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Livestock pathology in the central African region: some epidemiological considerations and control strategies

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Abstract

Disease consistently features among the major constraints of livestock production in the central African region, orchestrating important economic losses. This article reviews livestock diseases of economic importance, including foot-and-mouth disease, trypanosomosis and dermatophilosis in cattle, *peste des petits ruminants* and gastrointestinal helminthosis in sheep and goats, and Newcastle disease in poultry. Some aspects of epidemiology such as pathogen identification, prevalence and risk factors are examined in the light of research findings in the region. Control tools such as vaccines, chemotherapeutic or prophylactic agents, and protocols developed for their efficient use are also reviewed. Constraints to the effective use of these tools have been identified as mostly due to institutional insufficiencies and measures for improvement have been proposed. These include the promotion of private professional veterinary services endowed with greater responsibility in animal health care, creation and promotion of community-based animal health care units in areas of marginal professional coverage, and adoption of a regional approach to the control of diseases of economic importance.

Keywords: animal health, epidemiology, disease control, livestock, central Africa

Introduction

Livestock plays an important socio-economic role in the lives of rural people at the micro-level and of the entire population at large in the semi-arid and sub-humid regions of sub-Saharan Africa. Livestock systems are evolving rapidly as a result of a changing environment, from extensive nomadic and transhumant to semi-sedentary and fully sedentary systems integrated with cropping. de Leeuw *et al.* (1995) stressed that relevant and adequate information is essential for decision-making aimed at optimizing the performance of these systems. In a review of the state of veterinary epidemiology, James (2005) noted that acquisition and availability of such information remain the principal constraint to the application of available epidemiological techniques in disease monitoring and control. Meanwhile disease has consistently featured among the major constraints of livestock production in the region (Awa *et al.*, 2004; Thys *et al.*, 2005). An estimated 10 million km^2 of land in the humid and sub-humid regions of sub-Saharan Africa are tsetse infested (Van den Bossche and Chigoma, 2001) and about 30% of cattle in the region graze on the fringes of infested zones (Black *et al.*, 2001). Direct losses through infections and indirect losses arising from the unsuitability of tsetse-infested areas to livestock rearing in sub-Saharan Africa were estimated at US$5 million per year (ILRAD, 1994). Pathologies of similar economic importance include dermatophilosis and foot-and-mouth disease in cattle (Achukwi and Saliki, 1990; Awa *et al.*, 2004, 2008a, b; Sow *et al.*, 2005) *peste des petits ruminants* and gastrointestinal helminthosis (Ndamukong *et al.*, 1989; Awa *et al.*, 2002; Njoya *et al.*, 2005a) and Newcastle disease (ND) in poultry (Maho *et al.*, 2004; Mopaté and Maho, 2005; Awa *et al.*, 2008a, b).

Meanwhile, measures taken to reduce disease prevalence in most countries of the region have often not been effective because of several factors including difficulties

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in the control of animal movement, inability of government to put in place sustainable disease monitoring and control operations, and, more importantly, the lack of good organization of the animal health sector and the services it offers. During the last two decades in the central African region, animal health care shifted from state monopoly to shared responsibility with veterinarians in private practice. Most of the latter however have not been able to establish successful practices because of several reasons, including the lack of initial investment capital, the intrusion of charlatans into the profession, and restrictions on their service mandate by the state.

The objective of this paper was to review and update information on animal health and health management, which is useful in the identification of new constraints as a first step towards definition of research and development priority.

