to botulism was furnished. From toxic carcass material an organism of the botulinus type was eventually isolated in pure culture, and shown to be closely related to the parabotulinus organism of Seddon. It was definitely a C type, not an A or B.

It is unnecessary to go into the symptoms of lamsiekte, which are essentially those of a bulbar paralysis as seen in any type of botulism and they have been described in great detail in the article of Theiler and co-workers (1927). Material from carcasses from cases of lamsiekte which have occurred in various parts of South Africa, has been tested, and it is certain that all these cases were true botulism. It is not as yet certain that all the toxins from different areas or even from the same areas are identical. Up to date the existence of the A and B types as the cause of botulism in any species of animal in South Africa has not been proved, nor has human botulism been described as yet. That the A and B types exist is, from the evidence in other countries, almost certain. A point of considerable interest is whether more than one type of *Clostridium botulinum* C exists in South Africa as the cause of " lamsiekte." The writer, from a study of many strains of the organism from various sources, has come to the conclusion that there may be varieties of it, and is at present attempting a classification of the known types serologically and by cross-toxin-antitoxin tests.

The distribution of the " lamsiekte " organisms on a well-known and heavily infected farm has been studied by Scheuber (1929). He was not able in his experiments to find the spores of the organisms, except under or close to " lamsiekte " carcasses. Possibly with improved technique and dealing with larger quantities of soil, it will be found that the organisms are present in the soil away from carcases. Blow-fly infection of carcasses is very likely a cause of spread of the organisms from one carcass to another, but it would seem that soil infection must play a part. In the intestinal contents of lamsiekte carcasses, Scheuber was in most cases able to find the organisms, and in addition a fair percentage of cattle, especially those not receiving bone-meal, showed the organisms in the faeces.

A number of points still remain to be elucidated in connection with " lamsiekte " such as the distribution of the bacteria in the soil and falling off and increase in virulence under certain conditions. As a result of the recent work on formalized toxins carried out by various investigators in different parts of the world, it has been found possible to immunize animals against botulinus toxins by means of anatoxins. If it were necessary we could at any time immunize cattle fairly satisfactorily against " lamsiekte," but as this would tempt farmers to neglect bone-meal feeding, it would be inadvisable to recommend such immunization.

(3) Botulism in Sheep and Goats.

Lamsiekte in goats has frequently been reported in South Africa usually in association with the disease in cattle. Experimentally they are very susceptible.

In sheep under natural conditions, the disease seems to be rare, probably because they do not, except under conditions, develop osteophagia. Seddon (1925) reported that it occurred in Australia and was inclined to connect the eating of rabbit carcasses with it.

Recently it has come to our notice through Mr. J. G. Bekker, Veterinary Research Officer in this Department, that sheep in the Bredasdorp District of the Cape Province, suffer severely from osteophagia, that their bones are light and brittle, and that lamsiekte is fairly common amongst them. From sheep carcass material from this area we have been able without difficulty to obtain toxic cultures of the botulinus type.

(4) Botulism in Other Animal Species.

Apart from the small laboratory animals which it is not intended to deal with, the other species of domesticated animals are resistant to the disease. The writer, in confirming the work of Theiler and co-workers on the toxin in lamsiekte, has shown that pigs and dogs are practically insusceptible to it. Rats are comparatively resistant as well.

It is difficult to explain this insusceptibility of pigs and dogs, but it has been suggested that it is related to the omnivorous and scavenging habits of these animals.

Botulism in Birds.

Though it is chiefly botulism in poultry that will be dealt with here, outbreaks of the disease in other species of birds may occur occasionally. Water birds may be affected, usually as a result of eating decomposing fish or snails when dams or streams run dry.

The symptoms in birds are fairly typical. There is first of all loss of appetite, uneasiness, ruffled feathers, and weakness of the legs, which rapidly goes over into complete paralysis. The bird when down lies with its head and neck stretched along the ground. Death almost invariably follows in a few hours.

In the United States botulism has long been known as a disease of poultry, usually under the name of " limber-neck." Since poultry diseases have become the subject of much intensive research, it has been recognized that the term " limber-neck " has been rather loosely used and may refer to true botulism, polyneuritis, neurolymphomatosis (leg weakness), or several other conditions. Dickson (1917) described outbreaks of botulism in poultry as a result of giving them some food such as spoiled maize or beans, which had produced the disease in human beings. Dickson and Burke (1918) refer to a number of outbreaks of botulism in fowls and turkeys after eating spoiled canned foods, chiefly of a vegetable type such as beans, peas, or asparagus. Hart (1920) described an outbreak where 643 fowls were lost from eating badly preserved string beans. Wilkins and Dutcher (1920) in an article on " limber-neck " in poultry showed that the fowl was rather resistant to botulinus toxins experimentally. They produced " limber-neck " symptoms in fowls by feeding them with larvae of *Lucilia caesar* from " limber-neck " carcasses.

An article of great interest by Bengtson (1922) describes the isolation of an organism from *Lucilia caesar* larvae which had fed on " limber-neck " carcasses. This organism was shown to be a species of the *Clostr. botulinum*, but did not correspond to either the A or B types. The name *Clostr. botulinum* C was therefore given to it. Fowls proved rather refractory to its toxin when dosed with it, but in some cases they did show symptoms.

