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Cysticercosis in Swine and Bovines, with special reference to South African conditions.*

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PART I.

Introduction.

IN discussing the etymology and history of, what we understand in the ordinary English of the meat industry, as "measles" in pork and beef, it is quite insufficient to consider the "bladderworm" stage of the parasite only, without discussing the historical advancement of knowledge regarding the adult tapeworm which succeeds the "bladderworm". The measle, bladderworm or larva, found in the muscles of the pig, for example, and the adult resultant tapeworm of man are so closely related, that one cannot be successfully described or discussed, without investigation of the corresponding stage in the other.

It is obvious, however, that in an article on "Cysticercosis", the bladderworm stage of the common parasite should receive the fuller consideration, although the adult, parent or final stage of the parasite must also receive attention, since we are merely dealing with two stages of a parasite, usually passed in two different hosts, and in order to arrive at a plan of campaign towards eradication of the parasite at either stage, we should understand the histology, pathological anatomy and peculiarities of both. It will be noticed that the word "usually" has expressly been used in the previous statement. The normal intermediate host of one of the two parasites to be discussed is the pig, and the final host, or host of the mature tapeworm is man. Under certain circumstances, however, man may actually be the host at both stages, and thus play the rôle, in the intermediate stage, of the pig, and be the harbourer of the pig measle. Then again, in addition to the pig and man, the dog and the monkey may also be the intermediate hosts of the pig measle bladderworm. We shall, therefore, not depart from the limits justified by the title of our subject, if we deal with tapeworm larvae of the same species as those of the pig in, for example, man, the dog,

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and the monkey, since the pig must in every case be considered as the original host of that particular bladderworm, which is followed by an adult tapeworm stage in man, and followed in turn by a second embryonic generation in, say, another pig, which may then be the precursor of various series of adult and embryonic generations alternating between man, the dog, man, the pig, man, the monkey, etc.

Etymological Discussion

The intermediate, or bladderworm stage of certain tapeworms is known as the *cysticercus* stage. The pathological infection of an animal body with *cysticerci* is known as cysticercosis.

The name *cysticercus* is derived from the Greek words *Kystis*, a bladder, and *Kerkos*, a tail. (Italic, instead of Greek lettering will be used throughout this work, when names of Greek derivation are defined). The pig measle is known as *Cysticercus cellulosae*, the bladderworm of the cellular or connective tissue, on account of its usual location in the connective tissues between fibres. The beef measle is known as the *Cysticercus bovis*, i.e., the bladderworm of the ox, or in some parts of Europe it is called *Cysticercus inermis*, the unarmed bladderworm.

The adult tapeworms of the above-mentioned *cysticerci* are the *Taenia solium* and the *Taenia saginata*, respectively. The Latin name *Taenia* is derived from the Greek word *Tainia*, a ribbon or a fillet. *Taenia solium* means the solitary tapeworm (French " *Ver solitaire* "), a name to which Leuckart took strong exception. *Taenia saginata* means the " stout " or " fat " tapeworm. The two respective species were first named by Rudolphi and by Goeze.

It is difficult to account for the adoption of the English term " measles ", except that the bladderworms visible in the musculature of a measly pig somewhat resemble the spotted eruption characteristic of the human disease of that name. The name is most misleading to the layman, who generally associates the parasitic disease of the pig or ox with the entirely different human disease. Not only the English, but also the French adopted a misnomer for ordinary usage in describing the disease in the pig and the ox. The French name for the disease, *Ladrerie*, is said to have been derived from the Greek *Laidros*, deformed or awkward, or from Lazareus or Lazarus, whose name has been corrupted in common speech to " Saint Ladre ". *Ladrerie* was sometimes used in former days as synonymous with " leper "and " leprous ", and it is not known by what affiliation this designation of *Ladrerie* has passed from leprosy to a parasitic affection, from which it is absolutely different. (Neumann).

How the Afrikaans word *masels*, or the immediately pre-Afrikaans South African Dutch word *mazelen* came into use is a mere conjecture. One would feel inclined to believe that measles was totally disregarded, or otherwise unobserved by our early Dutch, Huguenot and German South African ancestors. The Afrikaans

word *masels* is distinctly a literal translation of the English designation of the human disease, and one is inclined, further, to theorize that measles was first observed by our English fellow-ancestors after the arrival of the 1820 settlers in South Africa, who, probably had seen measly pigs in Great Britain. In support of this theory one may cite the fact that measles in pigs was well known in Europe even in the Middle Ages, and if our first Dutch, French and German ancestors had recognized the disease in whatever pigs were slaughtered at the Cape in the early days, one feels sure that posterity would not have lost the Dutch names *finnen* and *gortigheid*, or the German *finnen* and *finnenkrankheit*, or the French *ladrerie*. Instead, in Afrikaans to-day, we use a literally translated English misnomer.

History has, therefore, unfortunately lost trace of the origin of knowledge of pig and beef measles in South Africa. Whether measles was an indigenous disease among our early native stock, or/and whether our aborigines were tapeworm carriers, is unknown. It is also unknown whether measles in pigs and cattle was first introduced into South Africa by tapeworm carriers among the early Portuguese visitors, or among subsequent Dutch, French, German and English settlers, or whether it came from the northern interior of Africa with the Bantu invasion. Nor, of course, is it known whether the infection was brought to South Africa by means of importation of infected livestock, or whether humans brought and established the "vicious circle". Support is lent to the theory that the Bantu might have brought the disease from the north, by the fact that the Bantu invaders were closely related to the Ethiopians and Nubians, who in turn were closely associated, geographically, with the Egyptians, and the latter at least had placed a ban on the consumption of pork, for various reasons, whereas the Abyssinians were among the first to be described during the last century, as heavily infected with *Taenia saginata*.

Historical Survey.

That pig measles was known and recognised from the very earliest days can be learned from ancient writers. The parasitic nature of the measle, however, or its pathogenicity to man, was not known. It is hinted, however, by some authors, that the injunctions to Moses, which led to the Mosaic Laws were prompted by a knowledge that the meat of pigs, under certain conditions, might be dangerous, rather than "unclean" in the literal sense. Thus in *Leviticus* xi, 3, we read "*Whatsoever parteth the hoof and is clovenfooted, and cheweth the cud, among the beasts, that shall ye eat*"; and in the next verse: "*And the swine, though he divide the hoof and be clovenfooted yet cheweth not the cud, he is unclean to you*". It is debated by some, as to whether Mosaic Law meant that the pig was "unclean" physically, or "unclean" due to its possible diseased condition. Vorwahl (1923), has written against this discussion, and indeed against the Bible's reference to the uncleanliness of the pig. He is of opinion that the Israelites followed the views of the Syrians, viz. the pig should be considered a sacred animal.

In Greek literature are found several references to measly pork. Thus Aristophanes, B.C. 424, in his "Comedy of the Knights", mentioned the then existing custom of examining the tongue of the pig, in order to detect the presence of the so-called "glandular tumors".

Later Aristotle (B.C. 384-323) wrote and described what we would to-day understand to be measly pigs. "Measly pigs are those which have bad meat on the shanks, neck and shoulders", he wrote, "In those parts we find most measles. When only a few measles are found the meat is sweet, but when numerous, the meat becomes watery and unpalatable. As far as we know, we only find measles disease in pigs. Sucking pigs have no measles". It was also he who first attempted a description of the symptoms: "Measles mainly appear under the tongue. Those pigs with measles appear weak in the hind quarters". Aristotle's remarkable description was almost exactly reproduced by Rufus, and later it was mentioned by Pliny, Didymaeus, Plutarch, Aretaeus, Archigenes and Androsthenes.

Von Ostertag refers to Herodotus and Plutarch, who taught us that the Egyptians were forbidden to eat pork for the reason that it produced "an excess of humors and eruptions". The Phoenicians did not eat the meat of cows or swine, but held the flesh of dogs as a delicacy. On the other hand, the Romans were extremely fond of pork. Vosgien (1911) mentions that Roman vendors of pork had to guarantee the meat against measles.

During the third century A.D., Androsthenes compared pig measles with tubercles. Aretaeus compared measly pigs with people suffering from elephantiasis.

Perhaps one of the first references to a connection between tapeworms and the ingestion of pork was suggested by Anthimus (511-534 A.D.), who wrote to Theodoric, King of the Franks, that he suspected that human beings developed tapeworms by eating raw fat pork. (Le Coultre, 1928). His suspicion was certainly not unjustifiable, although he did not know the relationship between the *cysticercus* and the tapeworm.

During the 8th Century, Pope Boniface pointed out the necessity of cooking or smoking pork thoroughly, before consumption.

The Mohammedans were also forbidden the use of pork by their Prophet, on the grounds that the pig was unclean.

Later in the Christian era we find that in Germany and in France, definite regulations regarding the inspection of pigs were framed. Von Ostertag gives very interesting historical quotations regarding meat inspection in the Middle Ages in Germany, with special reference to the treatment of measly pork. The following quotations from von Ostertag are to the point.

In the year 1261, Count Raoul IV of Neuchatel decreed that "meat showing eruptions should not be sold as good meat, and under the roof of a meat market, pork containing eruptions, or meat killed by wolves or dogs, should not be sold".

The Augsburg Charter of 1276 laid down the following most interesting regulation: " If a butcher kills a measly hog, he shall sell it to no one without a statement of this fact. All the parts of such animal shall be sold in the same booth, and if it is sold whole, it shall be only after declaration ".

In Bamberg in 1306, the City Laws forbade the sale of measly meat, and in Würzburg in 1343, punishment was enacted for " all persons who offer for sale measly and mangy meat ". In 1346 the inhabitants of the village of Wolfmannshausen agreed " to bring at an appointed time all their hogs to the Monastery of Fröwenrode, where they shall be appraised and inspected by viewing the tongues. Those, which from the appearance of the tongues, shall be considered clean and worth the estimated price, shall be retained by the Monastery ".

Similar Charters are cited for Zwickau (1348), in which the sale of measly meat was forbidden in the booths, and for Hamburg, and also for Lübeck and Stade in 1375, where it was laid down that measly meat was required to be sold in a special booth on a white cloth. In 1376 the butchers of Regensburg were punished for selling measly pigs.

In Aachen, during 1385-1386, special pig inspectors or " *Finnenkückers* " were appointed, whose instructions were to examine all pigs offered for slaughter sale, and to " brand all unclean pigs with a distinctive cut ". These pig inspectors assumed office under oath to carry out their duties fairly and scrupulously, irrespective of the social standing, race and domicile of the vendor.

In Passau in 1394, meat inspectors were appointed, whose instructions were " to throw measly pork into the Danube, and the vendor was compelled to return the price of the hog to the buyer ".

Landshüt in 1401, went a step further, and passed an Ordinance prescribing that butchers should not sell " Jew meat, or measly meat anywhere else than between the tables, and that neither Jew meat, nor measly meat should be offered as good meat ".

In Wimpfen in 1404, a Charter laid down that measly meat was to be sold in a " measly booth ", three steps removed from the ordinary meat booths. In 1414 the butchers of Ulm asked the Council to adopt the following regulations, namely regulation of the traffic in measly pork, bulls' meat and Jew meat. Whoever offered such meat for sale was not allowed to sell any other meat at the same time. " *If a butcher pickled measly pork immediately after slaughter, and the twelve sworn masters of the market were satisfied of that fact, the butcher was allowed to sell other meat* ".

Steffen von Bergendorff was made to take the oath to keep the peace in 1434, after having been imprisoned in the City of Regensburg, because he attempted to sell hogs in which the bladder-worms had secretly been punctured, so that the inspector could not recognize them.

The town of Marbach in Alsace appointed sworn meat inspectors in 1437. Their duties, among others were to determine whether measly meat had been worked out into sausages.

In the year 1582, the Palatinate State Laws decreed that the meat of measly hogs, if not badly infested, should be offered for sale outside the shambles or butcher shops, at a place to be determined upon by the authorities. "In case, however, the measly meat in question is found to be quite unclean, it shall be absolutely rejected and shall not be sold, nor used."

The Slaughter Ordinances in Rostock forbade the sale of measly hogs in 1699.

The detailed directions to meat inspectors in Brüchsal about the year 1784, forbade the sale and consumption of animals suffering from certain diseases, among which *cysticercus* disease was expressly mentioned.

It will now be interesting to record that in France, in the Middle Ages, and up till the time of the French Revolution, similar Ordinances to those enacted in Germany were enforced.

In the thesis of Vosgien (1910-11), is found a number of quotations. In France, about the year 1375, specific pig inspectors were appointed. The inspectors, or *langueyeurs* had to ascertain whether pigs were measly or not, by an inspection of the pigs' tongues. A *langueyeur* could not be a butcher and an inspector at the same time. Huges Aubriot, 1375, ordained that "No one dare act as *langueyeur* until he has been proved competent by the master butchers". The duties of the *langueyeur* were fully described in the Edict of Charles VI in 1403.

The Ordinance of Robert d'Estouteville, Guard to the *Prévoté de Paris*, dated 1475, established: "No one may buy or sell, or make sausages from exhausted pigs, or measly pigs".

The *langueyeurs* were quite important personages, and held very high office. Later, they were actually appointed by the King.

According to Gach, it was decreed in France, as long ago as 1476, that measly pork could be salted for forty days, and then sold in the halls. Vosgien, however, records that in 1601 the Parliament of Paris decreed that measly pork, after having been salted for 40 days, could be sold in a specific place to be named by the *Prévot de Paris*, and had to be marked by a *drapeau blanc*, (white flag).

Vosgien also relates the punishment which was meted out to an offender. On May 28, 1716, the Chamber of Justice of Paris condemned one, Antoine Dubout, to the following punishment, because he had issued measly meat to the soldiers: "He was to be exhibited in a public place, *nu en chemise*, *la corde au cou*, with a burning wax candle in each hand, and with a placard on his chest and back, bearing the inscription of the nature of his offence". In addition Dubout was fined 50,000 livres, was banished from the City, and was deprived of all his rights as a butcher.

From about the middle of the 18th Century systems of meat inspection became less thorough in France and in Germany. In practising their professions correctly, qualified veterinarians had shown the public that the meat of animals suffering from certain diseases was harmless, but, unfortunately, local authorities appeared to misconstrue that teaching, and confusion resulted, to the extent that it was assumed that the meat of all diseased animals, including measly meat, was harmless. That unfortunate state of affairs continued in both Germany and France until 1852, when Küchenmeister startled helminthologists, veterinarians, medical men and hygienists, by proving that the *Cysticercus cellulosae* was the embryonic stage of the human *Taenia solium*.

Historical Review of Early Literature and Researches on Cysticercus-Taenia.

Although, as has been mentioned, measles was known to the ancients, up till the year 1685 *cysticerci* were regarded as glandular tumours. During that year Hartmann discovered the parasitic nature of *cysticerci*. He described the *Cysticercus tenuicollis* as parasitic, and followed his researches further. In 1688 he recognized the animal nature of the *Cysticercus cellulosae*. Ten years later, Malpighi, having worked independently of Hartmann, confirmed the latter's work, and further described the head process of the *cysticercus* very closely. "In verminous pork, called *Lazarioli*, live numerous colonies of worms, which are the cause that the sale of such animals is forbidden by public edict", wrote Malpighi, and continued: "These worms are in abundance in the cellular interstices of the muscle fibres of the thighs. They appear in the shape of small oblong tumours, as little sacs filled with transparent fluid, in which floats a white globular body. Should the envelope break, when pressed slightly, the worm squirts out of the vesicle, and one sees its horns coming out like those of snails. The rings fold over themselves, and the animal rolls into a ball. At the top is a little head, and on the rolled up worm there is what looks like a little umbilicus at the extremity of the vesicle".

The animal nature of the bladderworms was not universally accepted, and confirmation of the findings of Hartmann was further effected by Fabricius and by Goeze.

In discussing the history and development of knowledge of cysticercosis-taeniasis, Leuckart repeatedly alluded to the bitter feud which, during the middle of last century, existed between himself and his equally famous co-worker Küchenmeister. To Leuckart's credit, however, he gives all honour to Küchenmeister as the scientist who established the connection between the hook-bearing *Taenia solium* and the *Cysticercus cellulosae* of the pig. Küchenmeister observed the fact that the "structure of the head and hooks corresponded so perfectly in the two forms, that the most careful investigation could establish no differences between them". (Leuckart.)

In 1841, Steenstrup considered that the *cysticerci* could be regarded as the first step in the development of helminths, but to which they were related, he could not determine. Van Beneden

followed by von Siebold, in 1850 dispelled Steenstrup's doubts. It must be pointed out, however, that prior to 1850, von Siebold maintained that *cysticerci* were tapeworms with hydropically degenerate bodies, which was due to the fact that they had developed in an abnormal host, and were not necessarily intermediate stages.

In 1854 van Beneden successfully infected a pig with bladderworms, four and a half months after he had fed the animal on *Taenia solium*. In spite of van Beneden's test, some doubt existed as to the origin of the bladderworms, and whether they actually resulted from the eggs of the tapeworm which had been administered by van Beneden. In 1855 Haubner fed single proglottides (segments) of *Taenia solium*, followed by larger pieces, at various times to three pigs. He killed the pigs, and dissected them at various periods after initial feeding, and thus established the growth of the infection with *Cysticercus cellulosae*. At about the same time, Leuckart performed a similar series of experiments on five pigs, with the same results. Later Mosler and Gerlach confirmed by further experiments the findings of van Beneden, Haubner and Leuckart.

Küchenmeister's Experiment.

This experiment caused a complete revolution in the science of meat inspection, and it is proposed to quote, in almost full detail, Neumann's description of Küchenmeister's research. Küchenmeister published the results of his experiments in 1855.

For three consecutive days prior to her execution, a condemned woman prisoner was given seventy-five *cysticerci* in her food, by Küchenmeister, who had made the necessary arrangements with the prison authorities. At the autopsy, made 48 hours after death, Küchenmeister found 10 young *taeniae*, 4 mm. to 8 mm. long, " some of which already carried several hooks ". (Neumann p. 681). Küchenmeister repeated the experiment on another prisoner condemned to death. This subject was given 20 measles on two occasions—one four months and the other two and a half months—before execution. At the autopsy he found 19 *taeniae*, eleven of which had already mature *proglottides*. Küchenmeister's experiments were repeated and the results confirmed the following year by Leuckart, who gave four fully developed *Cysticerci cellulosae* in milk to a young tubercular subject, who voluntarily offered himself as a subject. Two months later, Leuckart found *proglottides* in the excretum of his subject.

With reference to historical literature on the *Cysticercus bovis* and its adult counterpart, the *Taenia saginata*, there is very little written before the 18th Century. Leuckart, however, is of opinion that the Ancient Greeks carried and encountered the *Taenia saginata* more frequently than the *Taenia solium*. He cites as evidence for his theory the fact that the former is a more common disease in Mediterranean countries and the East, than the latter disease-causing parasite; and cites too the writings of Hippocrates, " the tapeworm subject voids in portions the ripe joints of the worm ", a phenomenon, which Leuckart points out, is much more usual and striking in the case of *Taenia saginata* than of *Taenia solium*. If Leuckart's conclusions are correct, then we must believe

that beef measles must, also, have been fairly common in Ancient Greek times, although they were never observed. An important factor in regard to the occurence of *Cysticercus bovis* is that the cysts are generally isolated and more frequently than not, are found singly or a mere few, in a carcass. That factor, possibly, was the reason why they were not noticed by the Ancients, or otherwise, in comparison with the usual heavy nature of the infestation of pigs, they were not considered worth while troubling about.

On similar grounds, Leuckart holds the opinion that the Arabian physicians mainly investigated *Taenia saginata.* The Arabians considered the various segments as separate entities formed into a chain, and that the chain constituted what is now known as tapeworm. These views were supported by Vallisnieri and also by Coulet at the beginning of the 18th Century, and by Linné, whose description constituted a comparison between a tapeworm and a plant of many shoots.

With regard to the older descriptions of tapeworms, we learn from Aëtius and Paulus Aeginata, that they considered the tapeworm as a metamorphic product of the intestinal mucous membrane. "*Lumbricus latus transmutatio, ut ita dicam, est membranae intestinis intrinsecus agnatae in corpus quoddam animatum.*" (Leuckart.)

Ancient Chinese Medical Views.

Gear and Pedersen (1934) give an interesting reference to the work of Chu and Chiang (1931), who translated twelve old writings, which illustrated the type of knowledge and opinion held by Chinese medicine concerning helminths. These twelve works extend over a period from Tsang Kung Lieh Chuan 180 B.C. to Pien Chiao Hsin Shu in 1767 A.D., and as Hoeppli in an introduction to the study points out, there are several remarkable similarities in the different texts. According to Gear and Pedersen, the same theories with slight variation persist through the twelve works, and are sufficiently illustrated in an extract quoted by those authors, from the translation given of the Ch'ao Shih Ping Yuan of 605 A.D.

"The 'Tsun Pai Ch'ung' is also one of the nine worms. It is about one inch long, white in colour and flat in shape. The attack is due to the weakness of one's viscera. It is said that the infection is due to drinking of "white" wine and eating of raw beef and raw grains. It is also said that eating of raw fish followed by a drink of cold milk likewise produces the infection. It weakens one's general physical condition and produces pain and weakness of the kidney and feet. If the worm grows to one foot in length it causes the death of the host."

Gear and Pedersen quote Hoeppli, who says: "It is very remarkable, however, that several times the 'Ts'un Pai Ch'ung' which, in our opinion, is a tapeworm, is said to be produced by eating raw meat, a belief which is evidently not purely speculative, but rather the result of observation".

Actual beef measles, had, however, been seen for many years, but they were considered as tumours. In 1684, Redi in Italy and Hartmann and Wepfer in Germany recognized the animal nature of the larvae from their movements and organisation. (von Ostertag). In 1767 Linnaues and in 1781 Pallas saw parts of *Taenia saginata*, but in 1782 Goeze described the parasite.

Perhaps Knox, who served in South Africa as an Army Surgeon, might be considered as one of the first writers who connected an outbreak of tapeworms among humans with the ingestion of beef. Edmonds (1922) refers to Knox's report of an outbreak of tapeworms among soldiers who had participated in the Kaffir War in 1819. Knox ascribed the cause of the infection as due to the fact that " the soldiers had eaten the meat of oxen which had been driven too fast, and were exhausted ". Leuckart states that he examined some specimens of the Cape tapeworm, which were sent to him, and he was satisfied that they were *Taenia saginata*. Leuckart makes special reference to " Knox's outbreak ", and strongly hints that this outbreak and its association with the ingestion of beef and certain other factors were instrumental in causing the experiments he conducted in 1861, which definitely established the relationship between *Taenia saginata* and *Cysticercus bovis*. The various factors which Leuckart considered were the reports of ancient and modern travellers, and particularly of Duvaine in 1860, that from earliest times, almost without exception, the Abyssinians who ate no pork were heavily infested with tapeworms; that Jews and Mohammedans, who likewise ate no pork, were frequently infested with tapeworms; and lastly, Weisse's report from St. Petersburg in 1857, that he had often fed raw beef to delicate children, and that tapeworms had frequently been developed in his patients. Leuckart, also, very fairly, mentioned that Hüber and Schmidt had already noted the probability that the ox could be the intermediate host of *Taenia saginata*. The latter had mentioned to Leuckart that with some certainty he had traced the existence of *Taenia saginata* to the ingestion of a meat salad made from raw beef.

Leuckart's Experiment.

Describing his experiment, Leuckart states that in November 1861, he gave about a yard of some 80 ripe segments of *Taenia saginata* to a calf four weeks old, and about 8 days later he repeated the feeding with a smaller dose. He mentions that the animal he experimented on seemed to be so slightly affected by the experiment, that he was about to extract a muscle, when, 25 and 17 days after the first and second feedings, respectively, he found the calf dead. On post-mortem examination he found all the muscles, and especially those of the breast and neck, and the psoas, had been penetrated by cysts, which measured about 2 to 4 mm. by 1·5 to 3 mm. in size. He found those cysts numerous everywhere, " and in many places they lay so thickly together, that their total number must have been many thousands, yet, it seemed at first as if the death of the animal under experiment could hardly have been caused by them ", writes Leuckart. " It was, however, indeed the *cysticerci* which had killed the calf. Further examination showed that the distribution of the parasites was in no way confined to the peripheral muscles of the body ", he concludes.

Among other localities Leuckart found "crowds of cysts followed the course of the swollen lymphatic vessels and glands into the inguinal region." "Some of the glands were not only reddened, but were full of extravasated blood, which permeated throughout their entire mass", continues Leuckart; and he concludes, "I had almost no scruple in referring the death of the animal to the pathological state of inflammation of the lymphatics. The latter may also be traced to the state of inflammation which resulted from the immigration and development of such number of parasites."

Leuckart's colleagues Seitz and Mosler agreed with his views and "so have all my successors concluded", writes Leuckart, "except Küchenmeister". Leuckart bitterly quotes the writing of Küchenmeister: "Leuckart's first experiment, taken by itself teaches us nothing, except that, after abundant feeding with the *proglottides* of *Taenia mediocannelata* (Küchenmeister's nomen for *T. saginata*), the animal remained long, apparently unhurt, till suddenly, 25 days after feeding it died and exhibited a miliary tuberculosis caused by the Cestode brood. Without the subsequent experiments, I cannot regard the first as of special value in regard to *Taenia mediocannelata*".

On December 27th, that year, Leuckart repeated the experiment on a second calf, but remembering the severe results of his first experiment, and the resultant death of the calf, he used smaller doses of segments, and repeated these at five to six day intervals, until the calf received about 50 segments. Twenty days after the first infection, many pathological phenomena appeared, for example, loss of appetite, fatigue, ruffling of the hair and fever, but those clinical signs subsided, till finally perfect health returned. Forty-eight days after the first, and thirty days after the last feeding, Leuckart extracted the sterno-hyoid muscle of the left side. In this muscle he found about a dozen cysts. The cysts were of various size, representing various stages of development. In examining those embryos, Leuckart made the striking discovery that although the bladderworms were the "descendants and young forms of a hookless tapeworm, they were furnished with a distinct, though small *rostellum*, and with the rudiments of hooks". Later, Leuckart watched the development of the *cysticerci* by extracting other muscles at various periods. He thus proved, conclusively, that one of man's principal food animals, the ox, was the intermediate host of the human tapeworm *Taenia saginata*. All but one pair of the following list of subsequent investigators obtained positive results from confirmatory experiments:—

Germany.— Mosler (1864); Röll (1865); Gerlach (1869); Zürn (1871); Zenker (1872); Probstmayr (1879).

France.— St. Cyr (1873); Masse and Pourquier (1877).

Belgium.— van Beneden Junior (1879).

Italy.— Perroncito (1877).

England.— Simonds and Cobbold (1866)—negative results.

Commenting on the report of Gerlach, Leuckart states, *inter alia* " Gerlach killed his experimental calf 5 months after feeding, and found that it was penetrated through and through with bladder-worms ".

Conversely, shortly afterwards, Oliver and Perroncito infected themselves and their respective assistants with *Taenia saginata*, after having ingested *Cysticercus bovis* bladderworms.

PART II.

A Survey of the Incidence of Cysticercosis in Swine and Bovines.

In providing a survey of this nature, it must be explained that figures representative of the incidence of infection as observed at abattoirs in many countries, must be regarded as not necessarily indicative of the actual extent of infestation in such particular countries, since, in many cases infected stock slaughtered may have been imported from elsewhere, and the survey would then, rather, tend to show the surmised incidence of infection in the export country. In some countries also, reliable statistics have not been compiled, and, therefore, data given must frequently be judged more as speculative than actual. In some other countries statistics of infection were available many years ago, but more recently, owing to a decreased incidence of infection, the relatively few cases have not been recorded.

The statistics supplied in the following pages have been obtained from (*a*) old, recent and contemporary literature; (*b*) as the result of personal enquiry from the respective authorities and from the obliging replies sent by those colleagues; (*c*) from " speculative " sources reflecting the incidence of infection found among exported stock slaughtered and found infected in foreign countries. It might be explained that questionnaires were forwarded to no less than fifty countries, and replies were obtained from the vast majority of them. It is regretted that no statistics are available for a few important territories.

A. The Incidence of Cysticercosis in Swine and Bovines in Europe.

Great Britain.

Through the kind favour of Col. T. Dunlop Young of London, enquiries were made from the abattoir reports from most of the important centres, but not a single instance of measles was reported for the year 1935.

Robertson (1920) accidentally infected some if his patients at Leith (whom he had placed on a raw beef diet for tuberculosis) with *Taenia saginata*. It can, therefore, be presumed that *C. bovis* must have occurred at that time among Scottish slaughter cattle.

Stockman (1909) stated that although no statistics on the frequency of measles were available in Britain, there was little doubt that it existed in British swine at that time. "In the past few years the author has met with several cases, and others have been reported by practitioners." (Stockman, 1909). Cameron (1933) suggests that both species are sometimes met with in the British Isles..

Germany.

According to von Ostertag (1934), the incidence of *C. bovis* in oxen varied between 0·321 per cent. in 1904 and 0·27 per cent. in 1928. In Berlin the percentage of animals infected fell from 0·84 in 1913 to 0·33 in 1922, and rose to 0·617 in 1928. In Breslau, Mahlendorff (1930) recorded the incidence of infection at that abattoir during 1929-30 to be over 1 per cent. The highest percentage (1·54) was during the month of November, 1929 (i.e. during the period under report).

According to Leeb and Berngrüber (1932), during 1931, 1·906 per cent. of slaughtered bovines were found to be measly in Würzburg, and there was evidence that infection was increasing throughout the State of Bavaria. According to Krueger (1934), 2 per cent. of all cattle slaughtered in Kottbus were infected with *C. bovis*.

Junack (1926) draws attention to the fact that for Prussia for the years 1922 and 1923, 18 and 11 bovines, respectively, were shown as measly, whereas the thousands of cattle which were passed after treatment (cooling for 21 days), were not mentioned. Thus the last-named numbered 403 and 398 for Berlin alone. Junack mentions that, by not including all these lightly infested bovines in the count, a false impression is given. Thus, on the one hand hygienists, and on the other hand butchers get the wrong impression that *C. bovis (inermis)* is not of much moment any longer from a point of view of Public Health and Food Economy.

In Germany the incidence of *C. cellulosae* has diminished to almost nil in German-reared pigs. Most of the cases found during the past few years at German abattoirs have been in imported slaughter pigs. Thus Berdel (1930) records that at Frankfurt a.M. abattoir, between 10.9.29 and 19.11.29, out of 1,415 pigs imported from Lithuania, 100 were found to be measly (i.e., 47 heavily infested and 53 lightly infested). The same author quotes Meyer, who stated the year before that 19·47 per cent. of slaughtered Russian pigs were found to be measly at Barnaul. In the Saxon foreign-import meat inspection halls 39 out of 13,472 half-pigs were found measly during 1925-26. (Berdel.)

Von Ostertag (1913) showed the gradual diminution in the number of measly hogs in Germany thus:—

(a) *Kingdom of Prussia.*		(b) *Kingdom of Saxony.*		(c) *Berlin.*	
	Percentage.		*Percentage.*		*Percentage.*
1876–1882.....	0·324	1894.....	0·151	1883–1890.....	0·577
1886–1889.....	0·181	1896.....	0·617	1892–1893.....	0·319
1890–1892.....	0·122	1899.....	0·010	1895–1896.....	0·099
1899.....	0·09			1899.....	0·043

Ministerialdiregent Professor Dr. Müssemeier of Berlin kindly supplied the following official table showing the incidence of cysticercosis (measles) in Germany for the ten years, 1925-1934:—

Year.	Heavily infested.				Lightly infested.			
	Cattle.		Pigs.		Cattle.		Pigs.	
	No.	Per/1000.	No.	Per/1000.	No.	Per/1000.	No.	Per/1000.
1925.....	112	0·03	193	0·02	6,174	1·91	336	0·03
1926.....	102	0·03	178	0·01	6,801	2·09	256	0·02
1927.....	103	0·034	92	0·01	7,110	2·23	186	0·01
1928.....	166	0·05	98	0·01	9,555	2·69	222	0·01
1929.....	167	0·04	567	0·03	11,257	2·82	646	0·04
1930.....	194	0·05	753	0·04	11,501	3·24	975	0·05
1931.....	278	0·06	219	0·01	11,950	3·53	283	0·01
1932.....	247	0·06	60	0·00	135,368	3·83	133	0·01
1933.....	224	0·06	49	0·00	141,188	4·08	131	0·01
1934.....	350	—	46	—	16,697	—	108	—

Note the steady increase in numbers and per thousand in cases of *C. bovis* in Germany.

Switzerland.

The statistics given for Switzerland were kindly obtained by Dr. W. Frei, of the Veterinary Pathological Institute of the University of Zürich, from the abattoirs at Basel, Zürich and Berne. The statistics cover periods ranging from 15 years to 25 years, and may be taken as fairly representative for Switzerland. The statistics are those for pigs and adult bovines only. The incidence of *C. bovis* in calves is very low.

At the Abattoir at *Berne*. Statistics kindly supplied by the Director:—

Year.	Bovines slaughtered.	Measly.	Percentage.	Year.	Bovines slaughtered.	Measly.	Percentage.
1921.....	4,175	16	0·38	1930....	5,487	18	0·30
1932.....	5,116	16	0·31	1931....	4,788	20	0·42
1924.....	6,205	18	0·29	1932....	4,745	34	0·72
1925.....	5,098	7	0·14	1933....	5,650	21	0·37
1926.....	4,615	8	0·17	1934....	7,202	17	0·23
1927.....	4,799	18	0·38	1935....	8,518	15	0·18
1928.....	5,012	9	0·18	1936....	5,496	10	0·18
1929.....	4,974	13	0·26				

Very nearly half the cattle killed at Berne were imported.

NOTE.—During the above period only one measly pig was slaughtered (during 1926, out of over 20,000). This pig was imported from Italy.

At the Abattoir at *Zürich*. Statistics kindly supplied by the Director:—

Year.	Bovines killed.	Measly.	Per-centage.	Year.	Bovines killed.	Measly.	Per-centage.
1910.....	11,838	20	0·17	1923....	12,929	14	0·11
1911.....	11,181	24	0·21	1924....	17,629	6	0·034
1912.....	10,918	20	0·18	1925....	14,902	17	0·12
1913.....	11,150	15	0·13	1926....	12,660	21	0·17
1914.....	11,835	26	0·22	1927....	20,042	14	0·069
1915.....	5,177	8	0·15	1928....	12,011	13	0·11
1916.....	13,369	24	0·18	1929....	19,740	21	0·106
1917.....	13,558	32	0·24	1930....	13,477	9	0·067
1918.....	20,015	44	0·22	1931....	7,920	3	0·038
1919.....	18,062	27	0·15	1932....	9,854	4	0·041
1920.....	10,994	13	0·12	1933....	17,036	15	0·088
1921.....	3,946	6	0·15	1934....	17,569	9	0·051
1922.....	11,531	19	0·16	1935....	11,340	10	0·088
				1936....	15,575	16	0·13

During the period 1910-36, over half-a-million pigs were slaughtered, of which number only 52 were measly.

At the Abattoir at *Basel*. Statistics obtained from annual reports for the years 1915 till 1935. Reports kindly supplied by Dr. J. Unger, Director of Abattoirs:—

Year.	Bovines.	Measly.	Per-centage.	Year.	Bovines.	Measly.	Per-centage.
1913.....	18,285	15	0·082	1925....	13,663	72	0·52
1914.....	16,639	15	0·09	1926....	13,770	22	0·16
1915.....	14,546	24	0·17	1927....	13,045	40	0·31
1916.....	12,621	17	0·14	1928....	13,618	32	0·23
1917.....	13,402	12	0·09	1929....	14,732	39	0·27
1918.....	17,455	45	0·26	1930....	12,720	39	0·31
1919.....	14,211	61	0·43	1931....	13,388	49	0·37
1920.....	10,221	61	0·61	1932....	13,975	40	0·29
1921.....	9,807	27	0·28	1938....	15,425	13	0·29
1922.....	11,858	39	0·33	1934....	16,485	38	0·23
1923.....	14,224	52	0·37	1935....	16,533	24	0·15
1924.....	18,167	100	0·55				

During the period quoted above more than one million pigs were killed at Basel, and of that number only eleven were found measly, the last (one pig) being in 1931, and previous to that, one pig in 1924.

Special Notes relative to the Reports for the Abattoir for Basel:—

1920: Of 61 measly cattle, 11 were imported, viz., from *Denmark* 6 out of 1,165; from *Canada* 2 out of 615; from *Italy* 2 out of 222; from *Lichtenstein* 1 out of 52.

1921: of 27 measly cattle, 16 were imported, viz., from *Denmark* 7 out of 2,427; from *Czechoslovakia* 5 out of 1,228; from *Canada* 4 out of 1,145.

1922: Of 39 measly cattle, 13 were imported, viz., from *Denmark* 1 out of 439; from *Germany* 1 out of 93; from *Canada* 1 out of 152; from *France* 3 out of 43; from *Czechoslovakia* 5 out of 788; from *Argentine* 2 out of 770.

1923: Of 52 measly cattle, 28 were imported, viz., from *Holland* 1 out of 191; from *South West Africa* 1 out of 204; from *Argentine* 8 out of 908; from *Denmark* 18 out of 5,024.

1924: Of 100 measly cattle, 87 were imported, viz., from *Canada* 1 out of 392; from *South West Africa* 2 out of 117; from *Czechoslovakia* 17 out of 235; from *Germany* 8 out of 1,340; from *Argentine* 11 out of 3,742; from *Denmark* 58 out of 8,833.

1925: Of 72 measly cattle, 56 were imported, viz., from *Austria* 19 out of 1,502; from *Italy* 14 out of 1,394; from *Canada* 8 out of 2,321; from *Czechoslovakia* 7 out of 624; from *Germany* 5 out of 539; from *Hungary* 3 out of 1,821.

1926: Report does not give separate origin of measly stock.

1927: Of 40 measly cattle, 19 were imported, viz., 14 out of 411 from *Czechoslovakia;* 2 out of 2,713 from *Hungary;* 3 out of 991 from *France.*

1928: Of 32 measly cattle, 4 were imported, namely from *France* 2 out of 1,910; from *Hungary* 2 out of 480.

1929: No stock imported.

1930: Of 39 measly cattle, 16 were imported, all from *Hungary*, i.e., 16 out of 2,889.

1931: Of 49 measly cattle, 23 were imported, viz., from *Germany* 1 out of 233; from *Hungary* 22 out of 3,814.

1932: Of 40 measly cattle, 3 were imported, viz., 1 out of 376 from *Hungary*; 2 out of 56 from *Czechoslovakia.*

1933-1935: No records of imported cattle.

In older Swiss literature, Buri (1915) mentioned that in Eastern and North-Eastern Switzerland the incidence of *C. bovis* was higher than in Western Switzerland. Thus, for Eastern Switzerland he gave an incidence of 1·5 to 2·3 per cent., and for Western Switzerland 0·3 to 0·4 per cent.

Krupski (1917) found at Liestal a percentage of 5·9. This high percentage Krupski attributed to more thorough inspection of predilection sites.

Holland.

Le Coultre (1928) obtained the following data from Professor van Oijen:—

At *Rotterdam* from 1918 to 1923, only cases with living *Cysticerci bovis* were noted. The percentage infection varied between 0·001 and 0·003. From 1924 to 1927 cases with degenerated measles were also noted, and the percentage was then between 0·1 and 0·2.

At *Haarlem*, in ten years up to 1927, the incidence varied between 0·33 per cent. and 0·6 per cent.

At *Alkmaar* the incidence varied between 0·1 per cent. and 0·5 per cent.

At *Leiden*, in adult bovines, between 1918 and 1922 the incidence of infection varied between 0·1 per cent. and 0·66 per cent.; in 1923 it was 0·04 per cent.; and between 1924 and 1927 it varied between 0·2 per cent. and 0·4 per cent.

At *Groningen*, in ten years the incidence varied between 1·03 per cent. and 1·5 per cent.

At *Arnhem*, the figures were: 1918, 1·51 per cent.; 1919, 2·45 per cent.; 1920, 2·94 per cent.; 1921, 3 per cent.; 1922, nearly 4 per cent. (238 cases out of 5,927 bovines slaughtered); from 1923 to 1927 the percentage varied between 2 and 2·75 per cent.

At *Nijmegen*, the percentage varied from 1918 tot 1922, between 0·22 and 0·4. From 1923 to 1927 a sudden tremendous increase in the percentages occurred, thus for the five years 1923-1927, inclusive, the figures were 3 per cent.; 3·7 per cent.; 4·7 per cent.; 4·4 per cent. and 3·2 per cent., respectively.

[Le Coultre ascribes this increase in the incidence, as observed at Arnhem and Nijmegen to more thorough inspection technique. School (1933) expressed a similar opinion.]

At *Utrecht* the percentages varied from 1918 to 1927 between 0·23 and 0·61.

Recent Statistics.

Professor C. F. van Oijen of Utrecht kindly supplied me with the following statistics for the years 1933 and 1934:—

Cysticercus bovis was found in 1933 in 4,515 adult bovines, and in 1934 in 4,572 adult bovines. According to Prof. van Oijen, the number of cases of cysticercosis, so far as this concerns the whole country, has again risen, namely from 0·83 per cent. to 0·92 per cent.

At *Leeuwaarden* an increase in the number of cases of cysticercosis in bovines has been noted, which is reflected in the following statistics:—

	Dead Specimens percentage cases.	*Living Specimens percentage cases.*
1930	0·69	0·016
1931	1·07	0·059
1932	1·74	0·06
1933	1·6	0·06
1934	1·64	0·1

At *Rheeden*, 9·2 per cent. of the total slaughtered bovines were found measly—105 cases. "The percentage is still steadily increasing". (Prof. van Oijen.)

At *Arnhem*, *Cysticercus bovis* was found in 257 adult bovines (4·45 per cent.). "Percentage is still increasing". (Prof. van Oijen.)

At *Utrecht*, 128 adult bovines were found measly. The percentage this figure represents was not given.

At *Apeldoorn*, 64 adult bovines were found measly (2·1 per cent.).

At *Zutphen*, 138 adult bovines were found measly (4·24 per cent.).

At *Doetinchem*, in adult bovines 4·07 per cent. were found measly. (The number of cases has increased.)

At *Amersfoort*, 17 cases were measly (percentage not given).

At *Amsterdam*:

1st quarter, 9 cases living or 0·08 per cent. and 24 cases dead measles, 0·32 per cent.

2nd quarter, 7 cases living or 0·07 per cent. and 18 cases dead measles, 0·18 per cent.

3rd quarter, 8 cases living or 0·09 per cent. and 47 cases dead measles, 0·52 per cent.

4th quarter, 20 cases living or 0·17 per cent. and 93 cases dead measles, 0·75 per cent.

At *Haarlem*, where the percentage cysticercosis is considerably higher than at Amsterdam, the increase was not so obvious, as is shown in the subjoined table:—

1st quarter, 10 cases living measles—0·45 per cent. and 37 cases dead measles—1·7 per cent.

2nd quarter, 7 cases living measles—0·3 per cent. and 38 cases dead measles—1·6 per cent.

3rd quarter, 8 cases living measles—0·33 per cent. and 55 cases dead measles—2·3 per cent.

4th quarter, 7 cases living measles—0·28 per cent. and 62 cases dead measles—2·5 per cent.

Only three cases of *C. cellulosae* were found in pigs in Holland during the years 1933 and 1934. Kerstens (1931) showed that it was dangerous to presume that *C. cellulosae* was non-existent in Holland. He referred to a case he found in a pig which was slaughtered domestically by a farmer.

Belgium.

Professor V. Rubray, Rector of the *Ecole de Médicine Vétérinaire*, Cureghem-lez-Bruxelles, writes (5th March, 1937):-

"1. As regards infection of the pig, we find only one or two cases per year, out of about 150,000 subjects slaughtered at the abattoirs.

2. In cattle, during the war, 1 to 2 per cent. were found infected, but nowadays it is as rare as in the pig.

The result of this notable decrease in the incidence of cysticercosis we attribute to our hygienic measures and the fact that the ox and the pig are given no facility to become contaminated by human excretum."

France.

In spite of exhaustive enquiry into recent French literature, and personal communications to French authorities, the present author was unable to obtain any recent information as to the incidence of *C. cellulosae* and *C. bovis* in France at the present time.

Vosgieu (1911) gave the percentages recorded at three centres. *C. cellulosae* in pigs:—

Paris: 1900, 0·03 per cent.; 1901, 0·05 per cent.; 1904, 0·01 per cent.; 1906, 0·0175 per cent.; 1910, 0·034 per cent.

Bordeaux: 1905, 0·05 per cent.; 1906, 0·063 per cent.; 1909, 0·024 per cent.

Limoges: 1890, 0·76 per cent.; 1895, 0·62 per cent.; 1900, 0·48 per cent.; 1905, 0·41 per cent.; 1910, 0·27 per cent.

According to Ballou (1913) (le Coultre, 1928), the percentage infected bovines was as high as 17·42 (i.e. 23 cases out of 132 bovines) at Troyes-sur-Aube. Raymond (le Coultre, 1928) found the percentage to be 3·5 in bovines in Paris in 1908 and 1909.

If we were to consider the incidence of infection in French bovines exported to Switzerland as a criterion of the extent of infection in French domestic cattle, then the incidence of *C. bovis* in that country is very much lower at the present time. During the years 1922-32, 3,140 cattle from France were slaughtered at the abattoir at Basel, Switzerland, and of this number only 8 were infected (0·25 per cent.). The maximum record of infection was shown in 1922, when 3 French cattle out of 43 were found measly at Basel. (Approximately 7 per cent.)

Spain.

Owing to conditions at the present time, it is not possible to obtain statistics from this country. According to Vosgien (1910-11), 0·29 per cent. of pigs slaughtered in Madrid in 1910 were found to be measly. Out of 61,457 pigs slaughtered in that city during 1910, 180 had measles.

Portugal.

Dr. Fernando de Fontes Pererira de Mello kindly supplied the following statistics relevant to the incidence of cysticercosis in Portugal:—

1. *Cysticercus cellulosae*—(Portugal).

	1933	1934	1935
Number of cases	312	429	437
Percentages	0·184%	0·209%	0·213%

2. *Cysticercus bovis*—(Lisbon abattoir).

Number of cases: 153.

Percentages of slaughtered bovines: 0·003 per cent.

These cases came from:—

Alentejo (Portugal)	1
Ribatejo (Portugal)	1
Angola (West Africa)	151

Italy.

Cysticercus cellulosae was relatively common in Italy about the year 1870. Thus, Pellizari (Leuckart, 1886) estimated the number of measly pigs in Italy to be 1 per 3,000, but Perroncito (Leuckart) stated that in Turin 1 pig in every 250 was measly, and in Milan 1 in every 70.

In reply to a request for information on the present incidence of cysticercosis in Italy, the Union Minister Plenipotentiary at Rome very kindly submitted the following translated *Note Verbale* dated 17th March, 1937, from the Royal Italian Ministry of Foreign Affairs.

Note Verbale (17.3.37).

"In Italy, due to the continuous and strict reinforcement of the Legislative Regulations dealing with sanitary supervision over meat, infection through *Cysticercus cellulosae* has become rare, so much so that in many big abattoirs in the Kingdom, where the meat of thousands of pigs has been controlled for many years, there has not been found a single case.

The same thing can be said about *Cysticercus bovis*, which, for example, has for more than 10 years not been found in the Rome abattoir, notwithstanding the continuous and regular research as with *Cysticercus cellulosae*, in points where the infection is most likely to be found.

It should also be considered that in Italy butchering for private use is, by regulation, under veterinary control, and it is to be borne in mind that this too, has advantageously contributed to reaching the favourable situation indicated above".

From 1920 to 1932, 16 export Italian bovines out of 1,837 were found measly at the abattoir at Basel (Switzerland).

Austria.

Vosgien (1910-11) gives the following statistics for the Vienna abattoir:—

In 1902: 4,109 cases of measles out of 594,539 pigs slaughtered —0·671 per cent.

In 1903: 3,425 cases of measles out of 564,813 pigs slaughtered —0·606 per cent.

In 1904: 3,213 cases of measles out of 579,317 pigs slaughtered —0·555 per cent.

In 1905: 4,243 cases of measles out of 575,340 pigs slaughtered —0·737 per cent.

In 1906: 3,421 cases of measles out of 600,244 pigs slaughtered —0·569 per cent.

In Wiener-Neustadt, Schmidt (von Ostertag, 1913) found between the years 1901 and 1910 that 1·8 per cent. of pigs were measly.

According to Schmid (1930), 89 pigs out of 54,461 slaughtered at Wiener-Neustadt (i.e., 0·17 per cent.) were found measly in 1929. Of this number 57 came from Yugoslavia: 16 from Hungary; 11 from Poland.

According to the same author, 17 bovines out of 5,439 were measly at Wiener-Neustadt during 1929.

The *Chef der Veterinärverwaltung des Oesterreichischen Bundesministerium für Land-u.Forstwirtschaft* writes (letter dated 8.1.37): " In the years 1930 to 1935 were found in the abattoir of the Capital City of Vienna:—

1930: *Cysticercus cellulosae* in 2,983 pigs out of 696,233 slaughtered—0·43 per cent.

1931: *Cysticercus cellulosae* in 2,441 pigs out of 860,707 slaughtered—0·28 per cent.

1932: *Cysticercus cellulosae* in 2,702 pigs out of 711,932 slaughtered—0·38 per cent.

1933: *Cysticercus cellulosae* in 2,153 pigs out of 687,660 slaughtered—0·31 per cent.

1934: *Cysticercus cellulosae* in 967 pigs out of 735,244 slaughtered—0·13 per cent.

1935: *Cysticercus cellulosae* in 793 pigs out of 647,678 slaughtered—0·12 per cent.

1930: *Cysticercus inermis* (*bovis*) in 73 cattle out of 129,050 slaughtered—0·057 per cent.

1931: *Cysticercus inermis* (*bovis*) in 120 cattle out of 128,463 slaughtered—0·094 per cent.

1932: *Cysticercus inermis* (*bovis*) in 155 cattle out of 130,449 slaughtered—0·12 per cent.

1933: *Cysticercus inermis* (*bovis*) in 114 cattle out of 108,895 slaughtered—0·104 per cent.

1934: *Cysticercus inermis* (*bovis*) in 156 cattle out of 105,852 slaughtered—0·14 per cent.

1935: *Cysticercus inermis* (*bovis*) in 217 cattle out of 113,874 slaughtered—0·19 per cent.

During the years 1901 to 1928, in Wiener-Neustadt, 8,697 pigs out of 1,101,544 slaughtered, were found to be measly, i.e. 0·79 per cent. Between the years 1926 and 1928, in Wiener-Neustadt, among slaughtered bovines 0·14 per cent. of the cattle from Lower Austria, 0·49 per cent. from the Burgenlands, 0·189 per cent. from Hungary and 0·49 per cent. from Roumania were found to be measly ".

The *Chef* then stresses the point that one should observe that in Vienna a large number of the slaughtered pigs and cattle comes from the neighbouring states, Yugoslavia, Hungary, Roumania and also from Poland. This also applies to slaughter pigs in Wiener-Neustadt.

According to the various annual reports for the abattoir at Basel, Switzerland, Dr. Unger found, between 1920 and 1932, that 20 out of 1,595 bovines imported from Austria (including Lichtenstein) were measly.

Hungary.

According to Brener (Vosgien), the statistics of *C. cellulosae* at Budapest abattoir during the years 1902-1905 showed that 10,265 pigs out of 987,908 slaughtered, were measly, that is 1·03 per cent.

These pigs were analysed as follows, as regards origin:—

0·64 per cent. of Hungarian pigs were measly.

3·91 per cent. of Croatian pigs were measly.

2·26 per cent. of Serbian pigs were measly.

Judging from his observations at Wiener-Neustadt, Schmid (1930) estimated that between 1926 and 1928, 0·189 per cent. of Hungarian cattle were measly. This percentage represented the Hungarian export cattle which were found measly at Wiener-Neustadt.

During the years 1920-1932, 12,093 Hungarian cattle were slaughtered at Basel, Switzerland. Of this number 46 were found to be measly, approximately 0·38 per cent. The highest number was 22 out of 3,814 in 1931. (*Jahresbericht des Schlachthofes von Basel-pro* 1920 *bis* 1932.)

Czechoslovakia.

In 1896 Prettner found that 3·44 per cent. of pigs slaughtered at Prague were measly. In 1902 it was found that 1,823 cases were measly out of 356,579 pigs slaughtered at Prague, that is 0·51 per cent.

In 1909 in Dux, Liebscher found *C. cellulosae* in 2 per cent of pigs, and in 1910 in 1 per cent. of pigs. In both years *C. bovis* was found in 0·6 per cent. of cattle by Liebscher.

For Karlsbad, Messner (1930) shows that the incidence of *C. bovis* during the twenty-five years, 1905-1929, had fallen from 2·6 per cent. and 3·0 per cent. in 1905 and 1906, respectively, to 0·44 per cent. in 1916. The following year it increased to 1·4 per cent., but fell suddenly to 0·2 per cent. in 1918. Then, between the years 1919 and 1922, the percentage oscillated round about 1·1. Between 1923 and 1927 the percentage varied from just below 0·5 to 0·8. In 1928 it rose to 1·44 per cent. and in 1929 it was 2·55 per cent., the third highest record during the 25 years under report.

During the years 1920-1932, forty bovines from Czechoslovakia, out of 3,961 slaughtered at Basel, Switzerland, were measly, that is over 1 per cent. Of this number, 14 out of 411 were found to be measly in 1927. Dr. Unger, Director of the Basel Abattoir, made special mention of this record percentage (3·4) in consignments from a single country. (*Jahresbericht des Slachthofes von Basel-Stadt pro* 1927.)

In a letter dated 3rd February, 1937, the Czechoslovak Republic Ministry of Agriculture supplies the following statistics in respect of the incidence of cysticercosis at their three principal abattoirs:—

Abattoir.	Year.	Slaughtered.		Cysticercosis found.			
		Bovines.	Swine.	Bovines.		Swine.	
		No.	No.	No.	%	No.	%
Prague.....	1930	—	434,427	—	—	802	0·18
	1931	—	366,471	—	—	306	0·083
	1932	—	374,711	—	—	742	0·19
	1933	—	263,615	—	—	226	0·036
	1934	—	333,915	—	—	93	0·028
	1935	67,796	381,090	70	0·103	223	0·103
	1936	57,629	370,638	174	0·302	333	0·089
Brno.....	1930	18,804	50,321	2	0·011	12	0·024
	1931	16,864	55,368	—	—	1	0·0018
	1932	18,471	51,706	1	0·0054	7	0·013
	1933	16,253	41,100	2	0·012	17	0·041
	1934	18,062	43,345	5	0·028	3	0·006
	1936	17,911	56,991	4	0·022	1	0·001
	1936	14,711	55,160	1	0·0067	8	0·014
Bratislava.....	1930	9,915	50,645	2	0·0201	1	0·002
	1931	9,999	57,430	1	0·01	4	0·007
	1932	10,727	55,924	3	0·027	3	0·0052
	1933	10,304	48,379	2	0·019	8	0·017
	1934	10,927	55,324	10	0·092	3	0·006
	1936	10,150	56,914	8	0·076	—	—
	1936	9,250	56,669	36	0·39	3	0·005

Yugoslavia.

It is not clear what the extent of infection with *C. cellulosae* and *C. bovis* is at the present time in this multi-raced Kingdom.

Between the years 1902-1905, Brener found that 3·91 per cent. of the Croatian pigs and 2·26 per cent. of the Serbian pigs were found measly in the abattoir at Budapest (Hungary).

According to Vosgien, cysticercosis is quite rare in Croatia and Slavonia, but very common in Serbia. Martel, according to Vosgien, found in 1905 that from 8 per cent. to 12 per cent. of Serbian pigs were measly. In Bukowina and in Dalmatia, figures of 6 per cent. and 5 per cent., respectively, are given.

Schmidt, according to von Ostertag, found 0·83 per cent. of Croatian pigs to be measly at Wiener-Neustadt, Austria, between 1901 and 1910.

According to Kukuljevic (1906) 0·5 per cent. of pigs in Serbia were found to be measly in tongue-inspections, without resorting to meat inspection. Kukuljevic attributed the high incidence of measles in pigs in Serbia to the unhygienic customs in that country, where

pigs are allowed to wander about the streets and on open fields, and thus greater facility for infection existed than would have been the case had proper stying and husbandry been practised.

Rumania.

Schmidt (1930) found that between 1926 and 1928 0·49 per cent. of Rumanian cattle slaughtered at Wiener-Neustadt, Austria, were measly.

The Director of the *Directiunea Zootechnica si Sanitara Veterinaria* kindly supplied the following official statistics showing the recentmost incidence of *C. cellulosae* and *C. bovis* as observed in Rumania:—

Year.

1933: 5,981 cases, i.e., 1·05 per cent. of the total pigs slaughtered at the abattoirs were measly.

110 cases, i.e. 0·014 per cent. of the total bovines slaughtered at the abattoirs were measly.

1934: 7,984 cases, i.e., 1·25 per cent. of the total pigs slaughtered at the abattoirs were measly.

139 cases, i.e., 0·018 per cent. of the total bovines slaughtered at the abattoirs were measly.

1935: 4,604 cases, i.e., 0·77 per cent. of the total pigs slaughtered at the abattoirs were measly.

168 cases, i.e., 0·018 per cent. of the total bovines slaughtered at the abattoirs were measly.

Bulgaria.

Dikoff (1931) mentioned in his article that as regards eradication of taeniasis, Bulgaria had yet to commence, and a good deal had yet to be accomplished in meat inspection. According to Dikoff, the actual extent of human infection with *Taenia solium* and *Taenia saginata* is not known in that country, but *C. cellulosae* is encountered on an average in 0·39 per cent. to 2·45 per cent. in Bulgarian pigs. Since 1920 Dikoff has noticed no decrease in the incidence. Pig dealers know the disease, and frequently bring pigs to slaughter houses where no inspections exist, rather than risk condemnation at properly controlled abattoirs.

Cysticercus bovis, according to Dikoff, is very common. In Schumen the incidence of infection is 2·97 per cent. in adult bovines (buffaloes) and 5·8 per cent. in calves.

Russia.

According to von Ostertag, *C. cellulosae* is a common disease in Russian pigs. Thus, Menzel, according to von Ostertag, mentioned that during 1904 and 1907, 1·68 to 3·21 per cent. of Russian pigs imported into Germany were found to be measly, notwithstanding the fact that in the live inspection (tongue) of the export pigs 10 per cent. were withdrawn.

Hoffmeister (von Ostertag) mentioned that in 1918 in Berlin 5 per cent. of pigs imported from Russia and the Balkan States were measly.

Berdel (1930) quotes Meyer (1929), who found that 19·47 per cent. of all slaughtered Russian bacon pigs were measly at Barnaul.

Lithuania.

At Frankfurt a.M. Berdel (1930) found, in the short period between 10th September, 1929 and 19th November, 1929, that 100 out of 1,415 imported Lithuanian pigs were measly (7 per cent.). On one day (28th October, 1929), no less than 16 out of 81 were found to be measly, and on 1st October, 1929, 12 out of 65.

Poland.

For the official abattoirs in Poland for the year 1935, Trawinski (1937) gives the following statistics:—

C. cellulosae: 12,765 cases out of 3,604,737 pigs slaughtered (0·38 per cent.).

C. bovis: 1,168 cases out of 1,148,483 bovines slaughtered (0·1 per cent.).

Sweden.

Cysticercus cellulosae is said always to have been a very rare parasite in Sweden.

According to Vosgien (1910-11), the following percentages infections were observed at the abattoir at Malmoé:—1906: 0·024 per cent.; 1907: 0·00034 per cent. (1 out of 28,616 pigs); 1908: 0·021 per cent.; 1909: 0·010 per cent.; 1910: 0·0068 per cent.

Von Ostertag supplies the following statistics for Götenburg:—1908: 0·004 per cent.; 1909: 0·009 per cent.

Denmark.

Cysticercus cellulosae has only very sporadically been found in Denmark. Thus, Vosgien states that between 1888 and 1895 only one measly pig was found out of 1,344,296 pigs slaughtered.

According to Nielsen (1934), *C. cellulosae* last appeared in Denmark before 1929.

According to Elvinge (1929), the incidence of *C. bovis* is steadily increasing in Denmark. This was very noticeable at the abattoir at Odense, between 1st January, 1927 and 1st October, 1929. In the year 1927, out of 8,483 slaughtered adult bovines, 2·07 per cent. had dead measles and 0·12 per cent. live measles. In 1928, out of 9,145 adult bovines, Elvinge found 3·15 per cent. with degenerated measles and 0·26 per cent. with live measles. In the year 1929 (9 months only) in 6,959 adult bovines, Elvinge found degenerated measles in 2·71 per cent. of carcasses and live measles in 0·39 per cent. of carcasses. The mean percentage for adult bovines was 2·90 per cent. Elvinge then gives statistics for the year 1922, in which the percentage measles in adult bovines was 0·18. The cattle originated from the same areas.

Nielsen (1934) states that *C. bovis* is increasing in some localities. At Sonderborg the incidence is 1·21 per cent. of inspected carcasses.

During the years 1920-32, out of 17,889 exported Danish bovines slaughtered at the abattoir at Basel, Switzerland, 90 were found measly (0·50 per cent.).

B. The Incidence of Cysticercosis in Swine and Bovines in Asia.

Syria.

It is not known to what extent cysticercosis occurs in Turkey proper, but it is surmised that the incidence of *C. cellulosae* must be negligible, on account of the predominant Mohammedan population. Definite statistics of the incidence of *C. bovis* are, however, available for certain Mandated States, which formerly formed part of Levantine and Asiatic Turkish Empire, e.g., Syria and Lebanon and also Palestine.

At Homs, Syria, Valade found 116 cases of cysticercosis in 615 bovine carcasses (i.e., 18·86 per cent.) in 1925-26.

Reference is made, in a subsequent part of this work, to a survey made by Yenikomshian and Berberian (1934) of the incidence of *T. saginata* infection in various parts of Syria and Lebanon. Although these authors do not give any statistics of *C. bovis* infection in cattle, it is reasonable to presume that *C. bovis* is very frequent in Syria and in parts of Lebanon, where raw beef, as "Kibbi neyyi" is customarily eaten, and the incidence of *T. saginata* is up to 12 per cent. in certain parts. The authors stress the absence of *T. solium* infection, due to the fact that in many parts of the country Mohammedanism is the predominant Faith, thus implying that *C. cellulosae* must be correspondingly rare in pigs.

Reference is also made to the survey by Penfold, Penfold and Phillips (1936), who found that more than one-quarter of the Syrian-born inhabitants of the State of Victoria, Australia, were *T. saginata* carriers. (See Part V.)

Palestine.

Mr. J. M. Smith, M.R.C.V.S., Chief Veterinary Officer to the Government of Palestine, writes (15.1.37):—

"1. The incidence of *Cysticercus cellulosae* is very low in Palestine, and very few swine are kept. For instance, during the last ten years only 2,112 pigs were slaughtered at the Municipal Abattoirs of Jerusalem, and of these four only were found to be affected with *Cysticercus cellulosae*.

2. With regard to *Cysticercus bovis*, this disease is endemic in this country. According to Jerusalem Abattoir figures, 10 per cent. to 22 per cent. of the cattle drawn from Hebron and Nazareth sub-districts were found to be affected with *C. bovis*. The percentage in respect of cattle drawn from other areas is lower.

3. The average annual percentage of *C. bovis* in the Jerusalem slaughter-house varies from 6 per cent. to 8 per cent."

Arabia, Iraq, Iran, Hedjaz and *Oman.*

No statistics are available for these territories, but, speculatively, one may reasonably presume that on account of the prodominantly Mohammedan populations, *C. cellulosae* must be very rare, whereas, like in Syria and Palestine, and on account of the proximity of these territories to Syria and Palestine, *C. bovis* must be a very frequent parasite.

Persia and *Afghanistan.*

No statistics are available for Persia and the more primitive Afghanistan.

Siberia.

Hjortlund, according to von Ostertag, found that 12·5 per cent. of Siberian pig-fillets were measly, when imported into Copenhagen.

Kowalesky (according to Vosgien) found at the abattoir at Tachkend (Turkestan, Russian Siberia) the following percentages of pigs measly:—1907: 0·641; 1908: 1·013; 1909: 0; 1910: 0·540.

India.

As regards the actual incidence of *C. cellulosae* in pigs in India, literature is extremely silent, and what little has appeared has frequently been somewhat contradictory. Thus, many British medical observers have stated that only the lowest caste Indians will touch or consume pork, and on that score they have presumed that the incidence of *C. cellulosae-T. solium* must be relatively low in India.

Rao (1935) mentioned the presence of *C. cellulosae* in the Madras Presidency and mentioned that he felt sure that the incidence was considerably higher than had been anticipated, so also was the incidence of *T. solium.* Then again, what is claimed to be the only recent authentic records concerning the prevalence of cysticercosis in swine and bovines, were published from Madras and Coimbatore where it was stated that 50 per cent. of swine were infected with *C. cellulosae.* (*Indian Vet. Journ., Vol.* 3, *p.* 52, 1926-27.) The same notes give the incidence of *C. bovis* in Madras and Coimbatore to be 1 per cent. Gaiger, in his check list of parasites in the Punjab, mentions the existence of bovine cysticercosis. Mr. J. F. Shirlaw, M.R.C.V.S., of the Imperial Institute of Veterinary Research, Muktesar, mentions, however, in a letter dated 23rd March, 1937, that his impression, gauged on ten years' service in the Punjab, is that the disease must be of infrequent occurrence, since he found no measles in any bovines in routine post-mortem examinations.

