bacilli from human and bovine tuberculosis.)

Tuberculosis is not rare among carnivorous animals in captivity and has been described in the lion, tiger and other species of Felidae and also in the bear, jackal, fox, genet and coati. Lydia Rabinowitsch (1907) obtained a culture of human type from a lion which died of pulmonary tuberculosis in the Zoological Gardens, Berlin. This appears to be the only instance in which the type of infection has been determined in one of the Felidae, but it is not unlikely, since these animals are fed with uncooked meat and offal, that in the majority of the cases the infecting bacillus was bovine. Additional exact observations on the susceptibility of the wild species of Felidae to the two types of mammalian tubercle bacilli would be of great interest. The domestic cat is, as I have shown (1928), susceptible to casual infection with bovine though apparently insusceptible to human tubercle bacilli, and in this respect resembles the domesticated species of Bovidae. One would like to know whether the wild species of Felidae are also more resistant to human tubercle bacilli or are, like the wild species of Bovidae, equally susceptible to the two mammalian types.

The form that tuberculosis assumes in the wild Felidae resembles in certain features that in the domestic cat. Both in the wild and in the domestic felines the lungs, which are often the most severely affected organs, may be riddled with cavities.

As the domestic dog is susceptible to casual infection with both types of mammalian bacilli, it is not improbable that tuberculosis in the wild Canidae might be caused sometimes by human and sometimes by bovine tubercle bacilli. Rabinowitsch (1906) obtained bovine tubercle bacilli from a jackal (*Canis cancrivorus*) which died of general tuberculosis in the Zoological Gardens, Berlin.

In the tuberculous coati the disease involved almost exclusively the serous surfaces, particularly those of the peritoneal cavity, and was of the fibro-caseous variety, the organs showing no visible tubercles. Serous membrane tuberculosis is the form usually met with in coatis; Herbert Fox (1923) gives details of a similar case.

Rodentia. This order is represented by one animal, a rabbit, which died of severe general tuberculosis of apparently alimentary origin. The infection was due to virulent bovine tubercle bacilli.

Chiroptera. This order also is represented by one animal, an Indian fruit bat, which died of severe thoracic tuberculosis. The right lung was in a condition of caseous pneumonia and the bronchial glands on that side were large and caseous throughout. There were no lesions visible to the naked eye in the abdominal organs or glands. The distribution of the lesions suggested respiratory infection and it was therefore very surprising to find that the

animal was infected with virulent tubercle bacilli of bovine type. The source of the infection in this case was not ascertained. Dr H. H. Scott made enquiries and was informed that these animals were never given fresh milk, though occasionally they might be given condensed milk. This is apparently the only recorded example of tuberculosis in a bat. Herbert Fox, whose observations extended over a period of 20 years, does not mention an instance and no case prior to 1926 is recorded in the *Proceedings of the Zoological Society*.

Marsupialia. Among the animals in this series there was one marsupial, a rufous rat-kangaroo (*Aepyprymnus rufescens*). The lungs of the animal were extensively tuberculous and several lobes were in a condition of caseous pneumonia. Bovine tubercle bacilli were obtained from the lesions.

This is the second case of tuberculosis in this species of animal in which the type of tubercle bacilli causing the infection has been ascertained. N. Lucas (1925) while pathologist to the Zoological Society of London made an autopsy on a rat-kangaroo which died in the Gardens six weeks after arrival. He found an enlarged mesenteric gland full of greenish pus which contained acid-fast bacilli in large numbers; there were discrete soft white tubercles in the liver but none elsewhere. The bacilli from the mesenteric gland were passed through three guinea-pigs in succession, none of which developed more than an enlarged inguinal gland with pus in its centre, and a culture was obtained from the inguinal gland of the third guinea-pig. This culture exhibited the characteristics of the avian type of bacillus.

In 1927, as previously mentioned, Dr H. H. Scott sent me tuberculous glands from a Kangaroo Island kangaroo (*Macropus fuliginosus*), which died of general tuberculosis $3\frac{1}{2}$ years after admission to the Zoological Society's Gardens. I obtained cultures from the glands directly and through the guinea-pig and proved them to be identical with tubercle bacilli of the avian type (see Z. 73). In the *Proc. Zool. Soc.* (1928) Dr Scott describes the appearance and distribution of the lesions in the kangaroo.

Tuberculosis is not of frequent occurrence among marsupials. Herbert Fox (1928) of Philadelphia states that among 324 autopsies upon marsupial animals only two cases of tuberculosis were found, both in pet opossums. In each instance the disease was limited to the abdomen. H. H. Scott (1928) examined the records of the Zoological Society of London from the beginning of the present century and found, besides the three referred to in this paper, thirteen cases recorded as exhibiting tuberculous lesions. The diagnosis of tuberculosis was confirmed in only one instance by finding acid-fast bacilli in the lesions. It is very probable, however, judging from the descriptions of the characters and distribution of the lesions, that eight of the others were cases of tuberculosis. The remainder were doubtful.

SUMMARY OF RESULTS IN MAMMALS.

The results of this investigation show that tuberculosis in captive wild mammals may be caused by any one of the three types of tubercle bacilli—human, bovine or avian.

In the Primates, which under experimental conditions are susceptible in an equal degree to bovine and human tubercle bacilli, natural tuberculosis may result from infection with either type. The human tubercle bacillus is however found more frequently than the bovine bacillus. Taking the condition of the regionary lymphatic glands of the body as an indication of the probable portal of entry of the infecting bacilli, *e.g.* greater enlargement and more advanced caseation of the thoracic than of the abdominal lymphatic glands as denoting respiratory infection, it would appear that the monkey may become infected with bovine tubercle bacilli, as well as with human tubercle bacilli, not only through the alimentary tract but also by inhalation.

Avian tubercle bacilli, which are not pathogenic for apes and monkeys experimentally, have not been found in any spontaneously infected monkey examined in this country.

In the Ungulata, as in the Primates, only the human and bovine types of tubercle bacilli have been obtained from the tuberculous lesions, but in this order the bovine tubercle bacillus has occurred the more frequently. It is an interesting fact that the human tubercle bacillus, which is incapable of producing progressive tuberculosis in domestic cattle, goats and pigs, can cause tuberculosis in the wild species of ruminants and pigs equal in severity to that set up by the bovine type of bacillus.

