Brucellosis in pastoral and confined livestock: prevention and vaccination

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Summary
The traditional lifestyle and beliefs of pastoralists and small-scale farmers with confined livestock, together with certain farming environments, create favourable conditions for the spread and transmission of brucellosis. The risks associated with these practices are difficult to control because of a lack of alternatives and simple and/or affordable solutions. Brucellosis affects the health and productivity of livestock as well as that of their owners and caretakers and can have a deep economic impact. The control of brucellosis is likely to be cost effective. Good quantitative information on brucellosis in livestock and the human population is essential for demonstrating the benefits of intervention. Effective vaccines for the control of brucellosis in cattle and small ruminants are available and cheap, and in high-risk areas there is an urgent need to start large-scale vaccination programmes. Risks for the spread and transmission of brucellosis, such as the migration of herds with frequent contacts with other herds at common feeding grounds and near water sources, are inherent in the way of life of pastoralists. Such risks may need to be accepted when developing a control programme. Thus, the control of brucellosis by vaccination is expected to be more effective for confined livestock. Essential to the success of mass vaccination in controlling brucellosis is achieving a high degree of protection of adult livestock in a very short period and vaccinating young stock before natural infection can occur. To reduce the risk of transmission of infection from neighbouring areas where animals are not vaccinated, a region-wide approach is important. Because shepherds and farmers may have very little knowledge of infectious diseases and the consequences of infection, providing disease information and education is important to help them understand the need for control measures. Public health services can also assist in encouraging acceptance of control programmes in livestock by creating awareness of brucellosis as a human disease. To reduce costs, brucellosis control programmes can be combined with other veterinary or public health activities or interventions. An up-to-date livestock census and an effective surveillance system are crucial for the control of brucellosis, as the disease may quickly re-emerge from remaining foci of infection. Although test and slaughter may be an option for the management of remaining or re-emerging foci of infection, such a strategy is frequently not an option because of the cost.

Keywords
Traditional farming practices and the need for brucellosis control and prevention

Pastoralists are characterised by dependence on livestock, physical remoteness and a lack of education and of physical and social resources (5). Pastoralists raise their livestock on marginal land and are constantly or seasonally migrating in search of fodder and water. They often have no, or poor, access to medical, veterinary, educational, or other services, and live at the edge of a sustainable livelihood. Small-scale farmers keeping confined livestock share many of these characteristics, often working in poor hygienic conditions. As a consequence, they are equally vulnerable to pests and to a range of adverse conditions, including droughts and famine. In confined farming systems, livestock are kept in an outdoor, non-grazing area where animals are confined by means of fences or other structures, such as feedlots, paddocks, corrals, exercise yards, holding areas or hooped structures. This, however, does not safeguard the animals from infectious diseases, because animals are exchanged frequently. In many countries where major livestock diseases are endemic, including zoonoses such as brucellosis, the traditional livestock farmers constitute a significant segment of the population. Climate change threatens their habitats in a variety of ways that are likely to lead to further impacts on their livelihood. For that reason, measures to improve their health and their livestock’s health should be prioritised. By affecting the health of the human population, and the health and productivity of their livestock, brucellosis can significantly impair economic development. Control of brucellosis in the livestock of these pastoralist communities is challenging not only because of the number and complexity of risk factors involved, but also because these risk factors are tightly linked and often inherent to the farming practices. Migration and contact with other animals on common grazing grounds or at water sources form a major risk for transmission of brucellosis in pastoral livestock, but other factors such as poor farm hygiene, exchange of infected animals and contact with wildlife could also contribute. Traditional beliefs and practices may interfere with the acceptance of disease control measures and may be hard to change because of a lack of alternatives. All of these factors contribute to the spread of brucellosis and, when combined with the food habits and lifestyle of pastoralists, enhance transmission of brucellosis to the human population and make control of brucellosis in these communities challenging (9).

