

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 incision, 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 incision into each internal masticatory muscle.

Heart:- First external inspection, then an incision into the left ventricle up to the septum; subdivision 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%) 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 mease 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 Gycticerci 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 surmised 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) Excision 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 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 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 Fleischschau im Deutschen Reich" for 1905, in which the incidence of bovine measles was analysed as follows:-
Bulls 0.6% ; oxen 0.56% ; cows 0.17% .

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 re-infected owing to its proximity to a tapeworm carrier. He quotes two cases in which he found only one totally calcified measles in the masticatory muscles, 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 May 1st to December 31st, 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. cellulosa. 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 a 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 & 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

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 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:- ~~(XXXXXX)~~ "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 stage 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 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 examinations 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 generalized, 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 that 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 differential diagnosis of C. cellulosae.)
3. Sarcocystis blanchardi. (See differential diagnosis C. cellulosae, sarcosporidia (S. miescheriana)).
4. Actinomycotic nodules (See differential diagnosis C. cellulosae.)
5. Small tubercles. (do. do. do.).

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.

<u>YEAR</u>	<u>CALVES SLAUGHTERED</u>	<u>INFECTED</u>	<u>%age.</u>
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% are infected with these lesions (measles), but odd consignments show almost 100% 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 cysticerco-
sis in calves at the Johannesburg abattoir.

<u>YEAR</u>	<u>NUMBER SLAUGHTERED</u>	<u>NUMBER INFECTED</u>	<u>%age.</u>
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%).

Writing from Kenya, Dabney (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
 "Fat" calves 19

984
 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 2929 "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%, whereas in 1922 it was only 0.06%.

According to Dikoff (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%. 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 excrement, since few Bulgarian farms had W.C. accommodation.

According to Nakanishi (1926), the incidence of C. bovis in calves was 37.5% 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 ~~the~~ 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' mouths.
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.

NATURAL INFECTION OF THE ADULT BOVINE WITH CYSTICERCOSIS.

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 excrement 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 I.} ~~a subsequent part~~ 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 excrement will be ingested by bovines are, therefore, considerably less on vast cattle runs.

Conditions of drought leading to the ready ingestion of human excrement 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 excrement. 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% 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 animal 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 ranging for grazing during the day considerably reduces their chances of picking up eggs voided by one or two native herds."

Dr M^onnig, 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." (M^onnig, 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 (October 27th, 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 excrement 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 cachectic 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 excrement 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 excrement 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 outbreak 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 Zwijenenberg (1920), K. Müller (1927) Wernery (1931), Krueger (1934 and 1935), and also Dr. Mussemeier of Berlin. Among those who favoured the opinion that flood waters disseminated taenia ova and thus greatly contaminated grazing were Profé and also Prof. C.F. van Oijen of Utrecht.

Dr. Mussemeier 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 (Abwassern), 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 that time 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% of all cattle slaughtered in Kottbus were found infected with cysticercosis. Later (1935), after Profé 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, Profé (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. Profé 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 G. 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 grondegaan), 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 here 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 slaughterstock from coastal native areas (see Incidence Survey, figures for King Williamstown, 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 Chovis 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.

Lievre (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 excrement 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.