Infection in the Ungulates appears to be predominantly respiratory, since in the majority of cases the thoracic organs showed more severe and more advanced lesions than the abdominal. The lesions in the lungs of deer, antelopes and sheep, like those in the domestic goat, are very prone to break down and form cavities communicating with the bronchi. It is evident that infection in these species of animals may lead to dissemination of tubercle bacilli by coughing or by means of the dung.

During the period of collection only a few cases of tuberculosis occurred in animals belonging to other Orders. Three of these animals—an Indian fruit bat, a Pardine genet and a rufous rat-kangaroo—presented features of particular interest. All three animals had severe thoracic tuberculosis and were infected with tubercle bacilli of bovine type which were extremely abundant in the lesions; there was apparently no evidence of infection having occurred by way of the alimentary tract.

A Kangaroo Island kangaroo with widespread glandular tuberculosis yielded avian tubercle bacilli. This is the second captive marsupial animal discovered to be infected with tubercle bacilli of avian type. The first instance was a rat-kangaroo reported by N. Lucas (1925). The results in marsupials show that members of this Order are susceptible to casual infection with two types of tubercle bacilli—avian and bovine.

DETAILS OF AUTOPSIES ON THIRTY-SEVEN MAMMALS AND RESULTS
OF THE BACTERIOLOGICAL INVESTIGATIONS.

Abbreviations used. G.P. =guinea-pig; T. =tuberculosis; G.T. =general tuberculosis; intrav. =intravenously; intrap. =intrapitoneally; subcut. =subcutaneously; t.b. =tubercle bacilli; local T. =local lesion and tuberculosis of nearest glands; G.(M.)T. =general (miliary) tuberculosis.

Z. 13. (31. i. 1924.) Uganda chimpanzee (*Anthropopithecus troglodytes*).

Autopsy. Lungs contained some caseous pneumonic patches (a few t.b.). Spleen was closely beset with caseous softening nodules, 2 to 5 mm. in diameter (t.b. very scanty). Liver contained scattered caseous nodules up to a hempseed in size.

Bacteriological. Two G.P.s were inoculated intrap., one with pus from the spleen, and one with pus from the lung. They died in 31 and 28 days respectively and showed G.T. of only moderate severity. A culture obtained directly from the lung was eugonic. With this culture two rabbits were inoculated, one intrav. with 0.1 mg. and one subcut. with 20.0 mg. The former, killed 233 days later, showed slight T. of the lungs, three caseous foci in the muscles and T. of a knee and a metacarpal joint. The latter, killed after 206 days, showed local T. and very slight T. of lungs.

Z. 15. (1. iii. 24.) Axis deer (*Chitala cervus axis*).

Autopsy. Lungs beset with fibro-caseo-purulent nodules, discrete and in aggregations (scattered short t.b.). Thoracic glands not enlarged. One mesenteric gland was caseo-purulent (no t.b.). The rumen showed a moderate number of subserous flattened caseous or caseo-calcareous nodules. No intestinal ulcers.

Bacteriological. An emulsion of lung nodules was inoculated into three guinea-pigs, two intrap. and one subcut. Of the two former one died in 26 days and showed early G.T.; the other died in 40 days of severe G.T. The third G.P. died in 96 days of G.T. not of full severity. Cultures obtained directly from the lung, mesenteric gland and rumen were dysgonic. The strain from the lung was tested subcut. on six rabbits, two receiving 5.0 mg. each, two 7.5 mg. and two 10.0 mg.; the first four were killed 50 to 69 days after inoculation and showed G.T. of bovine type but of less than the usual severity; the other two died in 69 and 95 days of typical severe G.T.

Z. 16. (8. iii. 24.) Grey-cheeked mangabey (*Cercocebus albigena*).

Autopsy. Lungs closely beset with caseous tubercles, nodules and masses; left upper lobe in a condition of caseous pneumonia. Spleen, liver and kidneys contained scattered caseous tubercles and nodules. A small mesenteric gland was caseous throughout (moderate number t.b.). Visceral pericardium showed a few tubercles.

Bacteriological. Two G.P.s inoculated intrap., one with spleen and the other with mesenteric gland, died in 27 and 47 days of typical subacute G.T. Direct cultures from the spleen and mesenteric gland were eugonic. The spleen strain was inoculated subcut. into a rabbit (dose 20.0 mg.) which when killed 144 days later showed a large cystic local lesion only.

Z. 17. (12. iii. 24.) Orang-utan (*Simia satyrus*), 25 years old.

Autopsy. Lungs contained large breaking down caseous areas (numerous t.b.). Bronchial glands enlarged and congested; no caseous foci seen. Spleen showed small round white areas.

Bacteriological. Pus from the lung caused T. in a G.P. A culture obtained directly from the lung was eugonic and produced in a rabbit inoculated subcut. (dose 20.0 mg.) local T. and a dozen miliary tubercles in the lungs.

Z. 18. (20. iii. 24.) Antelope (*Oryx beisa*).

Autopsy. Lungs; in the portion sent there were two nodules, one, 4 cm. in diameter,

composed of firm grey substance containing caseous streaks and foci, the other pea-sized, caseous and softened. The animal died of carcinoma of the liver.

Bacteriological. Two G.P.s inoculated intrap. with emulsion of lung nodule died in 49 and 60 days of typical severe G.T. A direct culture from the lung was dysgonic. Two rabbits inoculated subcut. each with 10.0 mg. died of typical severe G.T. in 35 and 37 days. Two other rabbits developed G.T. of a more chronic type and were killed 107 and 133 days after inoculation.

Z. 19. (20. iii. 24.) Woolly monkey (*Lagothrix lagotricha*).

Autopsy. Lungs congested and closely beset with greyish-white firm caseous nodules up to 5 or 6 mm. in diameter, irregular in outline and in places confluent. Bronchial glands only slightly enlarged, showed caseous areas in the cortices.

Spleen and liver closely beset with miliary caseous tubercles. Intestines showed ulcers and the caecum sub-mucous abscesses. Mesenteric glands enlarged and caseous.

Bacteriological. Two G.P.s inoculated intrap. with spleen material died in 25 and 29 days of severe typical G.T. A culture from the spleen was dysgonic and produced G.T. in two rabbits, one dying in 26 days of severe disease, the other in 70 days, the disease not being quite of full severity.

Z. 21. (8. iv. 24.) Reindeer (*Rangifer tarandus*). Born in the Gardens.

Autopsy. The piece of lung sent contained many reddish grey nodules with central calcareous foci and one large mass, the size of a Victoria plum, which showed a central cavity and a thick caseous wall (numerous short t.b.). There were similar nodules in every lobe and some contained a little thick pus.