Control and prevention of brucellosis and the importance of surveillance

Mass vaccination is the mainstay of brucellosis control in livestock, but should be combined with other measures that limit the spread of the pathogen, allow identification of animals and herds, and increase community participation (Box 1). The efficacy of brucellosis control programmes depends on a range of factors. Before a control programme can be developed a situation analysis and needs assessment should be performed. A situation analysis is essential, as most endemic countries have little information on the prevalence of brucellosis, its geographical distribution, the major risk factors involved in transmission, and the knowledge, attitudes and practices (KAP) of farmers and livestock owners. The situation analysis should involve policy-makers and provide information on livestock numbers, legislation, resources and the capacity of veterinary and laboratory services. Based on the results of the situation analysis, a needs assessment and a risk analysis can be performed and used to design a vaccination programme, identify complementary measures, and determine human and financial resources that will be required. Solutions can then be developed to minimise the effects of major risks of transmission, such as a lack of human resources, the absence of a cold chain for vaccine storage or intense cross-border migration of unvaccinated animals. The greatest risk is most likely the introduction of infected animals through migration or trade from neighbouring non-vaccinated areas or countries. Unless strict measures can be taken to control trade and prevent introduction of potentially infected animals, it will be necessary to continue vaccinating susceptible animals. To minimise the risk of reintroduction from neighbouring unvaccinated areas a region-wide approach would be more beneficial.

Equally important to a well-designed control programme is the presence of an effective surveillance system (12). The surveillance system determines baseline prevalence, monitors the progress and effectiveness of the control programme, and is crucial for disease monitoring after the cessation of vaccination. Mass vaccination should minimise further spread of disease, but small foci may persist and post-vaccination surveillance is essential for their early detection. A quick resurgence of brucellosis has been seen in countries where a lack of resources, or the allocation of the limited resources to other livestock problems, leads to the ending of mass-vaccination programmes. The control of brucellosis by mass vaccination is considered to be cost effective and cost–benefit analysis may help to convince policy-makers of the need to control the disease and provide funds. Evidence is available that demonstrates that mass vaccination is
Control and prevention or eradication?

Tools for the control, prevention or eradication of brucellosis exist and eradication of bovine brucellosis has been achieved in several developed countries. However, eradication from small ruminants has never been achieved, and given the complexity and cost of eradication, the first priority in developing countries should be control and prevention. Eradication from livestock requires a high level of regulatory organisation including: ability to trace, test, identify, isolate and remove infected animals and herds with compensation of farmers for depopulated animals, and strict enforcement of movement and trade restrictions. Weaknesses in any of these aspects could severely reduce the chance of success. The priority in endemic countries should be control, prevention and disease surveillance.

Costs and benefits of brucellosis control

The expected positive impact on economic development should be an incentive for developing countries to implement prevention and control programmes. Vaccines for brucellosis are inexpensive and modelling based on a planned 10-year annual mass-vaccination campaign for the control of the disease in cattle and small ruminants in Mongolia has demonstrated their cost-effectiveness (17). However, sufficient quantitative information on the impact of brucellosis on public or livestock health, and associated economic costs, is lacking for countries where the disease is endemic. While the control of brucellosis in many countries may be complicated, it can be argued that benefits to human health and livestock productivity would outweigh the costs of control programmes; particularly if human and animal health sectors combine activities and share costs. The cost–benefit ratio of brucellosis control efforts could be improved by combining them with control efforts for other diseases.