It is astonishing that the recorded incidence of *C. bovis* should be so low in India at the present time, since during the latter part of the last century several English writers, and especially Fleming (Neumann, 1892) found in Punjab in 1869 that 5·55 per cent. of cattle slaughtered and inspected by him were heavily infected, and in 1868, 6·12 per cent.

Malaya.

At the abattoir at Singapore during 1935, Mr. J. T. Forbes, M.R.C.V.S., Municipal Veterinary Officer, found the following percentages of cysticercosis:—

Country of Origin.	Percentage in Beef.	Country of Origin.	Percentage in Pork
Bali	3·03	Bali	0·67
Siam	1·14	China	0·05
Saigon	0·85	Saigon	0·33
Malaya	1·17	Malaya	0·0004

NUMBER OF ANIMALS SLAUGHTERED IN SINGAPORE DURING 1935 AND ORIGIN.

Origin.	Cattle.	Pigs.
Bali	6,387	75,187
Siam	5,656	2,486
Saigon	1,880	37,416
Malaya	837	126,180

In a letter dated 19th November, 1936, Mr. Forbes, writes:— "Singapore depends largely on outside sources for its supply of slaughter animals. We have a very large Chinese population in Singapore, which accounts for the large number of pigs slaughtered. The Chinese usually roast their pork to a cinder and this may account for the rarity of Cysticercosis-Taeniasis in that group."

The analysis supplied by Mr. Forbes is interesting, since it shows separately the respective percentages measly animals found for the various countries from which Singapore derives its meat supply.

As regards incidence of infection of stock of purely Malayan origin, it may be noted that Mr. Forbes records that 1·17 per cent. of bovines were infected and only 0·0004 per cent. of pigs.

French Indo-China. (*Cochin China* and *Annam.*)

In Part III of this work mention is made that Bergeon (1928) frequently found *C. cellulosae* among dogs (138 cases in five years) in Hanoi, Tonkin. Bergeon mentioned the frequency of *Taenia solium* among the Tonkinese. Although the actual incidence of infection in pigs is not given, it can reasonably be presumed that *C. cellulosae* does, with frequency, occur in pigs in that territory.

Bergeon also mentioned that *T. saginata* is also readily found in Tonkin, hence, speculatively, we may attribute this frequency to a fairly high incidence of *C. bovis* in that territory.

From a point of view of territorial incidence survey, we may here repeat that Mr. J. T. Forbes, in 1935 found that 0·85 per cent. of 1,880 bovines and 0·33 per cent. of 37,416 pigs exported from Saigon, were found measly at Singapore abattoir.

Siam.

The present author was unable to obtain authentic data of infection from this country, but that *C. bovis* occurs relatively frequently in Siam, may be speculated from the report of Mr. J. T. Forbes for Singapore. In 1935, Siam exported 5,656 cattle to Singapore, of which number 1·14 per cent. were infected with *C. bovis.*

Netherlands East Indies.

At the instigation of the Dutch Colonial Government, le Coultre (1928) made a detailed enquiry into the incidence of cysticercosis in bovines and pigs on the Island of Bali in 1927. Le Coultre also had comparative statistics for some of the other parts of the Netherlands East Indies. By careful inspection, le Coultre found that on Bali 2 per cent. to 3 per cent. of pigs were infected, and 20 per cent. to 30 per cent. of bovines were measly. At Boeleleng the percentage was as high as 32·23 (407 out of 1,260). At Makassar in 1927, 1·29 per cent. of pigs were found measly, and at Soerabaia 0·6 per cent. At Denpasar in 1927, 22 per cent. of bovines were found to be measly (178 out of 809). At Mataram (Lombok) in 1926, 5·6 per cent. of bovines were measly. At Batavia in 1925, 3·26 per cent. of oxen were measly.

According to the *Tijdschrift voor Diergeneeskunde* 60, page 915, 1935, it would appear that there has been little or no decrease in the incidence of cysticercosis on Bali. The statistics given in that volume of the *Tijdschrift* are bovines 23·59 per cent. infected and pigs 2·98 per cent. infected.

Note that at Singapore in 1935 Mr. J. T. Forbes found that only 3·03 per cent. of Balinese bovines and 0·67 per cent. of pigs were measly.

China. (Including Hong Kong and Shanghai.)

As in the case of India, and indeed, of the Orient generally, statistics regarding the incidence of cysticercosis in pigs and cattle in China are most vague, and it has been almost impossible to arrive at a true estimate of the prevalence of this condition in that country.

In Shanghai and Hong Kong meat inspection is carried out under the control of European veterinarians, and in both those cities it would appear that no cases of either parasite have been found for a number of years.

Chinese medical literature occasionally quotes sporadic occurrences of *C. bovis* and/or *C. cellulosae*, but as far as is known no article has yet been published, which portrays a true reflection of the incidence of cysticercosis.

Dr. H. Pedersen, Municipal Veterinary Officer, Shanghai, writes (12.1.37):—"Uniform inspection in Shanghai over a period of many years has not revealed a case of either of these infections in hogs or bovines. It would appear thus that these parasites are non-existent in the areas from which we obtain our supplies. It is known, however, that *C. cellulosae* is prevalent in North China, but with the exception of Tsingtao, where it is stated that this infection is present amongst hogs to the extent of about 1½ per cent. we have no statistics." Similar letters were received from Messrs. D. L. McWhirter, M.R.C.V.S., and H. C. Watson, M.R.C.V.S., both of whom have had vast experience in meat inspection in the French Concession at Shanghai and at Hong Kong, respectively.

Gear and Pedersen (1934) mention that in the Shanghai municipal inspection no case of *C. bovis* was found, nor has it ever been reported from Hong Kong. Similarly, as regards *C. cellulosae* in pigs, meat inspection in Shanghai of over one million pigs did not reveal a single specimen of *C. cellulosae*; and in Hong Kong from 1910 to 1933, where an examination of over 200,000 pigs has been made annually, only two cases are reported, both in 1928.

Kuang Wu (1936) mentioned that Shu (1935) made a survey of helminths in cattle in Soochow, but he did not find *C. bovis*. In Hong Kong, Chen (1935), according to Wu, did not find *C. cellulosae* and *C. bovis* among the animals he studied; and in Canton, Chen (1936) reported the absence of *C. cellulosae* among the hogs he examined. Wu failed to find *C. cellulosae* or *C. bovis* in the abattoirs at Hangchow.

Faust (1923), according to Mills (1923), wrote: "Twenty-five years ago infestation with *T. saginata* was common in North China. The infection was brought down from beyond the Great Wall, by cattle which were slaughtered immediately and offered for sale on the markets. To-day such infection occurs rarely in Peking and vicinity. The cattle come from the same locality and are presumably infected, but for economic reasons they are fattened for a period of from several months to a year in local yards and, when slaughtered, are relatively free from infection." Mills states that these remarks by Faust are somewhat misleading, and that Faust was mistaken. Mills secured various samples of beef from a butcher in Peking. One piece, weighing three pounds, contained four measles, and another weighing five pounds, contained ten measles. By casual examination, the butcher, a German, found five infected animals in less than 300 examined, or roughly 2 per cent. Mills points out that all this meat was taken from the hind legs, therefore, according to the theory of commoner seats of infection, a far higher number would have been found if the predilection sites (head, tongue, etc.), had been carefully examined.

Mills (1924) recorded two cases of *C. cellulosae* from pigs in Peking.

Japanese Empire.

According to Prof. S. Yoshida, *C. cellulosae* in pigs has never been found in Japan proper, and *C. bovis* very rarely in cattle.

Dr. S. Yokogawa, of Formosa, however, suggests a relative prevalence of *C. cellulosae* in pigs in Manchukuo, in the fact that out of 18 cases of human cysticercosis reported from Japan proper, no less than 16 contracted the infection in Manchukuo.

According to Eguchi and Nishiyama (1930), it would appear that *C. cellulosae* is a rare parasite in pigs everywhere in Japan, except in the Prefecture Okinawa, where it is fairly prevalent. These authors supply an interesting table showing the incidence of *C. cellulosae* in this Prefecture, from their observations at abattoirs, and they found that in 1916 only 0·01 per cent. of pigs were infected. In 1920, infection was 0·91 per cent. and in 1923, 1·03 per

cent., which percentage remained more or less uniform until 1926, when there was a sudden rise to 2·71 per cent., and thereafter a steady decrease, illustrated thus: 1927: 2·14 per cent.: 1928: 1·83 per cent.; 1929: 0·94 per cent.

Prof. Yoshida supplies a recent translated article by Nakanishi, who found that in Korea 33 per cent. of adult cattle were measly. Nakanishi (1926) found that 37·5 per cent. of Korean calves were measly.

C. The Incidence of Cysticercosis in Swine and Bovines in Oceania.

Australia.

According to Drabble (1934), *Cysticercus cellulosae* has never been found in Australian pigs.

A mild outbreak of *C. bovis* was recorded from the State of Victoria a few years ago. This outbreak occurred as the result of the grazing of slaughter cattle on the Werribee Sewage Farm, and caused great consternation among the meat-consuming public of Victoria.

According to personal advice from Mr. Drabble, a few (not more than half a dozen) sporadic cases of *C. bovis* have been found on meat inspection in abattoirs in New South Wales over a number of years.

New Zealand.

Mr. W. C. Barry, M.R.C.V.S., Director Live Stock Division, Department of Agriculture, New Zealand, writes (5.1.37):—

"So far as is known, no cases of cysticercosis in pigs or cattle have occurred in this Dominion at any time."

Phillipine Islands.

Schwartz and Tubangui (1922) obtained statistics from the Ascarraga abattoir, Manila, which showed that just over 1 per cent. of pigs were infected with *C. cellulosae*. This was the average over five years.

C. bovis is rarely found in the abattoir at Pandacan, Manila (Schwartz, 1925), but native cattle are never slaughtered at abattoirs and their meat is thus never inspected. The incidence of *T. saginata* is considerably higher than that of *T. solium*. (Schwartz and Tubangui, 1922.)

D. The Incidence of Cysticercosis in Swine and Bovines in the Americas.

Canada.

According to Mr. George Hilton, Veterinary Director-General, Canada, measles in pigs and cattle is a very rare disease in Canada.

The Report of the Veterinary Director-General for the year ended 31st March, 1935, gives the following statistics:—

Cysticercus bovis found at establishments under inspection:

44 Carcasses. (Bovine.)

774 (Portions) of carcasses. (Presumably infection was confined to heads, viscera, etc.)

Cysticercus cellulosæ.

42 Pig carcasses.

12 (Portions) of carcasses. (Presumably infection was confined to heads, viscera, etc.)

During the year under report 1,350,370 bovines were slaughtered in Canada, and 2,862,125 pigs were slaughtered. Presuming that each of the measly "portions" came from separate measly animals, 818 measly bovines and 54 measly pigs were found during that year, reflecting a very low percentage.

It is, however, interesting to recall that during the years 1920-32 Dr. Unger found 16 out of 4,652 bovines of Canadian origin to be measly at the abattoir at Basel in Switzerland, representing a percentage of ·34.

United States.

In submitting a tabulated statement showing the numbers of each species of animal slaughtered, by years, from 1926 to 1935, in which the number of carcasses of each species condemned on account of cysticercosis is given, Dr. J. R. Mohler, Chief of the Bureau of Animal Industry, United States Department of Agriculture, writes (2.11.36):—"Inasmuch as all infested carcasses are not condemned on account of slight cases of infestation being passed after prescribed freezing or sterilization, this does not supply information upon which percentages at which the condition prevails may be determined."

Year.	Cattle.		Swine.	
	Slaughtered.	Condemned.	Slaughtered.	Condemned.
1926	10,098,121	129	40,442,730	76
1927	10,049,589	169	42,650,443	71
1928	9,040,028	121	48,347,393	57
1929	8,284,324	123	47,163,573	61
1930	8,280,778	131	46,688,860	98
1931	8,215,203	99	44,047,458	58
1932	7,974,502	103	45,852,422	21
1933	7,735,588	125	45,698,053	20
1934	9,652,952	149	45,773,196	35
1935	12,809,448	257	34,413,317	38

Since the "Lightly" infested carcasses are not given in Dr. Mohler's summary, we may, according to general observations presume that at least ten times the number of measly carcasses shown were treated by freezing, etc. Multiplying thus the number by ten, 2,570 measly carcasses out of approximately 12,000,000 were found in 1935, or roughly 1 in 5,000—still a very low incidence.

According to Ransom (1911), the average percentage of *C. bovis* at that time was 0·6. Later (1913), Ransom stated that 1 per cent. of all cattle slaughtered in the United States were infected with *C. bovis* (*Journ. of Agric. Research*, *Vol.* 1, *p.* 15).

According to Price (1925), *C. cellulosae* is frequently found in Texas in pigs. Price points out that this is understandable considering the large Mexican and Negro populations.

Central America.

According to Hall (1927), the incidence of *C. cellulosae* in swine in Central America is astonishingly high, the parasite occurring in from 5 to about 30 per cent. of swine, usually in gross infestations. As a result of rigid sanitation caused by a campaign against hookworm in Panama, Dr. Mattatall, according to Hall, reported that at the Panama City abattoir the incidence of *C. cellulosae* dropped from 15 per cent. to 5 per cent. According to Hall "the occurrence of *T. saginata* in man in the Central American countries shows the concomitant presence of *C. bovis* in cattle. Dr. Mattatall, however, finds the *C. bovis* to be a very rare parasite in Panama City."

Nauck (1931) wrote that *C. cellulosae* was a common disease in Costa Rica.

West Indies.

According to Cameron (1930), *C. bovis* is occasionally found in the West Indies. *C. cellulosae* is sometimes seen, most frequently in the Southern Islands.

Brazil.

No definite data have been obtained from Brazil, but Palais (1933) refers to the occurrence of *T. saginata*, which would suggest a corresponding frequency of *C. bovis*.

Argentine.

The incidence of *C. bovis* and *C. cellulosae* is relatively low in the Argentine, as is shown by the subjoined table forwarded by Señor A. Andrieu, Chief of the Sanitary Police, Buenos Aires.

The figures show the number of cases and the numbers per 10,000, as observed at the principal abattoirs and *frigoríficos* during the five years 1932-1936:—

Year.	Bovines. (*C. bovis.*)		Pigs. (*C. cellulosae.*)	
	Cases.	No. per/10,000.	Cases.	No. per/10,000.
1932	204	0·92	11	0·25
1933	461	1·97	67	1·04
1934	1,322	5·06	343	3·77
1935	2,254	8·50	342	3·74
1936	1,671	5·48	860	8·71
TOTAL	5,912	4·58	1,623	4·28

Chile.

Señor Rogelio Montero, Chief of the Meat and Animal Sanitation Department, Santiago, supplies the following statistics showing the incidence of *C. cellulosae* in swine as observed at the Santiago abattoir.

Year.	Condemned.	Total Inspected.	Percentage Measly.
1933	3,242	77,199	4·2
1934	3,410	89,042	3·8
1935	3,880	98,653	3·9
1936	3,493	92,862	3·8

Señor Montero states that no statistics are available of the incidence of *C. bovis* in Chile, but this is quite an uncommon disease.

E. The Incidence of Cysticercosis in Swine and Bovines in Africa.

Tunis.

At the abattoir at Sousse, Coussi (1933) found the incidence of *C. bovis* (average for five years) to be 2·25 per cent.

According to some of the older writers, e.g., Alix (1887), it was formerly estimated that 5 per cent. of bovines in Tunis were infected with *C. bovis*.

Senegal.

At Dakar, Teppaz (1923) estimated the incidence of *C. bovis* at approximately 10 per cent.

French Guinea.

Claverie (1928) found that approximately 50 per cent. of bovines were infected with *C. bovis* in French Guinea.

Sierra Leone.

Mr. J. Martin, Director of Agriculture, Sierra Leone, supplies the following data in respect of the incidence of *Cysticercus bovis* as observed at the abattoir at Freetown. Mr. Martin states (letter dated 1st February, 1937), that there are no other centres in Sierra Leone in which cattle are slaughtered to any extent:—

Year.	Bullocks slaughtered.	Measly.	Percentage.
1931	2,818	2	0·0709
1932	2,904	1	0·0343
1933	4,593	20	0·435
1934	4,460	18	0·403
1935	4,274	6	0·140
1936	3,278	10	0·305
Total	22,327	57	0·255

It may here be mentioned that Maplestone (1924) found 3·32 per cent. of 500 inmates of Freetown gaol to be infected with *T. saginata*.

Abyssinia.

It is not known to what extent infection with *T. saginata* occurs among Abyssinians at the present time, or what the present incidence of *C. bovis* is in that country, but about forty years ago, according to several writers (Leuckart, Neumann, von Ostertag, etc.), practically 100 per cent. of the Abyssinian population considered "a *Taenia saginata* one of their most treasured possessions," and correspondingly, it is presumed that a very big percentage of bovines must have been measly.

Kenya Colony.

Cysticercus cellulosae is a relatively uncommon parasite in pigs in Kenya, but it does occur sporadically. For instance, in Nairobi abattoir in 1934, four pigs were condemned out of 1,959 pigs inspected, whereas in 1935, *C. cellulosae* was not detected at Nairobi abattoir, "but one case of extremely heavy infestation was diagnosed at the Veterinary Research Laboratory." (Daubney, 1936.)

A steady increase in the incidence of *C. bovis*, as observed in the Nairobi abattoir, is reflected in the subjoined table.

The Medical Officer of Health, Nairobi, recently informed Stock Owners' Conference that were the standard raised so that any animal with a single viable *Cysticercus* was condemned, the percentage of condemned cattle would be increased by 4·7 in the case of grade cattle and by 7·4 in the case of native cattle. (NOTE.—Cattle are not condemned unless six viable measles can be demonstrated in the carcass.) If all measly cattle were thus to be condemned at Nairobi the incidence of *C. bovis* would be in the vicinity of 25 per cent.

Table from the Seventh Annual Report of the Medical Officer of Health, Nairobi.

OXEN SLAUGHTERED AND CONDEMNED FOR MEASLES.

Year.	Grade.			Native.			Total.		
	Killed.	Condemned.	Percentage condemned.	Killed.	Condemned.	Percentage condemned.	Killed.	Condemned.	Percentage condemned.
1927	5,634	—	—	5,178	—	—	10,812	490	4·5
1928	4,907	—	—	6,827	—	—	11,734	740	6·3
1929	4,151	—	—	7,617	—	—	11,768	975	8·2
1930	4,214	277	6·5	7,243	683	9·4	11,457	960	8·3
1931	4,306	388	9·0	9,375	1,227	13·0	13,681	1,615	11·8
1932	3,054	321	10·5	11,044	1,568	14·1	14,098	1,889	13·3
1933	2,924	326	11·1	12,968	2,158	16·6	15,892	2,484	15·6
1934	4,531	600	13·2	10,264	1,820	17·7	14,795	2,420	16·3
1935	4,806	495	10·2	9,007	1,894	21·0	13,813	2,389	17·2

Uganda.

The Acting Director of Veterinary Services gives the following statistics reference to the incidence of *C. bovis* at the Kampala abattoir for 1935:—

Cattle Slaughtered	4,336
Condemnations—	
Hearts	685
Tongues	248
Quarters	140
Complete Carcasses	58

It is difficult to understand these figures, but on the presumption that measles were found in 685 ox hearts (ignoring the tongues, quarters and carcasses), then 685 out of 4,336 bovines were measly, or 15·8 per cent. Including the possible number of bovines in which measles may only have been found in the tongue, or in a quarter, or in a carcass, and not in the heart, it can be concluded that from 15 per cent. to 25 per cent. of the Uganda cattle are infected with *C. bovis*. The Director states that the percentage of infected carcasses amongst Western Province cattle is higher than amongst Eastern Province stock, both areas might be termed "Native Reserves" as there are no European owned stock farms in either area.

Tanganyika.

In 1916 von Ostertag referred to the wide distribution of *C. bovis* in both British and German East Africa, before the war. He also mentioned the frequency of *T. saginata* infection in those territories among natives, owing to their habits of eating imperfectly cooked meat. Von Ostertag quoted Veterinary Officer Manleitner, who found a very high percentage infection in cattle in Aruscha; Veterinary Officer Meyer, who found 2 bovines out of 14 measly in Shirati; whereas in Muansa Veterinary Officer Gärtner found no measles in 24 bovines examined. In Bukoba, von Ostertag estimated that 90 per cent. of bovines were infected. In general, infection ranged from 1 to 10 per cent. or higher.

At that time (about 1916) no definite survey had been made of the incidence of *C. cellulosae* in pigs, but von Ostertag mentioned that most of the pigs consumed before the war were imported from the Union of South Africa, where the percentage infection in pigs was said to be very high, according to von Ostertag.

Hammer (1922) states that during his period of service in German East Africa he found approximately 15 per cent. of bovines measly in the Uhehe Highlands. Hammer's pre-war findings coincided very nearly with present day statistics from Tanganyika.

Captain H. J. Lowe, M.R.C.V.S., Veterinary Research Officer, Mpwapwa, supplies the following tables showing the monthly percentages measles found at various abattoirs from January to August, 1936. Only when more than 2 per cent. of cases were found, were these included in the returns. According to Capt. Lowe, practically all the beef consumed in the Territory is derived from native-owned animals, that is from Native Reserves.

During the period under report only one pig was condemned (during May, at Iringa), and a total of 392 pigs were slaughtered at all abattoirs.

Tanganyika Territory.—Abattoirs at which more than 2 per cent. of Bovine Carcasses were Sterilized for C. bovis.

Abattoirs.	1936: Percentages.							
	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.
Tukuyu	16·1	—	6·6	—	—	—	2·8	9·1
Iringa	14·9	15·1	15·5	12·6	21·6	8·1	11·7	14·3
Moshi	9·4	7·4	8·0	6·6	9·1	13·5	11·8	7·0
Dar-es-Salaam	9·1	12·4	13·2	13·0	10·8	8·8	9·3	9·2
Morogoro	8·5	8·3	6·0	9·3	—	3·8	3·4	3·4
Kondoa	6·9	—	—	—	—	11·1	6·2	—
Aruscha	6·5	—	6·2	6·6	8·8	—	2·5	3·6
Singida	4·3	6·2	5·2	11·1	6·6	—	—	3·8
Dodoma	3·4	4·6	4·7	6·1	6·1	4·6	6·6	9·1
Korogwe	2·5	—	—	3·2	—	3·0	—	—
Mpwapwa	—	16·6	14·3	18·4	11·1	18·6	3·2	3·6
Musoma	—	3·3	4·5	10·5	3·4	8·6	—	8·0
Mbeya	—	—	5·4	2·3	5·5	8·9	9·8	13·3
Songea	—	—	—	7·4	—	4·0	—	5·3
Tanga	—	—	—	—	—	2·3	—	3·4

Judging from these monthly returns, it would appear that Iringa, Moshi, Dar-es-Salaam and Mpwapwa draw their slaughter cattle from the centres of heaviest infection.

Belgian Congo.

Prof. Rubray, Rector of the Royal College of Veterinary Medicine at Cureghem-lez-Bruxelles, Belgium, kindly supplied the following statistics, relative to the incidence of *C. bovis*, as observed at the abattoir at Stanleyville, from January to October, 1936:—

	Bovines Slaughtered.	Infested with Cysticercosis.	Percentage Infested.
January	69	6	8·7
February	72	5	6·9
March	78	4	5·1
April	75	7	9·3
May	75	11	14·7
June	70	6	8·6
July	63	10	15·9
August	68	4	5·9
September	68	5	7·4
October	72	4	5·6
Total for Ten Months	710	62	8·7

Angola.

Statistics of the actual incidence of infection with either parasite in pigs and cattle, respectively, are not available for Angola, but it is interesting to record that at Lisbon in 1933, 1934 and 1935 only 153 bovines were found measly, and of this number 151 were imported from Angola. The total number of bovines exported from Angola and slaughtered at Lisbon during those years was not given.

Madagascar.

Detailed statistics from this French African Island Colony have from time to time been published, and from these data it has been possible to compare relatively early and recent percentages of *C. cellulosae* and *C. bovis*.

Geoffroy (1906) stated that the percentage of measly pigs found at Tananarive in 1905 was 7·01.

Poisson (1926), and also at the Pan-African Agricultural and Veterinary Conference at Pretoria in 1929, stated that in Madagascar the pig is especially reared by the people of the centre of the island (*hovas* and *betsileos*). At about that time the incidence of *C. cellulosae* in pigs, as observed at various abattoirs and meat canning factories was:—

At Diego-Suarez	4-5 per cent.
At Tamatave	10 per cent.
At Tananarive	12-15 per cent.
At Antsirabe	12-20 per cent.

In the districts of the bramble fields in the high plateaux, it was said to have been even higher.

Buck, Lamberton and Randriambeloma (1935) found that 13 per cent. of 4,500 pigs examined at the abattoir at Tananarive, that year, were measly.

A geographical map giving a survey of the incidence of porcine *C. cellulosae* on the Island in 1928, was kindly donated by Dr. H. Poisson, Retired Veterinary-Director-General, now domiciled in Tananarive. This map gives the following percentages:—Diego-Suarez, 2·40; Tamatave, 10·41; Tananarive, 9·76; Antisirabe, 12; Ambositra, 12; Ambohimahasoa, 12; Fianarantsoa, 13; Tulear, 2; Majunga, 6-7.

An extract of the Archives of the Veterinary Service (kindly supplied by Dr. Poisson) gives the following percentages of *C. cellulosae* as observed in Madagascar in 1936:—

(1) *Central Region*:—

Tananarive: 9·47 at Municipal abattoirs.
7·10 at Androrosy and Ambohimanarina.
11·84 at factory at Soanierana.

Antsirabe: 12·25 at municipal abattoir and factories.

Fianirantsoa: 21·20.

(2) *Eastern Region*:—

Tamatave: 7·35. (Mean average.)

Factory of Society Rochefortaise: 8·82. (Come from Centre and taken to Tamatave.)

City Abattoir: 5·89. (Come from Centre and taken to Tamatave.)

(3) *North-west Region*:—

Majunga: 6·92.

(4) *Northern Region*:—

Diego-Suarez (abattoir and factory): 3·03.

According to Poisson (1928), between 1912 and 1927 only occasional sporadic cases of *C. bovis* were observed at the various abattoirs in Madagascar. Dureiux (1934), stated that *C. bovis* had been found at abattoirs on the Island since 1917, but the maximum percentage is 3 per cent. In 1936, according to an extract from the Archives of the Veterinary Service, 0·19 per cent. of bovines slaughtered at the abattoir at Tananarive were measly.

Portuguese East Africa.

According to Dr. Jose Botelho, Abattoir Inspector and Municipal Veterinary Officer, Lourenco Marques, the average percentages during the last three years have been:—

Cysticercus cellulosae in pigs ... ... 3·6

Cysticercus bovis in cattle ... ... 3·15

Northern Rhodesia.

The Medical Officer of Health, Ndola, kindly furnished the following statistics showing the number of cases and percentages of *C. cellulosae* and *C. bovis* observed at the Ndola abattoir during the years 1932 to 1935:—

Year.	Pigs slaughtered.	*C. cellulosae* Pigs infected.	Percentage.	Cattle slaughtered.	*C. bovis* Cattle measly.	Percentage.
1932.....	122	7	5·7	1,164	65	4·7
1933.....	250	21	8·4	1,217	49	4·0
1934.....	335	17	3·1	1,652	18	1·0
1935.....	493	23	4·6	1,961	22	1·1
TOTAL....	1,200	68	5·0 (approx.)	5,994	154	2·7

The Medical Officer of Health attributes the reduction in the percentage of infested animals to the fact that butchers now purchase slaughter stock from ranches having a " clean " record, and as far as possible avoid the purchase of animals from ranches which are known to be *foci* of infestation.

Southern Rhodesia.

It has been very difficult to obtain reliable statistics of the incidence of cysticercosis from Southern Rhodesia, since few of the townships, with the exception of Salisbury and Bulawayo have properly controlled abattoirs in which authentic statistics are kept.

The Abattoir Superintendent, Salisbury, informs me that the average annual percentage measles in pigs is about 3 per cent., and in bovines about 2 per cent.

The Superintendent of the Municipal Abattoirs, Bulawayo, has forwarded the following data, relative to observations at Bulawayo for the last five years ended 30th June, 1936:—

Swine:

(1) Number of measly carcasses: 1,434.
(2) Percentage these figures represent: 6·7.
(3) It is estimated that 1,148 (or 80 per cent.) of these measly pigs are of native origin.

Bovines:

(1) Number of measly carcasses: 230.
(2) Percentage these figures represent: 0·38.
(3) It is estimated that 180 (80 per cent.) of these measly bovines are of native origin.

Judging from the available statistics from Southern Rhodesia, it would appear that *C. bovis* is not a common parasite in that country. This may be attributed to the fact that probably a large percentage of slaughter stock, even of native origin, may be raised under semi-ranging conditions, under which they do not come in contact with humans.

South West Africa.

Windhoek is the only centre in South West Africa from which any statistics could be obtained. According to these statistics, in 1931, 1,100 pigs were slaughtered at the abattoir, of which number only one was found infected with *C. cellulosae*. Since then no cases have been found. (NOTE.—Von Ostertag in 1916 alleged that before the war it was frequently found that 50 per cent. of the pigs exported from the Cape to German South West Africa were measly. This high percentage almost trebles those from the centres showing the extreme maximum incidence at the present time. It will be noticed that but a few Transvaal and Orange Free State centres give a return of over 10 per cent. infection in pigs, so that von Ostertag's estimate appears almost fantastic.)

With reference to the occurrence of *C. bovis*, the following data are given:—

In 1933, of 3,816 bovines slaughtered, 10 were infected.
In 1934, of 3,821 bovines slaughtered, 12 were infected.
In 1935, of 3,874 bovines slaughtered, 8 were infected.
In 1936, of 2,687 bovines slaughtered in 9 months 8 were infected.

The remarkably low incidence of *C. boris* in South West Africa may be explained on similar lines to that of Southern Rhodesia. In the next survey (that of Bechuanaland Protectorate), it will be observed that Mr. Hay found no cases of *C. boris* among cattle from Ngamiland and Ghanzi, areas comprising vast open ranges, remote from human habitations, and bordering on South West Africa.

It will be recalled that Dr. Unger found 3 out of 321 cattle imported from South West Africa measly at Basel (Switzerland) in 1923 and 1924 (0·94 per cent.).

Bechuanaland Protectorate.

The only abattoir in this Territory is situated at Lobatsi, from which centre export beef is forwarded. Mr. W. Hay, Government Veterinary Officer in charge of meat inspection at this abattoir states that no pigs are slaughtered there, and that 1·05 per cent. are found to be measly. No measly cattle have been found among those originating from Ngamiland and Ghanzi. Commenting upon Mr. Hay's report, the Chief Veterinary Officer of the Bechuanaland Protectorate, writes (24.11.36):—"Our experience at Lobatsi shows that measles is not evenly distributed but occurs in batches of cattle, which fact has led to the reasoning that only cattle in areas thickly populated by natives contract measles."

Basutoland.

The Principal Veterinary Officer, Basutoland, writes (letter dated 30.10.36):—"It is impossible to estimate even the approximate number of cases met with on post-mortem examination throughout the Territory. The Territory is occupied by natives only and pigs are raised exclusively for domestic purposes. Pigs are either kept in sties or allowed to range. The latter virtually become village scavengers and about 10 per cent. of these are infected, whereas 2 per cent. of the former are infected. In connection with cattle, I am afraid I am unable to furnish any data because we have no meat export trade."

Union of South Africa.

The statistics given in the following tables, showing the percentages of *C. cellulosae* and *C. boris* at the various abattoirs in the Union, were obtained as the result of a personal questionnaire to the respective Abattoir Directors or Superintendents, Medical Officers of Health, Health Inspectors, or Town Clerks of the centres, all of whom kindly supplied the data given. There are, unfortunately, some centres from which most evasive replies were obtained, and a few, including fairly large towns, from which no replies whatsoever were obtained. Consequently, since it was my policy to include only first-hand authentic information in this survey, reference to the subjoined tables and the "incidence maps" will show the exclusion of

some very important centres bordering on, or close to, Native Territories. If suitable statistics had been kept at these excluded centres, it is possible that some very interesting information may have been presented.

Cape Province.

Abattoirs.	Average number of *C. cellulosae.*	Average number of *C. bovis.*	Percentage *C. cellulosae.*	Percentage *C. bovis.*	Average Years.
Aliwal North	4	14	0·5	1·5	1
Beaufort West	1	1	0·67	0·25	3
Bedford	—	—	2·75	1·5	5
Burghersdorp	—	4	—	0·87	1
Cradock	11	5	2·49	0·75	5
Capetown	292	492	4·26	1·12	5
East London	438	408	7·69	5·69	3
Fort Beaufort	8	33	9·29	6·1	6
George	11	3	2·61	0·53	6
Graaff-Reinet	19	—	3·33	—	4
Kimberley	59	88	1·68	1·22	10
Kingwilliamstown	82	92	4·7	5·2	6
Mafeking	23	41	6·67	2·67	3
Malmesbury	16	2	4·27	0·32	5
Middelburg	14	23	2·9	0·94	5
Mossel Bay	1	1	1·37	—	1
Paarl	—	—	3·33	1·75	—
Port Elizabeth	170	653	1·76	7·29	5
Queenstown	50	11	3·3	0·67	5
Riversdale	13	7	5·8	3·0	1
Stellenbosch	7	29	1·58	2·44	4
Swellendam	22	24	3·0	4·0	—
Uitenhage	20	10	3·0	0·6	5
Upington	—	5	—	0·89	1
Vryburg	4	2	7·0	0·3	5
Worcester	11	4	1·97	0·31	5

Natal

Abattoir.	Average number of *C. cellulosae.*	Average number of *C. bovis.*	Percentage *C. cellulosae.*	Percentage *C. bovis.*	Average Years.
Dundee	7	62	2·70	5·80	5
Durban	998	928	5·16	2·68	10
Greytown	3	27	1·69	3·84	5
Ladysmith	—	—	2·0	4·0	—
Newcastle	20	7	2·45	0·158	—
Pietermaritzburg	43	477	1·77	5·3	5
Vryheid	8	59	2·9	4·3	10

Orange Free State.

Abattoir.	Average number of *C. cellulosae.*	Average number of *C. bovis.*	Percentage *C. cellulosae.*	Percentage *C. bovis.*	Average Years.
Bethlehem	32	38	15·2	2·13	5
Bloemfontein	74	443	2·13	4·87	2
Brandfort	1	12	—	5·0	—
Clocolan	9	8	9·0	2·01	3
Fauresmith	—	3	—	—	2
Fieksburg	135	7	25·0	1·09	10
Frankfort	6	12	5·03	2·01	—
Harrismith	9	—	4·51	—	3
Heilbron	1	1	0·88	0·08	3
Kroonstad	41	10	4·262	0·45	5
Lindley	6	5	6·0	2·10	2
Parys	13	11	5·5	1·51	4
Senekal	21	12	25·07	2·0	10
Wepener	3	—	9·43	—	5
Winburg	8	1	4·14	0·3125	8

Transvaal.

Abattoir.	Average number of *C. cellulosae.*	Average number of *C. bovis.*	Percentage *C. cellulosae.*	Percentage *C. bovis.*	Average Years.
Barberton	—	—	—	5·31	—
Boksburg	—	81	—	1·22	2½
Brakpan	77	69	4·27	0·71	3
Germiston	32	260	1·04	1·48	5
Johannesburg	3,148	834	4·42	0·75	11
Klerksdorp	30	24	4·91	1·37	1
Krugersdorp	80	190	6·10	1·46	4
Lichtenburg	5	2	19·48	0·18	3
Middelburg	30	30	11·49	3·04	8
Nelspruit	10	43	6·41	2·03	1
Nigel	43	90	5·02	2·80	1
Pietersburg	219	68	4·95	2·97	3
Potchefstroom	111	41	15·30	1·23	5
Pretoria	595	297	7·85	1·98	11
Randfontein	31	198	3·96	2·30	4
Rustenburg	53	98	10·12	5·11	4
Springs	25	146	3·91	1·20	5
Volksrust	12	1	5·0	1·06	1
Witbank	20	80	8·97	2·75	6

Average Number of Carcasses per Year.

Cape Province	1,276	*C. cellulosae.*	1,952	*C. bovis.*
Natal	1,079	,,	1,560	,,
Orange Free State	359	,,	563	,,
Transvaal	4,521	,,	2,551	,,
TOTAL FOR UNION	7,235	,,	6,626	,,

Discussion.

In a note which was compiled by Dr. H. H. Curson towards the end of 1936, for a Native Affairs Departmental Bulletin, and accompanying which two tables and graphs were supplied, the position in the Union is very clearly defined. The statistics given in the tables of Dr. Curson's note, are subjoined hereto, and are in respect of the nine principal abattoirs in the Union, plus that of Kingwilliamstown, which town borders on the Transkeian Territories. Reference to the graphs shows a steady increase in the numbers and percentages of measly bovines and pigs, from observations at the respective abattoirs. Undoubtedly the steady increase in the incidence may be due to general better inspection technique, but also, it may be possible that a larger percentage of slaughter stock is derived from native areas.

The accompanying " Incidence Maps " may not be quite indicative of the actual incidence of infection in the various areas. For instance, no details were obtainable from abattoirs in, or close to definite native areas, such as Eshowe, Kokstad, Umtata, Grahamstown, Kuruman, Zeerust, Waterberg, Lydenburg, or Zoutpansberg. Yet, the abattoirs at Durban, East London, Port Elizabeth and Johannesburg obtain a fairly large percentage of their slaughter pigs and cattle from those areas. For smaller centres, the figures and percentages may be accepted as almost truly indicative, since stock slaughtered at the smaller abattoirs are generally reared in the same districts. At the Bloemfontein abattoir we were able to trace definite " black " areas of origin during the past three years. Thus, in consignments from Theunissen in the Orange Free State, and also from Thaba 'Nchu and Tweespruit, we frequently found a fairly large percentage of infected cases.

Mr. W. A. Dykins, M.R.C.V.S., the author's colleague in Durban reports (letter dated 21st September, 1936) " the incidence of measles in cattle in the years under review has increased, and regarding pigs the converse seems to be the case. I do not think any special significance should be attached to the latter, as farmers and others who have doubts about their pigs do not consign them to abattoirs where efficient meat inspection is in vogue, so, in my opinion, the low incidence gives rise to a wrong impression ". Mr. Dykins adds that the cattle with the highest infection come from native areas such as Swaziland, Gollel, Candover, Mkuzi, Richmond and Ixopo, and attributes this, naturally, to " absence of proper sanitary measures ".

In another letter, dated 20.6.36, Mr. Dykins stated: " I definitely find that the highest percentages of measles are to be found amongst cattle ex native areas, such as Swaziland and the portions of Zululand contiguous thereto. A high percentage is frequently met in animals from the Midlands of Natal, and actually from the so-called well managed farms ".

The Town Clerk, Newcastle, writes (17.11.36): " The greatest number of cases at this abattoir have been in pigs and cattle purchased in or near the Utrecht (Natal) District. As regards

percentage infection at East London, Dr. P. W. Laidler, Medical Officer of Health, writes (11.1.37): " A large proportion of the stock was from native areas ".

Mr. H. J. Lubbe, Abattoir Superintendent, Graaff-Reinet, writes (19.11.36): " We have had no records of measles in bovines at this abattoir. As regards the origin of measles in swine, farmers in this District allow their swine to run wild amongst the prickly pears, which we have here in abundance. Sanitary conveniences are provided on most farms for the Europeans only, the natives being allowed to use the veld ".

Mr. H. A. Waterson, Health Inspector, Mafeking, writes (30.12.36): " The percentage infection in pigs was very high in 1933 and 1934, as most pigs slaughtered at that time were brought from Native Reserves ". (The percentages given for 1933 and 1934 were 7 and 8, respectively.)

Mr. C. J. Grobler, Health Inspector, Malmesbury, writes (27.10.36): " It will be observed that the incidence of measles in bovines is comparatively low. This is due to the fact that, as a country town, local butchers must of necessity slaughter from a reserve, that is, selected stock and not direct from rail or the open market as in large centres. In purchasing stock, butchers steer clear of coloured areas and natives territories, for instance Queenstown and vicinity. Local supplies of bovines are very limited and are obtained from as far afield as Okanja and Gobabis in South-West Africa, from the Eastern Province and from Namaqualand; consequently the recorded incidence of *C.bovis* at this abattoir cannot be taken as a criterion for the Malmesbury area, where it is of very rare and doubtful occurence, while pigs are bought and raised purely locally, and *C.cellulosae* is fairly rife".

Mr. J. L. Marais, Health Officer, Middelburg, Cape, writes (12.12.36): " Most cases of measles found here, during the past five years have been in oxen from the Transkei. No cases of measles have ever been found here in cattle bred in the Middelburg District".

Mr. D. Benham, Health Inspector, Riversdale, writes (9.11.36): " All the oxen infected came from the same part of the district, and since the butchers have stopped buying from that area, I have not found any measly carcasses ".

Mr. L. Becker, Abattoir Superintendent, Swellendam, writes (24.11.36): " Pigs coming from areas exclusively or predominantly inhabited by coloured people, or from farms along the main arterial roads, are obviously treated with suspicion, even by the butchers of towns of the size of Swellendam ".

Mr. G. P. Louw, Health Inspector, Upington, writes (31.10.36): " In the last ten months, one case of *C. bovis* was definitely of native origin, four others came from South-West Africa ".

Mr. C. M. de Jager, Abattoir Superitendent, Volksrust, writes (26.10.36): " The majority of bovine cases of measles are animals purchased from natives, sepecially from the Lowveld ".

Mr. E. J. Scallan, Health Inspector, Rustenburg, writes (27.10.36): "We have farmers in the district who speculate in cattle and pigs and purchase these animals from natives and sell them on the sales or to the butchers as their own".

Mr. F. R. Carter, Abattoir Superintendent, Potchefstroom, writes (30.11.36): "About 15 per cent. of cattle slaughtered here are of native origin, and about 75 per cent. of cattle bought from native areas are condemned. Most of the pigs slaughtered at this abattoir are drawn from native areas". Mr. Carter stated that when he first arrived at Potchefstroom 10 years ago, the highest condemnation of meat was 5,000 lb. weight. During the first 8 months of his service he condemned 40,000 lb. weight, and nowadays the condemnation weights are less than half that amount. Mr. Carter states that "the butchers are now very careful where they buy their stock".

The Abattoir Superintendent, Nigel, states (28.10.36) that the majority of pigs slaughtered at that abattoir are obtained from farmers in the locality. It has been his experience, however, that the majority of pigs of known native origin have been infected with measles.

Mr. D. Arnold, Abattoir Superintendent, Krugersdorp, writes (10.11.36): "Oxen slaughtered here are bought all over the country, but the principal sources of supply are the Johannesburg Market, parts of the O.F.S., and Rustenburg. From Rustenburg we get about 30 per cent. oxen per month and to my mind about 60 per cent. would be of native origin".

The Town Clerk, Barberton, writes (27.10.36): "In such centres as Sabie, Noordkaap, Sheba, Eureka, Louwsereek, Hectorspruit, Komatipoort, Kaapsche Hoop, Nelshoogte, animals are slaughtered in abattoirs where no post-mortem examinations are made. It has been conclusively proved in the Barberton Municipal Abattoir, that the incidence of measles (*cysticerci*) in cattle is on the increase. During the past six months, of all those slaughtered, the percentage infested was as high as 5·31".

Mr. P. G. Joubert, Health and Meat Inspector, Fauresmith, makes the following observation in regard to the origin of infected bovines at various abattoirs where he formerly served in the Cape, (letter dated 29.10.36): "Much depended on the vicinity from which stock were obtained. For instance, it was noticed that bovines from the Eastern Province were the most frequently infested, with the Transvaal a good second and the Free State third. Measles disease was practically never found in stock brought from South-West Africa. Measles was common in pigs reared at the Cape".

In his Annual Report for the year ended 30.6.35, Col. J. Irvine-Smith, Director of Abattoir Department, Johannesburg, makes the following observation. (Page 3): "Measles infestation (bladder-worm) of export cattle from Natal ranges from 2·7 per cent. to 60 per cent., with an average of 4·05 per cent.

TABLE I.

Giving Total Number of Carcases Detained for Measles at Principal Abattoirs.

From Dr. Curson's Paper—" Measles in Cattle and Pigs ".

Town.	1925.		1926.		1927.		1928.		1929.		1930.		1931.		1932.		1933.		1934.		1935.		1936.	
	Total Measly.		Total measly.		Total measly.		Total measly.		Total measly.		Total measly.		Total measly.		Total measly.		Total measly.		Total measly.		Total measly.		Total measly.	
	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.
Port Elizabeth	260	235	397	225	201	320	356	310	440	252	577	144	551	109	492	124	905	134	670	292	647	193	—	—
East London	72	419	44	484	55	571	231	450	193	530	215	463	108	274	127	276	184	324	391	521	440	474	—	—
Kingwilliamstown	—	—	—	—	—	—	—	—	—	—	37	18	32	21	64	45	154	75	168	189	98	147	—	—
Capetown	—	—	—	—	—	—	—	—	—	—	—	—	425	386	474	301	422	209	604	315	534	251	—	—
Kimberley	—	—	69	45	130	61	85	55	40	62	81	62	72	68	57	84	47	46	125	77	170	30	—	—
Pretoria	168	490	201	480	219	475	321	444	298	569	315	682	301	624	318	634	301	817	378	667	443	664	—	—
Johannesburg	1,084	3,350	994	36,98	1,158	3,300	892	3,225	922	3,569	806	3,054	734	2,232	518	2,223	644	2,571	732	3,618	690	3,788	—	—
Bloemfontein	116	132	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	504	93	382	56
Durban	—	—	382	978	620	744	661	790	613	898	811	1,224	—	—	870	1,113	1,118	893	1,217	1,457	1,635	1,052	1,450	831
Pietermaritzburg	—	—	—	—	—	—	192	91	268	79	313	88	371	61	343	37	329	48	530	52	557	48	625	31

Table II.

Town.	1925.		1926.		1927.		1928.		1929.		1930.		1931.		1932.		1933.		1934.		1935.		1936.	
	Percentage condemned.		Percentage condemned.		Percentage condemned.		Percentage condemned.		Percentage condemned.		Percentage condemned.		Percentage condemned.		Percentage condemned.		Percentage condemned.		Percentage condemned.		Percentage condemned.		Percentage condemned.	
	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.	Ox.	Pig.
Port Elizabeth	2·6	4·6	3·9	3·0	1·9	3·2	3·1	3·2	3·6	2·5	5·4	1·4	5·8	1·2	6·1	1·4	10·8	1·5	7·2	2·8	6·5	1·7	—	—
East London	0·9	11·7	0·5	11·3	0·6	11·6	3·3	10·5	2·3	12·2	2·8	12·1	1·7	7·1	2·3	6·2	3·3	7·2	5·4	9·1	5·9	8·4	—	—
Kingwilliamstown	—	—	—	—	—	—	—	—	—	—	1·3	2·6	1·9	1·1	4·6	3·6	9·2	4·4	8·7	9·8	5·7	6·7	—	—
Capetown	—	—	—	—	—	—	—	—	—	—	—	—	1·1	4·3	1·2	5·2	0·95	3·8	1·3	4·4	1·1	3·6	—	—
Kimberley	—	—	1·1	2·6	1·9	2·4	1·1	1·8	0·47	1·4	0·9	1·3	0·9	1·1	0·8	1·1	0·7	0·8	1·8	2·4	2·5	1·3	—	—
Pretoria	—	9·25	1·3	7·34	1·3	7·32	1·6	6·29	1·8	9·09	2·0	8·97	2·0	7·07	2·4	6·97	1·9	7·53	2·3	8·51	2·4	7·95	2·7	—
Johannesburg	1·05	6·02	0·95	6·49	1·03	4·58	0·81	4·5	0·78	4·88	0·72	4·36	0·67	3·06	0·48	2·89	0·61	3·22	0·62	4·41	0·57	4·20	—	—
Bloemfontein	1·14	7·47	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5·5	3·7	4·6	1·8
Durban	—	—	1·3	8·4	1·8	4·7	1·8	4·5	1·5	4·6	2·1	5·9	—	—	2·4	4·9	3·5	4·1	3·6	6·4	4·7	5·1	4·1	3·0
Pietermaritzburg	—	—	—	—	—	—	2·3	2·4	2·9	2·5	3·3	2·8	4·2	2·1	4·1	1·1	3·9	1·5	5·6	1·7	6·04	2·8	7·0	1·7

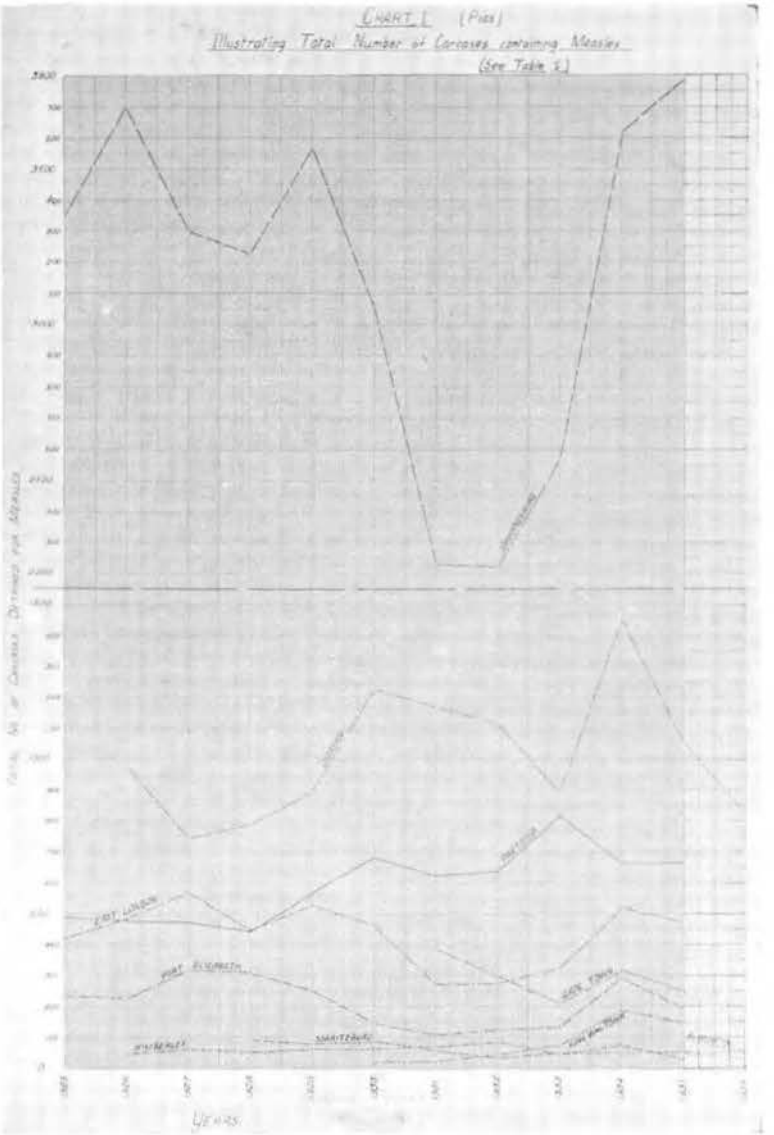


CHART I (PIGS).

Graphical Illustration showing the Total Number of Carcasses containing Measles at the nine Principal Abattoirs of the Union, plus Kingwilliamstown, adjoining Transkei.

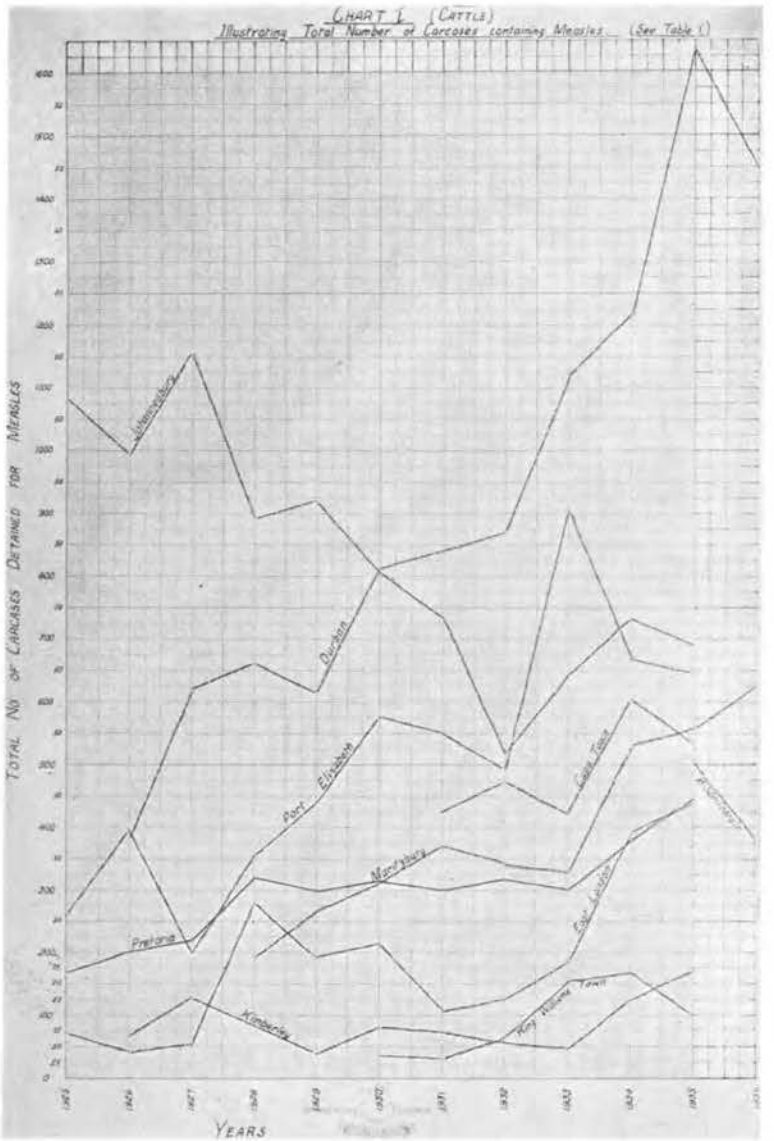


CHART 1 (CATTLE).

Photograph of Graph in Dr. H. H. Curson's Note "Measles in Cattle and Pigs". 1936.

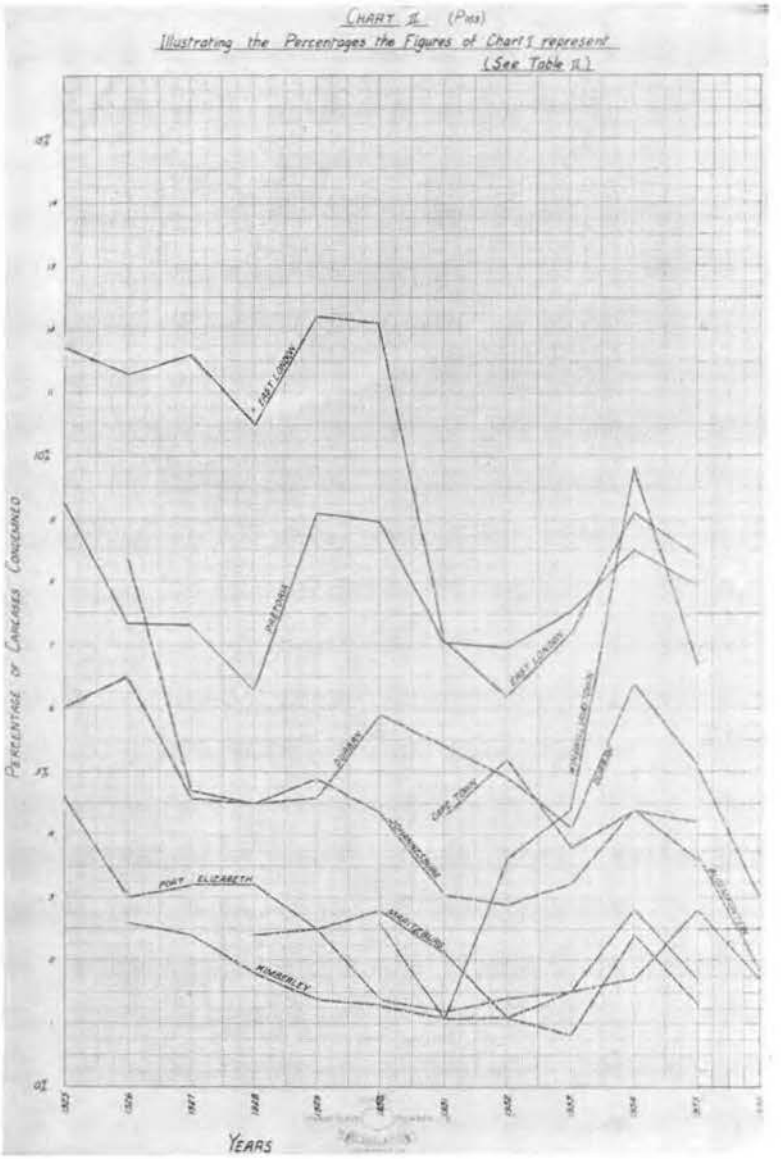


CHART II (PIGS).

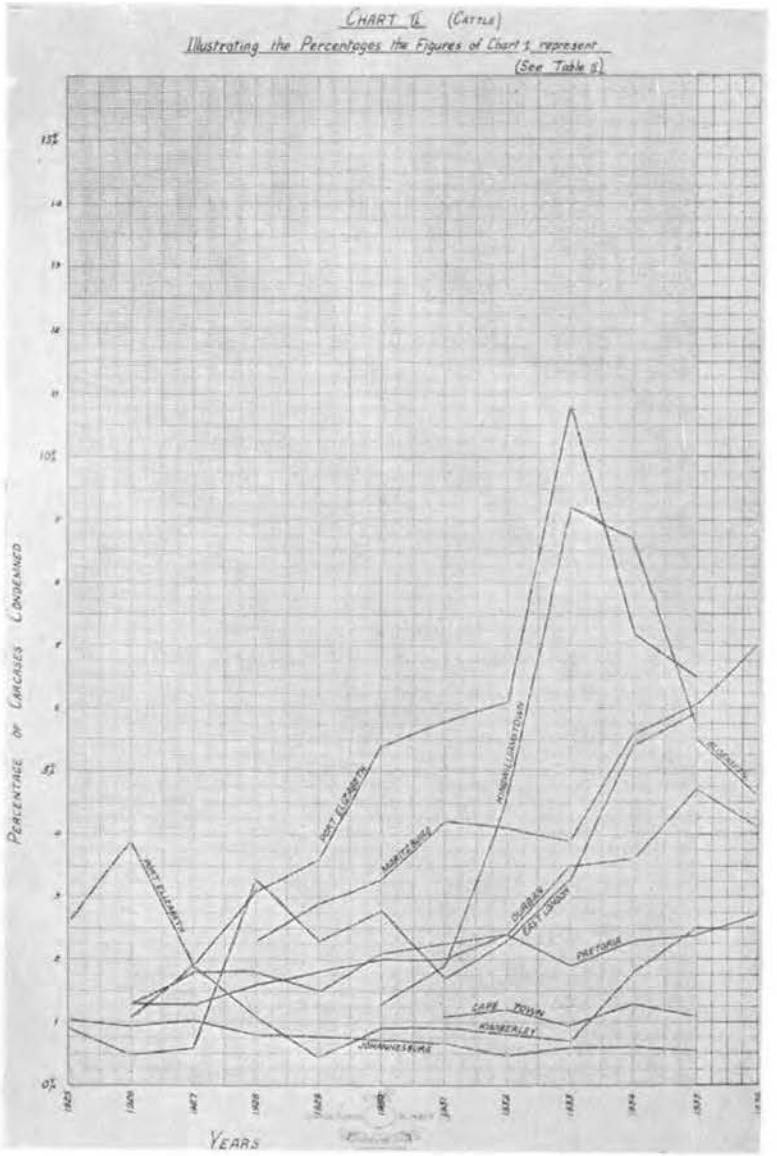


CHART II (CATTLE).

Summary.

Reference to the accompanying " Incidence Maps " will clearly show the areas in which the largest percentages of infection are found. These are marked in black, in respect of Pig Measles. The largest Union centres, e.g. Johannesburg, Capetown, Durban, Pretoria, Bloemfontein, Port Elizabeth, East London, Pietermaritzburg, Kimberley and all the Witwatersrand towns obtain their slaughter stock from various parts of the Union, so that it is difficult to fathom the incidence of infection and its origin. A more correct reflection is probably shown by the recordings of the smaller abattoirs, where much of the stock slaughtered is reared locally.

Heavy infection in pigs is reflected in such centres as Ficksburg, Clocolan, Senekal, Wepener and Bethlehem, which are situated close to the Basutoland border, and in the Transvaal a very interesting " black zone " may be traced from the North-West Cape (Mafeking and Vryburg), through Lichtenburg, Potchefstroom, Rustenburg, Pretoria, Witbank to Middelburg. It is correct to state that a large percentage of pigs slaughtered in this " black zone " originates from native areas. The Vryburg and Mafeking Districts have numerous Native Reserves; Lichtenburg District has a large Reserve near Delarey, many native-owned or leased farms, and the district adjoins the vast Moiloa Native Reserve of Marico; Potchefstroom has numerous native farms; Rustenburg District, likewise, has many Native Reserves; Pretoria and Witbank Districts have many native areas, and Sekoekoeniland forms a considerable portion of Middelburg District. It is with regret that no figures are available for the Transkeian Territories, but relatively high percentages were obtained from Kingwilliamstown, close by.

The incidence of *C. bovis* is highest in Natal, the extreme Eastern Transvaal and also in the Eastern Cape, namely at the abattoirs at Kingwilliamstown, East London, Port Elizabeth and Fort Beaufort, and it can safely be presumed that a large percentage of the bovines slaughtered at those abattoirs are of native origin.

The following tables show a summary of the average percentages, in reverse order of frequency, of the incidence of *C. cellulosae* and *C. bovis* at South African abattoirs. The averages given are over periods ranging between 1 and 10 years.

Average Percentages of C. cellulosae *at Union abattoirs.*

Aliwal North	0·5	Dundee	2·70
Beaufort West	0·67	Bedford	2·75
Heilbron	0·88	Middelburg (C.)	2·9
Germiston	1·04	Vryheid	2·9
Mossel Bay	1·37	Swellendam	3·0
Stellenbosch	1·58	Uitenhage	3·0
Kimberley	1·68	Queenstown	3·3
Greytown	1·69	Paarl	3·33
Pietermaritzburg	1·77	Graaff-Reinet	3·33
Port Elizabeth	1·77	Springs	3·91
Worcester	1·97	Randfontein	3·96
Ladysmith	2·0	Capetown	4·26
Bloemfontein	2·13	Kroonstad	4·26
Newcastle	2·45	Brakpan	4·27
Cradock	2·49	Malmesbury	4·27
George	2·61	Winburg	4·4

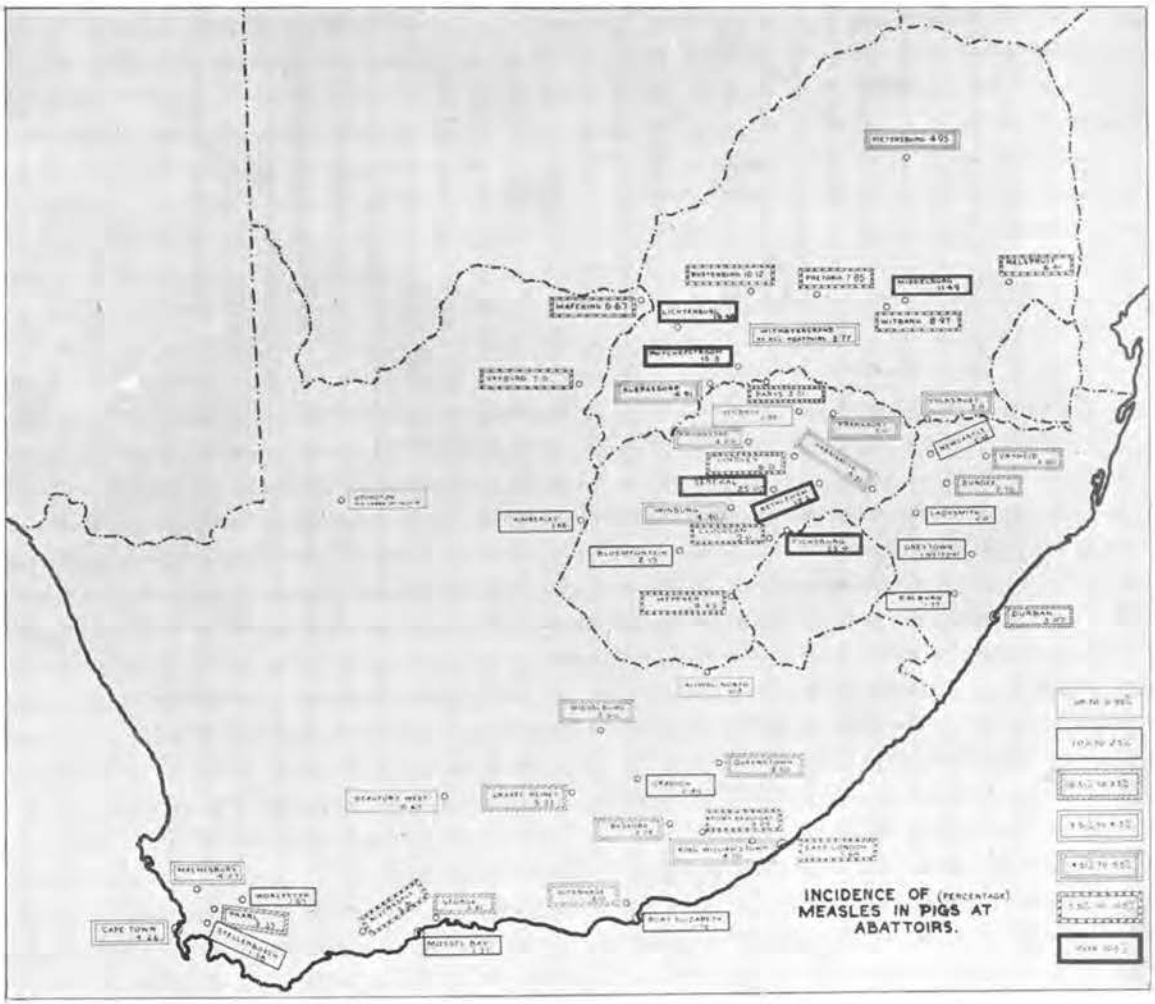
Johannesburg	4·42	Vryburg	7·0
Harrismith	4·51	East London	7·67
Kingwilliamstown	4·70	Pretoria	7·85
Klerksdorp	4·91	Witbank	8·97
Pietersburg	4·95	Clocolan	9·0
Volksrust	5·0	Fort Beaufort	9·29
Nigel	5·02	Wepener	9·43
Frankfort	5·03	Rustenburg	10·12
Durban	*5·16	Middelburg (Tvl.)	11·49
Parys	5·51	Bethlehem	15·2
Riversdale	5·8	Potchefstroom	15·3
Lindley	6·0	Lichtenburg	19·48
Krugersdorp	6·10	Ficksburg	25·0
Nelspruit	6·41	Senekal	25·07
Mafeking	6·67		

* Durban.—The percentages given for Durban, of *C. cellulosæ* and *C. bovis* in the accompanying maps, viz., 3·07 and 4·16 respectively, were for the 12 months ended June, 1936. At the time the maps were compiled, I did not have all the data for Durban. The percentages shown in the tables, viz., 5·16 in pigs and 2·68 in bovines, are the average percentages for 10 years ended 1936.

