
CONTROL OF INFECTIOUS DISEASES: II

By

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THE sheep industry in all parts of the world suffers economic losses from diseases in the flocks, one of the most important being blue tongue which was first recognized in southern Africa and more recently diagnosed in other parts of Africa, in some Near East countries, in some parts of the United States of America and in Portugal and Spain. The disease, caused by a virus with considerable powers of resistance, may spread rapidly within a given area, causing a mortality of about 10 per cent. in most outbreaks although the death rate may vary between 2 and 80 per cent. Much research work has been carried out on blue tongue, especially in South Africa, but there are still some important problems awaiting solution.

Field evidence indicates that the causal virus may be insect-transmitted and that sheep exposed to species of culicoides (midges), especially in low-lying, moist districts at night in the infected areas, contract the infection. Outbreaks occur only during the late summer months but it does not follow that sheep will become infected even when large numbers of midges may be present under conditions considered good for transmission. This may be because the midges do not carry the virus from one season to another and that the true reservoirs of the infection, at present unknown, are not present.

There is not yet exact information on the spread of the disease into non-infected areas or countries. It is known from experimental work that sheep which have recovered from the infection may continue to harbour the causal virus in a much reduced state of virulence for some weeks (120 days). Such recovered sheep may, therefore, continue to be a cause of residual infection.

Mutton Breeds more Susceptible

Blue tongue is essentially a disease of sheep, all breeds being susceptible, but mutton breeds more than Merinos. Variations of individual susceptibility occur within a breed. Cattle are also susceptible but to

a lesser degree. Affected cattle have been found in Israel and the infected European countries. It may be that the absence of the clinical disease in cattle in South Africa arises because of the exposure to the infection of the young animals when they are in a protected state from the passive immunity derived from their dams. Although cattle may show little or no clinical evidence of the infection, they can nevertheless, harbour the causal virus. There is evidence from experiments that the virus may be present for up to 70 days following artificial infection. It is also known that wild rodents may carry the infection.

Symptoms of the Disease

Blue tongue is characterised by a high temperature lasting from a few days to over a week, by reddening of the membranes of the mouth and nose, by discharge from the nose, by swelling of the lips, tongue and the space between the branches of the lower jaw, by peeling of the top layers of the skin of the lips and nostrils, by a general reddening of the skin, interfering with the nutrition of the wool and so causing breaks in the wool, sometimes by inflammation of some of the structures of the feet and by loss of bodily condition : affected lambs may show diarrhoea.

There seems to be little doubt that blue tongue is insect-transmitted but information on the reservoirs of the causal virus is still lacking. As it is impossible yet to eradicate the transmitting insects, prevention of the disease must consist in the annual mass vaccination of susceptible animals. From time to time different types of vaccine have been produced. The type now in general use is a vaccine consisting of four different strains of the virus whose virulence has been much reduced by passage through developing chick embryos : it is produced in a freeze-dried form and can, therefore, be kept for long periods under suitable conditions. This vaccine is giving generally satisfactory results : it is cheap, easily prepared, easily transported and safe to use except, perhaps, in ewes vaccinated for the first time during pregnancy, from a small number of which there is some evidence from America that abnormal lambs were born. Although, on the whole, this vaccine gives satisfactory results, a disadvantage is that, because so many strains of the virus are used in its preparation, a high immunity against all of them may not be established.

Swine Fever or Hog Cholera

In pigs, the disease which causes the greatest economic losses, generally speaking, is probably swine fever (hog cholera). It is found in most parts of the world where pigs are kept. The incidence varies from country to country: in some, the disease is endemic and, in spite of the efforts to control and eradicate the infection, repeated outbreaks occur, often associated with the movement of pigs. Some countries, which raise pigs on an extensive scale, have remained free from swine fever: this, to a large degree, is due to the prohibition of importation of pigs and pig products from other countries. It is well known that such importations, especially of pig products, have introduced the disease into countries which were free from the infection. The application of severe veterinary measures, following early recognition of the disease, have eradicated the infection in some of these countries.

