Acta vet. scand. 1990, *31*, 159–168.

Bovine Cysticercosis in Denmark

A study of possible causes of infection in farms with heavily infected animals

By *Bente Ilsøe, Niels Chr. Kyvsgaard, Peter Nansen* and *Svend Aa. Henriksen*

Department of Veterinary Microbiology, Royal Veterinary and Agricultural University, and National Veterinary Laboratory, Copenhagen, Denmark.

Ilsøe, B., N. C. Kyvsgaard, P. Nansen and S. Aa. Henriksen: Bovine cysticercosis in Denmark. A study of possible causes of infection in farms with heavily infected animals. Acta vet. scand. 1990, 31, 159–168. – Epidemiological studies were made on 14 farms from which, during a 2 year period, 38 cattle had been condemned at slaughter, due to massive infections with *Cysticercus bovis*. By on-site investigations and interviews, attempts were made to identify the transmission routes of *Taenia saginata* eggs from human faeces into the environment and further on to cattle.

The most frequent sources of infection were found to be sludge from septic tanks illegally applied on pasture or crops, in some cases after having been mixed with animal slurry. Animals in permanently housed herds were infected through the fodder or by contamination of the indoor environment by such slurry containing *Taenia* eggs. Other herds were infected by grazing pastures in close proximity to municipal sewage treatment plants. In contrast to earlier Danish observations, application on farmland of sewage sludge from municipal treatment plants was not involved in any of the reported outbreaks. This apparent change coincides with the implementation of more restrictive legislation for the agricultural use of sewage sludge in Denmark.

Taenia saginata; Cysticercus bovis; transmission; infection sources; septic tanks; sewage effluent; sewage sludge.

Introduction

The prevalence of recorded cases of bovine cysticercosis in slaughtered cattle in Denmark is generally low, at present 0.1 % (*Anonymous* 1988 b). However, regionally, in the southern part of Jutland, the prevalence can reach 0.7 % (*Ilsøe & Kyvsgaard* 1988). Infections are classified as being light, if 10 cysts or less are found at the sites of predilection (heart, masseters, tongue and diaphragm). Such carcasses are subjected to freezing, and the costs of this and the lower grading of meat quality are covered by the meat industry. Consequently these light infections receive little attention from the farmers, although they represent the main part of the detected infections. The much smaller number of cattle with heavier cysticercosis infections (more than 10 cysts found) call for more attention, as such carcasses are condemned without economic compensation. Such outbreaks, if epidemic of nature, may result in substantial economic losses for the farmer (*Nansen & Henriksen* 1986).

Dispersion of *T. saginata* eggs into the environment of cattle has been related to several incidents: Infected persons of the farmer family, farm personel or other people defecating in the environment of cattle (*McAninch* 1974, *Holt* 1985), use of sewage

sludge to fertilize pasture (*MacPherson et al.* 1978, *Holt* 1985) or irrigation of pasture with sewage effluent (*Jepsen & Roth* 1950, *Arundel & Adolph* 1980, *Wilkens* 1981). It has been stated that the relative significance of sewage sludge to the dynamics of transmission of bovine cysticercosis is not clear (*Havelaar et al.* 1983, *Gemmell* 1986).

In Denmark a cysticercosis storm caused by the application on pasture of stabilized municipal sewage sludge was described by *Haugaard* (1975). In a more extensive Danish study, comprising 15 herds with cases of massive cysticercosis, likely infection sources seemed to be pasture application of sewage sludge, septage, night soil or animal slurry containing human faeces, or streams carrying sewage effluent (*Nansen & Henriksen* 1986).

Out of 370 Scottish farms with cases of bovine cysticercosis, sewage sludge had been applied on 21 farms only (*Collier & Reilly* 1984). An obvious decrease in the number of "cysticercosis storms" in Scotland, was ascribed to intensive information to farmers, recommending an interval of 6 months between sludge treatment of pasture and the turnout of cattle (*Holt* 1985).

Along with certain other microbiological and toxicological hazards, the risks of sewage sludge containing infective *T. saginata* eggs are considered to be an obstacle in promoting the re-use of sewage sludge to the farmers. At present, only one third of the total amount of sludge produced in Denmark is used on agricultural soils (*Ilsøe & Kyvsgaard* 1988).

