ON THE OCCURRENCE OF "WORM-NODULES" IN CATTLE—A SUMMARY.

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For the past two years a considerable amount of attention has been paid, both in the Commonwealth and in Europe, to the occurrence of "worm-nests" or "worm-nodules" in cattle in various parts of the world, but more particularly in Australia. Since these nodules are known to be common and widespread in this state (Queensland), which is an important meat-producing country, and since their presence is causing heavy financial losses to pastoralists and meat exporters, I have deemed it advisable to bring together for public information, a summary of what is known regarding this parasitic condition. As "worm-nodules" may be produced in man, camels, horses, etc., by allied parasites (*Onchocerca*, spp.), casual reference is made to them also. The following account refers to that form of Onchocerciasis met with in Australian cattle:—

Macroscopic appearance:—The naked-eye appearance has been described fully by various authors (Gibson, Park, Cleland and Johnston, Leiper, Gilruth and Sweet), so that only brief mention need be given here. The nodules vary in diameter, from under two to four centimetres in the case of approximately spherical forms, while others of an elongate shape may possess a long axis, measuring 7 cms., or even greater. Gilruth and Sweet (1911, p. 7) found one reaching 11 cms. by 8 cms., whilst, very rarely, they meet with others so small that their diameter was only six millimetres. On cutting across a nodule, one notices that the "worm-area" lies at or near the centre, though occasionally quite eccentrically. There is very little variation in the size of this area though the thickness of the surround

ing fibrous capsule may vary greatly in different nodules. The parasite, *Onchocerca gibsoni*, Cleland and Johnston, lies coiled in the worm area in such an intricate manner that it is impossible to extract the female entire. The small male worms may occasionally be obtained in an unbroken state. These nematodes are seen to lie in a definite tunnel or canal, within which they appear to be capable of a slight movement. Gilruth and Sweet (1911, p. 10, figs. 3, 4, 37) have figured a tunnel in which the male and female worms are lying side by side. The actual nodules are, of course, the result of irritation of the surrounding cells of the host-tissue, set up by the presence of the parasite. An eosinophilia is also present. When the worms dies, it degenerates, becoming calcified and finally breaking down, the worm area undergoing a degeneration also. This condition is more frequently met with in older animals. The statements that tuberculosis is commonly associated with this alteration are not substantiated.

Seat of infection, etc. :—The commonest situations in which the parasite occurs are the brisket and flank, between whose muscles and in whose subcutaneous tissues the worm-nodules lie. The affected areas have been defined as follows :—(Gilruth and Sweet, 1911, p. 5, 6.) " The commonest situation is the region of the brisket, chiefly the triangular outline formed by the junction of the ribs with the costal cartilages, especially between the fourth and sixth ribs, but often extending backwards to the tenth, and, at times, forward to the second rib. Frequently they are superficial, *i.e.*, in the subcutaneous tissues, but more often they are situated between the posterior portion of the superficial pectoral muscle and the anterior part of the posterior deep pectoral, between the posterior portion of the deep pectoral and the external abdominal oblique, and between the panniculus and the posterior portion of the external oblique, rarely deeper. . . The other situation is the external surface of the hindlimb, especially behind the femoro-tibial joint, and the groove leading upward to the pelvis, anterior to the gluteus maximus, and even near the angle of the haunch. While occasionally superficial and readily detected, they are often under the dense subcutaneous fascia lata, when they are much more liable to be overlooked." They mention the

reported occurrence of nodules in other situations, such as " on the inner side of the thigh, in the groin and even throughout the body," but they are " strongly inclined to the opinion that such conclusions have resulted from small tumours of different origin being mistaken for these nodules." Dodd (1910, *a*, p. 86) mentioned that they may occur in the connective tissues in any part of the body. We found them mainly in the brisket (C. and J., 1910, *c*, p. 92), but referred to their presence in certain other situations. Dr. Cleland and myself have seen an encapsuled specimen, said to have been taken from the neighbourhood of the spleen, a situation similar to that from which *Filaria lienalis* was recorded by Stiles.

In regard to the number which may be found in an animal, we (Cl. and J., 1910, *c*, p. 92) have recorded the finding of twenty-one in the brisket alone. As many as fifty has been counted from one host (Gilruth and Sweet, p. 6.), while a yearling (p. 4) was found to harbour twenty-four. Gibson (1893, p. 577) mentioned that he had been informed by butchers that, in rare instances, nodules were so numerous and so distributed in an animal, that condemnation of the whole carcase was necessary.

