Feature Article

Is the camel conquering the world?

Bernard Faye[†,‡]

[†]UMR SELMET, CIRAD-ES, Montpellier, France
[‡]Faculty of Biology and Biotechnology, Department of Biotechnology, Al-Farabi University, Almaty, Kazakhstan

Implications

- The expansion of large camelids around the world has continued since their domestication. Trade routes and warfare were historically the main ways for the species expansion in Middle-East and North Africa.
- Camel farming is not limited to arid countries nowadays.
- There is a growing camel dairy industry in Western countries.

Key words: caravan, climatic changes, domestication, large camelids, trade

Introduction

Large camelids have long been called the "ships of the desert" for their importance in the desert regions of Africa and Eurasia. Although their reputation as an animal of the nomads and for caravans of merchants recalls their mobility far exceeding that of other domestic herbivores, the use of this species for transportation and in animal agriculture remains confined to the deserts of northern Africa and Asia.

However, the geographical distribution of large camelids has grown in the last 30 years. As they gain popularity, the species has been confronted with new environmental contexts. So much so that one may wonder if they are not conquering the world. Here, we take a closer look at the journey of the camel from its early ages of domestication to its role in a world facing climate change.

Short Prehistory and History of Camelids Family

The large camelid family originated in North America about 40 million years ago. From this original nucleus, two migrations, one to South America through the Isthmus of Panama, the other to the Asian continent via the Bering Strait, gave rise to the two current large branches of the camelid family: the small Andean camelids (Lamini tribe) and the large camelids (Camelini tribe). The divergence between these two groups occurred 11 million years ago in North America, and the ancestor of the small camelids, the Palaelama, would have arrived in the Andean mountains between 1.8 million years and 11,000 years before our era (BP) (Wheeler, 1994). For its part, the ancestor of the great camelids (Camelops?) would have migrated to Asia between 8 million years and 15,000 years BP (Burger, 2016). The large camelids in turn divided into the dromedary (one-humped camel) and the Bactrian (two-humped camel), 4–5 million years ago, the former migrating to the hot lands of the Arabian Peninsula, the latter to the cold lands of central Asia (Burger et al., 2019). A final divergence occurred less than a million years ago between the Bactrian camel and the wild camel of Tartary (Hare, 1999).

The current family of large camelids includes three genera and seven species. The genus *Camelus* includes two domestic species which are the dromedary (*Camelus dromedarius*) also called the Arabian camel or single-humped camel, the Bactrian (*Camelus bactrianus*) or double-humped camel, sometimes called the Asian or Mongolian camel. The wild camel (*Camelus ferus*), long regarded as Bactrian camel that remained wild (ancestor of present Bactrian camel) has recently been recognized as a different species through genetic studies showing a clear divergence in the full genotype. *C. ferus* is therefore a "cousin" and not a direct ancestor of the Bactrian camel.

Domestication occurred for Bactrian camel between 5,000 and 6,000 years ago, likely in an area more western than previously thought, toward Uzbekistan and present West Kazakhstan, rather than toward Mongolia. The name "Bactrian" comes from a region (former kingdom conquered by Alexander the Great) located between Afghanistan, Iran, and Kazakhstan (Burger et al., 2019). The domestication of the dromedary would be more recent (3,000–4,000 years) and likely occurred in the south-east of the Arabian Peninsula (current Sultanate of Oman, United Arab Emirates, and southern Saudi Arabia) (Fitak et al., 2020). According to current data, large camelids are therefore among the last large species domesticated by humans (Figure 1).

Thus, the population of Bactrian and dromedary camels in the process of domestication was limited to a relatively small geographical area, Central Asia for the former, South of the