In 1984, more restrictive rules for the agricultural use of sewage sludge were implemented in Denmark. Application is hereafter allowed only on arable land, and in the case of raw sludge, direct deposition 10 cm into the soil is required. During a subsequent period of 12 months such areas must be used only for grain or seed crops, or grass for pelleting, however not for pasture. Machinery for the handling of sludge must be adequately cleaned before being used for other purposes (*Anonymous* 1984). In order to evaluate the risk of spreading of infective *T. saginata* eggs with sewage sludge after the implementation of these rules, a surveillance project was carried out, which included epidemiological surveys on light and massive cysticercosis infections over a period of 2 years (1986–1987) (*Ilsøe & Kyvsgaard* 1988, *Kyvsgaard et al.* 1991 a).

The following report is focusing on observations and considerations with regard to those herds from which animals with high level cysticercosis infections have been reported, with special regard to determination of possible infection routes.

Materials and methods

Epidemiological investigation

During the period from October 1985 to October 1987, the inspecting veterinarians at all Danish slaughterhouses were instructed to report, with a maximum delay of 1 week, all cases of total condemnations of carcasses due to detection of massive infections with bovine cysticercosis. After each reporting, interviews of the farmer, the local veterinarian and other relevant persons were carried out, and on-site analyses of the farm, pastures and feed crop production areas were performed. Answers to specific questions about herd size, feeding, management and the possible spread of septic tank or sewage sludge were sought. Information obtained from the municipal departments of Public Works about the local human waste collection, treatment and disposal practices were mapped. When searching for confirmed cases of taeniasis, the medical practitioners in each area were contracted.

The evaluation of the potential infection

sources was based on circumstantial evidence, as no conclusive proof could be given in any of the cases, due to the time lapse between the event leading to the contamination of the animal environment with *Taenia* eggs and the detection of the cysticercosis infections at slaughter.

Serological investigations

In 2 of the herds (no. 6 and 14) sera from all cattle and calves in the herd were tested for the presence of antibodies to bovine cysticercosis, using a *T. saginata* metacestode antigen (*Gibbens et al.* 1986). An ELISA method modified after *Harrison & Sewell* (1981) was applied (*Ilsøe & Kyvsgaard* 1988, *Kyvsgaard et al.* 1991 b).

Human incidence

The annual incidence of human taeniasis was estimated through the figures of the sale of Yomesan® (Niclosamid), which is the only cestocide available for human use in Denmark. The data were kindly provided by Bayer Denmark Ltd.

Results

Thirty eight cases of condemnations of cattle with massive cysticercosis infections were reported in 1986 and 1987, representing 14 herds. It can however not be entirely confirmed whether all massive cases diagnosed were actually reported to us. The herds were widely dispersed in the country, several in proximity of tourist or resort areas. In 1986 the heavy infections accounted for only 1.8 % of the total annual number of cysticercosis infections detected.

Table 1 shows the number of cattle infected in each herd, the management practices and 1 or 2 probable causes of infection as revealed by the investigation.

Table 1. Herds with animals condemned at slaughter due to bovine cysticercosis. Probable sources of infection.

Herd number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of animals with heavy cysticercosis	2	2	3	1	1	14	1	1	5	1	1	1	1	4
Number of animals per herd	205	20	70	15	150	280	100	4	28	80	?	4	700	132
Management practices:														
Dairy herd	x	x	x	.	x	x	x	.	.	x	x	.	.	x
Fattening stock only	.	.	.	x	.	.	.	x	x	.	.	x	x	.
Infected animals on pasture	.	x	x	x	x	.	x	x	.	x	?	x	.	.
Infected animals permanently housed	x	.	.	.	.	x	.	.	x	.	.	.	x	x
Probable infection sources found by the investigations:														
Septic tank sludge on grass or feed, separately or with slurry	x	.	x	.	.	x	.	.	x	x	.	.	.	x
Grazing next to sewage plant	.	.	.	x	x	.	.	.	.	.	.	.	.	.
Sewage sludge from plants on property	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Human defaecation on pasture probable	x	x	.	.	.	x	.	.	.	.	.	.	.	.
No infection source found	.	.	.	.	.	.	x	x	.	.	x	x	x	.