Age incidence :—As a result of careful ante- and post-mortem examinations of a large number of cows and bullocks of various ages, Gilruth (p. 4, 5) found that there was a heavy infection in the case of yearlings, as in old animals, and that one sex was as liable to become parasitised as the other, but that in the older animals there was usually a greater percentage of degenerated nodules. The youngest animal recorded as having been found to be infected was between six and seven months old (C. and J., 1910, *c*, p. 92 ; six to eight months—G. and S., 1911, p. 5). This is conclusive evidence that the worm can mature very rapidly, and also suggests that the life of the parasite probably does not extend over many years.

Degree of infection :—The most important statements regarding the degree of infection are those of Gilruth (1911, p. 3), who has had opportunities of investigating this side of the question. He states that " so far as could be ascertained, no cattle station in Queensland is entirely free from the parasite," that at least twenty per cent. of animals on " clean " stations are affected, and that a complete

examination would possibly show that fifty per cent. is a nearer approximation. He instances a case in which ten per cent. were found to be infected after " very careful examination by manipulation, using incision only when certain or doubtful, but later on, when the brisket of a number were partially dissected, another 25 per cent. were found to harbour the nodules." Thus 35 per cent. of the cattle, from a " notoriously clean station," from the south-western portion of Queensland, were parasitised by *Onchocerca gibsoni*. In two mobs, from different parts of north-western Queensland, the same observer detected their presence in 60 per cent. of the animals " without any manipulation," and as a result of " a more careful examination by dissection," found *every* animal to contain " from one nodule upwards." It is known that the heaviest infection occur in the more northerly districts, and that the degree lessens as we pass southward. Gilruth and Sweet believe that this state of affairs is not due to the conditions of " soil, climate, rainfall or management." Gibson (1893, p. 577) mentioned that he had been informed by Mr. Stanley, the New South Wales Government Veterinarian, that at least 50 per cent. of the cattle slaughtered about that time (1892) in Sydney, contained worm-nests, but Gilruth and Sweet (p. 3) doubt this large percentage. Our own experience did not reveal such a high degree of infection. Hancock (1911, p. 25) states that " since examination has been systematically made, at least 50 per cent. of all consignments from Queensland ports have been found to contain a variable percentage of affected carcases." Judging from Gilruth and Sweet's findings, Hancock's estimate would be greatly increased if a more searching examination were carried out. The Editor of the *British Medical Journal* (3rd Dec., 1910, p. 1797), mentioned that about 75 per cent. of the carcases were found to be parasitised. Macfadden's findings (1911, p. 2) corroborate those of Gilruth. He stated that at first ten per cent. of the quarters in each consignment mere examined for the presence of nodules, but on a more complete examination, it was noticed that a much larger percentage was infected, and in some instances " as many as a hundred per cent. of those already passed " were found to contain worm nests. The Editor of the *Journal of Meat and Milk Hygiene* (1911, p. 23), in a footnote to our paper

(Cleland and Johnston, 1911, *a*, p. 21-23), refers to the fact that "in one consignment of 1,500 hind quarters which recently arrived in London, 808 were found to be infected." This is about 54 per cent., and the number would probably have been greater had fore-quarters been examined. If we consider what a large amount of meat is exported from Australia, especially Eastern Australia, to Great Britain and elsewhere, we must realise the seriousness of this parasitic invasion. Macfadden (1911, p. 3) states that between 60,000 and 70,000 quarters of Australian beef arrived per month, between July and October of last year (1910) at the port of London alone.

Effect on host :—In regard to the result of this parasitism on the health of the infested animal, it is of importance to note that no authors, excepting Barnard and Park (1894), have mentioned any deleterious effect produced by the presence of the *Onchocerca*. In reference to the statements made by these authors, we (Cleland and Johnston, 1910, *c*, p. 93) have already suggested that tubercular and actinomycotic tissues, from various parts of the body, had been inadvertently mixed with true worm nodules, and hence their mistake in believing that tubercle commonly follows the parasite. Dodd (1910, *a*, p. 86), Hancock (1911, p.25), Nicoll (1911, p. 73), Gilruth and Sweet (1911, p. vii) and others agree with us in our assertion that the presence of the nematode is not any in way detrimental to the host.

Public health aspect :—From the point of view of public health and meat inspection, we must admit that the presence of animal parasites in food is undesirable. We think that they should be removed, but even if eaten, whether unconsciously or otherwise, as already pointed out by us (1910, *a*, p. 174 ; 1910, *c*, p. 98), no harm would result. Dr. Gibson (1893, p. 579) fed a dog on worm-nests for a considerable time without ill effect. Then again, the parasite can only survive the death of the host for a very short time. The same remark applies to the embryos. Besides this, there is no possibility of direct transmission through eating, even if the same species were able to live in man which is most improbable.

