

# Chapter 6

## TADs in the Dromedary



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**Abstract** The transboundary diseases in camel are mainly linked to the regional camel meat market from Sahelian countries (from Mauritania to Somalia) to the Arabian peninsula and North Africa. Indeed, the camel flow in relationship with this market is based on live animals' export. Because the camel trade can be formal and informal with interconnections between both sectors and despite veterinary controls in the main exporting ports, some diseases such as Rift Valley fever (RVF), PPR-like disease, and MERS-coronavirus can spread from exporting countries to importing ones. However, the epidemiological status of these different diseases is quite variable and the transmission to humans in case of zoonosis (RVF and MERS-Cov) is not necessarily due to transboundary camel trade despite the impact of outbreak on the regional camel market. Globally, dromedary camel is less affected than other ruminants by infectious diseases under transboundary surveillance. But, because camel breeding is concentrated in countries where the disease surveillance systems often lack means, where the frontiers in desert areas are often “porous,” and where the herd mobility is difficult to assess, the risk of transboundary diseases' transmission through borders is not negligible. Nowadays, the challenge of TADs control is limited to Rift Valley fever, but special attention must be paid to emerging diseases, including the recent discovery of prion disease in Algeria.

**Keywords** Camel diseases · Meat market · Live camels' export · Rift Valley fever · MERS-coronavirus

The transboundary flow of living camel in Sahelian countries is linked to two main features: (1) the herd moving for accessing resources under the management of the camel owners located more or less close to one frontier and (2) the market export of living animals for slaughtering or other purposes such as breeding or racing. The

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**Photo 6.1** Cohabitation of camels with other species around water point, region of Garissa, Kenya (Photo: B. Faye)

relative importance of these camel flows is not deeply studied, at least from a quantitative point of view.

## The Camel Flows in Sahelian Countries

### *The Camel Herd Mobility*

The camel being linked to ecosystems marked by the poverty of their resources (water and pastures), mobility is one of the main strategies for securing farming system (Faye 2013). This mobility can be pendular (transhumance) or random (nomadism) based on short or long distance. For example, the mobility of Afar tribes across the border between Ethiopia and Djibouti is based on short distance (Faye 1994). In reverse, the movement of camel herds in Chad can be of a large amplitude from North Chad up to beyond RCA (Central African Republic) border (Aubague et al. 2011). Thus, the transboundary camel herd moving is not necessary linked to the distance of the cameleers' camp to the border. However, the potential risk for disease spread increases with the covered distance, the cohabitation between animals of different origins (and different species) occurring mainly around water point (Photo 6.1) throughout the transhumance route.

## ***The Camel Market for Export***

Contrary to camel milk, essentially limited to local or national market, camel meat is the object of transboundary trade based on living animals. The camel population in the world estimated to 35 million heads (FAOstat 2019) is probably underestimated (Faye and Bonnet 2012) due to the difficulties of census for a mobile species and the absence of official vaccination. So, it is difficult to assess the exact percentage of camels involved in such transboundary trade. The camel flow in relation to the living camel export is consequently also underestimated. In Sahelian region, the camel flow for export is mainly from South to North. Camels in Mauritania, Mali, Niger, Chad, Sudan, and Ethiopia are the main exporting countries of living camels to North Africa (Morocco but overall Libya, Egypt, and Algeria to a lesser extent) and to the Arabian peninsula (Faye et al. 2013). For example, the slaughtering rate which is around 7% at world level reaches 95% in Egypt, 75% in Saudi Arabia, 50% in Emirates, and 31% in Morocco and Libya which shows the importance of imports for the national camel meat markets. In reverse, less than 5% of the camels are slaughtered in Sahelian countries for their local demand. Probably, this percentage is also underestimated due to a large part of slaughtering occurring in the remote pastoral area, not included in the official data (Aklilu 2002). Along the Red Sea, some ports (Port-Sudan, Djibouti, Hargeisa, Mogadishu) are hubs for camel export by boat to Saudi Arabia, Yemen, Oman, Qatar, Bahrain, and Emirates. In Western and Central Africa, the export is achieved by land, sometimes using trucks but overall by foot as the “forty-days road” from El-Obeid (Sudan) to Aswan (Egypt) through the Nubian Desert. If the main flow is South-North (Africa) or South-South (Horn of Africa), recently new flows occurred from the same Sahelian countries to coastal countries like Senegal (coming from Mauritania) or Nigeria (coming from Niger and Chad). Indeed, the recent demand for camel meat for dietetic reason (camel meat is poor in cholesterol and has a high protein value) or even for supposed virtues (it is believed that camel meat is aphrodisiac and cures hypertension) is increasing significantly in these countries (Kurtu 2004; Kadim et al. 2008; Raiymbek et al. 2015).