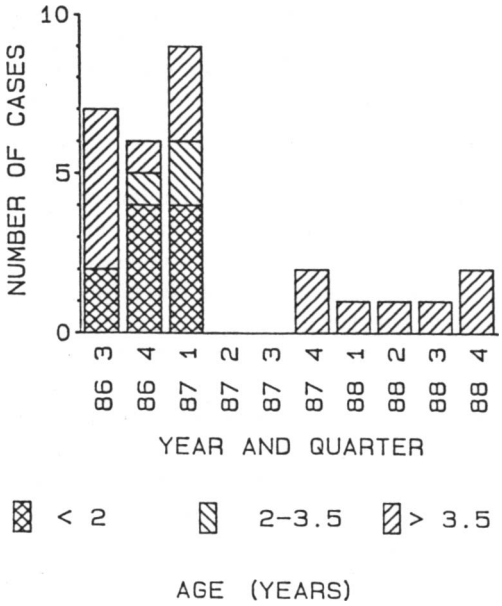

Figure 1. Number of animals with cysticercosis infections detected at slaughter in each quarter of a year from herd 6, subdivided into 3 age groups (< 2 years, 2–3.5 years and > 3.5 years of age).

Remarks about the individual herds

Herd 1. Two categories of potentially contaminated feed had been used: a) Hay harvested from a meadow where a municipal contractor had recently spread the contents of septic tanks of summer cottages. b) Fresh grass harvested just after the end of the camping season, on a camping site without adequate toilet facilities.

Herd 2. The herd had grazed a pasture bordering a lake where tourists angled all day during the summer. There were no toilet facilities.

Herd 3. Prior to the grazing season, animal slurry was applied on a pasture by a muck spreader which had previously been used when emptying septic tanks of summer cottages and camping sites.

Herd 4. A stream, carrying the effluent and occasionally the untreated surplus wastewater from a municipal sewage treatment plant 300 meters upstream, had been flooding a meadow grazed by the cattle. In the community of a few thousand inhabitants from whom sewage was led to the plant, one *T. saginata* infected person had recently been identified.

Herd 5. The cattle had grazed a pasture next to a municipal sewage treatment plant and had access to a creek carrying the effluent and untreated wastewater from the plant. Aerosols of wastewater were blowing onto the pasture from a biological filter tank placed 2 meters above ground level. The plant received wastewater from a small town with a thousand inhabitants and from a hotel and a camping site.

Herd 6. Grass cut for feeding on 2 fields had probably been contaminated by: a) Campers or visitors on a neighbouring airstrip where vintage aviation rallies with participants from many countries were held. No toilet facilities existed, and the grass field bordering the airstrip was an obvious alternative. b) An agricultural contractor also handling septic tank sludge was suspected of having emptied residue contents of a muck spreader on another grass field when passing at returning home.

Five members of the farm household and one employee were subjected to faecal examination, all with negative results. The herd was situated in the area also covered by an epidemiological investigation on light cases of cysticercosis, therefore these cases had also been recorded, and the course of this cysticercosis storm was closely followed for a period exceeding that of the other herds in this investigation. The serological investigation demonstrated that the infection was probably widely spread among all age groups of this herd (*Kyvsgaard et al.* 1991 b). Cysticercosis infections were detected in 29

slaughtered animals during a period of 2 1/2 years, although further contact to the possible infection sources had been avoided after the detection of the first cases. Fig. 1 shows the number of infections in different age groups as detected in each quarter of the years. Approximately 20 animals had been slaughtered every quarter. In the second and third quarter of 1987 another slaughterhouse outside the area was used, and the lightly infected cattle had therefore not been recorded. It is notable that after the first year, infections were found only among animals above 3.5 years of age. This suggests that all the affected animals from this herd had been infected at approximately the same time, after which the contact to the source of infection had been discontinued.

Herds 7, 8 and 11. The owners had no interest in participating in the investigation, in herd 8 and 11 because the cattle production had ceased.

Herd 9. When emptying the slurry pits, a muck spreader from a haulage contractor had been overloaded, resulting in contamination of seed hay used for feed. After the outbreak was detected, the owner chose to slaughter most of the remaining animals of the herd on the farm and illegally sell the meat as uninspected, but it was later heard that these animals had been "full of cysts".

Herd 10. Septic tank sludge had been spread and ploughed into a field subsequently used for fodder beet production.

Herds 12 and 13. In both herds the infected animals had been purchased shortly before they were slaughtered.