Methods of combating the Disease

Undoubtedly, the most satisfactory results following the appearance of the disease in a country are obtained from a slaughter policy with restrictions of movement, the destruction of carcasses of the slaughtered animals and careful disinfection of infected premises. By adopting such a system a country can, usually within a reasonable time, be freed from the infection. In countries in which the disease is endemic, however, a slaughter policy is usually impracticable, although the restriction of movement of pigs out of or into prescribed infected areas will prevent spread to other areas. The application of regulations for the cooking of all garbage (swill) has also a considerable value in preventing spread of the disease.

In countries in which swine fever is endemic, vaccination is usually practised, sometimes on an extensive scale. The simultaneous infection of the living causal virus and protective serum was used for many years and, although effective in controlling the disease, was not entirely satisfactory because some pigs became ill within a few days and breaks in the immunity were sometimes found after a few months. These occurrences were seen in spite of strict control of the potencies of the virus and serum. Extensive research in the United States of America has shown that these losses were due, probably, to the development of variants of the virus which were not affected by the serum.

Other types of immunising agents against swine fever have become available: there is the vaccine consisting of the virus exposed to the dye, crystal violet; and the vaccine containing the virus attenuated

by passage through rabbits, used alone or simultaneously with protective serum. In general, these vaccines are giving favourable results: but unsatisfactory results, which are seldom found, are the subject of study at the present time.

African Swine Fever is Different

It is to be noted that the disease named African swine fever which, as its name implies, occurs in parts of Africa, is not the swine fever which occurs in other parts of the world. The causal agents are different and the protection against swine fever as carried out in many countries does not protect against the African disease. The African disease appeared recently in Portugal and was eradicated by the adoption of a slaughter policy.

All the diseases already discussed in these articles are, generally speaking, diseases of animals and not normally of human beings. There is some evidence that the viruses of foot-and-mouth disease and Newcastle disease have caused some localised human disease, usually very mild in character and quickly responding to treatment. There are, however, a number of infectious diseases of animals which also cause serious diseases in man. In this article, two are discussed.

Bovine Tuberculosis infects Humans

Bovine tuberculosis in cattle is responsible for considerable losses in production throughout the world where demands are made for high production in cattle and where husbandry methods favour the spread of the infective causal agent. In some of the less developed countries, and in regions where cattle are mostly on wide, free range, the incidence of the disease may be very small, but where milk production on intensive lines is carried out, bovine tuberculosis may exist to a marked extent. The freedom or comparative freedom of some regions from bovine tuberculosis is maintained to a considerable extent by the precautions taken to prevent its introduction. In considering bovine tuberculosis we must also remember that it is a disease of human beings, occurring mostly in children and adolescents. The causal agent is conveyed mostly by the consumption of products, especially milk, derived from tuberculous animals, as well as contact with infected livestock. Infected animals other than cattle may sometimes cause the disease in human beings. Monkeys, dogs, cats and pigs are all susceptible to bovine tuberculosis and may transmit the infection.

Infection means lower Milk Yield

In view of the damage done by the disease, much attention has been given to its eradication not only from herds of cattle but also from

whole countries. Some countries have been freed from the disease in the cattle : some will soon be free, while in others rapid progress is being made in the eradication of the infection. It has been shown, repeatedly, that higher production results from herds free from bovine tuberculosis, the lower production in infected herds being not only due to the direct effects, but also to the indirect effect of the disease in opening the way for other diseases.