## ***Formal and Informal Camel Trade***

### **Camel Trade in the Horn of Africa**

In a recent analysis of the camel flow in the Horn of Africa, using different sources of data to assess the importance of the camel chain in the economy, a gap was observed between official data (41,000 camels should be exported every year on average from Ethiopia) and the true potential of export. Such a gap is because only a part of the camel flow is passing through official way (Belachew 2005; Alary and Faye 2016). In Somalia, for example, only 10% of the exported animals would use formal trade.

This low part could be explained partly by insecurity along the export routes, especially since the Somalo-Ethiopian war in 1977 and the civil war in Somalia since the 1990s. Indeed, Somalia was the most important camel exporting country all along the twentieth century, and the Horn of Africa represents more than 60% of the estimated camel world population. The pivotal role of Somalia in this regional camel trade started at the end of the nineteenth century; the Somali pastoral area (that covered the eastern part of Ethiopia, northern part of Kenya, and central and northern part of Somalia) established a well-functioning market chain to supply the Brittany garnison established at Aden in 1839. The international trade was extended to include the Persian areas and the borders of the Indian continent (Djama 1999). The economic boom of the Arabian peninsula with the development of “oil era” stimulated the demand for camel meat and the transboundary camel trade in the region.

But, due to insecurity evocated above, the camel trade is now competing with other countries of the region such as Djibouti, Sudan, Kenya, and Eritrea and even Australia where a feral camel population is problematic for the environment. Globally, the camel farming systems in the Horn of Africa are not well organized to produce high-quality meat. The main consequence of this competitive trade was the variability in the origins of the camels and a more important breeding camel population in the importing countries.

Moreover, the traditional pastoral camel fattening in the Horn of Africa and central Africa is providing mature camels mainly for the trade with Egypt or Libya. In that case, the animals are slaughtered rapidly after their arrival, decreasing the epidemiological risks. In reverse, the demand in the Arabian peninsula is for young camels (1–2 years), fattened for 3–6 months in the importing countries, in special feed-lots where the epidemiological risks could be more important. In addition, a part of the exported camel stock is used for breeding and for racing which is a very popular activity in the Arabian peninsula. In Africa, in reverse, the camel feed-lots are not developed, except in Tunisia to provide the local market with young camels of 250 kg live weight (Khorchani et al. 2005).

Another consequence of the new insecure environment is the disorganization of official services, such as veterinary services, customs, and banking services especially in the export ports. This has consequently favored the official position of Djibouti and Port Sudan in the international market of live animals for the region and the development of various networks of smugglers who export animals via Yemen traders who then re-export animals to Saudi Arabia (Alary and Faye 2016). Except in the peaceful Somaliland, the bargaining power of the traditional traders’ networks was weakened (Little et al. 1998).

Regarding the formal market of live camels, the main stakeholders are legal exporters who have their own collecting points where camels are fed, treated, and eventually vaccinated before being exported by rail or truck to the export port. At Djibouti, for example, infrastructure for the transit of the camel herds (Photo 6.2) was implemented including quarantine (usually for 21 days), paddocks, water, and feeding resources for export or re-export from neighboring countries, especially to



**Photo 6.2** Camels for export at Nagad park- Djibouti (Photo: Abdallah Barkat)

Saudi Arabia and Emirates. Sanitary controls are certified by international agreement society (Faye 2003).