Herd 14. The slurry pits and the stable of this herd had obviously been soiled at the flushing of slurry channels carried out by a contractor who also used the equipment for emptying septic tanks at summer cottages. A fifth animal dead by accident was also found to be massively infected. The serological investigation revealed generally high antibody titres in this herd, although some differences in the antibody levels of certain age groups were encountered. This observation could be used for estimating the approximate time of infection and thereby further confirm the assumed infection source (*Kyvsgaard et al.* 1991 b).

General findings

It is notable that sludge from sewage treatment plants had not been applied on any of the present farms. None of the interviewed herd owners reported being or having been infected with tapeworms, and they had no knowledge of infections among their household members of employees.

Follow-up interviews carried out approximately a year after the initial detection of cysticercosis showed that, with the exception of herd 6, the period during which slaughter animals with cysticercosis infections were detected had been limited to about 6 months.

Human T. saginata infections

The annual incidence of *T. saginata* infections could be estimated to approximately 0.02 %, or 17:100,000, as the sale of niclosamide in a year (1986) constituted 997 doses. It can only be regarded as a rough estimate, as it is expected that a proportion of the *Taenia* infections are not diagnosed or not treated, and there is a possibility that some of the doses of Yomesan were used for treating other cestode infections (*Diphyllobotrium* or *Hymenolepis* infections, which however seem to be very rare in the Danish human population). *Götsche* (1951) found that 60 % of Danes infected with *T. saginata* received anthelmintic treatment within 2 months after the diagnosis. If it is estimated that the duration of the infection is 2 months, the prevalence of infections at pre-

sent will be (17×2/12) = 3 in 100,000 persons.

Discussion

Relatively few animals in each herd were detected as being infected with cysticercosis. However, the actual prevalence of cysticercosis in each herd was probably, as suggested by the serological tests, higher than apparent from the number of infections detected in the relatively small proportion of the animals slaughtered annually. It was furthermore recognized that some of the farmers, after the appearance of the first case of massive cysticercosis, had withheld animals from slaughter, sold animals live on markets or disposed of the remaining animals through other channels.

Five out of 14 herds representing 26 out of the 38 heavily infected animals had been kept indoor all their life. These animals had probably acquired the infection from feed contaminated in the field, or through the soiling of stable premises or feed with animal slurry accidentally containing human faeces.

The most frequent infection source of bovine cysticercosis as identified by this investigation, was sludge from septic tanks. Septic tanks are found in only a few percentages of Danish houses, mostly in rural and resort areas (*Anonymous* 1988 a). The high relative importance of septic tank sludge as a source of massive cysticercosis as compared to the role played by municipal sewage sludge, may be explained as follows:

The capacity of toilets and septic tanks seems to be inadequate on many camping sites and at resort areas in the peak tourist season, which coincides with the grazing season, where no arable land is available for sludge application by injection. In addition, many sewage treatment plants collect a fee for receiving sludge collected by private contractors and for this or other reasons application onto pasture or green crops obviously takes place. Furthermore, it was revealed that some farmers and haulage contractors had mixed septic tank sludge and animal slurry in the same muck spreaders, or that these had been used for both separately, but without the required cleaning in between.

Regarding the estimated low prevalence of human taeniasis, the probability of actually finding a person excreting tapeworm eggs among the limited number of people in a Danish household with a septic tank is very small, but it must be taken into consideration that most of the herds probably infected through septic tank sludge were situated in regions visited by many tourists. The majority of international tourists visiting the summer cottages and resort areas of Denmark come from European countries south of Denmark, where the incidence of Taeniasis is expected to be higher. Thus the given estimate of the Danish annual incidence of Taeniasis of 0.02 % can be compared with estimates obtained on a similar basis, reported from West Germany of 0.09 % (*Zimmermann* 1985), from Holland of 0.7–0.14 % (*Havelaar et al.* 1983) and from Belgium of 0.4 % (*Geerts* 1986). Consequently, the over a million tourists visiting Denmark every summer would be expected significantly to add up to the number of *Taenia* eggs excreted into the environment in the above-mentioned farming regions.

In case a tapeworm carrier is found among the members of a household with a septic tank, the sludge will contain much higher concentrations of eggs than municipal sewage sludge from cities with one or only a few cases of Taeniasis. This is a consequence of the higher degree of dilution with water and wastewater from other sources in the treatment plants where, furthermore, less

eggs will settle in the sludge: The time allowed for sedimentation in the tanks of sewage plants is usually too short and, unless the treatment includes prolonged settling, a substantial amount of the *Taenia* eggs will be present in the sewage effluent (*Arundel & Adolph* 1980, *Jepsen & Roth* 1950, *Wilkens* 1981, *Pike* 1988, *Ilsøe & Kyvsgaard* 1988).

