Chapter 13
Major Infectious Diseases with Impact on Goat Production in North African Countries

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Abstract Goat industry provides a vital food source (meat and milk) of many North African inhabitants. The goat populations in North Africa are more than 17 million heads, and most of them are reared under traditional husbandry system. In spite of the advantages of goats rearing in the region, diseases can substantially affect the optimal and cost-effective production. In this chapter, we describe the major infectious diseases with impact on goat production in North African countries (Morocco, Algeria, Tunisia, Libya and Egypt) and the control measures adopted in each country. The main diseases threatening the goat industry are peste des petits ruminants, bluetongue, foot-and-mouth disease, sheep/goats pox, brucellosis and Rift Valley fever. The current epidemiological situation of those goat diseases in the region can be considered as very dramatic. Therefore, the implementation of a regional control approach is needed to prevent and control these devastating diseases.

13.1 Introduction

According to the Food and Agriculture Organization (FAO), an estimated 95% of the goat population is concentrated in developing countries (FAO 2014). These animals play a significant economic role in many rural areas of the world, because they adapt easily to all production systems, under most climatic conditions and convert very efficiently their feed into highly nutritious milk and meat that could cover the nutritional needs of the inhabitants in developing countries (Morand-Fehr et al. 2004; Boyazoglu et al. 2005).

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Because of its geographical location and its borders with Middle Eastern and Sahelian countries, where major infectious diseases are present, the North African region is vulnerable to them, including peste des petites ruminants (PPR), blue-tongue (BT), foot-and-mouth disease (FMD), sheep/goats pox, brucellosis and Rift Valley fever (RVF), which affect livestock production in these countries (OIE 2016).

Livestock is one of the most important components of agriculture in North African countries. Its contribution to the agricultural gross domestic product (GDP) ranges from 20 to 25%. It employs more than 20% of the active rural population and provides products such as milk, meat, wool and skins to other sectors (agri-food and artisanal industries). Goats have an important economic and social role; their estimated contribution to the region GDP varies each year from 1 to 3% (FAO 2014).

In this chapter, we describe the major infectious diseases with impact on the goat's production in North African countries (Morocco, Algeria, Tunisia, Libya and Egypt) as well as the adopted control measure of these diseases according to the available literature.

13.2 Goat Population in North Africa Region

Goat population is one of the main sources of meat and milk production in North African countries that plays a vital role in food security (Rancourt et al. 2006). The goat populations in North Africa is estimated to be more than 17 million goats (Table 13.1). Although intensive husbandry structure has recently been introduced, the majority of the goat herds in the region are reared under traditional extensive system (FAO 2014).

In spite of the advantages of goats rearing in the region, diseases pose significant challenges to ideal and profitable production in those countries (Boyazoglu et al. 2005; Canali 2006). Furthermore, the local goat population in North Africa is characterized by its heterogeneity because of the mixing of different breeds (Table 13.1). This population is considered as rustic and with poor productive

Table 13.1 Goat population and main breeds reared in North African countries

Country	Goat census (heads)	Main goat breeds
Algeria	5,000,000	Arabia, Berber, Kabyle, Makatia, Mzabite, Sahelian, Tuareg
Egypt	4,000,000	Baladi, Barki, Saidi, Sharkawi, Sinai, Wahati, Zaraibi
Libya	1,800,000	Mahali, Like Targhai, Tibawi
Morocco	5,000,000	Attaouia, Berber, Yahyaouia
Tunisia	1,500,000	Arabia, Nubienne, Maltaise

Source FAO (2014)

traits. Actually, it is difficult to distinguish pure breeds that could present specific qualities to be developed (FAO 2014).

13.3 Peste des Petits Ruminants

PPR is a highly contagious disease of small ruminants especially in goats (also see Chap. 20 of volume 1) (Banyard et al. 2010). It is caused by a virus belonging to the *Paramyxoviridae* family. The disease is characterized by high fever, stomatitis, purulent ocular and nasal discharges, pneumonia and diarrhea with severe dehydration often leading to death (Diallo et al. 2007). The morbidity and mortality rates can be as high as 90% depending on some intrinsic and extrinsic factors (Albina et al. 2013).

PPR is enzootic in all Africa (except the most southern part). Considering the significance of the small ruminant's industry in the socio-economic livelihood of the poor communities, PPR has been linked with food security achievement. Therefore, PPR has been classified as a notifiable disease by the World Organization for Animal Health (OIE) and as the next disease to be eradicated by the Food and Agriculture Organization (FAO) (Banyard et al. 2010; Albina et al. 2013). Although PPR virus (PPRV) exist as one serotype or strain, partial sequence analysis points towards the presence of four lineages (I, II, III and IV) (Kwiatek et al. 2011).