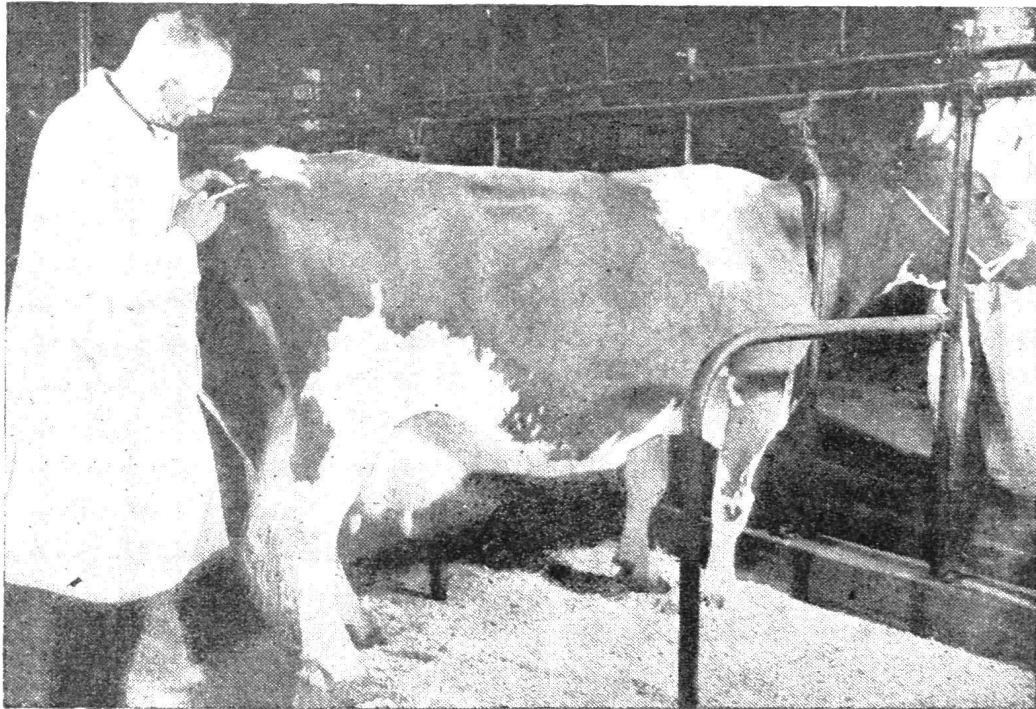
Some earlier attempts to control bovine tuberculosis in herds did not always prove entirely successful. The essentials in controlling and eradicating the disease are to discover the infected animals, to remove them at once from all contact with the other stock, to disinfect the premises occupied by them and to ensure that no further infection is introduced into the herd. While there may be a variety of ways in which the causal organism may enter a herd, the most important is the infected bovine, especially the animal which, so far as the eye can judge, is healthy. The disease may be present in some organ or tissue of the animal, even for long periods during which no outward signs are obvious. This is the dangerous animal because, quite suddenly, the infection in its quiescent form may become active and spread rapidly throughout the herd, even before any marked evidence of the disease is seen in the originally infected animal. Unfortunately, this animal is quite often a high producer and the owner fails to appreciate the harm which it may be doing. Such an animal also constitutes a danger to human beings.

Tuberculin Test is Safest Check

An acutely infected animal, with obvious signs of ill-health, may be diagnosed as suffering from bovine tuberculosis by the recognition of the causal agent in its bodily secretions or excretions, e.g., milk, sputum and faeces. Diagnosis by this method is not always satisfactory, because the causal micro-organisms may not regularly appear : it cannot be applied to the type of animal in which the lesion containing the active agents, but not excreting them, is temporarily sealed off. The only satisfactory diagnosis of bovine tuberculosis today is the application of the tuberculin test, especially by the intradermal method : there are few infected animals which fail to react to the test.