Information sources

This review is principally based on research carried out in the sub-humid and semi-arid savannah zones of the central African states of Cameroon, Chad and the Central African Republic (CAR) either in the framework of national research programmes, projects initiated by individual researchers or regional projects such as Projet Régional de Recherche sur les Petits Ruminants (PRRPR) involving Cameroon, Chad and Niger, Pôle Régional de Recherche Appliquée au Développement des Savanes d'Afrique Centrale (PRASAC) involving Cameroon, Chad and the CAR, and *Projet Garoua* in Cameroon. Data were generated through surveys, observational studies and experimentation and cover a period of about two decades from the late 1980s. In a few cases, unpublished findings from the authors' note books have been exploited. Aspects of livestock pathology investigated include disease epidemiology (pathogen identification, disease quantification and identification of risk factors), development and tests of treatment and control methods as well as analysis of existing animal health care delivery systems. The principal livestock species involved were cattle, small ruminants (sheep and goats) and poultry.

Bovine pathology (microbial and parasitic diseases)

Endemic bacterial diseases of cattle in the region such as pasteurellosis, black quarter, anthrax and contagious bovine pleuropneumonia are generally kept under reasonable control through annual vaccination campaigns and therefore epidemic outbreaks are rare. For pasteurellosis, there is need to reformulate the vaccine following the identification of the B6 serotype of *Pasteurella multocida* (Njongmeta *et al*., 2001) not yet incorporated into the current vaccine. No vaccination is done against viral diseases ever since rinderpest vaccination was stopped almost a decade ago in Cameroon as a first step towards declaring the country free of the disease. The rinderpest situation is similar in Chad but in the CAR, outbreaks are still reported along its borders with Sudan.

Unlike those for which vaccines are routinely administered, cattle diseases of primary economic importance in the region are foot-and-mouth disease (FMD), trypanosomosis and dermatophilosis (Awa *et al*., 2004, 2008a; Bayemi *et al*., 2005; Achukwi and Musongong, 2009).

FMD

FMD is a highly contagious viral disease of even-toed ungulates caused by a virus of the genus *Aphthovirus* and the family *Picornviridae* (King, 2000). It is endemic in Africa, causing economic losses in cattle through calf mortality, drop in milk production, loss in weight gain and loss of draught value (Abel *et al*., 1992; Awa *et al*., 2006). Seven known serotypes of the virus exist and antibodies from one serotype do not cross-protect against another. For this reason up to four outbreaks per year may be reported in the same herds in this region. A seroneutralization test against the seven serotypes on serum obtained from cattle recovering from natural infection in north Cameroon (Tanya, 1985) gave strongly positive results for types A, Asia 1, Sat1 and Sat3 and weakly positive for types O, C and Sat2. Although the author wondered if the weak positive results were due to cross reactions, he concluded that the existence of all the serotypes in the region was very likely. Four years later, the National Veterinary Laboratory (LANAVET) of Cameroon detected a high titer of antibodies against type O by an unspecified serological test in samples from infected cattle from the same area of the previous study. Meanwhile the same laboratory had earlier confirmed the presence of antibodies against types A, O, Sat1, Sat2 and Sat3 from the North West Province of Cameroon. Ekue *et al*. (1990) indicated that types A and O are prevalent in the high plateaus of the west and the Adamawa regions of Cameroon. Recently, more accurate molecular tools permitted in-depth studies of FMD in the Adamawa region of north Cameroon, confirming the existence of types O, A and Sat 2, with an average clinical prevalence over 12 months of 60% (Bronsvoort *et al*., 2004a, b). The authors concluded that the high level of endemicity and the potential for disease spread present a significant challenge for control and eradication.

Trypanosomosis

In the central African region, bovine trypanosomosis caused by both *Trypanosoma vivax* and *Trypanosoma congolense* is prevalent in areas where rainfall is above 1000 mm (Awa *et al*., 2004). In such areas, it is considered

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the most important cattle disease. Prevalence of trypanosomosis determined through detectable parasitemia varies from 7% in areas of low vector density to up to 50% in high vector density areas. Achukwi and Musongong (2009) reported a 14.3% prevalence in *Bos indicus* and *Bos taurus* cattle in one such area, the Faro Division of North Cameroon. High prevalence areas are thus not suitable for permanent cattle rearing but are frequented in the dry season by transhumant herds in search of food and water. During such periods, though the vector population is reduced, the disease threat remains and herd owners recognize the importance of treating their animals with trypanocides on return from transhumance (Awa *et al*., 2006). The tsetse eradication campaigns in north Cameroon that went on for more than a decade ended in 1994 without achieving much success. Investigations in that project area 10 years later revealed tsetse re-infestation and accompanying high prevalence of trypanosomosis in cattle (Achukwi, 2004).