Graham and Boughton (1924) were able to isolate an organism apparently identical with the *Clost. botulinum* C of Bengtson, later classified in Bergey's Determination Bacteriology as *Clost. luciliae.* They were able to confirm Bengtson's observations as to the resistance of fowls to the C type toxin.

Experience in South Africa has shown that botulism in poultry, though not common, is not really rare. In the *Agricultural Journal of the Cape of Good Hope,* 1893, references are to be found to " lam*siekte* " (botulism) in ducks due to eating maggots from decomposing meat or eating the meat itself. The symptoms were typical of botulism. Most farmers have had experience of the disease in ducks, but do not know of it in fowls. It is a common experience in some parts of the Western Province of the Cape that when dams dry up or get very low and there are a lot of dead fish, snails, etc., lying about, that ducks die from " lamsiekte." From experiments done during the work on " lamsiekte " in cattle, it was shown that fowls were not very susceptible to the toxin which produced the disease in cattle, but that pigeons, ducks, and turkeys were fairly susceptible. A point of interest is the susceptibility of the ostrich to botulism. " Lamsiekte " in the ostrich has long been known in the districts where the birds were kept for feather production, and the cause was quite obscure until light was thrown on the subject by the work on " lamsiekte " in cattle. The birds showed typical symptoms as seen in fowls, and it is now known that the cause was the eating of bones containing the toxin. Experimentally by dosing ostriches per os with " lamsiekte " toxin the typical disease could be produced without much difficulty.

In recent years a few outbreaks of botulism in poultry have come to our notice, and there is little doubt that the disease has a wide distribution, but is not often reported on account of the low value of the birds on the whole.

Recently a number of water-birds, mainly exotic species of ducks, died suddenly in the Pretoria Zoo. The symptoms shown were very like those of botulism. No bacteria could be isolated from the blood or organs, but from the intestinal contents of several, cultures in anaerobic media produced toxins of the botulinus type. These have not yet been typed, but the symptoms produced by them in guinea-pigs were quite typical. The source of the outbreak was not traced, but it occurred just after a heavy rain. All the birds were from one pool and attempts were made to trace the source of the bacteria by allowing fish from the pool to decompose and then testing the decomposed material for botulinus toxins, but without success. Faeces were collected from the ground where the birds were, but did not prove to contain botulinus spores. A full description of the outbreak has been given in an article by the writer (1929).

Very recently another outbreak was investigated, but has not yet been described. It occurred in a flock of turkeys. The owner brought in one of the dead birds and described the symptoms shown by the affected birds. There is little doubt that here again botulism was being dealt with as the symptoms were typical. From the intestinal contents of the dead bird very toxic cultures were obtained, which produced typical symptoms of botulism in guinea-pigs. In the intestinal contents actual toxin could not be traced, but this is rarely possible in cases of botulism.

We have no evidence as to the occurrence of the disease in carrion birds such as vultures, but in common with animals that are scavengers, it is more than likely that they have a strong natural resistance to botulinus toxins.

Notes on the Relationships of the Botulinus Types.

As promised in an earlier part of this article, a few notes will be given on the types of the *Clostr. botulinum* met with and their relationships as far as we understand them.

The A and B types may be put in a class by themselves, and in general one may say that the B type is the more widely distributed of the two, and the cause of botulism of the forage poisoning type as seen in the United States of America. Distinct from the A and B types, and so far found only in decomposing animal matter, is the C type.

The C types of Bengtson and Graham and Boughton, the parabotulinus organism of Seddon, the lamsiekte and equine paralysis organisms of the writer are apparently all very closely related.

Graham in a personal communication has stated that his C antitoxin neutralizes the toxin of *Clost. parabotulinum equi.* The toxin of the latter organism, however, is very much more virulent for the horse than the C type of Graham, which appears to have little toxicity for this animal. Pfenninger (1924) found that C type antitoxin would neutralize C toxin as well as Seddon's parabotulinus toxin, but that antitoxin against the parabotulinus toxin would only neutralize it and not C toxin. From this one might draw the conclusion that these two organisms are closely related, but not identical.

The writer, in comparing the toxins of Seddon's organism, the C type of Graham and the *Clostr. parabot. equi* with that of the " lamsiekte organism " (*Cl. parabotulinum bovis*), found that the antitoxin against the toxin of the latter organism would not neutralize the toxins of any of the other types.

Recently in studying the toxins of a variety of botulinus toxins obtained from different sources in South Africa, the writer has come to the conclusion that they are all of the C type, but that individual variations occur amongst them as judged by toxin-antitoxin.

Very recently Meyer and Gunnison (1929) have expressed the opinion as a result of their own work, that the " lamsiekte " organism should be called *Cl. botulinum* D.

Conclusions.

In this paper an attempt has been made to review the literature in relation to botulism in the domesticated animals, more especially as it affects the study of the disease in South Africa. One must conclude that the distribution of the disease is very wide and that under certain conditions, as in the case of " lamsiekte " in cattle, it may cause heavy mortality.

As far as we know at present, the C types of the *Cl. botulinum* alone are responsible for the outbreaks of botulism seen in domesticated animals in South Africa, but the absence of the A and B types has not been proved.

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