PPRV outbreaks occurred across the world have resulted in the spread of the disease into PPR free areas within the African continent (Kwiatek et al. 2011). The recent results from the FAO project «*Toward a harmonized strategy for the control of Peste des Petits Ruminants in North Africa TCP/RAB/3302*» provide profound perceptions into PPR epidemiological situation in Morocco, Algeria, Tunisia, Libya and Egypt updated up to 2012–2013. These results illustrated a 40–70% herd prevalence in these countries, except in Morocco, which adopted 4 years of mass vaccination program (the last campaign was in 2011) (EFSA 2015). On the other hand, the results of the molecular studies in Morocco, Egypt, Libya, Tunisia and Algeria showed that the lineage IV of PPRV is circulating throughout the region (Kwiatek et al. 2011; Sghaier et al. 2014; Kardjadj et al. 2015).

A homologous PPR vaccine is available since 1989; this vaccine confers protection against PPR for at least 3 years (Diallo et al. 2007). However, only in Morocco, PPR was well controlled at the national level through mass vaccination, thus providing very strong evidence that PPR control can be achieved in Northern Africa and other endemic territories. Moreover, after the vaccination campaigns in Morocco, the epidemiological situation was assessed. No viral circulation could be observed among young unvaccinated animals, and a good immune protection rate was achieved in vaccinated adults (FAO 2013). However, assiduous vigilance is still needed because there is a risk of PPR reoccurrence given the illegal cross-border livestock movements. Early detection of such reoccurrence is a necessary condition for a rapid response and effective management of possible

outbreaks of PPR. This fragile PPR-free situation in Morocco highlights the importance of designing and actually implementing a regional PPR control strategy, relying on coordinated mass vaccination in affected countries, together with post-vaccination monitoring and efficient active surveillance measures. In particular, a better knowledge of legal and illegal livestock movements is of critical importance (EFSA 2015).

13.4 Foot-and-Mouth Disease

FMD is a highly contagious disease in ruminants including goats. It is caused by FMD virus (FMDV), that belong to the *Picornaviridae* family. The virus exists as seven immunologically distinct serotypes, viz. O, A, C, Asia 1, Southern African Territories (SAT) 1, SAT 2 and SAT 3. FMD is constantly present in many developing countries with three predominate serotypes (O, A and SAT 1) (Rweyemamu et al. 2008).

FMD is characterized by fever and blister-like sores on the tongue and lips, in the mouth, on the teats and between the hooves. The disease causes severe production losses and while the majority of affected animals recover, the disease often leaves them weakened and debilitated; vaccination or recovery from infection with one serotype will not protect against subsequent infection with another serotype (Belsham 2005). Control of FMD is difficult due to the emergence of new strains (Domingo et al. 2005). Phylogenetic studies of the VP1-coding region have been used to define genotypes, which occur in defined geographic areas (topotypes) for each serotype (Knowles and Samuel 2003).

Historically, four serotypes have circulated in North Africa (O, A, SAT 2 and C) with type O being the most prevalent serotype, followed by serotype A (WRLFMD 2016). FMD in small ruminants is generally silent; however, the role of small ruminants in the epidemiology of FMD in African countries is well documented. The small ruminants contaminate river water, ponds, pastures, the shrubs and other environmental elements (Rweyemamu et al. 2008). For example, in 1989, in a Tunisian FMD free area, a cattle was infected after importing sheep and goats from the Middle East. Subsequently, the disease spread into FMD free territories of Algeria and Morocco (Knowles and Samuel 2003). Furthermore, in 1999 a West-African topotype (O/CIV/8/99) was isolated in cattle in Algeria, which spread to Tunisia and Morocco causing severe outbreaks in sheep and goats as well as in cattle (Samuel et al. 1999). On the other hand, the FMD epidemiological situation in Egypt and Libya is different compared to Tunisia, Algeria and Morocco (Samuel et al. 1999), due to the fact that, since 2000, FMD is considered endemic in Egypt and Libya; where several outbreaks of FMD have been reported due to serotypes A, O and SAT (OIE 2016).

The last FMD episode in the North African countries was in 2014–2015; when the topotype O/ME-SA/Ind 2001d spread from Saudi Arabia to Egypt, Libya,

Tunisia, Algeria and Morocco. This FMD episode caused huge economic losses in cattle, sheep and goat industries in these countries (Kardjadj 2016).