Brucellosis surveillance

A properly designed and well-functioning surveillance system is one of the most important tools of a brucellosis control effort, and is required to determine the need for control measures, for monitoring progress, for quality assurance in assessing the efficacy of vaccination and level of protection, and, most importantly, for post-vaccination surveillance. The control of brucellosis requires different levels of effort depending on the epidemiological situation. For most endemic countries, there is a lack of detailed and recent information on brucellosis. Spread, prevalence and
Transmission of brucellosis may differ between areas, and may change in time due to introduction of infected herds or animals from other areas. Therefore, up-to-date quantitative epidemiological information obtained through a properly designed surveillance system is crucial when planning a brucellosis control programme. Accurate livestock census information is essential for the interpretation of epidemiological data and planning. To make optimal use of the collected information, a properly designed electronic data storage and analysis system is essential. The use of a geographical information system (GIS) could be useful for planning control actions, for monitoring progress, and for localisation of problematic areas during vaccination and post-control surveillance (4). Proper identification of herds and individual animals is essential during all stages of control programmes. Although ear notching is sufficient for the identification of vaccinated animals and determination of vaccination coverage, proper identification of individual animals could be important for investigating problematic areas and for tracing seropositive, sick, or infected animals. The identification of individual animals may help in identifying sources of outbreaks and for tracing illegally transported or sold animals. Disease surveillance for brucellosis is based on serological testing. All serological tests for brucellosis react with post-vaccination antibodies for the two most commonly used vaccines, *Brucella abortus* S19 and *B. melitensis* Rev.1. As post-vaccination antibodies may persist for a long time under certain conditions, this should be considered when monitoring seroprevalence rates as a measure of natural infection during and after vaccination. The specific factors that contribute to the persistence of antibodies after vaccination have not been precisely defined but may include age, sexual maturity and pregnancy. Therefore, proper planning and timing of vaccination campaigns is critical, especially when coping with year-round mating activity.

Not only is information on brucellosis in livestock important, but information on the presence of brucellosis in the human population can be decisive in setting up a brucellosis control programme. Information on the presence and impact of the disease in the human population is crucial for creating public awareness and convincing policy-makers to take action. However, the disease is notoriously misdiagnosed and underreported. Brucellosis is not a reportable disease in many countries. Public health services can be of assistance, especially during the early stages of a control programme, by increasing awareness of disease, acceptance of control programmes, and community participation. Simple means, such as point-of-care testing, use of mobile-telephone-based reporting, and automatic data entry into a central database, could simplify data collection and analysis (6). Knowledge of the number and spatial distribution of human cases can function as an indicator of programme success and a means of identifying problematic areas. Poor development of medical services might hamper the value and optimal use of information on human cases of brucellosis.

Central role for mass vaccination

Essential to the control of brucellosis are the effective and well-proven live attenuated vaccines, such as S19 for use in cattle and Rev.1 for use in sheep and goats, for which the optimal dose and preferred route of administration have been well established (1, 10). The various limitations of these vaccines include: interference with serology, abortifacient effect when used during pregnancy, virulence for humans, and shedding (of S19) in a small proportion of vaccinated animals, with risk of infection for veterinarians or farmers and when unpasteurised milk is ingested (2, 3). Also, these vaccines are heat-labile and therefore require specific logistics, storage and quality-control precautions when used in remote areas. The two vaccines have been effectively applied in combination with a variety of other complementary control measures, such as movement control and trade restrictions, in countries with well-organised veterinarian services and adequate budgets. A proven brucellosis vaccine for pigs is not available. The goal of vaccination is to achieve a high level of protection for all adult and young animals in a short period of time. The aim of vaccination programmes is to reach 100% coverage and to continue vaccination for at least the production cycle of the livestock. The recommended vaccination strategy consists of mass vaccination in the first year, followed by either entire flock vaccination every two years or annually (or biannually, depending on the breeding practice) in combination with vaccination of all newborns and any non-vaccinated adult animals/flocks (2). The alternative strategy – annual vaccination of all newborns – is not recommended, because complete vaccination and protection of all newborns before infection may occur under field conditions cannot be achieved and this approach would always leave a significant proportion of the population unprotected.