In the informal market (notably to Yemen), camels are shipped on Yemenite boats without the use of quarantine or veterinary services although controls could be achieved in the native countries (Ethiopia, Sudan, etc.). Despite the pressures from local governments to legalize and harmonize all the sanitary procedures, some stakeholders may use illegal practices along the chain either for the financial/customs procedure to facilitate the conveying of animals or for the veterinary procedures to avoid the legal procedure imposed by importers. These circumventing acts aim to maintain the international market of live animals in the region.

In the region, there is also the trade of live camels for merchandises' transport where the purchasers of animals can be different from the sellers of merchandises. In this system, camels are the main mechanism used to transport illegally the merchandises. The animals used cross the borders and come back to their native country. This smuggling activity is particularly important between Ethiopia, Somalia, and Djibouti.

However, the two chains (formal and informal) are not truly waterproof. A combination of formal and informal circuits can occur, for example, the combination of illegal crossing of the Ethiopia-Somalia-Djibouti border (despite a strengthening control, especially by the Ethiopian government) and legal re-export from Djibouti or Somaliland port to the Arabian peninsula.

### **Camel Trade in Central Africa**

If few data are available in the Horn of Africa, the situation of camel trade in central Africa is less described. In Chad, in a recent report (Mankor and Koussou 2015),

three main trade routes are described according to the destination: Libya, Egypt, and Nigeria.

The trade route to Libya is more important (85% of the export). The camels are gathered at Abeche in Chad (the main camel market for export in the country), coming from different regions of the country, and then conveyed to Sebha and Koufra in Libya. The export activity is seasonal and is linked to the transhumance of the cameleers. The peaks of export are August (at the beginning of transhumance) and October (at the return). Twenty-five percent of the export occurs during these 2 months. The moving of camels is ensured by truck or by foot. The duration of the travel is 7–10 days by truck and 50–60 days by foot across the desert. However, this circuit is destabilized since the political insecurity in Libya. From Abeche, a part of the camels is exported to Egypt via Sudan, mainly by foot. The export to Nigeria is achieved from N’Guéli station, close to N’Djamena, but is also disturbed since the Boko-Haram exactions.

Between 2007 and 2015, the official number of exported camels increased from 3000 to 45,000 heads, but this increase could be partly due to a better control of the trade. Moreover, the camel traders complain regularly about illegal taxes imposed by the custom and security forces. Due to this constraint, an important part of the camel export escapes from official control. Similar observations could be done in Niger where the insecurity due to the threat of AQMI attacks is more pronounced. Consequently, the importance of the camel flow is not truly quantified.

### **Camel Trade in Western Africa**

In Western Africa, the most important camel population is encountered in Mauritania where the camel meat (and milk) market for local consumption is the highest of all the regions: indeed, camel meat represents more than 25% of the total consumed red meat in the country. The live camel export is also an important economic activity although the statistics are debatable. Officially, camel is the main species among the animals’ export in the country. In the year 2000, the main countries of destination were Morocco and Algeria, but since the Moroccan border is officially closed for sanitary reasons, the camel export market was diversified and oriented to other North-African countries. Although the retail prices are higher in North Africa, a recent trend of export to Senegal as underlined above is observed. This new destination is associated with the implementation of specialized butchers beyond the border, the only purpose of this export being the slaughtering (Faye 2016).

The camels are conveyed mainly by foot, most of the time without official control and with exchange of shepherds when crossing the border. The price differential is important and is the main driver for this export. However, the pressure of the demand is so high that the Ministry of Livestock has forbidden the export of the young females to maintain the national camel herd (Renard 2005). The camel export is in the hands of livestock merchants who buy the animals on the local end markets and export them.