Robinson (1910, p. 6) reported that Dr. Collingbridge, the Medical Officer of Health for London, had stated that

" the portions of meat containing the parasite are obviously unfit for food and should be destroyed." We do not agree with this remark. The meat in unaffected, though the connective tissue immediately surrounding the worm is affected, since the formation of a dense fibrous capsule or " worm nodule " is the result, but the effect does not extend beyond this. The Editor of the *British Medical Journal* (3rd Dec., 1910, p. 1797) mentioned " that the meat in question is little, if at all, deteriorated in quality, that it is perfectly safe for human consumption, and that its unsightly condition may be remedied by the removal of the nodules." Nicoll (1911, p. 73) says, that " there is no evidence to show that the meat suffers, or that it is dangerous for human consumption, and the fact that is has been eaten for some time, both in this country and in Australia, without ill consequences being remarked, may be taken to support the Australian view."

Distribution in Australia :—The greatest percentage of infection appears to occur in Queensland, especially in the more northerly and westerly regions, and as one passes southwards, the condition becomes less common. Though occurring in New South Wales, its presence is more or less restricted to the Northern Rivers and the Hunter districts, though it may be found occasionally in cattle elsewhere. It is difficult, however, to trace the origin of cattle brought in for slaughter, but a large percentage come " overland " from Queensland to Sydney, Melbourne and elsewhere. Hence at the abattoirs in these cities and in Hobart, nodules are met with. The occurrence of the condition in Victorian-bred cattle is doubtful, while Tasmania appears to be free from it. It is well-known in Western Australia and in the Northern Territory. The distribution outside of Australia will be referred to in another place.

The parasite :—The main papers dealing with the parasite (*Onchocerca gibsoni*) infesting Australian cattle are those of Cleland and Johnston (1910, 1911), Leiper (1911), and Gilruth and Sweet (1911). The worm had usually been referred to as *Spiroptera reticulata*, which is a parasite infesting horses in Southern Europe. Barnard and Park (1894, p. 644), Park (1893, also in Tryon, 1910),

Shipley * (1910), and Hancock (1911, p. 25) refer to it under that name ; Leiper* (1910), as *Onchocerca reticulata* ; Bancroft (1893), as *Strongylurus* sp. ; Cleland (1907, p. 88), and Johnston (1909, p. 412), as *Spiroptera* sp. ; and Tryon (1910, p. 81), as *Spiroptera* (*Onchocerca*) sp. ; while Cleland and Johnston, a little later (1910, *a*, p. 174) described it as a new species of Filaria, *F. gibsoni*. Later in the same year (1910, *c*, p. 96), they removed it to the genus *Onchocerca*. Later authors (Leiper, 1911 ; Nicoll, 1911 ; Gilruth and Sweet, 1911), have followed them in calling it *O. gibsoni*. The synonymy of the nematode may be summarised thus :—

Onchocerca gibsoni (C. and J., 1910, *a*), Cleland and Johnston (1091, *c*).

? *Filaria lienalis*, Stiles, 1892 (undescribed).

Spiroptera reticulata, Park, 1893, Bernard and Park, 1893 ; Shipley, 1910, etc. (*nec.*, Diesing, 1841).

Strongylurus sp., Bancroft, 1893.

Spiroptera sp., Cleland, 1907, Johnston, 1909.

Filaria gibsoni, Cleland and Johnston, 1910 *a*.

Spiroptera (*Onchocerca*) sp., Tryon, 1910.

Onchocerca reticulata, Leiper, 1910 (*nec.* Diesing).

Filaria (*Onchocerca*) *gibsoni*, Clel. and Johnston, 1910, *d*.

Onchocerca gibsoni, Clel. and Johnston, 1910, *c* ; Leiper, 1911, etc.

Onchocerca reticulata, Diesing, known more commonly but less correctly, as *Spiroptera reticulata*, is a distinct, but closely allied, parasite infesting the horse, and is known under various synonyms, *e.g.* : *Filari reticulata*, *F. cincinnata* and *Spiroptera cincinnata*. *F. lienalis*, Stiles, may be a synonym of *O. gibsoni*, and is evidently an *Onchocerca*, as Leiper (1911, *a*, p. 10) has suggested. Its specific identity with the Australian worm seems to me to be unlikely. The main distinctions between *O. gibsoni* and *O. reticulata* have been tabulated by Leiper (1911, *a* ; p. 10).