As a general rule, a control strategy based on mass vaccination is considered to be effective at low to medium (5% to 10%) animal or herd prevalence rates. Depending on the species and breeding system, 6 to 12 years of regular annual or biannual vaccination are required. Vaccination should be carefully planned with respect to periods of migration, and follow-up vaccinations may need to be planned for unvaccinated females that were pregnant at the time of vaccination. The timing of vaccination of young stock is equally important: they should be vaccinated before sexual maturity in order to reduce the length of the period that they are unprotected and susceptible to infection. Biannual vaccination of young stock may be required especially in cases of year-round breeding. At lower prevalence rates, or when a significant portion of the livestock population has been vaccinated and protected, introduction of test and slaughter is recommended, either alone or combined with continued vaccination of young replacement animals.
depending on disease prevalence. A rapidly effective vaccination strategy for brucellosis control in areas with high prevalence has not been identified, although a test-and-slaughter strategy, as used for resolving isolated foci of brucellosis or herds with a high disease prevalence, has been recommended. Financially, this option is unattractive and unlikely to be feasible in resource-poor countries; moreover, uninfected and vaccinated replacement animals may not be available. There is a need for well-designed research trials to determine the efficacy of vaccines under field conditions with high disease prevalence.

Most successful use of Rev.1 and S19 vaccines to control brucellosis has occurred in developed countries. Much less information is available regarding the use of these vaccines in traditional pastoral and confined livestock systems in resource-poor countries. However, there is ample evidence that, provided a strong commitment is made and sufficient resources are available, a significant reduction in the prevalence of brucellosis can be achieved under these less than ideal farming conditions. A recent pilot study in Tajikistan demonstrated a strong reduction in seroprevalence of brucellosis in sheep and goats after several biannual rounds of Rev.1 vaccination (16). Importantly, extra efforts may need to be made to manage issues such as:
- access to reliable livestock census information
- livestock identification
- procurement
- appropriate distribution
- storage of effective vaccines, with relevant quality assurance procedures to ensure viability
- use of a standardised system for monitoring seroprevalence
- vaccination coverage.

In addition, disease education sessions to increase understanding and acceptance of control measures, provide specific disease information, explain risks associated with transmission and highlight specific measures to minimise the further spread or re-emergence of the disease should be provided. Education could also cover the safe disposal of potentially infectious animal materials and restrictions in trade or exchange of infected and/or untested animals. It may not be feasible to investigate the impact of other major risk factors, such as migration of animals and contact at common feeding grounds or water sources. Contact between herds enhances the risk for spread of brucellosis, and hence, pastoralism inherently constitutes a risk factor for brucellosis. For these reasons, control of brucellosis in pastoral livestock could be more complex and require more time and resources than control in confined livestock. As contact with livestock from uncontrolled areas is a risk factor for re-emergence of the disease, a country or region-wide approach, whereby the programme is instigated in all high-risk areas, would be particularly beneficial. Separation of seropositive animals and the use of fencing systems to prevent contact with wildlife could be options for farmers with confined livestock. However, preventing contact between pastoral livestock and wildlife may be difficult to achieve unless specific zones for each are established and enforced.

A key question that remains is when vaccination can be phased out. No definite answer can be given as this depends on vaccination coverage, the presence and effectiveness of other complementary measures, and, most importantly, the presence of an effective post-vaccination plan. Proper monitoring of vaccination coverage and livestock movements will be required to quickly respond to any sign indicating reappearance of the infection. Premature termination of vaccination has been a common cause of failure in brucellosis control programmes and can result in a rapid re-emergence of the disease. Mathematical modelling may help in setting an acceptable end point for vaccination. Mathematical modelling may also help to determine the effectiveness of (combinations of) different control measures under different levels of available resources (13). For instance, modelling has indicated that, in areas in which sedentary herds are in close contact with transhumance herds, targeting both herd types is essential for optimal effects.

**Complementary measures**

Measures that complement vaccination include tracking of animals, movement control and separation, test and slaughter, and wildlife control. Tracking vaccinated animals is essential for determining population coverage and identifying non-vaccinated herds or non-vaccinated animals in vaccinated herds. Although a simple identification method such as an ear punch might be sufficient for vaccinates it does not allow identification of individual animals, which is preferable when tracing sources of infection, or controlling trade and livestock movement.