## Camel Trade and Transboundary Diseases

The main diseases in camels such as mange, trypanosomiasis, camel pox (the only camel disease controlled by vaccination), gastrointestinal parasites, or calf diarrhea are so endemic and common that the herd mobility has a weak impact on the spread of the diseases. The risk of the live camel flows described above in disease spreading is limited to few emerging diseases that had significant impact on the camel trade. Its concerns mainly Rift Valley fever (RVF), PPR-like disease, and MERS-coronavirus.

### *The Rift Valley Fever Outbreaks in Dromedary*

The Rift Valley fever (RVF) is a zoonotic arboviral disease caused by a Phlebovirus transmitted by mosquitoes. This disease can affect dromedaries. In camels, RVF provokes abortion and over-mortality among the young animals. It is not a specific disease to camels. In addition, the disease can be transmitted to humans and could be lethal. Thus, several outbreaks in Africa largely affected human population in Egypt in 1977 and in West Africa in 1987. In Mauritania, the first severe outbreak occurred in 1987 in Senegal Valley causing the deaths of 28 people. This first outbreak was attributed to some changes in the pluviometry regime marked by late and intensive rains. Later, other outbreaks occurred, in 1998, 2002–2003, and 2010 (in the North of the country) and in 2012, all over the country (El-Mamy et al. 2011, 2014). The last outbreak was probably started by a sick dromedary camel, slaughtered by the owner before it died, but causing the deaths of several contaminated people with intestinal and hemorrhagic symptoms (El-Mamy et al. 2014). The virus being probably introduced through affected camels transported by truck in grazing areas, the risk of spreading all along the export routes could be high. However, thanks to the rapid appropriate control measures (restriction of livestock movement, re-allocation of locust control teams for mass insecticide spraying, risk communication, and public awareness campaigns) by the veterinary and public health authorities, the spread of the virus was limited, although the fall of the livestock's price (up to 40% decrease) created an attractive opportunity for the traders. Yet, the risk of transboundary dissemination to North African countries having similar ecosystem and rainfall conditions is high. Such epidemiological risk encouraged, since 2000, the creation of the Mauritanian Network for the Epidemio-surveillance of Animal Diseases (REMEMA) under the OIE rules and supported by FAO. This network, based on "sentinel herds," has made it possible to control the international exchanges of camels during the outbreaks.

However, on the opposite side of the continent, the epidemiological situation was not identical. The virus is endemic in Egypt and Sudan due to the favorable ecosystems for the vectors (Aradaib et al. 2013; Sayed-Ahmed et al. 2015). Outbreaks were also described in Kenya and Somalia. All species are affected including camel. It is by animal export that the virus reached the Arabian peninsula for the first

time in 2000, affecting Saudi Arabia and Yemen. During this outbreak, around 40,000 animals including sheep, goats, cattle, and camels died, whereas about 10,000 of them aborted (Al-Afaleq and Hussein 2011). The main species imported in the Arabian peninsula from the Horn of Africa are sheep and camel. In consequence, restrictions on livestock movement were imposed by Saudi Arabia (1998 to 2000, 2001 to 2004, and 2007) due to health issues in the Horn of Africa and insufficient veterinary control (Faye 2003; Hassan et al. 2014) which landed pastoralists in economic crisis (Pratt et al. 2005) and disturbed the camel trade (Antoine-Moussiaux et al. 2012).

Control and surveillance system was implemented based on the FAO/OIE recommendations: syndromic surveillance (abortion, mortality of the young animals, presence of vectors), participatory surveillance (semi-structured interview of pastoralists), and risk-based surveillance (risk mapping, climatic factors surveillance) in order to identify epidemiological indicators and establish an early warning system. The system is completed by laboratory analyses for confirmation of the disease.