The dispersal of *Taenia* eggs from municipal sewage treatment plants was the probable infection source in 2 of the herds. Regarding the estimated prevalence of human taeniasis of 3:100,000 it is obvious that only sewage sludge from treatment plants of Danish cities with tens of thousands of inhabitants would have a substantial probability of containing *T. saginata* eggs. But in plants of such size, *Taenia* eggs would be present in the sludge and the effluent only in very low concentrations. Both herds concerned had grazed at a short distance from or directly next to a sewage treatment plant of cities with only a few thousand inhabitants, in which the egg concentration would be expected to be somewhat higher. Furthermore the cattle of these herds had direct contact to the streams carrying both the effluent and the untreated surplus wastewater from the plants. It remains unclear whether egg transmission by vectors also had contributed, although this may not be likely for the transmission of massive cysticercosis infections under Danish conditions (*Kyvsgaard et al.* 1988), unlike conditions concerning Taeniid eggs elsewhere (*Lawson & Gemmell* 1983). Our observations are consistent with the previous finding that wastewater effluent may induce bovine cysticercosis infections in grazing cattle (*Jepsen & Roth* 1950, *Arundel & Adolph* 1980, *Wilkens* 1981). *Gemmell* (1986) stated that the infection pressure on an area is largely depending on the distance from the site of deposition of *T. saginata* eggs. In an investigation carried out parallel to the present, streams carrying the effluent over long distances from sewage treatment plants were seen to be responsible for a large proportion of the much more numerous and geographically widespread light cases of cysticercosis infections (*Kyvsgaard et al.* 1991 a).

Based on the reported observations, it may be concluded that, considering the actual epidemiological situation in Denmark, the agricultural use of sludge from municipal sewage treatment plants does not seem to be of significant importance for the transmission of infective *T. saginata* eggs resulting in massive cysticercosis cases. The apparent change in this respect, compared to results of earlier investigations (*Haugaard* 1975, *Nansen & Henriksen* 1986) coincides with the implementation of the new legislation for agricultural use of sludge.

In the present study, a serological method was used as a support to the epidemiological investigation. This investigation revealed that even though the method used was not suited for individual diagnosis of cysticercosis (*Harrison et al.* 1986, *Sewell et al.* 1986), it nevertheless was a useful tool for evaluating the dating of the contamination and for revealing the source of the infection (*Kyvsgaard et al.* 1991 b). Further improvement of serological methods may lead to safe diagnosis of individual animals (*Sewell et al.* 1986, *Harrison & Parkhouse* 1985). This would be useful in wide-scale epidemiological investigations and as an antemortem diagnostic tool, making it possible to limit the losses in a local epidemic outbreak.

The application of methods used for the isolation of Taeniid eggs from environmental samples by immunochemical methods (*Craig et al.* 1988), and for specific detection of *T. saginata* eggs by DNA hybridization (*Flisser et al.* 1988), will hopefully further

improve the possibilities for identifying transmission modes and geographical patterns. The availability of such tools and their use immediately after the detection of the first case of infection in a cattle herd, would also be of importance for providing conclusive proof of the infection source.

Further propagation of municipal arrangements for the emptying of septic tanks, and further information to farmers and contractors about the legislation and the infection risks involved in handling septic tank sludge, could result in a decrease in the number of outbreaks of massive bovine cysticercosis. Information to farmers about the insignificant relative importance of municipal sewage sludge to the spreading of massive bovine cysticercosis, could lead to an improved acceptance of re-using sewage sludge as fertilizer in agriculture, and thereby assist in solving the problems of disposal of the growing amounts of sewage sludge.

Acknowledgements

The authors wish to thank Mr. Niels Midtgaard and Mrs. Lykke Kieler for practical assistance, Dr. Leslie Harrison, Edinburgh, for assistance with the implementation of the serological technique, and E. T. Rask D.V.M., Tinglev, and Lene Dam D.V.M., Høng, for assistance with the blood sampling.

This work was part of a project supported by the Ministry of Agriculture, the Ministry of the Environment and the National Association of Local Authorities.