Average Percentages of C. bovis *at Union abattoirs.*

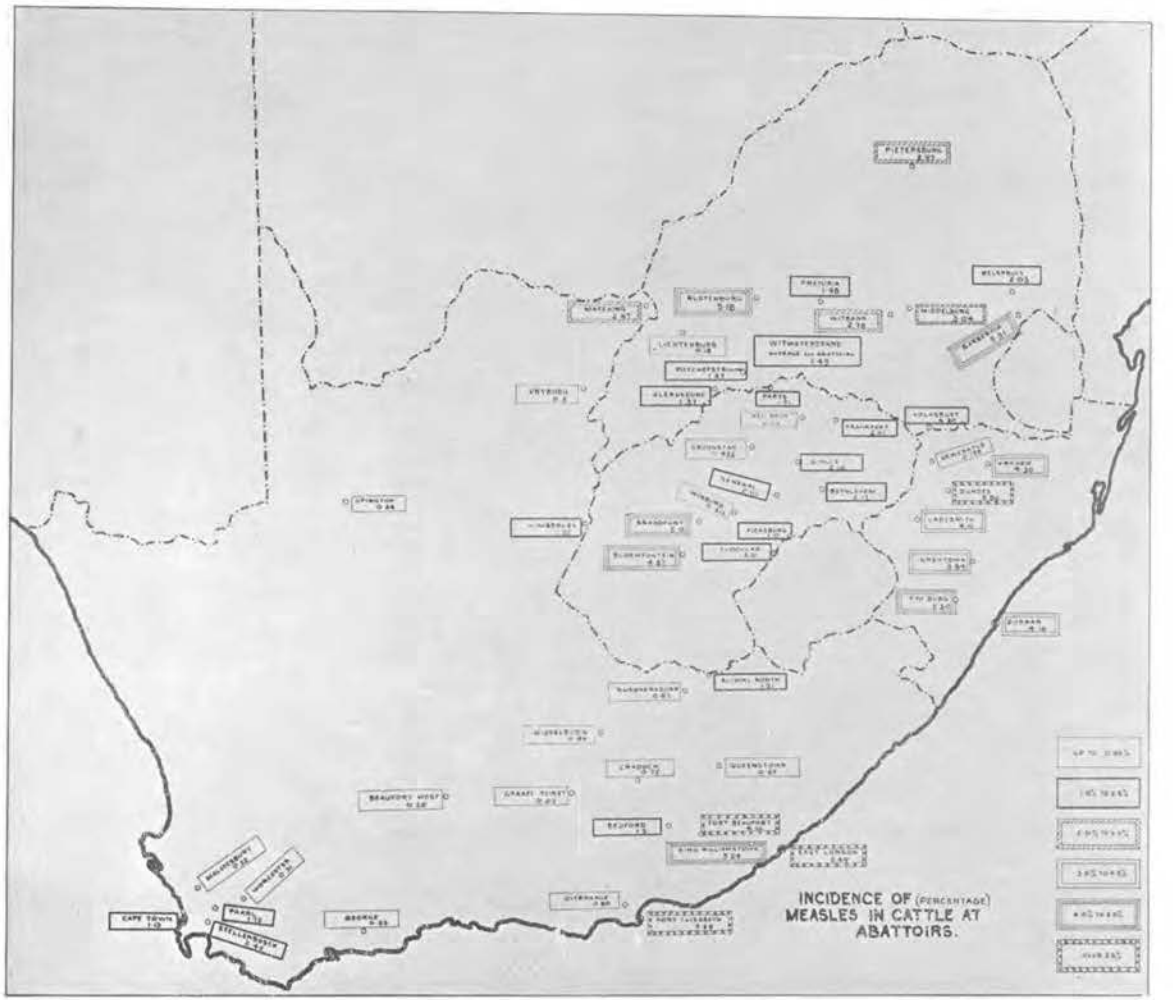
Heilbron	0·08	Pretoria	1·98
Newcastle	0·158	Clocolan	2·0
Lichtenburg	0·18	Senekal	2·01
Beaufort West	0·25	Lindley	2·10
Vryburg	0·3	Nelspruit	2·03
Worcester	0·31	Frankfort	2·03
Malmesbury	0·32	Bethlehem	2·13
Kroonstad	0·45	Randfontein	2·30
George	0·53	Stellenbosch	2·44
Uitenhage	0·6	Mafeking	2·67
Queenstown	0·67	Durban	*2·68
Brakpan	0·71	Witbank	2·75
Johannesburg	0·75	Nigel	2·80
Cradock	0·75	Pietersburg	2·97
Burghersdorp	0·87	Riversdale	3·0
Upington	0·89	Middelburg (Tvl.)	3·04
Middelburg (C.)	0·89	Greytown	3·84
Ficksburg	1·09	Ladysmith	4·0
Volksrust	1·06	Swellendam	4·0
Capetown	1·12	Vryheid	4·3
Springs	1·20	Bloemfontein	4·87
Kimberley	1·22	Brandfort	5·0
Boksburg	1·22	Rustenburg	5·18
Potchefstroom	1·23	Kingwilliamstown	5·2
Klerksdorp	1·37	Pietermaritzburg	5·3
Krugersdorp	1·46	Barberton	5·31
Germiston	1·48	East London	5·69
Aliwal North	1·5	Dundee	5·8
Bedford	1·5	Fort Beaufort	6·1
Parys	1·51	Port Elizabeth	7·29
Paarl	1·75		

* Durban.—The percentages given for Durban, of *C. cellulosæ* and *C. bovis* in the accompanying maps, viz., 3·07 and 4·16 respectively, were for the 12 months ended June, 1936. At the time the maps were compiled, I did not have all the data for Durban. The percentages shown in the tables, viz., 5·16 in pigs and 2·68 in bovines, are the average percentages for 10 years ended 1936.



MAP I.

Showing average percentages *C. cellulosae* at Union Abattoirs.



MAP II.

Showing average percentages *C. bovis* at Union Abattoirs.

PART III.

In his " Text-book of Meat Inspection " von Ostertag divides the animal parasites found in meat inspection into (i) those not transmissible to man through the consumption of meat, and, (ii) those parasites transmissible to man through the consumption of meat. In the latter category he mentions but three parasites:

(*a*) *Cysticercus inermis (bovis)* in cattle.

(*b*) *Cysticercus cellulosae* in swine.

(*c*) *Trichinella (trichina) spiralis* in swine.

An endeavour will be made in Part V of this article to show the import of the two first-named parasites on hygiene, with special reference to South African conditions.

The *Trichinella spiralis* will receive no further consideration in this work, since it is neither a *cysticercus*, nor has its occurrence in South Africa been recorded.

On the other hand, there is a number of *cysticerci* found in the viscera and tissues of slaughter animals, including pigs and bovines, which, although meat may be condemned owing to their presence, will not give rise to an adult tapeworm in man. Some of these *cysticerci*, however, are of importance when arriving at a differential diagnosis, and will be mentioned in that section.

A. Morphology, Development and Life Cycle.

1. Cysticercus cellulosae.

The *Cysticercus cellulosae* is a round to oval bladder, which in young specimens may frequently be spherical, but in older specimens it generally has an oval or even elliptical shape. The maximum recorded size is 20 mm. by 10 mm.

It consists of (*a*) the so-called bladderworm capsule, or caudal vesicle, (*b*) the parasitic head and neck, or *scolex*. The actual bladderworm is enveloped in a whitish-gray transparent outer connective tissue membrane, formed by the host tissues as a protective reactor against the surrounding muscular tissue of the host. The caudal vesicle consists merely of an outer cuticle and a subcuticular layer. The caudal vesicle is easily removed from the connective tissue capsule, and is of delicate structure, containing a variable amount of fluid. It is very transparent, showing the invaginated *scolex* inside the bladder. One portion of its wall is narrowly folded to form, what was formerly called, and is still so-called by some writers, the *receptaculum scolicis*. The *scolex* is invaginated into the *receptaculum*, being attached to the fold of the vesicle by its neck portion. The opening or " *hilus* ", into which the *scolex* is invaginated, is extremely narrow and barely visible. The *scolex* and its *receptaculum*, in the early stages of development grow in unison, but after a time the *scolex* outgrows its *receptaculum*.

The resultant restriction to the longitudinal growth of the *scolex* causes it to form a bow or bend into an S-, or 6-shape, as Yoshino (1934) describes it. This constriction causes the comparatively long neck of the *scolex* to make one-and-a-half complete coils, and transversely folds it in the invagination process to resemble a closed concertina. The neck is transversely striated and contains numerous calcareous corpuscles, which are characteristic of tapeworm tissue. Ransom suggests that the calcareous corpuscles are composed of calcium albuminate. When treated with acid, however, the corpuscles dissolve, giving off gas, and they may, therefore, probably be composed of calcium carbonate.

The size of the head varies with the maturity of the *Cysticercus*. When mature it measures from about 0·6 mm. to 1mm. in diameter. The head is spherical in shape. Its dome is formed by a prominence, the *rostellum*, a strongly muscular structure, which is capable of contraction and expansion. The *rostellum* measures about 0·36 mm. in height and diameter, and is armed with two rows of hooks. Owing to its contractive and expansive powers the *rostellum* may sometimes be deeply sunk into the wall of the head, and sometimes protruded into a dome-like proboscis. Four prominent suckers are situated antero-laterally, with the *rostellum* approximately equidistant from each. They measure from 0·4 mm. to 0·5 mm. in diameter. Leuckart, in describing the range of movement of the suckers, mentions that " the whole four may be raised up like arms, extend in different directions, and then contract. This is very marked when the suckers feel about in front as though trying to fix themselves to some object situated in front of the head. As often as this motion takes place the apex is observed to sink in, and to remain in this position until it again protrudes and allows the hook-apparatus to unfold itself ".

FIGURE 1.

C. cellulosae head, showing rostellum with hooks, and on the left two suckers prominently, other two suckers less prominent. This scolex evaginated artificially after 28 days cooling.

Photograph by Director of Veterinary Services, Onderstepoort. Magnfn. 40×.

Specimen, Bloemfontein Municipal Abattoir.

FIGURE 2.

Completely evaginated scolex of *Cysticercus* mentioned under Figure 1.

Magnfn. 7×.

The double row of hooks is arranged into a circle on the *rostellum*. The anterior hooks are the larger, and the posterior, or smaller hooks always individually occupy the spaces between each anterior pair of hooks, thus alternately there are large and small hooks. The shape of the hooks is characteristic and a distinct " handle ", " guard " and " blade " can be recognized. The root processes are thick and the tips curved. The total number of hooks in *Cysticercus cellulosae* is from 22 to 32. Yoshino found the number of hooks in the specimens examined by him to be 22, 24, 26 or 28. The large hooks measure from 0·16 mm. to 0·18 mm. and the small hooks 0·11 mm. to 0·14 mm. (Yoshino's measurements are 0·128 mm. to 0·162 mm., and 0·100 mm. to 0·125 mm., respectively.)

In describing the development of the hooks on the *rostellum*, Yoshino states that they differ in shape according to the development of the *Cysticercus cellulosae*: " The initial hooks on the rudiment of the *rostellum* in *C. cellulosae* about 40 days old are like needles or spines, and gradually they curve outwards like the horns of cattle ".

The histological structure of the *scolex* of *Cysticercus cellulosae* about 40 to 50 days old is similar to that of the mature *Cysticercus*, and there are recognizable two pairs of excretory canals and very many calcareous corpuscles in the muscular layer developed from the spindle cells in the first cell layer.

In the adult *Taenia solium*, the head is joined to the body or *strobila* by a neck, usually four times as long as the head itself. The *strobila* is segmented, the segments being called *proglottides*, which, in the case of the mature segments, are longer than broad. The *proglottides* are formed behind the neck, in a continuous chain. The anterior segments are the youngest, and push the older, mature and gravid *proglottides* farther and farther to the posterior of the host's intestine. The total length of the worm is about 3·5 m. and in rare cases up to 8 m.

The structure of the *strobila* is simple. Externally it possesses a cuticular layer, which contains numerous fine pores, through which the parasite absorbs its nourishment. Immediately below the cuticle is a subcuticular layer, with a layer of cells on its inner surface. Below the cuticle are layers of delicate transverse and longitudinal muscles. The interior of the body consists of the parenchyma, which is divided by a strong layer of transverse muscles into cortical and medullary portions. The cortical portion of the parenchyma contains numerous oval calcareous corpuscles, similar to those mentioned in the description of the *scolex*, and are distributed throughout the length of the *Taenia*. They may measure up to 0·019 mm. In the medullary portion are situated the excretory, nervous and reproductive systems. All tapeworms are devoid of an alimentary canal, absorption of nourishment taking place through the pores in the cuticle, and excretion through " flame-cells " and a pair of dorsal and ventral longitudinal canals on either side of the *strobila*. At the posterior part of each *proglottis*, each pair of canals is joined by a transverse canal, and in the *scolex* itself all canals are joined by transverse loops.

The nervous system consists of two large longitudinal and several smaller nerve trunks, which run throughout the *strobila*. These are joined by several ganglia and transverse commissures at the *scolex*.

The *Taenia solium* and all *taeniae* are hermaphrodite parasites. The male reproductive organs are the first to appear in young *proglottides*. They consist of: (i) Numerous *testes*, which secrete into (ii) *vasa efferentia* uniting to form a (iii) *vas deferens*, which forms a (iv) *seminal vesicle*, and ends in (v) a *cirrus-pouch*, containing a *cirrus*, opening at the genital pore, which lies in a sinus on the lateral margin of the *proglottis*, close to the genital pore of the female organs. The genital pores are situated on irregularly alternate margins in successive *proglottides*.

The female generative organs consist of: (i) A *vagina*, opening at the genital pore. It is a narrow tube, bearing (ii) a *seminal vesicle*, and ends in the (iii) *ootype*, surrounded by Mehlis' gland, where it is joined by the oviduct and the vitelline duct. (iv) The *ovary*, which is single and lobed, is situated at the posterior part of the *proglottis*. (v) The *ootype* is also in contact with the *vitelline gland*. (vi) The *uterus* is characteristic, and one of the main differential diagnostic features of the species. It has a median longitudinal stem with 7 to 12 lateral branches.

Self-fertilization may take place in each individual sexually mature *proglottis*. Tapeworms may also bend double and the male products developed earlier in younger *proglottides* may fertilize the female products developed later in older *proglottides*.

The embryonic egg-shell is thick and radially striated, spherical, rarely ovoid in shape, and measures 0·042 mm. in diameter. Leuckart's measurements were 0·06 mm. and those of Yoshino 0·043 to 0·068 mm. The embryonic development takes place in the uterus, and the eggs contain a spherical embryo, with three pairs of hooks, the *hexacanth embryo*. The embryo with its embryonic egg shell is known as the *oncosphere*. Yoshino (1934) found that under abnormal circumstances the embryo may have 8, 10, 12, 14, 16 or 18 hooks, instead of 6.

Gravid proglottides measure 10 to 12 mm. long by 5 to 6 mm. broad. The gravid segments are passed to the exterior by the human host, in his excretum, and are frequently detached in short chains. The worm may live in man for years, and sometimes more than one individual may be present in one host. Yoshino (1934) intentionally infected himself with *Taenia solium* and studied many gravid *proglottides*. He found that the gravid proglottides just discharged move about, alternately extending their anterior ends then contracting themselves. "During the extensions the eggs are pushed out from the uterus through the anterior end of the *proglottis*. With the extensions and contractions from 31,000 to 55,300 eggs are evacuated and only 480 to 1,500 eggs remain in the *proglottis*," he wrote. Leuckart found that the contents of the uterus of each segment was 6 cubic mm., and it held some 53,000 eggs.

Development of Cysticercus cellulosae.

The egg hatches after it has been swallowed by the pig (also by man, the dog, or in at least one instance the monkey, as was reported by Walker), and the *hexacanth embryo* penetrates into the intestinal wall. The migratory course of the embryo in the body of its intermediate host, the pig, was carefully studied by Yoshino in 1933. This writer experimented upon a number of pigs, which he fed with large numbers of eggs of *Taenia solium*. He obtained the following results:—

(1) The eggs of *Taenia solium* hatch in the upper part of the small intestine of the pig and the greater number of freed embryos enters the mucous membrane of that portion, while a smaller number penetrates into the middle or lower parts of the intestines.

(2) The number of hours required for the hatching of the eggs varies, and Yoshino saw freed embryos in the mucous membranes of the intestines 15 to 48 hours after the experimental feeding, and they were also found in the internal organs and muscles within 24 to 72 hours after feeding.

(3) Embryos found in the intestinal wall usually had no hooklets, having lost them by penetrating through the tissues. During the early stages, 15 to 48 hours after feeding, specimens with one or two hooklets could be seen.

(4) The youngest *Cysticercus cellulosae* or transitional forms found in the intestinal wall were spherical or ovoidal in shape. They consist of round cells, and under the microscope appeared grayish-white in colour, and measured 0·024 mm. to 0·03 mm. in length and 0·021 mm. to 0·026 mm. wide. The transitional forms were mostly found in the tunica propria and rarely in the tela submucosa and the muscular layers. In those cases the blood vessels in the tunica propria, into which the transitional forms were about to penetrate, or had penetrated, were congested and enlarged. The youngest *Cysticerci cellulosae* were rarely found in the abdominal cavity of a pig between 24 and 72 hours after the experimental feeding. Those *Cysticerci cellulosae* found in the internal organs or muscles of a pig between 24 hours and 72 hours after experimental feeding were light greenish in colour and spherical or ovoidal in shape. They consisted of round cells. Between 24 and 48 hours after experimental feeding, the size of the *Cysticercus* was 0·024 to 0·042 mm. in length and 0·021 to 0·036 mm. wide. Between 48 and 72 hours after feeding the dimensions were 0·03 mm. to 0·058 mm. long and 0·027 mm. to 0·054 mm. wide.

(5) Between 6 days and 15 hours and 12 days and 15 hours after experimental feeding, the young *Cysticerci cellulosae* appeared macroscopically as almost transparent and colourless spots, and were difficult to find within the muscles and organs, unless they were detached from them. Under the microscope they were light greenish in colour, and spherical, ovoidal or cylindrical in shape. At 6 days and 15 hours after experimental feeding they were generally solid, but larger specimens were somewhat cystic. Those examined 12 days and 15 hours after experimental feeding were cystic, contained

a sticky fluid, "and through the cyst wall a spot could be seen, which might have been the rudiment of the head and its *rostellum* ". (It is extremely unlikely that the last surmisal of Yoshino is correct. In such young stages there would be nothing more than a slight thickening of the wall where the invagination will later occur. The scolex is formed much later at the bottom of the invagination or receptaculum).

(6) At 12 days and 15 hours after experimental feeding the young *Cysticerci cellulosae* were quite large and cystic, and contained fluid. The cyst wall became thinner than in younger specimens and consisted of a cuticular membrane and a subcuticular layer. At a point destined to become the receptaculum, a great number of ovoidal cells began to accumulate, and the cuticular layer of that portion became thicker and curved into the accumulated cell-layers.

At 12 days and 15 hours after experimental feeding the young *Cysticerci* were found in the liver, especially in bleeding areas in the parenchyma. They were also found in the brain, especially in the cortical substance of the cerebrum. Within 12 days and 15 hours after experimental feeding the young *Cysticerci cellulosae* were found in body muscles and heart muscles and were accompanied by round cell infiltrations.

From the above results Yoshino concludes that the embryos hatch in the small intestine of the pig, penetrate into the intestinal wall, and the majority enter the blood stream by the capillaries in that region. They are then carried to the internal organs and muscles, where they develop into *Cysticerci cellulosae*. Others penetrate through the intestinal wall into the abdominal cavity and die there.

On the later stages of development of the *Cysticercus cellulosae* various observers have recorded as follows:—

Hutyra and Marek.

At 20 days *Cysticercus cellulosae* is about the size of a pin head, and the head is visible as a small white point.

At 40 days it appears as big as a mustard seed, and the head may be plainly seen, but it has neither suckers nor hooks.

At 60 days the cyst is as big as a pea, with head with suckers and hooks, but no neck.

After 3 months the "bladderworm" is fully developed and behind the head the transversely striped neck may be seen.

Braun-Seifert.

The complete development of the *Cysticercus cellulosae* takes from 2½ to 4 months.

Männig.

The *Cysticercus* requires about ten weeks for its complete development in the pig. After about two months the bladderworm is already infective as the suckers and hooks are sufficiently well developed to allow the scolex to attach itself.

Yoshino.

At 20 to 30 days the *Cysticercus cellulosae* measured 1·1 mm. to 4·1 mm. by 0·8 mm. to 3·2 mm.

At 40 to 50 days dimensions were 3·4 mm. to 8·2 mm. by 2·9 mm. to 6·0 mm.

At 60 to 70 days dimensions were 5·6 mm. to 8·5 mm. by 3·1 mm. to 6·5 mm. At the last named stage it might be fully developed and infective, but may still increase in size and measure 8·0 mm. to 14·5 mm. in length, by 4·5 mm. to 8·0 mm. in width between 254 and 325 days after feeding.

Twenty days after experimental feeding the rudiment of the scolex may become gradually distinguishable.

Forty to fifty days after feeding the scolex has developed fully with four suckers arising from its invaginated surface, and in its blind end the rostellum provided with hooks is formed. It measures from 0·83 mm. to 1·97 mm. in length.

In *Cysticercus cellulosae* 60 to 70 days old, the scolex is fully developed and its elongated neck is bent within its receptaculum, showing on its invaginated surface many foldlike septa, because the scolex grows much more rapidly than the receptaculum. According to the development of the bladder the neck of the scolex elongates rapidly, and on its invaginated surface numerous fold-like septa appear. Outgrowing the receptaculum, it bends as a whole into an S-, or 6-like shape and the receptaculum becomes a thin membrane.

The histological development of the head, according to Yoshino, is as follows:—

At 20 days the rudimentary scolex is a simple tube, consisting of cuticle and subcuticular layer. The subcuticular layer may again be divided into an outer (first cell) layer, which directly joins the cuticle, and consists of spindle cells, and an inner layer (second cell layer) of polymorphic cells. At 40 to 50 days the scolex is almost fully developed and is provided with four suckers and the rostellum. In this stage the suckers are hemispherical and measure 0·225 mm. to 0·352 mm. in diameter. Still later, at 60 to 70 days, the suckers measure 0·325 mm. to 0·384 mm. in diameter.

II. Cysticercus Bovis.

The general structure of the *Cysticercus bovis* and its resultant adult *Taenia saginata* resembles the *Cysticercus cellulosae-Taenia solium* closely, with the following enumerated points of difference:—

(*a*) Intermediate host, the ox; very rarely man. Adult host, man only.

(*b*) The outer connective tissue membrane is very much thicker than that of *Cysticercus cellulosae*, and much more firmly attached to the caudal vesicle.

(*c*) The bladder itself is much less transparent, and contains a thicker fluid, which is frequently more turbid than in *Cysticercus cellulosae*. The scolex is, therefore, less visible.

(*d*) The bladder is decidedly more greyish in colour, and very frequently the fluid contents give the bladder a reddish-brown tint. Piettre (1922) gives the opinion that the red colouration may be ascribed to the absorption of haemoglobin from the surrounding muscles. Valade (1927) suggests that the reddish tint apparently results from histolysis of muscle fibres as the result of the excretion of toxic materials by the scolex.

(*e*) The *Cysticercus bovis* usually measures 7·5 mm. to 9 mm. by 5·5 mm. when fully developed.

(*f*) The scolex, especially in the adult stage is very much larger than that of *Cysticercus cellulosae-Taenia solium*. It is 1·5 mm. to 2 mm. in diameter.

(*g*) The embryo is a hexacanth (six-hooked) larva, but neither in the *Cysticercus* nor in the adult stage has the scolex a rostellum and hooks.

(*h*) The four suckers are even more muscular than those of *Cysticercus cellulosae-Taenia solium*, are larger, with unusually thick walls. As compensation for the absence of hooks, the suckers are capable of greater suctorial attachment.

(*i*) Pigmentation around the suckers is very well-marked in the adult *Taenia saginata*, and gives the worm the appearance of possessing a big black head. Pigmentation occurs to a much less extent in *Taenia solium*.

(*j*) The adult tapeworm is much longer than *Taenia solium*, and may measure from 4 to 10 m. in length.

(*k*) Gravid proglottides are from 16 to 20 mm. in length and from 4 to 7 mm. wide.

(*l*) Gravid segments are generally voided singly, very rarely in chains, and may sometimes be liberated spontaneously to the great discomfort and embarrassment of the human carrier.

(*m*) The gravid uterus has 15 to 35 lateral branches on either side.

(*n*) The embryonic egg-shell is ovoidal, rarely spherical, and measures 0·045 mm. by 0·043 mm.

(*o*) Malformations are quite common in *T. saginata*. These may take the form of specimens with multiplication of the generative openings. (Leuckart.) Supernumerary joints, and sometimes duplication of strobilae have been recorded. Palais (1933) described a specimen obtained from Brazil, in which the two strobilae were attached one at right angles to the other. Leuckart states that he found only one case of malformation in *Taenia solium*.

(*p*) The worm has been known to live in man for 20 years. Very rarely is more than one specimen found in one host, and in that respect Leuckart was correct when he took exception to the name *Taenia solium* (solitary tapeworm), and pointed out that *Taenia saginata* was by far the more solitary.

(*q*) With regard to the development of *Cysticercus bovis*, Braun (1900), quoting Hertwig, gives the following table:—

Age of cysticerci in weeks.	Connective tissue		Cysticerci.		Scolex./mm.	
	Length /mm.	Breadth /mm.	Length /mm.	Breadth /mm.	Natural.	Extended artificially.
4.....	4·0	3·5	2·25	2·25	0·5	0·7
6.....	4·2	3·5	3·0	2·5	1·0	1·3
8.....	4·5	3·5	3·25	2·75	1·5 × 1·0	2·9
10.....	5·0	3·75–4·0	3·5	3·5	1·7 × 1	3·3
12.....	5–6	3·75–4·0	4·0	4·0	1·8 × 1·0	3·5
14.....	6·0	4·5	5·0	4·5	2 × 1	4·0
16.....	6·0	4·5	5·0	4·5	2 × 1	4·25
18.....	6·25 × 7·00	4·5	6·0	4·5	2 × 1·25	5·0
22.....	6·5–8·0	4·5	6·0	4·5	2·25 × 1·75	5·5–6·25
28.....	7·5–9·0	5·5	7·0	5·0	2·5 × 2	7·0

(*r*) *Cysticerci* take about 18 weeks to attain full development. It is usually taken that a diagnosis of cysticercosis will be made in meat inspection from the 6th week onwards—both in the case of *C. bovis* and *C. cellulosae*.

Second, or Adult Stage of Life-Cycle of Both Species.

If man eats viable measly pork or beef, which may be undercooked, or insufficiently cured in the case of ham, the adult stages of the respective parasites are commenced within him.

The bladderworm is swallowed, and within 24 hours, as a rule, the scolex evaginates from the surrounding caudal vesicle into which it had been invaginated. The evagination is caused by the stimulation of the head by digestive juices which permeate through the "hilus" of the invagination. The head attaches itself to the mucosa of the intestine, by means of its hooks and suckers (*Taenia solium*), or suckers only (*Taenia saginata*).

After having obtained lodgment by means of the scolex, the tapeworm grows, and from the neck the strobila develops. The mature and gravid segments are pushed further to the posterior by the younger segments. Self-fertilization may occur within the proglottides, or proglottides may fertilize one another, and gravid segments are voided.

Contrary to the opinions in many text-books, Yoshino (1934), who examined stools for *Taenia solium*, and Alcaraz (1932), Pardina (1932) and Franzani (1933), who examined stools for *Taenia saginata*, found that in the majority of cases numerous eggs were found in the faeces, whereas comparatively few remained in the voided proglottides. Pardina explains the fact that the detached gravid segments extrude eggs through a ruptured uterine branch. Alcaraz, referring to *Taenia saginata*, explains that segments are expelled singly, causing rupture of the uterus, followed by active expulsion of the ova. Kouri and Basnuevo (1933) found that eggs of *Taenia saginata* were observable in 80 per cent. of stool examinations, in infected cases.

Moore (1916) observed the rate of growth of a *Taenia saginata* in a student at the Potchefstroom (Transvaal) School of Agriculture. He gave the student a vermifuge, which caused the patient to excrete a length of tapeworm, which, according to its appearance, gave Moore the opinion that the entire worm minus its head and neck had been passed. Some time later, the patient was again troubled with the tapeworm, and a second vermifuge was administered, with the result that the entire worm was passed. The time between the first and second vermifuges was 72 days, and the length of worm passed on the second occasion was 19 ft, 3 in. Moore thus estimated that all but the head and neck grew in that time.

When the pig, or the ox, ingests the eggs of the respective species of which it is the intermediate host, the life-cycle is resumed.

B. The Hosts and Pathogenicity of Cysticercus cellulosae.

In the adult stage the *Taenia solium* has only been known to develop in man. Young, immature *Taenia solium* may, however, live for a very short period in dogs and possibly in some other carnivores.

Experimentally we tried to infect six dogs, a jackal (*Thos mesomelas*) and a baboon with *Taenia solium* at the Bloemfontein Municipal Abattoir. In none of these subjects did ripe proglottides or ova pass in the faeces. Dogs Numbers 1 to 4 were destroyed and examined 90 days, 70 days, 60 days and 30 days, respectively, after having been fed large numbers of *C. cellulosae*. Dog Number 5 was killed 3 days after feeding, and dog Number 6 was killed 24 hours after feeding. In not a single case were mature, or immature *Taeniae solium*, or even evaginated scolices observed.

Similarly, all attempts to infect the jackal failed. At various periods, over four months, he received countless thousands of viable *Cysticerci cellulosae*. Since infection over a prolonged period did

not result, he was finally given some pork containing numerous viable *Cysticerci cellulosae*, and destroyed two days later. Post-mortem examination revealed several mature *Taeniae marginata (hydatigena)*, and many thousands of *Echinococci granulosus*, but not a trace of *Taenia solium*. The infections with *T. marginata* and *E. granulosus* had resulted from experimental feedings with numerous *Cysticerci tenuicollis* and *Echinococcus* cysts, which had been administered when we first obtained the jackal, about four months previously.

Infection tests were contemporarily tried on an adult male South African baboon. The baboon was kindly presented for experimental purposes by the Chairman of the Parks Committee and the Curator of the Bloemfontein Municipal Zoological Gardens. He was well housed at the Abattoir, and his diet consisted mainly of fruit, vegetables and bread. He refused to eat meat, whether raw or cooked. At first he was given about fifty *Cysticerci cellulosae* hidden in bread, but, with the natural wiliness of his kind, he frequently broke the bread into crumbs and removed all traces of *cysticerci*. Measles were then stuffed into the pulp of bananas by means of a sharp stick or a pencil, and the canal thus formed was again closed over, so that the baboon could neither detect the presence of the measles in the bananas, nor could he notice that the bananas had been interfered with. He took the bananas readily and by this means approximately 750 viable *Cysticerci cellulosae* and a few *C. bovis* were fed to him, over a period of four months. In order to ensure that only live measles were fed to him, we always tested viability of the *cysticerci* from the same pigs in 5 per cent. sodium taurocholate solution and by actual infection tests on a human subject, according to Keller's and Iwanizky's methods. At no time did our baboon excrete *Taenia* segments. Four months after the original feeding the baboon died from acute pneumonia, contracted during a sudden cold and wet spell. A careful post-mortem examination was made, which revealed pneumonia, but not a single tapeworm, mature or immature, was found.

Under natural conditions, the baboon is not carnivorous in the true sense of the word, although he may feed on locusts, scorpions and grubs. In a few instances they have been known to attack flocks of sheep, causing wilful destruction. A favourite practice of these marauding troops of baboons is to disembowel sheep, and leave the carcasses on the veld, but it is very doubtful if they will at any time attack and make a meal of pigs. It is, therefore, most unlikely that the baboon will acquire natural infection of *Taenia solium*. Although our experiments were numerous attempts to infect one baboon, it can reasonably be concluded that the baboon is immune to infection with *T. solium*, even with attempts at artificial infection. It is also very unlikely that any of the higher anthropoid apes are subject to the parasite. In conclusion, it may be mentioned that in 1932 Clarenburg recorded that he failed to infect various monkeys with *Taenia saginata*. His subjects were fed several *C. bovis*, fresh specimens, as well as some which had been preserved in a cooler for three weeks.

In the cystic stage a number of animals has been named as intermediate hosts. Authentically it is accepted that the pig, man, the dog and recently, the monkey are definite hosts. In addition it has been mentioned by some writers that *C. cellulosae* was found in sheep, goats, cattle, horses, antelopes, deer and bears, " but the identification of the *cysticerci* was undoubtedly erroneous in many cases ". (Mönnig, 1934.)

The *cysticerci* found in sheep and goats were very probably *C. ovis* which closely resembles *C. cellulosae*, and has a rostellum bearing 24-36 hooklets. Von Ostertag (1934) mentions that Ciurea examined seven cases of suspected *C. cellulosae* in sheep and found that they were actually typical cases of *C. ovis*.

In cattle and wild buck they may have been the *Cysticercus* of *Taenia hyaenae*, a tapeworm from the hyena. In 1932 Martinaglia encountered a peculiar measle in a bovine carcass at the Johannesburg Abattoir. " The *cysticerci* were armed and unlike the bovine bladderworm. On further identification Dr Mönnig of the Veterinary Research Laboratory, Onderstepoort considered the hooks of this *cysticercus* resembled those of *T. hyaenae* ".

It is possible that the *cysticerci* found in equines, antelopes, etc., were mistaken by some writers for *C. cellulosae*.

Some years ago, during three years' service in the wilder parts of the Bechuanaland Protectorate, the present writer found what he took to be *C. cellulosae* in two African bush pigs (*Potamochoerus choeropotamus*). Both wild pigs were shot by native attendants, and in curiosity the writer inspected the carcasses, which were found to be heavily infested with measles, which closely resembled those of the domestic pig. Unfortunately, owing to his remoteness from civilization at the time, the writer was unable to examine the *cysticerci* microscopically, or, since it was also impossible to send specimens away, owing to no preservatives being available, it was impossible to have them definitely identified. Dr. Mönnig mentioned to the writer that Mr. Harris, who was engaged on the Government's tsetse-fly campaign in Zululand, reported similar cases to him. According to Daubney (1936), up to date there is no record of *C. cellulosae* from any of the wild pigs of East Africa.

Infection in the Pig.

The infestation of the pig with *Cysticercus cellulosae* is usually of a very heavy and generalized nature. In this respect it often differs from the infestation of the ox with *C. bovis*.

In the pig " predilection sites " are sometimes mentioned, but that term, in South Africa, is really only applicable in the exceptional cases of light infestation.

At the Bloemfontein Abattoir we made a systematic study of so-called " predilection sites " in order to ascertain whether these sites corresponded with those described by older overseas authors.

During the calendar years 1935 and 1936, 180 pigs were found measly. Of this number the great bulk were grossly infested, and only 30 had less than 10 measles in the routine inspection incisions. The ratio of 5 : 1 heavily to lightly infested carcasses was more or less fairly representative of infection in other parts of South Africa. It is interesting to record that from Swellendam an exception to the rule was reported. The Abattoir Superintendent of that small centre advised me that he had noticed considerably more pigs lightly infested in the Swellendam abattoir than during his previous service in abattoirs in the Transvaal and Northern Orange Free State.

In the subjoined table the ratios of heavily infested to lightly infested carcasses are given for some centres in the Union. The ratios given are only in respect of such centres where actual observations were recorded and the details were available. A number of superintendents of other abattoirs, who did not keep actual records, advised me that in general the nature of infestation was very heavy, and lightly infested cases were rare.

Table showing ratio of heavy infestation to light infestation.

Ladysmith (Ntl.)	3 : 1	Rustenburg	100 : 0·2	Graaff-Reinet	12 : 1
Newcastle	7 : 4	Bloemfontein	5 : 1	Middelburg (C.)	4 : 1
Potchefstroom	7 : 3	Kroonstad	3 : 1	Port Elizabeth	52 : 1
Germiston	3 : 1	Bethlehem	19 : 1	Queenstown	19 : 1
Klerksdorp	13 : 2	Fort Beaufort	8 : 1	Riversdale	7 : 1
Middelburg (Tvl.)	10 : 1	George	7 : 3	Uitenhage	19 : 1
Nigel	5 : 1				

The Superintendent of the Fort Beaufort abattoir made the following observation: 1 cyst 1 carcass; 2-5 cysts 2 carcasses; 5-10 cysts 2 carcasses; over 10 cysts 40 carcasses.

Von Ostertag (1913) gives the following table showing the ratio of heavily infested carcasses to lightly infested carcasses at the Berlin Abattoir:—

Year.	Total number of measly pigs.	Extensively infested.	Lightly infested.
1895–96	627	304	323
1896–97	509	251	258
1899	325	118	207

Judging from the above table, it would appear that in Germany, about 40 years ago, the ratio of lightly infested pig carcasses to heavily infested pig carcasses was found to be slightly higher in favour of light infestation. Von Ostertag, however, points out that the ratio of heavy infestation is much higher in the case of hogs than in the case of bovines with *C. bovis*.

Le Coultre (1928) gives the following ratio obtained during his investigations in the Netherlands East Indies in 1927:—

Boelelleng: 36 cases; 17 heavily infested; 19 lightly infested.

Denpasar: 23 cases; 18 heavily infested; 5 lightly infested.

Makassar (1926): 85 cases, all with less than 13 measles.

Soerabaia: All cases heavily infested.

In the usual cases of infestation with *C. cellulosae*, pigs may harbour many thousands of parasites. It is quite common that hardly a fraction of an inch of the carcass may be noticed free from bladderworms.

In order to arrive at a quantitative estimate of the number of bladderworms in heavily infested pig carcasses, I caused a count to be made in small pieces of meat from two heavily infested pigs at Bloemfontein abattoir. In each case the head was removed, the vertebrae and the bones of the limbs were stripped of meat, and the actual mass of meat itself weighed. The first pig weighed 75 lb. stripped, and the second, a fairly large pig, 150 lb. No viscera of any kind were included in the weights. In each case a small piece of pork, 1 inch cubed, was excised from the deep-seated musculature on the medial aspect of the thigh. Each small piece of meat weighed $\frac{3}{4}$ ounce. In the first piece we found 80 measles, which represented some 128,000 *cysticerci* in the pig, minus its head, heart, liver, brain and tongue, all sites where many measles might have been found. In the second piece we found 184 measles, which represented some 588,800 *cysticerci* in the 150 lb. pig, minus its head and viscera.

Hall (1920) found 70 *cysticerci* in a small piece of pork which weighed 5 grammes. Thus he estimated that so many thousand measles were to be found in the entire carcase.

Küchenmeister found 133 measles in 17 grammes of pork, representing about 80,000 to the kilogramme or 2½ lb.

At Bloemfontein we judged all carcasses is which more than 10 *cysticerci* were found, in the routine incisions, as heavily infested. During the calendar years 1935 and 1936, 150 heavily infested pig carcasses were found. Statistics are not available of the predilection sites in all the heavily infested carcasses. More accurate observations were made in respect of the thirty lightly infested carcasses. Ten heavily infested pig carcasses were, however, carefully surveyed. Measles were invariably found scattered throughout the musculature of the carcasses. They were more densely located in the muscles above the elbow and in the neck muscles. Infection of the thigh muscles (leg of pork) was very heavy, and invariably numerous measles were found in the perineal region. Although in the ten heavily infested pigs, closely examined, a fairly heavy infestation of the masticatory muscles was observed, it was relatively less heavy than would have been the case of gross infestation of *C. bovis* in the ox. It will be observed that not a single measle was found in the masseters or the pterygoid muscles of the 30 lightly infested pig carcasses. (See predilection sites in light infestations.)

In three of the ten observations *Cysticerci cellulosae* were found in the fat and subcutaneous tissues. The abdominal muscles, intercostals and cervicals were invariably infested. As a rule the degree of infestation was lighter in the abdominals and intercostals than in the cervicals, where usually, numerous cysts were found. Other sites in which measles were invariably found in the ten observations were, in order of density: the psoas muscles; the sub-vertebral muscles; the tongue; the heart; the oesophageal musculature; the diaphragm. In six out of the ten observations *cysticerci* were found in the brain; in two out of the ten observations in the eyeball and conjunctiva. In none of the special observations were *cysticerci* found in the testicles of boars, or in the vagina and uterus of sows, respectively. (Of the ten special observations, two were boars, five were sows and three were castrates.) On at least one other occasion in each gender did we find measles in the respective generative organs. Intra-uterine infections of foetuses were never observed, although on a few occasions pregnant -sows were inadvertently slaughtered.

In the six cases of cerebral cysticercosis, cerebral *cysticerci* were found singly in 2 cases, six cysts in 1 case, eight cysts in 1 case, and numerous cysts in 2 cases.

Predilection Sites in Light Infestations.

In most countries regulations governing meat inspection lay down standard routine incisions which are to be made into carcasses, with a view to inspection for *cysticerci*. Such routine incisions are made into a carcass so as to expose surfaces where measles are most frequently found, without mutilating the carcass. In lightly infested pig carcasses it is quite possible to miss *cysticerci* which may be present, but have not been exposed during the routine inspection.

Irvine-Smith (1911), in " The Report of the Director of Abattoirs and Live Stock Market, Johannesburg, 1910-11 ", mentions that during that year under report two pig carcasses, bearing the abattoir " passed " stamp, were afterwards found in butcher shops to be measly. In the one case measles were found by the butcher himself, and in the other case by one of the Municipal Health Inspectors. Col. Irvine-Smith points out that it would have been difficult to detect measles in those cases, without mutilating the carcasses.

For the inspection of pig carcasses for *cysticerci* in South Africa, Regulations have been framed under Section 115 of the Public Health Act, No. 36 of 1919 (Government Notice No. 2118 of 1924, as amended by Government Notices Nos. 2015 of 1925, 112 of 1929 and 1456 of 1933.)

Paragraph 13 (i) reads:—" An incision shall be made into each shoulder behind the elbow, except in the case of a carcass intended for export overseas. In the case of a pig carcass intended for bacon an incision shall be made in the fillet (psoas muscle) in lieu of the aforesaid incision."

Paragraph 16 (i) reads:—"Every meat inspector finding evidence of bladderworm disease (measles) in a slaughtered animal during examination in accordance with Regulation 12 (General examination for all carcasses) and 13, shall further make the additional examination of:—

Head: Inspection incisions into inner and outer muscle of the jaw.

Tongue: Inspection of the surface and incisions into the muscles of attachment and the tongue proper.

Pluck: Examination of the heart and oesophagus.

Stomach and Intestines: Examination of the outer surface of the stomach and intestines.

Carcass: The following inspection incisions shall be made into *each* side of the carcass:—

Muscles of the shoulder behind the elbow ...	7 incisions.
Chuck (by which is understood the muscles on the dorsal aspect of the thoracic cavity)	1 incison.
Muscular diaphragm	2 incisions.
Fillet	3 incisions.

Apart from the foregoing, three incisions must be made into the pillars of the diaphragm."

It will be observed that according to the above regulations the meat inspector is virtually allowed to make only one incision into each shoulder behind the elbow, or in the case of bacon pigs, into the psoas muscles in lieu of those incisions, and three incisions into the pillars of the diaphragm. He is only entitled to make the subsequent incisions enumerated in paragraph 16 (i) after he has found evidence of bladderworms in the routine incisions.

Cysticerci cellulosae are occasionally encountered in most unusual locations, and may very easily be overlooked in routine inspection. In September, 1935, I reported an interesting case in the *Journal of the South African Veterinary Medical Association*, 6 (3), p. 191. The senior meat inspector at Bloemfontein abattoir, on examining the submaxillary lymphatic glands of a pig for tuberculosis, found a *cysticercus* in the gland of one side. I confirmed his diagnosis of *C. cellulosae*. In none of the legal routine incisions were *cysticerci* found, but on making the secondary incisions laid down by paragraph 16 (i), *Cysticerci cellulosae* were found in the following locations:—

In 7 incisions into the M. Triceps Brachii and M. Deltoideus on each side 2 *cysticerci*; Psoas muscles 1 *cysticercus*. No *cysticerci* were found in any other incisions. It is plain that but for the fortunate discovery of a *cysticercus* in the submaxillary lymphatic gland, a very unusual site, the carcass would have been passed as fit for human consumption.

In November, 1936, Dr. Bekker, Municipal Veterinary Officer, Pretoria, encountered several *cysticerci* in a pig's liver. No *cysticerci* were found in routine incisions. Being in doubt as to whether these bladderworms were *C. cellulosae* or *C. tenuicollis*, Bekker sent the liver to Dr. Mönnig, Onderstepoort. In answer to an enquiry from me as to the identity of the *cysticerci*, Dr. Mönnig replied:—"The bladderworms in the pig liver sent by Bekker are unfortunately not fully developed. The hooks are still young and imperfect, and so it is not possible to identify them, but the number of hooks coincides with that of *C. cellulosae*."

For economical reasons it has been customary in most South African abattoirs to condemn all pig carcasses found infected with measles, although instructions in Paragraph 16 (2) and (3) do not preclude lightly infected pig carcasses from receiving similar treatment to lightly infected bovine carcasses in cold storage at *minus* ten degrees Centigrade for 14 days.

In Bloemfontein, therefore, we were afforded the opportunity of studying predilection sites in thirty lightly infected carcasses, which were minutely dissected.

Measles were found:—

In muscles above the elbow only (Triceps, etc.) ...	10 cases.
In muscles above the elbow, plus psoas	4 cases.
In muscles above the elbow, plus psoas, plus thigh muscles	3 cases.
In muscles above the elbow, plus thigh muscles ...	5 cases.
In muscles above the elbow, plus cervicals	2 cases.
In muscles above the elbow, plus heart	1 case.
In muscles above the elbow, plus tongue	1 case.
In muscles above the elbow, plus tongue, plus cervicals	1 case.
In heart only	1 case.
In muscles above the elbow, plus psoas, plus submaxillary lymphatic gland	1 case.
In heart, plus tongue, plus oesophagus, plus cervicals	1 case.

In other words, in 30 specially observed lightly infested carcasses at Bloemfontein, *cysticerci* were found:—

In muscles above the elbow in	28 cases.
In muscles of the thighs in	10 cases.
In psoas muscles in	8 cases.
In muscles of the neck in	4 cases.
In the heart in	3 cases.
In muscles of the tongue and tongue itself in	3 cases.
In muscles of the oesophagus in	1 case.
In submaxillary lymphatic gland in	1 case.

According to these observations the muscles above the elbows must overwhelmingly be accepted as the commonest predilection site. In only two cases in the 30 pigs which had less than 10 measles in the ordinary routine incisions, did we not find measles in that location.

In grossly infested carcasses we observed bladderworms in the following organs:—

> Liver three occasions; kidneys twice; brain six times; eyeball twice; testicle once; vagina and uterus once; stomach and exterior of the intestines once. In all those cases infestation was very heavy, and the commoner sites were "swarming" with measles.

To summarize, judging from our observations at Bloemfontein, I regard the order of frequency of infestation in the various parts of the pig's carcass to be:—

1. The fore-quarters above the elbows (shoulder of pork).
2. The hind limbs above the hocks (leg of pork).
3. The psoas muscles and muscles on the ventral surface of the vertebrae.
4. The cervical muscles and the intercostals.
5. The tongue and its muscles.
6. The heart and the perineal region.
7. The oesophagus and the diaphragm.
8. The muscles of the face and the abdominal muscles.
9. The brain.
10. The liver, fat and superficial fascia.
11. The eyeball, conjunctiva, etc.
12. Sexual organs, and internal organs not mentioned above, also lymphatic glands.

Von Ostertag (1913) gives the following predilection sites:—Abdominal muscles; muscular portion of the diaphragm; lumbar muscles; tongue; heart; muscles of mastication; intercostal muscles; cervical muscles; the gracilis and the sternal musculature. He mentions that the heart and the brain should be named as frequent locations for the hog bladderworm.

Kukuljevic (1906) mentions that on four occasions he found *Cysticerci cellulosae* in the eyeball of pigs, and more frequently in the brain.

Hutyra and Marek (1916) mention that *Cysticercus cellulosae* is sometimes found in the spinal cord. They mention the following order of frequency:—Deep muscles of the shoulder and chest; abdominal muscles; nape and neck muscles; diaphragm; intercostals; adductors of the thighs; less frequently in the muscles of the tongue and the heart, "and in very severe cases in the brain, eyes, liver spleen, lungs, lymphatic glands and fat."

Vosgien (1911) found the following order in the pig:—" The muscles of the chest, diaphragm, tongue, heart, muscles above the elbows, and less frequently the intercostals, psoas, masticatory muscles and muscles in the vertebral region."

At Boeleleng (Dutch East Indies), in 1927 Le Coultre found the order of frequency of infestation in 29 pigs to be:—Muscles of mastication; shoulder and the muscles of the upper arm; psoas muscles; neck muscles; vertebral muscles; tongue muscles; abdominal muscles; muscles of hind legs below the patella; muscles of fore legs below the elbow; intercostals; and lastly came the diaphragm, heart and brain.

The Japanese workers Eguchi and Nishiyama (1930) found the predilection sites in infested pigs in Prefecture Okinawa to be:—Skeletal muscles and heart, and then in the brain, orbit and cheeks. Out of 42 infested pigs they found measles in one case in each of the following locations:—Spleen, kidneys, stomach, intestinal wall.

Hertwig (1885) mentioned that *Cysticerci cellulosae* were rarely found in the liver, lungs, spleen and kidneys.

Irvine-Smith (1910-11) advised the Johannesburg Municipal Council at that time, in his annual report that " the following parts of pig carcasses are closely examined:—Tongue and heart; muscles of the neck; breast; intercostals; midriff and psoas."

Degeneration of Cysticercus cellulosae.

Quite frequently degenerated *cysticerci* may be found in pigs, although more rarely than is the case with *Cysticercus bovis* in beef.

Von Ostertag states that degeneration usually occurs at an early developmental stage. At Bloemfontein we frequently observed degenerated measles in old pigs, although on one occasion I noticed both caseous and apparently viable *cysticerci* in a pig of about 12 months old. This observation differs from that of von Ostertag, who states (1934) that all parasites in the case of *C. cellulosae* are affected (simultaneously?) by the process of decay, contrary to the rule in *C. inermis* (*bovis*).

Degeneration of the *cysticercus* takes the form of caseation and calcification—progressive stages of the same degeneration. The fluid contents of the cyst progressively dry to caseation and ultimately to calcification. Progressive atrophy of the cyst itself occurs, and the shape of dead *cysticerci* is affected. Dead *cysticerci* appear as elongated, sometimes slitlike structures which, occasionally may be barely visible to the naked eye, appearing as white specks, and sometimes they may be the size of hemp seeds. During the caseous stage of degeneration the pig measle may appear gray in colour, but when calcified it is usually pure white.

Neumann states that it is usually age that brings about degeneration of the *cysticerci*, and their transformation into small, round, hard and compact grains, impregnated with calcareous matter and destitute of fluid. The pork butchers (in France) name the disease

dry measles. Neumann adds that the degeneration of the *cysticerci* is centripetal, that is, it begins with the external membrane and finishes with the scolex; and this is most evident in caseous or pseudo-purulent degeneration. When numerous *cysticerci* have degenerated, the heart and skeletal musculature are found to be sprinkled with white granules. (Neumann.)

Under the microscope, a tough connective tissue membrane and a more or less strongly calcified centre may be demonstrated in the calcified structure. (von Ostertag.) Sometimes demonstration of the classical calcareous corpuscles and hooks in a degenerated cyst may serve as a diagnostic feature of the former bladderworm.

Symptoms in the Pig.

Clinical symptoms of *Cysticercus cellulosae* infection are extremely rare in the pig. The severe constitutional disturbances sometimes met with in the human infection seldom reveal themselves in pigs.

MacArthur (1934), in discussing the incidence of human cysticercosis in the British Army, mentions the prolonged period after initial infection, before constitutional disturbances occurred in patients he studied. He mentions the fact that the parasites may be present in the human body for several years (e.g. six to eleven years), before cerebral symptoms become apparent. In the case of the pig, in applying MacArthur's remarks on the human disease, it is less likely that cerebral symptoms will develop, since it is seldom that a pig will be allowed to live to that age before slaughter. MacArthur also states that it is his belief that *cysticerci* while alive, usually enjoy a relative tolerance on the part of the host, but that after their death they act as foreign irritants and bring about the degenerative changes in the tissues of the human host. He makes it clear that severe pathological changes of the infected tissues only appear a number of years after initial infestation.

Some of the older writers, however, have recorded severe constitutional disorders in pigs. Gréve, according to Neumann, reported that he noticed in many measly pigs an increased sensitiveness in the snout, which prevented their burrowing. In eating grain off a hard floor they avoided contact with that part as much as possible, by raising the nose and upper lip and prehending the food with their tongues. Tapped slightly on the end of the nose with a stick, the measly pig squealed with pain, while a healthy pig would remain indifferent. Very measly pigs had the snout more or less soft and flaccid.

In a pig suffering from gross infestation with measles, Sabotta (1880) observed complete paralysis of the tongue, which was invaded by *cysticerci*. The prehension of food was, therefore, impossible, " and the animal perished from inanition ". Florman (1819) saw a very manifest turning round in circles in a case where *cysticerci* were located in nerve centres. Rehrs (1842) witnessed epileptiform convulsions, grinding of the teeth, ptyalism and rabid-like vertigo. At the autopsy Rehrs found in the cerebrum and cerebellum an

enormous number of *Cysticerci*, " several of which were of exceptional size ". Rabid-like symptoms were also noted by Foucher (1874). Vertigo and a form of blindness in which case the brain was softened and contained more than a hundred *cysticerci*, were observations made by Neubert (1861). Lippold (1875) had a case in which the pig died after presenting all the symptoms of encephalitis. On post-mortem twelve *Cysticerci cellulosae* were found in the pia mater.

Neumann mentions that in chronic and generalized infections pigs may be feeble, easily put out of breath, have difficulty in following the herd, may later develop diarrhoea, foetid breath, prostration, then death.

Hutyra and Marek mention that in very severe infestations similar symptoms to those described above, may appear, and in addition hoarseness may result owing to involvement of the laryngeal muscles. (It is perhaps possible that in some of these cases, the pigs were also infested with *Trichinella spiralis*, which is known to cause muscular weakness and particularly hoarseness.)

Daubney (1936) mentions a case which, quite recently, was brought to the Veterinary Research Laboratory, Kabete, Kenya Colony. The affected animal was fevered and showed all the clinical symptoms of acute muscular rheumatism. It experienced considerable difficulty in rising, and any movement or manipulation occasioned pain. Post-mortem, the carcass was found to be grossly infested with viable *Cysticerci cellulosae*, and the infestation, according to Daubney, " had undoubtedly been responsible for the clinical manifestations ".

Clinical symptoms are not likely to be noticed at abattoirs, since pigs are generally slaughtered within twenty-four hours of their arrival. In practice no cases showing clinical symptoms of constitutional derangement were observed at Bloemfontein, although in some dressed carcasses infestation was so heavy that barely spaces of 5 mm. could be found between the measles. It was, however, noticed that on rare occasions the flesh of heavily infested carcasses had a pale colour and was slightly dropsical.

In living cases the disease is generally recognised only in cases where the parasites are situated in a visible mucous membrane, e.g. in the conjunctiva of the eye, or in the lens. Externally *cysticerci* may sometimes be seen or felt with the hand in the tongue, mostly at the edges on the under surface, or in the fraenum linguae. Sometimes also *cysticerci* may be felt in the folds of the rectum, or in the anal ring. In heavily infested pigs *cysticerci* may be seen " bubbling " out of the perineal region, with the first incision of initial dressing of the carcass, but ante-mortem they are difficult to palpate in that region. Inspection of the tongues of pigs for measles has been practised since the days of Aristophanes, was commonly practised in Germany and in France in the Middle Ages, and is practised in most countries, where porcine cysticercosis is a common disease, at the present time. Tongue inspection is a common practice of South African farmers, some of whom consider

themselves experts and have actually told me that only a certain percentage of their pigs reach the Bloemfontein Abattoir, since they withold all pigs found to be measly by means of the tongue inspection, and they sell such pigs to their natives, instead of providing us with so much material for our by-products department.

The South African method of inspection consists of the following: The pig is thrown onto its side. Taking advantage of its squeals, a stout stick or plank is forced between the jaws, and with his hand wrapped in a towel or cloth, the farmer grabs the tongue pulls it out of the mouth and examines it. His native attendants, meanwhile, use the stick as a lever to hold the mouth open. The Serbian method of inspection, according to Kukuljevic (1906), was almost identical to the South African method.

That measles can only, with certainty be diagnosed in very grossly infested cases, is shown by the following observations conducted at Bloemfontein Abattoir, where we instituted a three months' inspection of living pigs' tongues. During that period exactly 25 per cent. of the total measly pigs slaughtered showed *cysticerci* in their tongues.

Natural Infection of the Pig.

The pig is naturally a scavenger and burrower, and may almost be termed omnivorous. When not confined to a sty, its natural instincts are to haunt the precincts of rubbish heaps, manure and excretum dumps, latrines and the dirtier parts of the farm-yard. In the more primitive parts of South Africa, among European as well as native habitations, pigs frequently have the run of the farm-yard, and may even enter the kitchen or native huts. On many farms latrines or privies are neither provided for Europeans nor natives, and in the vicinity of native huts, or in the rural locations and reserves such commodes are quite unknown. The primitive and unhygienic farmer, and nearly all natives will walk barely a hundred yards from the homestead in order to perform their natural functions. That type of farmer (fortunately becoming more scarce) or native very rarely takes the trouble to sty his pigs. The only feed which is provided for the unfortunate pigs consists of an occasional ration of pumpkin, a few mealies, potato peels and other rubbish from the kitchen, and further the pigs must forage for themselves. The most natural result is that the pig will follow its owner and act as an " efficient scavenger ". It is well known that among many of our so-called " Poor Whites " this mode of scavenging is encouraged. I was once told that privies on farms were unnecessary evils, since they stank and encouraged flies. That particular " farmer " and his entire household used the rear of a quince hedge close to the homestead, since it was far " cleaner and the pigs cleaned up everything ".

In the western Cape pigs are frequently driven to pick up acorns under the beautiful old oaks on the farms. Unfortunately, at the same time the farmers' Cape Coloured servants select the shade of those oaks as lavatories. Heavy infestation among Cape pigs frequently follows.

Le Coultre (1928) relates a similar state of affairs among the native Balinese. He picturesquely describes the remarks of an old Headman who stated that he merely whistled for his pig to come and clean up his excretum. Except for the fact that the primitive ones among our South African farmers and natives have perhaps not trained pigs to follow their whistles, there is very little difference between our most primitive farm hygiene and that of Bali.

Undoubtedly a similar state of affairs must exist in the more primitive parts of Russia, Serbia, Lithuania and other parts of Europe, where the incidence of *C. cellulosae* is still high.

Commenting on the usual heavy nature of infestation in pigs, Veenstra (1921) asks the following questions: " Does a pig generally become more heavily infested than a bovine? Or do the eggs develop more readily in the pigs' bodies than in those of bovines? Or do more *T. saginata* eggs get lost into the soil?" He then adds that pigs are less particular than bovines in picking up their food. Veenstra's queries can be elucidated by the fact that proglottides of *T. solium* are voided in chains, seldom singly, and although the majority of the eggs may escape from the proglottis, the contact intestinal faeces of the human host must, therefore, probably carry more *T. solium* eggs than would be the case with *T. saginata*, where segments are voided singly and sometimes spontaneously. In other words, more *Taenia solium* proglottides become gravid and " ripen " at a time than those of *Taenia saginata*. It stands to reason, therefore, that the voracious pig, in ingesting, as it commonly does, an entire human stool, will take in many thousands of ova.

Infection of the pig with *C. cellulosae* can only result from the ingestion of ova of *T. solium*, most frequently obtained by the ingestion of entire stools, or from the ingestion of excreted gravid proglottides in which ova may be present.

Unfortunately, infection of pigs belonging to scrupulously particular farmers may occasionally result, owing to the wantonness of their native swine-attendants. Three such instances occurred in the Bloemfontein District within a few weeks of each other, during the past year. Each of the three farmers could be classed among the foremost pig breeders in the Province, and when measles were found among a number of their respective pigs, their faith in the theory of the mode of infection was rudely shaken. One of them told me he could not believe it, since his pigs were scrupulously stied and fed, a fact of which I had already full knowledge.

I told each farmer that I was sure one of his native staff had been relieving himself in his sty, and advised them to keep a careful watch. It was not long after, when two of the three farmers enthusiastically told me that each had caught a native, one of whom actually carried tapeworm, in the act. What those two farmers did to their respective native culprits was not mentioned, but can well be imagined!

According to Gerlach infection of the pig occurs more readily in the young subjects, e.g. up to half a year old. On the other hand there are not many records of infection in sucking pigs. The reason for this may be that sucking pigs remain with the dam, and their

diet consists mainly of milk. They are, however, not scavengers. Unlike infection of the bovine with *C. bovis*, intra-uterine infection of foetuses with *C. cellulosae* has seldom or very rarely been recorded. Hervieux (1838) recorded a case in sucking pigs. " The sucking pigs were found affected with measles—two in a litter of twelve." He further hinted at prenatal infection: " A sow that was reared by the writer, was mated to a very healthy boar, and the former bore six measly sucklings ".

At Bloemfontein our record of the youngest measly pigs was 10 weeks. In December 1934 we found four out of a consignment of six small sucking pigs, 10 weeks old, to be heavily infested with mature viable measles.

Diagnosis and Differential Diagnosis of *C. cellulosae* in Pork.

In ante-mortem cases, except for the examination of the tongue already described, there is no practical method of diagnosis. Serological tests have been tried, but are not specific and are not practical under ordinary conditions. Sparapani (1915) tried precipitin tests.

On post-mortem examination, or in practical meat inspection, there is really only one parasite which may be confused with *C. cellulosae*, viz. *C. tenuicollis*, the immature stage of *T. hydatigena* (*marginata*) of the dog. As a general rule the latter *cysticercus* does not develop in muscles, and is most frequently found under the large serous membranes, the peritoneum and pleura, and chiefly in the omentum, mesentery and liver. Its size may vary from that of a pea to that of a tennis ball. When situated in the parenchyma of the liver, it may be confused with *C. cellulosae*, since its size is restricted, seldom exceeding that of a pea Older text-books and writers maintained that *C. tenuicollis* was never found in muscle fibres. Recently Mönnig (1934), referring to some American literature, stated that " *Cysticerci* (*tenuicollis*) developing in muscles may not be so large and have possibly sometimes been mistaken for *C. cellulosae* ". Larger vesicles, *e.g.* those found under serous membranes, on the omentum, etc., are filled with fluid, may be quite flaccid, and are hardly likely to be mistaken for *C. cellulosae*. These larger *cysticerci* evaginate the scolex very easily, and reveal a scolex with an unusually long neck, from the end of which hangs the flabby bladder. The evaginated scolex may be studied and will reveal a rostellum bearing two rows of hooks numbering from 26-44 (cf. *C. cellulosae* 22-32). The larger hooks are 0·17 to 0·22 mm. long (cf. *C. cellulosae* 0·16 to 0·18 mm.) and the smaller hooks 0·11 to 0·16 mm. (cf. *C. cellulosae* 0·11 to 0·14 mm).