Bacteriological. Three G.P.s inoculated with lung, two intrap. and one subcut., died in 34, 38 and 57 days respectively of severe G.T. A direct culture from the lung was dysgonic. Two rabbits were inoculated subcut. each with 10.0 mg. of the culture; one died in 62 days of typical severe G.T.; the other was killed 118 days after inoculation and showed only moderate T. of the lungs, which were crepitant and contained superficial and marginal caseating patches and discrete caseating tubercles and nodules, and a few miliary tubercles in spleen, kidneys and intestines.

Z. 22. (6. v. 24.) Rabbit (*Oryctolagus cuniculus*).

Autopsy. Lungs closely beset with coalescing caseating nodules. The pleura—mediastinal and diaphragmatic—was thick and caseating. The spleen contained four caseous nodules and the kidneys several abscesses on surfaces and in substance. The mesenteric glands were all enlarged and caseating. Liver, many white tubercles. There were numerous t.b. in the lesions.

Bacteriological. Two G.P.s inoculated intrap. with spleen and lung respectively died in 39 and 48 days of severe G.T. A culture from the lung was dysgonic and highly virulent for a rabbit, which died of typical severe G.T. 66 days after subcut. inoculation of 10.0 mg.

Z. 24. (10. v. 24.) Collared peccary (*Tayassa tajacu*).

Autopsy. The lungs were adherent, congested and beset with caseous tubercles and irregular caseous areas. The bronchial glands were enlarged; the one sent for investigation was caseous and breaking down (moderate number slender beaded and vacuolated t.b.).

Bacteriological. A little of the pus from the gland produced acute G.T. in a G.P. inoculated intrap. An emulsion of lung produced a mild form of G.T. in a guinea-pig. Direct cultures from the lung and gland were eugonic. The lung strain (20.0 mg. inoculated subcut.) produced a small local lesion only in a rabbit, killed 138 days after inoculation.

Z. 25. (11. vi. 24.) Chimpanzee (*Anthropopithecus troglodytes*). This animal had lived in the Zoo for over 25 years.

Autopsy. The lungs contained purulent abscesses, not numerous. Bronchial glands

enlarged. The peritoneal and pleural cavities were full of clear yellow fluid. The peritoneum—parietal and visceral—was closely studded with flattened firm caseous nodules, confluent in places and forming plaques of tuberculous tissue. The abdominal organs were matted together. The pleura was well studded with nodules. Intestines not ulcerated. Abdominal glands caseous and breaking down. Numerous pea-sized abscesses in left kidney. Tubercle bacilli were scanty in the lesions.

Bacteriological. Four G.P.s were inoculated intrap., two with peritoneal nodule and two with mesenteric gland; one out of each set was killed 22 and 57 days later and showed G.T. not severe; the other two died 150 and 128 days after inoculation of typical severe chronic G.T. Direct cultures from a peritoneal nodule and a mesenteric gland were eugonic. The nodule strain was tested intrav. on a rabbit, dose 0.1 mg. The rabbit was killed 163 days later and showed scattered superficial and marginal nodules in the lungs, a purulent nodule and a few scars in the kidneys, a small abscess in the thigh muscles and miliary tubercles in the iris of each eye.

Z. 26. (11. vi. 24.) Capuchin (*Cebus fatuellus*).

Autopsy. Both lungs severely affected with caseous pneumonia. Bronchial glands very large and caseous. Round the head of the pancreas was a mass composed of greenish pus. Nothing else was seen in abdomen.

Bacteriological. An emulsion of the lung produced acute T. in two G.P.s inoculated intrap. A direct culture from the lung was dysgonic. Two rabbits were inoculated subcut. each with 10.0 mg.; one died in 33 days of severe G.M.T.; the other was killed when dying 66 days after inoculation and showed cysticercosis and G.M.T. not severe.

Z. 27. (23. vii. 1924.) African rhinoceros (*Rhinoceros bicornis*).

Autopsy. Two small portions of lung were sent; one was hepatised and showed what appeared to be grey tubercles; the other was crepitant and showed no definite tubercles but there were indefinite grey foci; the interlobular septae were distinct and the bronchi contained muco-purulent material. Dr N. Lucas made the following notes: "Tuberculous nodules on pleura and surface of liver; right lung showed pneumonic consolidation of the upper lobe and miliary T. of the lower lobe; in left no miliary tubercles but fibrous areas spreading from pleura."

Bacteriological. A G.P. inoculated subcut. and killed 39 days later showed early G.T. A culture from this G.P. was dysgonic and highly virulent for two rabbits inoculated subcut.

Z. 28. (13. viii. 24.) Chital deer (*Axis axis*). India. Lived in Zoo five years.

Autopsy. The lungs contained a moderate number of fairly evenly distributed nodules, ranging in size from a hempseed to about 1 cm. in diameter. The nodules were caseous and softened and had fibrous walls.

Bacteriological. Pus from the lung produced severe G.T. in two G.P.s inoculated intrap. A direct culture was dysgonic and highly virulent for a rabbit, 10.0 mg. inoculated subcut. producing typical severe G.T. in 59 days.

Z. 29. (7. x. 24.) Burrhel sheep (*Pseudovis nahura*). Nine years in the Zoo.

Autopsy. Lungs; caseous pneumonic areas in right anterior lobe, cavity, size of hen's egg, containing greenish pus in right posterior lobe; caseous masses up to a hazel nut in size in left anterior and six small cavities in left posterior. The two layers of pleura on right side were firmly adherent. Bronchial glands enlarged, red and soft. Omental gland contained small caseous masses. An emulsion of two caseous nodules showed scattered t.b.

Bacteriological. An emulsion of the lung caused G.T. in four G.P.s. A dilute emulsion of a gland from one of the G.P.s was inoculated into two rabbits, one intrav. and one subcut.; they died in 34 and 60 days respectively of severe typical G.T. A culture through the G.P. was dysgonic.

Z. 30. (13. x. 24.) Gemsbok (*Oryx gazella*).

Autopsy. The lungs contained many cavities, up to a plum in size, filled with greyish-green pus, and numerous miliary caseous tubercles. The bronchial glands were almost entirely calcareous; portal gland also. Liver contained one or two small caseous areas. In smear preparations of the lesions t.b. were scanty.