References

Anonymous: Bekendtgørelse nr. 574 af 14. november 1984 – om anvendelse af slam i landbruget. (Notice no. 574 of 14th November 1984 on agricultural application of sludge). Danish Environmental Agency 1984, 3 pp.

Anonymous: Danish Environmental Agency. Personal communication to mr. Keld Hansen. 1988 a.

Anonymous: Danish Veterinary Services. Personal communication. 1988 b.

Arundel JH, Adolph AJ: Preliminary observations on the removal of *Taenia saginata* eggs from sewage using various treatment processes. Aust. vet. J. 1980, *56*, 492–495.

Collier PW, Reilly WJ: Cysticercosis and sewage sludge. Ann. Trop. Med. Parasitol. 1984, *78*, 259.

Craig PS, MacPherson CNL, Watson-Jones DL, Nelson GS: Immunodetection of *Echinococcus* eggs from naturally infected dogs and from environmental contamination sites in settlements in Turkana, Kenya. Trans. Roy. Soc. Trop. Med. Hyg. 1988, *82*, 268–274.

Flisser A, Reid A, Garcia-Zepeda E, McManus DP: Specific detection of *Taenia saginata* eggs by DNA Hybridization. Lancet 1988, *2*, 1429–1430.

Geerts S: Tapeworms, meat and man, a complex interrelationship. Academic session held at an International Colloquium at the Instituut voor Tropische Geneeskunde, Antwerpen 11–12 December 1986, 1–19.

Gemmell MA: General epidemiology of *Taenia saginata.* In: Epidemiological Studies of Risks Associated with the Agricultural Use of Sewage Sludge: Knowledge and Needs. (Block, Havelaar and L'Hermite eds.). Proc. of a CEC seminar, Metz, May 1985. Elsevier 1986, 60–71.

Gibbens JC, Harrison LJS, Parkhouse RME: Immunoglobulin class responses to *Taenia taeniaeformis* in susceptible and resistant mice. Parasite Immunol. 1986, *8*, 491–502.

Götzsche NO: Bidrag til *Taenia saginata*'s epidemiologi. (Contribution to the Epidemiology of *T. saginata*). Nord. Vet.-Med. 1951, *3*, 957–983.

Harrison LJS, Sewell MMH: A comparison of the Enzyme-Linked Immunosorbent Assay and the Indirect Haemagglutination technique applied to sera from cattle experimentally infected with *Taenia saginata* (Göeze, 1782). Vet. Immunol. Immunopathol. 1981, *2*, 67–73.

Harrison LJS, Holt K, Sewell MMH: Serum antibody levels to *Taenia saginata* in cattle grazed on Scottish pastures. Res. Vet. Sci. 1986, *40*, 344–346.

Harrison LJS, Parkhouse RME: Antigens of Taeniid Cestodes in Protection, Diagnosis and Escape. Curr. Top. Microbiol. Immunol. 1985, *120*, 159–172.

Haugaard P: Tinter og slutdisponering af slam. (Cysticercs and the final disposal of sludge). Dansk Vet. Tidsskrift 1975, *58*, 541–546.

Havelaar AH, Oosterom H, Notermans S, van Knapen F: Hygienic aspects of the application of sewage sludge to land. In: Proc. of the Int. Symp. on Biol. Reclamation and Land Util. of Urban Wastes. Naples 11–14/10 1983. (Zucconi, de Bertoldi and Coppola, eds.) 1983, 167–200.

Holt K: Taenia saginata in the Scottish Environment. State Vet. J. 1985, *39*(114), 14–21.

Ilsøe B, Kyvsgaard NC: Rapport om overvågningsprojekt vedr. anvendelse af slam i landbruget. (Report of a surveillance project on the agricultural use of sewage sludge). National Veterinary Laboratory and the Royal Veterinary and Agricultural University, Copenhagen 1988, 157 pp.

Jepsen A, Roth H: Parasitologiske og bakteriologiske problemer vedrørende spildevand, specielt i forbindelse med oversprøjtningsmetoden. (Parasitological and Bacteriological Problems of Sewage Disposal, especially with Regards to the Sprinkler Irrigation Method). Nord. Vet.-Med. 1950, *2*, 967–991.

Kyvsgaard NC, Ilsøe B, Willeberg P, Nansen P, Henriksen SAa: A case-control study of risk factors in light *Taenia saginata* light cercosis in Danish cattle. Acta vet. scand. in press 1991 a.