Losses in production due to trypanosomosis have been well documented. Rowlands *et al*. (1999) found that there was a decrease of 57% in calf mortality and an increase of 8% in adult male body weight of cattle in a farm where trypanocide use and vector control were instituted over a period of 10 years in the Ethiopian highland region. In the tsetse zone of the Benue valley of north Cameroon, a mean weight difference of 49 kg was observed between treated and untreated zebu cattle over 4 months during peak vector activity (Awa and Ndamkou, 2006).

Dermatophilosis

Bovine dermatophilosis caused by *Dermatophilus congolensis* occurs worldwide but is of particular importance in the warm humid tropics with high prevalence and associated economic losses (Faibra, 1989; Hermeso de Mendosa *et al*., 1994; Chitikobo *et al*., 2004). Studies in Cameroon indicated that the disease is an important cause of production losses and placed as the third most important cause of milk loss in zebu/exotic cross dairy cattle (Mbah, 1982; Tanya and Salah, 1985; Bayemi *et al*., 2005). Observations in Ngaoundere, Cameroon, indicate that high prevalence rates are associated with inadequacies in livestock production systems (especially with respect to tick control) even with local zebu breeds. Under such situations prevalence may be above 50% in hybrid dairy animals (Achukwi, unpublished data). Success has been recorded in the northwest region of Cameroon in dairy farms involving European hybrids with local zebu cattle, thanks to the strict tick control and other husbandry protocols. Losses due to the disease in a high prevalence herd scaled to 100 heads of cattle in terms of loss in milk production and skin value in north Cameroon were estimated at over 1.7 million francs annually (Awa *et al*., 2009).

Farmers in the central African region identify dermatophilosis as an important endemic condition with a herd prevalence of >90% (Awa *et al*., 2004, 2008a). Prevalence at the individual animal level of 1.8% is on a decrease in southern Chad compared to 10–40% reported by Faibra in 1989. However, it is worth noting that survey data may underestimate prevalence, given that culling due to the disease is common as more cases are found in cattle markets and slaughter houses. Recent studies (Awa *et al*., 2009) revealed an incidence of 32% within 3 months in research zebu cattle in north Cameroon, giving an indication of a higher prevalence than previously reported (CZR, 1988).

It has been widely documented that temperate cattle breeds and their crosses with the tropical zebu are more susceptible to dermatophilosis than pure zebus. Recent studies have also revealed that clinical prevalence is higher in sedentary than in transhumant zebu herds (Awa *et al*., 2009), explained by factors related to the different livestock systems. Sedentary herds tend to have closer animal-to-animal contact which favors pathogen transmission (Woldemeskel and Taye, 2002). Furthermore, intensive practices common to sedentary herds such as permanent grazing space and night enclosures favor the concentration of pathogens and their vectors.

The association of dermatophilosis with infestation by the tick *Amblyomma variegatum* has been extensively documented (Stachurski, 1993; Camus and Barre, 1995; Molia *et al*., 2008) and livestock owners in this region are aware of this and place a lot of importance on tick control as a preventive measure.

Small ruminant pathology

Peste des petits ruminants (PPR) and gastrointestinal helminthosis have been identified as the most important diseases of sheep and goats in the region and are responsible for high mortalities (Martrenchar *et al*., 1997a; Njoya *et al*., 1997).