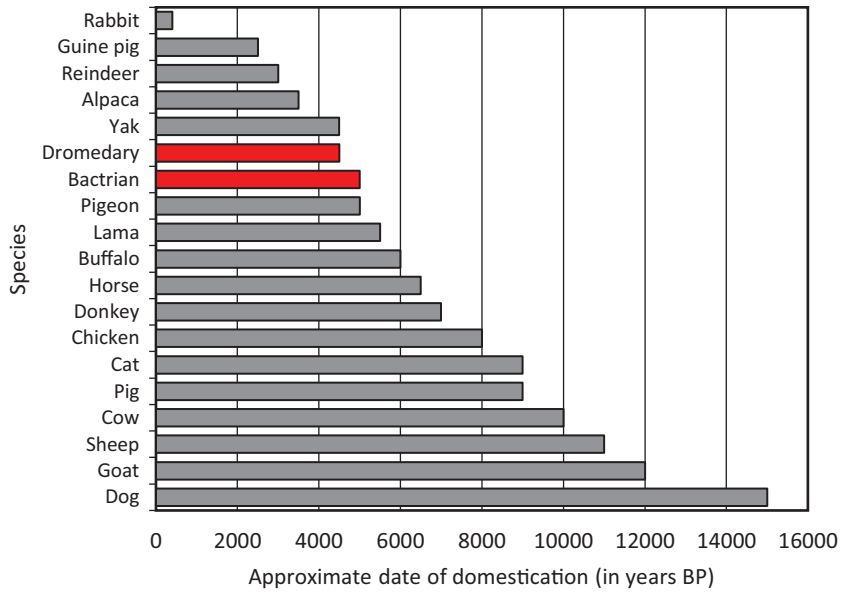

Figure 1. Approximate dates of domestication of animals (retrieved from https://fr.mahnazmezon.com/articles/science/animal-domestication-table-of-dates-and-places.html).

Arabian Peninsula for the latter. This implies a total separation of the two species that were domesticated in the Asian space. Indeed, the camelid family expanded long after domestication with the creation of crossbreeds and hybrids. Crossbreeding between dromedaries and Bactrian camels was practiced all along the trade routes of the Asian continent ("Silk Roads"), and the new animal combined the strength of the Bactrian and the endurance of the dromedary, necessary qualities in caravan travel. Crossbreeding is popular nowadays to obtain females that produce more milk than their parents and are higher in fat by heterosis effect (Faye and Konuspayeva, 2012). Such practice is common in Kazakhstan for dairy production and in Turkey for wrestling (Dioli, 2020), a very popular cultural event in Anatolia.

Crossbreeding is still common today. Different breeding schemes occur, depending on whether the male is a dromedary or Bactrian camel at different generations, leading to a range of crossbreeds distinguished by a more or less subdivided large hump on the back and fur distribution (Figure 2).

In addition, true intertribal hybridization has occurred with the crossing between a dromedary and lama at an experimental farm. It led to a sterile animal named the *cama* (Skidmore et al., 2002). However, the expansion of camelid family by crossbreeding requires previously an expansion of the geographical distribution of each species. This expansion was linked to desertification, war, and trade.

The First Migrations of the Domestic Large Camelids

The two species of domestic camel were known and described by the ancient Greek and Roman thinkers of the time: Aeschylus, Herodotus, Aristotle, or Pliny (Agut-Labordère and Redon, 2020). As early as the first century before Christian Era (BC), the Romans readily distinguished the camel, a pack animal devoted to the transport of goods, from the dromedary, a saddle animal used by the Roman meharists (i.e., using camel as riding animal). Formally, the word "dromedary" designated only racing or riding camels, and the word "camel" was for pack camels. The words did not distinguish between the two species with one hump (now called the dromedary) and two humps (Bactrian), both being camels. However, the migration of the dromedary to the African continent started earlier than the Roman empire.

Camel and desertification

The introduction of the dromedary camel in the Egyptian desert is attested during the first millennium BC but was limited to commercial incursions for carrying goods from the Arabian Peninsula. Its presence increased from the 5th century BC accompanied a significant increase in activity on desert roads, improving the capacities of the caravans formerly reliant on donkeys and mules. Through their presence, the dromedaries boosted the relationships between the Eastern Desert of Egypt to the Nile Valley and beyond, cementing ties between the Asian and African world (Agut-Labordère and Redon, 2020). According to some historical sources, the introduction of the dromedary camel in Egypt through the Sinai Peninsula is probably linked to the Assyrian invaders from the beginning of the 7th century BC and to Persian invaders in the region at the end of the 6th century BC. But in all cases, the dromedary camels were in the hands of the Arab tribes (Barnard, 2012).

At the same time, the Sahara became arid (the aridity started around 3900 BC), leading to a favorable environment for the

Figure 2. Crossbreed dromedary*Bactrian for wrestling in Turkey (Photo: Bernard Faye).

camel (Jung et al., 2004). The presence of the dromedary camel in the western Egyptian desert occurred since the end of the 5th century BC. Yet, access to camels in central part of the Sahara appeared slightly before the Roman Empire, as documented by petroglyphs in the Libyan desert. Thus, from the Arabian Peninsula, Near-East and Egypt, the dromedary camel started its expansion into the Sahara alongside desertification.