The hooks of *C. cellulosae* are more curved (sickle-shaped) than those of *C. tenuicollis* (scythe-shaped). According to Von Ostertag, the root process of the smaller hooklets of *C. cellulosae* has no cleavage as is found in that of *C. tenuicollis*. In the 1913 edition of von Ostertag's " Handbook of Meat Inspection " mention is made that " Schwarz examined 1,000 specimens each of *C. cellulosae* and *C. tenuicollis*. He noticed that in *C. tenuicollis* as a rule one or more small hooklets were demonstrable, the basal process of which was bifurcated. In the thousand specimens of *C. cellulosae* examined

by Schwarz this was not the case in a single instance. Reissmann has confirmed these observations ". In his 1934 " Text-book of Meat Inspection ", however, von Ostertag mentions that the small hooklets of *C. tenuicollis* are characterized by their bifid form, " but it must be noted that in the small hooklets of *C. cellulosae* there is also a division through a median furrow ".

Manegold (1931) showed the tremendous variations between the number of hooks, predilection sites and size of *C. cellulosae*, *C. tenuicollis* and *C. ovis* quoted by different text-books and authorities. In order to establish a differential diagnosis he found that 32 hooks were the commonest in 500 *C. tenuicollis* scolices, not 36-38 as was frequently quoted in many text-books. In the majority of cases (95·6 per cent.) 28-36 hooks were found.

It is very improbable that *C. cellulosae* will be confused with any other pathological conditions, but the following have been mentioned in the discussions on differential diagnosis:—

(*a*) *Echinococcus cysts*. These either have no scolex (sterile form), or numerous brood capsules, each with many scolices. The cuticle of the *Echinococcus* is thick and concentrically laminated.

(*b*) Calcified *C. cellulosae* may (very improbably) be confused with calcified *Sarcosporidia-Sarcocystis miescheriana*. These parasites may be about 4 mm. long by 3 mm. wide, readily undergo calcification, and are the commonest form of calcareous concretion in the muscle fibres of swine. They are especially found in the abdominal muscles and the diaphragm. (They are more likely to be confused with *Trichinella spiralis*.) In uncalcified specimens the sickle-shaped sporozoites may be demonstrated.

(*c*) Small actinomycotic nodules may possibly be taken for *Cysticerci cellulosae*. In actinomycosis radiation of the mycelium may be demonstrated microscopically.

(*d*) Tuberculosis of lymphatic glands may be confused with caseous *cysticerci* in those locations. Microscopical examination will settle the diagnosis.

Dead (caseous) *C. cellulosae* may be identified *microscopically* by demonstration of the characteristic calcareous corpuscles and the nature of the hooklets.

Vosgien (1911) mentions two methods of identifying *C. cellulosae* in sausages and other minced meats. The first is that of Schmidt-Mulheim, in which the product is warmed to 40° C. in 6 to 8 times its volume of a 1 in 122 hydrochloric acid solution. *Cysticerci* with hooks resist this treatment and become visible. The second is that of Rissling, who employed a soda solution.

Infection with Cysticercus cellulosae of other Animals.

The only other animals in which infection with *Cysticercus cellulosae* need be discussed are man, the dog and the monkey. Human cysticercosis will receive consideration later in this work.

Infection in the dog has generally been accepted as a scientific fact, whereas until 1936 few authentic cases in the monkey were recorded. In 1936 Walker recorded what he believed to be a definite

case of *C. cellulosae* in a monkey. He mentions that the monkey is cited in many scientific books as an intermediate host of *Taenia solium* but in actual fact the condition in that animal has extremely rarely, authentically, been found. Medical literature during the past 50 years has been silent on that subject, and the only other records which Walker could find were four cases mentioned by Vosgien, the one found in the eighteenth century, and the other three in the nineteenth century.

Relating the case history of his subject, Walker reminds us that the exact incidence of infection in monkeys will not be known until post-mortem examinations are systematically performed on large colonies of monkeys, over a prolonged period of time. His subject was an immature *Macaca mulatta*, bought from an eastern animal dealer. Enquiry from the dealer led to the information " that the animals in that lot were from Lucknow, that several had worms, got very skinny, and eventually died ". Apparently the type of worm was not investigated. A large flap of bone was turned down on the left side of the skull, with the intention of stimulating the cerebral cortex, but upon opening the dura mater " quite unexpected pathology was found ". " Both in the subdural and subarachnoid spaces were numerous cysts ranging in size from 3 mm. to 15 mm. Those in the subdural space were so loosely attached that when the dura was opened they fell out. Even those in the subarachnoid space enucleated readily when the arachnoid was nicked." On close examination Walker saw several cysts within the brain substance, partially covered by the cortex. After this he killed the monkey and did a complete post-mortem examination. He found that practically every muscle in the body contained one or more cysts. He gives the following description of his obervations: " The muscles of the back had many; those of the extremities likewise were studded with cysts. Even the intercostal muscles and the diaphragm had cysts. Two cysts were found within the heart muscle. The liver, spleen and both kidneys contained typical cysts. There was no evidence of any primary worm from which the infection may have arisen."

Walker then proceeds to describe the microscopical features of the scolices of the bladderworms. He points out that the severe pathology of human cysticercosis was not observed in the monkey. When the scolices were examined under the microscope " four suckers, surrounding the rostellum with a number of hooklets " were seen. The actual number and the characteristic features of the hooklets were not mentioned, and this fact may be cited as the main argument against the diagnosis of Walker, who maintains that he had dealt with a typical case of *C. cellulosae*. He, somewhat inconclusively, unfortunately, claims that " the presence of both suckers and hooklets on the scolex serves to define the larva as that of the *Taenia solium*."

Nevertheless, Walker has apparently been the first author in the last 50 years to have described a case, which to all appearances may be accepted as a case of generalized *Cysticercus cellulosae* in a monkey.

If Walker's diagnosis is scientifically correct, it is quite possible that, as he has pointed out, the incidence may be higher than has been anticipated among the various species of monkeys. In South

Africa it has been noticed that most tamed monkeys are scrupulously particular of their food. In the wild state it may be possible that monkeys will eat human excretum, especially if other normal foods are scarce, and ova of *Taenia solium* may be consumed by the ingestion of contaminated roots, herbs, etc. It is also not at all unlikely that human beings may contract *Taenia solium* through eating measly monkey flesh, since in South Africa several native tribes, e.g. the Amaxosa and some Bechuanas are very fond of monkey flesh.

It is an old accepted fact that *Cysticercus cellulosae* does, with varying incidence, occur in the dog. No doubt the incidence of infection with *Taenia solium* among humans, as the result of eating dogs' flesh only occurs in eastern countries, but universally dogs are susceptible to infection with *Cysticercus cellulosae* as the result of ingestion of human excretum containing ova of *T. solium*. As far as is known only two cases of canine cysticercosis have been observed in South Africa. Two brains of dogs suspected of rabies were found at the Onderstepoort Laboratory to contain many *C. cellulosae*. These brains were forwarded by Field Veterinary Officers to be examined for rabies, but both were negative for that disease.

Interesting statistics may have been brought to light if it had been possible to hold autopsies on all dead roaming dogs, especially the so-called " Kaffir dog " variety and scavenging and marauding farm dogs. It obviously does not follow that because in countries where dogs' flesh is not eaten, and man will not contract *Taenia solium* from that source, the converse infection of the dog with *C. cellulosae*, through eating infected human excretum may not result. Walker's remarks, therefore, regarding the possible fairly high incidence of cysticercosis among monkeys are equally applicable to dogs, if a thorough survey could be made in parts of Europe and America, Asia and Africa, Continents in which *T. solium* is still fairly common.

It is quite possible that the early Phoenicians, who ate no pork, but were very fond of dogs' flesh, may have contracted *Taenia solium* from measly dogs' meat.

Poisson (1930) recorded a case of *C. cellulosae* in a dog in Madagascar.

Undoubtedly, clinical symptoms are more apparent in dogs than in pigs, and cases resembling human cysticercosis, with its accompanying cerebral, nervous and ocular symptoms have been recorded by a number of writers. The main reason for this may be attributed to the fact that in general only such dogs which have shown rabid-like signs, epileptiform symptoms, blindness, etc., have been autopsied, and for every one of those cases, many hundreds of cases of ordinary intra-muscular cysticercosis may have passed unobserved, that is, the dogs have eventually died natural deaths and been buried or discarded into the rubbish bin, without further examination. On the other hand, in cases which have definitely been autopsied, cysts have most commonly been found in the brain in dogs, and less frequently in the conjunctiva, in the eyeball, sub-retinal, and in the general intramuscular tissue. From cases actually observed, the brain may, therefore, be cited as a " predilection site " in the dog.

Among many others, Ball and Marotel (1903), Lesbre (1882), Repiquet and Salvatori (1906) and Van der Slooten (1892) recorded cases of canine cerebral cysticercosis. Rivolta (1865) found cerebral cysticercosis in a dog which died suddenly from epilepsy, without having shown any evidence of previous illness.

Vogel (1870) autopsied and found *Cysticerci cellulosae* in the eyes of a dog which had gone blind.

Siedamgrotsky (1871) recorded a case which was suddenly seized with cramps and convulsions, especially of the jaws; " then it had fever, prostration, accompanied by vertigo and delirium, and death occurred during the day; 23 *cysticerci* were found lodged in the superficial part of the two cerebral hemispheres; nothing abnormal was observed elsewhere." Lesbre (1882) described a case in which the dog had been paralysed for two days, but for a long time previously it had " grinding of the teeth, was excited, and had attacks of vertigo ". On post-mortem 30 to 40 *Cysticerci cellulosae* were found in different parts of the brain.

Generalized intra-muscular cysticercosis was described by Dufour and Gacon (1889), who found *cysticerci* in the neck muscles, the tongue, the general musculature, the heart and the lungs. Leblanc and Megnin (1873) found *cysticerci* in the neck, the liver and the pancreas. Suffran (1909) found a number of small swellings in the skin of a four years old fox-terrier dog. On microscopic examination the swellings proved to be *C. cellulosae*. Trasbot and Railliet (1887) examined numerous canine *cysticerci* and found that they were identical with those of pigs. They confirmed the fact that dogs were hosts of *Cysticercus cellulosae*.

Most recent reports of cases of canine cysticercosis cellulosae originate from Asia.

Rao (1933) writes that *C. cellulosae* occurs in the pig and in the dog in the Madras Presidency of India.

Meyer (1933) records that dogs are frequently used as food animals in the Bataklands, Residency Tapanoeli, Dutch East Indies. In the Sub-division of Toba dogs are slaughtered in the abattoir and the flesh is sold in bazaars. Whilst inspecting dog carcasses for *Trichinella*, Meyer found *Cysticerci cellulosae* in a dog. The cysts were mainly in the heart muscles and had the same appearance as those in pigs. Later he found four more cases. He points out that in that part of the Dutch East Indies dogs eat human excretum as readily as pigs do.

Bergeon (1928) reports cases of cysticercosis in dogs in Hanoi (Tonkin). In 1919 he first discovered *cysticerci* to be the cause of rabid-like symptoms in a ten-years-old dog. After that he caused all dog carcasses to be examined in their " Section ", and found 138 cases of *Cysticercus cellulosae* between 1919 and 1924. Bergeon accounts for the high incidence of canine cysticercosis by the frequency of taeniasis among the Tonkinese. The natives are readily infected with *Taenia solium* owing to their habit of eating almost raw dogs' flesh, which has been lightly smoked over a straw fire. All Bergeon's cases were *C. cellulosae* and no case of *C. bovis* was found

in dogs, although *T. saginata* is relatively common among the natives. Bergeon recommends that meat inspectors in the Far East should carry out systematic inspections of all dog carcasses slaughtered.

C. Infestation of the Bovine with Cysticercus bovis.

As far as scientific investigations have gone, the *Cysticercus bovis* has only been found in the bovine and, very rarely, in man. Older writers have recorded measles resembling as they thought, *C. bovis* in antelopes, deer, etc., but they were probably mistaken, and very likely the *cysticerci* they encountered were armed forms, e.g. the *Cysticercus cervi* in deer, or kindred forms.

Practically and scientifically we may, therefore, regard the bovine as the only domesticated animal which harbours the intermediate stage of the *Taenia saginata*.

Infestation in the adult bovine is usually of a very light nature. Most observers, throughout the world, have in routine inspections encountered but a few cysts in infected carcasses, or in the usual inspection incisions, and, exceptionally cases of gross or light generalized infestation have been met with. The present author has never yet come across a case in which infestation in any way resembled, in severity, that of a grossly infested pig carcass with *C. cellulosae*. Neumann, however, quotes J. Fleming, who counted 300 living *cysticerci* in a pound of psoas muscle.

Predilection Sites.

Owing to the nature of bovine infestation, it is justifiable to regard certain locations as "predilection sites". It is quite impossible to incise a bovine carcass at random, and, for that reason, Regulations lay down certain incisions in which *cysticerci* are frequently found. The incisions are to be made into muscle groups where as little mutilation of the carcass, as possible, will result.

Between 1st May, 1936, and 31st January, 1937, twenty-five bovine carcasses were totally condemned at the Bloemfontein abattoir. By minutely dissecting these carcasses, an opportunity was afforded to study the predilection sites, especially in those portions of the carcass which usually escape incision. These operations entailed a good deal of time and work, but it was felt that a true and representative survey of the most common sites of infestation could only be made by carving a series of condemned carcasses into as thin slices as possible.

It is admitted that a more comprehensive idea and summary would be formed only after about a hundred or more carcasses are so treated, but, on the other hand the ratio of light infestation to heavy infestation in South Africa is about 10:1, and grossly measled material in an abattoir of the size of this, is relatively scarce. In addition to the observations in the 25 heavily infested carcasses, records were made in 113 consecutive lightly infested carcasses.

Le Coultre, during his observations in Bali in 1927, was afforded the unique opportunity of boning every infected carcass, and thus studying predilection sites. Under European conditions we are precluded from emulating Le Coultre's investigations.

A fairly comprehensive idea of the most commonly infested muscle groups may be obtained by reference to the subjoined table, which shows the number of measles which we found in each group, in 25 carcasses at Bloemfontein.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Carcass Number.	Total Measles.	External Masticatory	Internal Masticatory.	Tongue.	Œsophagus.	Heart.	Diaphragm.	Sternal Muscles.	Ext., Thorax and Intercost.	Cervicals and Rump.	Ext., Muscles of Vertebræ.	Shoulders and Elbow.	Extensors and Flexors of Carpus	Psoas.	Hind Limbs.
1	30	3	2	—	—	—	1	—	2	5	3	6	—	—	8
2	31	4	1	—	—	1	—	—	—	3	4	6	1	2	9
3	33	—	1	2	—	1	—	—	—	—	5	8	2	—	14
4	91	12	3	—	2	—	2	—	6	5	8	22	4	1	26
5	47	7	4	1	—	—	—	—	3	2	4	16	—	—	10
6	38	11	3	—	—	—	—	—	5	—	—	8	3	—	8
7	73	6	—	9	—	2	—	—	—	16	—	22	4	—	14
8	19	3	1	—	—	1	—	3	—	—	2	4	—	—	5
9	24	7	—	—	—	—	—	—	—	3	4	3	—	2	5
10	42	6	2	—	1	—	—	1	2	—	2	9	3	—	16
11	328	29	3	12	22	7	12	—	—	15	7	101	16	12	92
12	64	16	3	—	—	—	—	7	2	5	—	17	—	—	14
13	21	3	2	—	1	1	—	—	1	2	—	7	—	—	4
14	29	9	1	4	—	—	—	1	—	—	—	12	—	—	2
15	44	7	—	2	—	2	—	—	1	5	3	16	—	—	8
16	40	5	2	1	—	—	1	2	—	3	2	8	—	2	14
17	49	3	—	—	—	—	—	—	2	4	2	23	2	—	13
18	105	17	3	—	2	3	2	—	6	9	5	27	—	—	31
19	37	6	2	1	—	1	—	2	3	5	—	8	6	—	3
20	73	13	—	—	—	—	—	4	—	7	—	31	2	—	16
21	70	6	3	—	—	—	—	—	—	3	7	19	—	4	28
22	44	7	2	—	—	—	—	1	—	1	2	14	1	—	16
23	85	3	2	—	—	2	—	—	—	3	8	26	—	2	39
24	53	13	1	—	—	—	—	—	—	1	1	7	11	—	19
25	28	3	3	—	—	—	—	—	—	1	3	2	3	1	12
TOTAL	1,498	199	44	32	28	21	18	21	33	98	72	422	58	26	426

Judging from the foregoing table, in 25 heavily infested carcasses, it would appear that the hind limbs harbour the most parasites.

Out of a total of 1,498 measles found in the 25 animals—

([14])426 measles were found in the hind limbs in 25 animals;

([11])422 measles were found in the shoulder and elbow in 25 animals;

199 measles were found in the external masticatory muscles in 24 animals;

([9]) 98 measles were found in the cervicals and hump in 20 animals;

([10]) 72 measles were found in the external vertebrals, etc., in 18 animals.

([12]) 58 measles were found in the extensors and flexors of carpus in 13 animals; 44 measles were found in the internal masticatory muscles in 20 animals;

([8]) 33 measles were found in the external thoracic and intercostals in 11 animals;

32 measles were found in the tongue and its muscles in 8 animals;

28 measles were found in the oesophagus and its muscles in 5 animals;

26 measles were found in the psoas muscles in 8 animals;

21 measles were found in the heart in 10 animals;

([7]) 21 measles were found in the sternal muscles in 8 animals;

18 measles were found in the diaphragm in 5 animals.

In two cases the total number of 433 measles was found, that is, 328 in one carcass and 105 in the other. A more representative average would be arrived at by subtracting the 433 measles from the total of 1,498, thus giving 1,065 measles in 23 carcasses, an average of 46·3 per carcass.

([7]) *Sternal muscles group* included superficial and deep pectorals.

([8]) *External Thoracic and Intercostal group* included Posterior deep pectoral, Latissimus dorsi, Serratus ventralis, External abdominal oblique, and Intercostals proper.

([9]) *Cervicals and Hump group* included Trapezius, Omo-transversarius, Upper Brachio-cephalic, Rhomboideus.

([10]) *External vertebral muscles group* included Serratus dorsalis, Longissimus costarum, Longissimus dorsi.

([11]) *Shoulder and Elbow group* included all muscles on the lateral and medial aspect of the shoulder and humerus up to elbow.

([12]) *Extensors and Flexors of Carpus group* included Extensor carpi radialis, Extensor digitalis communis, and lateral and medial Digital extensor, and Superficial and deep digital flexors—all from elbow to carpus.

([14]) In this group were included all muscles of the hind limbs.

It will be noticed that *cysticerci* were found in the shoulder and elbow and in the thigh muscles of all 25 cases. In 24 out of the 25 cases measles were found in the external masticatory muscles. The fact that less than half the number of measles was found in this group compared with the shoulder and the thigh, may be ascribed to the fact that in the latter pairs very large groups of muscles were dissected, whereas the sections of the masseters were considerably smaller. Statistics such as those shown in the table may, therefore, be misleading. I quite agree that the group of muscles known as the masticatory (internal and external) must certainly be considered as a most important predilection site, and in Bloemfontein it was extremely rare that no measles were found in this group in an otherwise measly carcass.

The analysis formed by our careful dissection has brought to light the fact that the hind quarters of beef are as important from the point of view of measles location, as the fore quarters. It is quite possible that numerous measly carcasses may escape detection because no provision is made in Regulations for the incising of any part of the hind quarter, except the psoas muscles, which, as our table shows, cannot be considered a very important predilection site.

In view of the comparatively frequent and heavy nature of infestation of the hind limbs, it was further decided to record the actual groups of muscles of the hind limb, in which measles were found, in the last six carcasses we dissected. The following was our recording:—

Carcass No. 20.—Sixteen measles in both hind limbs. Muscles
Semimembranosus 4 measles.
Biceps femoris, lateral vastus, semitendinosus 8 measles.
Adductors 4 measles.

Carcass No. 21.—Twenty-eight measles in both hind limbs.
Gracilis, Adductors and vastus medialis group 12 measles.
Semimembranosus 1 measle.
Semitendinosus 5 measles.
Biceps femoris and lateral vastus 10 measles.

Carcass No. 22.—Sixteen measles in both hind limbs.
Gracilis and medial vastus 5 measles.
Vastus lateralis 2 measles.
Rectus femoris 1 measle.
Semitendinosus 4 measles.
Adductors 4 measles.

Carcass No. 23.—Thirty-nine measles in both hind limbs.
Vastus medialis, Pectineus and Quadratus femoris 21 measles.
Biceps femoris 1, lateral vastus and Semitendinosus 9 measles.
Adductors 9 measles.

Carcass No. 24.—Nineteen measles in both hind limbs.

Gluteus medialis 3 measles.

Gracilis and adductors 5 measles.

Semitendinosus 5 measles.

Gastrocnemius (fleshy belly of lateral head) 4 measles.

Carcass No. 25.—Twelve measles in both hind limbs.

Medial vastus 3 measles.

Biceps femoris, rectus femoris, vastus lateralis 7 measles.

Adductors 2 measles.

It will be noticed that measles were found in the adductors of all six carcasses (twelve hind quarters) observed. It must be emphasised that the adductors and most of the other large muscles on the medial aspect of the thigh should be considered very important locations for *Cysticerci bovis*. The large muscle groups on the lateral and posterior aspects of the pelvic limb are also important sites, but it would be impracticable to incise into them in ordinary meat inspection, without grossly mutilating the carcass. On the other hand the writer found that an incision parallel to and about an inch below the pelvic symphysis, deeply into the adductor muscle, did no material damage to the appearance of the quarter. The incision coincides, more or less, with those which butchers make in their shops in cutting up the steaks. The opinion of one of the local butchers was asked as to objections which might be raised against possible mutilation of the quarter by the making of such an incision, and he replied naively: " We will not object to the cut being made, but will be very annoyed if that will lead to your finding more measles ". Practically, the incision is best made while the carcass is still on the floor, just after the abdomen has been opened and the pelvis cleft. If the incision is to be made after the carcass has been hoisted, meat inspectors will have to stand on ladders. When made on the ground, the cut surfaces gape open, but when the carcass is hoisted, it is difficult to see into the cut, and a hook is required to pull the two surfaces apart. Several measles were found in an incision about an inch below the pelvic symphysis into the adductors, in carcass No. 23, described above.

In the subjoined observations of various workers, it will be noticed that very few writers in Europe mention incisions into the shoulder-elbow muscles or the thighs. Two notable exceptions are Buri and Krupski, who worked in Switzerland during the Great War period.

There can be little doubt that the recorded incidence of bovine cysticercosis will become considerably higher, if our co-workers in Europe were to incise into, e.g. the *triceps brachii* and the *adductor*.

Working on Bali Island, Le Coultre found 1,337 measly carcasses. He divided these into three groups:—

1. *Cysticerci* in head only, in 838 cases.
2. *Cysticerci* in head and carcass, in 300 cases.
3. *Cysticerci* in carcass only, in 199 cases.

If Le Coultre had followed the custom of inspection of Holland and of Germany, he would have missed the 199 measly cases entirely.

It will also be noticed that those writers, who were probably privileged to dissect the entire carcasses, chiefly refer to the muscles of the hind limbs and/or those of the fore limbs as predilection sites. (See Hammer, Teppaz, Valade, Claverie, Alix, Le Coultre, Morot.)

Von Ostertag's expression " the more you look, the more you will find " is very applicable to the meat inspector's search for *Cysticercus bovis*. The inspector's permitted range of incisions is too limited, and although it may be felt that in the standardized routine incisions prescribed in South Africa, he will probably encounter most measles, the possibility of undetected measles in the not incised hind limbs must not be overlooked.

Reference to our table also discloses the frequency with which measles were found in the vertebral muscles and in the extensors and flexors of the carpus.

It is interesting to record that in none of the 25 observed cases did we find measles in any of the viscera (except the heart) nor in any glands. No measles were observed in the fat in these cases, nor in the brain, nor the eyeball.

The hump is very definitely a very common site for measles.

Exceptionally unusual infestations with measles have been encountered in South Africa.

In 1935 we found more than 50 apparently viable measles in the tongue of an ox, and yet we failed to disclose a single measle in any of the secondary incisions prescribed by Regulations. This carcass was not minutely dissected.)

Mr. Thatcher, Health Inspector, Fort Beaufort writes:—

> " I have specimens of measles found in bovines in the kidney, submaxillary and inguinal lymphatic glands, hard fat of the heart and in some instances in other hard and soft fats of cattle."

The Town Clerk, Kimberley, advised me that in one case they found measles in the lungs of an ox.

Mr. W. J. Armstrong, Meat Inspector, Vryheid writes:—

> " I would say the tongue is the commonest site. I had a peculiar experience about a year ago. While the animal was being skinned, I noticed measles lying on the surface side of the shoulder and when I did the shoulder cut nothing was to be found, but found the head, tongue and heart heavily infested."

It has been mentioned that we also studied the predilection sites in 113 consecutive lightly infested carcasses. It was impossible to dissect those carcasses minutely, since, in accordance with paragraph 16 (2) and (3) of Section 115 of Act No. 36 of 1919, as amended by

various Government Notices, they were subjected to fourteen days freezing at -10° C. We had, therefore, to accept the number of cysts found in the routine and secondary incisions as indicative of the commonest sites of infection.

Except in one case, in which a viable *cysticercus* was found in the *M. Semitendinosus*, no incisions were made into the hind limb. The measle found in the semitendinosus muscle was encountered purely accidentally. A small piece of this muscle had to be excised from the quarter on account of bruising, and to our utter astonishment we found a viable *Cysticercus bovis* exposed. Not a single measle was found in any of the secondary incisions which were subsequently made. This was another instance in which coincidence fortunately stopped a measly carcass from being passed as fit for human consumption.

In recording the sites of infection in the 113 lightly infested carcasses, we found:—

Measles in the masticatory muscles only, in	40	cases.
Measles in the masticatory muscles plus shoulder, plus tongue in	5	,,
Measles in the masticatory muscles plus shoulder, plus heart in	2	,,
Measles in the masticatory muscles plus shoulder plus psoas in	1	,,
Measles in the masticatory muscles plus shoulder, only, in	35	,,
Measles in the masticatory muscles plus psoas, only in	1	,,
Measles in the masticatory muscles plus diaphragm, plus sternum in	1	,,
Measles in the masticatory muscles plus diaphragm, plus shoulder	1	,,
Measles in the masticatory muscles plus sternum (brisket), only, in	1	,,
Measles in the masticatory muscles plus heart in	2	,,
Measles in the masticatory muscles plus tongue in	5	,,
Measles in the shoulder muscles, only, in	10	,,
Measles in the shoulder muscles plus tongue in	5	,,
Measles in the shoulder muscles plus psoas in	1	,,
Measles in the shoulder muscles plus sternum (brisket) in	1	,,
Measles in the tongue plus the heart in	1	,,
Measles in the semitendinosus muscles, only, in	1	,,

Analysing the actual number of measles found, and the various number of cases, we found in the 113 carcasses:—

In the masticatory muscles in	94	cases	129	measles.
In the muscles of the shoulder above elbow	61	,,	113	,,

In the tongue	16	cases	17	measles.
In the heart	5	,, ...	6	,,
In the psoas muscles	3	,, ...	3	,,
In the sternal muscles (brisket) ...	3	,, ...	3	,,
In the diaphragm	2	,, ...	2	,,
In the semitendinosus muscle	1	,, ...	1	,,

Thus in 113 lightly infested carcasses we found 274 measles. Of the 129 measles found in the masticatory muscles, 98 were found in the external masticatory muscles and 31 in the internal masticatory muscles.

The ratio of light infestation to heavy infestation is reflected in the following statistics:—

> From July 1st, 1934, till December 31st, 1936, 1,060 bovine carcasses were found to be measly at the Bloemfontein abattoir.

Of this number 953 carcasses were lightly infested, that is, they were treated in the freezing chamber according to Regulations, and 107 were grossly infested, that is more than six measles were found in the incisions into the carcass, excluding the head and the viscera, or a total of ten measles in the carcass, including the head and the viscera.

Mode of Inspection.

Regulations governing the inspection of carcasses for measles were discussed earlier in Part III of this work, in the section dealing with the routine inspection of pig carcasses. For the inspection of bovine carcasses, the routine is the same as that of pig carcasses, except that the following provisions are specifically made:—

> Paragraph 13 (*a*) includes a clause which lays down that the cheek muscles of bovines shall be examined by two or more linear incisions on the outside and a linear incision on the inside, which shall all be made parallel to the lower jaw.

The meat inspector is not authorized to make a routine incision into the substance of the tongue, unless he has found evidence of measles in the routine incisions, nor is he allowed to make any inspection incisions, other than those for the examination of the lymphatic glands, into the pelvic limb.

Various Authors on Predilection Sites and Inspection Technique.

Up till 1888 very little was known of beef measles in Europe, and between the years 1883 and 1889 only four cases of bovine cysticercosis were found at the Berlin abattoir. About that time Hertwig recommended that the muscles of the pharynx should be incised for the examination for rinderpest, and this led to incisions into the internal masticatory muscles. A number of measles was thus found. The method was further improved by Glagé, who incised the external masticatory muscles and found still more measles in

those muscles. This led to the first " predilection sites," discovered, as van Oijen (1929) suggests, " by pure accident ". Further observations led to the discovery of yet other " predilection sites ", for example, the heart, the tongue and later the neck muscles.

Von Ostertag (1913) gives the following table showing the frequency with which beef measles were found between 1888-90 at the Berlin abattoir:—

1. In the masticatory muscles ... ... in 360 cases.
2. In the heart ... ... in 41 cases.
3. In the tongue ... ... in 10 cases.
4. In the thoracic muscles ... ... in 1 case.
5. In the cervical muscles ... ... in 3 cases.
6. In the general musculature ... ... in 22 cases.

He mentions that with the exception of the heart, the vital organs of cattle are not usually infested with *cysticerci*. Only in cases of extensive invasions are the lymphatic glands, lungs, liver and brain infested.

Von Ostertag quotes Morot, who found in an African beef animal that the internal masticatory muscles were less strongly infested than the tongue and the heart. *Cysticerci* were also found in large numbers in the muscles of the *shoulder*, *fore leg*, *back*, *rump* and *hind quarter* (*Cf.* table of infestation in the 25 cases dissected at Bloemfontein.)

Flohil (1910) quotes Beunders, who found at the Groningen (Holland) abattoir the following order of frequency of infection:—

(1) Heart; (2) Internal masticatory muscles; (3) External masticatory muscles; (4) Tongue; (5) Diaphragm.

Le Coultre, during his investigations in Bali in 1927, had the opportunity to dissect all infected bovine carcasses. Le Coultre had, therefore, the privilege to compile a very accurate estimate of the predilection sites from actual observations of a number of carcasses. At the abattoirs at Boeleleng and at Denpasar the combined number of measly carcasses during 1927 was 937 out of a total of 3,810 slaughtered during that year.

Measles were found:—

In the masticatory muscles	in	778	cases (83 %)
In the tongue	in	131	,, (14 %)
In the shoulder muscles	in	114	,, (12 %)
In the adductors	in	109	,, (11·6 %)
In the cervicals	in	70	,, (7·5 %)
In the intercostal muscles	in	45	,, (4·8 %)
In the psoas muscles	in	42	,, (4·5 %)
In the infra-vertebral muscles	in	36	,, (3·8 %)
In the sternal muscles	in	24	,, (2·6 %)

In the diaphragm	in	19 cases	(2·0%)
In the abdominal muscles	in	17 ,,	(1·8 %)
In the heart	in	14 ,,	(1·5 %)

He also found 5 cases with measles in the oesophagus, 4 in the hump, 1 each below the elbow and the patella, 1 in the brain and 1 in the kidney.

Alix (1887), working in Tunis, found the following order of frequency of infection:—Tongue, heart, muscles of the thigh, muscles of the shoulder, croup, intercostals, pectorals and psoas.

Hammer wrote in 1922 that in former German East Africa he found the most important predilection sites to be:—The adductors, the muscles of the neck, the tongue and lastly the heart. Hammer was privileged to incise other parts of the carcass than those prescribed in customary European inspection technique. According to Capt. H. J. Lowe, M.R.C.V.S., of the Department of Veterinary Science and Animal Husbandry, Tanganyika, who wrote to me in 1936, the chief predilection sites in Tanganyika at present are—(1) the heart; (2) the muscular mass of the upper part of the hind leg, i.e. Biceps femoris and Semitendinosus and also the Triceps of the arm; (3) the tongue; (4) the masseters.

Teppaz (1923) working in Dakar (Senegal) found the following order of frequency:—Cervical muscles, masticatory muscles, heart, diaphragm and adductors.

Vallade (1927) gave the following order of frequency as representative of his observations at Homs (Syria).—Diaphragm, heart, psoas muscles, masseters, adductors and cervicals.

Claverie (1928) found the anconeus muscle the most frequent site of infestation in French Guinea. It is difficult to understand how he incised the anconei and found more measles there, than in the larger superlying triceps muscles, in which group measles are, definitely, very frequently found. Claverie's custom was to make two incisions into the anconeus muscle on each side.

Prof. S. Yoshida of the Osaka Imperial University, Osaka, Japan, supplied a translation of a recent paper written by Nakanishi, who found the following order of infestation in Korea; Heart muscle 75 per cent. of cases; trunk muscles 47·7 per cent. of cases; tongue 30·0 per cent. of cases; masticatory muscles 23·5 per cent. of cases; diaphragm 20·3 per cent. of cases; lungs 19·77 per cent. of cases; cutaneous muscles 18·9 per cent. of cases; retina 10·5 per cent. of cases; pericardial sac 9·1 per cent. of cases; gastric wall 8·5 per cent. of cases; lymph glands 6·5 per cent. of cases; oesophagus 5·2 per cent. of cases; kidneys 5·2 per cent. of cases; pancreas 3·9 per cent. of cases; bladder 3·3 per cent. of cases.

Nakanishi, therefore, gives a totally different order of infestation, and he found the masticatory muscles to be, relatively, of much less importance as a predilecton site, than most European writers. The comparatively high percentage of cases with pulmonary, retinal and lymph glandular cysticercosis is also worthy of note.

Ransom (1911) described the predilection sites observed in the United States as Heart 70 per cent., masticatory muscles 47 per cent. of cases. Dr. Mohler, Chief of the Bureau of Animal Industry, United States Department of Agriculture, informed me that the most prevalent seats of infection in the United States at the present time are: (1) The muscles of mastication. (2) The heart. (3) The muscular portion of the diaphragm.

Veenstra (1921) found the following order of frequency at Amsterdam: Out of 26 single measled cattle he found the external masticatory muscles infested 16 times, the heart 5 times, the tongue 3 times, the internal masticatory muscles twice.

Reitsma (1931) found at Rheeden (Holland) the following order of frequency: (1) Heart. (2) Left external masticatory muscles. (3) Right external masticatory muscles. ((4) Diaphragm. (5) Left internal masticatory muscles. (6) Right internal masticatory muscles.

Reitsma mentions an interesting fact, to which he cannot ascribe any reason, namely that he, and some other observers have found more measles on the left side (masticatory muscles) than on the right side. Most authorities maintain that the majority of measles are found near the edge of the jaw bone, but Reitsma and Veenstra disagree with this view.

Van der Slooten (1936) wrote that it was doubtful whether the so-called predilection sites were truly the most common sites of infestation. He found that the hump was commonly as heavily infested as the usual muscle groups inspected. (Note that at Bloemfontein we found 98 measles in the hump and cervical muscles in 20 out of 25 grossly infested carcasses.)

Buri (1915) and Krupski (1917) found the following order of infestation at Berne and Liestal, respectively:—

Both observers: Masticatory muscles, heart and diaphragm.

Buri: Rarely in the tongue, sternal muscles, biceps femoris and intercostals.

Krupski: Rarely in the tongue, shoulder muscles, abdominal muscles and gracilis muscle.

Funck (1930) pointed out that next to the masticatory muscles the oesophagus is the most common site of infestation. During four years' observation at Neumunster, out of 120 adult bovines with live *cysticerci*, he found: 105 cases of measles in the masticatory muscles, 13 cases in the oesophagus, 5 cases in the heart, 5 cases in the abdominal muscles and one case in the diaphragm. *Cysticerci* thus appeared in the oesophagus in 10·3 per cent of cases, and in all these 13 cases only one live measle was found in the whole carcass. In 1935, Funck recorded that in five cases he found measles to be extremely shallow in various facial muscles, the lips, etc., and not necessarily in the usual sites. Funck advised that these superficial muscles should receive careful attention. He also maintained that all ox heads should be examined on a table, so that the light could be shone more readily into the cheek cuts.

Cattoneo (1932) also found that the oesophagus could be considered an important predilection site of *C. bovis*. Out of 40 cases investigated, he found measles in the oesophagus in 17 cases.

Messner (1931) described a case of a 6-years-old ox in which a number of *cysticerci* was found in the oesophagus only, in Karlsbad.

Coussi (1933) found at the abattoirs at Sousse (Tunis) that the heart was the most common site to be infested, during five years' close examination. Out of 621 animals infected 524, i.e., 84·37 per cent. showed cardiac *cysticerci*: 318, i.e., 51·2 per cent. showed measles in the masseters; and 260, i.e., 42·19 per cent. in the tongue.

Krueger (1935) found the predilection sites to be, in order of frequency: Masseters, tongue, diaphragm and heart. The heart was infested in only 10 per cent. of cases.

Stengel (1932) advocated opening the pericardium in each carcass, since he frequently found measles just below the pericardium.

The necessity for careful inspection of the liver for *cysticerci* has recently been mentioned by Poisson (1934), by Buck, Lamberton and Randriambeloma (1935) and previously by Schlegel (1918). Poisson records a case of infection with *Taenia saginata* in a patient in Madagascar, as the result of the ingestion of a prescribed raw liver diet. Buck and his co-workers found two *C. bovis* in the liver of a cow. Schlegel found a *C. bovis* in the liver of a cow. It was the only measle found in the carcass.

Professor P. G. Malkani supplied me with photographs of *cysticerci* in the heart, liver and lung of a bovine in India. (See Fig. 3.)

Mahlendorff (1929) names a case in which he found a *C. bovis* in the subcutaneous fascia and in one kidney, while the usual predilection sites were quite free.

Remarks on Inspection Technique and Recommendations by some Writers.

Many recent workers in Europe have stressed the point that meat inspectors should be allowed greater authority and more liberty for inspection. For example, in 1932 B. Müller suggested the standardization of inspection technique in Germany, by making two incisions into each masseter. The masseters are considered the most probable site of infection by workers in Europe, and many consider that by increasing the number of masseteric incisions, a very much larger percentage of measles will be found, and that there will be a corresponding impetus towards the eventual eradication of bovine cysticercosis. Among these writers mention may be made of Künibert Müller quoted by Le Coultre, who in 1905 recommended that the external masticatory muscles should be incised onto the *crysta zygomatica*, and the flaps formed turned right back. By this means Müller found 4·6 per cent. infected at Guben, and Junack 2 per cent. in Kottbus.

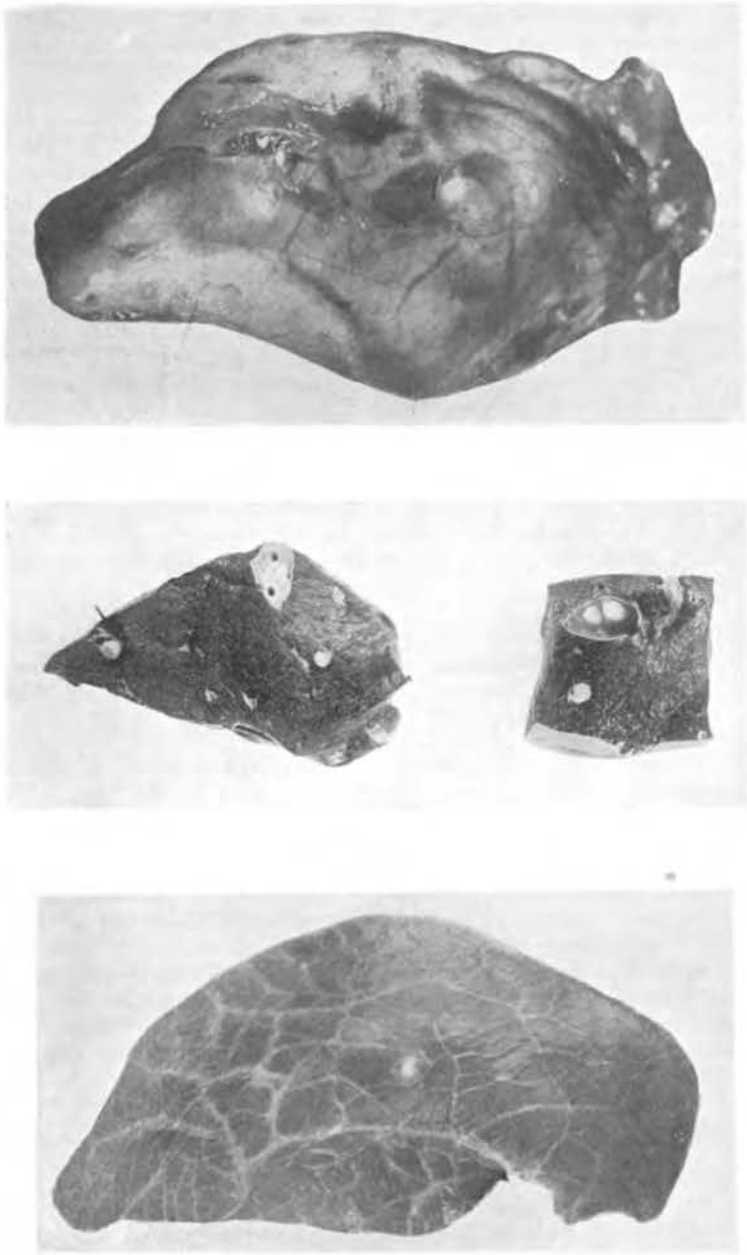


FIG. 3.—Appendix "A". Photographs of *Cysticerci bovis* of the heart, liver and lung of an ox. Reproductions of photographs supplied by Prof. P. G. Malkani, Patna, India.

K. Müller (1927) recommended doubling the number of incisions into the masticatory muscles. He also advised making incisions into the muscles under the tongue. All incisions should be examined very carefully, and only sharp, firm knives should be used. To ensure efficiency, not more than 50 to 60 bovines should be inspected by one inspector per day.

Mahlendorff (1930) found 0·81 per cent. to 0·91 per cent. measles in cases where one cut was made, and 1·06 per cent. to 1·54 per cent. in cases where more than one cut was made. Mahlendorff mentioned that prior to June, 1929, only one incision was made into each masseter at Breslau. In April, 1929, he found 0·81 % infected, and in May 0·94 per cent. In June that year he made two incisions into each masseter and found in: June 1·11 per cent.; July 1·39 per cent.; August 1·06 per cent; September 1·11 per cent.; October 1·53 per cent.; November 1·54 per cent.; December 1·22 per cent.; and in 1930 in January 1·42 per cent.; February 1·35 per cent.; March 1·08 per cent.

Kern (1930) expressed the opinion that the problem of eradication of *Taenia saginata* could be solved by thorough inspection technique. He always insisted on two incisions into the external masticatory muscles, and if possible into the internal masticatory muscles as well.

In *Zeitschr. f. Fl.-und Milchhyg.* 40, p. 386, von Ostertag (1930) recommends a double incision of the masticatory muscles, and if necessary, even transverse cuts, when many more measles will be found.

Platschek (1931) recommended three or even four incisions into each masseter. Similar recommendations were made that year by Wernery, who advised that the number of incisions in the external masticatory muscles be increased from two to three on each side.

The new inspection technique in Germany, since 13th October, 1934, provides, according to personal information supplied by Dr. Heinrich Wagemann: "A careful inspection of the tongue, heart and external and internal masticatory muscles. At least two incisions must be made parallel to the mandible, and while the carcass is being dressed, cut surfaces must be inspected for measles. The incisions into the masticatory muscles must be made from the border of the mandible to the upper half of the inside of the jaw, and as far as it can be cut into, upwards to the lymphatic glands of the ear on the outside of the jaw."

All German writers, however, do not necessarily hope that a greater number of incisions into the masseters will be the main solution of the taeniasis problem. Several writers stress the fact that the low incidence recorded at certain abattoirs is mainly due to slackness in inspection technique. Among these Junack was a leader. Junack (1926) formed the following conclusions: "The apparent big decrease in the incidence of cysticercosis in some areas may be attributed to careless inspection during and after the war, owing to shortage of staff, or owing to various modifications in inspection, or

owing to removal of *cysticerci*, surreptitiously, by butchers themselves. Other local difficulties may also be responsible." In support of his statements, Junack quotes:—

"The incidence of measles in Berlin was 22 times as high as that of the outlying areas (*Auszenbezirke*), whereas actually the slaughter stock came from the same regions." Furthermore, according to Junack, in 1923 and 1924, 101 measly cattle were found at Bremen, whereas not a single case was found at Mecklenburg Strelitz, Schaumburg Lippe and Hohenzollern. In 1931 Junack wrote that during the war meat inspection was not too thorough, and it was possible that in some places where troops served it might have been absent altogether. Under such conditions soldiers acquired tapeworm infection and later, in turn infected German cattle with *C. bovis*. Owing to closer meat inspection more cases of *C. bovis* have been found, but in Junack's opinion, yearly 5,000 to 6,000 more cases may be found, if inspection technique were still more thorough.

Similar views were expressed by Profè (1934), who pointed out that it was difficult to compare the incidence of *C. bovis* in various places, because there was a big variance in the thoroughness of meat inspection.

In addition to advising uniformity in inspection technique, Zeug (1931) mentioned that the number of incisions required, and their locations, should be definitely stipulated in Regulations. That the human element was an important factor in the discovery of *cysticerci* was clearly shown by Zeug. Thus, there was a big variation in the efficiency of the work performed, comparatively, in the following groups of inspectors:—

(1) The number or percentage of full-time abattoir veterinarians who found measles.

(2) The number or percentage of veterinary practitioners, who spent a small part of their time at abattoirs, and who found measles.

(3) Unqualified assistant inspectors, who found measles.

Zeug qualified his remarks by giving actual statistics.

Wernery (1931) blamed perfunctory meat inspection for the failure to eradicate bovine cysticercosis. He mentioned several instances in which a much higher percentage measles was found after deeper and larger incisions of the masticatory muscles were made.

After having made only one incision into each masseter, Juraske found only 0·16 per cent. of cases measly at the Jena abattoir, but when he increased his masseteric incisions to two on each side, Juraske found that the percentage had increased to 1·29. (Wernery, 1931; von Ostertag, 1930.)

Wernery recommended that the Regulations should lay down precisely, as to where and how incisions should be made, and mentioned that in certain parts of Prussia, where specific incisions were made, the percentage measles was much higher than in other districts.

Buri, working in Switzerland in 1914 and 1915, caused a big increase in the number of *C. bovis* carcasses to be found at the abattoir at Berne, where he incised the masticatory muscles freely. The result of his system of incisions was an increase in the number of cases from 1 and 5 in 1912 and 1913, respectively, to 23 and 39 in 1914 and 1915, respectively. Buri was convinced that nine-tenths of the cases of *C. bovis* found, resulted from the extra incisions into the masticatory muscles, and he persisted with this practice, despite the determined protests of the butchers. It was he, who in 1915 recommended that Switzerland should adopt the German method of inspection, since the incidence of *C. bovis* was high and warranted it

Guillebeau (1917) objected to the severe German mode of inspection, and considered that this method was too rigid for Switzerland, in which country raw, or insufficiently cooked meat was seldom eaten, although he freely admitted that the incidence of taeniasis was high in those parts of Switzerland, where the so-called *Landjäger* was commonly eaten.

The same year, 1917, Krupski attacked the mild views expressed by Guillebeau, and proved that at Liestal he found a percentage of 5·9 in cases in which he freely incised the masticatory muscles. He was a staunch advocate for the introduction of the German method of inspection, into Switzerland. Krupski compared the great variation in inspection technique and mode of control of cysticercosis, as was practised at various Swiss centres. Thus he quotes:—

> Zürich—only the predilection sites which could be inspected without incisions, and thus not the masticatory muscles, were inspected.
>
> Basel—*idem*, and two masticatory muscles were incised.
>
> Schaffhausen—*idem*, and besides an attempt was made to detect the responsible tapeworm carrier by investigations at the place of origin of the infected bovine.
>
> St. Gallen—*idem*.

The American Edition (1934) of the work by Edelmann, Mohler and Eichhorn states that it is absolutely necessary to make several cuts into the inner and outer muscles of mastication, to inspect carefully the tongue and its musculature, and also to inspect carefully the heart, externally and internally, after laying open the chambers and cutting through the dividing wall. It is understood that all surfaces as well as cut surfaces of the remaining muscle should be inspected for beef measles.

Leighton (1927) quotes that the following inspection custom is followed in the United States:—

> "The presence in the flesh of cattle of a certain cyst capable of producing tapeworm in man can usually be detected by examining the inner and outer cheek muscles. Therefore, these muscles are laid open by slicing cuts for the detection of the cyst."

The United States of America Bureau of Animal Industry Order 211, Regulation 11, Section 16, Paragraph 3 defines a careful examination of the heart, muscles of mastication, tongue, diaphragm and its pillars and those portions of the carcass rendered visible by the dressing.

In Canada, although the incidence of bovine cysticercosis is relatively low, it would appear that a thorough inspection of the head is made, similar to the practice formerly in vogue in Germany and in Holland. Paragraph 12 of the Canadian Meat Inspection regulations reads:—" The tongue must be so loosened as to expose the internal muscles of mastication. These, and the external muscles must be incised, cutting parallel with the lateral surface of the jawbone, the cut surfaces to be minutely examined. The surface of the heart must be closely scrutinized and the heart then opened or inverted. This can best be done by placing the left ventricle uppermost, when one incison, the full length of the organ, will be sufficient to permit an examination of the cut surfaces and of the interior; or the heart may be everted and incisions made into the musculature of the organ."

Working in Denmark, Nielsen (1934), showed that on several occasions infected carcasses could have escaped detection owing to the absence of *cysticerci* in the recognised predilection sites, or owing to a perfunctory inspection.

As regards inspection technique in Holland, Tenhaeff (1907) wrote that in Utrecht up till that year only the internal masticatory muscles were incised. Up till 1905 approximately only two measly cattle per annum were found at that abattoir. In 1907 von Ostertag visited the Utrecht abattoir, and pointed out the desirability of incising the external masticatory muscles as well. Coincidentally, von Ostertag demonstrated the method of incision into the external masticatory muscles and found a degenerated *cysticercus* in his incision. That season Tenhaeff found 74 cases of cysticercosis, after having followed von Ostertag's recommendations.

Veenstra (1921) laid special stress on the careful inspection of the masticatory muscles. He recommended two large incisions, and incisions into the tongue. If necessary, the masticatory muscles should be cut into thin strips. He felt convinced that only the inspection of the predilection sites would be sufficient to eradicate taeniasis-cysticercosis in a decade. Veenstra recommended the following technique:—

> *Masticatory muscles.*—Two parallel incisions through each external masticatory muscle, and one deep incison into each internal masticatory muscle.
>
> *Heart.*—First external inspection, then an incision into the left ventricle up to the septum; sub-division of both halves of the left ventricle into flakes like an onion; then a longitudinal incision through the right ventricle. The cut surfaces and the endocardium to be thoroughly inspected.
>
> *Tongue.*—Thorough palpation and incision of the muscles.
>
> *Diaphragm.*—Inspection and palpation. (No mention of incisions.)

Reitsma (1931) quotes Article 31 of Section 285 of the Netherlands Meat Inspection Regulations of 5th June, 1920, which laid down that the tongue, heart and external masticatory muscles were to be incised—the latter by " various longitudinal cuts ". Reitsma strongly recommends that five to ten transverse incisions be made as well. By doing this he claims a far more thorough inspection, as was proved by his results.

Schoon (1933), in his discussion on the eradication of bovine cysticercosis, based on his experience in meat inspection, mentions that the high incidence of *C. bovis* (4 per cent.) observed at Nijmegen, is due to his method of inspection. Two even, clear cuts are made into the masticatory muscles on either side of the jaw, and three into the heart. Schoon mentions that the large percentage of cases with a single measle is notable.

Professor C. F. van Oijen of Utrecht, Holland, informed me (1936) that at Rheeden in 1934 special attention was directed towards the muscular coat (*spier-rok*) of the oesophagus. The mucous membrane (*slijmvlies*) was excised, stretched out and carefully inspected. This technique was responsible for the finding of thirteen measles, of which three appeared to be viable. According to Prof. van Oijen, the increased incidence of measles in some parts of Holland can mainly be ascribed to the result of more thorough inspection technique.

At Karlsbad (Bohemia), Messner also paid special attention to the inspection of the oesophagus.

In Great Britain, it must be freely confessed, inspection technique for *Cysticercus bovis* falls far short of that practised in Holland, Germany, Denmark, or particularly in South Africa.

In Scotland, Regulations prescribe that " the cheek muscles shall be examined by a linear incision parallel to the lower jaw." Gerald Leighton (1924), writes:—" A special instruction states that an examination must be made of the cheek muscles, and this must be done by cutting into them in a line parallel to the lower jaw. This is a proceeding which has not been hitherto very common in this country, though a few inspectors carry it out. It is, however, a very important point, and the object is to ascertain whether the muscle is infected with a parasite known as the ' beef bladderworm ' or ' beef measles '." Leighton's quotation is not from the lay press, or from a non-technical article to farmers, butchers, or other laymen interested in the meat industry, but actually appears in " A Handbook of Meat Inspection—A guide to the Public Health (Meat) Regulations (Scotland) 1924 ". Leighton, therefore, frankly informs students and others interested in the science of meat inspection that up to 1924, although regulations provided for a cursory inspection for measles, little or no notice was taken of them.

The present writer is probably not alone in the surmisal that if a mode of inspection on the German principle, which is not as complete as that of South Africa, be instituted into Great Britain, the incidence of measles in that country will be considerably higher, and may even startle some authorities.

Colonel T. Dunlop Young, one of Britain's greatest authorities in meat inspection, kindly agreed to enquire into the incidence of measles in Britain, from records of most of the principal abattoirs. On my behalf, he very kindly instituted a searching enquiry, and he failed to find a record of a single instance of *cysticercus* infection in the reports of the various abattoirs during 1935. It seems almost incredible that the incidence of *C. bovis* could have been " nil " in Great Britain.

In 1920, Robertson sounded a warning to meat inspectors and meat consumers in Great Britain. In his " Meat and Food Inspection ", pp. 136-138, he states that inspection of meat for measles in Great Britain should receive greater attention. The possibility of infection of his patients with *T. saginata* was forcibly brought home to him when, as Medical Officer of Health for Leith (now a suburb of Edinburgh), he prescribed a raw meat diet for tuberculosis cases at the Leith Isolation Hospital. Several of his patients developed tapeworms.

For Syria, Valade (1927) recommended the following inspection:

(1) Excission of the diaphragm, which must be hung on hooks for careful examination.

(2) Heart: Careful inspection of the coronary grooves. Then an incision into, and inspection of the myocardium and the endocardium.

(3) Psoas muscles: These must be examined along their entirety. (In Vallade's opinion *cysticerci* are more frequently found superficially in the muscle fascia than in the muscle fibres.)

(4) The external masticatory muscles must be cut into thin strips. (In the event of one or more measles being found in the above four sites, then the following incisions should be made.)

(5) A series of incisions must be made plumb down the medial surface of the thigh into the adductor muscle.

(6) Incisions into the superficial cervical muscles.

In Bloemfontein we cause two long incisions to be made, widely apart and parallel to the lower border of the mandible, and to pass in an upward direction to sever the parotid gland. This procedure has been in practice since the middle of June, 1934, when my Senior Meat Inspector, Mr. H. M. Downes, and I assumed office shortly after each other at this abattoir. The internal masticatory muscles are cut with two incisions on each side, as long as possible. The effective series of incisions into the masticatory muscles gave the following immediate results.

June, 1934 ... ... 39 cases (between 18th June and 30th June).
July ... ... 64 cases.
August ... ... 65 cases.
September ... ... 57 cases.

Mr. Downes assumed duty on June 18th and prior to his arrival, namely from 1st to 17th June, 1934, only 7 cases of measles were found. During May, 1934, 13 cases were found; during April, 1934, 15 cases were found.

These figures prove that effective incisions and efficient work is rewarded with successful results. The slaughter stock belonged to the same firms of butchers throughout the period recorded, and originated from the same parts.

We were blamed for the butchers' misfortunes, but, despite the complaints from the butchers that we were too drastic with our technique, I insisted on the two long incisions into the masseters, and instructed Mr. Downes and the Junior Inspector to persevere with the practice. It is is also interesting to relate that the Superintendent of one of our larger Union abattoirs visited Bloemfontein some time ago, and, upon witnessing our technique, remarked: "If we were to make those cuts in our abattoir the butchers would revolt!"

The writer has, indeed, noticed at some of our larger abattoirs, and at nearly all the smaller abattoirs which he has visited, that the masseteric incisions, and frequently those into the triceps brachii are far too short and shallow to be effective.

Our South African meat inspectors should bear in mind that Regulations restrict their routine incisions to a bare minimum, and in those parts of the carcass where they are expected to make their incisions, and the size of such incisions is not definitely prescribed, they should err on the side of long and deep cuts and should determine to make these as long as possible.

The Age and Sex of Infested Animals (Excluding Calves).

It has already been mentioned that during the period 1st July, 1934, to 31st December, 1936, 1,060 cattle were found to be measly at Bloemfontein abattoir. The total number of bovines (excluding calves) slaughtered was 21,764, giving a percentage of 4·87.

We noticed that there was very little difference in the percentages measles among cows and oxen, but bulls were relatively less frequently infested.

The following table shows the numbers and percentages, also the ratios of light to heavy infestation in the sexes.

	Total stock slaughtered.	Found measly.			Percentage.
		Total.	Heavily infested.	Lightly infested.	
Oxen.....	19,305	957	94	863	4·96
Cows.....	2,249	99	12	87	4·40
Bulls.....	210	4	1	3	1·90
Total.....	21,764	1,060	107	953	4·87

Several writers in Europe mention the disproportion of infestation between the various sexes.

Krueger (1935) found that the incidence in bulls was twice that in cows.

Braun-Seifert (1923) quotes an extract from "*Ergebnisse der Schlachtvieh -und Fleischbeschau im Deutschen Reich*" for 1905, in which the incidence of bovine measles was analysed as follows:—Bulls, 0·6 per cent.; oxen, 0·56 per cent.; cows, 0·17 per cent.

Von Ostertag explains the comparatively heavier incidence of cysticercosis in the male sex by the fact that male bovines are generally slaughtered early, whereas infection is usually acquired early, and that the bladderworms die off later, at about the usual age that cows are slaughtered.

In Bloemfontein, in 215 consecutive measly carcasses, we found—

74 carcasses to be over 5 years old;
126 carcasses to be 4 to 5 years old;
15 carcasses to be 3 years old.

Admittedly, these figures are no criterion, since the numbers of animals slaughtered at the various ages were not included in our recordings. The vast majority of cattle slaughtered at this, and indeed at most South African abattoirs are well over three years old.

Flohil (1910) mentioned that Beunders at Groningen (Holland) found a percentage of 0·41 infected between the years 1904 and 1908. According to Beunders, cysticercosis was equally found in cases under two years old and in cases above that age.

Degeneration of the Cysticercus Bovis.

Degeneration of the beef bladderworm occurs readily, and according to some authorities fairly early. (*Vide* frequency of degenerated *cysticerci* in calves.) Cysts in the various stages of degeneration are very frequently encountered on meat inspection.

In Germany and in Holland recorders frequently discriminate between degenerated and apparently viable cysticerci. Judging by various reports, it would appear that many of our co-workers in Europe make a distinction in their returns between dead and live measles, although all carcasses showing measles, whether dead or alive, may be treated in the same way.

Apparently the Regulations in Germany are similar to those of South Africa, in so far as that all carcasses are condemned or detained for treatment (e.g. by freezing), irrespective of whether viable or degenerated *cysticerci* are found.

Hock (1934) criticises the German custom. He considers it quite unnecessary to condemn carcasses containing only dead *cysticerci*. If the cysticerci are so numerous as to render the meat "substantially changed", then it can be condemned under other sections of the Regulations. If the dead *cysticerci* are few, then the meat is, in Hock's opinion, not unfit for human consumption.

Most observers have argued against the views expressed by Hock. The possibility that dead *cysticerci* and live bladderworms may be present in various parts of the same carcass, has been recorded by several writers on the subject.

Prillwitz (1930) pointed out the fact that although only degenerated measles may be found in a certain part of an ox carcass, it may be possible that live measles may be present elsewhere in that carcass, owing to the fact that the animal may have become reinfected owing to its proximity to a tapeworm carrier. He quotes two cases in which he found only one totally calcified measle in the masticatory muscle, and with further inspection, he found viable measles in the tongue muscles.

Haas (1929) found numerous measles in a very young calf. These were diagnosed at the Veterinary School at Albert to consist of both degenerated and viable specimens.

Holtz (1929) recorded two cases in calves. In the first case eight calcified and three viable measles were found in the heart, and a number of dead measles and two living measles in the masseters. In the second case Holtz found two viable and six dead measles in the heart and three measles in the external masticatory muscles, and also three live measles in the diaphragm. Further examination produced a number of translucent cysts with apparently healthy scolices in the superficial fascia, hump, shoulder, hind quarters, etc.

Le Coultre (1928) mentioned several cases in which he found both living and degenerated *cysticerci* in the same carcass.

Reitsma (1931) recorded finding three living measles in the heart, after having found many dead measles elsewhere.

Van der Slooten (1936), writes:—" It is of little importance as to whether the parasites found are alive. We must bear in mind the fact that even though a parasite may be dead, others, elsewhere in the carcass may still be alive. There is no reason to pass as fit for human consumption meat which may merely show one or two degenerated measles." He continued:—" It is important to examine any groups of calcified measles very carefully, since one may frequently find a perfectly normal and viable *cysticercus* in the area covered by the calcified cysts."

It is, therefore, right to assume that any cases showing only degenerated measles in the standard routine incisions, may, nevertheless, have some living *cysticerci* elsewhere in the carcass. For that reason we made no attempt at the Bloemfontein abattoir to record separately the actual number of cases showing degenerated cysts and the number showing only apparently viable cysts. I agree with the views expressed by Van der Slooten that it is of no importance as to whether cysts found are dead or viable.

In the 25 heavily infested carcasses which were closely studied, the measles were all viable. Those carcasses were specially used for viability tests after various periods of freezing, and superficial measles were, in each case, tested by Keller's simulating infection

test for viability, before the carcasses were frozen. It is a remarkable fact that from 1st May to 31st December, 1936, only two carcasses, which were totally condemned, were not so used, owing to only degenerated measles having been found in the inspection incisions.

During 1936, however, my attention was drawn to four measly carcasses in which we found both degenerated and apparently viable *cysticerci*. These were the only four cases which we observed, but there were probably several more.

The process of degeneration, namely the progressive stages of caseation and calcification, is similar to that of *C. cellulosae*. Caseation follows the death of the bladderworm, and is succeeded by the deposit of calcium salts first in the outer capsule and later in the vesicle itself. It has not yet been established how long, under normal circumstances, a mature *cysticercus* will live, before death and progressive degeneration will result. It has been found that *cysticerci* may live in the ox for periods in excess of one year.

In an experimental calf killed 244 days after experimental feeding, Saint-Cyr found only dead cysticerci, the majority of which were in an advanced stage of calcification (Neumann). Simmonds and Cobbold, saw numerous yellow points—chalky deposits, which were dead and calcified *cysticerci* in the muscles of a heifer killed more than a year after the first experimental feeding (Neumann).

Clarenburg (1932) describes his finding a few degenerated *Cysticerci bovis* among numerous (40) living *C. bovis* in an experimental calf killed exactly nine months after the first feeding.

Degenerated or even calcified cysts may be found in the same host with young, viable *cysticerci*, owing to the fact that the particular bovine host may, over various periods of time, have acquired two or more separate infections with *T. saginata* ova.

Daubney (1926) records an interesting fact that has recently been discovered by research, namely that calcification of worm cysts may be greatly accelerated by a course of treatment with the calcifying vitamin, vitamin D, which is present in codliver oil and other fish oils. It is necessary to administer the oil every alternate day for a period of a few weeks, and one must give an overdose, which does not leave a great margin of safety.

This method, mentioned by Daubney, may be of academic and scientific interest, but it will not be of much use in practice.

1. Measles cannot be diagnosed clinically.
2. Serological tests for measles are equally unpractical and non-specific.
3. It would be quite senseless and extremely expensive to treat herds of cattle from areas where the incidence of measles may be high, over a prolonged course. There will only be an effect on the small percentage of measly bovines, which may then be assisted towards more rapid calcification of those measles, and the calcified measles may or may not, later, be detected at the abattoir.

Very interesting research on the subject of immunity of cattle to *Cysticercus bovis* was recently done by Penfold, Penfold and Phillips in Australia. These authors describe their findings in the *Medical Journal of Australia* 1 (13) pp. 417-423 (1936). They refer to a survey by Clapham (1933) on immunity to helminths, and if her survey is complete " only one instance of immunity to the larval stage of cestodes has been proved." The writers and Clapham refer to the work of Miller and Massie (1932), who have shown that the albino rat can be immunized against *Cysticercus fasciolaris*, the larval stage of *Taenia taeniaeformis of* the cat. The writers also refer to immunity to adult cestodes, as worked on by Turner, Berberian and Dennis (1932-33), which work has " probably great practical possibilities in preventing hydatid in man and other animals."