Tuberculin, produced from *M. tuberculosis*, has long been used in the diagnosis of tuberculosis in animals but the type of tuberculin, the methods of its application and the interpretation of the results have changed over the years. Most of the tuberculin in use today is a purified form which consists very largely of tuberculo-protein,

produced during the artificial culture of the organism. The site of the injection of tuberculin is also varied: in some countries, the neck is used while in others the injection is made into the fold of skin at the top of the tail—the caudal fold. A difficulty in the use of tuberculin is the sensitivity of animals in which infections other than true bovine tuberculosis exist: this also causes reactions to some types of tuberculin. Most of the tuberculins in use are derived from mammalian strains of *M. tuberculosis*, sometimes the true bovine strain, sometimes the human strain, sometimes a mixture of both strains. Tuberculins from these strains produce reactions not only in animals suffering from bovine tuberculosis but also in animals with other sensitivities caused, e.g., by the avian strain of *M. tuberculosis*, by the causal agent of Johne's disease and by the micro-organisms which give rise to so-called "skin tuberculosis". The result is that, in the application of tuberculin of mammalian origin, an animal suffering from any of these infections may react positively. This difficulty can be overcome to a large extent by the use of two tuberculins simultaneously—one of mammalian origin and one of avian origin. Reactions to both tuberculins will be found in most animals with any of these infections, but the difference in the reactions as shown by their character and size assists in the determination of the presence or absence of bovine tuberculosis. The tuberculin test should be regarded as a herd test rather than as a test applied to an individual animal and the health history of a herd is of much value in the interpretation of the results of tuberculin tests.



Veterinarian injects tuberculin to commence a tuberculin test

Photo by courtesy F. A. O.

Herd Tests should be Repeated

In the eradication of bovine tuberculosis, the removal of animals reacting to tuberculin is essential, together with disinfection of the premises. It is also necessary to continue tuberculin testing at stated intervals in the remaining non-reacting animals in order to detect those in which the duration of the infection had not been sufficiently long to ensure their sensitivity at the former test. It may be necessary to repeat the tuberculin test in a herd a number of times until no reactors are found at two successive tests: it is only then that the herd may be accepted as free from bovine tuberculosis. Ideally, the disposal of reactors should be by slaughter and this is the system in some countries. It has been demonstrated, however, that, with the application of satisfactory precautions against the introduction of the infection, herds can be maintained free from the disease, although there are infected herds in the surrounding area.

Cattle Owners encouraged to Co-operate

The eradication of bovine tuberculosis from a country may begin by consideration of individual herds but, soon, the plan must concern areas until the whole country is covered. Cattle owners are usually encouraged to co-operate in any eradication scheme by the award of bonuses for milk from herds free from the disease or by an annual capitation grant: these are usually made available for a specified number of years.

Vaccination of cattle against bovine tuberculosis has been fully considered. While vaccines are used in human beings and experiments show that they also set up resistance to bovine tuberculosis in cattle, the many difficulties encountered in their application to cattle have resulted in a general veterinary opinion against their use.

Domestic animals, other than cattle, suffer from bovine tuberculosis. Swine, for example, are quite susceptible and in some countries, the disease in them is extensive. Swine also suffer from avian and human tuberculosis and, in the application of tuberculin tests, it is always necessary, as it is sometimes in cattle, to use tuberculin of mammalian and avian origins. The possibility of the transmission of bovine tuberculosis from swine has to be considered when eradicating the disease from an individual cattle herd, an area or a country.

May be confused with other Diseases

While, usually, the clinical picture of the disease is sufficient for recognising its presence, even the advanced disease may be confused with other conditions, especially internal parasitism. Microscopic examination of scrapings from the intestinal lesions may show the casual organism in infected animals, but the absence of the bacillus is not to be regarded as freedom from the infection, especially in animals in which the clinical symptoms have not yet developed to a marked extent. Other methods of testing for the presence of the disease have been the subject of study. The product, johnin, prepared by the cultivation of the causal organism in special liquid medium, is sometimes used for diagnosis, especially in the early stages of the disease. It is usually injected intradermally. Avian tuberculin is also sometimes used for diagnosis, injected intradermally, and causes a local reaction similar that produced by johnin. Although these products are useful in some cases, they are not entirely reliable. Serological tests have also been studied and are said to be particularly useful for diagnosis, especially in infected animals over a year old

Bearing in mind that large numbers of the bacilli are excreted in the faeces of infected animals and that young animals are particularly susceptible to the disease, methods of control should include the early detection and removal of infected animals and the early separation of the calf from its dam so that it may be reared out of contact with the infection.