The original account (1910, *a*) contains a few inaccuracies regarding the male worm, but these were corrected and a more detailed description of the male, female and embyro was given in a larger report published some months later. (August, 1910, *c*.) Gilruth and Sweet have shown recently (1911), that there is a considerable amount of

* Quoted in an abstract of a report (1910)—Editor *Jour. Meat and Milk Hygiene*, 1911, p. 24.

variation in the mature parasites. The following summary is taken mainly from the papers just referred to :—

The female is very long, but its exact length is unknown, owing to the impossibility of extracting it entire. By adding the lengths of all the fragments collected from a single nodule, apparently containing only one parasite, we (1910, *c*) found measurement to be 97 cm., while Gilruth and Sweet found it to vary from 52 to 140 cms. The cuticular ornamentation is in the form of series of spirally arranged ridges, each ridge being made up of a series of undulations. The anterior end is bluntly rounded, bearing a tiny papilla on each of the three small lips which surround the mouth. The diameter in the anterior part of the worm is from ·08 to ·16 mm., and throughout the greater part of the body is from ·37 to ·5 mm. The vulva varies in its position, being situated between ·46 and 1·23 mm. from the anterior extremity. The nerve-ring lies at from ·142 to .188 mm., and the excretory pore at from ·36 to ·38 mm. from the head end. The anus is located at about ·20 mm. from the posterior extremity.

The male is a very thin and relatively short worm with much less pronounced cuticular ornamentation. It is scarcely half the width of the female and its length varies between 3·75 and 5·3 cm. (Leiper ; Gilruth and Sweet.) It is thus approximately only about one-twentieth of the length of its partner. The nerve-ring is situated at from ·17 to ·2 mm., and the excretory pore at ·25 mm. from the anterior end. The cloaca lies at a distance of from ·048 to ·072 mm. from the posterior extremity.* The two spicules are unequal. The longer is from ·14 to ·197 mm., and is a curved rod with a twisted stem and a pointed distal termination. The smaller spicule is swollen characteristically at the outer end. Its length varies from ·08 to ·094 mm. There are six, probably seven, pairs of pipallæ on the tail end of the male. There is a peri-anal group, consisting of four pair, and a caudal group of two pair. At the extreme end there is a pair of minute projections, which probably represents the seventh pair.

* In our paper (1910, *c*, p. 94) the distance in one case is given as ·072, and in another ·65 mm. The latter is a misprint for ·065 mm. In our preliminary report (1910, *a*), the length of the smaller spicule was given as ·047, instead of ·082 mm., and some of the papillæ were overlooked.

In the peri-anal group, the first pair are usually slightly more prominent and somewhat separated from the remaining three pair, which are really ad-anal or post-anal in position, the first pair being distinctly pre-anal. Gilruth and Sweet (p. 15) have noted a certain amount of variation in the arrangement. The alae are not very prominent. The tail end has a spiral twist, similar to that recorded as occurring in *O. volvulus*. (Parsons, 1909, p. 363.)

The embryos measures from ·22 to ·35 mm. in length by ·003 mm. in width, the anterior end being obtusely rounded or nearly straight, and the posterior extremity tapering. Gilruth and Sweet have estimated that there may at one time be as many as two million embryos and fertilised eggs in one female.

The internal anatomy of the parasite does not call for attention in this paper. (Cleland and Johnston ; Leiper ; De Does ; Gilruth and Sweet.)

Transmission :—From the economic point of view, the most important feature is the means of transmission. If this be known, then one may hope to be able to formulate measures to limit the degree of infection, by reducing the numbers of the transmitting agents, as is now being done in the case of mosquito destruction in order to lessen malarial and other mosquito-borne infections. Direct transmission of a filarial worm is quite unlikely. We (1910, *c*, p. 98), as well as Gilruth and Sweet (1911, p. 26), failed to inoculate calves by injecting living embryos subcutaneously. An intermediate host appears to be necessary. In some few cases it is known to be a crustacean inhabitating fresh water, but more frequently it is a blood-sucking insect, usually a mosquito. The latter method of transmission presupposes the presence of filarial embryos in the blood of the final or definitive host. But, as yet, these have not been found in the general circulation of cattle affected with *Onchocerca*, nor in horses harbouring *O. reticulata*, nor in men infested with *O. volvulus*. In the case of man, filarial embryos belonging to other *Filariidae* may be met with in the blood, but in cases of an infection by *O. volvulus* alone, such larval forms have not yet been detected. We have given a summary of our results (1910, *c*, p. 97), which were all negative, embryos being found in the peripheral parts of the tumours,

but not in the blood, though searched for in films taken by night as well as by day, in case there should be any periodicity. Since the nodules are practically restricted to those portions of the animal which come in contact with the ground, and since they are frequently subcutaceous in situation, we were led to suggest that a fresh water crustacean might act as a transmitting agent in a manner analogous to that known to occur in the human guinea-worm, *Dracunculus medinensis*. Dr. Cleland and myself have not been able, as yet, to infect *Cyclops* and *Daphnia* with the embryos, the latter living only a very short time in water. We have, therefore, been driven back to our first idea, that a biting insect or a tick might be the actual transmitter. The lack of material in Sydney, and the pressure of official business, prevented our following up this matter as thoroughly as we wished.