PPR

PPR caused by a paramyxovirus is an important disease of small ruminants, and is widely distributed in the sub-Saharan belt of Africa (Roeder *et al*., 1994). It is considered as the primary cause of small ruminant mortality in the region. Epidemics occur annually during particular periods of the year that vary slightly from one area to another. Flock mortalities are generally above 50% and sometimes even higher than 80% (Idriss *et al*., 1989; Saliki *et al*., 1989; Awa and Ngo Tama, 1997). Goats are generally more susceptible than sheep and dwarf goats are more susceptible than the Sahel breed according to the findings of Idriss *et al*. (1989). Epidemics occur mainly during the cold dry period from November to January

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according to farmer reports in the savannah region of central Africa.

Bacterial pathogens of importance that could complicate the epizootiology of respiratory pathology of small ruminants are *P. multocida* and *Mycoplasma* spp. Martrenchar *et al.* (1995) identified several serotypes of *P. multocida* and considered them to play a significant role in the respiratory tract pathology of small ruminants. Although they also isolated *Mycoplasma mycoides* subsp. *mycoides* and *Mycoplasma ovipneumoniae* from apparently healthy animals, no clinical case has been recorded.

Gastrointestinal helminthosis

Nematodes and cestodes in the gastrointestinal tract of sheep and goats have been shown to contribute significantly to high mortality (Ndamukong *et al.*, 1986, 1989; Awa and Njoya, 1997). Post mortem examination conducted on sheep that died at the IRAD Garoua research station in 1994 revealed the presence of the nematodes *Haemonchus contortus*, *Trichostrongylus colubriformis*, *Oesophagostomum columbianum*, *Gaigeria pachyscelis*, *Bunostomum trigonocephalum* and *Trichuris glubolusa*, and the cestode *Moniezia expenza*. Up to 75% of mortalities were attributed to helminth infections, particularly hemonchosis and monieziosis. There was evidence of resistance of *H. contortus* to benzimidazoles. In farmers' flocks, diarrhea is a frequent disease symptom observed throughout the rainy season and is often associated with helminth infections.

Poultry pathology

Avian pathology as a constraint to poultry production is not a peculiarity of this region but a continent-wide problem. ND features as the most important health problem (Mopaté and Idriss, 2001; Alabi and Isah, 2002; Maho *et al.*, 2004; Awa *et al.*, 2004, 2008b; Mopaté and Maho, 2005) particularly in traditional poultry where vaccination is not routinely done. In the semi-arid and arid regions of Cameroon and Chad, two epidemic periods have been noted: the first peak during the intense heat of March and April and the second in the cold dry months of December and January, causing mortality that varies from 70 to 100% (Awa and Ngo Tama, 1997; Maho *et al.*, 2004; Mopaté and Maho, 2005; Awa *et al.*, 2008a, b). The role of Gumboro disease in traditional poultry at present seems to be ill-defined but its importance in intensive production units has been underscored (Alabi and Isah, 2002).

Factors that favor high disease prevalence and epidemics include poor access to veterinary services and medication, poor housing (Swatson *et al.*, 2001; Awa *et al.*, 2006) and dissemination through gifts and sales of exposed birds during outbreaks (Maho *et al.*, 2004; Nzietchueng *et al.*, 2007).

Pig pathology

In the central African region, pig pathology of economic importance consists of hemorrhagic diseases such as erysipelas and more importantly African swine fever (ASF). These conditions are, however, limited to the humid regions of the south where epidemics are frequent, orchestrating enormous economic losses (Ekue and Tanya, 1985). Genetic characterization of the Cameroon isolate of the ASF virus through restriction enzyme analysis revealed the viral genome was quite stable in pig-to-pig transmission and similar to that from other regions of Africa, notably Angola, Democratic Republic of Congo and Senegal (Ekue and Wilkinson, 1999a, b, c, 2000). A serological survey in the semi-arid North and Far North Provinces of Cameroon (Awa *et al.*, 1999) revealed the absence of ASF antibodies. This finding coupled with the fact that no outbreak has ever been reported led the authors to the conclusion that the region was free of the virus.