Currently, the rapid spread of SAT2 and A in Libya and Egypt establishes the need for a robust surveillance system to detect and respond effectively to newly emerged strain in the region (Ahmed et al. 2012; Ryen et al. 2015). Even if, Algeria, Tunisia, Morocco and Egypt have contingency plans for immediate vaccines procurement; the unstable political situation in Libya invariably put their neighbours at constant risk as result of free movement of animals across borders (WRLFMD 2016). Furthermore, the livestock population in Algeria and Morocco is highly susceptible to SAT2, and effective vaccines are only used in Tunisia and Egypt (Kardjadj 2016). In Libya, the routine implementation of vaccination programs has been severely affected by its current unstable political situation. It is expected that serotypes SAT2 and A will spread extensively and will affect seriously to livestock in the region (Hall et al. 2013; Kardjadj 2016).

Control and preventive measures for FMD are similar to other transboundary animal diseases, which would include surveillance, animal movement control, vaccination, quarantine and fair economic compensation. The FMD epidemiological status in the region required intensive monitoring of the circulating FMD strain, rapid typing of the isolated FMD strain at OIE or FAO Reference Centres and contingency plans for immediate vaccines procurement (Kardjadj 2016).

13.5 Bluetongue

BT is a viral disease of cattle, sheep and goats characterized by inflammation of mucous membranes, oedema and haemorrhages which can be responsible for up to 75% mortality in livestock (Maclachlan 2010). BT virus (BTV) is transmitted by several species of *Culicoides*, critical for the geographical range of the disease (Tabachnick 2004). BTV is the prototype of the genus *Orbivirus*, within the family *Reoviridae*; and of which 26 distinct BTV serotypes have been identified (Maan et al. 2011). The disease severely affects sheep, cattle and goats, being these latter considered as the main bluetongue reservoir (Maclachlan 2010).

In 1956, and for the first time in North Africa BT was reported in Morocco, although no clinical cases were reported until 2004 when the second epidemic caused by a BTV-4 was declared (Mellor et al. 2008). In 2006, a new serotype (BTV-1) originated from Algeria reemerged and caused the third epidemic in Morocco (Cêtre-Sossah et al. 2011). Egypt was affected by BT several times: the reported serotypes were BTV-1, 2, 4, 10, 12 and 16 (Mellor et al. 2008). Bluetongue is generally mild in indigenous sheep of Egypt and Libya since the classical symptoms of the disease are not commonly seen (Mellor et al. 2008).

BT was reported for the first time in Tunisia in 1999–2000 due to serotype 2; molecular studies comparing the Tunisian strain to those isolated in Corsica the same years showed 99.4% homology between them. Subsequently, the disease spread into the northeastern part of Algeria between July and September 2000 and,

then, the virus spread to other parts of the country (Hamida 2000). In July 2006, serotype 1 of BTV was reported in central Algeria; this strain spread into other North African countries (Tunisia, Libya and Morocco) and South European countries (Spain, Italy, Portugal and France). This wide movement of BTV may have been caused by windborne movement of adult *Culicoides* (Cêtre-Sossah et al. 2011).

13.6 Sheep Pox and Goat Pox

Sheep pox and goat pox (also see Chap. 20 of volume 1) are considered to be a single disease by the OIE, referred to here as Sheep Pox and Goat Pox (SPGP). The two diseases are clinically indistinguishable. Strains of sheep pox virus (SPPV) and goat pox virus (GTPV) cannot be differentiated serologically, although distinct host preferences exist with most strains causing more severe disease in the homologous host (Bhanuprakash et al. 2006; Diallo and Viljoen 2007). SPPV and GTPV belong to the Poxviridae family (Diallo and Viljoen 2007). Sheep pox and goat pox in enzootic region are related with substantial production losses in milk, meet and wool; furthermore, SPGP increased the abortion herd rates and the mortality rates among young lambs (Yeruham et al. 2007).

SPGP are endemic in Africa (except for southern Africa), Asia, and the Middle East (OIE 2016). Although infection with SPGP virus in North African countries was previously described, and an annual sheep vaccination was conducted since the 80s (Achour and Bouguedour 1999), the disease is still responsible for substantial economic losses in small ruminants breeding. Clinically, the classical SPGP vesicular form is usually observed in these countries and characterized by the appearance of skin lesions on the entire body surface evolving from macules, to papules, vesicles or vesiculo-pustules and crusts at the end of disease evolution (OIE 2016).