Immunising Susceptible Animals

Some work has been carried out in immunising susceptible animals with vaccine containing the live virulent organisms incorporated in an excipient composed of mineral oil and finely ground limestone. It is injected into young animals which are negative to johnin and avian tuberculin tests. The injection produces a hard swelling which may persist for some years. There is evidence that vaccination is useful in heavily infected herds. Although the effects of a single injection of the vaccine may continue for some years, it is considered advisable to repeat vaccination every 15 months or even at shorter intervals. Treated animals become sensitive to tuberculin. This may cause some difficulty in the interpretation of results of the tuberculin test in treated herds. The use of the comparative tuberculin test, however, is of much assistance in determining the significance of the reactions.

From evidence collected in various countries, it is becoming apparent that Johne's disease is more prevalent throughout the world than was formerly appreciated. The need for the careful veterinary examination of all imported animals for the detection of this and other diseases must be stressed.

Three Strains of Brucellosis

Brucellosis is another highly contagious disease of cattle and other animals, transmissible to human beings. There are three more or less distinct strains of the causal agent—*Brucella abortus*, *Br. melitensis* and *Br. suis*, all of which may infect domestic animals on occasion although it is generally recognised that brucellosis is caused by *Br. abortus*, *Br. melitensis*, and *Br. suis* in cattle, in sheep and goats and in swine, respectively. Abortion is often a symptom of brucellosis, hence the commonly-used term "contagious abortion" in cattle. Many infected females, however, do not abort, especially when the disease has been present in a herd for some years and the infection may be present in male animals. The only way to diagnose the disease is by the recovery of the causal organism from the aborted calf, the foetal membranes or the discharges from the genital tract, or from the milk. The use of the agglutination test is also very valuable. In the absence of measures to control and eradicate *Br. abortus*, the disease may persist in the herd, resulting in an occasional abortion and irregular and difficult breeding. It may also happen, especially if susceptible breeding cattle are introduced into the herd, that the disease again becomes acute and a typical "abortion storm" results. The infection is easily conveyed to non-infected females by the discharges from the genital tract of infected animals, and even through their milk. While *Br. abortus* continues to be excreted from the infected genital tract until all discharges following abortion or calving have disappeared, the organism may still be found in the milk at irregular intervals over a long period.

The control and eradication of brucellosis in cattle may be accomplished in two ways. One is similar to the procedure for eradication of bovine tuberculosis, viz., the diagnosis and removal of infected animals, together with thorough disinfection and the prevention of further introduction of the disease. The infection has been eradicated from many herds by these measures; but, because of the ease with which the causal organism can be conveyed, considerable difficulties have been experienced in maintaining herds in a state of freedom.

Immunity lasts for some Years

The other method is the protection of animals by vaccination. This has been practised for many years, using vaccines prepared in different ways. It has been clearly shown that vaccines must consist of living *Br. abortus* so attenuated or reduced in virulence that their injection does not set up the disease. The most universally used vaccines at the present time consist of such organisms as the well-known Strain 19, discovered in the United States of America in a naturally-attenuated form. This organism has been shown, by carefully controlled experiments, to retain its state of attenuation after having been passed through many cows and thus its safety for use as a vaccine is ensured. The injection of a single dose of this vaccine into non-pregnant cattle sets up a relatively high state of immunity lasting for some years.