Although pig production in the savannah region is not economically constrained by pathological causes, it is associated with pathogens that pose a risk to public health. Prevalences of 33% for tuberculous lesions and of 12% for the human tape worm *Taenia solium* cysts were recorded in slaughtered pigs in Garoua (Awa *et al.*, 1999). In a recent study, Mopaté *et al.* (2009) employing a less sensitive technique of oral examination of live pigs recorded prevalence of 10% in Pala (South Chad) and 6.4% in Garoua. This condition is favored by the prevailing practices where pigs roam freely and easily gain access to pathogens in human wastes.

Control and prevention strategies

Disease control and prevention strategies include prophylactic treatments to keep endemic conditions at acceptably low levels, immunization of animals through vaccinations, elimination or evasion of disease vectors and adopting livestock practices that minimize the risk of exposure.

Farmer solutions

The presence of both state and private veterinary services on the field in the region is largely insufficient. Therefore in most cases the farmers take the initiative to manage the health of their animals. A study of veterinary inputs and services in Cameroon, Chad and CAR (Hamat Mal-Mal *et al.* 2009) revealed that practically all livestock owners rely on modern drugs for treatment and prophylaxis, with 20–30% combining this with traditional remedies. Cattle are privileged for treatment while sick small ruminants and poultry are more often salvaged for consumption. The majority of farmers buy drugs from the village

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markets and it is difficult to evaluate their quality since both veterinarians in private practice and quack drug dealers frequent the same markets.

The most commonly used drugs are trypanocides and antibiotics. Anthelmintics are used to a lesser extent. Unlike trypanocides on which farmers seem to be well informed about dosing, antibiotics are administered in sub-normal doses in virtually all cases (Awa *et al*., 2009). Although Miller *et al*. (2006) indicate that there is evidence of substantial gains in productivity from the use of antimicrobials by farmers, possible development of multiple resistances as a result of underdosing and the use of inappropriate antimicrobial agents is a cause for concern.

Traditional pharmaceutical agents are primarily of plant origin (salts derived from plant ashes, extracts from barks and leaves of trees) but the range is wide and includes unusual substances like cow's milk injections for the treatment of lumpy skin disease and animal urine and donkey feces against FMD. Medicinal plants in common use include *Khaya senegalensis*, *Vitellaria paradoxa* and *Acacia albida*. The most targeted diseases are trypanosomosis and FMD. The practice of traditional pharmacopoeia is more common among the traditional Fulani cattle rearers. Schillhorn van Veen (2005) asserts that although abuse and quackery exist in the practice of ethnoveterinary medicine, the practice seems to make sense in areas without adequate veterinary services and its acknowledgment empowers the farmers to solve their herd health problems more cost-effectively.

Role of state and private animal health services

National ministries of livestock in the region for a long time enjoyed an exclusive mandate of administering veterinary services to farmers until the early 1990s when the veterinary profession was liberalized and those in private practice permitted to share in this responsibility. In most cases, the mandate of the private veterinarians has been limited to clinical operations and drug sales while mass vaccination campaigns and major disease surveillance and interventions remain the exclusive responsibility of state veterinary services. Activities in this domain are directly under the ministries of livestock in Chad and Cameroon but in CAR, the responsibility has been given to a special organization l'Agence Nationale du Développement de l'Elevage (ANDE), affiliated to the livestock ministry (Hamat Mal-Mal *et al*. 2009).

Farmers complain that the presence of state veterinary services is felt only during cattle vaccination campaigns that take place usually once a year except in cases of emergency. The private veterinarians see their exclusion from vaccination campaigns as a major setback to their progress. Veterinary centers, often located too far away from farmers, offer minimal clinical and pharmaceutical services since private veterinary clinics are expected to assume a greater part of the responsibility. An elaborate coverage on state and private animal health services in the region is provided by Hamat Mal-Mal *et al*. (2009).