Bacteriological. Three G.P.s inoculated with pus from lung died in from 27 to 68 days of severe G.T. A direct culture was dysgonic and highly virulent for two rabbits (10.0 mg. subcut.; death from severe G.M.T. in 29 and 41 days).

Z. 31 (14. x. 24.) Humboldt's woolly monkey (*Lagothrix lagotricha*). Only 10 days in Zoo.

Autopsy. Lungs contained scattered grey miliary tubercles; left pleura adherent. Liver contained miliary tubercles. Spleen much enlarged, closely beset with caseous nodules (very numerous t.b.).

Bacteriological. An emulsion of spleen produced G.T. of human type in two G.P.s. A direct culture was eugonic and of slight virulence for a rabbit; the rabbit was inoculated subcut. with 25.0 mg. and when killed 118 days later showed a large cystic local lesion and marginal and superficial tuberculous patches in the lungs.

Z. 32. (18. x. 24.) Rufous rat-kangaroo (*Aepyprymnus rufescens*).

Autopsy. Lungs; left lung adherent to ribs, both lobes enlarged and solid and composed of a greyish yellow opaque friable substance; the right middle lobe was in a similar condition; the other lobes on the right side were red and hepatised and closely beset with greyish soft yellow tubercles and nodules ranging from a pinpoint to a hempseed in size. A bronchial gland did not show caseation. Liver cirrhotic and congested. Smears from lung showed enormous numbers of t.b. rather above average length, beaded and vacuolated.

Bacteriological. A G.P. inoculated subcut. with lung died in 73 days of chronic G.T., the glands except the nearest showing fibrosis and in some instances calcification with little caseation. A direct culture was dysgonic and produced in two rabbits inoculated subcut. each with 10.0 mg. severe G.M.T. and death in 34 and 36 days.

Z. 35. (12. xi. 24.) Brown capuchin (*Cebus fatuellus*).

Autopsy. A posterior lobe of the lungs was sent. This was extensively replaced by breaking down caseous substance; the crepitant parts contained discrete nodules (t.b. very numerous).

Bacteriological. A G.P. inoculated intrap. with lung died of severe G.T. in 34 days. A culture obtained directly from the lung was dysgonic and highly virulent for a rabbit inoculated subcut.

Z. 36. (26. xi. 24.) Blesbok (*Damaliscus albifrons*). In the Gardens for 13 years 5 months.

Autopsy. The lung contained numerous miliary tubercles, singly and in aggregations, and here and there a pea-sized nodule which shelled out from a fibrous capsule (t.b. numerous, beaded or granular, some rather long).

Bacteriological. Two G.P.s inoculated intrap. with emulsion of lung died in 24 and 26 days of G.T. A culture obtained directly from one of the nodules was eugonic and produced in a rabbit inoculated subcut. with 20.0 mg. a small local lesion only.

Z. 38. (18. xii. 24.) Arabian oryx (*Oryx leucoryx*). In Gardens since May 1920.

Autopsy. The lungs contained moderately numerous evenly distributed tubercles and small nodules and less numerous larger masses. The lesions were caseo-calcareous and had fibrous walls. In each lower lobe there was a cavity about 2 in. across full of creamy pus. The bronchial glands were not much affected and contained grey areas with calcareous foci (t.b. moderately numerous). Pleural adhesions. No enlarged abdominal glands.

Bacteriological. Two G.P.s inoculated intrap. with tuberculous material from lung died in 54 and 58 days of severe G.T. A culture from the lung was dysgonic. A very small

dose of a direct primary culture was inoculated subcut. into a rabbit which died in 49 days of severe G.M.T.

Z. 39. (24. xii. 24.) White-nosed coati (*Nasua narica*).

Autopsy. The viscera were sent. The omentum was much thickened and composed of fibro-caseous substance. The mesentery was thickened throughout its whole extent and composed of yellowish white caseous substance; the folds of the mesentery were adherent to themselves and to the intestines. The diaphragmatic pleura and the pericardium were similarly thickened and the lungs were adherent to the diaphragm. No tubercles were seen in the lungs, liver and spleen. The mesenteric glands were not apparently affected. One bronchial gland on left side showed slight caseation in cortex. The omentum showed extremely numerous slender beaded t.b.

Bacteriological. Two G.P.s inoculated intrap. with omentum died in 25 days of subacute G.T. A culture obtained from the omentum was eugonic and of low virulence for a rabbit. The rabbit was inoculated subcut. with a 14 days old primary culture (2.0 mg. or more) and was killed 205 days later; the post-mortem showed a cystic local lesion and three submiliary tubercles in the lungs.

Z. 40. (30. xii. 24.) Burrhel sheep (*Pseudovis nahura*).

Autopsy. A portion of a lung and a bronchial gland were sent. The lung was crepitant but congested; throughout the lung at pretty regular intervals and in moderate number were vesicles or cavities ranging in size from a rape seed to a pea or larger. The majority of these vesicles were cysts with an extremely thin grey wall lined internally with a greyish yellow pus. One vesicle rather larger than a pea in the thin margin was a little collapsed but contained a fair quantity of pus, swarming with t.b. The walls of the vesicles were so thin that the pink lung parenchyma could be seen through them.

The gland was the size of a filbert and was composed practically throughout of caseous softened pultaceous substance (scattered t.b.).

Bacteriological. A G.P. inoculated intrap. with pus from lung died in 14 days of early G.T. Two G.P.s inoculated intrap. with emulsion of thoracic gland died in 62 and 93 days of severe G.T. A rabbit inoculated subcut. with pus from the lung died in 59 days of severe G.T. A culture obtained directly from the lung of the sheep was dysgonic and virulent for the rabbit, 1.0 mg. inoculated subcut. causing death from G.T. in 67 days.

Z. 43. (6. i. 25.) Common macaque (*Macacus fascicularis*).

Autopsy. Lungs; apex adherent to ribs; left upper lobe one caseating mass; elsewhere tubercles and pea-sized nodules. Liver, spleen and kidneys contained caseous nodules up to a large pea in size; the liver also contained numerous submiliary tubercles (t.b. scanty). Bronchial glands large and caseous. The left thyroid was a caseating mass the size of a pea. Tubercles on peritoneum and on pleura. Small ulcers in intestines. A mesenteric gland was enlarged, caseous and softened.

Bacteriological. Pus from the liver and kidney produced G.T. in guinea-pigs. A culture from the kidney was eugonic and of low virulence for the rabbit.