Regarding the Bactrian camel, its presence was documented since the 4th millennium BC outside its cradle in Central Asia, reaching the Iranian plateau and the city of Sumer at the end of the IIIrd millennium BC where probably the first crossbreeding with the dromedary occurred (Fitak et al., 2020). The Bactrian camel was depicted in Assyria (actual North Iraq) on an obelisk dated 825 BC, attesting to the history of the double-humped camel in the Near-East. The presence of the Bactrian camel was also documented in Mongolian petroglyphs dating from 2,000 to 3,000 BC and in Western China over 1,000 BC (Yam and Khomeiri, 2015).

Finally, at the beginning of the Christian era, dromedary and Bactrian camels occupied already most of the arid lands of the Old World in Africa and Asia, from Mauritania to Western China, with an incursion in the European part of the Roman Empire, up to Germany (Pigière and Henrotay, 2012).

Camels and war

If the geographical expansion of the camel accompanied desertification, the mobility of the camel herds was linked mainly to war and trade. The use of camels as riding and pack animals is probably as old as their domestication, as evidenced by petroglyphs in Saudi Arabia or Mongolia (Figure 3).

These two functions (packing and riding) are highly useful for a mobile army. Sumerian frescoes, dating from 2000 BC, show raids from the current north of Saudi Arabia toward the Tigre and Euphrates valleys, conducted by Arab tribes mounted on camels. The camel in war is not only used for carrying the fighters but also for the transportation of goods intended for the army: forages for the horses, weapons, and all types of military supplies. In antiquity, camels were also regularly represented on frescoes, in cases of victory, both as booty and as a means of taking away the furniture loot. Dromedary camels participated in many military campaigns in Egypt, notably in the 6–5th centuries BC, supported by the Persians and the Assyrians, with the support of the Arab tribes (Cousin, 2020). Later, during the Arab conquest, the dromedary camel accompanied the Arab troops through the north of Africa to Spain (Insoll, 1996). The use of camels for war led even Napoléon Bonaparte, in collaboration with Desaix, to create a dromedary camel regiment during his Egypt campaign in 1799 (Cvikel and Goren, 2008). Such military activities continue today through the "Meharist companies" and other "camel corps" maintained in desert countries, even if the advent of 4 × 4 vehicles tends to limit the interest of such units in modern conflicts (Wilson, 2016).

These military campaigns allowed for the expansion of camels through arid lands of the Old World, away from where animals were domesticated; however, these main routes for invasion followed pre-established trade routes.

Camel and trade

The use of large camelids as pack animals along trade routes is probably as old as domestication, particularly in the Arabian Peninsula, the cradle of the domestic dromedary. The legend of the Queen of Sheba, for example, likely symbolizes the birth of trade, with caravans from the Kingdom of Sheba (present-day Yemen) taking gold and spices to the land of Solomon (present-day Israel) and returning south, loaded with olive oil

Figure 3. Petroglyphs showing people hunting antelope on Bactrian camel back (Alashan desert, Inner Mongolia, China) (Photo: Bernard Faye).

and grain. There is sufficient archeological evidence confirming the presence of trade routes in the Peninsula from the 12th century BC (Finkelstein, 1988) called the "incense roads," unifying the south of Arabia to Mediterranean Sea and Mesopotamia thanks to caravans of dromedaries. Bactrian camels and probably hybrids (crossbred dromedary*Bactrian) were widely involved in the "Silk Road" unifying the Far-East (China) and Europe (Frankopan, 2015).

After the migration of dromedary in the north of Africa accompanying the Islamic conversion of West Africa (7–8th centuries after Christian Era) many trans-Saharan trade routes contributed to the link between the north and south margins of Sahara, justifying the camel's nickname of "ship of desert," given by the Arab people. Trade routes occurred between the western desert from modern Morocco, contributing to the development of oases like Sigilmassa to the Niger Bend and to the development of Timbuktu (Lightfoot and Miller, 1996). Other routes from Tunisia to the Lake Chad area, from the east of the Fezzan to Lake Chad, or from the Nile Valley in present Sudan to Egypt fueled the expansion of the dromedary all over arid lands of northern Africa.