Kyvsgaard NC, Ilsøe B, Henriksen SAa, Feld NC, Nansen P: Evaluation of an enzyme-linked immunosorbent assays (ELISA) for detection of *Taenia saginata* cysticercosis in cattle. Acta vet. scand. in press1991 b.

Kyvsgaard NC, Ilsøe B, Henriksen SAa, Nansen P: An attempt to evaluate the spreading of *Taenia saginata* eggs in the environment. Acta vet. scand. 1988, *29*, 511–513.

Lawson JR, Gemmell MA: Hydatiosis and Cysticercosis: The dynamics of transmission. Adv. Parasitol. 1983, *22*, 261–308.

MacPherson R, Mitchell GBB, McCance CB: Bovine cysticercosis storm following the application of human slurry. Vet. Rec. 1978, *132*, 156–157.

McAninch NH: An outbreak of cysticercosis in feedlot cattle. Can. Vet. J. 1974, *15*, 120–122.

Nansen P, Henriksen SAa: The epidemiology of bovine cysticercosis (*C. bovis*) in relation to sewage and sludge application on farmland. In: Epidemiological Studies of Risks Associated with the Agricultural Use of Sewage Sludge: Knowledge and Needs. (Block, Havelaar and L'Hermite eds.). Proc. of a CEC seminar, Metz, May 1985. Elsevier 1986, 76–82.

Pike EB: Parasites in Sewage Effluents. Water Research Center Environment Report PRD 1403-M/2-B (ME 9125 SLD) WRc Environment, Medmenham Lab. England 1988, 1–31.

Sewell MMH, Harrison LJS, Holt K: Serodiagnosis of bovine cysticercosis and the application of sewage sludge to pasture. In: Epidemiological Studies of Risks Associated with the Agricultural Use of Sewage Sludge: Knowledge and Needs. (Block, Havelaar and L'Hermite eds.). Proc. of a CEC seminar, Metz, May 1985. Elsevier 1986, 102–105.

Wilkens S: Untersuchungen über die Ansteckungsmöglichkeiten von Rindern mit *Taenia saginata* und *Sarcocystis* spp. auf Abwasserverregnungsflächen und über das Absetzverhalten von Helmintheiern in vitro. (Investigations of the risk of infection in cattle by *Taenia saginata* and *sarcocystis spp.* by irrigated sewage plant efficient and in vitro trials on the rate of sedimentation of helminth eggs). Inauguraldissertation, Tierärztliche Hochschule Hannover. 1981, 122 pp.

Zimmermann G: Kritische Betrachtung zur Verbreitung der Zystizercose beim Rind und Vorschläge zu verbesseren Bekämpfungsmassnahmen der Rinder-Bandwurm-Invasion beim Menschen. (Evaluation of the occurrence of cysticercosis in cattle and suggestions for improved control of tape worm transmission to man). Tierärz. Umsch. 1985, *4*, 257–264.

Sammendrag

Bovin cysticercose i Danmark – en undersøgelse over mulige smittekilder i besætninger med højgradige infektioner.

Epidemiologiske undersøgelser blev gennemført i 14 kvægbesætninger, fra hvilke ialt 38 dyr var blevet kasseret som følge af massiv infektion med *Cysticercus bovis*. Gennem besætningsbesøg og interviews blev de sandsynlige smittekilder søgt klarlagt. Den almindeligste smittekilde var septiktankindhold, der havde kontamineret græsningsarealer, foderafgrøder eller staldmiljø, i nogle tilfælde gennem ulovlig opblanding i husdyrgylle. I enkelte af besætningerne var smitten sket ved græsning på arealer umiddelbart op til rensningsanlæg. Her havde kreaturerne desuden haft adgang til at drikke fra vandløb, der bortledte renset effluent og overløbende spildevand. Ingen af de ramte ejendomme havde udspredt slam fra kommunale rensningsanlæg. Sådant slam tillægges derfor ikke mærkbar betydning som smittekilde for bovin cysticercose i den nuværende epidemiologiske situation.

(Received June 27, 1989; accepted August 9, 1989).

Reprints may be requested from: Bente Ilsøe, Dept. of Veterinary Microbiology,
Royal Veterinary and Agricultural University, Bülowsvej 13, DK-1870 Frederiksberg C, Denmark.