Z. 46. (13. i. 25.) Red-eared cercopitheque (*Cercopithecus erythrotis*). Gold Coast.

Autopsy. A portion of lung contained pea-sized caseous nodules. Bronchial glands on right side large, caseous and softened throughout. Broncho-pneumonia both lungs. No T. of alimentary system or liver or spleen.

Bacteriological. Pus from the bronchial glands produced chronic G.T. of human type in a G.P. A culture from a bronchial gland was eugonic and of low virulence for the rabbit.

Z. 55. (3. iv. 25.) Sooty mangabey (*Cercocebus fuliginosus*).

Autopsy. Miliary tubercles and caseous areas up to a filbert in size throughout the lungs; left lung adherent and showed caseous masses. The adhesions were infiltrated with tubercles. Bronchial and mediastinal glands matted together and caseous. Spleen normal. Liver, one

tubercle. Portal gland caseous. Ulcer with peritoneal tubercles in small intestine. Two mesenteric glands caseous. Miliary tubercles in Sylvian fissure. Tubercles on spleen and diaphragm, pleura and pericardium. For a fuller account of this case (also of Z. 58), see H. H. Scott and J. Beattie (1928).

Bacteriological. A culture obtained directly from the lung was eugonic and of low virulence for a rabbit. The latter was inoculated subcut. with 20.0 mg. and killed 189 days later; the post-mortem showed a local lesion, caseous areas in a scapular gland and scattered miliary tubercles in the lungs.

Z. 56. (11. iv. 25.) Sooty mangabey (*Cercocebus fuliginosus*).

Autopsy. Lungs; right upper lobe was almost completely replaced by caseous breaking down substance; the other lobes were congested and contained discrete nodules and patches of early tuberculous pneumonia. Right tuberculous empyema. Tracheo-bronchial glands enlarged, caseous and breaking down. Spleen, discrete caseous nodules up to a hempseed in size. Liver, no tubercles.

Bacteriological. The results in this case were identical with those obtained in Z. 55.

Z. 57. (22. iv. 25.) Indian fruit bat (*Pteropus medius*).

Autopsy. The right lung was massive, four times the size of the left, and composed throughout of firm but friable yellow caseous substance. The left lung was red, hepatized and contained several foci of tubercle up to a date stone in size. The right pleural cavity was obliterated, the pleural surfaces being united by caseous tubercles. The bronchial glands on the right side were large and caseous throughout (there were numerous t.b. in the lesions). Right axillary gland was caseous; left swollen and showed a few caseous foci. A few miliary tubercles on pericardium. Nothing abnormal in abdomen.

Bacteriological. An emulsion of lung produced severe and rapidly fatal T. in two G.P.s. A culture obtained directly from the lung was dysgonic and highly virulent, a rabbit inoculated subcut. with 15.0 mg. dying in 34 days of severe G.M.T.

Z. 58. (8. v. 25.) Sooty mangabey (*Cercocebus fuliginosus*).

Autopsy. Lungs showed breaking down caseous pneumonia of two lobes and discrete tubercles and nodules in the other lobes; right tuberculous empyema. Bronchial glands large, caseous and softened. Two small tuberculous deposits on visceral pericardium. Spleen, two caseous nodules. Portal and cervical glands enlarged, caseous and softened. Mesenteric gland not enlarged. Smears showed long and vacuolated t.b.

Bacteriological. Some of the pus from a bronchial gland was inoculated subcut. into a G.P. which when killed 82 days later showed chronic G.T. of human type.

A culture from the bronchial gland was eugonic and of low virulence for the rabbit. A rabbit inoculated subcut. with 20.0 mg. and killed 273 days later showed a local lesion, T. of a scapular gland and one grey tubercle in the lungs.

Z. 59. (4. iv. 25.) Pardine genet (*Genetta pardina*). W. Africa.

Autopsy. There was a tuberculous abscess of the chest wall involving first four ribs in front and extending to pleura and pericardium; secondary empyema and tuberculous pericarditis and pleurisy. The lungs were congested and pneumonic in places. There was yellow lymph between the lobes of each lung and between the bases and the diaphragm. Bronchial glands swollen and hyperaemic. Liver, two minute tubercles seen. Spleen, no tubercles. A smear from the pus showed vast numbers of t.b. and resembled a pure culture; the t.b. were mainly of medium length and in small clumps.

Bacteriological. Two G.P.s inoculated subcut. with pus from chest wall died in 42 days of severe caseo-necrotic G.T. A culture obtained direct was dysgonic and highly virulent for a rabbit inoculated subcut. (death in 34 days of severe G.M.T.).

Z. 60. (10. vi. 25.) Black mangabey (*Cercocebus atterimus*).

Autopsy. Both the liver and the lungs were beset with firm greyish or greenish yellow nodules varying from a millet seed to a hempseed in size, those in the lungs being on the whole

smaller than those in the liver. Pleura also affected in similar manner. Spleen and kidneys did not appear to contain nodules. The glands in the hilus of the lung were caseous. One deposit at lower pole of left thyroid. Omentum thickly studded with yellow tubercles. Liver like the lungs but masses rather larger. Kidneys, numerous yellow deposits, miliary tubercles up to a hempseed in size in cortical areas only. Mesenteric glands swollen.

Bacteriological. According to Dr H. H. Scott the nodules were of a mycotic nature but smears also showed a few acid-fast bacilli; he therefore concluded that there was in this animal a mixed infection. Emulsions of a bronchial gland and the liver produced G.T. of a chronic type in G.P.s. Cultures from the G.P.s were eugonic. They were not tested on the rabbit.

Z. 61. (16. vi. 25.) White-bearded gnu (*Connochaetes albo-jubatus*). In the Gardens 12 years.

Autopsy. Lungs crepitant, contained moderately numerous firm nodules, from a millet seed to a split pea in size, and scattered large ones up to a thrush's egg; there were many small cavities in the interior. Mediastinal glands enlarged and tuberculous. Pleural adhesions and tubercles on upper surface of diaphragm. No alimentary T.

Bacteriological. Two G.P.s inoculated subcut. with pus from lung died in 57 and 62 days of severe caseo-necrotic G.T. A culture from the lung was dysgonic and a small dose (1 to 2 mg.) inoculated subcut. into a rabbit caused severe G.T. and death in 41 days.

Z. 62. (13. vii. 25.) Pig-tailed macaque (*Macacus nemestrinus*).

The tissues received were a pneumonic lung, a caseous and softened abdominal gland and a portion of the spleen which contained a caseating nodule. The animal died of G.T.