Penfold and his co-workers artificially infested 88 oxen with *Taenia saginata*. These oxen all developed *C. bovis*, that is none were immune. The workers therefore assumed that thirty oxen, acquired from the same parts were also free from infection at the time of commencement of their experiments, since the incidence of infection in Victoria was very low, other than in cattle which had been grazed on a sewage farm. These thirty cattle were drenched with 400,000 *Taenia saginata* eggs (carefully counted), and Penfold and co-workers estimated that 11,000 to 30,000 *cysticerci* developed in each ox. In this way they studied the rate of degeneration, and absorption of the measles. In these heavily infested oxen no live *cysticerci* were found that were older than nine months and *cysticerci* older than seven months were seldom found. " Almost all cysts ten months old or more had contents which were dry dirty yellow and hard, but they were never so hard that they could not be crumbled between the finger and the thumb. The young degenerated cysts of recent infestations had moist green pasty contents."

Penfold and co-workers then drenched three oxen with 400,000 viable *Taenia saginata* ova. A fourth ox from the same batch was not drenched and the four (three artificially infested and one not infested) were depastured on non-contaminated land for fifty-three weeks and five days. After that time, i.e., 30.1.1935 two of the already infected (drenched) oxen, and the undrenched ox were given a drench containing 400,000 *Taenia saginata* ova. All four oxen were slaughtered on 17.4.1935, that is eleven weeks after the second drenching (30.1.35), or sixty-five weeks after the first drenching. The originally undrenched ox showed definite evidence of a recently acquired infestation, that is, as the result of the drenching on 30.1.35. Only about one in every hundred measles were still alive, which the authors said " was quite consistent with an infestation of only eleven weeks of age."

The ox which was not drenched the second time, that is on 30.1.35, showed a recovery of the primary infestation of sixty-five weeks' duration. Only two dead *cysticerci* were found in the whole carcass, and these were approximately one millimetre in the widest diameter. The other two oxen, namely those which had undergone two drenchings at fifty-four weeks' intervals were found to have almost recovered from the original infestation, and immune to the second infestation, i.e. after sixty-five weeks. Experiments were

then similarly repeated to determine whether immunity still remained seventy weeks after the cattle were artificially infested. They found the same results, and concluded that "at least some oxen, seventy weeks after being heavily infested with *Cysticercus bovis*, are immune to further infestation; two oxen showed no significant signs of a very heavy primary infestation of seventy-nine weeks duration."

In discussing the practical application of their immunity tests, Penfold, Penfold and Phillips state: "If a live vaccine were to be used and the cattle given the disease, it would be advisable to determine the following: (i) the minimum dose of eggs required to produce a solid immunity; (ii) the stages at which the immunity develops and when it disappears, if at all; (iii) the age at which all cysts die when cattle are given the minimum immunizing dose; (iv) the time necessary for all cysts to be absorbed in cattle immunized with the minimum immunizing dose."

The authors suggest that immunity probably shows itself in two ways. First, as it develops as a result of the primary infestation it kills these primary immunizing *cysticerci*. Secondly, having developed, it prevents the eggs subsequently ingested from developing into *cysticerci*. As the immunity is probably quantitative, cysts may possibly take longer to die and, therefore, to be absorbed, if only a few are present.

Symptoms and Diagnosis of Cysticercosis Bovis.

Clinical symptoms of cysticercosis in bovines are even more rare than in porcine cysticercosis. Manual examination of the tongue has almost invariably led to negative results. Neumann, however, quotes J. Fleming, who stated that the *cysticerci* may be recognised by examining the tongue, on the lower surface and sides of which they form more or less salient projections, which roll under the finger when pressed upon. Fleming went further and stated that he found on the side of a tongue the largest *cysticercus* he ever encountered, nearly 4 cm. long! It is extremely doubtful if Fleming was actually dealing with *C. bovis*.

After artificial infection, when large numbers of proglottides and ova have been fed to the subject, clinical symptoms may, however, appear. The severe results on the host, in Leuckart's artificial infections of calves were mentioned in Part I of this work. Most of the workers who confirmed Leuckart's experiments, observed clinical symptoms in their subjects. Masse and Pourquier noticed that their experimental calf became greatly emaciated, after showing signs of illness. Zurn's calf showed a temperature of 40° C., rapid pulse, tympanites, emaciation and difficulty in rising. After the calf died Zurn found that infestation was generalised, but the heart was particularly heavily infested. (Neumann.)

Hutyra and Marek mention that Ciga noticed severe cysticercal lameness in an ox. Schmidt found a cyst in the anterior chamber of the eye of a bovine. Ottele noticed high temperature, rapid pulse, laboured breathing and intense itching of the head in a 10 years old cow, as the result of *cysticerci*.

Zwijnenberg (1920) recorded a case in a cow, which showed the following clinical symptoms. The temperature was 41° C., frequent pulse, irregular and hardly perceptible. Appetite was diminished, peristalsis normal in quantity, but slightly intensive; rumination was irregular and totally absent from time to time; faeces normal in consistency; salivation light. Milk was withdrawn. At first he suspected foot and mouth disease, which existed in the neighbourhood. After a few days he ruled foot and mouth disease out of the question, but diagnosed septic myocarditis, on account of the cardiac symptoms. At the request of the owner he, nevertheless, treated the animal on rational lines, without success. After four more days he noticed further complications, e.g. photophobia, severe lachrymation, hypopyon. Eventually the owner agreed to the destruction of the cow. On autopsy Zwijnenberg noticed that the large muscle groups were " sowed " with gray cysts the size of peas. These were also found in the masticatory muscles, the heart, lungs, kidneys, salivary glands and the udder. In the myocardium alone, Zwijnenberg found some sixty cysticerci. Microscopical examination proved definitely the diagnosis of *Cysticerci bovis*.

An interesting case of cerebral *Cysticercus bovis*, complicated with generalized tuberculosis was related by Hoefnagel (1923). He stated early in 1923 a bovine from the district was brought to the Utrecht (Holland) abattoir. Before slaughter it was noticed that the beast had an " unsteady " gait. Furthermore, the animal persisted in moving forwards with the head high. After slaughter it was seen that the bovine had a generalized tuberculosis, lesions being particularly found in the lungs and pleura, and also many small tubercles in the pia mater. He was greatly astonished, when he examined the brain more closely to find a live and viable *Cysticercus bovis* in the *pedunculus cerebri*. He then examined the carcass more minutely for further *cysticerci*, but found no more cysts. It is not likely that the presence of the single *C. bovis* in the brain was responsible for the peculiar symptoms, nor did Hoefnagel suggest that this was the case.

Serological tests have been tried in bovines, but in general they have not been considered to be specific. Clarenburg (1932) records a successful complement fixation test on an experimental calf. As antigen he used an alcoholic extract of *T. saginata*. During the first month of artificially infecting his calf he obtained a positive reaction, whereas negative reactions were obtained with the blood sera of all non-infected calves.

The diagnosis of *C. bovis* is comparatively easily made on meat inspection. Like in the case of *C. cellulosae*, the following conditions may, occasionally, be mistaken for *C. bovis*, in the degenerated state especially.

1. *Cysticercus tenuicollis*. Armed *cysticercus*. (See differential diagnosis of *C. cellulosae*.)
2. *Echinococcus cysts*. (See differentiation diagnosis of *C. cellulosae*.)
3. *Sarcocystis blanchardi*. [See differential diagonsis *C. cellulosae*, sarcosporidia (*S. miescheriana*).]

4. Actinomycotic nodules. (See differential diagnosis *C. cellulosae.*)

5. Small tubercules. (See differential diagnosis *C. cellulosae.*)

The living *C. bovis* can hardly be mistaken for any other parasite, especially if the scolex is examined microscopically. The four suckers and the absence of a rostellum and hooklets are the most notable features. Also note the calcareous corpuscles, characteristic of tapeworm tissue.

Cysticercosis in Calves.

The incidence of *Cysticercus bovis* in calves is not high in South Africa, judging from observations at our abattoirs. The extent of infection may, of course, be considerably higher than is anticipated, due mainly, it is believed, to the fact that calves are seldom slaughtered after six weeks old. Then again, South Africa is not, to any extent, a veal consuming country.

From the two principal abattoirs of Natal, however, quite startling reports of the incidence of *C. bovis* among calves have been forwarded.

The Manager of the Pietermaritzburg abattoir writes:—

> "An aspect of measles infection which is puzzling, is the number of calves found to be infected. I sometimes wonder whether this may not be due to the fact that while cows are driven to their grazing ground away from human habitations, the calves are kept back and often allowed to wander about in the vicinity of the native quarters, etc. The following figures show the number found to be infected at this abattoir during the past five years."

Maritzburg Abattoir, Incidence of C. bovis *in Calves.*

Year.	Calves slaughtered.	Number infested.	Percentage.
1931–32	559	31	5·54
1932–33	552	34	6·15
1933–34	670	37	5·52
1934–35	624	28	4·48
1935–36	673	47	6·98

Mr. W. A. Dykins, M.R.C.V.S., Director, Municipal Abattoir, Durban writes:—

> "We deal with about 5,000 calves per annum, and I would say that 2 per cent. are infected with these lesions (measles), but odd consignments show almost 100 per cent. infection."

In Kimberley slaughter of calves takes place between the ages of six to twelve weeks. Although a strict watch has been kept, no trace of *C. bovis* has been found among calves.

The Superintendent of the East London abattoir reports:—

> "No case has been observed in this abattoir since it was opened; the reason for this may be the fact that calves slaughtered here are very seldom older than seven to ten days."

In Port Elizabeth and in Cape Town no cases of *C. bovis* have been found in calves under six months old. Similarly, during two and a half years' close inspection at Bloemfontein, we found no cases.

In Pretoria only two cases of *C. bovis* were observed in calves, during the past five years.

Col. J. Irvine-Smith, M.R.C.V.S., supplies the following table, which shows the very light incidence of cysticercosis in calves at the Johannesburg abattoir.

Year.	Number slaughtered.	Number infected.	Percentage.
1931–32	12,585	9	0·072
1932–33	12,999	5	0·038
1933–34	14,941	15	0·100
1934–35	15,538	5	0·032
1935–36	16,763	3	0·018

It will thus be seen that the recorded incidence of *C. bovis* is extremely low in calves in the Union of South Africa, with the exception of Natal, where it is remarkably high. No information on this subject was sought from the smaller abattoirs, where the amount of veal slaughtered would be very small, and the incidence of measles in calves would be, presumably, negligible.

The incidence of *C. bovis* in calves is very high in Kenya Colony. At the Nairobi abattoir in 1935, 94 calves were condemned for *C. bovis* out of 537 slaughtered. (17·5 per cent.)

Writing from Kenya, Daubney (1936) has shown that hand-reared calves have frequently been infected from the hands of attendants who have carried *T. saginata*. Ova of the *Taenia* can very easily obtain lodgment under the finger nails of an infected person, and thus be conveyed directly into the calf's mouth, in hand-rearing.

In Europe, measles are commonly found in calves. In several countries the statistics show comparatively high infestations.

In Holland during 1930, the following percentages measles were recorded:—

The Hague ... ... 1·58% in "grazing calves" (*graskalveren*).

Amsterdam ... ... 0·04% in "fat" calves (*vette kalveren*).

(Reference: *Tijdschr. v. Diergeneesk.*, 59, *p.* 51.)

Leiden ... ... Living *C. bovis* in 1 "grazing" calf.
Dead *C. bovis* in 10 "grazing" calves.

For the years 1933 and 1934, Professor C. F. van Oijen of Utrecht supplied the following information:—

	Infections 1933.	*Infections* 1934.
"Grazing" calves	796	984
"Fat" calves	19	16

Rheeden ... ... In 1934 1 "fat" calf was infected.

Arnhem ... ... 6 "grazing" calves (2·3%) and 1 "fat" calf were infected.

Utrecht... ... ... 67 "grazing" calves were infected.

Apeldoorn ... ... 4 calves were infected.

Amsterdam:

1st quarter: "Grazing" calves, 0 living; 5 cases or 0·4% dead measles.

2nd quarter: "Grazing" calves, 1 case living measles: 0·28%.

3rd quarter: "Grazing" calves, 2 cases living measles: 0·2%, and 3 cases dead measles: 0·3%.

4th quarter: "Grazing" calves, 9 cases living measles: 0·59%, and 30 cases dead measles: 1·9%.

Nijmegen ... ... (1935) (Reference *Tijdschr. v. Diergeneesk*, 63 (19). 2 out of 2,929 "grazing" calves measly (pp. 1135-36.)

Leeuwaarden ... ... (Reference, *Idem*, pp. 1135-36.) (1935) 60 calves (1·49%) measly.

For Denmark, Elvinge (1929) gives a summary of infestation in calves, in the abattoir at Odense:—

1927: 0·32% calves showed degenerated measles, 0·12% live measles.

1928: 0·58% calves showed degenerated measles, 0·14% live measles.

1929: 0·91% calves showed degenerated measles, 0·20% live measles.

Elvinge notes that the incidence of measles in calves was increasing. The average for the three years was 0·72 per cent., whereas in 1922 it was only 0·06 per cent.

According to Dickoff (1931) the incidence of *C. bovis* was very high in Bulgaria among calves, at that time. In the District of Schumen it was 5·8 per cent. The high percentage among calves could be attributed to the fact that calves were allowed to wander about the farm-yard, and easily picked up human excretum, since few Bulgarian farms had W.C. accommodation.

According to Nakanishi (1926), the incidence of *C. bovis* in calves was 37·5 per cent. in Korea. Nakanishi found 153 calves out of 408 to be infected.

Dr. Mohler, Chief of the Bureau of Animal Industry, United States Department of Agriculture, kindly supplied statistics which showed a very low incidence of *C. bovis* in calves in the United

States for the period 1926 to 1935, inclusive. According to these statistics, the average infection is about 20 per annum, out of approximately five million calves slaughtered.

A Review of a few Case Records of Cysticercosis in Calves.

Sandig (1924), Haas (1928) and other writers recorded cases of intra-uterine infection in calves.

Haas (1928) described a case of generalized measles in a calf, three weeks old. He found quite a number of cysts in the lungs, of which quite a few were transparent, while others were hardened in a capsule, which, if incised gave forth a yellowish fluid. In some there " was even a caseous mass ". The cysts were slightly smaller than a pea. Apart from the lungs, Haas also found measles in all skeletal muscles, the heart and in the external and internal masticatory muscles. The opinion of the authorities at the Veterinary School at Albert was to the effect that infection must have been intra-uterine.

Brügemann (1928) found a case of generalized measles in a calf four weeks old. Apart from the heart, measles were found in the abdominal muscles, internal masticatory muscles, external masticatory muscles, shoulder muscles, etc. Altogether Brügemann found about 200 measles in this case. The calf was fed on milk only, in the stable.

Holtz (1929) found two cases of cysticercosis in " fat " calves, closely after each other, although up till then such cases had seldom been found. In the first case, a calf about 10 weeks old, he found cysts in the heart and in the pillars of the diaphragm. In the second case, encountered 8 days after the first, he again found several *cysticerci* (both viable and degenerated). Holtz discovered that both calves came from the same farmer, from whom he instituted enquiries. The calves were kept in a stable and fed on milk. This particular farmer had been treated for *Taenia saginata* four years previously. On the farm a water-closet was used, which emptied its contents onto the lands. Holtz came to the conclusion that the milk bucket, which had been used for the feeding of the calves, must have been rinsed in the water furrow which conveyed the deposits from the W.C., and that thus segments or ova must have reached the calves.

Dräger (1929) found a nine weeks old " fat " calf heavily infested. The measles varied in size from that of a wheat seed to that of a pea. Most of them were dead, but quite a few were alive. Dräger mentioned that this case somewhat contradicted the old view that only in old measles would degeneration occur.

De Vries (1930) at Haarlem, found a heavily infested " fat " calf, four months old, and mentioned that he had found one the year before, as well. Up to that time measles in " fat " calves was considered a rare condition. In both calves he found the heart heavily infested, but all measles were of the same size and were more or less uniformly distributed throughout the musculature. The specimens were about 5 mm. in size, and were, therefore, not quite full grown.

Messner (1931) described a few cases of *C. bovis* in three weeks old calves, the nature of which led him to believe that the cause of the heavy infestation could only have been due to direct infection from a *Taenia saginata* carrier. Infection could have been carried over in milk-pails, or through the carrier's fingers causing contact with the calves' mouths.

(It is improbable that more than one calf would, coincidentally, be infected intra-uterine from different mothers. The fact that the calves were only three weeks old, and that a heavy infestation was actually visible, makes one believe that infection *might* have been intra-uterine, since beef measles are usually observed at 6 weeks in meat inspection.)

Some of the sources of infection in calves have been mentioned in the foregoing review of case histories.

It might be mentioned that the South African counterpart of the Dutch " graskalf ", or " grazing " calf is seldom slaughtered at our abattoirs. Usually sucking bull calves are slaughtered at periods from a few weeks old to about four months old. If calves are weaned and turned out to graze, their ultimate destinies are usually those of milk cows, or in the case of males, those of trek oxen, or ranch oxen, and eventually they may reach the abattoir, in a fairly advanced adult stage. Hence, we are more liable to find infection in a small percentage of cases in sucking calves, and in the great bulk of cases in full grown animals.

As a summary, the origin of infection in young calves in South Africa may be ascribed to the following factors:—

1. Direct infection from a tapeworm carrier. This, one should imagine, is a fairly common source of infection in South Africa. Native attendants, by coaxing calves in cases of hand-rearing, may easily convey infection by ova on their fingers, direct into the calves' mounths.
2. Isolated cases, such as the case described by Holtz in Holland, in which drinking utensils might have come into contact with ova or proglottides voided by a carrier.
3. Deliberate defaecation in calf kraals, by carriers. This factor needs little elaboration upon. Native servants on farms will readily use, equally, a pig sty, cattle kraal, a stable or a calf kraal for defaecation.
4. In native habitations in South Africa, it is the usual practice to drive cows away from the *stads* or kraals during the day, to their grazing. Calves remain behind and pick up whatever " succulent " material they possibly can find around the huts. The native's sense of hygiene is not over-developed, and frequently he uses the rear of his hut, or the kraal itself, to relieve himself. Either the fowl, the pig or the calf acts as a scavenger. The Superintendent of the Pietermaritzburg abattoir considers this the most probable source of infection in Natal.

Environment and physical conditions play a large part in the natural mode of infection of the adult bovine.

Whereas in Europe and in some parts of Asia (e.g., Bali) floods must be considered as the premier disseminators of *Taenia saginata* eggs, it is felt that in South Africa these factors are less responsible. In fact, some abattoir observers believe that measles is far more frequently encountered during, or just after severe droughts. During the severe droughts, such as those we experienced in South Africa in 1933 and several years previously, natural grazing was reduced to a minimum, and the probability that bovines would freely ingest human excretum was greater.

Theoretically and practically it is accepted that moisture is the most important factor in the viability of all helminth ova. On the other hand, it has not yet been established how long a pasture will remain infective with *taenia* ova; what amount of drought the *T. saginata* ova will withstand, and whether bovines can freely become infected when grazing on pastures under conditions of drought. The present writer does not hold a somewhat dogmatic view that the *T. saginata* ova can necessarily withstand excessive drought ,and that grazing on drought-stricken veld is more likely to cause infection than on green, rain-soaked pasturage. The latter condition will certainly maintain the vitality of the ova.

I am, however, of the convinced opinion that in South Africa cattle will more readily ingest human excretum during times of drought, than during periods of plenty.

It will be noticed in the map and survey of the incidence of measles in Part II of this work, that the incidence of measles is relatively much lower in those areas, e.g., the Vryburg District, where wide open ranges exist as cattle runs, under ranching conditions, than in the areas where cattle are customarily brought in to human habitations at night. Under such ranching conditions, even in times of drought, there is more available grazing and less opportunity for contact with groups of humans. It may be possible that any *Taenia saginata* ova will die off quickly on such ranges, unless, of course, the humanly deposited faeces are ingested soon after excretion. The chances that human excretum will be ingested by bovines are, therefore, considerably less on vast cattle runs.

Conditions of drought leading to the ready ingestion of human excretum are of greater importance close to human habitations. This is particularly noticeable in areas occupied by natives, for example in our Native Reserves, where all land is " common property " and unfenced and consequently badly " trodden out ". Most natives in the Reserves bring their stock to cattle-posts at night. The cattle are kraaled overnight and let out early next morning. Having been kraaled without food during the night, the hungry bovines (herds consisting of milk cows, dry cows, numerous bulls and tollies, all mixed) will snatch up whatever " luscious-looking " material may be lying about the *stad*, and this frequently contains human excretum. Often some green grass may grow in the vicinity of water-holes at the

cattle-posts, and any bush or grassy cover near these water-holes is used by the herd boys and women water-carriers for defaecation. As a rule this will be the only grass available near the *stad*, which is generally trodden quite bare. The African native will defaecate anywhere within his *stad*, his cattle kraal, close to his water-holes or on the nearest fringe of bush surrounding the *stad* or the cattle-post. It can be assured that he will not go much beyond the first fringe of bush.

According to older writers, Leuckart, Neumann and others, in Abyssinia, where a very high incidence of *C. bovis* formerly existed, and where the incidence of *T. saginata* was almost 100 per cent. among the natives, very similar conditions existed. The hygienic customs of the African natives are similar from the Cape to the North Coast of Africa. Their primitive methods of cattle husbandry are also, more or less, uniform throughout the African Continent. Thus, Daubney (1936) relates an almost identical source of infection in Kenya. He writes that experience shows that in Kenya measles infestation is contracted largely in the neighbourhood of the homestead buildings, or at other places where natives are concentrated. Night *bomas* (the equivalent of our kraals) are frequently constructed near the homestead and are semi-permanent structures, complete with one or two mud huts of the Masai type, in which the herds and their families sleep. Any grass or bush in the immediate neighbourhood of the *boma* is used as cover by the natives during defaecation, "until eventually the whole area becomes heavily contaminated with viable tapeworm eggs." Each morning the cattle leave the *boma*, and after having been shut up all night without food, they eagerly snatch up a few mouthfuls of grass immediately they leave the enclosure. "It is here that most infestations are contracted; wide ranges for grazing during the day considerably reduces their chances of picking up eggs voided by one or two native herds."

Dr. Mönnig, at the International Hygiene Conference at Johannesburg in 1936, correctly referred to the fact that whilst man in civilised communities has done almost everything in his power to safeguard his own person from contraction of *T. saginata* and *T solium*, through the agencies of meat inspection, very little has been done in the way of educating the farmer and the native in safeguarding his bovine or his pig from the converse infection. "We know little about the viability of tapeworm eggs under natural conditions, how long a pasture may remain infected, and by what agencies (flies, dungbeetles, birds, etc.), tapeworm eggs may be spread." (Mönnig, 1936.)

The Manager of the Pietermaritzburg abattoir supports my view that times of drought are the most favourable for the natural ingestion of tapeworm eggs, by the bovine. He writes (27th October, 1936):—"I believe that a drought has the effect of increasing the number of animals to be found infected with measles. This may be attributed to the fact that animals are forced, through shortage of food, into grazing in areas adjacent to native kraals, etc., where they would not graze in normal times. An increase in the percentage of cattle infected has been noticeable at this abattoir during periods of drought in the past."

(One of the local butchers, who at one time was a big loser through condemnations of beef carcasses for measles, recently, in conversation informed me that during the great drought of 1933 he actually saw cattle eating human excretum in the Thaba 'Nchu Native Reserve, where, at that time, not a blade of grass was to be seen.)

In other parts of Africa, e.g., in Senegal, Teppaz (1923) states that at Dakar he observed more cases of measles among lean cachetic cattle than among stock in good condition. Teppaz also mentions that he ascribes the high percentage of cases in cattle in Senegal to the fact that the Senegalese graze their cattle on the excretum dumps of the towns, where little grass grows, and cattle are compelled to gnaw the ground. It would appear that the Senegalese use any unfenced ground for defaecation.

From Asia Minor, Valade (1927) records that the sanitary customs of the Syrians are equally disgusting. Human excretum is dumped at random around the towns.

In South Africa there have been no records that *C. bovis* has been contracted on sewage farm pastures. In some other countries mild outbreaks of *C. bovis* have been recorded, as a result of pasturage on sewage farms. The only outbreaks of *C. bovis* infection, of any importance, in Australia occurred a few years ago among cattle which had been pastured on the Werribee sewage farm in Victoria. According to Mr. J. Drabble, B.V.Sc., Veterinary Officer in charge of meat inspection at the New South Wales State Abattoir, when the outbreak at Werribee was reported in the Press, the public of Victoria refused to buy beef. This caused a good deal of consternation among cattle owners, and the Government had to assure the public that cattle from the sewage farm would, in future, be slaughtered and utilized for purposes other than human consumption.

In Germany and in Holland there appears to be a good deal of difference of opinion as to whether pasturage on sewage contaminated lands (including the feeding of cattle with hay and other fodder grown on such lands), or whether pasturage on flood-water lands is the greater danger of infection of bovines with *C. bovis*. Among writers who held the opinion that sewage contaminated pasturage was the greater danger were Zwijnenberg (1920), K. Müller (1927), Wernery (1931), Krueger (1934 and 1935), and also Dr. Müssemeier of Berlin. Among those who favoured the opinion that flood waters disseminated *taenia* ova and thus greatly contaminated grazing were Profè and also Prof. C. F. van Oijen of Utrecht.

Dr. Müssemeier of Berlin, in a personal letter (15.12.36) expressed the opinion that the feeding of bovines on hay and other cattle-fodders grown on *Rieselfeldern* was the greatest source of infection in Germany. He defined the term "*Rieselfeldern*" as "those lands which are flooded with city drainage waters (*Abwässern*), which may even contain human faeces." (In other words sewage contaminated lands.)

Zwijnenberg (1920) was of opinion that the increase in the number of cases of cysticercosis in bovines in Holland and in Germany since the Great War, could be attributed to the greater amount of human faeces which were at times used for manuring grazing lands, owing to the shortage of fertilizer.

K. Müller (1927) pointed out the risk of depositing human excretum on grazing lands. Lands used for depositing human faeces should only be used for agricultural purposes. Another source of infection in Müller's opinion was the habit of some farmers to defaecate in stables.

Wernery (1931) believed that the spreading of measles resulted mainly from the grazing of cattle on lands used by humans for defaecation, or on lands on which faeces were deposited.

Krueger (1934) expressed the opinion that the chief source of infection of bovines was the grazing on lands contaminated with sewage (*Rieselfeldern*), or the feeding of stock with hay, grass and other food-stuffs grown on such lands. He mentioned that in Kottbus 190 tapeworm carriers were receiving medical attention, and that 2 per cent. of all cattle slaughtered in Kottbus were found infected with cysticercosis. Later (1935), after Profè had attacked his views, Krueger reiterated his previous remarks, and stressed the point that grass from *Rieselfeldern* was twice as effective in spreading *T. saginata* ova and thus infecting cattle with *C. bovis* as other green fodder in Kottbus.

Against the opinions expressed by Krueger, Profè (1934) wrote. He somewhat severely criticised Krueger's opinion, and maintained that Krueger had not cited sufficient proof that the Kottbus cattle were infected through grazing on the *Rieselfeldern*, or from fodder grown on such lands. Profè was of opinion that far more tapeworm eggs were conveyed in flood-waters from streams which covered grazing lands.

Prof. C. F. van Oijen informed the present writer (13/10/36) that he ascribed one of the main reasons for the large percentages of cases of *C. bovis* at some of the Dutch abattoirs, e.g. Rheeden, Arnhem, Amersfoort and Haarlem, to the fact that they were situated on, or close to, some of the large rivers. He wrote as follows:—

> "One can imagine that the water of the Rhine will become heavily infected with *taenia* eggs in the densely populated industrial areas of Germany. The Rhine-water floods the grazing of the parts where many of the stock slaughtered in the above-mentioned towns come from. In the event of the eggs not dying off (*niet te gronde gaan*), the chances of infection for these cattle are much higher. We have confirmed the bacteriological contamination of the Rhine-water by the mentioned industrial areas, deeply into our territory. It is, therefore, also probable that the *taenia* eggs may arrive quite viable, although we have no actual proofs to that effect."

Watkins-Pitchford (1923) was at least one South African writer who favoured the probability that flood waters could be considered the main disseminators of cysticercosis infection. His opinion is strongly supported by the fairly heavy incidence of measles at some of our South African abattoirs, which draw their slaughter-stock from coastal native areas (see Incidence Survey, figures for Kingwilliamstown, East London, Fort Beaufort and Port Elizabeth). Watkins-Pitchford, quoting from the Annual Report of the Director of the

Johannesburg Abattoir for the year 1922, stated:—" Bovine infestation varies according to the districts from which cattle are received: cattle from coastal areas show a greater percentage of infestation than cattle from inland districts. This peculiarity is doubtless to be attributed to the relative dampness of the pasturage and greater frequency of streams—factors which facilitate the survival and distribution of the segments and ova of the worms when passed in human faeces ".

Le Coultre (1928) attributes the very high incidence of *C. bovis* on the Balinese *sawahs* to flooding conditions. *Sawahs* are lands (rice, maize, ground-nuts, etc.) which are irrigated from the streams by ordinary damming and flooding. Le Coultre mentions the possibility that one or two tapeworm carriers in the mountains may, by defaecating in the streams, cause thousands of *taenia* eggs to be disseminated over the *sawahs*. After the harvest of the crops it is customary to graze stock on some *sawahs*. Under other circumstances stock (including cows) are used for cultivation while the crops are growing, and what little grazing they obtain, they do on the *sawahs*.

Lievré (1933) attributes the occasional heavy infestations of individual cattle in France to the ingestion of complete segments in human stools passed in stables, on grazing lands, etc.

Nielsen (1935) expresses the opinion that bovine infestations in Denmark are most frequently acquired in summer, but he cannot attribute any direct cause for that.

To summarize, the present writer is of opinion that the main source of infestation in South Africa is the native's insanitary customs. Conditions of drought undoubtedly play an important part in the propagation of this parasitic species, in so far as that under such conditions, especially in the badly trodden-out Native Reserves, hardly a blade of grass may survive in the veld. Native cattle then frequently remain in the vicinity of the *stad*, where they may still find morsels of food, whereas out of the drought-stricken veld nothing is to be found. These morsels of food frequently consist entirely of human dejecta.

On large open ranges the probability that the bovine will ingest human excretum is much less.

In the interior of the Union streams play little or no part in the propagation of *taenia* ova, since, in general, our interior streams consist of dry sandy spruits, which, more frequently than not run only after heavy rains. A greater danger, from this source, in the present writer's opinion is that on occasion a *taenia* carrier may defaecate into, or on the edge of pools (*kuile*) of standing, sometimes stagnant, water in these *spruits*. Such contaminated water may then be an important source of infection to the bovine, especially if cattle use the pools for drinking. It is extremely doubtful if flood waters are as important in South Africa, as they are claimed to be in Europe, in dissemination of cysticercosis. When our South African rivers come down in flood, the huge volume of water generally flows swiftly, between the very steep banks of our rivers. Very rarely is the country

so flat that the banks are simply flooded over, and that adjoining grazing is very much affected. Direct contamination of confined areas of grazing, kraals, drinking places and occasional shortage of food are the main source of infection in South Africa.

PART IV.

A. The Judgment of Measly Carcasses.

In many countries in which the incidence of *Cysticercus bovis* is low, it is customary to condemn a measly carcass, irrespective of whether only a single measle, which may even be degenerated, or many measles may be found in the inspection incisions. In some other countries with a relatively high incidence of beef measles, it has been considered wilful waste to condemn lightly infested carcasses outright. Ways and means of sterilising such lightly infested carcasses have been found, so that after various modes of treatment the infested carcasses have been considered, or even rendered, fit for human consumption. These various methods of sterilisation, and the time required for the treatment of the carcass according to whatever method may be employed, have been based upon the results of tests for the viability of measles subjected to the various processes.

With regard to *Cysticercus cellulosae*, it has been customary in many countries to condemn measly pig carcasses outright, no matter how light the infestation of the carcasses may be. This somewhat severe judgment, it is supposed, has been based on some of the erroneous opinions of many of the older writers who considered, e.g., that the pig measle was not destroyed by freezing, or correctly so, that the older chilling method of sterilisation had comparatively little effect on the *C. cellulosae*.

Furthermore, it was considered uneconomical to treat measly pork carcasses for definite (formerly prolonged), periods in freezing chambers. The last named is probably the reason why few abattoirs in South Africa encourage the treatment by freezing of measly pork carcasses.

Judgment of Measly Carcasses in Great Britain.

According to Leighton (1927) amongst the English recommendations are:—

Section V.—Instructions as to the action to be taken in the event of evidence of other disease being found in carcasses of bovines, swine, etc. (other than tuberculosis).

A. The entire carcass and all the organs shall be condemned if evidence of any of the following conditions is found:—

(Amongst others):

6. *Cysticercus bovis* (measly beef), if generalized in the meat substance.

7. *Cysticercus cellulosae* (measly pork), if generalized in the meat substance.

With regard to the judgment of measly carcasses in Scotland, Leighton (1924) quotes:—

> "In the event of evidence of *Cysticercus bovis* (beef measles) being found in a carcass and/or in a head, the carcass and/or the head may be passed for human consumption provided that they are placed in cold storage at a temperature not higher than 20° Fahrenheit, for a period of at least three weeks, or, alternatively, they shall be seized." The Section is, of course, devised to permit of saving such measly carcasses slaughtered at abattoirs where suitable refrigeration is available, since it is believed that a temperature of 20° F. for three weeks is lethal to the *Cysticercus bovis*.

Section A of Part V of the Scotland Meat Regulations (1924) provides that the entire carcass and all the viscera of pigs infected with *Cysticercus cellulosae* shall be condemned.

The Judgment of Measly Carcasses in Germany.

In the fourth (English) edition of his "Handbook of Meat Inspection", von Ostertag (1913) gives the following official Regulations concerning the method of procedure with measly hogs up till that time.

For the Kingdom of Prussia, the following Ordinance was passed on February 16th, 1876:—

"1. That fat obtained from measly hogs by rendering or cooking may be utilized unconditionally, but that lean meat can only be admitted for sale or for use in one's own household in cases where it is only slightly infested with *cysticerci* and is thoroughly boiled under police supervision after having been previously cut up. (According to a decision of the Second Criminal Senate of the Imperial Court, March 25th, 1884 (p. 106), the rendered fat of measly hogs is to be sold under declaration.—von Ostertag).

2. That no objection whatever, from a sanitary police standpoint can be raised against the use of suitable parts of measly hogs in the preparation of soap or glue, or against the free utilization of the skin and bristles, and the chemical utilization of the whole body, and that these uses are to be permitted without hesitation."

3. That in all cases in which hogs are found to be badly infested with *cysticerci*, care must be exercised by the police to secure the certain destruction of the carcass, after this has been utilized as far as possible.

With reference to the utilization of viscera free from *cysticerci*, a decree of the Ministeries of the Interior and Education, June 26th, 1883, permits the fat, liver and intestines of hogs found to be measly to be freely admitted to the market as food for man, provided they

have been found, upon examination, to be free from *cysticerci*. Von Ostertag (1913) gives the following Regulations, in accordance with the opinion of the Royal Superior Medical Committee, May 20th, 1882, which were applicable to Bavaria:—

1. The meat of hogs extensively infested with cysticerci is to be withheld from consumption and from the public market and is to be rendered harmless in a suitable manner. In the case of fat hogs, the separation and removal of the bacon is to be allowed at the request of the owner. No objection can be raised to the technical(1) utilization of such animals.
2. In cases where the *cysticerci* occur only sparingly in the meat, it may, according to(2) the opinion of a scientific meat inspector, and after it has been properly cooked under police supervision, be turned over to the owner for use in his own household.

   The owner is to be properly instructed concerning the danger to human health from measly meat and is to be made cognizant of the police regulations concerning the control of such matters.
3. The public sale of meat, slightly infested, is to be permitted in *freibanks* under declaration of the danger from the meat only after it has been properly cooked under police supervision.

In the Kingdom of Saxony, the meat of hogs slightly infested with cysticerci is to be admitted to the market in a cooked or pickled condition, as unmarketable. The fat may be treated by rendering instead of boiling or pickling. The liver, spleen, kidneys, stomach and intestines of measly hogs may be utilized in a raw condition as non-marketable, provided they are found to be free from *cysticerci* by veterinary inspection.

In his work of 1934 von Ostertag gives the following directions for the treatment of pork or meat of other animals (canines) infected with *Cysticercus cellulosae*:—

1. In the dog, the whole carcass is unfit for food.
2. In a mild infestation in swine, the flesh is fit for food when cooked, steamed or pickled but not when chilled or frozen.
3. The fat of infested swine is fit for use.
4. The cooking and steaming of cysticercous pork is sufficient when the innermost parts are grayish-white and there is no red meat juice.

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(1) and(2) The wording is precisely as that of von Ostertag.

(3) It is not clear what is meant by "technical utilization", but it is presumed that von Ostertag interprets the Regulation to mean that the meat of measly hogs may be used as fertilizer, meat meal and for other technical purposes, but not for human consumption.

(2) The wording of this Regulation is not quite clear, but, here again, it is presumed that von Ostertag infers that, if in the opinion of a qualified meat inspector (presumably a veterinarian) the carcass is not too grossly infested, the owner may receive it for his own use, but not for sale.

For measly cattle, in his " Handbook of Meat Inspection ", 1913, von Ostertag states than in the Kingdom of Prussia the method of procedure with the meat of measly cattle was regulated up till 1912 by a ministerial decree of November 18th, 1897, which read as follows:—

> " Since the conditions for the destruction of the beef measle worm have been more accurately determined by detailed investigations, than in the case of the pig measle worm, we have compiled ' the principles for the sanitary police procedure with measly cattle and calves.' While we hereby repeal all previous regulations and order that until further notice, procedure in this case shall be governed according to the principles hereby formulated. We call attention at the same time to the following statements:—
>
> Meat is to be considered well boiled, when a uniform gray colour is observed on a fresh cross section.
>
> The content of salt solution is to be accurately determined or controlled in the preparation of brine, or by means of the alkalimeter.
>
> The pieces to be utilized in pickling shall not be heavier than 2½ Kgm.
>
> Pickled meat is to be kept under police control during the prescribed period.
>
> For the determination of the temperature in cold storage rooms in operation in public abattoirs, tested maximum and minimum thermometers are to be used, and reliable self-registering hygrometers for the determination of the moisture.
>
> The temperature and moisture content of the room are to be taken during the forenoon and evening of each day and to be registered in tabular form.
>
> When properly equipped, cold storage rooms in operation in public abattoirs can be considered as ' suitable '. The district veterinarian, in co-operation with the local police authorities, shall decide in each individual case whether the conditions for the proper treatment of the meat by cooking or hanging are present. The meat of cattle which are only slightly infested with *cysticerci* may be hung in quarters in special apartments under police control; that of calves in a similar condition, without quartering. In a given apartment, only the meat of one or several measly animals slaughtered on different days should be placed in the same apartment, only when the pieces of meat are so stamped that all possible confusion is avoided.
>
> Although it has been demonstrated by previous investigations that decomposition of meat does not take place in cold storage rooms with the required temperatures and moisture content, it should, nevertheless, be determined by a veterinarian after the lapse of 21 days and before the meat is discharged, whether the meat has kept well and is not tainted.

By means of the provision that the meat of animals slightly infested with *cysticerci* and which has been rendered suitable for human consumption, shall be sold only to the consumer or for domestic use, it is intended to prevent commercial middlemen, butchers, sausage makers and hotel keepers from obtaining possession of such meat. If considered necessary, the resale of this meat is to be forbidden under the penalty of law."

Von Osterdag then proceeds to quote the Principles governing the Sanitary Police Procedure with measly cattle and calves: —

According to the number of *cysticerci* found in the routine incisions, distinction is made between—

(*a*) animals with at most ten living *cysticerci*: *slightly infested animals*;

(*b*) animals with more than ten living *cysticerci*: *heavily infested animals*.

For free utilization as human food are admitted—

(1) rendered fat, unconditionally;

(2) the liver, spleen, kidneys, stomach and intestines of animals slightly infested with *cysticerci*, in so far as these organs are found upon veterinary inspection, to be free from *cysticerci*;

(3) animals slightly infested with *cysticerci* in which the *cysticerci* which are found, are according to veterinary opinion, in a condition of complete calcification.

It is permitted to sell meat of animals slightly infested with *cysticerci*, after its dangerous properties have been removed under veterinary supervision, for domestic use, or for sale in special booths, *freibanks*, etc., in pieces not larger than 2½ Kgm., and for sale only to the consumers and under statement of its measly nature.

The necessary treatment required is—

(1) thorough boiling, or,

(2) pickling for twenty-one days in 25 per cent. brine solution, or,

(3) preservation for twenty-one days in suitable cold storage rooms in which a temperature of 3° C. to at most 7° C. prevails, and a moisture content of 70 to at most 75 per cent.

The carcasses of animals badly infested with *cysticerci* are to be utilized for technical purposes, or otherwise rendered innocuous under police supervision.

For the Kingdom of Saxony, von Ostertag (1913) states that the meat of measly cattle, according to Section 5 of the New Regulations, Appendix 6 to Section 16 of the Regulations for carrying out the Saxon Meat Inspection Law (principles underlying the judgment of meat), is to be thoroughly boiled, pickled or refrigerated.

In the Grand Duchy of Baden, the following principles prevailed, prior to 1913 (von Ostertag, 1913):—

1. Meat is to be considered as unfit for food, when the *cysticerci* are present in such number that they are seen on the majority of the cut surfaces in the body musculature.
2. The meat of animals slightly infested with *cysticerci*—that is, animals in which only isolated *cysticerci* occur, except in the muscles of mastication—is to be considered as fit for food, but not marketable, after a previous boiling, pickling or refrigeration for three weeks under police supervision. The temperature in cold storage must not exceed 5° C. If the *cysticerci* are shown to be dead, this procedure is not necessary.
3. The meat of animals in which only isolated *cysticerci* occur in the muscles of mastication is marketable, but in such cases the head is to be treated according to No. 2.

Von Ostertag (1934) gives the following summary of the revised German Regulations for the treatment of beef infested with *C. bovis*:—

1. *Severe Infection.*—Living or dead *cysticerci* found in the majority of the seats of predilection and other muscles after incisions in more than one place; or a watery or discoloured condition of the flesh, without reference to the degree of cysticercous infection.

   Judgment.—The whole carcass is unfit for human consumption, with the following exceptions—fat, liver, spleen, kidneys, stomach, intestines, brain, spinal cord and udders, provided they are free from *cysticerci* after careful inspection, otherwise they are unfit, except the fat.
2. *Mild Infection.*—All cases in which living *cysticerci* are found, excluding cases of severe infection, and cases with watery or discoloured flesh.

   Judgment.—The whole carcass is fit for human consumption when the flesh has been pickled or kept in a cooling or freezing room for 21 days, and the *cysticerci* thereby rendered innocuous. Fat, liver, spleen, kidneys, stomach, intestines, brain, spinal cord and udders are fit, provided they are found free from *cysticerci*; otherwise they are to be treated as other parts of the body.

According to von Ostertag (1934), the following official directions are in force in Germany at present, for the preservation of beef with slight *cysticercus* infection, for twenty-one days in a cooling room or in a freezing chamber:—

A. 1. The meat must be cooled to air temperature and its surface well dried in air before it is placed in the cooling room.
   2. The infected meat must be kept separate, under lock and key, from other meat.
   3. The day of introduction into the cooling room must be clearly marked on each portion of meat.

4. The separate parts or quarters of the animals must be hung so as to be exposed to air on all sides. The abdominal integument must be extended so that it does not lie upon other parts of the flesh.

5. The temperature in the cooling-room must be kept at 0° C. to plus 4° C. The humidity of the air should be:—

   At plus 4° C. not more than 75 per cent.

   At plus 3° C. not more than 78 per cent.

   At plus 2° C. not more than 81 per cent.

   At plus 1° C. not more than 85 per cent.

   At 0° C. not more than 88 per cent.

6. The humidity is to be registered by a self-regulating hygrometer, which must be tested from time to time.

7. Meat which has been kept in the cooling-room for twenty-one days, must not be sent to market till it has been certified by a veterinary inspector as of good quality and free from taint.

B. 1. Before the meat is placed in the freezing-room it must be cooled to air temperature. When a cooling-room is at hand, further cooling to about plus 5° C. is suitable.

   Directions 2, 3, 4 and 7 are the same as for the cooling-room.

5. The average temperature of the freezing-room should be at least −6° C. to −8° C.

6. The frozen meat should not be cut up before thawing, but should be thawed "in the piece". Any mould present on the surface should be removed with a knife before thawing.

   The best temperature for thawing is from plus 5° C. to plus 6° C., and a humidity of 75 per cent.

Buri (1915) proposed a scheme for the judgment of measly beef, applicable to Switzerland, which coincided almost identically with that in use in Germany at that time. In this scheme Buri discriminated between "single measled", "multi-measled" and "heavily measled" bovine carcasses.

(According to von Ostertag, quite a number of workers in Germany and elsewhere, amongst whom were Müller, Noack and Lauff, raised objections to the detention for treatment of "single-measled" carcasses, especially those in which no further *cysticerci* were found after careful search.)

Judgment of Measly Carcasses in Holland.

In Holland, the Netherlands *Vleeschkeuringswet* of 1919 as amended in 1922, prescribed *inter alia*:—

Lightly infected beef carcasses can be passed as fit for human consumption:—

(*a*) After sterilization, and also after the meat has been

(*b*) ten days in a freezing chamber at -10° C., or,

(*c*) has been pickled for three weeks in 20 per cent. salt solution, in pieces of 3 Kgm., or,

(*d*) has been preserved for three weeks in a chilling-room at a maximum temperature of plus 4° C.

For France, Piettre (1922) recommended any of the following modes of treatment of lightly infested measly meat. According to that writer, it would appear that up till 1922 no Regulations existed in France for the treatment of measly meat:—

(*a*) Heating; (*b*) Pickling; (*c*) Freezing; (*d*) Cooling chambers.

Referring to Syria, Valade (1927) recommended:—

(*a*) Total condemnation in cases of generalized cysticercosis.

(*b*) Total condemnation of emaciated carcasses with only a few localized *cysticerci*.

(*c*) Passing of the carcass in those cases in which only one or two measles are found in the predilection sites named by him.

Judgment of Measly Carcasses in the United States.

The United States Bureau of Animal Industry Order 211, Regulation 11, Section 17, is quoted by Edelmann, Mohler and Eichhorn (1934). This Regulation allows the passing for sterilization of carcasses affected with *Cysticercus cellulosae*, but if the infestation is excessive, the carcass is condemned.

Edelmann, Mohler and Eichhorn state that measly carcasses of pork are sterilized by high temperatures and strong brine solutions, but provision for the freezing of measly pork carcasses has not yet been incorporated into the American meat regulations.

> "Meat is considered heavily infested when the measles are found alive or dead in large numbers in areas as large as the palm of the hand, on incising muscles in the favourite locations of the measles. This is the case, as a rule, when in the majority of the cut surfaces more than one measle is found in each section."

The same writers quote the Bureau of Animal Industry (U.S.A.) Order 211, Regulation 11, Section 16, which deals with the judgment of measly beef carcasses:—

> "Carcasses of cattle (including the viscera) infested with tapeworms cysts known as *Cysticercus bovis* shall be condemned if the infestation is excessive, or if the meat is watery or discoloured. Carcasses shall be considered excessively infested if incisions in various parts of the musculature expose on most of the cut surfaces two or more cysts within an area the size of the palm of the hand.
>
> A carcass in which infestation is limited to one dead and degenerated cyst may be passed for food after removal and condemnation of the cyst.

Carcasses of cattle showing a slight or moderate infestation, as determined by a careful examination of the heart, muscles of mastication, tongue, diaphragm and its pillars, and portions of the carcass rendered visible by the process of dressing, may be passed for food after removal and condemnation of the cysts, with the surrounding tissues, provided the carcasses and parts, appropriately identified by retained tags, are held in cold storage, or pickle for not less than twenty-one days, under conditions which will insure proper preservation; and provided further, that if the temperature at which such carcasses and parts are held in cold storage does not exceed 15° F., the period of retention may be reduced to six days. As an alternative to retention in cold storage or pickle, such carcasses and parts may be passed for sterilization. Fats of carcasses passed for food or for sterilization under the above provisions may be passed for food provided they are melted at a temperature of not less than 140° F. The edible viscera, except the lungs and heart, of carcasses passed for food or for sterilization under the provisions of the above paragraphs may be passed for food without refrigeration or other process of sterilization, provided they are found to be free from infestation upon final inspection. The intestines, weasands and bladders from beef carcasses affected with *Cysticercus bovis* which have been passed for food or for sterilization may be used for casings after they have been subjected to the usual methods of preparation and may be passed for such purpose upon completion of the final inspection."

Judgment of Measly Carcasses in Canada.

The Canadian "Meat and Canned Foods Act" of 1924 as revised 29th March, 1932, provides for the treatment in cold storage for twenty-one days of carcasses slightly affected with *Cysticercus bovis*.

Section 15 prescribes that such carcasses must be reported on a prescribed form, and must be re-inspected on the day they are taken out of cold storage, and if then condemned, they must be certified on another form as "condemned on re-inspection".

In Australia no regulations for the sterilization of measly carcasses exist. According to Drabble (1936), pig measles has never been found in that country, and also, according to personal advice from that author (1936), "Wholesome meat is cheap and plentiful in Australia, and the public will not buy frozen measly meat."

The incidence of measles in Australia is so low, that the economic significance of destruction of the half-a-dozen, or so, measly bovine carcasses which have been found from time to time, has been negligible. It has been considered justifiable to condemn any carcass which might show a single measle.

JUDGMENT OF MEASLY CARCASSES IN SOME PARTS OF AFRICA.

Madagascar.

On the island of Madagascar, according to Poisson (1929), "a pig affected with cysticercosis, whether seriously or not, is not to be delivered for alimentation until it has been cut up in pieces weighing about one kilogramme, and boiled for three hours; this is to avoid any danger to public health."

Northern Rhodesia.

The Medical Officer of Health, Ndola writes (11.11.36):—

> "During 1933 efforts were made to reduce losses through cysticercosis by freezing, but it was found to be uneconomical, and since then all carcasses showing cysts are condemned, irrespective of the degree of infestation."

Tanganyika Territory.

The following information on the degree of infestation which justifies the condemnation of measly carcasses, has been kindly supplied by Capt. H. J. Lowe, M.R.C.V.S., of the Department of Veterinary Science and Animal Husbandry, Mpwapwa (24.10.36):—

> "In more civilized countries the presence of a single cyst would be sufficient to condemn the whole carcass, but in a country such as this, where the incidence of *C. bovis* is high, such a procedure could not possibly be enforced. As a general rule our method is to condemn only those carcasses in which more than half-a-dozen cysts can be demonstrated in two or more sites, and in other cases the carcass is sterilized by boiling and sold as cheap meat to the natives. This is admittedly not very satisfactory in that many infected carcasses are passed for human consumption after the few demonstrable cysts have been removed, but it is thought that any improvement must await the time, when by education, the natives can be persuaded to adopt more sanitary habits in regard to the disposal of excreta and general cleanliness."

Kenya Colony.

In Kenya the standard adopted in the past has been based on that formerly applied in South Africa and in certain parts of Germany. Carcasses in which less than six viable measles can be found by the meat inspector, are passed for consumption, after removal of the infected portions of meat. Carcasses in which six or more viable measles are found are condemned, and are treated in the by-products plant at the abattoir. It is proposed to tighten up the Regulations in respect of measled carcasses in the Nairobi Municipal Abattoir in the near future, and if the proposals that have been put forward are eventually adopted, a single viable *cysticercus* will be sufficient to cause the condemnation of the whole carcass (Daubney, 1936). Mr. Daubney informs me that the Medical Officer of Health (Nairobi) recently informed the Stock Owners' Conference that were the standard of inspection raised so that any animal with a single viable *cysticercus* was condemned, the percentage of condemned cattle would be increased by 4·7 in the case of grade cattle and by 7·4 in the case of native cattle.

Union of South Africa.

In the Union of South Africa, Section 115 of the Public Health Act, No. 36 of 1919, as amended by Government Notice No. 1456 of 1933, provides for the treatment of lightly infested measly carcasses in cold storage.

Paragraph 16 (2) of that Section now reads:—

> " Every carcass found to be infected with bladderworm disease (" measles " shall, together with the viscera, be condemned as unfit for human consumption and destroyed or treated and disposed of so as not to endanger health save where—
>
> (*a*) during examination as aforesaid less than ten bladderworms are disclosed; and
>
> (*b*) less than six cysts are found in the carcass apart from the head, tongue, pluck, stomach and intestines; and
>
> (*c*) cold storage to the satisfaction and under the control or supervision of the local authority, and in which a temperature of or below *minus* ten degrees Centigrade is continuously maintained, is available; and
>
> (*d*) the owner or his agent in charge of the carcass requests that it be placed in such cold storage, and furnishes a written undertaking to the satisfaction of the local authority to defray the cost of so doing."

Paragraph 16 (3):—

> " If the conditions specified in paragraph 16 (2) hereof are complied with, but not otherwise, the carcass, after removal of all obviously diseased portions, may be placed and kept in such cold storage for at least fourteen days, and may thereafter be examined and passed as fit for human consumption."

Since no Regulations are framed to the contrary, and no exceptions are made in the existing Regulations, of swine carcasses, these can also be treated in the freezing chamber. It has already been mentioned that on account of economy it is not customary in most South African abattoirs to freeze measly pork carcasses, and many abattoir superintendents and laymen are under the erroneous impression that the Regulations do not provide for the freezing of measly pig carcasses.

The writer was informed that at some centres, where no freezing facilities exist at the abattoir, the local authorities, by arrangement, permit the freezing of measly carcasses in the chambers on premises of commercial firms. I know of at least one case, in which a measly ox carcass was sent from one of the smaller rural centres to a Bloemfontein commercial house for the required freezing. The carcass was then, certainly, not under the supervision of the local authority concerned, nor could that particular local authority be *satisfied* that proper freezing at -10° C. was continuously being carried out for 14 days. Such dealings are quite illegal, because Regulations

expressly read that *cold storage to the satisfaction and under the control or supervision of the local authority*, etc., must be available. Cold stores on the premises of privately-owned commercial houses cannot be controlled or satisfactorily supervised by a local authority, and particularly so if that cold store is actually situated in another town, some two hundred miles away! It might be wise if the responsible Government inspectors could investigate such malpractices and satisfy themselves that abattoirs which do not possess freezing chambers do not permit the treatment of their measly carcasses in chambers quite out of their control.

Various amendments to this paragraph caused the time specified for freezing of measly carcasses to be reduced from 84 days to eventually 14 days. This reduction of the specified time resulted from reports on various viability tests with measly carcasses which had been performed in Europe.

B. Destruction of Cysticerci in Meat.

Various Methods of testing Viability of Cysticerci.

Cysticerus cellulosae and *Cysticercus bovis* in meat can be destroyed, and the meat rendered suitable for human consumption by any of the following agencies, without seriously damaging the food value of the meat:—

1. By heat up to certain temperatures.
2. By pickling in certain strengths of salt solution.
3. By cold storage at certain temperatures for specific, continuous periods of time.

Other agencies, e.g. electric rays may also be mentioned, but some writers (Clarenburg, 1932, and others) have had little or no success with them.

Before discussing the various methods of destroying *cysticerci*, it will be necessary to consider the various tests which have been employed for the viability of *cysticerci*. Such tests have been used with a view to proving whether or not *cysticerci* in meat, which has been subjected to any of the above methods of rendering it fit for human consumption, have actually been destroyed in the process, or, as von Ostertag at various times, Glietenberg (1931) and others have suggested, have been rendered innocuous, although not necessarily killed.

The reaction of *cysticerci* to external conditions, or to the influence of chemical, physical and physiological agencies, have been taken as criteria of the viability of the *cysticerci*.

Mönnig (1928) very conveniently classified the agencies which caused phenomena which were accepted by various workers up to that time as criteria of the capability of development of *cysticerci*. Mönnig's classification can, therefore, be followed to a great extent, with the additional details of some experiments by previous and subsequent workers.

1. *Reaction to Warming.*

"This," Mönnig mentions, "was the first criterion employed, and, in combination with other methods (warming in media), is still the most important, according to many authors. Perroncito (1877), Ostertag (1897), Ransom (1914), Porter (1923) and others employed this method."

Ransom (1914), according to Mönnig, states that if the heads show no movement in the retracted state, they should carefully be evaginated by pressure, after which they will sometimes still show movement.

Perroncito (1876) isolated *Cysticerci cellulosae* from pork and placed them on a Schulze's warm stage. At low temperatures (16° C. to 20° C.) the bladderworm remained inert, but when the temperatures passed 30° C. to 35° C., fairly lively movements of the scolices and particularly of the suckers were observed. The movements became even more intense as a temperature of 42° C. to 46° C. was reached, and gradually ceased after that temperature, until at about 48° C., they stopped altogether. In 1877 Perroncito observed that a temperature of 45° C. was sufficient to kill *C. bovis*. He based his criterion on his observation that at that temperature the *cysticerci* had a cloudy appearance, no motility was noticed when they were examined microscopically, and infection experiments on humans gave negative results.

Von Ostertag (1913), in describing his experiments of 1897, states that he found warming *cysticerci* on a stage the most convenient method. "Living *cysticerci*, when heated to a temperature of 30° C. to 40° C., exhibit under the microscope active movements of the rostellum, sucking discs and other parts of the head and neck, while dead *cysticerci* remain motionless. This thermo-microscopic investigation may be undertaken conveniently in the Nuttall microscope thermostat, or in the simpler and cheaper warming apparatus for microscopic investigation devised by Kabitz and Rissling.

Porter (1923) did not accept motility of *cysticerci* when warmed to certain temperatures, as any guide to viability. She found that while some living *cysticerci* certainly did show motile powers on gradual warming of the stage, some *cysticerci* which were definitely dead, showed the same movements. Porter mentioned that some isolated cysts which she had kept in boiling water for an hour, showed motility after cooling and subsequent re-heating on a warm stage. She also found the same type of movement on warm stages with certain materials (whether these had been frozen or not), such as indiarubber, parchment, pig's bladder, silk, catgut and chamois leather. To sum up, she did not consider that any test of viability based on movement of isolated *cysticerci* on exposure to heat could be regarded as a reliable criterion of the viability or otherwise of *cysticerci* in a joint or carcass that had been exposed to freezing.

2. *Appearance and Physical Condition.*

Mönnig (1928) quotes Ostertag, Killisch, Brohmann, Glagé, Reissmann and others, who observed changes in the appearance and physical condition of *cysticerci*, at death.

Von Ostertag (1913) quotes Hartwig, who found in *cysticerci* which had been exposed to a temperature of 65° C., and was thus killed, that the scolex, which in a living condition was unusually resistant to pressure, was so soft that it could be compressed between two glass slides, like beef tallow. "This alteration must be considered as an excellent criterion of the accomplished destruction of *cysticerci* by boiling. By means of the above demonstration, Hertwig simultaneously disproved the widespread erroneous view that *cysticerci* which had been killed by boiling or roasting could be detected in eating the meat, by a crackling sound between the teeth."

Killisch (1923) and Brohmann (1924) stated that the vesicles of live *cysticerci* are glistening and pale white, offering a certain amount of resistance on pressure, while in dead specimens they are turbid and easily burst.

"In live *cysticerci*, the scolex can be fairly easily extruded on pressure between the fingers, and appears to 'swing out' of the bladder; in dead *cysticerci*, the scolex is sticky, drawing threads and is not easily extruded, but frequently breaks, while a whitish turbid fluid exudes from it." (Mönnig, 1928.)

Annie Porter (1923) made direct observation on the physical condition of fresh *cysticerci* both macroscopically and microscopically, and carefully compared the results with those observed in *cysticerci* from carcases slaughtered at different times, and which had undergone various periods of freezing. She noted:—

(i) In the normal fresh *cysticerci* of *T. solium* and *T. saginata*, that they glistened in appearance, were whitish to pinkish in hue, firm to the touch, not easily ruptured. The fluid within the fresh, normal bladder was practically colourless, clear and contained very few cellular elements.

(ii) After three weeks' freezing of a large hind-quarter of beef, its superficial cysts might be slightly less firm than fresh cysts, but deep-seated cysts, on thawing, were practically as tense as fresh cysts.

(iii) After four weeks' freezing, and then gradual thawing, the superficial cysts showed slight change in the colour of the fluid in the bladders, though the change was rarely more than a very pale straw colour. Deep-seated cysts, or cysts well protected by fat rarely showed such change.

(iv) After six weeks' freezing, followed by gradual thawing, some of the more superficial cysts might show a pinkish tint, unlike that of the fresh bladders, as if some haemolysis had occurred within them. This was really some indication of change of physical condition; the wall of the *cysticercus* had become more porous. In Porter's opinion this was not necessarily indicative of the death of the *cysticercus*.

(v) After eight weeks' freezing, the *cysticerci*, when thawed, showed more marked colour changes. The superficial ones were brownish red, the deeper ones near bone were pinkish, and the deepest *cysticerci* or those well protected by layers of fat, still showed little change.

Porter found that cloudiness of the contents of the bladder was not necessarily a feature in dead specimens.

She also found that freezing up to three months seemed to make little difference to the morphology of the *cysticerci*. In the majority of cases the suckers of the worm retained their distinctness, the hooks of *Cysticercus cellulosae* or of *Echinococci* remained *in situ* and showed no tendency to separate, and the calcareous bodies showed no obvious signs of degenerative effects. Porter did not notice the dissociation of the calcareous corpuscles in frozen *cysticerci*, as was observed by Reissmann (1897).

Killisch (1923) also placed no value upon the casting of the hooks as a criterion of viability of *cysticerci*. He found that frequently the hooks of *Cysticerci cellulosae*, which might still be alive, although possibly damaged by cold, might be cast or loosened.

Schmey and Bugge (1931) used the demonstration of the excretory "flame" cells as a criterion of viability. Active "flame" cells were demonstrated by them up till 39 days after slaughtering.

3. *Warming in Saline and Bile Mixtures.*

A method of testing the viability of *cysticerci* by immersion in warm fluid media was first used by Perroncito (1877), von Ostertag (1897) and Glagë (1896).

These workers placed fresh, living *cysticerci* in water, which was warmed up to 37° C., or a maximum of 40° C. Von Ostertag noticed that a living *cysticercus* in this simple medium evaginated the scolex, which frequently showed lively movements.

An improvement on the earlier methods of Perroncito, Glagë and von Ostertag was effected by Franke (1914), who added various quantities of bile to the water, so as to cause the conditions to be more like those normally in the human intestine, in which the *cysticercus* had to evaginate and develop. Franke also found that active evagination of the scolices of *cysticerci* occurred in physiological saline solution, to which a few drops of ox or pig bile had been added, and which had been heated to a temperature of plus-minus 38° C.

A still bigger improvement on the Franke method was effected by Wagner (1922). He found that the most effective evagination of scolices occurred in concentrated bile solutions—50 per cent. concentrations, or stronger, at temperatures 41° C. to 42° C. Wagner also recommended the use of only ox bile for *Cysticercus bovis* tests and pig bile for *Cysticercus cellulosae*. These could be warmed on Nuttall's microscope thermostat at 37° C., gradually increasing the temperatures to 41° C.

Müller (1923) performed his tests with *C. tenuicollis* and found the most successful results by using 2 to 4 per cent. bile solution at 38° C. Killisch (1923) found ready evagination of scolices of *C. cellulosae* in 0·75 per cent. solutions of pig bile in saline. Movements could be readily seen of the evaginated scolices, when warmed from 30° C. to 49° C. and examined on Nuttall's microscope thermostat. Rhythmic movements of the head to the right and the left were visible to the naked eye, and expansion and contraction of the suckers were plainly visible.

Glietenberg (1930) used pure pig bile, undiluted, and claimed very good results.

Sachs (1931) described the following method of testing the viability of *Cysticercus bovis* by evagination tests:—

(*a*) The measle is carefully removed from its connective tissue capsule.

(*b*) The liberated measle is then placed in a shallow watch glass in fresh ox bile. (No pig bile nor physiological saline solution is used.)

(*c*) If an incubator is not available, the watch glass is floated on the surface of water heated to 40° C.-42° C., and the water bath is covered with a lid, if better results are to be expected.

(*d*) After 1 to 3 minutes the scolex is evaginated and under the microscope lively movements may be observed.

Clarenburg (1932) obtained the best results in 5 per cent. bile solution, and he found the optimal temperature to be 40° C. He gave the following table in respect of measles taken from veal which had been preserved for 38 days in a cooler (probably his results may have been even more conclusive if he had used fresh measles for this particular test for the best strength of bile solution):—

Out of 10 *cysticerci* in 100 per cent. bile, after 1 hour, 1 completely evaginated.

Out of 10 *cysticerci* in 50 per cent. bile, after 1 hour, 1 completely and 2 partly evaginated.

Out of 10 *cysticerci* in 25 per cent. bile, after 1 hour, 1 completely and 5 partly evaginated.

Out of 10 *cysticerci* in 5 per cent. bile, after 1 hour, 4 completely and 3 partly evaginated.

Out of 10 *cysticerci* in 1 per cent. bile, after 1 hour, 1 completely and 0 partly evaginated.