Research contributions to animal health improvement in the region

Effective disease management and prevention requires proper identification of disease etiologies and factors influencing their occurrence. Strategies are then developed either targeted directly at the cause or at the factors with the aim of reducing disease frequency. Identification of pathogens was covered under the different diseases treated above. In this light, one of the objectives of the works of Tanya *et al*. (1987) and Ekue *et al*. (1990) on FMD was to look at the possibility of proposing the production of an appropriate vaccine depending on the serotypes of the virus found in Cameroon. The results obtained indicate that this objective is difficult to attain since all seven known serotypes exist in the region. Polyvalent vaccines exist, for example a quadrivalent vaccine against serotypes Sat1, Sat2, O and A in Malawi but it may not be easy to produce a vaccine that will protect against seven serotypes. FMD control in this region thus remains a problem aggravated by extensive livestock mobility, an inalienable aspect of the predominantly traditional livestock production system.

Unlike for FMD, there have been considerable advances in the control of PPR through vaccination. Up to the late 1990s, vaccination against PPR in the region was done using the bovine tissue culture rinderpest vaccine (TCRV) (Martrenchar *et al*., 1997b; Njoya *et al*., 1997). This vaccine was withdrawn from use progressively as a step towards the eradication of rinderpest from the region. It thus became necessary to develop a specific vaccine against PPR. The joint efforts of CIRAD and LANAVET led to the production of Capripestovax, specific for PPR (Diallo *et al*., 1989; Martrenchar *et al*., 1997b, 1999). Studies have been conducted to evaluate the efficacy of the vaccine and to define conditions of use that will provide optimal results. Martrenchar *et al*. (1997b) found that the vaccine was efficacious at doses as low as $10^{0.8}$ $TCID_{50}$ in protecting animals against experimental infections.

The immune response of *Fulbe* sheep and *Kirdi* goats of north Cameroon to vaccination with Capripestovax was investigated by Awa *et al*. (2002). They found that pre-vaccination antibody prevalence in animals that were last vaccinated 3 years before with TCRV was 29 and 44% in sheep and goats, respectively. Antibody seroprevalence rose to 100% after vaccination and stayed above protection threshold during the 12 months observation period. Maternal antibodies in kids and lambs from vaccinated dams were detectable at up to 6 months of age but fell below protection threshold at 3.5 and 4.5 months of age in lambs and kids, respectively. These results reaffirmed

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the annual vaccination interval and indicated the appropriate ages of vaccination of young animals from immunized dams.

The combined effects of vaccination and strategic anthelmintic treatment consisting of deworming at the beginning and at the end of the rainy season was evaluated in terms of productivity parameters and expressed in an economic model at the farmer level (Awa *et al.*, 2000; Njoya *et al.*, 2005b). The application of the package resulted in significant increases in fertility and growth rates and reductions in mortality. In economic terms, farmers' profit margins rose 2–3-fold in goats and 3–4-fold in sheep when only animal sales from increased sales in treated flocks were considered.

Similar developments have been made with regard to ND. Although efficient vaccines exist, vaccination of traditional poultry flocks is generally not practiced despite the enormous economic losses incurred each year from mortalities due to the disease. The major constraint associated with this is the inappropriateness of the intensive vaccination programmes practiced in intensive commercial poultry farms which often involve the use of vaccines that need to be maintained in a cold chain. Having identified high risk epidemic periods in the Savannah region of central Africa, 2 to 3 vaccination campaigns per year are proposed (Awa *et al.*, 2008a, b; Maho *et al.*, 2009) to pre-empt outbreaks of ND in the cold dry period of December–January and the hot humid period of April–June. Field application of the programme using either an inactivated thermo-tolerant injectable vaccine produced by the Cameroon National Veterinary Laboratory or an imported live vaccine administered intra-occularly or in the drinking water in selected sites in Cameroon, Chad and the CAR led to reductions of mortality from over 90% to less than 20% in most cases during epidemic periods. The programme is highly appreciated by farmers but the major constraint is the difficulty of obtaining the vaccines either due to lack of information on supply sources or because the vaccines are found in far off veterinary pharmacies in urban centers.