Leiper (1911, *a*, p. 12), arguing from the structure of the embryo, believes the intermediate host to be a biting insect, such as *Stomoxys*, *Hippobosca* or *Tabanus*, or perhaps one of the *Ixodidae*. The *Hippoboscidae* may be excluded on account of their absence or rarity on our cattle. *Stomoxys calcitrans* is a common fly in parts of Eastern Australia, and may be responsible for the transmission, but this seems rather unlikely on account of the relatively slow, southward extension of the condition. The same remark applies to the *Tabanidae*. Gilruth and Sweet (p. 27) are not in favour of the idea that biting flies spread the parasite, for the same reason, nor do they think that ticks are responsible, as they state that the nodules were observed long before the advent of the tick in Queensland. They evidently refer to the " cattle tick " *Margaropus* (or *Boophilus*) *annulatus*, var. *australis*, but there are many other ticks which are known to infest cattle in Australia, *e.g.*, *Amblyomma*, *Haemaphysalis*, *Aponomma*, and *Rhipicephalus*, while an *Ixodes*, (*I. holocyclus*) attacks various animals here. None of these, excepting *M. annulatus* are, however, common on cattle, and may be disregarded for the present on that account. The calf louse (*Haematopinus vituli*, L.), is regarded by these workers (p. 28) as being the most likely transmitting agent, and point to certain facts which seem to them to support their contention, viz., that the infection in young and old cattle is about the same ; that lice

are frequently present on weakly young animals ; that the situation of the nodules is under those parts of the skin which most frequently harbour lice ; and that the southward advance is slow. They, moreover, found a living embryo in a louse* which had been fed on an inoculated part of a heifer. It seems to me that the mosquito, the true lice, and the " cattle-fly "—a species of *Musca*, frequently found associated with Queensland cattle—are the most likely agents. The great objection, however, lies in the fact that, as yet, the embryos have not been detected in the blood-stream, and have not been found beyond the nodule.† Even after centrifugalising large quantities of blood, Gilruth and Sweet were unable to detect their presence. In regard to the allied parasite, *O. gutturosa*, from the Algerian cattle, Emery (in Neumann, 1910, p. 271) mentioned that he had not been able to find embryos in the blood.

The life history is not yet known in any species of *Onchocerca*. Brumpt (1904, quoted by Fülleborn, 1908, p. 15), Fülleborn (1908, p. 15), and Rodenwaldt (F. and R., 1908, p. 83), found embryos of *O. volvulus* in the peripheral parts of the tumours from human beings, and the first named author believed that a *Tabanus*, *Glossina* or *Simulium* might act as a transmitter. None of these authors, nor Parsons (p. 366), detected embryos in the blood, but the latter worker states that the distribution of *O. volvulus* " suggests the existence of a riverine intermediary," and believes it highly probable that embryos must pass sometime in the general circulation (p. 367), the transmitting

* Dr. Cleland and myself have examined a large number of lice (*Haematopinus vituli*, L.) and Mallophaga (*Trichodectes bovis*, L., syn. *Tr. scalaris*, Nitzsch), taken in New South Wales from a young calf infected with nodules, but without result. Of course the Trichodect is not likely to be a normal carrier on account of its food being epidermal structures and not blood. Sometimes blood is found in the crop, but this is not usual, the blood entering from wounds along with the ordinary food.

† Park in a footnote to a paper (Barnard and Park, 1894, p. 645) refers to finding " young *Spiroptera* in some of the blood vessels." Though Dr. Cleland and myself, as well as Professor Gilruth and Dr. Sweet, have worked through series of sections, we have not been able to find embryos in the blood. Park's statement stands quite unconfirmed up to the present as regards Australian cattle. It may be mentioned, however, that De Does (1904) found the embryos in the blood of Javanese cattle, and thought that blood-sucking insects were the most likely transmitting agents.

agent being, by analogy, probably a blood-sucking insect.