### ***The PPR-Like Disease Outbreak in the Horn of Africa and Other Unidentified Diseases***

Since the end of twentieth century, new cases of camel diseases marked by severe symptoms, high mortality, and then impossibility to form a precise diagnosis have emerged in several Sahelian countries. The more emblematic new pathological event occurred in the Horn of Africa in 1995–1996. This disease was characterized by febrile attacks, highly contagious respiratory syndrome with high morbidity (up to 90%), and mortality varying from 5 to 70% depending on the herd and treatment administered (Roger et al. 2000). The high prevalence of peste des petits ruminants (PPR) in the zone as well as symptoms like those of rinderpest suggested the presence of morbillivirus (Roger et al. 2001). Similar observations were published in Sudan (Khalafalla et al. 2005) where several mortal epizooties have been reported in the early 2000s, as well as in Kenya, without clearly identifying the causal agent although PPR virus was suspected. The pastoralists of these countries considered those diseases as new ones and attributed to them vernacular names, e.g., *Firaanfir*, *Laaba*, or *Yudleye* (Khalafalla et al. 2010). The outbreak, however, was apparently confined in the Horn of Africa and has moved throughout the borders of the region in relation to herd mobility, but probably not exported to camel importing countries.

In Central and Western Africa, other unidentified camel diseases occurred. For example, in 2003–2004, several hundred camels died in Mali, Niger, and Chad showing nonspecific symptoms. Some witnesses spoke about a “stunning death.” No quantitative data were available because no exhaustive survey was carried out, but the death rates seemed very high. Anthrax was suspected for a moment as well as an acute form of trypanosomiasis, but the results of laboratory analyses did not confirm them (Faye et al. 2012). It seemed that all the dead animals were heavily infested by



ticks and hemoparasites such as *Anaplasma* and *Babesia*. Still in Niger, many cases of severe xerophthalmia associated with purulent or bilateral sinusitis causing eye loss were observed, without establishing the cause.

More recently in Somalia, Ethiopia, and North Kenya, sudden deaths concerning hundreds of camels were reported and their assumed causes included plant intoxication and mineral deficiencies until the main viral diseases (PPR, blue-tongue, foot-and-mouth disease, Rift Valley fever) were suspected, but at time of writing they have not been confirmed.

Thus, emergence of new diseases in this species, probably linked to the climatic change and geographical expansion of camel breeding, occurred in many places for the last two decades. Unfortunately, investigations have been hindered by the difficult access to sick animals, often located in remote areas. The risk of appearance of these diseases along the trading routes is obviously important.

### ***MERS-Cov***

Contrary to former camel emerging diseases described above, MERS-coronavirus is an important zoonotic disease. It was described for the first time in humans in Saudi Arabia in June 2012 and then in many other countries in all the continents (Gossner et al. 2016), but most of the cases occurred in the Middle East, especially in Saudi Arabia. At the world level, at the end of 2017, 2102 human cases of MERS-Cov were confirmed with at least 733 lethal cases. Camels were suspected among some other species at the origin of the outbreak as the main animal reservoir. Positive serology to MERS-Cov in almost 100% of camels in the Middle East testifies the wide circulation of the virus among the camel population, but without clear clinical expression of the disease. Finally, MERS-coronavirus can be regarded as disease for humans and infection only for camels (Younan et al. 2016).

However, if high seroprevalence was also observed in Sahelian countries (up to 100%!), and since more than 30 years, surprisingly, no human case was reported, except by human-to-human transmission. Finally, the absence of infection in human population close to camels in Africa leads to consider the transmission of the virus from camels to humans as unclear and could involve the immunological status of the human population in the Middle East (Al-Osail and Al-Wazzah 2017).