The fight against vector-borne parasitic diseases, especially bovine trypanosomosis, is based mainly on two approaches: control of the tsetse vector and chemotherapy/chemoprophylaxis of the host. In this region, the fight currently relies more on the latter, given that ambitious programmes aimed at tsetse control/eradication failed due to insufficient logistics and lack of follow up. Reiss *et al.* (1999) described the example of north Cameroon. Chemotherapy/chemoprophylaxis has for a long time depended on a few chemical molecules, the most common of which are diminazene aceturate and isometamidium, both widely used in this region. Unfortunately, trypanosome resistance against these compounds has been widely documented (Stevenson *et al.*, 2000; Anene *et al.*, 2001; Assefa and Abebe, 2001), including results from north Cameroon (Awa and Ndamkou, 2006). Thus vector control still remains indispensable to keep bovine trypanosomosis under check. Previous approaches to tsetse control through extensive sprays and deforestation are now abandoned in favor of baiting using traps or insecticide-treated animal hosts as live moving traps. This is a relatively cheaper and environmentally friendly approach but, as Hargrove *et al.* (2000) put it, its efficiency depends on the scale of application and it will be senseless for a farmer in the middle of an extensive tsetse zone to treat his animals alone. A cheap method of host treatment using pyrethroid footbaths with comparable results to spraying the entire animal, in terms of reducing fly population has been proposed (Stachurski *et al.*, 2005; Bouyer *et al.*, 2007). This method can easily be applied on a relatively large scale through the construction of communal footbaths.

An important option to the fight against trypanosomosis is the use of trypanotolerant cattle breeds. Apart from the well-known *Ndama* cattle, other local trypanotolerant breeds like the Doayo (*Namchi*) cattle of north Cameroon have been identified (Freeman *et al.*, 2004; Achukwi *et al.*, 1997, 2006, 2009). This is the main cattle breed thriving in the tsetse-infested zone of north Cameroon. These authors are currently working on the identification of genetic markers that could facilitate selection for trypanotolerance.

Onchocercosis is a disease of minor economic importance in livestock. However, the importance of research in bovine onchocercosis in Cameroon is seen in the fruitful exploitation of the bovine parasite, *Onchocerca ochengi*, in the development of drugs lethal to the adult human parasite *Onchocerca volvulus* (Renz *et al.*, 1995; Gilbert *et al.*, 2005), for prophylaxis (Tchakouté *et al.*, 1999) and vaccine development (Achukwi *et al.*, 2007).

Participative approach in animal health management

Animal health service delivery in the region without the active participation of the primary stake holders, the stock owners, has shown its limits characterized by deficiencies in temporal and spatial coverage by state and private veterinary services, interventions by non-professionals in the supply of pharmaceutical products and treatments, and failure to effectively keep disease under control. This constraint has been addressed in some parts of the continent especially eastern and southern Africa by the introduction of community based animal health services (Hüntter *et al.*, 2001; Mugunieri *et al.*, 2004; Ahuya *et al.*, 2005) with the objective of supplementing over-stretched professional animal health services in marginal areas. In this approach, use is made of the farmers' indigenous knowledge on disease epidemiology and traditional pharmacopoeia in the design and delivery of animal health care services. Efforts have been made in this region to actively involve farmers at the level of diagnosis (identification of constraints) as a prelude to the definition of research and development priorities, and to a lesser