We have suggested (C. and J., 1910, *c*, p. 98) that imprisonment within a nodule may not be the normal fate of *O. gibsoni*. Leiper (1911, *a*, p. 13) thinks that an examination of the viscera might reveal the presence of the parasite in an unencapsuled condition, where it would liberate its embryos into the blood stream. On the other hand, one would expect that if encapsulation be abnormal, that there should be a greater number of free than encapsuled parasites, and the detection of the embryos in the circulation should not be difficult. As all the known species of the *Onchocerca* are found more or less embedded in fibrous capsules, and as both males and females may occur together in these nodules, and in such relation to each other that fertilisation is readily effected, (Brumpt, *re O. volvulus*, quoted in Fülleborn, 1908, p. 15, and in Fülleborn and Rodenwaldt, p. 83 ; Gilruth and Sweet, p. 10, *re O. gibsoni*), it seems to me that the connective tissues, especially the subcutaceous, are *a* normal, and probably *the* normal habitat of the members of the genus.

Origin of the parasite :—The original home of the nematode is almost certainly the East Indies. We (C. and J., 1910, *c*, p. 99) showed that it was probably by way of Timor that infected animals (buffaloes) arrived in Northern Australia. De Does had already recorded the occurrence of worm-nests in cattle in Java, but we were at the time unaware of his work. Gilruth and Sweet (1911, p. 34, addendum) mention that cattle were imported from Coepang, about 1824, and from other parts of the East Indies in 1840. This evidence supports the conjecture that infected animals —either cattle or buffaloes, or both—came from the East Indies to the Northern Territory, and became the means of spreading the condition, which has gradually extended its range southward, eastward and westward.

It might be observed that *O. armillata* (Railliet and Henry, 1910, p. 250) parasitises Indian and Sumatran cattle and buffaloes, and an allied or perhaps identical worm occurs in Malayan and Indian cattle and buffaloes (Daniels, Tuck, Leiper, Lingard). *O. armillata* infests the aortic walls. *O. gutturosa* (Neumann ,1910, p. 270) occurs in the cervical ligament of cattle in Northern Algeria and Tunis. These parasites are distinct from *O. gibsoni*.

Historical Summary :—A brief historical summary has been reserved until now, in order to simplify reference. Only the main papers relating to Onchocerciasis in cattle, more especially in Australian cattle, come in for notice.

The first published record was that by Morris in 1880 (1881, p. 337), though Gilruth and Sweet (1911, p. 1) have been informed that the presence of nodules in the brisket of Queensland cattle has been known for at least forty years. In 1892, Gibson (1893, p. 576) communicated an article to the Intercolonial Medical Congress, in which he gave an account of the embryo and such facts of the female worm as he could extract; of the pathology of the condition; as well as of feeding experiments performed on a dog, but with negative results. In the same year, T. L. Bancroft referred to the presence of nodules in cattle in Brisbane and Rockhampton.

In 1893, Barnard and Park (1894, p. 642) read a short paper, entitled "Notes on *Spiroptera*, associated with Tuberculosis in Cattle," in which they give an account of the result of an enquiry into the condition as affecting Queensland cattle. The parasite was recognised as being similar to *Spiroptera reticulata* (*i.e.*, *O. reticulata*), which infests horses. No cattle under two years of age were found to be affected, and this led them to suggest that the worm probably takes at least a year to develop and cause trouble. They thought that human beings might become parasitised by infected meat or drinking water. The disease was stated to be absent in Tasmania, but probably present in South Australia. A short account of the embryo and of a fragment of an adult was given. "A section of a small tumour or nodule containing the worm has a perforated or reticulated appearance, hence the name *Spiroptera reticulata*" (p. 644). There seems to be little doubt but that various tissues, some tubercular, others actinomycotic, had become mixed with real "worm-fibromata" (as De Does called them), hence the mistake made by these authors in considering that degenerated worm-nests commonly became the seat of tuberculosis or actinomycosis. (C. and J., 1911, *c*, p. 93.)

Similar information was published by Park, in Dec., 1893, in the *Veterinary Journal* (1893, p. 102), and in a report to the Chief Inspector of Stock (quoted in Tryon,