Movement control and separation are crucial in the final stages of a control programme and to control disease outbreaks. Movement and mixing of herds and species are probably the main risks for transmission of brucellosis in pastoral communities since nomadic lifestyles require movement of herds to suitable water sources and pastures and risk may not be avoidable. Regional and trans-border migration might pose an even greater risk, in particular, movement of cattle from uncontrolled areas. Animals are often moved from areas with low market value to areas of higher prices for trade and slaughter purposes. These movements often include older and weaker animals that may have an increased risk for being infected with brucellosis. The sale of animals along the trade route and
contact with local herds can contribute to the spread of infection. Knowledge of such practices may be obtained through KAP studies (8). Separation of infected animals can help to contain the disease at farms with confined livestock. Given the high infectivity of the pathogen, other additional measures, such as farm sanitation and waste water containment, are essential in making separation practices effective in preventing disease transmission.

Once sufficient rounds of vaccination have been completed, and sufficient time has elapsed to minimise false-positive test results related to vaccine titres, test-and-slaughter procedures may be applied to eliminate any remaining loci of infection. Test-and-slaughter procedures may also be applied in low prevalence areas or to control an outbreak of infection. Test and slaughter requires high-quality serological testing procedures; detailed administration and sufficient logistics to identify herds and individual animals; and appropriate support to trace, identify, remove and slaughter seropositive animals. A test-and-slaughter approach also requires commitment of financial resources both for testing and for reimbursing/compensating farmers for slaughtered animals. For these reasons, test and slaughter is not a realistic solution in resource-poor countries with limited financial means, inadequate logistical resources, insufficient diagnostic capacity and not enough slaughter facilities. Test and slaughter can be ruled out as an alternative to vaccination for controlling brucellosis in resource-poor countries. If remaining foci of infection cannot be effectively eliminated, disease surveillance and management of these foci by mass vaccination and isolation becomes important. A test-and-slaughter strategy with reimbursement or replacement may be appropriate for confined livestock with a low prevalence of brucellosis. Replacement animals should be certified free of brucellosis and other pathogens, but limited availability and replacement costs will likely make this option unfeasible.

In order to be able to deliver appropriate information adequately, a good understanding of the current knowledge, concerns and practices of the affected human population is required (8). This information may be obtained by using questionnaires in combination with direct observations of farming practices, with specific attention being paid to identification of risk factors. Such information is best gathered in collaboration with local officials and other respected individuals, tribal heads, local veterinarians and public health workers. Their involvement will also be beneficial when providing disease information to the public and implementing control measures in livestock.

**Farm sanitation and food hygiene**

Raw milk and direct contact with infected animals and animal materials and fluids are the major risks for transmission of brucellosis to the human population. Pasteurisation of milk and use of protective clothing when dealing with infected animals (e.g. when assisting with lambing or handling abortion materials) are highly recommended but may be very difficult to implement under field situations because of a lack of proper supplies or because of traditional beliefs and practices. In general, measures to improve hygiene and sanitation are not popular. Measures to improve milk pasteurisation and farm sanitation are particularly valuable in protecting the human population in areas of high prevalence or where implementation of vaccination or other veterinary measures is cumbersome. The presence of an informal milk distribution circuit may increase the problem. Educating farmers and consumers about the disease can be beneficial, and the development of small milk pasteurisation plants at selected central locations should be considered.
Other complicating factors

Under certain conditions, wildlife can function as reservoirs for brucellosis. The establishment of specific wildlife-free or restricted zones may help to prevent contact with livestock and transmission of disease. The need for herd migration is often dictated by the availability of water and feeding areas, and is a custom deeply rooted in pastoralist life. Wildlife-free zones may restrict movement of livestock and establishment of these zones requires careful planning. While wildlife can function as a reservoir for infection, the influence of wildlife reservoirs on disease in livestock may be minor if prevalence in livestock is high. The control of brucellosis in livestock could result in a reduction of brucellosis in wildlife. In addition, predators and natural resistance of wildlife to disease may limit the importance of wildlife as a reservoir of infection. Also, wildlife species may not be as functionally effective as maintenance hosts or as able to transmit brucellosis (15).