extent at the level of seeking for solutions, as a number of on-farm research trials are carried out with the active participation of the farmers. There is, however, a severe deficiency at the level of problem solving due to inadequate coverage by professional services and the lack of empowerment of farmers in the handling of basic health problems. There are indications that professional state and private veterinary services will never be able to give adequate coverage to animal health, given that they are located mostly in townships far away from areas of livestock concentration often characterized by difficult access. The empowerment of stock owners in animal health management seems imperative. This can be achieved through the development of community-based animal health services (CBAHS). This initiative was taken in the CAR since 1992 (Hamat Mal-Mal *et al.* 2009) where the Fédération Nationale des Eleveurs Centrafricains (National Federation of Livestock Owners) operates a central pharmacy as well as trains personnel who are referred to as auxiliary veterinary staff, to deliver animal health services to members of the federation. This approach seems to be working well and could be adopted by the entire region and further developed to bring the services even closer to stock breeders by creating health care units in marginal areas poorly covered by professional veterinary services. This could also be a forum for the exploitation and development of indigenous knowledge in animal health management.

Deficiencies and perspectives

Livestock disease epidemiology in the CAR is complicated by extensive transhumant movement both within and across national frontiers in search of food and water. An important factor affecting such movements in recent times is the phenomenon of armed bandits who harass large stock owners, taking some of the breeders and/or their children hostage and asking for large sums of money as ransom. As a consequence, families move along with their animals to what they consider safer areas, often across national frontiers. Soon, they may find the new home unsafe and the movement continues. Animals thus contract new diseases such as trypanosomosis as they pass through tsetse-infested zones and disseminate other pathogens such as the FMD virus (Awa *et al.*, 2006) to in-contact animals along their way or at their destinations.

Another handicap in animal health management is the lack of a regional strategy in the prevention and control of important diseases, thus rendering national programmes ineffective because of unlimited animal movements as outlined above. Vaccination of cattle for example against important endemic diseases in the region such as black quarters, anthrax and pasteurellosis is routinely carried out in Cameroon but, according to Hamat Mal-Mal *et al.* (2009), no livestock vaccination of any sort has ever been done in the CAR since the Pan African endemic disease control programme (PACE) ended in 1992. The problem is compounded by persistent armed conflicts that result in unstable governments that do not last long enough to formulate and execute development programmes. There is a strong need to develop a regional disease monitoring and control programme and to harmonize implementation practices such as vaccination against the diseases that are common to the member states of the region.

Animal health care delivery systems are absent in most cases and where they exist, they are poorly developed and good legislation defining the role of the different actors is either absent or not respected. A case in point is the role of veterinarians in private practice in animal health care delivery. Recent findings revealed that there is presently no veterinarian in private practice in the CAR and only three in Chad (Hamat Mal-Mal *et al.* 2009). In Cameroon, where a considerable number exists, their functionality is hampered by the lack of an enabling environment. One of their major preoccupations is the chaotic situation reigning in the profession with the multiplication of drug vendors. This results in the loss of customers to those who offer cheap but ineffective services to the uninformed farmers.

There is lack of a functional legal framework governing private veterinary practice and one of the direct consequences is what the practitioners consider as their undue exclusion from mass animal vaccination campaigns. Governments are expected to completely liberalize the veterinary profession and ensure the implementation of existing laws or enact new ones where appropriate for its proper functioning. In marginal areas where professional health service providers are absent, stock holders should be empowered through training to handle basic animal health problems within the framework of community-based delivery systems; this is an approach that has yielded positive results in east and southern Africa (Hüntter *et al.*, 2001; Mugunieri *et al.*, 2004).

Conclusion

Disease still constitutes a major constraint to livestock production in the central Africa region. To a high extent, efficient tools for the control of most of the important diseases such as vaccines, chemotherapeutic agents and prophylactic programmes exist but considerable efforts still need to be put into the organization and functioning of animal health care delivery systems in order to achieve optimal results. Private professional veterinary services need to be promoted and given greater responsibility in animal health care and community-based animal health care units need to be developed in areas of marginal professional coverage. A regional approach and the setting up of functional epidemio-surveillance and disease reporting systems will be useful in keeping important diseases under control.

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