1910, p. 82-4). In the same year, Stanley (1893) referred to the presence of nodules in New South Wales cattle. For many years after this, little notice seems to have been taken of the condition in spite of its commonness. The fact that infected animals apparently do not suffer in health may have been responsible for this indifference towards the matter. The waste of meat incurred in removing the nodules from carcases and in condemning badly-infested portions, should have been sufficient reason for an investigation being undertaken. Apart from a few mere references dealing with the presence of worm-nests in cattle in West Australia (Cleland, 1907), in New South Wales (Johnston, 1909), and in Queensland (Pound, 1909), nothing was done until the latter part of 1909, when Dr. Cleland and myself in Sydney, and Drs. Gilruth and Sweet in Melbourne, began, independently, to devote special attention to the subject. Very shortly afterwards public notice was drawn to presence of these nodules in abundance in frozen carcases arriving from Australia, mainly from this State (Robinson, 1910, p. 6 ; Ann. Rep. Med. Off. Health, 1909, London, abstract in *Jour. Meat Milk Hyg.*, 1911, p. 24). It was suggested that such infected meat was possibly unfit for human consumption (Collingbridge—quoted by Robinson, 1910, p. 6). This led to severe measures being taken by the Health authorities in London and elsewhere (Robinson, 1910 ; Hancock, 1910, p. 25 ; Macfadden, 1911). Of course, a scare was created, and investigations were commenced by the Local Government Board (London). In the Annual Report of the Medical Officer for Health for the Corporation of London for 1909 (1910, p. 106-7)*, it was stated that in November, 1909, a large percentage of carcases of Queensland beef were found to contain encapsuled parasites lying in the connective tissues of the flank and brisket. The nodules, together with a small portion of the surrounding tissues, were removed and the rest passed as being fit for food. In cases where they were very numerous, the whole quarter was condemned. The parasite was identified by Shipley as *Spiroptera reticulata*, and by Leiper as *Onchocerca reticulata*. This report was probably issued early in 1910.

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* Abstract in *Journal Meat and Milk Hygiene* I., 1911, p. 24.

Meanwhile a short preliminary paper was published by Dr. Cleland and myself in the February (Feb. 2nd) number of the *N.S.W. Agricultural Gazette*, in which we briefly described the worm as a new species, *Filaria gibsoni*, quite distinct from, though closely allied to, *F. reticulata* of the horse. The idea that the nematode could be in any way injurious to human beings was disputed, as such nodules had frequently been eaten in Australia without any ill-effects having been detected. A more detailed report was reserved for official publication in the Annual Report of the Government Bureau of Microbiology, Sydney, for 1909, which, however, did not appear until August, 1910. This delay allowed the inclusion of some further details, and of information either unpublished or not available at the time of writing the earlier article.

There appeared in the same month (February, 1910), in the *Queensland Agricultural Journal*, two short papers on the subject, one by Tryon (1910, *a*), entitled "Verminous Tumours in Cattle," in which the writer gave a list of Australian literature, and made public some official information contained in reports by Park, and the other by Dodd (1910 *a*), who disagreed with Park's statements regarding the alleged frequent association between these nodules and tuberculosis. About the same time, Railliet and Henry (1910), in Paris, contributed a short paper on the *Onchocerca* group of parasites, and in it referred to the presence of encapsuled nematodes in the connective tissues of oxen having been recorded from Australia (Cleland ; Barnard ; Park), and from Java (De Does). They also dealt with allied worms causing the formation of worm-nests in other hosts. They discovered that there exists in the horse two species of *Onchocerca*, one *O. reticulata* preferring the legs as its habitat, though found elsewhere ; the other, *O. cervicalis*, frequenting the neck. *O. armillata* was described by them as a new species, infesting the aortic walls in oxen and buffaloes in India and Sumatra. Lingard (1905) had already called attention to the presence of aortic worms in Indian cattle. Neumann (1910, p. 270) shortly afterwards described another species, *O. gutturosa*, occurring fairly commonly in the cervical ligament in cattle in Algeria and Tunis. As already mentioned,

the Australian parasite, *O. Gibsoni*, prefers the brisket and flank.

The work of these French parasitologists was not available until after the publication of our official report on "Worm-Nests (Filariasis) in Cattle" (Cleland and Johnston, 1910, *c*). In this article, we reviewed the Australian literature and the public health and pathological aspects of the condition. We also gave a more detailed account of the anatomy of the worm and of its relationship to various other species of *Onchocerca*, such as *O. volvulus*, which causes nodules in man in certain parts of Africa (Fülleborn, Rodenwaldt, Parsons, etc.), and *O. reticulata*, which gives rise to a similar condition in horses (Pader). An account of experiments to determine the mode of transmission was also given. An allied parasite infesting the camel was dealt with incidentally, and was thought to be perhaps identical with *O. gibsoni*. The camel parasite is, however, a distinct species (*O. fasciata*), as Railliet and Henry (1910) have shown. Some of the ground traversed by these authors was also covered by ourselves. Their paper reached us in time to allow us to add a reference to it as an addendum to the above article in its rearranged condition, when it was published in the form of two papers (1910, *d*, 1910, *e*), by the Royal Society of New South Wales.

Early in the present year (1911), a number of papers appeared, the most important being one by Leiper (1911, *a*), an article by Macfadden (1911) accompanying it. Others were published, or rather republished, by the editor of the *Journal of Meat and Milk Hygiene* (Jan. 1911, p. 21-26), while the February number of the same journal contains a brief article by Nicoll (1911).