Cross-species transmission might be a problem in mixed herding areas. Brucella abortus has been isolated from species other than cattle, including sheep, and the finding of B. melitensis in cattle has demonstrated the susceptibility of cattle for this species of Brucella. Isolation of B. melitensis from bovine milk and vaginal secretions indicates that the microbe can be transmitted by infected cattle. The prevalence of B. melitensis in cattle, and the importance of cattle in the transmission of this pathogen, has not been studied in much detail. In addition, the efficacy of vaccination against B. melitensis infections in cattle has not been investigated. Although Rev.1 vaccination of cattle is currently not recommended and may involve some risk, use of this vaccine in cattle might be effective against B. melitensis. Mixed herding, which includes mixing livestock with camelids, is become increasingly common among pastoralists in an effort to cope with changing environmental conditions. It is imperative to know the species of Brucella present in infected mixed herds before vaccination is initiated. In camelids, S19 and Rev.1 vaccines remain unproven and sufficient data are not currently available to demonstrate that camelids function as maintenance hosts. If camelids are truly spill-over hosts, control measures other than vaccination should be instigated. Field studies could include evaluation of the importance of wildlife reservoirs and cross-species transmission.

Benefits of combined veterinary activities and medical services

Brucellosis is frequently a neglected disease and is not a high priority among livestock diseases in most endemic countries (7). Although awareness can be created by reporting human cases, brucellosis is frequently not a priority for the medical community and is not included in the curriculum of medical students. As a consequence, medical staff working at remote healthcare centres serving tribal communities that almost exclusively consume fresh unpasteurised milk may not be aware of the risk of brucellosis infection (11). Providing training, diagnostic tests, and therapeutics will strengthen the medical service response to brucellosis and improve treatment outcome (6). Identification of cases of human brucellosis provides epidemiological information that justifies the development of a brucellosis control programme in livestock. Basic medical services can help engender public trust and, if they provide the public with information on the disease, they can considerably improve the efficacy of a disease control programme by enhancing understanding, cooperation and adherence. For these reasons, involvement of the medical services can result in reductions in cost which may be greatest in hard-to-reach communities, such as pastoralists (14). The successful treatment of human cases may increase visibility of the disease within the community and increase appreciation of the beneficial impact of the control programme in reducing abortions in their livestock, even if noticeable results are not visible until well after it has started.

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La brucellose dans les systèmes d’élevage pastoral et confiné : prévention et vaccination

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Résumé
Les croyances et les traditions associées au pastoralisme et aux élevages familiaux confinés créent des conditions propices à la propagation et à la transmission de la brucellose, de même que certaines caractéristiques environnementales de ces élevages. Les risques associés à ces pratiques sont difficiles à maîtriser car il n’existe pas vraiment d’alternatives ni de solutions simples et abordables. La brucellose affecte la santé et la productivité des animaux d’élevage ainsi que celles de leurs propriétaires et des personnes qui s’occupent des troupeaux, avec des conséquences économiques extrêmement graves. Le coût de la lutte contre la brucellose est probablement très élevé. Il est essentiel de disposer d’informations quantitatives solides sur la situation de la maladie chez les animaux d’élevage et chez l’homme afin de pouvoir démontrer les bénéfices attendus d’une intervention. Des vaccins peu onéreux permettent de lutter efficacement contre la brucellose chez les bovins et les petits ruminants. Il est donc possible de lancer sans attendre des programmes de vaccination à grande échelle afin de couvrir les zones à haut risque. Certaines caractéristiques inhérentes au mode de vie pastoral, par exemple la migration des troupeaux et leurs contacts fréquents avec d’autres troupeaux dans les zones communes de pâturage ou à proximité des points d’eau sont autant de facteurs de risque de propagation et de transmission de la brucellose. L’existence probablement inévitable de ces risques doit être prise en compte au moment de concevoir les programmes de lutte. Ainsi, on peut s’attendre à ce que la vaccination soit plus efficace dans les systèmes d’élevage confiné. La réussite d’une campagne de vaccination massive des animaux d’élevage contre la brucellose passe par l’immunisation aussi rapide que possible d’une proportion aussi large que possible de la population adulte, et par la vaccination des jeunes avant qu’ils ne soient naturellement exposés à la bactérie. Il est important également de développer une stratégie régionale afin de réduire le risque de transmission à partir de zones adjacentes ne pratiquant pas la vaccination. Les éleveurs et les bergers connaissent mal les maladies infectieuses et leurs conséquences, et doivent donc être informés et sensibilisés sur le sujet afin de percevoir l’importance des mesures de lutte. Les services de santé publique peuvent également améliorer la manière dont les programmes de lutte sont perçus dans les élevages en expliquant que la brucellose est aussi une maladie humaine. Afin de réduire les coûts, les programmes de lutte contre la brucellose peuvent être conduits dans la foulée d’autres activités ou interventions de santé animale ou publique. Il est très important que les effectifs des cheptels soient connus et qu’un système efficace de surveillance de la brucellose soit en place, car le risque d’une réémergence rapide de la maladie à partir de foyers résiduels d’infection est important. Bien que le dépistage et l’abattage sanitaire des animaux infectés apportent une solution au problème des foyers résiduels ou ré-émergents, il s’agit d’une stratégie rarement adoptée en raison de son coût élevé.