13.7 Brucellosis

Small ruminant's brucellosis due to *Brucella melitensis* is a significant zoonosis with a serious threat to human health (Seleem et al. 2010). The epidemiological situation of brucellosis worldwide is regularly shifting, with the disease emergence in new areas (OIE 2016). *Brucella melitensis* has long been associated with the Mediterranean littoral. The public health and economic impact of brucellosis remain of particular concern in North African countries due to the danger that infected animals suppose for humans and other animals. The economic losses associated with the affected animals forced national veterinary services in the affected countries to encourage the improvement of animal husbandry systems (Benkirane 2006).

Thus, all endemic countries have struggled to control animal brucellosis using different strategies, which have led to various levels of success (Seleem et al. 2010). In the North African region, and despite its acknowledgment as a significant health hazard and the availability of proven control means, it continues to occur with a relatively high prevalence. Benkirane (2006) stated that the main reasons for brucellosis persistence in the region are:

– the adopted extensive type of husbandry;
– the lack in logistic and human resources to control the disease;
– the absence of a clear political control program.

The Algerian state adopted in 2006 a new prophylactic approach, to control brucellosis by vaccinating sheep and goats in steppe region with the Rev-1 vaccine (Kardjadj and Ben-Mahdi 2014). As a result, the herd prevalence in 2014 was decreased to 3.33% in the region compared to 5.7% prevalence reported in 2002 (Kardjadj and Ben-Mahdi 2014; Kardjadj et al. 2016).

Brucellosis was well controlled in Algeria's steppe region through vaccination, thus provide a very strong evidence that Brucellosis control can be achieved in Northern Africa. Moreover, after the vaccination campaigns in Algeria, Kardjadj et al. (2016) revealed no significant association between abortion history and brucellosis infection in Algerian small ruminants' herds.

13.8 Rift Valley Fever

RVF is an acute arthropod-borne disease affecting a wide range of animals, ranging from rodents to camels. However, small ruminants and especially goats are the most economically significant hosts, in which high abortions and neonatal mortality rate occur (Davies and Martin 2003). The growing worldwide significance of RVF is evidently confirmed by its geographical spreading out. The existence of a varied range of host and vector species along with the unique epidemiological characteristics of RVF has led to the appearance of new foci in previously RVF free Africa (Clements et al. 2007).

The first RVF outbreak in Egypt was recorded at Belbies city in Sharqiya Province in 1977 (Mahmoud et al. 1989). In 1994, RVF virus was isolated from 139 (31.7%) goats and 84 (57.1%) sheep in Kafr El Sheikh and Behira Provinces. Unfortunately, the locally produced RVF vaccine was ineffective (Abd-El-Rahim et al. 1999). In 2003, further outbreaks were encountered in various localities of Egypt (Hanafi et al. 2011).

In 2010, Di Nardo et al. (2014) reported the presence of IgG antibodies against the RVF virus in Sahrawi refugee camps in Tindouf district, at the southwestern border of Algeria with Western Sahara, Mauritania and Morocco. These camps practice high meat consumption, and to cover the high demand of meat of the refugee people a conspicuous livestock trade has been developed from Mauritania,

Algeria and Mali to the refugee camps. These livestock are vended in the refugee camps market areas, where they are incorporated into pre-existing herds (Di Nardo et al. 2014). This type of animal movement constitutes a serious RVF spreading threat to other free North African countries.

13.9 Abortive Diseases

Abortive goat diseases have a negative influence on livestock production, animal health and rural communities since the majority of the goat population are reared by the rural poor families as a means of alleviating poverty (Boyazoglu et al. 2005; Canali 2006), which occur in North Africa as well.

The husbandry and communal grazing system practiced in the North African region enables the spread of many infectious abortive agents such as *Chlamydia abortus*, *Campylobacter* spp., *Toxoplasma gondii*, *Listeria* spp., *Coxiella burnetii* and *Brucella melitensis* (Entrican 2009; Van den Brom et al. 2012; Lafi et al. 2014; Ababneh et al. 2014). Therefore, improved diagnostic capacity, suitable control strategies and regular monitoring system are required (Van Engelen et al. 2014).

13.10 Concluding Remarks

The health status of the goat population in North African countries can be considered as very dramatic. Thus, the application of a regional control approach is needed. Regional strategies to control animal diseases are focused to prevent, control and/or eradicate the major infectious diseases with impact on livestock production in the region.

It seems impossible for a single North African country to fully control an animal disease only at a national level, due to the communal border shared with other countries in the region. North African countries share, thus, many animal diseases. The main diseases present or potentially threatening the goat industry in the North African region are PPR, FMD, BT, SPGP, brucellosis and RVF. Therefore, the establishment of early warning systems and proper implementation of control measures at the regional level of these diseases are highly recommended to prevent the socio-economic losses related to them.

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