Vaccination at a young age renders animals resistant to the infection during the period of high susceptibility and lasts at least until a natural resistance develops with age. To obtain maximum results, the vaccine must be prepared by a process which is now well known throughout the world. Recent work has resulted in the preparation of this vaccine in a freeze-dried condition which means that, under satisfactory conditions of storage, it can be kept in a living and active condition over long periods. While the protection against infection is high, it may not always be absolute and "breaks" do sometimes occur. It is seldom, however, that an animal which has received potent vaccine at a suitable age, aborts even though some degree of infection may be present. The wide-scale use of the vaccine has been followed by a marked reduction in the incidence of brucellosis and this has led to the study of causes of abortion other than *Br. abortus*. A disadvantage of some importance with the use of the vaccine is the development of agglutinating substances in the blood of infected animals, so they may react to the agglutination test. This is of little consequence in many herds, for the object of the vaccination is to prevent the disease. On the other hand, in some cattle, particularly those for export, negative reactions to the agglutination test are required.

Age at Vaccination is Important

In considering such agglutination reactions, the age at which vaccine is injected is of importance; the older the animal, the more do agglutination bodies tend to persist. The normal practise is to vaccinate calves, female and male, between the ages of four and eight months. Animals vaccinated at a younger age will probably

fail to be protected in later life because the mechanism for the production of protective antibodies will not have developed to the extent of being stimulated by the vaccine. Most of the heifers vaccinated between these ages will react negatively or only at "low titre" to the agglutination test by the time they reach breeding age. In non-vaccinated animals, a "low titre", however, may indicate the beginning of a natural infection. The significance of such a titre may be clarified if it is known that the animal was vaccinated at a certain age and that, just before vaccination, the blood agglutination test was negative.

Brucellosis of sheep and goats presents an important problem in some regions. It is commonly found in north African countries, some parts of east, west and south Africa, some European countries, especially in southern parts of the continent, some Near East countries, in South East Asia, in Mexico and in some States of the United States of America and in South American countries. In addition to the losses in animals, the disease also causes "undulant fever" in human beings. Infection occurs by handling infected animals and by consuming products, especially milk or unripened soft cheese, prepared from milk from infected goats and sheep. Within recent years, much research work has been carried out on brucellosis in sheep and goats. More is now known about the stages of infection at which *Br. melitensis* is excreted and about the persistence of the organism in the animal body.

New Vaccines being Produced

Considerable progress has been made in the preparation and evaluation of different vaccines for the prevention of the infection. Work in the laboratory and with small numbers of sheep and goats has shown that at least two vaccines are satisfactory immunising agents. We must now await the results of large-scale field trials of these vaccines before one or both can be recommended for general use. Much of the work on testing the value of the vaccines was done in Tunisia through technical assistance provided mainly by the Food and Agriculture Organization of the United Nations.

The characteristics of the three classical types of brucella, as shown by laboratory tests, have been recognised for a long time. There is now evidence that there exist brucella which do not correspond exactly to any of the three. "Intermediate types" have been found. One such has been recovered from a few milking cows in England: it shows some of the characteristics of *Br. abortus* and some of *Br. melitensis*, and was originally found in the milk. This finding led to the enactment of the Brucella Melitensis Order of 1940 which, among

other things, provides for the slaughter of cows in which this organism is found. In spite of its presence in the milk of infected cows, there is no evidence whatsoever that any infection of human beings, handling or drinking milk, has ever occurred.

Hares may be "Reservoirs" of Infection

Br. suis infection is found mainly in some European countries, in some Asian countries, often only in imported swine, and in parts of the Americas. Many countries are entirely free, doubtless either because no swine are imported or because very strict precautions are observed. In many of the infected countries the incidence of the infection is being reduced. A characteristic of the disease, at least in some European countries, is that outbreaks occur sporadically, without any apparent introduction of the infection into a swine breeding herd. In this connection, the infection has been found in hares and it is very likely that these animals act as reservoirs of the infection which gains entrance, periodically, to herds of swine.

Up to the present time, no satisfactory vaccine has been developed for the prevention of the disease. The only control method, admittedly not entirely satisfactory, is the diagnosis of the infected animals by the blood agglutination test and their removal from the herd and, preferably, slaughter and the careful disinfection of premises. Testing has to be continued until no further reactors are found. The boar must be included in the tests because of the part played by the male in the transmission and spread of the causal agent.