Clarenburg, like Diemont (1923) found that the most rapid evagination of scolices occurred when the bile solution and the glass receptacle were first heated to 40° C. before the *cysticerci* were placed in them, and the test commenced. He also found that young *Cysticerci* evaginated more rapidly (after about 10 minutes) than older *cysticerci*, which sometimes took about eight hours to evaginate.

Malkani (1933) used fresh *Cysticerci bovis* for his tests. After having removed their outer connective tissue capsules, each cyst was placed in a petri-dish containing bile diluted with distilled water. Some petri-dishes were kept at room temperatures, while others were kept at an incubator temperature of 37° C. No change was visible in the cysts kept at ordinary room temperatures. In the case of those kept at incubator temperatures, peristaltic movements were seen, during which the alternate " protrusion and retraction of the extremity bearing the scolex was very striking." Evagination of the scolex occurred within 20 hours.

Instead of using bile, various bile salts have been employed by some authors. Amongst the bile salts which have been used have been sodium glycocholate, sodium taurocholate, sodium palmitate and sodium stearate. Clarenburg obtained very little success in evaginating scolices in sodium palmitate and sodium stearate. He found that sodium taurocholate gave better results than the glycocholate, and the optimal temperature was 40° C. A 1 per cent. solution of sodium taurocholate had almost the same successful results as a 1 per cent. bile solution. He did not obtain better results by using stronger solutions (3·5 per cent. and 10 per cent. solutions). Clarenburg, therefore, maintained that a 5 per cent. bile-saline solution was the best medium for artificial evaginations of scolices.

Using sodium taurocholate solution, Malkani, on the other hand, obtained his best evaginations of scolices of *C. bovis*. By using a 1 per cent. aqueous solution of sodium taurocholate at room temperatures, no movements or evaginations occurred, but at 37° C. incubator temperature, somewhat sluggish movements resulted and evagination of the scolices in 18 hours. By using a 5 per cent. aqueous solution of sodium taurocholate, very active movements resulted in a very short time in the incubator. Evagination of scolices occurred in 29 minutes to 2 hours. By using 1 per cent. and 5 per cent. aqueous solutions of sodium glycocholate, Malkani obtained rather less successful results. In these solutions cysts usually contracted somewhat and assumed a globular appearance, usually showed no movement, and evagination occurred usually more than 20 hours after.

Clarenburg also did evagination tests in various digestive juices. He found that evaginations did not take place readily in choline and acetocholine solutions, nor in pepsin in various concentrations in 0·2 per cent. hydrochloric acid. He, however, found good results in the used pancreatic extract, trypsinogen and pancreatin.

4. *Staining Reactions.*

These were sometimes used by earlier authors (Reissmann, who showed that dead *cysticerci* took aniline stains, whereas living *cysticerci* did not), but later workers (Killisch, Brohmann) did not consider them as sure criteria, except Porter, who based almost her entire criteria on the reactions she obtained to various stains. Mönnig, in reviewing Porter's work, states: " It must be noted here that the 'dead " *cysticerci*, used for comparison in Porter's tests were boiled and, since Porter's conclusions are based chiefly on

staining reactions, all other tests being regarded as unsatisfactory or indefinite, the conclusions arrived at on this basis must be read in this light, since dead tissues cannot be expected to stain like boiled tissues without further proof, and if they do not, they can likewise not be considered to be still alive."

Porter found that Delafield's haematoxylin and an acidulated solution of aqueous methyl green, particularly the latter, proved most effective. She found, for example, with methyl green solution, that dead cysts, namely those boiled for three hours, stained a deep green in the heads; cysts frozen for 22 days showed very faint green heads; cysts from a freshly killed animal remained unstained. She found that some cysts from carcasses frozen for 77 days stained very feebly, denoting, as she concluded, slight signs of life. Similarly faint stains were noticed in *C. cellulosae* from a pig frozen for 41 days.

5. *Infectivity Tests.*

These gave the only conclusive proof of vitality of *cysticerci*. Several writers, and in particular von Ostertag, have attempted to show that although *cysticerci* might be weakened owing to external influences, their power of infection to human beings has been considerably reduced.

Actual infection tests on human subjects were performed by Perroncito (1877), Zschokke (1896), von Ostertag (1897), Ransom (1914), Porter (1923), Schmey and Bugge (1930).

That infection of the human subject with *Taenia saginata* and even more so with *Taenia solium* was not without serious risk to the subject, was appreciated by several writers. Schmey and Bugge (1931) were criticised by various persons, who averred that their claim that 21 days', or even 40 days' chilling of beef was not sufficient to kill the contained measles or render them innocuous, was based on criteria obtained by artificial means, and not by actual infection tests on their own persons. They, therefore, performed infection tests on six persons, of whom three developed six *Taeniae saginata*. In the article in *Tierärzt. Rundsch.* 1931, p. 719, in which they describe their experiments, Schmey and Bugge stress the danger of actual infection tests on humans. They had, therefore, intended doing such infection tests with *C. tenuicollis* and *C. pisiformis* on dogs. In order to silence all criticism of their work, they undertook the infection tests, and remarked: "It is easy enough to utter criticism, but we wish our critics would undergo a tapeworm infection along with us, then they will change their tune."

I would not suggest that fear of infection prompted most workers between the end of last century, when von Ostertag and Zschokke performed their infection tests and quite recently, to discard actual infection tests. Franke's bile-saline method, with the subsequent improvements effected by Müller, Wagner, etc., was considered a good criterion, since conditions approached those of natural infection. Nevertheless, a certain amount of doubt must have existed as to the correctness and certainty of results obtained by those methods.

We are therefore, indebted to Iwanizky (1932), who devised a method which very nearly reached the identical to natural infection, without endangering the health of the subject on whom the test was to be applied. Iwanizky pointed out the fact that the methods employed up till 1932, to test the viability of health-damaging *cysticerci* did not come up to requirements. He, rightly, maintained that the only sure method of testing the viability of measles was by means of "infection tests" on the human subject. According to Iwanizky, even the apparently most effective method hitherto employed, namely that of Franke, had its defects, e.g., the use of pig bile instead of human bile; the use of artificially produced temperatures, instead of natural human body heat; the artificial isolation of the measles out of their capsules, and the absence of influences of the human digestive juices.

Iwanizky, according to Keller (1935) wrote:—"Even if it were possible to put aside all the defects in Franke's method, by using human bile instead of swine bile, and that first the measles could be subjected to the influence of the human stomach juices, which in practice is not as easy as it seems, the controlled results of the viability of the measles (by using such a modified method of Franke) would depend upon quite a number of circumstances, for example, on the power of assimilation of the gastric juices, on the intensity of the influence of these on the measles, on the temperature, etc.".

Iwanizky also pointed out the undesirability of self-infection tests, such as were performed on themselves and their assistants by von Ostertag, Schmey and Bugge, etc.

Actual human infection precludes the quick results sometimes necessary, since it takes a considerable time before the subject may be satisfied that he has, or has not, contracted tapeworm infection, and before he may observe segments in his stools. It has also been suggested that a measure of immunity in a subject to tapeworm infection may exist, which would negative infection tests: then again, it may be necessary for a subject to be repeatedly infected, which would lead to confusion in the results obtained, apart from the unpleasant discomfort which the subject would experience.

These were among the factors which Iwanizky considered, when he devised a new and relatively safe method of testing the viability of *cysticerci*. He removed the measles out of the muscles and sewed them into small silk bags. According to Keller, it is clear that Iwanizky did not remove the measles from their connective tissue capsules. The silk sacs were smeared with butter, placed on the back of the tongue and swallowed. Some 20 to 24 hours later, the subject recovered the silk bags in his stools, and the contents of the bags were then examined to see whether digestion and absorption, in the case of dead measles, or whether evaginated and developing scolices, in the case of viable measles had resulted. According to Iwanizky, the caudal vesicles were digested by the digestive juices of the subject, after evagination of the scolices therefrom, and the liberated scolices could be accepted as a definite criterion of viability of the future tapeworm.

Keller devised a still further improvement on Iwanizky's method, which he described in 1935. He realized that scolices evaginated or liberated from their caudal vesicles in the small intestine could be squashed inside the silk bag when passing through the large intestine. Keller explained that in the large intestine a coagulation of the contents of the intestine takes place, and the walls of the silk bags could thus be squeezed together, with resultant damage to their contents. Keller's modification consisted of placing the measles to be tested into small celluloid tubes, 10 mm. long, with an outside diameter of 7 mm. and a wall thickness of 0·5 mm. " These tubes are sewn into a stretched silk bag, so that the two open ends are covered by an even layer of silk." The interior of the celluloid tubes can be penetrated, through the taut ends of the silk covers, by the digestive juices from two sides, and the measles are " protected from outward pressure, as it were, in a small cage ". Another advantage mentioned by Keller is the fact that the smooth tube and the tautly drawn (drumlike) silk ends of the tubes show no pleats, as often happens in using silk bags. He found, also, that the best results were obtained after he had carefully removed the *cysticerci* from their connective tissue capsules. According to Keller, liberation of the scolices by this method, which precludes any outside interference with the measles, must be accepted as the most satisfactory criterion of viability of measles, and he considered it quite unnecessary to do control or contemporary experiments in gall. As an absolute test of the effectiveness of his method, Keller used for one experiment, only absolutely fresh measles (from a newly-slaughtered animal). He pointed out that by his method, out of 13 measles swallowed, 10 evaginated their scolices undigested, whereas by using Iwanizky's method, out of 12 measles swallowed, 6 were digested. (Probably as the result of destruction in the intestine.)

Having considered the various methods which have been employed to test the viability of *cysticerci*, and the phenomena which have been taken as criteria that such *cysticerci* were actually dead, or else rendered innocuous, or thirdly were still capable of development, we may now continue with the discussion of the agencies which have been found to be destructive to *cysticerci*.,

1. *The Effect of Heat on Cysticerci.*

Most of the early workers realized that heat, at certain temperatures, will with certainty cause the death of *cysticerci* in meat.

The most thorough investigations regarding the power of resistance to heat, of the bladderwroms of the pig, are due to Perroncito, 1872 (Leuckart).

Perroncito was at first inclined to the opinion that it required a temperature of at least 125° C. to render the bladderworms harmless, but he was afterwards enabled, by means of a more conclusive test, to establish that the measles are certainly killed when the temperature of the surrounding fluid reaches 50° C., or even below that, and when the *cysticerci* remain in it longer than a minute. One of Perroncito's assistants swallowed several *C. cellulosae* which had been heated to 50° C., and remained free from tapeworm infection.

Pellizari and also Lewis and Cobbold opposed Perroncito's views and fixed the lethal temperature of *C. cellulosae* at 60° C. The effect of thoroughly cooking measly pork was observed by Pellizari, who showed that in Florence the inhabitants were immune to *Taenia solium*, because pork was never eaten half raw like beef, by them, and from eating the latter they frequently developed *Taenia saginata*. Marchi, according to Leuckart, 1886, and von Ostertag, 1913, only found a single *T. solium* in a certain time in Florence, out of thirty-five *taeniae* examined by him, although during that time no fewer than 13,000 measly swine had been consumed in Florence.

Neumann (1892) pointed out the practical difficulty in knowing under what conditions the centre of a piece of flesh (pork) would reach the temperature destructive to the measle. In cooking large pieces of meat, Küchenmeister had noticed that after half-an-hour, when the external temperature was 60° C., the temperature of the interior had reached 55° C.; in about three-quarters of an hour, the exterior temperature was 77-80° C., and that of the interior 63° C. Pellizari, testing measly pork, put two pieces weighing 600 grammes and 10 cm. thick, in boiling water—one piece for five minutes, the other for half-an-hour. When removed, the temperature of the former was 45·5° C. in the centre, and that of the latter 81° C. Taking into account the loss of heat by radiation, these two temperatures may be estimated at 51° C. and 83° C. (Neumann). For roasted pork, Vallin (Neumann) has found that while its external temperature necessarily exceeds 100° C., beneath this superficial zone it is "touched" by cooking; a zone beneath this again oscillates between 52° C. and 53° C., but in the centre it does not exceed 46° C. to 48° C.

With reference to *C. bovis*, Perroncito (1877) observed that a temperature of 45° C. was sufficient to kill the measles. Perroncito found that *C. bovis* was sometimes destroyed at 44° C., often at 45° C. to 46° C., and between 47° C. and 48° C. it was always destroyed. Three of his assistants voluntarily swallowed a *C. bovis* each—one measle had been heated to 47° C., and gave no signs of life; another had shown no motility at 45° C.; the third was heated to 44° C. and had shown slight motile powers. In none of the three tests did a tapeworm develop.

Clarenburg (1932) found that *C. bovis* were killed within 15 minutes after immersion in boiling water.

2. *The Effect of Pickling on Cysticerci.*

Perroncito was among the first investigators who tested the possibility of destroying *cysticerci* in meat by pickling in brine. He used brine composed of 2½ parts saltpetre, 20 parts of cane sugar, 250 parts common salt, 1,000 parts water. He found that *cysticerci* contained in measly beef and pork were killed in fourteen days, provided the meat was no thicker than 6 cm., or when the brine was injected into the meat by means of a syringe. Von Ostertag (1913), in referring to his early investigations, described a process of demonstrating the completion of successful pickling of meat. He

employed a 1 per cent. solution of silver nitrate, which produced no striking change on the cut surfaces of fresh muscle meat, but, on the cut surfaces of completely pickled meat, a temporary milky cloudiness was produced (chloride of silver). Glagé found that a 2 per cent. aqueous solution of silver nitrate was even more effective in this test.

Schmey and Bugge (1931) found that by using a brine-pump the time required for pickling measly meat could safely be reduced from 21 days to 7 days. They mentioned that fat was slower in the pickling process than fleshy meat.

Clarenburg (1932) noticed that *C. bovis* was killed in 5 days in solutions of 20 to 25 per cent. brine.

3. *The Effect of Prolonged Preservation in Cold Storage on Cysticerci.*

Perroncito (1877) believed that *cysticerci* would only survive for a limited time after the death of the host. In an experimental calf he found that measles were dead 14 days after the slaughter of the animal. Von Ostertag (1897) found that this was not so in all cases, and that death of the *cysticerci* did not necessarily follow within such a short period, but by preserving beef in a cooler for three weeks, the *cysticerci* contained therein would be rendered innocuous. Von Ostertag performed various infection tests on human beings, with *Cysticerci bovis*, which had been preserved for periods varying between 16 days and 21 days. His tests resulted as follows:—

1 person ate 2 measles 16 days after slaughter of animal and got 0 taeniae.

1 person ate 1 measle 19 days after slaughter of animal and got 0 taeniae.

9 persons ate 52 measles 20 days after slaughter of animal and got 0 taeniae.

31 persons ate 166 measles 21 days after slaughter of animal and got 0 taeniae.

4 persons ate 15 measles 14-19 days after slaughter of animal and got 10 taeniae.

After 21 days' preservation of the meat, in another test, he again failed to infect a man with tapeworm.

Glagé (1896) found that 15 days' preservation of beef was not sufficient to kill the measles. He swallowed three measles from such beef, and developed two tapeworms.

Zschokke (1896) infected himself with one tapeworm after having swallowed five *C. bovis* which had been preserved for 16 days in meat, after slaughter of the host. He repeated the test with five measles from a bovine carcass which had been preserved for 21 days, and failed to infect himself.

Kabitz, according to Clarenburg (1932), developed three tapeworms from three measles out of beef preserved for 15 days.

Von Ostertag (1897), and indeed until about 1930, maintained that the preservation of measly beef for 21 days was quite safe from a public health point of view, since no infection resulted from such measles, although certain movements could still be noticed under observation in Nuttall's microscope thermostat. When Müller and Wagner in 1922-23, and van Santen in 1928 disproved von Ostertag's claim that measles could not survive the death of the host by 21 days, he then steadfastly maintained that although those workers, by means of Franke's test, had caused evagination of scolices of such measles, he was not satisfied that those measles were still capable of developing into tapeworms, although the tests of his opponents might have shown that they were not dead. Von Ostertag thus discriminated between " measles killed, or dead " and " measles not actually killed, but weakened and thus rendered incapable of developing ". This was considered and proved to be a very risky view, by Schmey and Bugge and by other subsequent workers.

Mönnig (1928) gives the following table showing the proportion of measles which still showed movements in von Ostertag's tests of 1897, with the number of days after slaughter of the host:—

Days after slaughter	14	15	17	18	19	20	21	22	23	24	25
Proportion showing movement.....	23/41	8/12	3/10	6/12	12/29	12/68	8/71	2/10	2/9	2/16	0/16

After 18 days' cooling, van Ostertag noticed only very slight movements, and on the 19th day the vesicle fluid was opaque; on the 20th day the heads became opaque. Von Ostertag then advanced further confirmatory evidence by performing digestion tests with hydrochloric acid—pepsin and incubation at 37° C. He found that eleven cysts which had been preserved in meat for 20 days, and had shown slight neck movements on warming, were completely digested within an hour.

As the results of these tests von Ostertag maintained that the rendering of measly beef harmless by preservation in cold storage (at temperatures just above freezing), was the most rational method, since the meat thereby underwent the least depreciation in value, suffered only a minimum loss of weight and found a ready sale as raw meat. The same treatment was not applicable to *C. cellulosae*, since von Ostertag found them alive 42 days after slaughter of pig carcasses.

Franke (1914) found that after 16 days' cooling half the measles tested, evaginated the scolices, but none after 20 days' cooling.

Wagner (1922) was probably the first worker to doubt the reliability of von Ostertag's views. He found that after 24 to 26 days' preservation of beef, the measles still showed movement, and evagination of scolices still occurred in concentrated bile solutions (50 per cent. bile solutions, or even stronger).

The danger of reliance on the opinion that 3 weeks' cooling of meat would be destructive to *C. bovis*, or otherwise render them innocuous, was further pointed out by van Santen (1928). This worker found that *C. bovis* was definitely not destroyed by three weeks' preservation of the meat, and, indeed, he found that after 37

days' cooling three out of 16 measles were capable of evaginating their scolices. Van Santen employed Franke's tests (1914), viz., warming in bile solution to 37° C. He supplied the following table as indicative of his results:—

After	19	days'	cooling,	out	of	16	tested measles,	9 living.
,,	20	,,	,,	,,	24	,,	,,	17 ,,
,,	21	,,	,,	,,	36	,,	,,	24 ,,
,,	22	,,	,,	,,	69	,,	,,	48 ,,
,,	23	,,	,,	,,	39	,,	,,	19 ,,
,,	24	,,	,,	,,	28	,,	,,	25 ,,
,,	25	,,	,,	,,	21	,,	,,	10 ,,
,,	26	,,	,,	,,	65	,,	,,	24 ,,
,,	27	,,	,,	,,	22	,,	,,	11 ,,
,,	28	,,	,,	,,	36	,,	,,	3 ,,
,,	29	,,	,,	,,	40	,,	,,	1 ,,
,,	30	,,	,,	,,	32	,,	,,	2 ,,
,,	31	,,	,,	,,	28	,,	,,	9 ,,
,,	33	,,	,,	,,	14	,,	,,	4 ,,
,,	35	,,	,,	,,	8	,,	,,	0 ,,
,,	36	,,	,,	,,	37	,,	,,	1 ,,
,,	37	,,	,,	,,	16	,,	,,	3 ,,
,,	38	,,	,,	,,	12	,,	,,	0 ,,
,,	40	,,	,,	,,	28	,,	,,	0 ,,
,,	41	,,	,,	,,	27	,,	,,	0 ,,

Van Santen thus found that 70 per cent. of measles were still living after 21 days' cooling. He also observed lively movements of the heads of some of the evaginated scolices of measles which had been chilled for 33 days. Van Santen found that measles in pieces of meat of 3 Kgm. were destroyed in three weeks, when preserved in 20 per cent. brine. He strongly advocated extending the period of chilling of measly meat to at least 40 days.

De Vries (1930) found that in his tests 17 per cent. of the measles were still capable of evaginating their scolices after 21 days' cooling.

Clarenburg (1932) described various evagination tests with measles obtained from a very heavily infested calf, which had been artificially infected. His tests were performed early in 1931. He kept his chilling-room temperature at ½° C. to 1° C., that is, just above freezing. Clarenburg found that after 3 weeks' cooling at those temperatures, putrefaction had set in, in the superficial musculature. This putrefaction had no apparent effect on the vitality of the *cysticerci*, and "even in putrefied meat very viable measles were noticeable." After 41 days' chilling he found that 12 scolices evaginated in bile solution.

Schmey and Bugge (*Berl. Tier. Woch.*, 1931), under the aegis of the German Ministry of Agriculture, did various tests and found that after 28 days' cooling *Cysticerci bovis* were still quite capable of

development, and after 39-42 days definite signs of viability were noticeable, e.g. evagination of scolices, movement of the terminal organs and demonstration of "flame" cells. They, therefore, pointed out that chilling measly meat was positively dangerous, and recommended that the period be increased to at least 28 days.

In order to render the atmosphere in cooling chambers intended for prolonged chilling of measly carcasses "germ free", May (1931) recommended the modern *katadynsterilisator*, which could be prepared by painting or coating the air channels of the cooling chamber with a prepared silver solution.

In causing confirmatory tests to be applied in the United States, Mohler (1933) found that *C. bovis* was still viable after 21 days' cooling. He found that some *C. bovis* were alive in meat after 26 days' cooling, but none was alive after 31 days' cooling.

Zunker (1935) had four negative results with infectivity tests with measles taken from bovine carcasses which had been chilled for 28 days, but he was not convinced that the capability of infection was lost in measles from beef chilled for that period.

Judging from the foregoing review of recent literature on the subject, it will be concluded that the chilling of measly bovine carcasses is not safe, from the public health point of view. In the light of our present knowledge, freezing of measly carcasses would appear to be the most effective method of rendering the meat safe for human consumption, and one would go so far as to say the least damaging to meat. Von Ostertag has steadily advocated preserving measly meat in a cooler for 21 days, but apart from those writers who pointed out the risk to public health, some of his other strong arguments have been negatived by several recent workers:—

(*a*) Clarenburg, who maintained a temperature just above freezing, found that putrefaction set in comparatively early. One feels that under commercial conditions in abattoirs, very rarely will it be practicable to preserve meat for such a period before putrefaction will do damage, in spite of von Ostertag's directions regarding the maintenance of low temperatures and humidity of the air, as we have already tabulated.

(*b*) Von Ostertag's claim that under *chilling* conditions the least loss of weight will occur, has been refuted, practically, by Wagemann (1935), who staunchly preferred the freezing of measly carcasses to the uncertain 21 days' cooling method. Wagemann pointed out that carcasses frozen from four to six days, so that the internal temperature registered by spear-thermometers, reached −3° C., showed a loss in weight of 3·4 to 6 Kgm., which amounted to 2·4 per cent. to 2·43 per cent. In comparison, Wagemann showed that in the case of 21 days' cooling, the loss of weight was 11 to 15 Kgms., amounting to 4·22 per cent. to 5·88 per cent.

Wooldridge (1933) mentioned that when meat is frozen, the water within the muscle fibre separates out as ice, which is formed in the spaces between the fibres; on thawing, the separated water containing a certain amount of nutritive matter and haemoglobin, drains away. This " drip " is more copious with beef than with mutton. However, if beef is frozen sufficiently rapidly the ice is formed within the fibre and no " drip " occurs on thawing.

Keller advised that thawing should take place slowly, so as to avoid a loss of juice. According to him a temperature of 5° C. is satisfactory. After the quarters have been thawed, the temperature should be quickly reduced by strong air current to about 0° C. This should be followed by a hanging in the halls for several days at a temperature between 0° C. and 4° C. to complete the " freshness " of the meat.

Kallert also suggested slow thawing of frozen carcasses, which should take four to five days, according to the weight of the carcass, at temperatures of 5° C. to 8° C.

At least one of the earliest investigators into the subject (Glagé, 1896) pleaded that freezeing was the most effective and safest method of rendering measly pork fit for human consumption.

Reissman (1897) found that *C. bovis* died within three days when kept at temperatures of −8° C. to −10° C. in the depths of pieces of meat. Under similar conditions *C. cellulosae* died within 4 days.

Boccalari (1903) found that both *cysticerci* died within six days at 0° C. to −2° C. (Mönnig, 1928).

Ransom (1914) used two heavily infested bovine carcasses, which, after having been kept in a cooler for 24 hours, were quartered and hung in a freezing chamber at temperatures between 11° F. and 15° F. He retained one quarter in the chilling room as a control. After six days' continuous freezing he examined 63 *cysticerci* on a warm stage and found no movement. He then swallowed six cysts and after 18 weeks was still free from tapeworm infection. On the eighth day all twelve measles from his control quarter of beef in the chilling room were still alive.

Killisch (1923) found that by freezing half-carcasses of pigs at temperatures of −8° C. to −12° C. for 3½ days all *cysticerci* were dead. He performed his tests with five heavily infested pig carcasses, which were delivered to him without skin or fat. He found that a 24-pound ham was frozen through after 48 hours, at a temperature of −8° C. to −10° C., and all measles were dead. In a 10-lb. ham, freezing was complete in the deepest muscles after 66 hours and all measles were dead after 7 hours at −6° C. to −8° C. In a 8½-lb. ham freezing at −2·5° C. to −6° C. killed all measles in 125 hours. Similarly, at that temperature all measles were killed in a 20-lb. ham in 150 hours. In a very large ham all measles were killed at −12°C. to −18°C. in 60 hours and with certainty within 72 hours at −10° C. to −15° C. He noticed that circumference of a ham which measured 64 cm. around its widest part was increased by 2·5 cm. by freezing at −12° C. to −18° C. for 66 hours. Working also on *C. cellulosae* Brohmann (1924) confirmed Killisch's findings.

M. Müller (1923) confirmed the experiments of Wagner (1922) and showed that after 8 days' freezing of measly bovine carcasses no measles were found to be viable. He also tested *C. cellulosae* from measly pork carcasses which arrived at his abattoir in a frozen state. Some of these *cysticerci* were still able to show slight movements, but none evaginated their scolices. Müller names this as proof of the weak resistance of *C. cellulosae* to temperatures below zero.

Van Oijen (1929) and later van der Slooten (1936) pointed out the futility of treating measly carcasses under conditions of cooling. "The only safe way is to freeze measly carcasses for at least 10 days at −10° C." (van der Slooten).

Schmey and Bugge (1930 and 1931) found that isolated measles were killed in three to four hours by freezing at −8° C. to −10° C. They found that a temperature of −6° C. was reached in three to four days in the innermost tissues of large pieces of meat at room temperatures of −8° C. to −10° C. According to those authors a freezing for 4 days is in every respect sufficient. Whatever refers to *C. bovis* is equally applicable to *C. cellulosae* in pig carcasses. Lightly infected pork need thus not be boiled, but can be made safe for human consumption in four days by freezing at low temperatures. (Compare the results of our Bloemfontein investigations in section C of this Part.)

Von Ostertag (1930) once more advocated against the freezing of measly meat, and against Schmey and Bugge's recommendations in particular, i.e. freezing measly meat for three to four days at −8° C. to −10° C. His reasons were: (1) Because after 21 days' chilling of meat, the measles evaginated their scolices, it did not follow that they were infective to man. (2) Freezing degenerated the meat, and there were not freezing chambers in all abattoirs in Germany.

Clarenburg (1932) found that in pieces of meat 6 cm. in thickness, which were placed in a freezing chamber at −8° C. to −10° C., the *cysticerci* were killed after 65 hours. He found that it took about 15 hours before the interior of the meat was cooled down to the same temperature as the air inside the chamber.

Feldforth (1934), in a series of experiments, exposed portions of beef infested with *C. bovis* to a temperature of −2° C. for varying periods of time. Viability was tested either by immersion of the cysts in a bile-saline solution at 41° C., or by swallowing the cysts in small silk bags. (Iwanizky's method.) He found that 2 days at −2° C. were lethal to cysts in meat up to half-a-pound in weight.

Scheerer (1935) found that *C. bovis* rolled up in slices of meat and exposed to a temperature of −2° C. are killed after 7 days and are no longer infective after 6 days. He concluded that slightly infested meat, frozen so that the innermost parts of the carcass remain at −2° C. for 6 days might safely be offered for sale. Zunker (1935) froze beef carcasses at an average temperature of −7° C. to −8° C. He read the internal temperatures of the meat by spear-thermometers,

instruments encased in steel tubes with sharp points, which were inserted deeply into the musculature of the hind quarters. [Keller, 1935, in *Zeitschrift für Fleisch-und Milchhygiene* 45 (17), pp. 321-322, had mentioned that in freezing cysticercous meat by the new rapid process, which aimed at maintaining the meat at −3° C. for 24 hours, it was not sufficient to control the temperature of the refrigerator. Keller mentioned that the more fat in a given carcass, the longer it would take to cool to −3°C. in the interior. Hence it was considered by him essential to read the temperature within the carcass. Keller described the use of a pointed steel tube, which was driven into the meat and which protected the glass stem-graduated thermometer.] Zunker explained that the kinds of changes which the animal tissue undergoes during freezing depends mainly on the speed of the freezing process. The faster the cooling down takes place, the finer is the crystal conglomerate in the frozen tissue. The killing off of living tissue depends on the complete freezing out of the fluid contents of e.g. the bladderworm, and the speed with which this is done is an important factor. "Just as with special care living fish may be frozen and later again be thawed without suffering harm, so also the measles under advantageous circumstances can sometimes stand the freezing very well. During the slow freezing of the whole animal carcass, the measles are killed with certainty, however."

Zunker found that it was necessary to keep an infected carcass in the freezing chamber until the temperature in the depths of the hind quarters registered −3° C. Even in the case of heavy carcasses, this took place within 7 days, and for safety's sake a further 24 hours could be allowed. In other words, Zunker recommended that measly carcasses should be frozen 24 hours longer than the time required for the temperatures in the deep muscles to reach −3° C. As an example he mentioned one quarter of beef, in which an internal temperature of −3·7° C. was reached in 5 days. That quarter, according to Zunker, was fit for issue on the 6th day. He was a staunch advocate of the freezing process of treatment for measly carcasses, in preference to the somewhat uncertain cooling process.

Kallert (1931) maintained that whereas certain plants and animals, according to Pictet, could withstand tremendous freezing, e.g. fishes frozen into blocks of ice at −15° C. survived by careful thawing, but were killed outright at −20° C.; frogs could withstand a temperature of −28° C., millipedes −50° C., snails −120° C., *cysticerci* belonged to the creatures which were very susceptible to freezing and were definitely killed in freezing temperatures. He found that only at temperatures of −6° C. to −8° C. all meat juice was frozen. Kallert quotes the experiments of Kallert and Plank, who found that hindquarters weighing 60 Kgm. were completely frozen through at temperatures of −6° to −8° C. in 6 to 7 days, while in fore-quarters this occurred in 5 days. According to Kallert, hind-quarters should be frozen at −8° C. to −10° C. for at least 10 days, and fore-quarters for at least 9 days. He found that a superficial layer of fat greatly retarded cooling in a carcass, the heat conductivity of fat being 35 per cent. less than that of muscle. Large and heavy quarters required 3 per cent. longer time for complete through freezing.

Annie Porter, working in Johannesburg in 1923, " under commercial conditions ", was probably alone among all modern observers in the results she obtained. She compared the resistance of *cysticerci* to the influence of cold, with those of fishes and snails, as was mentioned by Pictet, and felt that only after extremely prolonged freezing were *cysticerci* rendered innocuous. According to Porter's staining reactions, *C. bovis* would appear normal in the deeper parts of the carcass after the 49th day of freezing, while some *C. cellulosae* appeared unchanged in the deep parts on the 156th day. Her freezing-room temperatures varied between −7·28° C. and −16·2° C. On two occasions she swallowed *C. bovis* which had been frozen for 10 weeks and 12 weeks, respectively, with negative results. She also obtained negative results by feeding fresh and frozen *Cysticerci bovis* to puppies and rats. On the other hand, she based criteria of viability of *C. bovis* and *C. cellulosae* under freezing conditions on several results she obtained from freezing *C. fasciolaris* and *Echinococcus* cysts, and thereby infecting a cat and a dog respectively. A rat liver, containing *C. fasciolaris* was frozen for 30 days, and fed to a cat, which in due course developed *T. taeniaeformis*. A dog fed on a sheep lung containing *Echinococcus* cysts, which had been frozen for a month, developed *T. echinococcus*. Porter concluded that freezing at temperatures ranging from −5° C. to −18° C. for a period of about 10 weeks appeared to destroy the vitality of all the *cysticerci* in carcasses of beef and pork. For safety, according to Porter, a margin should be allowed on this, and a period of at least 12 weeks' freezing of slightly infested beef or pork at a temperature of 14° F., that is −10° C., should be undergone before the meat may be regarded as sterile and the *cysticerci* as dead.

A word of warning was expressed by Keller (1936), who stressed the necessity of maintaining a low temperature in freezing measly carcasses. He showed that by keeping pieces of beef infected with *C. bovis* at temperatures between −1° C. and −1·5° C. not all *cysticerci* were killed even after 23 days at this temperature, but 50 per cent. were killed after 11 days. At such a temperature the meat is frozen, but the host capsule surrounding the *cysticercus* itself is not frozen. According to Keller, at such high temperatures of freezing, infectivity, tested by Iwanizky's method, is retained until at least the eleventh day.

According to Mönnig (1928), about 1914, Ottesen found a method of freezing fish in a 21 per cent. solution of sodium chloride at −10° C. to −15° C., in which the fish froze ten to twenty times more rapidly and with much less loss of weight than in air.

Plank and Kallert (1915), referred to by Kallert (1923) and by Mönnig (1928), confirmed the claims of Ottesen, but they found that with larger pieces of beef, half pig carcasses and whole sheep carcasses, the period of total freezing was shortened only about eight times. In the experiments described by Kallert, the temperature of the salt solution was −14° C. to −15° C. He pointed out that halves of pig carcasses which were frozen through in three days at −6° C. to −8° C. in the air, were frozen through in three to four hours in brine. He claimed also, that smaller pieces of beef and lighter sheep carcasses would freeze sooner in brine. He found that

there was less loss of weight of carcasses frozen in brine than of those frozen in air. According to de Jong (1922), meat frozen in brine left no salty taste, and could be delivered to consumers as in the case of fresh meat.

According to Kallert a small amount of salt did penetrate into the tissues.

Drooglever Fortuyn (1922) (Mönnig, 1928), made comparative histological studies of normal meat, meat frozen in air, and meat frozen according to the above method. He found that refrigeration in air compressed the muscle fibres and drove them together in groups, relatively large cavities coming into existence between such groups; refrigeration in salt solution causes the appearance of cavities in the individual fibres but no compression of fibres.

Mönnig (1928) mentioned that the *cysticercus* is well protected by its vesicle, and he was inclined to think that the more rapid death of the *cysticerci* under this method of treatment, as was found by Brohmann (1924), was due to the very rapid freezing.

According to Brohmann, Ottesen found more rapid freezing of fish in 21 per cent. brine, if the solution was continuously stirred Brohmann did not stir the solution. He strongly recommended freezing measly pigs in brine at – 15° C. He found that by freezing pigs in brine at that low temperature all measles were destroyed in 12 hours. Unfortunately, he made no infection tests, but relied mainly on evagination tests in bile-saline solutions, for his criteria. Mönnig (1928) supplies the following summary of Brohmann's results:—

Shoulder 6 hours in brine at – 6° to – 8° C. 55/55 *cysticerci* alive.

Ham 6 hours in brine at – 10° C. 46/46 *cysticerci* alive.

Shoulder 8 hours in brine at – 5·55° C. 40/40 *cysticerci* alive.

Ham 12 hours in brine at – 10° C. to – 11° C. 42/42 *cysticerci* alive.

Shoulder 8 hours in brine at – 13° C. 40/40 *cysticerci* alive.

Ham 12 hours in brine at – 15° C. to – 16·5° C. 0/48 *cysticerci* alive.

"The pieces were all completely frozen when removed from the brine. *Cysticerci* from all depths were examined after the pieces had been allowed to thaw at room-temperature." (Mönnig.)

Schmey and Bugge (1930) pointed out that refrigeration technique had advanced so far that refrigeration in brine would result in obtaining a temperature of – 6° C. in a few hours.

C. Viability Tests with Measles taken from Chilled and Frozen Pork and Beef Carcasses at the Bloemfontein Abattoir.

The object of these tests was mainly to confirm the tests of overseas writers, and, if possible, to establish definitely, with what material we had available, the shortest period required for the freezing of measly beef and pork at temperatures of approximately – 10° C., under South African commercial conditions.

Method Employed.

(1) After the stipulated period of chilling or freezing, the *cysticerci* (*cellulosae* or *bovis*) were always removed from their connective tissue capsule.

(2) Physical characteristics of such treated *cysticerci* were observed, although no microscopic observations of loosening of the hooks in *C. cellulosae* were made.

(3) Control evagination tests in bile-saline solution and in sodium taurocholate were made in an incubator at 38° C.

(4) The main criteria in these tests were based on actual infection tests on several voluntary assistants, according to both Iwanizky's and Keller's methods.

(5) In view of the fact that the infection tests perfected by Iwanizky and by Keller have very nearly approached conditions of natural infection, it was not considered necessary to attempt reactions to warming on a stage, and the observations of the physical characteristics of frozen or chilled measles were merely those of noting cloudiness, discolouration and consistency of the fluid.

(6) Since the boiling or pickling of measly carcasses is not practised in South Africa, such tests were not attempted. All available material was, therefore, used in cooling and freezing tests.

With regard to control artificial evagination tests, we found the best results with 5 per cent. sodium taurocholate solution (Malkani's method). The *cysticerci* were carefully isolated from their connective tissue capsules and placed in a saucer containing 5 per cent. sodium taurocholate solution, which was then placed in an ordinary "Buck-Eye" egg incubator, of which the heat was regulated to 38° C. Evagination of scolices usually occurred within two hours in the case of viable *cysticerci*. It was found that this method worked very successfully with fresh (unfrozen) *cysticerci*, more sluggishly with those frozen for about 24 to 48 hours, or chilled for about 21 days, and frequently did not work with those measles from meat chilled longer than about 21 days, or frozen longer than 48 hours. On the other hand, we established definitely that the only sure criterion of viability of measles could be obtained by actual infection tests according to Iwanizky's and/or Keller's methods. In some cases we failed to obtain evagination *in vitro* of scolices of measles from meat frozen for three days and more, whereas ready and clear evaginations of such scolices occurred within the bag or tube in our subject's intestine. We used a slight modification of both Iwanizky's and Keller's methods. In the former we found that it frequently took some time to stitch the bags, as Iwanizky did, and frequently the sutures did not appear too secure. In order, therefore, to instil the fullest confidence in his personal safety in our subject, we tied the small silk bags with strong suturing silk, and cut the tied end as short as possible. All our subjects, European members of the Abattoir Staff, had no difficulty in swallowing them, and one subject in particular, never failed to recover the bags, or the celluloid tubes in

his stools. With reference to our modification of Keller's method, we found the same objection to suturing the silk cover. A single layer of silk was, therefore, wrapped round the celluloid tube containing from one to three measles, in such a way that the two open ends of the small cylinder were covered with a single layer of silk, drawn tautly, and the four corners of the silk coverlet were twisted together in a spiral and tied as closely to the body of the cylinder as possible. This spiral twisting caused the two single silk-layers covering the ends of the tubes to be drawn even more tightly, almost like a drum, than in the case of suturing the coverlet, or else fixing by means of artificial fixatives, e.g. acetone-cellulose solution, which took a considerable time to fix, and was treated with a certain amount of suspicion by our " chief " subject. Most of our subjects experienced a measure of discomfort in swallowing the hard celluloid tubes, measuring approximately 15 mm. long by 7 mm. diameter. Our " chief " subject, however, once more found no difficulty in the deglutition of the somewhat unwieldy " pills ", and for that reason experiments by means of Keller's method were confined to him, since he was quite prepared to use the celluloid tubes over and over again, he never " lost " any, and I was only able to obtain the tubes through the kind favour of the Director of Veterinary Services, Onderstepoort Laboratory, and could therefore, not abuse his favour by repeatedly applying for fresh tubes. The inner temperature of the meat in the freezing chamber was read on improvised spear-thermometers, ordinary low graded freezing thermometers, encased in sharp-pointed steel covers. One of these was kindly made for me by the Mechanical Engineer in charge of my Abattoir Refrigeration plant, and two were lent by the Director of Veterinary Services, Onderstepoort. (See Table A.)

Evagination tests with *C. cellulosae* from pork cooled for various periods have thus shown that the most successful results have been obtained with natural infection tests, according to Iwanizky's and/or Keller's methods.

In five per cent. sodium taurocholate, evagination nearly always occurred within two hours, and by using 30 per cent. pig bile-physiological saline solution in from 2 to 5 hours. After that, evaporation of the fluid contents of the saucer often occurred. In fresh measles, namely those which had not undergone prolonged chilling or freezing, evagination occurred more readily, and in a shorter time. After about the twenty-first day of chilling, putrefaction frequently set in, in the pork, but, according to the results obtained by our natural infection tests, it did not follow that the measles situated in badly putrefied areas, died in that situation. By our tests we established the fact that the *Cysticercus cellulosae* can remain infective up to 41 days after slaughter of the host, but we failed to find any alive after that day, although we only tried two more tests, on account of the undesirability of maintaining putrefied meat in the condemned meat section of our chilling room.

It is interesting to mention that after 35 to 41 days' chilling, we found only 4 out of 167 tested measles viable. After 34 days' chilling, 12 out of 30 pig measles were still viable; and after 30 to 33 days' chilling, 43 out of 123 pig measles tested were still viable.

TABLE A.

Evagination Tests with C. cellulosae—*Chilling Tests.*

Experiment No.	Part of carcass (weight).	Number of days chilled.	Method used: I. Iwanizky, K. Keller.	Number of Human subjects.	Number of tubes or bags swallowed.	Number recovered.	Total number of cysts swallowed.	Number of scolices Evaginated.	Number of cysts digested (dead).	Remarks.
1	Shoulder (21 lb.)	4	I.	3	10 B.	9	10	6	3	One bag was lost; 6/10 scolices evaginated in 5 % sod. taurocholate sol.
2	Shoulder (22 lb.)	6	I.	2	4 B.	4	8	6	2	4/10 Scolices evaginated in 5 % sod. taurochol.
3	Leg (18 lb.)	1	K.	1	4 T.	4	8	8	0	10/10 Scolices evaginated in 2 hours in 5 % sod. taurochol. and 7/10 in 30 % pig bile.
4	Leg (18 lb.)	2	K.	1	4 T.	4	8	7	1	4/10 Scolices evaginated in 30 % pig bile.
5	Leg (27 lb.)	3	K.	1	3 T.	3	9	9	0	—
6	Leg (30 lb.)	4	K.	1	3 T.	3	6	6	0	6/10 Scolices evaginated in 5 % sod. taurochol. and 4/10 in 30 % pig bile.
7	Leg	5	K.	1	2 T.	2	6	6	0	—
8	Shoulder (24 lb.)	6	K. I.	2	2 T, 2 B.	4	12	10	2	5/10 Scolices evaginated in 5 % sod. taurochol. and 2/10 in 30 % pig bile.
9	Shoulder (24 lb.)	7	K. I.	2	2 T. 3 B.	5	14	13	1	3/7 Scolices evaginated in 5 % sod. taurochol. and 1/7 in 30 % pig bile.
10	Shoulder (21 lb.)	8	K. I.	2	3 T. 3 B.	5	17	14	0	3 Cysts in 1 bag lost.
11	Leg (—)	9	K. I.	1	3 T, 3 B.	6	16	16	0	2/5 Scolices evaginated in 5 % sod. taurochol. and 1/6 in 30 % bile.
12	Leg (—)	11	K. I.	1	3 T. 3 B.	6	16	16	0	— —
13	Shoulder (—)	12	K. I.	1	3 T. 3 B.	6	12	9	3	—
14	Leg (17 lb.)	13	I.	1	5 B.	5	15	0	15	Meat was badly putrefied, and measles were stickily opaque. All artificial tests failed.

TABLE A—(*continued*).

Experiment No.	Part of carcass (weight).	Number of days chilled.	Method used: I. Iwanizky. K. Keller.	Number of Human subjects.	Number of tubes or bags swallowed.	Number recovered.	Total number of cysts swallowed.	Number of scolices Evaginated.	Number of cysts digested (dead).	Remarks.
15	Leg (32 lb.)	14	K. I.	1	3 T. 3 B.	6	18	10	8	—
16	Leg (30 lb.)	15	K. I.	1	2 T. 2 B.	4	10	10	0	5/6 Scolices evaginated in 5 % sod. taurochol. and 2/7 in 30 % pig bile.
17	Shoulder (17 lb.)	16	K. I.	1	2 T. 2 B.	4	10	10	0	—
18	Neck (18 lb.)	18	I.	1	2 B.	2	4	3	1	—
19	Leg (21 lb.)	17	K.	1	5 T.	5	15	7	8	
20	Leg (27 lb.)	18	K.	1	4 T.	4	12	9	3	3/6 scolices evagin. in 5 per cent. taurochol. and 0/5 in 30 per cent. pig bile.
21	Shoulder (17 lb.)	19	K. I.	2	6 T. 4 B.	10	30	29	1	
22	Shoulder (19 lb.)	20	K.	1	5 T.	5	15	13	2	
23	Leg (36 lb.)	21	K.	2	4 T.	6	20	15	2	One bag with 3 cysts lost; 3/10 scolices evagin. in 5 per cent. Sod. taurochol. and 2/10 in 30 per cent. pig bile.
24	Part of Leg	22	K.	1	4 T.	4	12	8	4	
25	Leg (31 lb.)	23	K.	1	4 T.	4	10	10	0	
26	Part of Leg	24	K.	1	4 T.	4	10	10	0	
27 & 28	Leg and Shoulder	25	K.	1	3 T. 5 T.	8	25	6 13	4 2	Two experiments on subsequent days.
29 & 34	Shoulder and Shoulder	26	K.	1	5 T. 4 T.	9	25	12 0	3 10	Two experiments with 10 days interval. Pork from different carcasses.
30 & 35	Leg Leg	27	K.	1	5 T. 5 T.	10	30	12 3	3 12	Two experiments and pork from same respective carcasses as 29 and 34.
31 & 36	Shoulder Leg	28	K. I.	2	3 T. 2 B. 5 T. 3 B.	13	39	7 9	8 15	Two experiments, pork from different carcasses.

TABLE A—(*continued*).

Experiment No.	Part of carcass (weight).	Number of days chilled.	Method used: I. Iwanizky, K. Keller.	Number of Human subjects.	Number of tubes or bags swallowed.	Number recovered.	Total number of cysts swallowed.	Number of scolices Evaginated.	Number of cysts digested (dead).	Remarks.
32 & 37	Leg Shoulder	29	K. I.	2	3 T. 2 B. 4 T. 4 B.	13	35	5 7	10 13	Two experiments, pork from same carcasses as 31 and 36.
33 & 38	Leg Leg	30	K. I.	3	4 T 2 B. 3 T. 2 B.	11	32	7 0	10 15	Two experiments with different carcasses.
39	Shoulder	31	K. I.	2	5 T. 5 B.	8	30	20	4	Two bags with 6 cysts lost.
40	Leg	32	K. I.	2	5 T. 5 B.	10	31	13	18	No artificial tests tried with experiments 24 to 41 inclusive.
41	Leg	33	K. I.	1	5 T. 5 B.	9	30	3	24	One bag with 3 cysts lost.
42	Shoulder	34	K. I.	1	5 T. 5 B.	10	30	12	18	0/10 scolices evagin. in 5 per cent. taurochol. and 0/9 in 30 per cent. pig bile.
43	Shoulder	35	K. I.	1	5 T. 5 B.	10	30	1	29	0/10 scolices evagin. in 5 per cent. taurochol. and 0/9 in 30 per cent. pig bile.
44	Leg	36	K. I.	1	5 T. 3 B.	8	24	0	24	0/10 scolices evagin. in 5 per cent. taurochol. and 0/9 in 30 per cent. pig bile.
45	Leg	37	K. I.	1	4 T. 4 B.	8	24	2	22	Two scolices in 2 tubes evaginated: none in the bags.
46	Carcass	38	K. I.	1	4 T. 4 B.	8	20	0	20	
47	Carcass	39	K. I.	1	4 T. 1 B.	5	14	0	14	
48	Carcass	40	K. I.	1	5 T. 6 B.	8	40	0	32	Three bags lost with 8 cysts.
49	Leg	41	K. I.	1	3 T. 2 B.	5	15	1	14	
50	Leg	42	K. I.	1	3 T. 2 B.	5	15	0	15	
51	Shoulder	50	K.	1	3 T.	3	9	0	9	Meat badly putrefied.

For illustrations see Figures 4 to 7.

FIGURE 4.

C. cellulosae scolices evaginated in 2 hours in 30 per cent. pig bile-saline solution. (2 days chilled.) Magnification 7 times.

FIGURE 5.

C. cellulosae scolices evaginated by Keller's method, after 19 days' cooling. Magnification 7 times.

FIGURE 6A.

C. cellulosae scolices evaginated Keller's method after 28 days' cooling. Magnification 7 times.

FIGURE 6B.

Microscopic view of head of same, showing suckers and rostellum. Magnification 40 times.

FIGURE 7.

C. cellulosae scolices, evaginated Keller's method after 32 days' chilling. Magnification 7 times.

Table B.

Freezing Tests with Cysticercus cellulosae.

Experiment No.	Number of Days in Freezer.	Temp. of Meat after 24 Hours Cooling (°F.).	Initial Temp. of Freezing Chamber (°F.).	Temp. of Freezing Chamber after 5 Hours (°F.).	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 24 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 48 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 3 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 4 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 5 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 6 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 7 Days.	Part of Carcass. (Weight.)	Method Iwanizky (I.). Keller (K.).	Number of Cysts Swallowed.	Scolices Evaginated.	Digested (Dead).	Remarks.
1	14	—	—	—	—	—	—	—	—	—	—	Carcass	—	35	—	35	1
2	12	—	—	—	—	—	—	—	—	—	—	Carcass	—	25	—	25	2
3	6	—	13	—	(1) — (2) 14	(1) — (2) 13	(1) — (2) 15	(1) — (2) 14	(1) — (2) 12	— (2) 13	—	Leg (30 lb.)	I.	12	—	12	8
4	4	—	12	—	(1) — (2) 13	(1) — (2) 13	(1) — (2) 12	(1) — (2) 16	—	—	—	Shoulder	K.	4	—	4	6
5	1	—	15	—	(1) — (2) 14	—	—	—	—	—	—	Leg (24 lb.)	K.	6	6	—	3
6	2	—	14	14	(1) 19 (2) 13	(1) 16 (2) 14	—	—	—	—	—	Leg (26 lb.)	K.	6	3	3	4
7	3	—	17	15	(1) 18 (2) 12	(1) 18 (2) 14	(1) 17 (2) 15	—	—	—	—	Shoulder (19 lb.)	K.	10	7	3	5
8	4	40	16	16	(1) 19 (2) 15	(1) 17 (2) 16	(1) 17 (2) 13	(1) 16 (2) 14	—	—	—	Shoulder (15 lb.)	K.	12	1	11	6
9	5	40	16	16	(1) 19 (2) 15	(1) 17 (2) 16	(1) 17 (2) 13	(1) 16 (2) 14	(1) 16 (2) 15	—	—	Shoulder (16 lb.)	K. I.	8	8	8	7
10	6	40	16	16	(1) 19 (2) 15	(1) 17 (2) 16	(1) 16 (2) 13	(1) 16 (2) 14	(1) 16 (2) 15	(1) 15 (2) 15	—	Leg (33 lb.)	K. I.	18	—	18	8
11	7	40	16	16	(1) 19 (2) 15	(1) 17 (2) 16	(1) 17 (2) 13	(1) 16 (2) 14	(1) 16 (2) 15	(1) 15 (2) 15	(1) 16 (2) 18	Leg (38 lb.)	K. I.	13	—	13	9
12	4	41	18	19	(1) 18 (2) 15	(1) 18 (2) 13	(1) 16 (2) 11	(1) 16 (2) 13	— —	— —	— —	Shoulder (16 lb.)	I.	18	—	18	6
13	5	42	18	19	(1) 18 (2) 15	(1) 18 (2) 13	(1) 16 (2) 11	(1) 16 (2) 13	(1) 18 (2) 14	— —	— —	Shoulder (19 lb.)	K. I.	18	—	18	7

TABLE B—(*continued*).

Experiment No.	Number of Days in Freezer.	Temp. of Meat after 24 Hours Cooling (°F.).	Initial Temp. of Freezing Chamber (°F.).	Temp. of Freezing Chamber after 5 Hours (°F.).	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 24 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 48 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 3 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 4 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 5 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 6 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 7 Days.	Part of Carcass. (Weight.)	Method Iwanzky (I.). Keller (K.).	Number of Cysts Swallowed.	Scolices Evaginated.	Digested (Dead).	Remarks.
14	1	39	15	15	(1) 20 (2) 16	—	—	—	—	—	—	Leg (21 lb.)	K. I.	15	5	10	3
15	2	39	15	15	(1) 20 (2) 16	(1) 18 (2) 15	—	—	—	—	—	Leg (19 lb.)	K. I.	15	—	15	4
16	3	39	15	15	(1) 20 (2) 16	(1) 18 (2) 15	(1) 18 (2) 15	—	—	—	—	Shoulder (18 lb.)	K.	10	—	10	5
17	4	39	15	15	(1) 20 (2) 16	(1) 18 (2) 15	(1) 18 (2) 15	(1) 17 (2) 15	—	—	—	Shoulder (19 lb.)	K. I.	15	—	15	6
18	1	41	19	19	(1) 23 (2) 16	—	—	—	—	—	—	Leg (42 lb.)	K.	7	4	3	3
19	2	41	19	19	(1) 23 (2) 16	(1) 20 (2) 15	—	—	—	—	—	Leg (44 lb.)	K.	8	—	8	4
20	3	41	19	19	(1) 23 (2) 16	(1) 20 (2) 15	(1) 18 (2) 16	—	—	—	—	Leg (26 lb.)	K.	8	—	8	5
21	3	40	20	20	(1) 23 (2) 17	(1) 20 (2) 16	(1) 18 (2) 15	—	—	—	—	Carcass (185 lb.)	K. I.	60	—	60	5
22	4	36	14	16	(1) 21 (2) 19	(1) 21 (2) 13	(1) 18 (2) 13	(1) 18 (2) 13	—	—	—	Carcass (87 lb.)	K. I.	40	—	40	6
23	4	38	16	16	(1) 18 (2) 14	(1) 17 (2) 14	(1) 17 (2) 11	(1) 15 (2) 11	—	—	—	Carcass (103 lb.)	K. I.	36	—	36	6
24	5	40	13	14	(1) 19 (2) 16	(1) 18 (2) 14	(1) 18 (2) 15	(1) 16 (2) 13	(1) 17 (2) 17	—	—	Carcass (71 lb.)	K. I.	50	—	50	7
25	5	41	15	16	(1) 23 (2) 16	(1) 20 (2) 14	(1) 17 (2) 15	(1) 17 (2) 16	(1) 15 (2) 9	—	—	Carcass (161 lb.)	K. I.	40	—	40	7
26	5	38	12	13	(1) 20 (2) 11	(1) 16 (2) 13	(1) 16 (2) 14	(1) 15 (2) 11	(1) 15 (2) 12	—	—	Carcass (48 lb.)	K. I.	30	0	30	7

TABLE B—(*continued*).

Experiment No.	Number of Days in Freezer.	Temp. of Meat after 24 Hours Cooling (°F.).	Initial Temp. of Freezing Chamber (°F.).	Temp. of Freezing Chamber after 5 Hours (°F.).	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 24 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 48 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 3 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 4 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 5 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 6 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 7 Days.	Part of Carcass. (Weight.)	Method Iwanizky (I.). Keller (K.).	Number of Cysts Swallowed.	Scolices Evaginated.	Digested (Dead).	Remarks.
27	5	39	18	16	(1) 18 (2) 14	(1) 18 (2) 15	(1) 17 (2) 13	(1) 14 (2) 12	(1) 15 (2) 13	— —	— —	Carcass (61 lb.)	K. I.	40	—	40	7
28	5	40	16	15	(1) 17 (2) 15	(1) 16 (2) 14	(1) 16 (2) 14	(1) 15 (2) 13	(1) 14 (2) 13	— —	— —	Carcass (80 lb.)	K. I.	50	—	30	7
29	5	39	16	16	(1) 21 (2) 14	(1) 20 (2) 15	(1) 19 (2) 12	(1) 18 (2) 10	(1) 17 (2) 13	— —	— —	Carcass (101 lb.)	K. I.	50	—	50	7
30	5	41	14	13	(1) 20 (2) 14	(1) 18 (2) 13	(1) 17 (2) 13	(1) 17 (2) 15	(1) 17 (2) 17	— —	— —	Carcass (62 lb.)	K. I.	60	—	60	7
31	5	39	13	14	(1) 18 (2) 13	(1) 16 (2) 12	(1) 16 (2) 14	(1) 15 (2) 13	(1) 15 (2) 15	—	—	Carcass (81 lb.)	K. I.	35	—	35	7
32	5	42	14	14	(1) 22 (2) 15	(1) 22 (2) 13	(1) 21 (2) 14	(1) 20 (2) 16	(1) 16 (2) 12	— —	— —	Carcass (202 lb.)	K. I.	20	—	20	7
33	5	37	18	17	(1) 19 (2) 17	(1) 18 (2) 15	(1) 18 (2) 17	(1) 18 (2) 12	(1) 17 (2) 14	— —	— —	Carcass (72 lb.)	K. I.	30	—	30	7
34	5	38	17	17	(1) 21 (2) 17	(1) 21 (2) 16	(1) 21 (2) 14	(1) 20 (2) 15	(1) 19 (2) 13	—	—	Carcass (98 lb.)	K. I.	30	—	30	7
35	5	39	16	18	(1) 20 (2) 16	(1) 21 (2) 15	(1) 21 (2) 17	(1) 18 (2) 14	(1) 18 (2) 12	— —	— —	Carcass (49 lb.)	K. I.	50	—	30	7
36	5	40	15	16	(1) 25 (2) 16	(1) 23 (2) 14	(1) 23 (2) 12	(1) 19 (2) 13	(1) 19 (2) 14	—	—	Carcass (131 lb.)	K. I.	24	—	24	7
37	5	41	11	12	(1) 20 (2) 13	(1) 19 (2) 14	(1) 19 (2) 13	(1) 19 (2) 17	(1) 19 (2) 18	— —	— —	Carcass (111 lb.)	K. I.	30	—	30	7
38	5	40	18	14	(1) 22 (2) 14	(1) 17 (2) 16	(1) 17 (2) 14	(1) 17 (2) 10	(1) 17 (2) 12	— —	— —	Carcass (36 lb.)	K. I.	30	—	30	7

Remarks Index to Foregoing Table (B).

1. A heavily infested pig carcass was frozen for 14 days. The weight of the carcass was not recorded at the time. The carcass was literally frozen to resemble a wooden box in consistency. Some of the *cysticerci* were removed and resembled crystals of ice. The carcass was thawed for 24 hours and 35 measles were removed from the innermost muscles. These were swallowed in their naked state by five members of the Abattoir Staff, N.F.V.; H.M.D.; M.C.; P.J.K.; and W.H.G.; each of whom swallowed seven measles. After twelve months, none of the subjects has developed tapeworm infection.

2. A heavily infested pig carcass was frozen for 12 days. Its physical condition resembled that of Experiment 1, after freezing. The carcass was thawed for 24 hours and 25 measles were removed from the deeper tissues and swallowed in their naked state by two natives on the staff and one European, R.P. After approximately 12 months, no tapeworm infestation has resulted.

3. *Experiment No.* 5.

Leg of pork weighing 24 lb. was frozen for 24 hours. The leg was practically frozen through. Six *cysticerci* were swallowed by W.H.G. according to Keller's method, and six scolices evaginated.

Experiment No. 14.

Leg of pork weighing 21 lb. was frozen for 24 hours. Fifteen cysts were swallowed by W.H.G. in 2 tubes and 3 silk bags. All were recovered. Five scolices (2 in each tube and 1 in 1 bag) had evaginated, and 10 presumably dead *cysticerci* were completely digested.

Experiment No. 18.

Leg of pork weighing 42 lb. was frozen for 24 hours. This was a fairly fat animal. Seven *cysticerci* in two tubes were swallowed by W.H.G. Both tubes were recovered. One contained 3 evaginated scolices and the other, one. Three *cysticerci*, presumably dead, were digested.

Contemporary artificial evagination tests were made, with the following results:—

2 out of 6 scolices evaginated in 5 per cent. sodium taurocholate solution.

1 out of 5 scolices evaginated in 30 per cent. pig bile-physiological saline solution.

Summary.

On three occasions W.H.G. swallowed a total of 28 *C. cellulosae*, which had been removed from pork frozen for 24 hours. Out of this number 15 scolices evaginated.

4. *Experiment No.* 6.

Leg of pork weighing 26 lb. was frozen for 48 hours. Meat was nearly frozen through. After 24 hours' thawing of the meat, W.H.G. swallowed two celluloid tubes, each with three measles. A total of three out of the six measles evaginated scolices. (This leg of pork was from the same carcass as that of Experiment No. 5, above.)

Experiment No. 15.

Leg of pork, 19 lb., was frozen for 48 hours. Freezing, in this case, was definitely complete. After 24 hours' thawing, 15 measles were removed and given to W.H.G. to swallow in 3 tubes and 2 bags. No scolices evaginated, and all the measles, presumably dead, were digested totally. (This leg of pork was from the same carcass as that of Experiment No. 14, above.)

Experiment No. 19.

Leg of pork weighing 44 lb. was frozen for 48 hours. Fat leg. Leg was nearly frozen through. After 24 hours' thawing of the meat, W.H.G. swallowed 8 measles in three tubes. All were digested. Artificial evagination tests in 5 per cent. solution taurocholate and 30 per cent. bile-saline solution were equally negative. This leg of pork was from the same carcass as that of Experiment No. 18.

Summary.

On three occasions W.H.G. swallowed 29 measles from pork frozen for 48 hours. Of this number, only 3 scolices evaginated.

5. *Experiment No.* 7.

A shoulder of pork weighing 19 lb. was frozen for three days. The shoulder was completely frozen through, and many of the measles resembled ice crystals. After 24 hours thawing of the meat, W.H.G. swallowed 10 measles in three tubes. The cysts were removed from the deeper part of the subscapular muscle. Of this number, 7 scolices evaginated, and three cysts were digested. The other shoulder and both hind legs were used in cooling tests. (See chilling tests Nos. 15 to 17, which showed fairly regular evagination results.)

Contemporary artificial evagination tests revealed the following negative results: 0/6 scolices evaginated in 5 per cent. taurocholate solution; 0/7 scolices evaginated in 30 per cent. pig bile-saline solution.

Experiment No. 16.

Shoulder of pork weighing 18 lb. was frozen for 3 days. Freezing was complete. After 24 hours' thawing of meat, W.H.G. swallowed 10 measles in 3 tubes. All were digested.

Experiment No. 20.

Leg of pork weighing 26 lb. was frozen for 3 days. Freezing was complete. After 24 hours' thawing of the meat, W.H.G. swallowed 8 measles. All were digested.

Experiment No. 21.

A whole carcass weighing 185 lb. was frozen for 3 days. Pig was of the large-boned, heavy variety, but not very fat. Freezing was quite complete. After 24 hours' thawing of meat, 60 measles in 5 tubes and 15 bags were swallowed by W.H.G. and three others. Two of the assistants " lost their bags. No scolices evaginated.

Summary.

On 4 occasions W.H.G. (assisted by three other persons on the last occasion) swallowed a total of 88 measles from pork frozen for three days. Of this number, 7 scolices (all on the first occasion) evaginated.

6. *Experiment No.* 4.

Shoulder of pork weighing 18 lb. was frozen for 4 days. Freezing was complete. After 24 hours' thawing of the meat, W.H.G. swallowed 4 cysts in 2 tubes. All measles were digested.

Experiment No. 8.

Shoulder of pork weighing 15 lb. was frozen for 4 days. Freezing was complete. After 24 hours' thawing of the meat, W.H.G. swallowed 12 measles in 4 tubes. Of this number, 1 scolex evaginated.

Experiment No. 12.

Shoulder of pork weighing 16 lb. was frozen for 4 days. Freezing was complete. After 24 hours' thawing of the meat, W.H.G. swallowed 18 cysts in 6 silk bags. All measles were totally digested.

Experiment No. 17.

Shoulder of pork weighing 19 lb. was frozen for 4 days. Freezing was complete. After 24 hours' thawing of the meat, W.H.G. swallowed 15 measles in 3 tubes and 2 bags. All measles were totally digested.

Experiment No. 22.

Whole carcass weighing 87 lb. was frozen for 4 days. Freezing was complete. After 24 hours' thawing, W. H. G. and P. J. K. swallowed 40 measles in 5 tubes and 8 bags. All receptacles were recovered. All measles were digested.

Experiment No. 23.

Whole carcass weighing 106 lb. frozen. W.H.G. and P.J.K. swallowed 36 measles. All measles were totally digested.

Summary.

Out of a total of 125 measles obtained from pork frozen for four days, and swallowed by W.H.G. and an assistant, only one scolex evaginated.

7. *Experiment No.* 9.

A shoulder of pork weighing 16 lb. was frozen for 5 days. Out of 8 measles swallowed, all were digested.

Experiments Nos. 24 *to* 38.