Macfadden (1911) gave an account of the official method of inspecting the carcases in London, the present inspection being much more detailed and thorough than that detailed by Hancock (1910), as being in force a short time before. He referred to the heavy infection occurring in some shipments, and to the difficulty of coping with large consignments of Australian beef arriving at the port of London.

Leiper's paper (1911, *a*) is a valuable one. In it he deals mainly with the anatomy, geographical distribution, and pathological effects of the parasite. In addition he

makes suggestions regarding the probable life-history, these having been referred to earlier. In regard to the geographical distribution, he refers (p. 10) to an encysted parasite found by Stiles in 1892 in cattle in the United States, and mentioned under the name *Filaria lienalis*, Stiles. A description was not published,* and at a later date (1894), this nematode was regarded as being "*Spiroptera reticulata.*" There is, therefore, little doubt, but that the parasite in question is an *Onchocerca*, perhaps identical with *O. gibsoni*, but I am inclined to believe that it will be found to be a different species, whose normal or original host may have been the bison. Some support for the idea that the two forms may be distinct is derived from the fact that Algerian oxen harbour a different species, *O. gutturosa*, Neumann, and that Indian and East Indian cattle may be parasitised apparently by two species, viz., *O. gibsoni* and *O. armillata*. Ford (1903)† met with one kind—"the aortic worms"—which form nodules in the aortic walls of Malayan buffaloes. These are regarded by Leiper (1911, *a*, p. 10), as belonging to *O. gibsoni*, while Railliet and Henry (1910) describe the aortic worms which infest oxen and buffaloes in India and Sumatra as a distinct form, which they named *O. armillata*. If these species be identical, then the latter will rank as a synonym of *O. gibsoni*, only a few weeks separating their respective dates of publication. They appear to me to be specifically distinct. Tuck (1907, 1908) referred to the aortic worms as well as to another kind—also belonging to the Filariidae—from Indian and Siamese bullocks. From the accounts given, we had regarded both of these as being distinct from *O. gibsoni*. It seems probable that the "aortic worms" (which are not yet recorded from Australia) are *O. armillata*, and that the ordinary "nodule worms" from the brisket and flank are *O. gibsoni*. As already mentioned, *O. gutturosa* is usually restricted to the cervical ligament.

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* In Stiles and Hassall's Index Catalogue of Medical and Veterinary Zoology, part 29, 1910, p. 2266, there is a reference to a paper by Stiles [1892, *q*] "On the presence of *Spiroptera reticulata* in cattle," but mention is made that the MS. was lost in the mail. The paper is, therefore, unpublished.

† Lingard (1905) recorded their presence in Indian cattle.

Leiper (p. 7) does not definitely group all the *Onchocerca* worms producing nodules in cattle under one species. He confines himself to stating that " this parasitic condition is known to occur not only in Australia, but also in the United States (Curtice ; Stiles), in the Malay States (Daniels ; Ford), and in India (Lingard)."

De Does (1904), Dood and Ouwehand* recorded the occurrence of worm-nodules (worm-fibromata) in Javanese cattle.

In Nicoll's article (1911), there is a brief summary regarding the parasite and the method of inspection of meat in England in order to detect its presence.

Quite recently an important paper by Gilruth and Sweet (1911), entitled " *Onchocerca gibsoni*, the cause of Worm Nodules in Australian Cattle," has been published along with the greater part of our report (C. and J., 1910, *c*, *d*, *e*) by the Commonwealth Government. The work of these authors has been frequently alluded to in the present article. They corroborate our findings generally, and give additional information regarding the anatomy of the worm and the variation met with in the parasites, as well as the early developmental stages of the embryos. Their suggestion that lice may act as transmitters has been already referred to.

The Report of the Agent-General for Queensland in London, 1910, has just been published (Robinson, Sept., 1911), and in it he again refers to the question of nodules in beef, mainly from the commercial side. A brief article will shortly appear in the *Queensland Agricultural Journal* (Johnston, 1911, *b*). There is also a brief reference made by Tryon (1911), in the Annual Report of the Agricultural Department, Queensland (1910-1911).

In concluding this summary, one must emphasise the fact that we need more definite knowledge regarding the means of transmission of the worm. " The elucidation of the life-history of the parasite is the most important part of the investigation of the disease. Until this is effected, no certain preventive measures can be framed or put into force." (Nicoll, 1911).

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† I am indebted to the kindness of Mr. Henry Tryon, Government Entomologist, for the opportunity of seeing this paper.

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