Mots-clés
Brucelosis en el ganado pastoreado o estabulado: prevención y vacunación

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Resumen
Las creencias y modos de vida tradicionales de los pastores y los pequeños granjeros que tienen ganado estabulado, junto con ciertas condiciones de producción, crean condiciones propicias a la propagación y transmisión de la brucelosis. Los riesgos ligados a tales prácticas son difíciles de controlar debido a la falta de alternativas y de soluciones sencillas y/o asequibles. La brucelosis, que afecta a la salud y la productividad tanto del ganado como de sus propietarios y cuidadores, puede tener profundos efectos económicos, por lo que seguramente el control de la enfermedad resulta rentable. Para demostrar los beneficios que pueden derivarse de medidas en este sentido es imprescindible contar con buena información cuantitativa sobre la brucelosis en el ganado y la población humana. Existen vacunas eficaces y baratas para combatir la brucelosis en los vacunos y pequeños rumiantes, y en zonas de alto riesgo es urgente poner en marcha programas de vacunación a gran escala. Hay factores de riesgo de propagación y transmisión de la brucelosis, como las migraciones de los rebaños, con frecuente contacto con otros rebaños en los pastos comunes o cerca de puntos de agua, que son inherentes al modo de vida pastoral, y quizá sea preciso aceptarlos a la hora de elaborar un programa de lucha. Es de prever, por consiguiente, que la lucha antibrucélica por vacunación resulte más eficaz en el ganado estabulado. Para que las vacunaciones masivas den buenos resultados contra la brucelosis es esencial lograr un elevado grado de protección del ganado adulto en un lapso de tiempo muy breve y vacunar a los ejemplares jóvenes antes de que pueda producirse la infección natural. Asimismo, con objeto de reducir el riesgo de transmisión desde zonas aledañas en las que pueda haber animales no vacunados, resulta importante abordar el control de la infección a escala regional. Dado que los pastores y granjeros saben a veces muy poco sobre las enfermedades infecciosas y sus consecuencias, es igualmente importante proporcionarles información e instrucción para ayudarles a entender la necesidad de las medidas de lucha. Los servicios de salud pública también pueden favorecer la aceptación de los programas de control explicando a los propietarios del ganado que la brucelosis también afecta al hombre. A fin de reducir costos es posible combinar los programas de lucha antibrucélica con otras actividades o intervenciones de salud pública veterinaria. Para combatir la brucelosis es esencial disponer de un censo ganadero actualizado y de un sistema eficaz de vigilancia, pues la enfermedad puede resurgir con rapidez a partir de los focos de infección remanentes. Aunque la realización de pruebas de detección y de sacrificios sanitarios es una posible vía para luchar contra los focos de infección remanentes o reemergentes, a menudo su elevado costo imposibilita tal estrategia.

Palabras clave
References