Bacteriological. A G.P. inoculated subcut. with pus from the lung died in 120 days of severe chronic G.T. A culture obtained directly from the lung was eugonic. It was not tested on the rabbit.

Z. 67. (11. iv. 26.) Wild boar (*Sus scrofa*). Forest of Crécy. "Rawly," a regimental pet, deposited in the Gardens, 13. iii. 1919.

Autopsy. The conditions found in this animal were stated by Dr Scott to be typical of broncho-pneumonic phthisis. The piece sent was almost entirely airless and composed of soft caseous areas surrounded by fibroid tissue and reddish hepatised lung tissue. Some of the caseous areas communicated with bronchi and showed cavities. There were pleural adhesions on both sides. Bronchial glands enlarged and caseous. No abdominal T.

Bacteriological. Two G.P.s were inoculated subcut. with an emulsion of tuberculous tissue from the lung. One, killed 53 days later, showed caseo-purulent areas in the inguinal glands and no sign of disease elsewhere. The other, killed 160 days after inoculation, showed a small ulcer, a few caseo-purulent foci in moderately enlarged and indurated inguinal glands and slight enlargement and induration of the sternal and portal glands; there was no T. elsewhere. A culture obtained through the G.P. was dysgonic. Its virulence was tested on guinea-pigs and rabbits.

G.P. intrap. 0.1 mg. D. 64 days	Atypical subacute G.T.
G.P. intrap. 0.1 mg. D. 104 days	No omental T. Grey miliary tubercles in small spleen and liver.
G.P. subcut. 0.1 mg. D. 155 days	Local ulcer. Inguinal and submental glands caseous. Numerous caseous tubercles in lungs. Nothing definite elsewhere.
G.P. subcut. 0.1 mg. D. 181 days	Healing ulcer. One inguinal gland, slightly enlarged, contained caseo-pus. One tubercle in lungs.
Rab. intrav. 0.1 mg. D. 31 days	Severe G.M.T.; lungs large and solid.
Rab. intrav. 0.01 mg. D. 47 days	Severe G.M.T.; kidney tubercles projected.
Rab. subcut. 5.0 mg. K. 89 days	Extensive local T., early "perlsucht" growths on pleura; no lesions elsewhere.
Rab. subcut. 20.0 mg. D. 114 days	Chronic severe G.T.; kidneys much enlarged, closely beset with nodules up to a hempseed in size, some projecting; right eye tuberculous.

The above results showed that the tubercle bacilli in the lung of the boar were of the bovine type but less virulent for the rabbit and the guinea-pig than standard bovine strains.

Particulars of three tuberculous monkeys from other sources

1. A young rhesus monkey, received on September 14th, 1927 from a dealer, died on November 6th, 1927.

Autopsy. Right submaxillary gland, size of a large pea, was caseous and softened throughout. The retro-pharyngeal glands were slightly enlarged and caseous. The mesenteric, ileo-colic and caecal, several colic, the pancreatic, retro-peritoneal and one iliac gland were enlarged, caseous throughout and softened. Spleen showed one minute yellow point. Intestines, liver and kidneys normal to the naked eye. Lungs showed one solid red patch and a few submiliary tubercles. One interbronchial gland was slightly enlarged and partly caseous; the left bronchial contained a caseous nodule.

Bacteriological. Pus from mesenteric glands showed extremely numerous t.b. Cultures from these glands were eugonic.

2. On July 4th, 1927 three large rhesus monkeys were received for experiment. One became ill in September and was chloroformed on the 16th of that month.

Autopsy. The lungs were adherent to the chest wall and to the diaphragm; the left caudal lobe was enlarged and three-quarters of its substance replaced by a caseo-purulent abscess, the rest of the lobe being collapsed and beset with recent miliary tubercles; the tip of the left cephalic lobe was red, hepatised and beset with miliary tubercles; the other lobes were crepitant and emphysematous. The bronchial and ventral mediastinal glands were enormously enlarged and caseous throughout (these during life had caused embarrassment to breathing). The trachea and bronchi contained muco-pus. There were five subpleural caseous softened nodules on the ribs and diaphragm. The spleen contained one pea-sized caseous nodule. Liver and kidneys normal. One gastric gland, two small pancreatic, the inguinal and iliac glands were caseous throughout. There were several subcutaneous abscesses, and one abscess was seen in the right crural space. The left testis was three times the normal size and caseous throughout. Smear preparations of pus from testis and a subcutaneous nodule showed numerous t.b.

Bacteriological. A culture from a bronchial gland was eugonic and slightly virulent for two rabbits.

Note. The other two monkeys were used for experiment. Subsequent bacteriological investigation showed that one of them was already infected when the experiment began. The type of infection in this case was human.

3. Pet monkey, species not stated. The right lung and bronchial glands only were sent. The right lung was composed of caseous breaking down substance; the bronchial glands were enlarged and caseous. Scanty long beaded t.b. were found in the lung pus. A culture from the lung was eugonic.

Z. 73. (5. ix. 27.) Kangaroo Island kangaroo (*Macropus fuliginosus*). Resident in the Gardens 3½ years.

Autopsy. I am indebted to Dr H. H. Scott for the following details. The carcass was well-nourished. The axillary glands on the right side were swollen and full of creamy pus. One was adherent to and communicated with the shoulder-joint which was distended with pus and showed erosion of the articular ends of the bones. There was a caseous abscess on each side of the top of the manubrium sterni involving the sterno-clavicular joints. On the left side of the trachea at the root of the neck there was a glandular mass the size of a tennis ball. The cervical glands above the latter, the iliac, lumbar and coeliac glands were swollen and caseated. The thoracic duct was distended with pus. The lungs showed sparsely scattered miliary tubercles and the spleen contained foci in its interior. The intestine was normal.

Bacteriological. The material received for investigation 2 days after the animal's death was several putrescent glands. They contained calcareous granular substance which microscopically appeared to be composed almost entirely of very small acid-fast bacilli. An emulsion of the granular substance was prepared and inoculated into two guinea-pigs subcutaneously. They died in 14 and 16 days of a subacute infection.

Two other G.P.s were inoculated subcut. with emulsion treated for some hours with potassium hydrate. One was killed 59 days later and showed a small local ulcer, a focus of pus in one inguinal gland and no sign of disease elsewhere. The other (G.P. 5022) killed 128 days after inoculation showed two millet seed sized caseous tubercles in one inguinal gland and no sign of disease elsewhere.