Fifteen whole carcasses of pork, weighing from 36 lb. to 202 lb., were frozen for 5 days. The heaviest carcasses, 161 lb. and 202 lb., were very fat. In each case the carcass was frozen right through. From these fifteen carcasses a total of 509 measles were swallowed by W.H.G. and three others. Of this number no scolices evaginated. A few silk bags were " lost ", but all measles in those recovered showed complete digestion. From four of the various carcasses contemporary experiments were tried in 5 per cent. sodium taurocholate solution and in 30 per cent. pig bile-physiological saline solution at 38° C. incubator temperatures, but no scolices evaginated.

Summary.

Out of 535 measles swallowed by my assistants, no scolices developed. The measles had been recovered from pork frozen for 5 days.

8. and 9. *Experiments* 3, 10 *and* 11.

Three legs of pork, each weighing approximately 30 lb., were frozen—2 for 6 days, and 1 for 7 days. Out of 43 measles swallowed, none evaginated their scolices.

The following short table summarizes the results of our freezing tests with *Cysticercus cellulosae*.

Days Frozen.	Total Measles Swallowed.	Total Evaginated.	Digested or Lost.	Percentage Viable.
1	28	15	13	53·57
2	29	3	26	10·35
3	88	7	81	7·95
4	125	1	124	0·80
5	535	0	535	—
6	30	0	30	—
7	13	0	13	—
12	25	0	25	—
14	35	0	35	—

Conclusions.

From our experiments with the freezing of measly pork, it will be noticed that at freezing room temperatures ranging from 14° F. to 19° F. (−10° C. to −7° C. approximately) and an internal temperature of the deeper tissues of a leg of pork of 20° F. to 23° F. (−7° C. to −5° C.), after 24 hours' freezing, *Cysticercus cellulosae* is still viable.

The percentage of viable measles found steadily diminishes from 2 days' freezing to 4 days' freezing, until after 5 days' freezing no more viable *Cysticerci cellulosae* were found. In view of the fact that one viable measle was found after 4 days' freezing, it would be dangerous to recommend that pork frozen for 4 days at temperatures oscillating between 13° F. and 16° F. (−11° C. and −9° C.) would be safe.

According to Schmey and Bugge, four days' freezing is sufficient to kill all *Cysticerci cellulosae*, and according to Killisch, all *C. cellulosae* are destroyed in half-pig carcasses in 3½ days. At Bloemfontein, on the other hand, we found that from a light shoulder of pork, weighing only 15 lb., and frozen for four days, 1 out of 12 measles was still viable. It is interesting to record that a temperature of 19° F. (−7° C.) was reached in the depths of the subscapular muscle within 24 hours, and of 16° F. (−10° C.) within 4 days.

From 17 experiments performed with measles from pork frozen for five days (including 15 whole carcasses), our results justify the presumption that even in heavy and fat (202 lb.) pig carcasses, *Cysticerci cellulosae* are destroyed. In the 202 lb. pig carcass (Experiment No. 32) the inner temperature registered by means of a steel-pointed thermometer inserted deeply into the musculature of the hind leg, reached 22° F. (−5·5° C.) in 24 hours, and 16° F. in 5 days. During that period the freezing room temperature oscillated between 12° F. and 16° F.

It is presumed that very few pig measles will remain viable if subjected to continuous freezing at −10° C. in pork, for 5 days. A safety margin of 2 days can be allowed, and after 7 days' freezing, lightly infested pig carcasses, provided they are not too fat, can safely be passed as fit for human consumption. There can be absolutely no objection, from a public health point of view, to the treatment of lightly infested measly pork carcasses, no matter how fat they are, for fourteen days at −10° C. continuous freezing, as South African Meat Regulations provide for at present, although few abattoirs make use of the concession.

Chilling Tests with Cysticercus bovis.

Only four such tests were performed at Bloemfontein, and one ox carcass was quartered, the quarters being kept in the cooler for 20 days, 27 days, 30 days and 31 days. Viability of the *cysticerci*, according to Keller's method, was tested, and scolices evaginated to the extent of 6 out of 14, from a fore quarter chilled for 20 days. No scolices evaginated from 17 measles from a hind-quarter chilled for 27 days. Putrefaction had, by then set in. At 30 days, the remaining fore-quarter and hind-quarter had badly putrefied, but, nevertheless, ten measles were removed from each after 30 days' and 31 days' chilling, respectively. These were also tested according to Keller's method, but no evagination of scolices occurred.

Since South African Regulations do not prescribe a period of 21 days' chilling, or longer, as an alternative to the freezing method of rendering slightly infested measly beef fit for human consumption, I

TABLE C.

Freezing Tests with Cysticerous bovis.

Experiment No.	Number of Days in Freezer.	Temp. of Meat after 24 Hours Cooling (°F.).	Initial Temp. of Freezing Chamber (°F.).	Temp. of Freezing Chamber after 5 Hours (°F.).	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 24 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 48 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 3 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 4 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 5 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 6 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 7 Days.	Part of Carcass. Weight (lb.)	Method used— I.—Iwanizky. K.—Keller.	Number of Cysts Swallowed.	Number of Cysts Evaginated.	Number of Cysts Digested (Dead).	Remarks Index.
1	1	44	19	—	(1) 29 (2) 14	—	—	—	—	—	—	Side of beef (248 lb.)	K.	4	4	0	1
2	2	41	17	—	(1) 28 (2) 15	(1) 27 (2) 13	—	—	—	—	—	Side of beef (262 lb.)	K.	2	0	2	2
3	2	—	16	—	(1) — (2) 17	(1) — (2) 12	—	—	—	—	—	Ox tongue	K.	8	0	8	2
4	1	44	20	—	(1) 23 (2) 9	-	—	—	—	—	—	Side of beef (361 lb.)	K.	10	10	0	1
5	3	44	20	—	(1) 22 (2) 9	(1) 22 (2) 11	(1) 20 (2) 10	—	—	—	—	Side of beef (350 lb.)	K.	14	7	7	3
6	2	41	12	—	(1) 24 (2) 11	(1) 23 (2) 11	—	—	—	—	—	Side of beef (254 lb.)	K.	12	1	11	2
7	1	39	12	—	(1) 23 (2) 15	—	—	—	—	—	—	Side of beef (245 lb.)	K.	8	8	0	1
8	3	41	14	—	(1) 25 (2) 16	(1) 23 (2) 14	(1) 23 (2) 11	—	—	—	—	Side of beef (250 lb.)	K.	12	9	3	3
9	3	42	14	—	(1) 28 (2) 18	(1) 24 (2) 12	(1) 23 (2) 11	— —	— —	— —	— —	Side of beef (248 lb.)	K.	10	2	8	3
10	4	43	19	14	(1) 28 (2) 10	(1) 22 (2) 12	(1) 23 (2) 19	(1) 14 (2) 14	— —	— —	— —	Side of beef (300 lb.)	K.	10	4	6	4

TABLE C—(*continued*).

Experiment No.	Number of Days in Freezer.	Temp. of Meat after 24 Hours Cooling (°F.).	Initial Temp. of Freezing Chamber (°F.).	Temp. of Freezing Chamber after 5 Hours (°F.).	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 24 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 48 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 3 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 4 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 5 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 6 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 7 Days.	Part of Carcass. Weight (lb.)	Method used— I.—Iwanizky. K.—Keller.	Number of Cysts Swallowed.	Number of Cysts Evaginated.	Number of Cysts Digested (Dead).	Remarks Index.
11	5	43	19	14	(1) 28 (2) 10	(1) 22 (2) 12	(1) 23 (2) 19	(1) 14 (2) 14	(1) 12 (2) 11	—	—	Side of beef (288 lb.)	K.	13	1	12	5
12	4	42	21	—	—	(1) 23 (2) 16	(1) 19 (2) 11	(1) 20 (2) 15	—	—	—	Hind quarter (160 lb.)	K.	10	4	6	4
13	6	41	23	15	(1) 21 (2) 18	(1) 19 (2) 17	(1) 20 (2) 16	(1) 19 (2) 17	(1) 18 (2) 15	(1) 17 (2) 11	—	Side of beef (289 lb.)	K.	12	0	12	6
14	7	40	23	15	(1) 21 (2) 18	(1) 20 (2) 17	(1) 20 (2) 16	(1) 19 (2) 17	(1) 16 (2) 15	(1) 13 (2) 11	(1) 13 (2) 13	Side of beef (290 lb.)	K.	9	0	9	7
15	5	41	20	18	(1) 22 (2) 17	(1) 21 (2) 16	(1) 16 (2) 14	(1) 16 (2) 15	(1) 16 (2) 12	—	—	Side of beef (250 lb.)	K.	11	0	11	5
16	6	40	19	18	(1) 22 (2) 17	(1) 20 (2) 15	(1) 20 (2) 13	(1) 19 (2) 13	(1) 17 (2) 12	(1) 16 (2) 13	—	Side of beef (316 lb.)	K.	15	0	15	6
17	7	40	19	18	(1) 22 (2) 17	(1) 20 (2) 15	(1) 20 (2) 13	(1) 19 (2) 13	(1) 17 (2) 12	(1) 16 (2) 13	(1) 16 (2) 15	Side of beef (312 lb.)	K.	12	0	12	7
18	4	42	13	15	(1) 21 (2) 14	(1) 22 (2) 16	(1) 20 (2) 14	(1) 18 (2) 12	—	—	—	Side of beef (281 lb.)	K.	7	2	5	4
19	5	42	13	15	(1) 21 (2) 14	(1) 22 (2) 16	(1) 20 (2) 14	(1) 18 (2) 12	(1) 17 (2) 14	—	—	Side of beef (289 lb.)	K.	11	0	11	5
20	5	41	16	16	(1) 25 (2) 15	(1) 24 (2) 13	(1) 23 (2) 13	(1) 20 (2) 11	(1) 18 (2) 12	—	—	Carcass (614 lb.)	K. I.	34	0	34	5

Table C—(*continued*).

Experiment No.	Number of days in Freezer.	Temp. of Meat after 24 Hours Cooling (°F.).	Initial Temp. of Freezing Chamber (°F.).	Temp. of Freezing Chamber after 5 Hours (°F.).	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 24 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 48 Hours.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 3 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 4 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 5 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 6 Days.	(1) Temp. of Meat (°F.). (2) Temp. of Freezer (°F.). After 7 Days.	Part of Carcass. Weight (lb.)	Method used— I.—Iwanizky. K.—Keller.	Number of Cysts Swallowed.	Number of Cysts Evaginated.	Number of Cysts Digested (Dead).	Remarks Index.
21	1	—	16	16	(1) — (2) 15	—	—	—	—	—	—	Ox head of above	K.	10	0	10	1
22	6	42	17	18	(1) 23 (2) 14	(1) 22 (2) 15	(1) 21 (2) 13	(1) 20 (2) 13	(1) 21 (2) 14	(1) 19 (2) 13	— —	Carcass (572 lb.)	K. I.	30	0	30	6
23	6	41	15	16	(1) 25 (2) 16	(1) 23 (2) 14	(1) 23 (2) 12	(1) 19 (2) 13	(1) 18 (2) 15	(1) 18 (2) 13	—	Carcass (713 lb.)	K. I.	30	0	30	6
24	6	39	12	14	(1) 21 (2) 14	(1) 20 (2) 15	(1) 19 (2) 13	(1) 18 (2) 12	(1) 18 (2) 12	(1) 18 (2) 13	— —	Carcass (548 lb.)	K. I.	25	0	25	6
25	6	44	13	13	(1) 22 (2) 13	(1) 21 (2) 14	(1) 19 (2) 13	(1) 19 (2) 12	(1) 19 (2) 11	(1) 18 (2) 12	— —	Carcass (631 lb.)	K. I.	35	0	35	6
26	6	43	19	19	(1) 24 (2) 12	(1) 22 (2) 13	(1) 20 (2) 14	(1) 18 (2) 15	(1) 18 (2) 12	(1) 17 (2) 13	—	Carcass (651 lb.)	K. I.	30	0	30	6
27	6	42	18	17	(1) 21 (2) 9	(1) [illegible] (2) 13	(1) 18 (2) 13	(1) 17 (2) 13	(1) 18 (2) 17	(1) 18 (2) 14	—	Carcass (5[illegible]8 lb.)	K. I.	32	0	32	6
28	6	41	18	16	(1) 20 (2) 13	(1) 21 (2) 12	(1) 20 (2) 13	(1) 19 (2) 13	(1) 19 (2) 15	(1) 19 (2) 14	—	Carcass (686 lb.)	K. I.	30	0	30	6
29	6	42	13	13	(1) 21 (2) 14	(1) 20 (2) 14	(1) 20 (2) 13	(1) 20 (2) 11	(1) 21 (2) 13	(1) 19 (2) 9	—	Carcass (949 lb.)	K. I.	40	0	40	6
30	6	38	11	12	(1) 21 (2) 16	(1) 20 (2) 15	(1) 20 (2) 16	(1) 20 (2) 15	(1) 19 (2) 14	(1) 19 (2) 15	—	Carcass (548 lb.)	K. I.	35	0	35	6
31	6	44	16	16	(1) 22 (2) 14	(1) 21 (2) 13	(1) 20 (2) 14	(1) 21 (2) 16	(1) 20 (2) 14	(1) 19 (2) 11	—	Carcass (438 lb.)	K. I.	30	0	30	6

did not consider that any useful purpose was served by using our available material on chilling tests. Secondly, it was very undesirable to keep rapidly decomposing beef in the condemned meat section of the abattoir chilling rooms.

Our viability tests with beef measles were, therefore, mainly confined to freezing tests, the results of which are tabulated in Table C.

As with *C. cellulosae*, we performed a number of contemporary tests in 5 per cent. sodium taurocholate solution, and in the case of *C. bovis*, with 30 per cent. ox bile-physiological saline solution, instead of pig bile. Viability of the fresh measles was always tested by Keller's method, prior to the carcass being placed in the freezing chamber. Twenty-four hours' cooling of the carcass was allowed in every case, prior to freezing.

Remarks Index to the Foregoing Table (C).

1. *Experiment No.* 1.

A side of beef weighing 248 lb. was frozen for 24 hours. In that time it was found that the beef was by no means frozen through, although freezing had penetrated a considerable distance into the deeper tissues. Twenty measles were removed from the deeper shoulder and thigh muscles. Our subject, W.H.G., swallowed four in two tubes according to our modification of Keller's method. All four scolices evaginated.

Contemporary tests were done as follows, in an incubator with governed temperature of 38° C:—

In 5 per cent. sodium taurocholate solution, 9 out of 12 scolices evaginated.

In 30 per cent. ox bile-saline solution, 1 out of 4 scolices evaginated.

Experiment No. 4.

A relatively heavy (361 lb.) side of beef was frozen for 24 hours. Here again, freezing was not quite complete. Our subject swallowed 10 measles in 4 tubes. All scolices evaginated.

Experiment No. 7.

A side of beef weighing 245 lb. was frozen for 24 hours. The same remarks apply, as above. Subject swallowed 8 *cysticerci* in 4 tubes. All scolices evaginated.

Experiment No. 21.

An ox head containing some 20 viable measles was frozen for 24 hours. Ten of these measles were selected, since they were "covered" up by the flaps of the masseteric incisions Our subject swallowed these 10 and all were found to be dead.

Summary.

Twenty four hours' freezing of beef carcasses split into halves (sides of beef) is not sufficient to kill *C. bovis*, since, in that time the freezing process has not had sufficient time to permeate into the deeper musculature. Shallowly situated measles such as those in the masseters are killed with ease after 24 hours' freezing.

For illustrations see Figures 8 to 11.

FIGURE 8.

Fresh *C. bovis* scolex evaginated in two hours in 5 per cent. Sodium taurocholate solution. Magn. 7×.

FIGURE 9.

Fresh *C. bovis* scolex evaginated in 2 hours in 30 per cent. ox bile-physiological saline solution. Magn. 7×.

FIGURE 10.

C. bovis scolices evaginated by Keller's method after 24 hours freezing. Magn. 7×.

FIGURE 11A.

C. bovis scolex evaginated by Keller's method after 24 hours, freezing. Magn. 7×.

FIGURE 11B.

C. bovis head, from scolex illustrated in Figure 11A. Note four suckers plainly visible. Magn. 40×.

2. *Experiment No. 2.*

Side of beef weighing 262 lb. was frozen for 48 hours. At the end of that time the temperature of the deeper tissues of the buttock had reached 27° F. (approximately −3° C.), and the room temperatures had fallen from 17° F. to 13° F. (approximately −10·5° C.). Freezing had, by that time, permeated completely into the deeper tissues.

A remarkable phenomenon occurred in this test, in so far as that neither of two *cysticerci* swallowed by our subject evaginated their scolices, whereas in 5 per cent. sodium taurocholate solution 4 out of 10 scolices evaginated in 2 hours, and in 30 per cent. ox bile-physiological saline solution 3 out of 10 scolices evaginated in 2 to 4 hours.

Experiment No. 6.

A side of beef weighing 254 lb. was frozen for 48 hours. Same remarks regarding freezing apply in this case as above. One out of 12 scolices evaginated by Keller's method.

Experiment No. 3.

An ox tongue was frozen for 48 hours. Freezing was definitely complete. No scolices from 8 measles evaginated by Keller's method.

Summary.

After 48 hours' freezing in sides of beef weighing approximately 260 lb., the freezing process has permeated considerably into the deeper musculature. The freezing action has, however, not yet

had sufficient time to destroy the viability of *C. bovis*. In small pieces of meat, for example an ox tongue, the freezing process is definitely complete, and few measles will survive the low temperature reached in the interior of such meat.

Illustrations see Figures 12 and 13.

FIGURE 12.

C. bovis scolices evaginated in 2 hours in 5 per cent. sodium taurocholate solution. Measles from carcasses frozen for 48 hours. Magn. 7×.

FIGURE 13.

C. bovis scolices evaginated in 2 hours in 30 per cent. ox bile-physiological saline solution. Measles from carcasses frozen for 48 hours. Magn. 7×.

3. *Experiment No. 5.*

A fairly heavy (350 lb.) side of beef from the same carcass as that of Experiment No. 4, was frozen for three days. After three days' freezing the inner temperature of the buttock, read on a " spear thermometer ", registered 20° F. (approximately − 7° C.). By that time freezing was complete. After 24 hours' thawing of the meat, W.H.G. swallowed 7 *C. bovis* in three tubes. All seven scolices evaginated. Contemporary artificial evagination tests were tried. Five *C. bovis* were treated in each of a 5 per cent. sodium taurocholate solution and a 30 per cent. ox bile-saline solution. Negative results were obtained.

Experiment No. 8.

A side of beef weighing 250 lb., from the same carcass as that described in Experiment No. 7, was frozen for 3 days. The inner temperature of the meat fell from 25° F. after 24 hours to 23° F. after three days. Freezing room temperature varied between 16° F. and 11° F. Freezing was complete. Out of 12 measles swallowed by W.H.G. in four tubes, no less than 9 evaginated their scolices beautifully. Contemporary artificial tests with 10 measles in each sodium taurocholate solution and 30 per cent. ox bile-saline solution, gave negative results.

Experiment No. 9.

A side of beef weighing 248 lb. was completely frozen through in three days. Inner temperature of the meat fell from 28° F. after 24 hours to 23° F. after 3 days. Room temperature fell from 18° F. after 24 hours to 11° F. after 3 days. Out of 10 measles swallowed by W.H.G., two evaginated their scolices.

Summary.

Three days' freezing of sides of beef is not sufficient to kill *C. bovis*. A temperature of 23° F. is easily maintained in the meat after 24 hours, provided the room temperature is kept below −10° C.

4. *Experiment No.* 10.

A side of beef weighing 300 lb. was frozen through for 4 days. The internal temperature of the meat registered 28° F. after the first 24 hours' freezing, and fell rapidly between the third and fourth days from 23° F. to 14° F., which temperature was the same as that of the freezing chamber. On the third day the temperature of the freezing chamber necessarily rose to 19° F., as the result of the opening of the chamber for about an hour, in order to take out, and place in a few lightly infested measly carcasses for Regulation freezing treatment. After 24 hours' thawing of the meat, W.H.G. swallowed three tubes containing 10 measles. Of this number four scolices evaginated. Contemporary tests with sodium taurocholate solution and ox bile-saline solution gave negative results.

Experiment No. 12.

A hind-quarter of beef weighing 160 lb. was frozen for 4 days. The initial temperature of the freezing chamber was 21° F., but after the quarter had been in the chamber 48 hours, the temperature had fallen to 16° F., and this was succeeded on the third and fourth days by 11° F. and 15° F. respectively. The internal temperature of the meat after the 2nd, 3rd and 4th days was 23° F., 19° F., and 20° F., respectively. Freezing of the quarter was complete. After 24 hours' thawing of the meat, W.H.G. swallowed 10 cysts, of which number 4 evaginated scolices.

Experiment No. 18.

A side of beef weighing 281 lb. was frozen for 4 days. Freezing was complete, and on no occasion during that time did the freezing-room temperature exceed a maximum of 16° F. (approximately −9° C.). The internal temperature of the meat fell from 23° F. (approximately −6·5° C.) after the first 48 hours' freezing to 18° F. (approximately −8° C.) after the 4th days' freezing. After 24 hours' thawing of the meat W.H.G. swallowed seven measles in 3 tubes. Of this number two evaginated their scolices. Contemporary tests with sodium taurocholate solution and bile-saline solution gave negative results.

Summary.

Out of a total of 27 measles from meat frozen for four days, swallowed by W.H.G., ten were still capable of evaginating their scolices under conditions tantamount to natural infection. Freezing in all cases was complete, and a uniformly low temperature was maintained. *Cysticercus bovis* is not destroyed by thorough freezing in all cases within four days. Illustrations see Figure 16.

5. *Experiment No.* 11.—A side of prime "young" beef weighing 288 lb. and containing a large quantity of fat, uniformly distributed, was frozen for 5 days. This side of beef was from the same carcass as that of Experiment No. 10. That freezing was complete can be gleaned from the following temperature records, which are specially repeated in this case:—

	Initial Temp. of Freezer.	Temp. after 5 Hours.	Temp. after 24 Hours.	Temp. after 48 Hours.	Temp. after 3 Days.	Temp. after 4 Days.	Temp. after 5 Days.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.
(1) Of Meat....	—	—	28	22	23	14	12
(2) Of Chamber	19	14	10	12	19	14	11

Only on one occasion, as was noted under the description of Experiment No. 10, did the freezing-room temperature exceed −10° C. for the reasons stated. It took forty-eight hours before sufficient thawing had occurred to permit of the side of beef being dissected in order to collect deep-seated *cysticerci*. Thirteen measles were given to W.H.G. to swallow in 4 tubes. Of this number one evaginated its scolex. I sent this evaginated scolex to Dr. H. O. Mönnig, Onderstepoort, with a request that he should examine and describe its condition, and, if necessary prepare it for photographing purposes. Dr. Mönnig kindly favoured me with the following report:—

"*Scolex of* C. bovis *evaginated after 5 days' freezing.*

The scolex is provided with two apparently normal suckers situated on two adjoining quarters. The other two quarters are slightly thickened, as if rudimentary suckers were present, but no such structure is visible. Between the latter two quarters there is a large invagination of which the opening is as wide as a normal sucker. The lumen of the invagination is then constricted, but widens out again to form a fairly large space in the centre of the scolex, from which two arms are given off in the directions of the two normal suckers and almost reaching these. The orifice of the invagination is lined with cuticle bearing a number of evenly-spaced striations directed from without inwards. The walls of the invagination within the scolex are thrown into a number of large folds. It is problematic whether the scolex could have attached itself normally to the intestinal wall and, if it could have done so, it is probable that the tapeworm would have had some difficulty in maintaining its position after it had grown to some length." Illustration of this scolex, see Figure 17.

Experiment No. 15.

Side of beef weighing 250 lb. was frozen for 5 days. Freezing was again complete and uniformly low temperatures were maintained. W.H.G. swallowed 11 measles, of which number none evaginated scolices.

Experiment No. 19.

Side of beef weighing 289 lb. was frozen for 5 days. This side was from the same carcass as that of Experiment No. 18. Out of 11 measles swallowed, no scolices evaginated.

Experiment No. 20.

Carcass of beef weighing 614 lb. was completely frozen through for 5 days. Note the low temperatures maintained of (1) the meat and (2) the freezing chamber. After 48 hours' thawing of the meat W.H.G. and two others swallowed 34 measles. Of this number no scolices evaginated. (One bag containing 3 measles was " lost ".)

Summary.

Out of a total of 69 measles swallowed by my assistants, one evaginated its scolex, after five days' freezing. Dr. Mönnig has aptly described the deformities of the head of this evaginated scolex, but, nevertheless, if we must accept the theory of complete evagination of the scolex as the best criterion of viability of measles, then we must bear in mind that occasionally viable *cysticerci* may survive in beef frozen for five days.

6. *Experiments Nos.* 13 *and* 16.

Sides of beef weighing 289 lb. and 316 lb. respectively, were completely frozen through for six days. Out of a total of 27 measles swallowed by my assistant, W.H.G., no scolices evaginated.

Experiments Nos. 22 *to* 31.

Having established the possibility that *C. bovis* might occasionally survive five days' continuous freezing, I decided to confine my tests after the twentieth experiment to measles from carcasses frozen for six days. Consequently, the last ten carcasses we obtained during the months of December, 1936, and January and February, 1937, were subjected to six days' continuous freezing. As many *cysticerci* as possible were collected from both sides of those respective carcasses, after the latter had been sufficiently thawed. The *cysticerci* were enclosed in tubes and silk bags and were swallowed by W.H.G. and two assistants. W.H.G., as usual recovered all his tubes, but a few of the silk bags were " lost " by his two confréres. Nevertheless, out of a total of 317 measles collected from 10 carcasses, no scolices evaginated.

7. *Experiments Nos.* 14 *and* 17.

Two fairly large sides of beef, weighing 290 lb. and 312 lb., respectively, were completely frozen for 7 days. Out of a total of 21 measles swallowed by W.H.G., no scolices evaginated.

The following short table summarizes the results of our freezing tests with *C. bovis*. (Sides, Quarters and Carcasses of Beef only):—

Days Frozen.	Total Measles Swallowed.	Total Scolices Evaginated.	Digested or "Lost."	Percentage Viable.
1	22	22	0	100·0
2	14	1	13	7·1
3	29	18	11	62·07
4	27	10	17	37·04
5	69	1	68	1·45
6	344	0	344	—
7	21	0	21	—

FIGURE 14.
C. bovis scolices evaginated by Keller's method after 3 days' freezing. Magn. 7×.

FIGURE 15.
C. bovis scolices evaginated by Keller's method after 3 days freezing. Magn. 7×.

FIGURE 16.
C. bovis scolices, evaginated by Keller's method after 4 days' freezing. Magn. 7×.

FIGURE 17A.

C. bovis scolex evaginated by Keller's method, after 5 days' continuous freezing. Magn. 7×.

FIGURE 17B.

Microscopic view of same scolex. See description of Experiment No. 11 Magn. 40×.

CONCLUSIONS.

From the results we obtained with the available material at Bloemfontein Abattoir, it is reasonable to conclude that *C. bovis*, frozen in whole sides of beef can withstand a considerable amount of freezing. That the beef *cysticerci* can remain viable under those circumstances, after 24 hours' to 4 days' continuous freezing, is without much doubt, if the fullest recognition of our criterion of simulating natural infection is to be accepted as the most conclusive evidence thus far provided by modern science.

Our table, giving the most meticulous daily temperature recordings, shows that the most thorough through freezing of the tested carcass was applied.

After five days' continuous freezing, on one occasion, my subject recovered an evaginated scolex. This scolex, as was described by Dr. Mönnig, was to a great extent deformed in the head process, and only two normal suckers could be noticed. Since malformations are not altogether unusual in *cysticerci*, it may be considered possible that this particular *cysticercus* may have evaginated a deformed scolex under normal and fresh conditions. It may also not be unreasonable to presume, that since one deformed *cysticercus* out of a not excessive number tested (69), was capable of evaginating its scolex, a few quite normal *cysticerci* might be able to do so, if swallowed by humans with the ingestion of measly beef frozen for five days. We may, therefore, reasonably presume that a five days' freezing treatment is risky, if we are to satisfy ourselves of the shortest period of freezing necessary for the destruction of *Cysticerci bovis*.

Superficial *Cysticerci bovis*, e.g. those situated in the tongue, or in the masseters of the face, are destroyed within 48 hours, according to our tests. Provided a temperature of $-10°$ C. is maintained for that period, through freezing of a relatively thin muscular organ, like the tongue, or of a thin flap-like muscle, like the masseter, will occur with certainty.

Judging from our tests, it would appear that no *Cysticerci bovis*, situated in the deep musculature of the shoulders or of the thighs can survive a period in excess of five days' freezing. After 6 days' freezing, 344 deep-seated measles (shallow measles were ignored and not used) failed to evaginate their scolices, when swallowed according to our modifications of Keller's and Iwanizky's methods. Similarly, we had negative results with 21 measles tested on two occasions after 7 days' freezing. If our results, offered not in a dogmatic manner, were to be accepted, it can reasonably be presumed that no *cysticerci* will remain viable after six days' continuous freezing, but there is a definite probability that a few individual deep-seated *cysticerci* can survive a five days' freezing.

The South African Regulations provide for a period of 14 days' continuous freezing at – 10° C., and there is no doubt at all, that this period is perfectly safe from the public health point of view. If any good purpose were to be served thereby, e.g. economy to the butchers, I feel that the period of freezing can with a margin of safety, be reduced to 10 days' freezing. The only objection I have to a ten days' freezing process is that, unless the abattoir is a large concern and several freezing chambers may be available, it will be difficult to organise control and maintenance of low temperatures. This can be elucidated by the following example. At Bloemfontein we only have one freezing chamber available at the present time. In order to maintain the low temperature required, we have set aside one morning a week (every Thursday), when we take out of, or place into, the freezing chamber the week's number of lightly infested carcasses, which, meanwhile, have been collected and kept in a part of the chill-rooms set aside for that purpose. This operation takes about an hour every week, and after that the freezing chamber is kept locked until the next week, except for a few minutes on certain occasions during the past year, when we were conducting our viability experiments. By setting aside a certain day once a week for working in the freezing chamber, a regular control can be exercised, whereas with ten days' freezing, irregular days of taking out or putting in carcasses will follow.

In agreement with Keller, one must stress the fact that low temperatures must be maintained, otherwise, as Keller found, all *cysticerci* may not be killed even after about 23 days' freezing at such high temperatures of, e.g. – 1° C. to – 1·5° C. (+30° F.). (See Table on next page.)

PART V.

The Importance of Cysticercosis in Meat in Relationship to Public Health.

It has been considered a moot-point as to whether the *Cysticercus cellulosae* in pork and its correlative *Taenia solium* in man, or the *Cysticercus bovis* and its adult *Taenia saginata* is the more important parasite, from the perspective of public health. At the present time it would appear that *Taenia saginata* is far more frequently found in humans than *Taenia solium*, in most countries where both parasites are encountered. Yet, in many countries, and in South Africa in particular, *Cysticercus cellulosae* in the pig is the more common larval form.

COMPARATIVE TABLE SHOWING THE RESULTS AND RECOMMENDATIONS OF VARIOUS WORKERS.

Temperatures and Periods of Freezing Lethal to Cysticerci.

Investigator.	*Cysticercus cellulosæ.*			*Cysticercus bovis.*		
	Temperature Required.	Time.	Part of Carcass.	Temperature Required.	Time.	Part of Carcass.
Reissmann (1897)	−8°C. to −10°C.	4 days	Depths	−8°C. to −10°C.	3 days	Depths.
Boccalari (1903)	−4°C. to − 6°C.	4 days	—	−4°C. to −10 °C.	4 days	—
Ransom (1914)	—	—	—	−9°C. to −12°C.	6 days	Quarters.
Killisch (1923)	−8°C. to −12°C.	3½ days	Half-pigs	—	—	—
Wagner (1922)	—	—	—	—	8 days	Carcasses.
Schmey & Bugge (1930)	−8°C. to −10°C.	4 days	Carcasses	−8°C. to −10°C.	4 days	Carcasses.
Kallert (1931)	—	—	—	−8°C. to −10°C.	9–10 days	Hindquarters.
Clarenburg (1932)	—	—	—	−8°C. to −10°C.	65 hours	6 cm. pieces.
Feldforth (1934)	—	—	—	−2°C.	2 days	½-lb. weight.
*Scheerer (1935)	—	—	—	−2°C.	6 days	Innermost parts.
†Zunker (1935)	—	—	—	−3°C.	6–7 days	Innermost parts.
Bloemfontein Abattoir (1936–37)	−10°C.	5 days	Carcasses	−10°C.	6 days	Carcasses.

* Scheerer explained that a temperature of −2°C. must be maintained for 6 days in the innermost parts of the carcass.

† Zunker maintained that a temperature of −3°C. in the innermost parts of carcass was lethal to *C. bovis* and it generally took 6 to 7 days to reach −3°C. in those parts.

It has hardly been found practically possible to conduct scientific surveys of the incidence of the two species causing human taeniasis in any country, and, therefore, recent literature is remarkably silent on the question. That either or both parasites occur almost universally may be gleaned from reference to the recent articles by Liévre (France, 1933); Cameron (Great Britain, 1933), Robertson (Great Britain, 1920); Krueger (1934), Junack (1926-31), Profé (1934) and many others in Germany; van der Slooten (1932), van Oijen (1929), Kerstens (1931), and many others in Holland; Cattaneo (1932) and others in Italy; Krupski (1917), Guillebeau (1917) and others in Switzerland; Dikoff (Bulgaria, 1931); Elvinge (1929) and Nielsen (1934) in Denmark; Grado (Sicily, 1935); Michail (Roumania, 1935); Eguchi and Nishiyama (Japan, 1930); Mills (1923-24), Gear and Pedersen (1934) in China; Rao (India, 1933); Yenikomshian and Berberian (Syria and Lebanon, 1934); Bergeon (French Indo-China, 1928); Le Coultre (Dutch East Indies, 1928); Price (U.S.A., 1925), Hall (U.S.A. and Central America, 1927); Nauck (Costa Rica, 1931); Palais (Brazil, 1933); Schwartz (1925) and Schwartz and Tubangui (1922) in Phillipine Islands; Penfold, Penfold and Phillips (1936) in Australia; Claverie (French Guinea, 1928); Teppaz (Senegal, 1923); Maplestone (Sierra Leone, 1924); Poisson (Madagascar, 1929 and 1934); Daubney and Carman (Kenya, 1928); Porter (1918), Watkins-Pitchford (1923), Cawston (1934 and 1935) and Mönnig (1934 and 1936) in South Africa.

A detailed survey of the incidence of human taeniasis is not given in every case by the above authors, in respect of the countries to which the various articles refer, but the extent of infection in some countries can be gauged from extracts from many of the articles According to Liévre (1933), in France in every hundred cases of tapeworm infection, only one is due to *Taenia solium*. The frequency of human infection is inversely proportional to the degree of infestation of the intermediate host.

According to Junack (1926) infestation of humans with *Taenia saginata* in Germany had a big increase during the war period, when many soldiers served in parts where no meat inspection existed, or where the inspection may have been of a perfunctory nature.

Special reference may be made to countries with predominantly non-European populations. Eguchi and Nishiyama (1930) report that *Taenia solium* is very rarely met with in Japan, with the exception of the Prefecture of Okinawa, where they found twenty-five cases of *T. solium*. Wu (1936) stated that in all, fifteen cases of *Taenia solium* have been reported from the following Chinese provinces: Shantung 1, Hupeh 1, Hunan 1, Yunnan 1, Kwangtung 1, Shansi 1, Szechuan 3, Hopei 5, Chekiang 1.

According to Wu, fifteen cases of *Taenia saginata* were also reported from the following Chinese provinces: Hopei 12, Yunnan 1, Anhwei 1, Fukien 1.

Mills (1924) stated that in 2 years he treated 12 patients for *Taenia saginata* in the Peking Union Medical College, including one American girl of 24. No cases of *Taenia solium* were observed by Mills. He believed that taeniasis was much more prevalent in

China than was supposed. Although very few patients were actually treated in clinics, a vast number was treated by native medicines in bazaars.

Liang (1932), quoted by Gear and Pedersen (1934), reported a case of *Taenia solium* infection, and in the Chinese hospital survey only two cases of *T. solium* were specifically diagnosed, one from Peiping and one from Nanking, both in Chinese subjects.

Rao (1933) reported a case of *T. solium* in Madras, India, and made special mention that he believed the *T. solium* was a more common parasite in India than has been revealed.

That *Taenia saginata* is quite a common parasite in Syria and Lebanon, is shown in the statistics supplied by Yenikomshian and Berberian (1934). These authors state that " taeniasis is much more common in Beirût and its surroundings than in Aleppo and Damascus. In both Syria and Lebanon, meat is frequently eaten raw as *Kibbi neyyi*, a national dish, or broiled. In Beirût more beef is eaten than in Aleppo and other parts of Syria, where mutton and goat meat is preferred ". In the four main cities of Syria and Lebanon and on the Amik plain the authors found the incidence of *T. saginata* in faecal examination to be: Aleppo 2·6 per cent., Damascus 3 per cent., Baalbek 3 per cent., Hamah 0 per cent. and Amik plains 5 per cent. In Beirût the incidence was found to be 12 per cent. In that particular area no *T. solium* was found, since the majority of the inhabitants were Mohammedans, who did not eat pork. On the coast belt and along the Orontes River the incidence of *Taenia saginata* was 10 per cent.

Penfold, Penfold and Phillips (1936) give a suggestion of the extraordinary incidence of *T. saginata* infection among Syrians. These authors conducted a survey of the incidence of tapeworm infection in the State of Victoria, Australia, and they found that 90 out of 1,830,000 people in that State had *Taenia saginata*. Of that number 42 were Syrian-born Australians. In the entire State of Victoria there were only 377 people who were born in Syria, and 42 were infected, or 11,000 per 100,000. The survey was conducted under the aegis of the Victoria Government, who offered a reward of £5 to carriers for the production of a complete *Taenia*. In addition a very thorough questionnaire was sent to all physicians and chemists.

According to Bergeon (1928) and le Coultre (1928), both parasites are relatively common among natives in French Indo-China and in Bali, respectively.

Mr. J. T. Forbes, M.R.C.V.S. of Singapore writes (19.11.36) that medical authorities have reported a very low incidence of taeniasis in Malaya, but Mr. Forbes has " reason to believe that the incidence of infection is considerably higher than is anticipated ".

In the Phillipine Islands, according to Schwartz and Tubangui (1922), the incidence of *T. saginata* was relatively high. About 30 in 4,000 stool examinations were positive. The incidence of *T. solium* was much lower.

Price (1925) believed that the incidence of *T. solium* was high in Texas, U.S.A., with its large Negro and Mexican population.

Nauck (1931) found that *Cysticercus cellulosae* in humans, due to the frequency of *T. solium* among the inhabitants was very readily acquired in Costa Rica.

In order to obtain knowledge of the incidence of infection with various kinds of worms among natives in Sierra Leone Protectorate, Maplestone (1924) examined the stools of 500 natives, inmates of the Freetown gaol. He found that 3·2 per cent. were infected with *T. saginata*.

Daubney and Carman (1928) examined the stools of the inmates of a Government reformatory in the Kenya Highlands and found the incidence of *T. saginata* to be 50 per cent. The inmates of this reformatory were boys drawn from all parts of East Africa, and represented almost all tribes.

Capt. H. J. Lowe, M.R.C.V.S., of the Department of Veterinary Science and Animal Husbandry, Mpwapwa, Tanganyika Territory, supplies copies of reports from some Medical Officers concerning the incidence of human tapeworm infestation in different parts of the Territory. (Letter dated 24.10.36):—

Dr. R. C. Speirs, Medical Officer, Moshi found 313 infected stools among 552 examinations from prisoners, sanitary porters, school boys and other native children. (April 1933.)

Dr. W. Hood-Dye, Medical Officer, Iringa found 34·17 per cent. of stool examinations positive for *T. saginata* among the Wahehe tribe, and 14·02 per cent. among the Wabena tribe. (August 1933.)

Dr. A. McA. Blackwood, Medical Officer, Dodoma, found among inpatients at his hospital that 34 out of 638 stool examinations were positive for *T. saginata*, or 5·32 per cent. (July 1933.)

Dr. J. S. Armstrong, Medical Officer, Singida, treated 2,456 cases for tapeworm at the Singida Hospital during the five years 1928-32. He calculated that the Singida Hospital served a population of 45,000-50,000 people. (May 1933.)

Dr. D. A. Skan, Medical Officer, Dar-es-Salaam, found 119 stool examinations out of 3,015 positive for *Taenia* infection. (April 1933).

We have already seen that many of the earlier writers mentioned the severe—almost 100 per cent.—incidence of *T. saginata* among the Abyssinians. (Reference Neumann, 1892; Leuckart 1886). To what extent the infection occurs in that country at the present time is not known, since little or no literature is available on the subject.

Poisson (1930) supplied statistics for the year 1927 of recorded cases of *T. solium* in Madagascar. He mentioned that the bulk of cases found in Madagascar were residents of the *hovas*, also among Europeans born in Reunion, and the disease was not unknown among Europeans resident in the Capital, and common among Indians at Farafangana.

According to Poisson, 49 cases of *T. solium* were recorded in Madagascar in 1927, of which number, 16 came from Farafangana, and 6 among the *tirailleurs* of the garrison at Majunga.

It is a great pity that regular surveys of the incidence of taeniasis are not undertaken in our civilized countries. In South Africa, Porter (1918) did a survey of the incidence of helminthic infection among natives in Johannesburg. In the Johannesburg

General Hospital she detected the ova of tapeworms in the excretum of 37 out of 375 native patients, and in 1 out of 60 European patients. " All of these patients had been admitted for diseases other than ' worms ', and many of them were surgical cases." Twenty-six of the natives harboured *T. saginata* and eleven *T. solium*. The European case harboured *T. saginata*. Porter further recorded 104 post-mortem examinations on native mine labourers. " Tapeworms were discovered in the intestinal canal in 20 instances. (12 *T. saginata* and 8 *T. solium*.)"

Watkins-Pitchford (1923) estimated the incidence of tapeworm infection among South African natives to be from 10 to 19 per cent., " and it is not uncommon amongst Europeans ". According to Watkins-Pitchford, between 1917 and 1923, 17 cases of tapeworm (12 *T. saginata* and 5 *T. solium*) were diagnosed in Europeans from microscopic examination of faecal specimens sent to the South African Institute for Medical Research, Johannesburg. " Such returns do not give, of course, any indication of the extent of the prevalence among Europeans. Many people harbour these parasites and are quite unconcious of the fact, because they never inspect their own dejecta. Those cases in which diagnosis is arrived at by microscopic examination of faecal specimens must represent a very small fraction of the total number."

Dr. A. J. Orenstein, Chief Medical Officer, Rand Mines, Ltd., very kindly supplied the following tables which show the incidence of worm infestations among natives employed on the City Deep Mine, Johannesburg. The tables were compiled by Dr. W. O. Fischer, for the years 1928-33, inclusive.

TABLE I.

Incidence of Tapeworm in 1,086 consecutive autopsies on Native Mine Workers of the City Deep Central Native Hospital.

Tribe.	No. of P.M.'s.	*Taenia saginata.*		*Taenia solium.*	
		No.	Per-centage.	No.	Per-centage.
Shangaan	333	4	1·2	—	—
Mchopi	170	5	2·9	—	—
Nyambaan	116	3	2·6	—	—
Tonga	32	2	6·3	—	—
EAST COAST NATIVES TOTAL	651	14	2·3	—	—
Basuto	215	5	2·3	1	0·47
Xosa	93	1	1·1	—	—
Zulu	34	2	5·9	—	—
Bechuana	29	—	—	—	—
Pondo	27	1	3·7	—	—
Fingo	9	—	—	—	—
Hlubi	9	2	22·2	1	11·1
Baca	8	2	25·0	—	—
Mocnda	5	—	—	—	—
Swazi	4	3	75·0	—	—
Cape Coloured	2	—	—	—	—
UNION NATIVES TOTAL	435	16	3·7	2	0·5
TOTAL	1,086	30	2·8	2	0·2

TABLE II.

Showing incidence of Tapeworm ova in the stools of Natives of the City Deep Mine in 1,016 consecutive examinations.

Tribe.	No. of Stools Examined.	Ova of *Taenia saginata*.		Ova of *Taenia solium*.	
		No.	Percentage.	No.	Percentage.
Shangaan	214	7	3·3	1	0·47
Nyambaan	38	1	2·6	—	—
Mchopi	31	2	6·5	—	—
Tonga	20	—	—	—	—
EAST COAST NATIVES TOTAL	303	10	3·3	1	0·47
Basuto	352	16	4·5	2	0·6
Xosa	145	4	2·8	1	0·69
Bechuana	68	1	1·5	—	—
Pondo	44	1	2·3	—	—
Zulu	36	—	—	—	—
Swazi	34	1	2·9	—	—
Baca	9	1	11·1	—	—
Fingo	8	—	—	—	—
Moenda	7	—	—	—	—
Hlubi	5	—	—	—	—
Cape Coloured	4	—	—	—	—
UNION NATIVES TOTAL	713	24	3·4	3	0·42
TOTAL	1,016	34	3·3	4	0·4

Since the above, according to Dr. Orenstein, Dr. Fischer in 1935 found *Taenia saginata* in 2·2 per cent. of 934 Union Natives (excluding Zulus); in 3·9 per cent. of 103 Zulus; and in 3·3 per cent. in East Coast Natives.

Note: By *East Coast Natives* is meant those from Portuguese East Africa.

Dr. C. G. Becker (17.2.37) kindly supplied statistics showing the number of positive examinations of the stools at the South African Institute for Medical Research, Johannesburg, for the years 1934 to 1936 (inclusive). The following table illustrates the numbers of cases found (ova and/or segments), and the statistics refer to *T. saginata*, except where special mention is made of *T. solium*.

Year.	Europeans.		Non-Europeans.		Total Stools Examined.
	Ova.	Segments.	Ova.	Segments.	
1934	14	25	21	9	4,700
1935	9	19 plus 1 *T. sol.* (segments)	11	3	3,844
1936	11 plus 1 *T. sol.* (ova and segs.)	13	30	2	3,813

Between the period 4.4.36 and 10.1.37, the following cases of Taeniasis were treated at the Pretoria Hospital. (Statistics kindly supplied by Dr. H. J. Hugo, Medical Superintendent.)

Europeans.

Age.	Sex.	Diagnosis.	Date.	Remarks.
11.....	F.	*T. solium*	4.4.36	
6.....	M.	,,	20.8.36	
10.....	F.	,,	7.9.36	One family, N.B.
3.....	M.	,,	7.9.36	One family, N.B.
8.....	F.	,,	7.9.36	One family, N.B.
4.....	F.	,,	30.9.36	One family, N.B.
5.....	M.	,,	23.10.36	One family, N.B.

Non-Europeans.

5.....	F.	*T. solium*	5.1.37	Basuto. Admitted in coma.
14.....	F.	,,	10.1.37	Basuto. Admitted as accident case.

Judging from these statistics, and from figures supplied by the medical authorities of two of our neighbouring Native Protectorates, it would appear that the incidence of taeniasis among natives and Europeans is not high in Southern Africa. Dr. J. W. Stirling, Principal Medical Officer, Bechuanaland Protectorate reports (4.11.36): "From reported cases one would conclude that infection in humans of tapeworms is not excessive. Out of 27,662 first attendances of out-patients in 1935, only 43 were for tapeworm infection." Dr. H. W. Dyke, Principal Medical Officer, Basutoland, reports (30.10.36): "Out of 133,021 out-patients there were 231 cases of tapeworm. These figures are for a three-year period at all Government stations. At Maseru out-patient department for the period 1st January to 30th September, 1936, out of 7,800 out-patients, there were 7 cases of tapeworm".

There can be little doubt that the figures given in the statistics, and also those of the two Native Protectorates are only indicative of a very small percentage of the actual infections. Reference to the Survey of the Incidence of Cysticercosis in an earlier Part of this work shows a particularly high incidence of *C. bovis* in Natal, where a large number of cattle of Zulu origin is slaughtered; in Barberton, which district borders on Swaziland; and in the coastal Cape-Eastern abattoirs, East London, Kingwilliamstown, Fort Beaufort and Port Elizabeth, centres which draw a good deal of their stock from the Transkeian Native Territories. The Eastern Orange Free State is a "black" area as regards *C. cellulosae*. Reference to the "Incidence Map" shows the proximity of the districts of Ficksburg, Senekal, Clocolan and Wepener to the Basutoland border. We have noted that the Principal Veterinary Officer for Basutoland estimated that the incidence of *C. cellulosae* in that Territory was about 10 per cent. in pigs. South African Statistics—the few which are available and not by any means truly indicative—appear to agree with the observations of Lièvre in France, that *T. saginata* is encountered

far more frequently than *T. solium*, and that the incidence of infection in the human is inversely proportional to the severity of the infection in the intermediate stage. Undoubtedly, if pork were not eaten in a well-cooked state, even by natives, the incidence of *T. solium* would be much higher everywhere in South Africa, but the omnivorous habits of the pig tend to the ready ingestion of the entire human stool, containing thousands of *T. solium* ova, and heavy infestation of the pig follows. A theory, which I think bears a good deal of fact and may possibly explain the somewhat anomalous disproportion between the relative frequency of infection in the pig and the rarer infection of the human in South Africa, with the adult tapeworm, *Taenia solium*, is that the risk of the human infection is very much greater through the *handling* of measly pork than through the *ingestion* of it. Leuckart bears out this point and mentions that he found infestation with *T. solium* far more frequently in women than in men, and especially among cooks and kitchenmaids who handled pork, and when found in males, most frequently in butchers. In our Native Reserves the older men and the women most frequently handle pork carcasses. Owing to the sticky nature of pig measles and the greasiness of the lard, viable *cysticerci* can readily be conveyed by the hands to the mouths of such carcass-dressers. The young men, from whom mine workers are recruited, eat well-cooked measly pork in their Native Reserves, but the handling and preparation of the raw pork is mainly done by their women-folk. On one occasion the writer could have been subject to tapeworm infection, when he found a viable *Cysticercus cellulosae* on the mouthpiece of his cigarette, after having minutely dissected a measly pig carcass for observation purposes. I do not suggest that the incidence of *T. solium* in South Africa is as great, or nearly so, as that of *T. saginata*, but I do believe that in actual fact the incidence of infection is not truly reflected in observations on native mine workers. A high percentage of infection with *T. solium* should be observed if systematic faecal examinations could be made of representative colonies of natives, including those who most commonly handle measly pork in the Reserves, namely the women. During 1936 I had occasion to apply to Dr. Viviers, District Surgeon, Vereeniging, for some information regarding the origin of a case of cerebral cysticercosis in a native who died in the Bloemfontein Mental Hospital. The patient originated from the Vereeniging District. (See Case History Native Lucas Mpake in a subsequent portion of this Part.) Dr. Viviers replied, *inter alia* (letter dated 10.12.36): "I know that at least 25 per cent. of the natives in this (Vereeniging) district are infected with *Taenia solium*. In compounds, of which there are many in this area, the incidence of infection is higher." Upon first sight the remarks of Dr. Viviers may appear to be a somewhat exaggerated "guess in the dark", but to those who know the South African native and his habits, it will be clear that no gross exaggeration is presented. During 1932, I had occasion to satisfy my curiosity as to the extent of infection of humans with tapeworm in one of the Native Reserves. On that occasion, along with an Extension Officer attached to the Native Affairs Department, I visited the *stad* of the Chief of the Moiloa Native Reserve in the Marico District (N.-W. Transvaal.) At a meeting of about 4,000 natives, which I addressed on the subject of anthrax control, I was eventually

questioned by one of the Headmen on the reason why so many of their cattle and pigs are condemned for measles, when sent to the Johannesburg and Pretoria abattoirs. After a brief outline of the life-histories of the two parasites I gave the opinion that many of the natives present must have been infected with tapeworm, and bluntly, in order to appease my curiosity, I asked those infected to show their hands. At first, apparent coyness caused only a few to admit, but after my assurance that there was really nothing to be ashamed of and that I would suggest a simple line of treatment to them, what I estimated to be between 15 and 30 per cent. of those present caused a mass of hands to be shown. It is, therefore, suggested that but a few of the actual carriers of tapeworm infection present themselves for treatment at various hospitals, such as those institutions for natives in Bechuanaland and Basutoland. As long as no great discomfort and physical pain due to the infection may be experienced by native carriers, these will not come to European physicians for treatment, and some, undoubtedly, are treated by their native " doctors ". The native's mentality and his suspicion of European interference with his ailments are amusingly reflected in a letter dated 14.5.33 from Dr. J. S. Armstrong, Medical Officer, Singida, Tanganyika, to Capt, H. J. Lowe, M.R.C.V.S., Veterinary Officer, Mpwapwa: " Upon receiving your letter I made an attempt to induce out-patients at this hospital to attend for the examination of their stools, but I regret that the only result was that all ran away before the treatment (of their other ailments) was completed."

In areas where proper meat inspection is not undertaken, the risk of infection to humans is great, and the incidence correspondingly high. Cawston (1935) related an astonishing fact. He wrote: " Seven years ago (therefore about 1928.—N.F.V.) some 30 per cent. of school children attending the clinic of the Potchefstroom Health Committee were found to be suffering from tapeworm infection, and this was used as evidence of the need for the establishment of an approved abattoir ". The Potchefstroom experience should surely have been a warning to smaller communities, especially those close to Native Reserves.

Unfortunately no statistics of the incidence of tapeworm infection in school children in the Union are kept. According to Dr. H. Maugham-Brown, Medical Inspector of Schools, Cape Province (letter dated 28.12.36), the incidence of infection in school children " seems to be higher in the Eastern Province than in the rest, more particularly in the areas which obtain their cattle from grazing areas occupied by natives ". The Chief Medical Inspector of Schools, Transvaal, writes (8.1.37):— " During the routine medical inspections the School Medical Officers do not examine all children on the presence of any intestinal parasites, on account of lack of time and facilities. Any statistics that may have been compiled out of facts obtained from medical inspections are very inaccurate and are only obtained from (*a*) direct information from the child, without being questioned in this direction, and (*b*) information obtained from the child on account of being questioned in this direction. Our experience, however, is that the incidence of tapeworm in European school children is fairly high in the rural areas of

the Transvaal, and especially in the so-called Bushveld Areas (e.g. Marico, Zwartruggens, Rustenburg, Waterberg, Lydenburg, etc.) and this, presumably, is closely connected with the fact that in these areas cattle farming is the main occupation, and that in addition to this the native population is probably heavily infected with tapeworms. Roughly stated, the incidence of tapeworm in European school children in rural areas of the Transvaal ranges from a fraction of a percentage to as high as 20 to 25 per cent.

On the strength of this collection of evidence, it is clear that the problem of taeniasis infection in rural and native South Africa is most important, and warrants the scientific investigation of the medical profession.

After having considered these various facts, we are still no further in our decision as to whether *Taenia solium* or *Taenia saginata* is the more important parasite in the field of public health. If we accept the frequency of occurence of each individual species, as gleaned from actual observations, which, admittedly, reflect an incomplete survey, then *Taenia saginata* must be considered of prior importance. If, on the other hand, we must accept available medical evidence as to which species is the more damaging to the host, and is responsible for the more grave sequelae, then one must surmise that *Taenia solium* is the more important.

We have already mentioned the fact that *Taenia saginata* is more frequently the more " solitary " species in the host. (See Parts I and II.) It stands to reason, that the ingestion of an insufficiently cooked, heavily infested piece of pork, may cause the development of a great number of *Taeniae solium*. The chances of gross infestation through the ingestion of measly beef are less, owing to the general lighter infestation of the bovine. An exceptional infestation of a native was mentioned, however, by Watkins-Pitchford (1923), who stated that on one occasion as many as twenty specimens of *T. saginata* were recovered on autopsy, from the intestines of a single native.

The Effect of Taeniasis Infection on the Human Host.

In the healthy adult an ordinary single infection with either parasite may not have very severe clinical effects on the patient. Yoshino (1934), who deliberately infected himself for experimental purposes with *Taenia solium*, found that the presence of a few adults in a patient would cause only slight gastro-intestinal derangement, which was usually more manifest in the early stages of infection. So little physical discomfort is felt by some of the more primitive peoples, e.g. the Abyssinians (Schimper, quoted by Leuckart) to infection with *Taenia saginata*, that these people maintain " that without this guest they would be unhealthy, and that they would suffer especially from constipation ". According to Leuckart, intestinal irritation and nervous derangement in the host is much less frequent in *Taenia solium* than in *Taenia saginata*, but on the other hand, the presence of the hooklets on the head of the former sometimes causes injuries to the intestinal mucosa. Attachment of both species occurs in the small intestine. " When in possession

of its full vital powers, the worm hangs so firmly that it is necessary to pull and bend it before it will quit its hold. And even after it has done so, it will attach itself again in a moment, if the head succeed in catching hold of a portion of the intestine." (Leuckart.)

According to Braun-Seifert (1923), the infection may cause the following derangements in man:—

1. *Absorption of Nourishment*: The loss of nourishment on the part of the host is usually compensated by the eating of larger amounts of food, owing to the abnormal appetite the patient develops (*Heiszhunger*).
2. *Digestive derangements*: Frequently diarrhoea, followed by constipation etc.—frequently flatulus, tympanites, sometimes spasmodic colicky pains, and sometimes a "pressure" in the abdominal region.
3. *Nervous derangements*.
4. In weaker individuals *anaemia* may easily follow.

Sequelae.

Braun-Seifert (1923) refers to Spengler, who performed an operation for appendicitis on a 29 years old woman, and found a live proglottis lodged in the appendix. According to Spengler, this proves that the presence of a foreign body will cause, through friction, the symptoms of appendicitis simplex. Martin, Pollag, Retzlaeff and Westermann found similar causes of appendicitis. (Braun-Seifert.)

Altenkamp (1935) recorded a case of acute appendicitis, in which the presence of a portion of the strobila of a *Taenia* was the cause. So also did Pytel (1935) refer to a case in which tapeworm infestation was the cause of appendicitis.

Farzane and Ibragimov (1935) found that ileus of the intestine had been caused by a conglomeration of *Taenia solium* segments.

Leuckart asserts that it is quite conceivable that the powerful contractions of *Taenia saginata* have an influence on the condition of the intestine. The projecting borders of the joints thus rub in a file-like manner over the villi and easily produce a congested state, which lasts a longer or shorter time according to the circumstances, and gives rise to many disease symptoms. If the disease continue long, the nutrition suffers. From this there often arises a condition which has a certain resemblance to anaemia, and which especially exhibits the many neurotic symptoms of this disease. "Singing in the ears, hallucinations, giddiness, fainting, pains in the joints, epilepsy, chorea and even mental diseases, have all been observed to be caused by the tapeworm, and not infrequently to disappear on the removal of the latter." (Leuckart.)

Burnet (1919) placed on record three cases of chorea, which had their origin in the presence of tapeworm, and were cured when the worm was expelled; he pointed out, however, that a rheumatic tendency might have been a predisposing cause.

Very interesting work on the subject of psychosis due to tapeworm infestation was done in South Africa a few years ago, by Dr. A. S. van Coller, who was formerly on the staff of the Bloemfontein Mental Hospital, and is now Physician Superintendent of the Mental Hospital, Grahamstown. Dr. van Coller very kindly supplied me with a memorandum of his research, and has given me permission to quote his hitherto unpublished findings.

Out of 450 cases, all suffering from psychosis, he found two groups, viz.

"a" Toxic Group (180).

"b" Exhaustion Group (130).

Both these groups he considered were directly due to tapeworm of the intestines. After treatment the "a" group responded almost immediately—that is, they recovered within three months. The "b" group was much slower—here recovery was slow—blood examination revealed a secondary anaemia in practically all cases. It usually took from three to twelve months for a recovery. The anaemia had disappeared by the time recovery was established. So in this group he reckoned the tapeworm had been present for such a term as to produce anaemia. The toxaemia, plus anaemia eventually caused a psychosis. The balance, that is 136 cases turned out to be a mixture of classical types, mostly Dementia Praecox. (The remaining four cases were of Cysticercosis of the brain, of which three died from epileptiform psychosis—see later.)

Dr. van Coller was of opinion that in these classical types (Dementia Praecox, etc.) the tapeworm acted mainly as a precipitating factor, not causal.

Dr. H. Egerton Brown of Pietermaritzburg, and formerly of the Union Mental Hospital Service, informed me (letter dated 25.1.37) that he was convinced that a certain number of cases of acute excitement (mania) among native admissions to the Mental Hospital was due to an absorption of a toxin secreted by the living *Taenia*, and he made it a routine treatment to try and expel the parasite in all cases of this nature. Dr. Egerton Brown kindly supplied a record of 207 positive cases of tapeworm infestation. Of this number 139 recovered after treatment and were discharged. Sixty-eight cases were relieved, or not improved. Of the recovered cases, diagnosis was Hebephrenia or Simple Dementia Praecox and Toxic cases. The relieved or not improved cases all showed an improvement for some time after treatment. "On retreatment, the same thing happened. Three cases of epilepsy due to tapeworm infection were discharged as recovered after treatment. No fits for many months after treatment, they have not been readmitted."

The findings of Doctors van Coller and Egerton Brown have been quoted to illustrate the occasional dangerous sequelae of tapeworm infection, and have, of course, a special South African interest.

Both species of human *Taenia* may occasionally show amazing tenacity of life. "These tapeworms grow to a length of twenty to thirty feet and can live for 12 to 20 years, or even longer."

(Monnig, 1936.) Franke (1931) referred to the tenacity of *T. saginata*. Some cases he knew of had harboured the parasite from 15 to 19 years, and in one case the patient required six vermicides before the tapeworm was eventually expelled. Leuckart quotes Cobbold, who had cases who evacuated proglottides daily for 11 years, and Wawruch, who mentioned several cases which lasted from twenty to twenty-five years, and in one case he even mentioned thirty-five years. " Of course, it is doubtful whether this is always the effect of the same tapeworm ". (Leuckart.) Leuckart mentions that occasionally after death of the tapeworm, and instead of resultant expulsion, mummification of *Taeniae may* occur within the host's intestine. Such mummified specimens were found by Cobbold and by Küchenmeister.

Conditions which were caused by what Shahan (1932) referred to as " migratory *taeniae* " have occasionally been recorded. A soldier in the Egyptian Army, with a history of occasional attacks of suffocation, died in hospital under Shahan's treatment, from a distressing dyspnoea. On post-mortem examination a tapeworm was found lodged in the larynx and upper part of the trachea. Shahan mentions a case in the literature in which incision of the drum of the ear for severe earache was followed by the passage of a tapeworm from the middle ear and eustachian tube. Cases are known in which the whole or portions of a tapeworm have been vomited. Lavalette (Leuckart) reported the case of a pregnant woman who expelled the proglottides singly through the mouth. Leuckart refers to cases in which proglottides, or even the entire strobilae had passed through fistulae of the bowels into the abdominal cavity. " Especially interesting in this connection is a case mentioned by Herz, in which the tapeworm issued through the navel, without, however, bringing any of the contents of the intestine with it, so that the patient could be dismissed as cured a few days after the exit of the worm ". Leuckart also records rare cases in which the tapeworm was expelled through the urethra. " In such cases, even when the ordinary signs of vesico-rectal fistula are wanting, it is evident that the worm can only have reached the urinary apparatus from the intestine. In one of three cases mentioned by Davaine, the tapeworm remained a year in the bladder, and expelled single proglottides at intervals of about eight days, until it was killed by an injected anthelminthic and then expelled at once. We need hardly add that expulsion of proglottides through the urethra is accompanied by violent and painful disorders, and that the above-mentioned cases interfere in many ways with the health of the host."

To summarize, we might mention that:—

(1) Simple infestations with either *Taenia* have not, as a rule, any serious damaging effect on the human hosts, but

(2) Anaemia, with resultant debility may follow.

(3) Frequently both tapeworms may show amazing tenacity of life, and may remain alive and actively eject mature proglottides for many years.

(4) Both species may be responsible for very serious sequelae, among which have been recorded:—

(*a*) Digestive derangements and pathological conditions of the intestinal tract—ileus of the bowel, appendicitis, intestinal fistulae, which may cause migration of the parasite to the uro-genital tract.

(*b*) Nervous and mental derangements—e.g. chorea, psychosis with dementia praecox, epilepsy due to *Taenia* infection.

(*c*) "Migratory *taeniae*" may lodge in the respiratory tract (usually in the upper part of the trachea and the laryax), and in rare cases segments may be found in the acoustic and olfactory regions, e.g. in the eustachian tubes.

THE INFESTATION OF THE HUMAN SUBJECT WITH CYSTICERCI.

Of perhaps greater importance from a clinical point of view than infection with the adult *Taeniae*, is the infestation of the human subject with *Cysticercus cellulosae* and *Cysticercus bovis*, which, according to Broughton-Alcock, Stephenson and Worster-Drought (1928) has been known since 1558. According to consensus of opinion, the former parasite is far more frequently met with in the human subject, and many authorities doubt whether actual cases of bovine cysticercosis have been encountered in man. Leuckart accepts, with a great deal of reservation, the probability of human infection with *cysticercosis bovis*. Mönnig refers to the possibility of such infection, but qualifies this with the reminder that the *C. cellulosae* is by far the more frequent parasite (1934). Von Ostertag (1934) states that *C. bovis* "has never been definitely found in man". It is, therefore, almost certain that by far the large bulk of cases of human cysticercosis (to be clearly distinguished from human echinococcis, or so-called hydatid disease) is due to infection with *C. cellulosae*.