The question of the transboundary transmission of the disease by trade route was investigated. MERS-Cov seropositivity and percentages of MERS-Cov RNA-positive camels were not more important in the two major Saudi camel import entrance ports of Jeddah and Gizan where an increased likelihood of contacts between imported dromedary camels from the Horn of Africa and local Saudi Arabian dromedary camels was expected. Finally, MERS-Cov prevalence appeared higher in local Saudi camels compared to those imported from Somalia or Sudan (Sabir et al. 2016). Recent investigations revealed the presence of two lineages of sub-Saharan MERS-Cov, genetically distinct from virus found in Saudi camels. Moreover, it is stated that the MERS-Cov is poorly transmissible from camels to humans, and

clinical human MERS disease is not proportional to potential exposure of humans to virus circulation in camels (Hemida et al. 2014). According to certain authors (Younan et al. 2016), the control measures of Saudi camels should be a priority to those imported from the Horn of Africa. Indeed, the control of an endemic coronavirus infection among nomadic tribes in Africa appears unrealistic. Moreover, the lack of human cases in Egypt or Libya who also import many camels from Sudan or Somalia seems to indicate that control system of the disease based only on the trade restriction is not necessarily efficient in the case of Saudi Arabia. However, it is probably different in camel countries “MERS-Cov free” as in Central Asia or Australia (Miguel et al. 2016). Besides, the World Health Organization does not recommend trade restrictions in relation to MERS but advocates for persons at risk (immune-depressed) to avoid close contact with camels (Mackay and Arden 2015).

However, even without official ban as for RVF, the MERS-Cov crisis has an indirect impact on camel meat consumption in Saudi Arabia and indirectly on the volume of live camel’s import. Thus, the decreasing demand for camel meat (despite the lack of risk because the virus does not survive cooking) affected 78% of the urban butchers and 22% of the rural butchers after mediatization of MERS outbreak (Fedoul 2014). The number of camel slaughtering decreased by 10 to 70% per week. In addition to the impact on the camel prices, the number of imported animals decreased by 21% between 2012 and 2013 (after the beginning of MERS outbreak) whereas this number increased regularly since the year 2000 (Fedoul 2014). No similar trend is observed in Sahelian countries.

### *A New Emerging Disease: Prion Disease?*

Prions are simple proteins causing fatal and transmissible neurodegenerative diseases, like Creutzfeldt-Jakob disease in humans, scrapie in small ruminants, or bovine spongiform encephalopathy (BSE) in cattle. The BSE outbreak started in 1996 in the United Kingdom has provoked an important crisis for both public health and cattle meat economy. Since this crisis, scientific community, stakeholders of the meat sector, and public health authorities were highly sensitive to the risks linked to animal prions, especially because of their potential passage to humans. Moreover, the presence of BSE conducted to ban live animals’ export in many countries, impacting the livestock economy. It is interesting to note that such a ban imposed by Egypt for European bovines after BSE outbreak is responsible for the high increasing demand for camel meat in the country.

Thus, recently, a camel prion disease was described in Ouargla region, Algeria (Babelhadj et al. 2018). The camels showed symptoms comparable to that of “mad cow disease.” The animals found in the desert had difficulty in getting up. At the abattoir, they showed aggressiveness and became nervous when forced to cross an obstacle and showed down- and upwards movements of the head and teeth grinding. These symptoms occurred in 3.1% of dromedaries brought at Ouargla abattoir in 2015–2016. The diagnosis was confirmed by detecting prion protein in brain tissues

from three symptomatic animals. Prion detection in lymphoid tissues is suggestive of the infectious nature of the disease. The potential risks for human and animal health are not yet assessed. Obviously, Algeria is not an important camel export country, but the exchanges with the Middle East and Maghreb represent a potential risk of transboundary spreading of the disease, especially because the true occurrence of the disease in Algeria and neighboring regions is unknown. However, a recent case was reported in Tunisia.

## Conclusion

Globally, dromedary camel is less affected than other ruminants by infectious diseases under transboundary surveillance. But, because its breeding is concentrated in southern countries (notably in Sahelian ones) where the disease surveillance systems often lack means, where the frontiers in desert areas are often “porous,” and where the importance of herd movements is difficult to assess, the risk of disease spreading through the borders is high, especially since the informal trade can be dominant and achieved by foot. For the moment, the challenge of TADs control is limited to Rift Valley fever, but special attention must be paid to emerging diseases, including the recent discovery of prion disease.

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