Cultures of tubercle bacilli were obtained directly from original material treated for 20 hours with 2.5 per cent. KOH and through three of the guinea-pigs. The primary colonies were very numerous on the egg and glycerin egg tubes sown with original material and with emulsion of the iliac gland of the G.P. which died in 14 days. Moderately numerous colonies appeared on the tubes sown with emulsion of the inguinal glands of the G.P. killed 59 days after inoculation. Only four colonies were obtained from the inguinal gland of the G.P. killed 128 days after inoculation.

All the strains exhibited the cultural characters of the typical avian tubercle bacillus.

Morphologically also the cultures were identical with avian t.b., film preparations of the primary colonies showing numerous branched and club-ended forms.

The virulence of the direct strain was tested on two fowls, two rabbits and two guinea-pigs.

Fowl 80 was inoculated intrav. with 0.01 mg. and died 52 days later. *P.M.*—Liver and spleen closely beset with minute grey tubercles (t.b. very numerous).

Fowl 79 was inoculated intramuscularly with 10.0 mg. and died 36 days later. *P.M.*—In the pectoral muscle there was a thin extensive sheet of yellowish-white caseo-necrotic substance. Liver and spleen were closely and uniformly beset with submiliary grey-white tubercles (t.b. numerous). There were no macroscopic lesions elsewhere.

Rabbit 3329 was inoculated intrav. with 0.01 mg. and died 78 days later. *P.M.*—Lungs a little enlarged, crepitant, somewhat oedematous and emphysematous, showed red airless patches infiltrated with a caseous network (t.b.) on the dorsal surfaces of the posterior lobes and in the ventral part of the right anterior lobe; elsewhere the lungs were crepitant and contained scattered submiliary opaque yellow tubercles and indefinite grey points. The tracheal, portal and mesenteric glands contained small caseous foci. The liver contained a moderate number of submiliary opaque white tubercles and numerous just visible grey foci. The spleen was enormously enlarged and composed mainly of firm yellowish-white caseo-necrotic substance. Kidneys pale and beset with minute irregular yellow foci. There were numerous yellow caseous tubercles in all the areolar tissue spaces—groins, axillae, neck, etc.—on the omentum and mesentery and in the appendix and sacculus.

Rabbit 3330 was inoculated subcut. and died 115 days later. *P.M.*—Very large local cyst, filled with caseo-pus. Scapular glands large caseous and softened. Lungs contained sparsely scattered caseous tubercles and a few small marginal caseous patches (t.b.). Liver and kidneys contained scattered caseous tubercles. Appendix and sacculus contained numerous caseous tubercles and the mesenteric glands caseous patches. One popliteal gland contained a small tubercle. Both ankle, one knee, one elbow and both wrist joints were tuberculous.

Two guinea-pigs were inoculated subcut., one with 4.0 mg. the other with 10.0 mg. of the culture. They were killed 140 days later, having increased in weight 260 gm. The former showed a hempseed-sized caseo-purulent nodule in an inguinal gland on each side and no sign of disease elsewhere. The latter showed a small ulcerated caseous lesion, a caseo-purulent nodule in one inguinal gland on each side and slight enlargement of an iliac and a manubrial gland. A few colonies of avian bacilli were obtained from the inguinal gland pus of this guinea-pig; none grew on tubes sown with fragments of liver and spleen.

Summary. A culture obtained directly from the tuberculous glands of a kangaroo was identical in cultural characters and in virulence for the fowl, rabbit and guinea-pig with the avian type of tubercle bacillus.

BIRDS.

A systematic examination of all the birds which died of tuberculosis in the Zoo during the period of collection was not undertaken. I asked however for a few cases in order to ascertain whether all avian strains from the Zoo were alike in cultural characters. I received tuberculous material from ten birds and obtained direct cultures in each instance. The birds from which the material was taken were three varieties of dove, a kingfisher, a rail, a pigeon, an egret, a pheasant, a gull and an eagle. All the cultures produced the moist slimy growths characteristic of the common avian type of bacillus. The original material from the eagle was inoculated subcutaneously into two guinea-pigs; they were killed 111 and 203 days later and showed local tuberculosis only. None of the cultures was tested on animals. In a paper published in 1917 I reported the results of examining tuberculous material from seven birds—a lapwing, a pigeon, an ibis, a goshawk, a quail, a grackle and a pheasant—which had died of tuberculosis in the Gardens of the Zoological Society of London. The strains of tubercle bacilli obtained from the lesions all proved to be of the common avian type.

BATRACHIA.

Material was received from four caymans, one frog and one snake, which had died in the Zoological Society's Gardens.

AUTOPSIES.

1. Rough-eyed caymans (*Caiman sclerops*). The appearance and distribution of the lesions in the caymans were very similar and the cultures obtained were identical. One description therefore will suffice for the four cases.

Both lungs contained milinary to hempseed-sized caseous nodules. Spleen and liver were closely beset with soft white tubercles; there were a few tubercles in the liver capsule. The left kidney contained three, the right one, the pancreas one, the testis one and the epiglottis two tubercles. Smear preparations showed numerous acid-fast bacilli, mainly long, curved and beaded.

2. Paradoxical frog (*Pseudis paradoxa*). The liver contained numerous soft white foci up to 2 mm. in diameter. A smear preparation showed small acid-fast bacilli in great abundance, the majority so short as to appear coccoid.

3. Vivacious snake (*Tarbophis fallax*). Small masses to the size of a hempseed were seen along the mesentery, particularly abutting the spine; a few were adherent to the vertebrae and two had become calcified. The lungs were affected and contained little caseous masses, the size of millet seeds. The lesions contained numerous acid-fast bacilli, short to moderate length and well stained.

MORPHOLOGY.

Cayman strain. On glycerin egg the bacilli were uniformly stained, mainly of medium length and showed parallel arrangement; there were many short stout forms.

Frog strain. On glycerin egg the majority of the bacilli were uniformly stained, straight or slightly curved, short or of medium length; some showed ill-defined beadedness, others were palely stained at the extremities.

CULTURES

Cultural Characters at 15° to 20° C.