In every case of human cysticercosis, the victim of infection has undoubtedly been directly or indirectly in contact with a *Taenia* carrier. Such infection may result from the following:—

1. *Auto-infection*: According to case histories, and also to the opinions of many authorities, it is less frequent that cases of human cysticercosis have been met with, in which on post-mortem or other examination evidence of *Taenia* infection was found. When such cases occur, auto-infection may result from:—

(i) Anti-peristalsis, in which reverse movements of the intestinal contents lodge in the stomach, and in such movements carry ripe proglottides of the *Taenia solium* with them. The ova are liberated and human infection follows on similar lines to that of the pig. (See Part III.)

(ii) Conveyance of ova on the fingers, or under the fingernails into the mouth, by a *Taenia* carrier. In such cases the tapeworm carrier, most commonly of *T. solium*, will infect himself with *C. cellulosae*. Vosgien

(1910-11) mentions that out of 579 cases of human cysticercosis observed by Auscher, 62 were infected with *Taenia solium*.

2. *Infestation due to ingestion of* Taenia *ova by a carrier and contamination of food-stuffs*: This mode of infection is probably responsible for the great bulk of cases of human cysticercosis. Chin (1933) was of opinion that the ingestion of insufficiently cooked vegetables was the greatest source of infection in China. A similar opinion was given by Vosgien (1910-11). Colonel F. P. Mackie (1934), in a discussion on MacArthur's paper on "Cysticercosis as seen in the British Army", comments on the fact that in India only the lowest caste inhabitants eat or touch pork, and it is probably they, in preparing and handling soldiers' food directly, or in eating houses in bazaars, who, as *Taenia* carriers, were responsible for the infection of the number of cases cited by MacArthur.

The use of human excretum as fertilizer for vegetable gardens is a grave source of infestation of cysticercosis to the human subject. Such vegetables as lettuce, parsley, celery and water-cress, the leaves or stems of which are generally eaten in a raw state, are positively dangerous if human excretum has in any way come in contact with them. It is highly probable that the majority of cases of human cysticercosis found in South Africa, especially in Europeans, originate through accidental infection through the ingestion of ova in the food. We run a grave risk of infection in South Africa through our close contact and association with our native population. Garth (1923) stressed the potential danger in a household of a *T. solium* carrier, whose contact with the rest of the family could cause the ingestion of *Taenia* ova by them.

It is a remarkable fact that most of the case histories in British literature have reference to infection in India and elsewhere in the Orient, and nearly all refer to subjects who served in the Army or Navy. [Reference articles by MacArthur (1934), Dixon and Smithers (1935), Dudley (1934), Dick (1936), Holmes (1934), Lindeman and Lyburn (1935), Marsh (1934), Perry (1936), Bronghton-Alcock, Stephenson and Worster-Drought (1928), Priest (1926), and Roth (1926).]

The incidence of *Taeniasis solium* is not known in India and China, but, according to MacArthur and others, it can only occur among the very lowest caste in India, and, as has been mentioned, according to Mills (1923 and 1924), Gear and Pedersen (1934) and Feng (1934), the recorded incidence of *T. solium* is very low in China. In our survey of the incidence of infection in pigs, it was also recorded that, from abattoir observation, the incidence of porcine *C. cellulosae* was almost negligible in that country. In South Africa, in many parts, the incidence of porcine cysticercosis is very high. Although we have no data to prove our surmisal, except the opinions of some medical observers, it is, nevertheless, almost undeniable that *Taenia solium* must be a very frequent parasite among our native population. It is they, who generally handle our food, and we are thus seriously exposed to a far more dangerous infection than we would ordinarily acquire through the eating of viable measly pork or beef.

It has been suggested by some writers (Vosgien, 1910-11) that heredity may also be a factor of transmission of infection. This factor we mentioned in dealing with infestation of the pig and the bovine.

Volovatz (1902), according to Vosgien, " in his highly documentary thesis draws attention to the fact that *cysticerci* have been found in placentae; this might explain the origin of this entozoon in new-born infants ".

Breast-fed, suckling infants, however, must run the smallest risk of infection, since their only diet is their mothers' milk. Heller (1874), according to Vosgien, mentions, however, a case of a 6 months old child who had a *cysticercus* in the mesentery. Vosgien also quotes Virchow (1877) who found this larva in a 9 months old child; Karewski (1877), who found *cysticerci* in a breast-fed child whose mother carried *Taenia solium*.

It would appear that in the majority of cases of human cysticercosis, the onset of infection occurs between the ages of 20 to 40 years. It is, thus, usually a disease of adults. According to Vosgien, out of a total of 478 cases observed, 206 occurred between those ages. Dudley (1934) described a case of epilepsy in a sailor, and based his diagnosis of *C. cellulosae* as being the cause of the disability on: Age of onset, 40 years; place of origin, China; infestation with an adult *Taenia solium;* plus X-Ray appearance of calcified cysts.

Locations of Cysticerci in Man.

The brain is commonly held to be the most frequent site for *Cysticercus cellulosae* in man, but this may merely be because cerebral symptoms, when they show themselves, are more marked than muscular symptoms (Chizzola, 1933). Similarly, MacArthur (1934) explains that ocular and orbital cysticercosis causes outward signs which can hardly be unobserved, whereas intramuscularly they may exist for years without the patient or his associates observing them. None of a large number of calcified cysts in the arms and legs of a case described by Chizzola, and demonstrated radiographically, was palpable. This rather suggests that *cysticerci* are usually situated intramuscularly, rather than subcutaneously.

McCrae (1931) quotes Stiles, who compiled statistics of the locations of infections as follows:—

In 155 cases, the brain was involved in 117 cases; the muscles in 32; the heart in 9; the subcutaneous tissues in 5 and the liver in 2.

Vosgien found the predilection sites in man to be:—

	Per Cent.
Eyes and adjoining structures	46.
Brain and Nervous System	40·9.
Skin and Cellular Tissues	6·32.
Muscles	3·7.
Other organs	3·2.

Cysticercosis of the Muscles, Skin and Intracellular Tissues and Other Organs: A Review of a few Recent Case Histories.

Priest (1926) mentions a case in which five years after enlistment in the Army a private became sick, showing abdominal pains and vomition. His liver was found to be enlarged. He then developed pain and swelling in the calf muscles, which on examination were found to be nodular. A few months later he had a " fit ". He showed a chain of nodules on the forehead and muscles. There was no evidence of the patient having harboured a tapeworm, so that he must have become infected through ingestion of extraneous segments of ova.

Radiology has been instrumental in the discovery of quite a number of cases of cysticercosis in man, especially when calcified cysts have been located in the limbs. Capua (1932), having detected calcified *C. cellulosae* in the musculature radioscopically, suggested that this method of diagnosis should be employed in all suspicious cases.

Roth (1926) describes a case of cysticercosis in a man 44 years of age, a hairdresser. He complained of pains in the left knee-joint, of five years' duration. For ten years the patient had suffered from epileptiform " fits ". He served in India from 1908 till 1911. Radiographs of the left knee were taken, which disclosed some 80 calcified cysts. It was then decided to take radiographs of the rest of the body, and these showed calcifications in the extremities down to the ankles and wrists. The pectoral muscles showed numerous cysts. Three bodies were seen to be lying in the pia mater of the brain. Similar cases were described by Gavazini (1934) and Casuccio (1933). Streignart (1933) demonstrated calcified *cysticerci* in the muscles of a peasant's leg which was X-rayed for fracture. Disseminated calcified *cysticerci* were found in a case by Kremser (1934), also by Grado (1935),and were demonstrated by X-Ray. Brailsford (1926) demonstrated *cysticerci* in the thigh of a patient radioscopically. Chin (1935) described thirteen cases in Peking, which showed " nodules " or tumors under the skin, and were found to be due to *C. cellulosae*.

According to MacArthur (1934) cysts may be detected in the muscles or subcutaneous tissues of any part of the body—the head and the face, including the eyelids and lips, trunk and limbs, but rarely in the hands and feet. They are found more commonly in the upper half of the body, not because the parasites are more numerous here, but because of the better cover afforded by the larger masses of muscles in the lower half. Among other unusual locations of *C. cellulosae* is the mammary gland. Such a case was described by Stumpf (1915).

In 26 cases of cysticercosis in the viscera and " other organs " mentioned by Vosgien, *Cysticerci* were found in the heart in 10 cases glands in 6 cases; digestive organs in 3 cases; lungs in 2 cases; and in the mouth in 1 case.

Cysticercosis of the Eyeball and its Annexes.

Vosgien (1910-11) mentions 372 cases of ocular (or related) cysticercosis out of 807 observations. Of these cases:—

The retina	was	affected	120 times.
The vitreous	,,	,,	112 ,,
Subconjunctiva... ...	,,	,,	84 ,,
Anterior Chamber ..	,,	,,	26 ,,
The orbit	,,	,,	19 ,,
The iris	,,	,,	7 ,,
The crystalline ...	,,	,,	2 ,,
The cornea	,,	,,	2 ,,

Vosgien quotes Hirschberg (1892), who " made a remarkable observation, that the *Cysticercus* apparently had a different predilection in various territories ". " It is difficult to explain ", states Hirschberg, " but the predilection of the *Cysticercus* in France is for the conjunctiva, in England for the posterior chamber, and in Northern Germany for the various parts in front of the eyeball ". One wonders, however, whether coincidence may not have been the more important factor which caused Hirschberg to have made this peculiar observation. Since von Graefe (1866) demonstrated the presence of the *Cysticercus* in the vitreous humour, many cases have been placed on record, and it is a condition which is easily recognized.

According to Burdon-Cooper (1921), three different species of tapeworm larvae occur in the eye, namely that of *Taenia solium*, that of *Taenia echinococcus* and the *Bothriocephaloid* tapeworms, but the first named is by far the most common.

It has been found possible to remove *Cysticerci* successfully in eye affections. Two such cases were described by Gomes (1919). In the one case the *Cysticercus* was located in the anterior chamber, and was removed without difficulty; the other was removed from the vitreous chamber by incising the sclerotic, the procedure being guided by ophthalmoscopic examination.

Pavia and Durando (1933) described a case of *C. cellulosae* which developed behind the retina of the right eye in a woman, 31 years old. The changes in the vision of the patient, as the cyst grew, were traced by the authors.

Among some interesting cases recorded of *Cysticercus* of the vitreous, mention may be made of a case described by Schweinitz and Wiener (1919). In this case the left eye was involved and was blind five months before the patient came under examination—blurred vision being noted ten months previously. There were no gross changes in the iris, but a few punctate deposits on Descemet's membrane and a few spots on the anterior capsule of the lens. The vitreous was cloudy with a few fixed vitreous opacities. There was a grey reflex in the upper and inner quadrant, " and a large globular mass in the central field of the vitreous, well in advance of the

maculose region; the outline of this was regular, the border translucent and from the lower edge protruded a tubular extension, transversely wrinkled, which terminated beyond a constricted neck in a head showing two bright dots—the position of the hooklets. Peristaltic movements and movements of the head were very active at times." The diagnosis of *Cysticercus* of the vitreous was readily made. The general examination of the patient revealed little except that the stools contained ova but no segments of the worm. Operation was undertaken and the cyst removed, when it ruptured promptly.

Kress (1924) gives a most graphic and interesting description of the development of a *Cysticercus* in the vitreous, which occurred in a woman of 26. In the author's own words it is summarized somewhat as follows. There was at the onset, what seemed to be a detachment of the retina, which, under dilatation at a later date proved to be a bluish-white cyst, which was of a perfect spherical shape and moved slowly in the vitreous, with movements of the patient's head. This bluish-white cyst had, practically at all times, an orange or orange-red halo at its periphery, shading off somewhat as do the colours of the spectrum. Later the greyish-white head and neck of the parasite put in an appearance, at about " 5 o'clock meridian ", and this neck could change its shape and become thicker through contraction, and it could bend itself and twist on itself, and at times invaginate or probably contract within the cyst until practically nothing but a slit was seen at its former site. The activity of the head and neck movements and of the suctorial and snout or rostellum areas, as well as the undulating movement of the vesicle proper, could be seen ophthalmoscopically. The eye had to be excised. Casanovas (1933) described a case of atrophy of the bulb of the eyeball, as a result of intraocular cysticercosis. Chica (1925) reported a very similar case to that described by Kress. He reminded us that this was the third case he had seen in Bucharest.

According to Feng (1934), less than 20 cases of ocular cysticercosis have been reported from China. Rao (1935) recalls that Wright of the Madras Ophthalmic Hospital has found that 3 per cent. to 6 per cent. of cases in that hospital had ocular cysticercosis. In consideration of this relatively high incidence of ocular cysticercosis, it must reasonably be presumed that the incidence of *T. solium* must also be relatively high in parts of India.

Cerebral Cysticercosis.

Cysticerci cellulosae may be present in the human brain, and also in other organs and the musculature for many years before clinical disorders become manifest. Although, in a case described by Billello (1934), more than 1,000 *cysticerci* were present in the cortex of the brain and the fourth ventricle, hardly any symptoms were present before death, and cysticercosis was not suspected. Occasionally records occur of admission to hospital for headache and unidentified fever, or for myalgia or rheumatic pains, " but these latter are usually of a degree so indefinite as not to impress the patient's memory." (MacArthur, 1934.)

In the brain, the *Cysticercus* becomes enclosed by a wall of sclerosed neuroglia, corresponding to the fibrous capsule found in extracranial tissues. Small round cells and a few plasma cells are present between the delimiting neuroglia and the surrounding normal brain tissue. " Unless the parasites have invaded the brain in overwhelming numbers, or have lodged in some particularly responsive centre, they cause little nervous disturbance while in their relatively quiescent stage, otherwise it seems impossible that anyone could survive for years—as we know to be a fact—with 200 *cysticerci* present in the brain." (MacArthur, 1934.) Surrounding the dead and disintegrating *Cysticercus*, the tissues undergo active degeneration (MacArthur, 1934; Heilmann, 1932). MacArthur believes that *Cysticerci* while alive usually enjoy a relative tolerance on the part of the host, but after their death they act as foreign irritants and bring about the degenerative changes. The degenerating tissues may be visible around the *Cysticercus* as a discoloured ring, according to MacArthur, perhaps 3 mm. or thereabouts in depth, shading off into the normal brain tissue. *Cysticerci* may be present in the brain or in the body muscles for many years before cerebral symptoms become evident. MacArthur refers to cases ranging from six to eleven years, and, according to MacArthur, when brain symptoms develop, they are subject to periods of exacerbation, followed by intervals of relative or absolute quietude, and the character of the symptoms may vary so markedly that an individual patient seen at intervals by different observers has been diagnosed as delusional insanity, disseminated sclerosis and cerebral tumour. Such cases of cerebral cysticercosis simulating clinical aspects of brain tumours, were also described by von Lehoczky (1933). Antonow (1932) stated that young *Cysticerci*, living at the time of the host's death, are enclosed in a thin capsule composed of an outer layer of granulation tiusse, containing giant cells. Around older *Cysticerci*, which have died, the capsule is thick and has in addition an inner connective tissue layer, giant cells being here and not in the granulation layer. As a final stage Antonow described a single thick layer of hyaline connective tissue. MacArthur has found that degeneration of human *Cysticerci cellulosae* has occurred somewhat in the reverse order from that described in the literature in respect of pig measles. Instead of degeneration commencing and progressing from the vesicle, he has noticed in some newly degenerated excised cysts that calcification commences in the scolex, and the bladder, with its fluid contents, has remained unchanged. The calcified scolex may lie " quite free " in this. According to MacArthur the cyst wall collapses after this, causing escape or absorption of the fluid, and leaving merely the solid calcified scolex. According to MacArthur calcification of cerebral *Cysticerci* takes many years to occur. He refers to the case of one soldier who was operated on eleven years after the onset of " fits ". Several cysts removed from the cerebral cortex showed no signs of calcareous change, although the cysts in the muscles had been calcified for three years and some for five years.

The location of the parasites in human cerebral cysticercosis may be very variable. According to Heilmann (1932), *Cysticerci* may be free in the ventricles, blocking Magendie's foramen or the Sylvian aqueduct. In one case Heilmann found Monro's foramen occluded.

Of the nervous manifestations, by far the most common is epilepsy. The attacks may resemble those of *petit mal*, or may be Jacksonian in type, with, or without, loss of consciousness. MacArthur has proved that *Cysticercus cellulosae* in the brain is a frequent cause of epilepsy in British soldiers who have served in India. Within about eighten months, just prior to 1934, MacArthur met with sixty such cases at the Millbank Military Hospital. Dixon and Smithers (1935) mention that of 258 suspicious cases examined at the Queen Alexandra Military Hospital, 79 have been proved to be due to cysticercosis, and 40 were doubtful. Broughton-Alcock, Stephenson and Worster-Drought (1928) described a case of a young soldier who had died, aged 28, after having served in India. For several years after he enlisted, the patient suffered from epilepsy. On post-mortem about 100 cysts were found in the half-brain.

Dick (1936) describes a case of a man 50 years of age, who had served in India 12 to 14 years ago. Between 1923 and 1933 he was engaged in a shipyard. In 1933, he began to suffer from epileptiform seizures and was later admited to an epileptic colony, where he remained until he died after about a year. He was subject to fits of depression, occasionally with confusion, and at one time he had an outburst of religious mania. In 1935, he began to suffer from cerebral vomiting, which increased in frequency and a severe and persistent headache developed over the occipital region. After death, autopsy showed numerous cysts in various parts of the brain.

Ramond (1933) described a rather unusual case in which a 35 years old woman showed symptoms of what appeared to be Jacksonian epilepsy, the cause of which remained obscure for some time. Eventually the cause was traced to a multiple infection with *Cysticercus cellulosae*. Flossbach (1932) mentions a case in a 43 years old woman, who had tapeworm in 1912. Twenty years later she had epileptiform convulsions due to cerebral cysticercosis. Lindeman and Lyburn (1935) had two cases of epilepsy in the British Army, due to cysticercosis, and they suggested several others. Similar cases in the British Indian Army were recorded by Holmes (1934) and by Perry (1936).

MacArthur mentions that the epileptiform seizures may at first be slight and incomplete, but after a year or so major seizures in rapid sequence may succeed. Frequently the " fits " may commence a long time after the presence of cysts are detected.

Other nervous derangements which may manifest themselves in cases of cerebral cysticercosis are acute encephalitis causing rapid death, melancholia, acute mania, delusional insanity and dementia praecox. A case of basilary and spinal meningitis due to *C. cellulosae* in a 61 years old patient, who had been under observation for some months, was described by Guillain, Bertrand and Thurel (1933). Diagnosis was confirmed by post-mortem examination. A similar case was reported by Liesch and Patrassi (1934).

MacArthur suggests that in the established disease, when the embryos have been " walled off " there is no diagnostic help to be gained from blood counts, but when the embryos are still active in

the body, no doubt an eosinophilia results. Presumably for the same reason, the complement-fixation and skin tests—which are group reactions—have not the high degree of success of the corresponding tests in schistosomiasis, filariasis and hydatid disease.

Rizzo (1932) diagnosed a case of human cerebral cysticercosis during life, largely upon the finding of an eosinophilia in the cerebro—spinal fluid, accompanied by a negative Wassermann reaction—the case did not harbour the adult *T. solium* and infection was confined to the central nervous system.

Fairley, according to MacArthur (1933), obtained a positive complement fixation in 5 cases out of 9 tested.

"Careful enquiries into the value of an eosinophilia, as suggesting the presence of *Cysticerci* has shown that the blood-count is not an entirely reliable guide. During the acute stage of infection with either *Taenia* or *Schistosoma*, most persons develop an evident eosinophilia. The complement-fixation test has proved of value in certain cases, but even this needs to be confirmed by other tests." (Cawston, 1935.) In infections with the adult tapeworm, however, Kawanishi (1932) found marked leucocytosis in four persons intentionally infected with *T. solium per os*. Eosinophilia was only 15 per cent. Neutrophiles showed an increase and lymphocytes a decrease.

As regards treatment, luminal and the bromides are sometimes helpful in controlling fits, but no medicinal treatment has as yet had any curative effect. MacArthur is of opinion that any drug which might be found to be lethal to live *Cysticerci* may be equally damaging to the tissues of the host. On account of the usual large number of cysts in the brain, surgical treatment cannot be resorted to.

Some Records of Human Cysticercosis in South Africa.

It will be noticed from the subjoined number of case histories supplied by various Mental Hospitals, that quite a number of cases of human cysticercosis has been encountered in South Africa. Nevertheless, literature is singularly silent on the subject of cysticercosis in humans in South Africa, and very little has been published in South African and Overseas journals by our medical observers.

Cawston (1935) refers to a case of the late Dr. Barry, in which the brain of an adult native who had died after being struck on the head, had revealed numerous *Cysticerci*. Apparently no ante-mortem symptoms were observed by those who had come in contact with the native.

Pirie and Ray (1920) showed a case of generalized cysticercosis in a native. There was a great number of *cysticerci* in the muscles, both of the trunk and the limbs, also in the diaphragm. There were moderate numbers of *cysticerci* in the brain, the heart and over the pleurae. There was no history of any illness in this native.

Strachan (1926) described the brain of a native male aged 56 years. This native was picked up in the street in a delirious condition, with a temperature of 101° F. On post-mortem examination his brain was found to be riddled with *Cysticerci cellulosae*. Strachan mentioned that he had found four cases in two years, and described a second case of a native with *C. cellulosae* in the heart, without brain lesions.

Fischer (1929) recorded, in his paper on " Autopsies on Native Mine workers ", cases of *Cysticercus cellulosae* accidently found in the brains of three patients, who died of other diseases. In two cases a number of cysts the size of a pea was found on the surface of the frontal convolution; they could easily be squeezed out, without leaving any visible damage to the brain substance. In the third case a single *Cysticercus* was situated in the left lateral ventricle.

Hospital Records.

Pretoria Mental Hospital.

The data of the undermentioned case histories were very kindly supplied by Dr. I. R. Vermooten, Assistant Physician Superintendent. Dr. Vermooten was able to find the records of only five cases between the years 1908 and 1934.

1. Male Native. Age 33: Admitted 4.8.16.

   Diagnosis: Epilepsy.

   Had epileptic fits since admission—put into bed after a succession of fits and remained in a semi-comatose state for seven days. Died 15.9.19. *Autopsy*: *Cysticerci* scattered throughout the brain substance. Cysts in floor of the ventricles. Cause of Death: Lobar pneumonia, aggravated by *Cysticerci* found in the brain.

2. Female European, M.B. Age 71; Admitted 10.7.18.

   Diagnosis: Senile Dementia with Epilepsy.

   She was demented and chattered incoherently. Suffered from fits.

   29.7.20: Has had 15 very severe fits during the last two days, and is now only semi-conscious—muscles continue twitching—condition critical.

   3.8.20: Continues to have seizures—only semi-conscious.

   6.8.20: Died. *Autopsy*: Head—Calvaria shows very prominent ridges laterally over the temples. Skull is soft and in parts extremely thin, e.g. parietal eminences and just behind the coronal suture. Base of skull normal. Dura Mater: Thickening present. Adhesions marked. Lining shows some congestion. *Sub-dural space*—contains a large amount of C.S.F. *Pia-arachnoid*—Well marked opacity and milkiness. *Encephalon*—As there are numerous cysts in the brain, no dissection has been made and the brain has been put in its entirety into 10 per cent. formalin to harden. Head only examined. Cause of death: *Cysticercus* of the brain.

3. Female European, A.P., admitted 20.12.19. Age 75.

Diagnosis: Senile Dementia.

She was demented and very restless. According to the case sheets on 26th May, 1920, she had a severe seizure, lasting nearly five hours.

10.6.20: Patient has been having frequent seizures during the past few days and is gradually becoming weaker.

10.7.20: Died. *Autopsy*: Head—Calvaria much thickened. Almost ½ inch in frontal and occipital regions. *Dura mater*—Thickening very marked. Lining injected. Adhesions—yes, to bone. *Sub-dural space*—Contains a large amount of C.S.F. Quite abnormal. *Pia-arachnoid*—Opaque and thickened. Separates fairly easily from brain. *Vessels of Brain*—Injected and more evident than usual. Small patch of atheroma in basilar artery. *Encephalon*—Weight 1,200 grms. Weight of right hemisphere 485 grms. Weight of left hemisphere 495 grms. Over the surface of both hemispheres and under the pia-arachnoid there are numerous cysts containing a turbid fluid and varying in size from about ⅛ inch to ½ inch in diameter. The cysts are over the left frontal region where there is quite a depression made on the surface of the brain. They are also numerous on the right parietal region.

Cause of Death: *Cysticercus* of the brain.

4. Male Native. J.M. Age 65. Admitted 8.10.21.

Diagnosis: Senile Dementia.

He is demented, unable to give an account of himself; speech indistinct; very deaf.

15.12.21: He went into *status epilepticus* and had six fits. *Autopsy*: *Cysticerci* in large numbers all over the brain, Ventricles, Cerebellum and Fourth Ventricle—*Cysticerci* present.

Cause of Death: *Cysticerci* of the Brain.

5. Male Native. Age 35. Admitted 31.10.25.

Diagnosis: *Cysticercus* of brain and symptomatic epilepsy. He was dull, rarely spoke. Knew his name, but could give very little further information about himself. Paraplegia of right arm and leg. Had innumerable fits of a Jacksonian type. Hemiplegia aggravated after fits. Few small cysts in pectoralis major of left arm. Shortly before death he was dull and demented. Quite unable to do anything for himself. Died 26.7.30. *Autopsy*: Both hemispheres of cerebrum covered with cysts; many of the cysts lie loosely on the brain surface. Several small cysts scattered throughout pectoralis major and biceps muscles.

Cause of Death: *Cysticercus cellulosae*.

Dr. Vermooten concludes: "I have no doubt that if a post-mortem had been done on all cases where the cause of death was ascribed to epilepsy, more cases of *Cysticercus* would have been discovered".

Dr. H. C. Watson, Physician Superintendent of the Bloemfontein Mental Hospital, informs me (letter dated 4.2.37), that between the years 1909 and 1914 he saw at least half a dozen cases of cerebral cysticercosis in the Pretoria Mental Hospital.

Dr. F. D. Crosthwaite, Physician Superintendent of the Mental Hospital, Potchefstroom, and formerly of the Medical Staff of the Pretoria Mental Hospital, very kindly supplied the following data regarding *Cysticerci* in the brain in natives. Dr. Crosthwaite states (letter dated 15.1.37) that what they were investigating was the incidence amongst natives, who were epileptic, of parasitic cysts in the brain, and of the frequency amongst these natives of the cysts as a cause of epilepsy—the figures supplied, refer exclusively to natives certified as mentally disordered (epilepsy with psychosis) in the Mental Hospital, Pretoria.

Period: 1911-1918.—Number of Autopsies 288.

Of these 288 autopsies, 10 revealed the presence of cysts, situated as follows: 9 in brain; 1 in the heart. Of these 10, 7 were males, 3 were women.

Of the 7 males, 4 had epilepsy, 2 were dementia praecox (hebephrenia), 1 had syphilitic brain disease with *cysticerci* in the heart. Of the three females, all were dementia praecox.

During the same period, 1911-1918, there were 334 deaths. Of these 334 deaths, 44 were epileptics. Of the 44 epileptics, 34 were autopsied, 29 being males and 5 females. No cysts were found in the women's brains, but 4 of the men's brains had *Cysticerci*. Counting the cases autopsied only, i.e., 34, *Cysticerci* were found as the exciting cause of the epilepsy in 11·706 per cent. of the cases.

Potchefstroom Mental Institute.

Dr. Crosthwaite states (15.1.37) that during his five years at Potchefstroom, two things have struck him; the very low death rate, and the impossibility, almost, of getting permission to perform autopsies. They have over 100 Europeans who are epileptics, but epilepsy amongst the feeble-minded (low grades, imbeciles and idiots) is of very common occurrence, and is due, when it occurs, to the imperfect development of the nervous system, and its general inadequacy and instability, or to the presence of gross anatomical lesions.

Bloemfontein Mental Hospital.

Case History: Native Lucas Mpake.—Kindly supplied by Dr. G. de la Bat, who attended the patient.

Native Male from Vereeniging. Age 55 years. Admitted 6.6.36, died 16.6.36.

Cause of Death: "*Cysticerci* of *Taenia solium* in brain."

Mental State on Admission: Restless and unnaturally talkative. Second day after admission he developed clonic spasms involving musculature generally. He gradually became more dazed and confused. Twitchings became more marked on the right side, especially the facial muscles. Eyes became fixed and staring.

Post-mortem showed numerous cysts scattered over the brain. None observed in the skin. Eyes were not examined.

Pretoria General Hospital.

Dr. H. J. Hugo, Medical Superintendent, Pretoria Hospital, records a case of *Cysticercus cellulosae* in a European male, 33 years of age, who was admitted to the General Hospital suffering from concussion, due to a fall under epileptic seizure. The *Cysticerci* were diagnosed by X-Ray examination. This case was admitted on 31.14.36.

Conclusion.

Dr. Cawston of Durban is at least one authority who strongly suggests that writers on this particular subject should stress the importance that regulations should provide for the compulsory autopsy on every deceased epileptic in South Africa. The fact that Dr. Crosthwaite found in his limited observations *Cysticerci* were the exciting cause of 11·7 per cent. of epileptic cases, suggests that a fairly high incidence of human cysticercosis exists in South Africa. Dr. Crosthwaite's observations were confined to native cases, and, although the incidence of this fatal condition must be higher among natives, there can be a grave suspicion that numerous European epileptics may also be affected with cysticercosis.

All Europeans resident in countries in which the incidence of *Cysticercus cellulosae* is high in pigs, are in danger of contracting *C. cellulosae* through the *interim* adult *T. solium* stage in their own, or somebody else's person, by direct or indirect contact with that person. The known incidence of *C. cellulosae* in pigs and *T. solium* is said to be low in India, and in that country only the very lowest caste handle or touch pork, and yet relatively large numbers of Britishers serving in that country have contracted, what might be termed a pitiable disease, through contact with but a percentage of the Indian native population. Attention may be drawn, however, to notes which appeared in the *Indian Veterinary Journal* 3, p. 52 (1926-27), in which it was estimated that the incidence of *C. cellulosae* was 50 per cent. in Madras and Coimbatore in pigs.

One should not appear to be an unwarrantable alarmist, in comparing conditions in South Africa, with its much larger source of infection, namely a high percentage of porcine cysticercosis, a correspondingly suspected high incidence of *T. solium* among natives, and the fact that in approximately 100 per cent. of South African households the preparation and cooking of food is performed mainly by natives, a large percentage of whom may be presumed to be potential *T. solium* carriers.

PART VI.

The Eradication of Cysticercosis-Taeniasis.

A. The Necessity for Eradication.

Two factors which demand the eradication of cysticercosis are economic and hygienic. In a country such as South Africa it is essential that we should take the economic factor into serious consideration. The meat industry is becoming more and more important in this country, and we are trying to compete on the overseas markets with rivals, where the incidence of *C. bovis* is considerably lower than in South Africa, e.g., Australia, New Zealand, Canada, United States and the Argentine. In 1935, this factor was forcibly stressed by Irvine-Smith in the *Annual Report of the Director of the Abattoir and Livestock Markets, Johannesburg.*

"The Natal Agricultural Union has forwarded a resolution to the South African Agricultural Union recommending that the Government should introduce legislation to permit meat passed by Government Inspectors to enter Municipal areas without further inspection. All meat is, at present, inspected under the national standard of meat inspection laid down by the Minister for Public Health under the Public Health Act, by inspectors approved by the Government, and for the protection of Public Health is re-inspected on arrival in England, and is also further re-inspected on introduction into any local authority's area. In the event of measles being found overseas, in Union of South Africa meat on these re-inspections, which are essential, the South African export trade would receive a nasty jar. It is the responsibility of the farmer to eradicate measles." (Irvine-Smith, 1935.)

In the same report Colonel Irvine-Smith wrote further: "If you want to achieve success in the meat trade, you will have to eradicate measles. We had a recent example in Durban. Your competitors will exploit the question of measly beef. The opposition in the Argentine and overseas will at once say that you are feeding the housewife overseas with measly beef and they may get hold of some measly beef and ruin your trade. This is an aspect which should be seriously considered." Irvine-Smith also reminds his Council that chilling does not kill the *C. bovis*, therefore the presence of measles in export chilled beef is so much more undesirable.

It will be recalled that approximately 7,000 pigs are condemned annually in the South African abattoirs from which statistics were obtained. (See Incidence Survey, Part II.) Since measly pigs are usually totally condemned, this means a dead loss to the pig breeder or to the butcher of approximately £17,500 per annum, assuming the round average dressed weight of pigs slaughtered at our principal abattoirs to be 120 lb., and the average price per lb. dressed weight paid by butchers or auctioneers to be 5d., and applying these averages throughout the Union.

It is also estimated that nearly 7,000 bovines are annually found to be measly at Union abattoirs. On the assumption that all these bovines were to be condemned outright, and that the average dressed weight per bovine carcass was 600 lb., sold at an average price of of 25s. per 100 lb. for good medium beef, this would mean a loss of £52,500 per year to the beef industry. At this rate the total loss, that is through *C. cellulosae* and *C. bovis* would be £70,000 per annum.

This loss is, however, reduced by the freezing of approximately 80 per cent. of measly beef carcasses (lightly infested) at six of the principal abattoirs in the Union. Nevertheless, the average price paid for this frozen beef at those abattoirs is approximately 15s. per 100 lb., which represents a loss of about 10s. per 100 lb. on average good medium carcasses, not considering the cost of applying the freezing treatment imposed by some of our abattoirs. Despite this, the fact that a large percentage of our measly beef is not condemned outright, there is a considerable reduction in the value of such treated beef.

It is obvious that the figures showing the average cost of measles per annum to the meat industry, refer only to the losses incurred at approximately 65 Union abattoirs, from which incidence statistics were obtained. Financially, however, it is doubted whether the toll of measles is greater than the estimate of £70,000, since it can safely be presumed that no statistics were kept at those abattoirs not included in our lists in Part II, or else they would readily have been supplied by the authorities of many other towns, who were approached. There are also many smaller places in the Union, where cattle are slaughtered and consumed, but no inspection of any kind exists. Such cattle, therefore, whether measly or not are consumed by the unsuspecting public, and presumably top prices are paid—hence, no economic loss in small townships in the remote rural areas and in Native Territories.

The hygienic necessity for the eradication of cysticercosis is quite obvious, and has been fully discussed in the previous parts of this work. The fear of human infection is perhaps the most important and logical reason why in the larger centres, and in those smaller centres where proper meat inspection is carried out, efficiency in duty has at least been instrumental in breaking the life-cycle of those parasites which are found on meat inspection.

B. A Plan of Eradication of Cysticercosis-Taeniasis

1. *Co-operation, but not Encroachment.*

There should be closer co-operation in this important aspect between the members of the medical and veterinary professions, each of whom should be independently responsible for the destruction of the life-cycle at the respective stage which falls within his province.

This can best be elucidated by the old saying " Shoemaker stick to your last." In other words place the responsibility of destruction of the adult tapeworm upon the medical man, and that of the destruction of the bladderworm on the veterinarian. Close co-operation in

this campaign need not necessarily lead to the encroachment by either profession on to the province of the other. At the present time, in South Africa in particular, there can be no gainsaying the fact that in many centres work which should purely be handled by veterinarians is being done by medical officers of health. I refer here to abattoir control, dairy control and control of inspections of meat emporiums. In South Africa there are at the present time only five municipalities which employ full-time veterinary officers, whose main duties are control of the respective abattoirs. In all other centres, including some of our bigger cities, the control of the abattoir is exercised by superintendents who have, or have not the certificate of the Royal Sanitary Institute in meat inspection, and these officials, who have no power to condemn meat, must call the medical officers of health, who in many cases know considerably less about diseased meat than the meat inspectors. In most of the larger centres where no veterinarians are employed, highly capable meat inspectors are employed, but most of these officers would preferably serve under the guidance of a veterinary officer, especially in intricate cases in which differential diagnosis involving cysticercosis is concerned. The urban meat consumer has the right to demand protection, and it should be made compulsory in all centres with a European population of 7,500, that a qualified town veterinary officer be appointed, who in smaller or larger centres could have control of the dairy inspection staff as well. It is not my intention to use this article as propaganda for the profession to which I have the honour to belong, but in many of the smaller urban areas (populations of 7,500) the main functions of the medical officers of health are the control of officials in charge of abattoirs and dairies, functions which could, with greater safety to the public, be performed by veterinarians. The position is not at all impracticable, and the fact that at present there are not sufficient veterinarians to take over such duties in all Union centres with populations of 7,500, does not mean that a number of young men will not take to the profession if sufficient inducement could be given. In the writer's opinion, as already stated, only co-operation between the medical and veterinary professions will eventually eradicate cysticercosis-taeniasis, hence the eradication of the bladderworm should be the function of the scientist best qualified for the purpose, viz., the veterinarian. Salaries of municipal veterinarians can be partly subsidised by Government, whose bounden duty it is to safeguard the health of the urban dweller. Thus, whilst eradication of the *Cysticercus* is the function of the veterinarian, that of *Taenia* must be done by the physician, who should be encouraged by legislation towards this important function, to obviate remarks such as those which Reitsma (1931) had occasion to use in Holland: "We must not lose sight of the fact that the object of the campaign against cysticercosis is the eradication of the *Taenia*. It is a remarkable fact that although veterinary scientists are paying a great deal of attention to cysticercosis, a state of lethargic rest exists in the medical camp as regards taeniasis, and one can obtain hardly any data regarding the disease either from the State public health authorities, or from private practitioners. The only facts the latter can state are that they have large and extensive practices, and once or twice a year they may treat a patient for tapeworm."

2. *More Thorough Meat Inspection.*

It has already been stated, in a previous Part of this article, that we in South Africa possibly permit a larger range of inspection incisions than is practised in most European countries. Nevertheless, even we can improve upon our technique. The present writer suggests the following technique in respect of examination for *C. bovis*:—

(*a*) Two long and parallel incisions into the masseters, on both sides of the face, in an upward direction, to completely sever the parotid gland below the ear.

(*b*) Two long incisions into the pterygoids, on each side.

(*c*) Numerous longitudinal incisions into the muscles of attachment of the tongue.

(*d*) Careful manual palpation of the whole of the heart; complete halving of the left ventricle; careful inspection of the myocardium.

(*e*) Careful manual examination of the oesophagus.

(*f*) A transverse incision into the hump, after the carcass has been cleft.

(*g*) Usual inspection of the viscera, without further incisions.

(*h*) A complete incision into the Triceps brachi and Deltoideus on each side.

(*i*) One incision into the Psoas muscles on each side.

(*j*) A deep incision into the Adductor muscle about an inch below and parallel to the symphysis pelvis.

(*k*) In the event of measles being found in any of the above locations, then the secondary incisions laid down by Public Health Act must be made.

It is doubtful whether the technique can be improved in respect of the inspection of pigs for *C. cellulosae*.

3. *Systematic Meat Inspection at all Abattoirs and Slaughter Poles.*

This suggestion is probably the most difficult to put into effect, and may even be considered impracticable. Reference will be made to the comments of the Town Clerk of Barberton, who mentioned that, whilst thorough inspection was being practised at Barberton, certain smaller townships in the vicinity were permitting the slaughter of bovines without any meat inspection, to the detriment of the Barberton stock-buyers. There is hardly a large or a small urban area in the Union, which is not faced with the same problems as Barberton.

I do not wish to emphasize in a dogmatic way that the Department of Public Health should appoint Meat Inspectors, who could be stationed at the urban centres of these small townships, and could from there do daily rounds of the slaughter poles of such small surrounding townships, but the matter certainly warrants the investigation of the Department. In many of these small townships daily slaughtering is not practised, and quite possibly such hypothetical inspectors could arrange for the slaughter days at the various small townships in their areas.

Such inspectors could either be paid by Government, or else the townships could be grouped and each group, subsidised by Government, could be responsible for the salary of its meat inspector. The Meat Inspectors must be qualified, holding the Royal Sanitary Institute's Meat and Other Foods Certificate. The aim should be the protection of all purchasers of meat, and the prohibition of unfair competition between dealers and butchers in the townships where no inspection exists, who slaughter measly meat without fear or scruple, and their less fortunate confrères in the more enlightened municipality close by, where up to date inspection is carried out.

An alternate suggestion may be to prohibit, *in toto* the sale of meat in any area controlled by a Village Management Board, Health Committee, or other form of Local Government, unless the meat had been slaughtered at a Public Abattoir, where proper meat inspection is practised. The small townships in the vicinity of an urban area would, therefore, be compelled to use meat slaughtered at a central abattoir (situated in the bigger town). The main idea at the back of such a scheme, it may be repeated, should be to safeguard, where possible, all purchasers of beef or pork from infection with taeniasis and to ensure that the unconscientious stock-raiser has no outlet for the sale of his measly stock, and thus to obviate the odious state of affairs mentioned by the Town Clerk of Barberton. (See Paragraph 4.)

Some Municipalities, e.g. Worcester, Mossel Bay, Burghersdorp, Clocolan, and to its utter disgrace, the fairly large City of Bloemfontein, permit the slaughter of pigs on farms, and the sale of the carcasses on the local market. The carcasses must be brought to the abattoir for inspection, with (in the case of Bloemfontein) the pluck attached—stomach, intestines and other viscera are not produced. In fairness to the Bloemfontein City Fathers, however, it must be mentioned that this arrangement was authorized by the Orange Free State Administration many years ago, and despite the efforts to have it rescinded by my colleague-predecessor and myself, it is still in force.

The reason why this was allowed is obvious—a Province existent on a purely farming industry naturally encourages that industry, although the more important aspect of Public Health is sadly overlooked. The results of this practice are clearly reflected in our observations at Bloemfontein. In two years we have found that 2·13 per cent. of pigs *slaughtered* at the abattoir have been measly, and yet, out of many hundreds of pigs slaughtered on the farms and brought to this abattoir for inspection, in three full years, my inspectors and I have found only two measly (both very lightly infected). Pigs, as we have seen, are more commonly very heavily infested, and obviously farmers do not bring to the abattoir for inspection, pigs which they see are measly, upon dressing. They have a ready sale for this measly meat to their natives, and a justifiable use for the lard for soap making. This statement is not made on mere conjecture, but is an actual admission of at least two farmers who occasionally patronise us with a few pigs for inspection. Here is an anomaly which can be immediately rectified by legislation. If the serious hygienic and economic importance of the disease were

to be brought home to them, even the most ardent, and at times almost fanatical legislators, who vigilantly safeguard the interests of the farmer, will vote approvingly for the compulsory slaughter of all pigs intended for urban consumption, at urban abattoirs.

4. *The Prohibition of Insurance Schemes.—Loss must be carried by the farmer or producer.*

In a number of our larger Union abattoirs bovine cysticercosis is included in insurance schemes. Premiums are imposed on all animals to be slaughtered and the farmer or butcher is quite indifferent as to whether or not his ox is condemned. The direct result of these insurance funds is that the farmer does nothing to safeguard his cattle from infection, whereas it should be his compelled duty to realize his obligations. What the farmer does not realize, however, as Mönnig (1936) puts it, is that he after all, pays the insurance premium himself, and that abattoirs are not philanthropic institutions which willingly, out of sympathy for the unfortunate farmer, refund the price of the ox lost to him, without making him pay extra for the many uninfected oxen which have passed inspection.

It is questionable whether such insurance schemes serve any useful purpose, and at several of our larger Union abattoirs (Bloemfontein, Port Elizabeth and Capetown) they are totally discouraged. At others, e.g. Durban, where an insurance fund is conducted, the capitation fee is 3s. 6d. for cattle from Natal proper (in the case of Durban), but 5s. 6d. for cattle from so-called " black " areas, as Swaziland and the Natal native areas, where the infection is high.

In his Annual Report for the year ended 30th June 1935, the Director of Abattoirs, Livestock Markets, Veterinary Services, Ice and Cold Storage Departments, Johannesburg, refers to consignments of export cattle from Natal, received at Johannesburg, which showed infestation rates varying between 2·08 per cent. and 60 per cent. in thirteen consignments from different owners. Colonel Irvine-Smith adds: " The only manner in which the Council could assist in the eradication of measles in meat was to decline to indemnify cattle from proved sources of infestation. With this object in view, it was decided that after 1st July, 1935, any owner forwarding a consignment of cattle for export containing measle infestation to the Johannesburg Abattoir, would have measles or bladderworm infestation excluded from his indemnification until three subsequent consecutive consignments had been received from him free from infestation. The Director is of the opinion that when measle infestation is discovered in a consignment of cattle, the whole consignment from that particular owner should be debarred from export, otherwise subsidised measly beef from South Africa will eventually be found on arrival in England ".

In considering this question from all points of view, the conclusion come to is that insurance schemes which include indemnification against measles, are definitely not in the interest of the country, and those of us whose calling assists towards the eradication of the menace of measles, should collectively press for legislation forbidding the inclusion of measles disease in abattoir insurance schemes.

As has been expressed, the farmer unwittingly pays an excessive slaughter fee (including his insurance capitation fee), which is quite needless, but he is perfectly satisfied as long as the payment of this capitation fee leads to his recovery of the price of any of his stock which may be condemned.

The practice at most abattoirs, where no insurance schemes are in vogue, is that loss through condemnation of carcasses for measles in bovines is borne entirely by the butchers, and not by the producers. In some cases butchers buy slaughter cattle from farmers out of hand, or at auction sales, and these cattle, if in good condition, may find themselves at the abattoir within a few days. In other cases butchers place nearly all their bovine purchases on stock farms, and they are withdrawn from time to time as the butchers' requirements dictate. Often, therefore, such slaughter bovines may run for several months on the butcher's own farm, among his reserve slaughter stock, in which case, after eventual slaughter and measles being found, the butcher will have difficulty in establishing scientific proof of the age and origin of infection. In those cases, however, in which bovines are slaughtered immediately, or within a few weeks of purchase, the butchers should have a " clear case ", in the event of measles infestation being found. Measles disease is, and should in every case be considered by buyers themselves, a latent defect, if found in stock slaughtered within a reasonable time after purchase. In this respect butchers can assist towards the eradication of measles, if they would all decline to pay farmers for such infected purchases. Unfortunately competitive buyers have spoiled the producers, with the result that at some places the butchers who insist on a measles-free guarantee from farmers are frequently ousted by their more generous competitors. This fact is very much in evidence in Bloemfontein, with the result that nearly all local butchers will suffer the loss of a purchase through measles, rather than provoke the displeasure of their sellers, who would immediately supply their rivals with stock, to their exclusion, should a refusal to pay for condemned measly cattle have occurred.

A similar state of affairs is related by the Town Clerk of Barberton, whose most interesting memorandum, dated 27.10.36, and the very useful suggestions it contains may be mentioned almost *verbatim*:—

" It is fair to state that in rural centres, such as Sabie, Noordkaap, Sheba, Eureka, Louwscreek, Hectorspruit, Komatipoort, Kaapsche Hoop and Nelshoogte, animals are slaughtered in abattoirs where no post-mortem examinations are made. In these rural centres where slaughtering is carried on, not under the exigencies of meat inspection, the percentage of bovines infested with this parasite must be just as high as is found in the Barberton Municipal Area (i.e. about 5·31 per cent.), as only a negligible amount of stock is local, the greater proportion being bought in the districts where this slaughtering takes place. This being the case it seems that condemning a carcass infested with measles in the Municipal Abattoirs is a needless procedure in eradicating either measles in cattle or tapeworm in man. It certainly protects the urban residents from contracting the parasite and as such renders these people safe,

out still the incidence in cattle is on the increase; this is due to the lack of systematic uniform inspection of meat at *all* slaughter poles. On several occasions this situation has been discussed by the butchers and our Health Committee, and it appears that if the butchers wish to obtain recompense for losses suffered from the farmer or stock owner, in practically every instance he is told ' if you do not wish to buy my stock without making me responsible for your losses I shall simply sell to other buyers in areas where no inspections are carried out. They never suffer losses '.

In one instance of ' X ', a most progressive attitude was adopted. He made himself responsible for half the loss the buyer of his stock had suffered, and immediately had all the natives on his estate examined for evidence of being the unwilling host of the tapeworm. Within a short time twenty were found to be harbouring this parasite. Thereupon he made a strict rule that all infested natives employed by him had to be successfully treated to remove the entire tapeworm, and furthermore that every new native hired by him had to submit to an examination. Any native breaking this rule would be dismissed from his service. This appears to be a very good measure for dealing with the problem and were all ranch owners, cattle breeders and farmers equally progressive and willing to help in the eradication of the parasite, the whole position would be materially improved.

As it is, legislation to enforce this result would have to be passed in such a manner that a high infestation of measles in the stock of any particular owner would reflect materially on that particular individual. If an owner were careless about sanitary measures, careless whether his cattle became infested or not, and did not feel the loss in any way, when on post-mortem examination they were found to be infested, and legislation were passed that he stands the loss when a bovine is condemned, much would have been done to ameliorate the position. It is suggested that measures be taken to improve sanitary conditions on his farm, free the hosts of their parasites and examine every new employee. The farmer should be brought to realize his responsibility in the matter and *all insurance schemes should be abolished.* In Barberton, as pointed out, the farmer, by reason of his many markets refuses to recognize his responsibility and the butcher, who must have stock, has to bear the loss himself, and only a few miles away his competitors buy and slaughter without thought as to infestation and with no fear as to monetary loss."

These remarks by the Town Clerk of Barberton embody several of the suggestions made in previous paragraphs, but, in order to use his memorandum in a concise form, without referring to extracts here and there, the memorandum has purposely, as it is, been embodied at this stage of our discussion.

5. *Avoidance of all possible sources of contact of the susceptible animals with human dejecta.*

Pigs should be kept in sites, and on no account must they be permitted to roam about the farmyard.

Suitable latrines or privies should be constructed on all farms for the use of Europeans, and separate latrines for natives. The latter may be constructed close to natives' quarters. Meat inspection, alone, will never successfully eradicate taeniasis, if we do not safeguard infection of our meat animals with *Taenia* eggs. Our primitive Europeans and our native population must be educated in the first principles of hygiene. This campaign may be difficult, but the obstacles are not insurmountable.

What would appear to be quite a practical suggestion, is the fencing off of strips of veld, within which natives may defaecate. Such narrow fenced strips, with narrow inlets, so that cattle cannot enter them, can be provided on various parts of the farm, especially close to such parts where the farm labour is most frequently required, and also in grazing camps for the herd-boys, etc. Such fenced surface latrines may not, however, overcome the possible spread of *Taenia* ova by such agencies as water, insects (dungbeetles, blowflies, etc.), birds, etc. The provision, therefore, of trench latrines, and the enforcement of the immediate covering up of the deposited excretum by the native may thus be more effective, although it may be a trifle more costly in money and labour. Covered bucket latrines are, undoubtedly the most effective.

On no account should slaughter bovines be grazed on lands fertilized by human excretum, sewage farms, etc., and the use of fodder (e.g. lucerne, etc.) grown on such lands must be entirely discouraged.

The Native Affairs Department, through its Extension Officers, can by lectures to tribes, assist towards the eradication of the parasite.

It is astonishing how little the general public knows of the life-history of the parasite. Our campaign must, therefore, be directed at the rural source of the disease. All three Departments interested, namely Agriculture, Native Affairs and Public Health, can collectively assist in the eradication of the parasite. The Department of Agriculture can take more serious notice of the scourge by encouraging or instructing its Veterinary Officers, Stock Inspectors and Extension Officers to lecture groups of farmers on elementary farm hygiene. If Extension Officers and Stock Inspectors have no scientific knowledge of Cysticercosis-taeniasis, this can soon be taught to them, by brief courses at Onderstepoort, or by arrangement, at most of the principal abattoirs where qualified veterinary surgeons are employed. Armed thus with Departmental Pamphlet-Bulletins, the officers of the Department of Agriculture can disseminate the necessary knowledge to groups of farmers' meetings, where these bulletins in both official languages can be distributed. Our farmers will then receive sufficient enlightenment to attack the parasite by means of the most primary weapon, that of farm hygiene, hygienic prophylaxis and the means of maintaining this prophylaxis.

Similarly Extension Officers of the Department of Native Affairs and Sanitary Inspectors, seconded for service in native areas, may deliver lectures in Native Reserves. Enlightenment of all concerned is what is most urgently required, and the writer has, in the course

of his former Government veterinary duties, often experienced that Native Chiefs are ever ready to co-operate in campaigns concerning the health of their live stock—their only real token of wealth or possessions. Good work, through enlightenment, has been accomplished by co-operation of native tribes in other veterinary campaigns in this country, e.g., the campaigns against East Coast fever, Scab and Anthrax, and if we did not have the whole-hearted co-operation of our native co-dwellers on our borders, we would not have effectively stamped out the few outbreaks of Foot and Mouth Disease which occurred, or prevented its further entry into the Union, in a remarkably short space of time, during 1933. This may all sound idealistic, but many of our present-day Native Chiefs are quite intelligent, and if instructed to do so, they may be trusted to enforce strict hygienic sanitary laws among their people. The trouble is that they have never yet, as a plan of campaign, been *requested* to do so, nor has the *necessity* for the enforcement of tribal latrine arrangements been brought home to them. The present writer considers that this is an experiment well worthy of a trial.

6. *Free medical treatment of* Taenia *carriers.—Rewards for Production of* Taeniae *by such carriers.*

The enlightenment of our farming and native populations should next be followed by free medical treatment. Liquid extract of male fern, or whatever vermifuge the Public Health Department may recommend should be available for all *Taenia* carriers, whether on farms, native reserves, or in towns. Magistrates, District Surgeries or Dispensaries, Justices of the Peace in rural areas, or Native Chiefs should be provided with quantities of the drugs required, and careful directions for use may be given to those who have to dispense the drugs and may have no knowledge of therapeutics. If the campaign were to end with the free treatment of *Taenia* subjects, these must be told that evacuated *Taeniae*, segments, etc., must be burned or buried, but must not be discarded where live stock can come in contact with the dejecta.

Instead of ending the campaign with the free treatment of known carriers, it might be more advisable to encourage, in some form or other, this free treatment. In Australia and in Germany (in Wurtemburg, and lately throughout the country) rewards have been offered for the production of every tapeworm or piece with the head. In this connection, Dr. Heinrich Wagemann of Flensburg, writes (letter dated 22nd November, 1936): " For every tapeworm or piece with the head, which is sent to the physician of the Government Health Department, the tapeworm carrier is paid 10 R.M. Only by these measures, I think, we shall be able to fight measles, and we hope that these measures, even after a considerable period of campaigning, will ultimately eradicate measles in cattle altogether ".

It is possible that such a campaign may cost a considerable amount of money, if applied in South Africa, but, in consideration of public health and the loss to the meat industry locally, as well as to the menace to our potential chilled beef overseas market, it may well warrant the offer of small rewards to all those, European or native, who produce either the complete *Taenia* or portions including the head. Perhaps free treatment, plus 2s. 6d. for each head may be a big incentive to our poorer Europeans and natives to rid

themselves of their health-destroying guests. Rewards have been offered by the Government for the production of evidence of destruction of other vermin, e.g., the brushes of jackals, and it is quite possible that the economic loss from these marauders has been less than that caused by the tapeworm carrier.

It may be interesting to relate that Hall (1927) wrote: "As one by-product of that work, it might be mentioned that following the hookworm campaign of treatment and sanitation in Panama, the incidence of *C. cellulosae* in swine at the Panama City abattoir dropped from 15 per cent. to 5 per cent., according to the inspector, Dr. Mattatall. This 10 per cent. reduction in condemnations resulted in an annual saving of 40,000,000 dollars, a very valuable by-product of a hookworm campaign."

A campaign directed against the tapeworm in South Africa, and not necessarily the by-product of some other helminthic campaign, may, in a few years, show a remarkable economic result.

In Switzerland in 1917, and in Germany quite recently, attempts have been made to trace a *Taenia* carrier through infection found in a bovine carcass at the abattoir. The origin of the infected bovine is traced. In this connection Dr. Wagemann (Flensburg) writes (22.11.36): "Since August, in Germany, we also search for the tapeworm carrier. Thus, when measles disease is found, the Police trace back the origin of the animal. It is sometimes found that the owner of the animal, or a member of his household is a tapeworm carrier. In case such a person is found, he is compelled to have himself treated by a physician." In South Africa the tracing of a tapeworm carrier, in this way, may be impossible, owing to our large areas and the fact that frequently the origin of a bovine cannot be traced, since before slaughter it might have changed hands several times. The tracing of the origin of a *Taenia solium* carrier may be more practicable, except in measly pigs forwarded by speculators, since pigs delivered at abattoirs are frequently reared by the consignors.

In conclusion, it is of value to insert here a translation of Forms "A" and "B", at present used in Germany in connection with that country's campaign against Cysticercosis-taeniasis.

Direction of Abattoir, or
Veterinary Meat Inspector

FORM A.

.....
(name)

Place..... Date.....

To the Sanitary Police in.....

for transmission to.....
(name and address of owner of animal)

Re: Information regarding Measles in Cattle.

From the consignment of....., in.....,
(bovine or calf)

from the butcher....., in....., dated.....193...
(address)

which was slaughtered and was diagnosed to be measly on examination.

The beef measle is the intermediate stage of the development of a human tapeworm. The finding of measles in an ox appears to prove that a tapeworm must exist in a human being in the particular part from which the animal comes from. It is essential that investigation should be made whether the owner or one of his family, or somebody in his employ is infected with a tapeworm. The symptoms are: constipation, gastric derangement, loss of appetite, temporary listlessness, constipation followed by diarrhoea, and the finding of segments of tapeworm in the excretum. Accordingly, you are requested to see that the tapeworm carrier submits him/herself to medical treatment. For every tapeworm, or part with *HEAD* attached, found as the result of medical treatment, and forwarded to the Health Department, Veterinary Division, 82/84 Unter den Eichen, Berlin, preserved in spirits, with the attached form B completed, the tapeworm carrier will be paid 10 R.M. (ten Reichsmarks) reward by the Government.

.....

(Signature of the Abattoir Director/or Veterinary Meat Inspector.)

FORM B.

To be filled in by the Physician.

Place..... Date.....

District.....

INFORMATION REGARDING FINDING OF A TAPEWORM.

According to the attached information from.....
the Abattoir Direction
Veterinary Meat Inspector

.....at.....dated....., I have found that this person.....
(owner of animal)

of.....found a tapeworm, and
(full address)

I am sending this in spirits, with head attached.

.....
Examining Physician.

To the Government Health Department,
Veterinary Division,
82/84 Unter den Eichen,
Berlin-Dahlem.

EPILOGUE.

1. From records obtained from the large majority of abattoirs in South Africa, it was gleaned that the incidence of *C. cellulosae* in pigs varies between a fraction of a percentage and 25 per cent. These percentages represent averages varying from one year's to ten years' observations.

From only three Union abattoirs were percentages of less than 1 obtained. Average percentages of 5, or over, were obtained from no fewer than 24 Union abattoirs, and of this number 7 returned percentages in excess of 10. A definite " black " zone is traceable on the map of the Union, extending from Vryburg and Mafeking in the North-West to Nelspruit in the North-East, passing through the whole of the central Transvaal, via Lichtenburg, Potchefstroom, Rustenburg, Pretoria, Witbank and Middelburg. A similar " black " zone is traceable along the whole of the eastern border of the Orange Free State (bordering on Basutoland), and this includes the areas which supply the abattoirs at Wepener, Clocolan, Ficksburg, Senekal and Bethlehem. In the Cape Eastern area heavy infection was also found at three abattoirs, Fort Beaufort, Kingwilliamstown and East London, which probably draw pigs from the Transkeian Territories.

The incidence of *C. bovis* is much lower than that of *C. cellulosae* in South Africa. From 18 abattoirs were percentages of less than 1 obtained. From only 9 abattoirs were average percentages of 5 or more obtained. The highest percentage infections were obtained from the far Eastern Transvaal (bordering on Swaziland), that is Barberton, from those Natal abattoirs which draw a large amount of slaughter bovines from Zululand, and from the four Cape Eastern abattoirs, East London, Kingwilliamstown, Fort Beaufort and Port Elizabeth.

In general it would appear that there is a slight decrease in the incidence of *C. cellulosae* in the Union of South Africa, but a decided increase in that of *C. bovis*, during the last few years.

2. *C. cellulosae* infestation in South Africa usually assumes a very heavy, generalized nature. Approximately 5:1 may be taken as a fairly indicative ratio of heavy infestation to light infestation.

In the case of *C. bovis* infestation, the reverse is the case.

3. On account of the usual heavy infestation in pigs, it is not customary to describe definite predilection sites, but in bovine infestation it must be stressed that the muscles of the hind quarters, in addition to the common " predilection " sites found by workers in Europe, are very frequent locations of infection. The hind limbs are not incised in measles inspection, and it is recommended that attention should be drawn to this important predilection site. Incisions can be made deeply into the adductor muscles, parallel to and just below the pelvic symphysis, without mutilating the quarter. The hump is another important site of infection, and regulations should provide for the incising of this area.

4. Thorough inspection technique is seriously advocated. At Bloemfontein it was found that thorough inspection, coupled with long and deep incisions into the prescribed sites, was rewarded by the finding of four times as many measly carcasses, compared with the figures recorded prior to the adoption of our technique, that is before my Senior Inspector and I assumed office, simultaneously, at this abattoir.

5. In South Africa, it would appear that the origin of infection in the pig is the same as in almost all other countries, in which a fairly high incidence of *C. cellulosae* still occurs. On primitive farms and in native locations it is customary to allow pigs to wander about the farmyard, or in the vicinity of human habitation. On many such farms and Native Reserves the most primitive hygienic arrangements exist. The pig, under such conditions, readily acts as a scavenger and becomes heavily infested.

It has been observed that the incidence of *C. bovis* is higher during, or just after, periods of drought, when there is little grazing on the veld, and when, consequently, bovines tend to remain near human habitations. The incidence of infection is least among cattle drawn from vast ranges. Streams play a small part in the dissemination of *T. saginata* ova in South Africa. Stagnant pools in rivers used as watering places for cattle, may be suspected as potential points of danger. Sewage contamination of grazing lands has not been observed as a serious source of infection in this country, and actual records such as those from Germany, Holland and Australia are not available in South Africa.

6. Actual viability tests were performed during twelve months by myself and my staff at the Bloemfontein abattoir, and the results obtained varied very slightly from those obtained by workers in Europe, but differed greatly from the extremely negative results obtained by Annie Porter, who was the only South African worker who had previously attempted such viability tests.

The results of our tests showed that *C. cellulosae* can survive the death of its host, and evaginate its scolex (tested by Keller's method) by at least 41 days, under ordinary chilling room conditions. *C. cellulosae* may, in exceptional cases survive four days' continuous freezing at approximately – 10° C., in a shoulder of pork weighing 15 lb.

Similarly, in an exceptional case it was proved that *C. bovis*, subjected to 5 days' continuous freezing in a side of beef weighing 288 lb. was still capable of evaginating its scolex by Keller's method.

In no case was it found that *C. cellulosae* survived a period in excess of four days' freezing, or *C. bovis* in excess of five days' freezing.

7. Judging from personal information obtained from various medical observers, there is sufficient evidence to presume that both species of tapeworm are relatively common among our native population, and not at all rare in Europeans in South Africa, especially in rural areas.

Furthermore, Dr. van Coller, working in South Africa found that a large percentage of cases of psychosis were due to tapeworm infection.

Comparatively large numbers of cases of epilepsy in humans have been found, on post-mortem examination to have been due to *C. cellulosae* in the brain, etc. Dr. Cawston of Durban asks that compulsory autopsies should be held on all deceased epileptics.

8. Cysticercosis in swine and bovines is a costly scourge to the agricultural industry of South Africa, and taeniasis is a serious and disgusting infection in its population. Together, the two diseases caused by two stages of a common parasite should receive the full and collective attention of the veterinary and medical professions. Ultimate eradication is *not* impossible although many years of costly campaigning may be entailed. The economic and hygienic results expected from such a campaign warrant the assistance of the State.

Cysticercosis-taeniasis can be eradicated by:—

(*a*) Close co-operation between the veterinary and medical professions.

(*b*) Closer inspection of swine and bovine carcasses at abattoirs in the larger urban areas, with, possibly, veterinary control in towns with more than 7,500 Europeans.

(*c*) Compulsory meat inspection at all other slaughter poles, by qualified meat inspectors. These slaughter poles to be grouped and the inspector stationed in the central urban area must control its inspections. Butchers in small villages, where no inspection exists must not unfairly compete with their colleagues in the larger urban areas, who suffer losses from condemnation. The farmer must have absolutely no loophole for the sale of his measly stock, without suffering the loss.

(*d*) Education of Europeans and natives in elementary hygiene, embodying studies of the life-histories of the two parasites. The assistance of extension officers, stock inspectors and sanitary inspectors can be obtained, to further this elementary teaching.

(*e*) The abolition of all insurance schemes, which include indemnification for measles, at abattoirs. These insurance schemes, which serve no useful purpose, have the effect that the careless farmer shows no appreciation of his responsibility for safeguarding his stock from infection.

(*f*) The compulsory slaughter of all pig carcasses intended for sale on urban markets, at urban abattoirs. The custom of many unconscientious farmers who dispose of pig carcasses they have noticed on dressing to be measly, to their unfortunate natives, is very strongly deprecated.

(*g*) Free treatment of *Taenia* carriers, and the offer of rewards to all such treated carriers for the production of either an entire tapeworm, or a portion with its head attached.

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