Strain	Primary colonies					Subcultures			Incubated at 37° C.
	Plain egg	Glycerin egg	Plain egg	Glycerin egg	Glycerin agar	Glycerin potato	Broth	Broth	
Cayman	Minute transparent with slightly raised centres	Larger than on egg, whitish translucent centres; old cultures were buff coloured	Thin moist whitish and translucent	Abundant soft moist, yellow and rather viscid	Thick soft wrinkled creamy yellow not tenacious	Moderately thick moist light brownish layer with shiny surface	Thick creamy white wrinkled membrane; moderate deposit	Thick creamy white wrinkled membrane; moderate deposit	Growth
Frog	Minute transparent coalescing to form dull glazed layer	Larger than on egg and translucent white; secondary ivory white viscid colonies up to 1.5 mm. appeared later	—	Thick moist opaque white with slight creamy tinge	As on egg	Moderately thick moist light brownish or greyish yellow	Membrane covering surface greater part moist opaque white and slightly wrinkled, rest thin and grey; broth clear	Membrane covering surface greater part moist opaque white and slightly wrinkled, rest thin and grey; broth clear	No growth
Snake	—	White raised smooth shiny and knob-shaped	Moist, whitish and translucent	Thick opaque milky white and like paint	Thick moist whitish semi-opaque and thrown into folds	Moderately thick opaque white moist and slightly wrinkled; old cultures light buff or dirty yellow	Membrane thick light brownish wrinkled; broth clear	Membrane thick light brownish wrinkled; broth clear	Growth

Snake strain. On glycerin egg the bacilli varied much in length from quite short to moderately long forms; all were regularly beaded. Grown at 37° C. the bacilli were very short and not beaded.

PATHOGENICITY.

Cayman strains. Cultures were not pathogenic for the guinea-pig. They were pathogenic for toads and frogs. Four toads were inoculated subcutaneously, the doses ranging from 10 to 20 mg. They died in 78, 141, 268 and 582 days respectively. The first toad died of cold; no lesions were visible in liver or spleen but smear preparations showed moderately numerous acid-fast bacilli. In the second and third toads the livers and spleens showed an ill-defined grey speckling; acid-fast bacilli were extremely numerous in these organs and were present in smaller numbers in the marrow and kidneys. Many were intra-cellular, some cells being packed with bacilli. The fourth toad showed in each deep cervical region collections of pus which contained numerous acid-fast bacilli; there was an ulcer of the skin over the left side of the thorax (not tuberculous) and a collection of caseo-pus in the left groin containing very numerous non-acid-fast organisms and numerous acid-fast bacilli. The liver was enlarged and the spleen firm and greyish red. Smear preparations from the latter showed dense clumps of acid-fast bacilli; the marrow contained scattered acid-fast bacilli.

Two frogs each inoculated subcutaneously with 10.0 mg. died in 267 and 280 days respectively. The livers and spleens showed a greyish mottling. Acid-fast bacilli were extremely numerous in these organs; they were pleo-morphic, some being slender and beaded, others clubbed and barred and vacuolated.

Cultures obtained from some of the above frogs and toads resembled the original.

Frog strain. The culture was not pathogenic for the guinea-pig but was pathogenic for frogs and toads. Three toads and two frogs inoculated subcutaneously died in 43, 87, 266, 271 and 273 days respectively. The tissues of all the animals showed extremely numerous small acid-fast bacilli, smear preparations in some instances resembling those from pure cultures. The livers and spleens of the animals which lived the longest were peppered with minute grey foci.

Three frogs were fed with portions of the tuberculous liver of the toad which died 266 days after inoculation. The frogs died 86, 131 and 223 days later respectively and showed macroscopically no sign of disease. Acid-fast bacilli were however found in their organs; they were scanty in the first, in moderate number in the second and very numerous in the third frog.

Snake strain. Inoculated subcutaneously into a frog and two toads, the bacilli multiplied abundantly in the tissues and caused death in 41, 30 and 114 days without the production of definite macroscopic lesions. No disease was produced in 114 days in a toad which had been fed with about a third of the liver of the acutely infected toad in whose tissues acid-fast bacilli were very numerous.

SEROLOGICAL REACTIONS.

A serum was prepared in the rabbit from each of three strains, namely, a cayman strain (Z. 37) and the frog and the snake strains.

Each of the sera agglutinated the homologous strain but had (little or) no agglutinative action upon the other two strains.

Each strain absorbed the agglutinin from its own serum but failed to remove any of the agglutinin from either of the other two sera.

The frog strain could not be identified with any of the following cold-blooded strains of tubercle bacilli: namely, Friedmann's turtle, Dubard, Bataillon and Terre's fish, Aronson's *Mycobacterium marinum* and Wilson's terrapin. (The terrapin strain on sub-culture yielded two varieties of colonies, one of which produces moist orange yellow easily emulsified cultures while the other produces dry ivory white coherent cultures which cannot be spread or emulsified.)

The snake strain is culturally and serologically indistinguishable from Cobbett's fish

tubercle bacillus; it however has not, like the latter strain, caused a violet discoloration of the egg medium.

The cayman strain appears to be serologically identical with Aronson's *Mycobacterium marinum*, the latter absorbing completely the agglutinin from the cayman serum. The terrapin (yellow) strain is agglutinated by the cayman serum but does not absorb the cayman agglutinin.

SUMMARY OF RESULTS IN BATRACHIA.

Cultures of acid-fast bacilli were obtained from four caymans, one frog and one snake, which died in the Zoological Society's Gardens.

The strains from the four caymans were identical and indistinguishable from Aronson's *Mycobacterium marinum*.

The snake strain closely resembled the fish tubercle bacillus of Bataillon, Dubard and Terre.

The frog strain could not be identified with any of the cold-blooded strains of tubercle bacilli mentioned above.

TABULAR SUMMARY OF THE RESULTS IN CAPTIVE WILD ANIMALS, INCLUDING THE CASES PREVIOUSLY DESCRIBED AND REPORTED BY F. GRIFFITH (2), COBBETT (2), F. AND A. S. GRIFFITH (2), AND N. LUCAS (1). (ENGLISH STATISTICS.)

Order	No. of cases of tuberculosis	Types of tubercle bacilli obtained			
		Bovine	Human	Avian	Reptilian (3 types)
		Mammalia			
Primates	30	8	22	—	—
Lemuridae	2	—	2	—	—
Ungulata	15	11	4	—	—
Carnivora	2	1	1	—	—
Rodentia	1	1	—	—	—
Chiroptera	1	1	—	—	—
Marsupialia	3	1	—	2	—
		Aves			
Various	17	—	—	17	—
		Reptilia			
Cayman	4	—	—	—	4 (Type I)
Frog	1	—	—	—	1 (Type II)
Snake	1	—	—	—	1 (Type III)

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