Thus, dromedary and Bactrian camels contributed to territorial connectivity. They moved huge quantities of wealth over thousands of kilometers from the Chinese Empire to the Roman Empire. As they crossed, the camels opened the region up to oases, water points, and nomads. Despite the current use of trucks, camel caravans still operate across short distances. They are also used today to transport nonperishable products, such as salt or dried cereals, in very remote places, or in some cases, manufactured products of contraband.

Trade routes have opened new territories for the animal, contributing notably to cross-continental dispersal of camel genes (Almathen et al., 2016).

Camel and Current Climatic Changes

Historically, camels have moved along trade routes and been raised in dedicated "caravanserais" operations, rather than living at established farms (Faye et al., 2017). The camel farming systems established in the between-oasis space were based on the mobility of the herds (nomadism or transhumance). However, this tradition is changing today under pressure from climatic changes and the globalization of the world economy. Indeed, since the droughts that struck Sahelian countries beginning in the 1960s, we have witnessed an expansion of the dromedary camel distribution area, including the southern part of countries as Mali, Niger, and Chad, but also neighboring countries as Senegal, Burkina Faso, Nigeria, Cameroon, and even Tanzania and Uganda (Faye et al., 2012; Wilson, 2017). In mountainous countries, such as Ethiopia, camels have expanded into higher altitudes in just the last 20 years, and the altitude limit of camel farming expanded from 1,500 m in the 1980s to 2,000 m today (Tefera and Abebe, 2012; Wilson, 2020). Even in equatorial countries, such as Uganda, camels are now used to secure their farming systems facing recurrent droughts (Asiimwe et al., 2020) contributing to an increase in the local camel population to more than 40,000 heads.

Overall, the boundary for camel farming expansion in Sahelian Africa has migrated southwards over more than 500 km in 30 years (Faye, 2020). This expansion appears not only linked to the movement of camel herds usually present in northern part of the Sahelian countries and reared by nomadic people, but also to the "adoption" of the camel by former cattle-breeders as the Peul in West Africa and Maasai in East Africa, that is, by "ethnic transfer" (Faye et al., 2012). The integration of camels in those new territories can be illustrated by a five-fold increase in camels in Sahelian countries since 1961 (Figure 4).

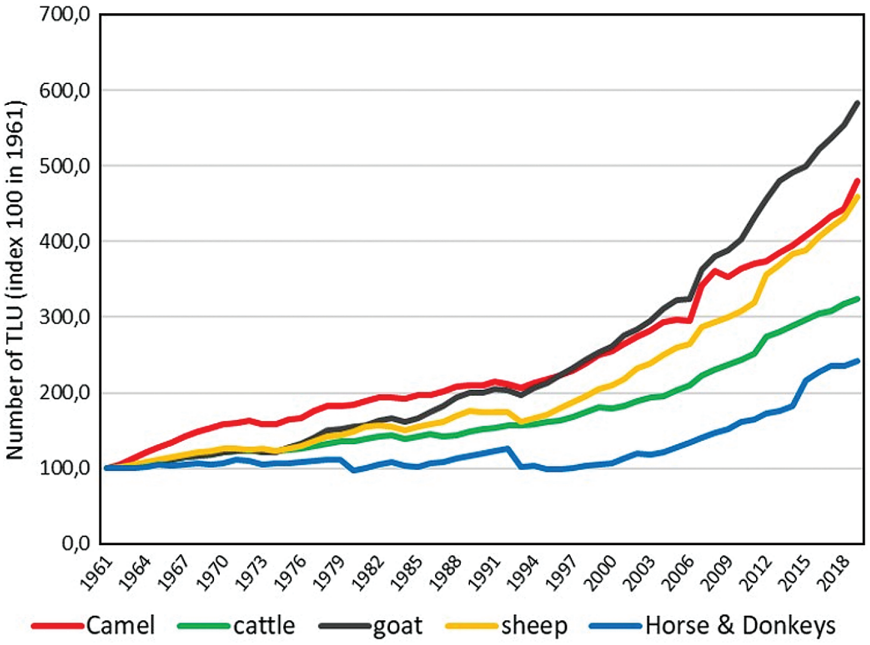

Figure 4. Changes in Tropical Livestock Units (TLU) index per species in West, Middle, and Eastern Africa 1961–2019 (calculated from FAOSTAT, 2021).

The Large Camelids Today: Demography and Biodiversity

Except in India, where the decline of the camel population has continued since the 1970s (Faye, 2020), camel herds around the world have grown at a regular pace for the last 20 years. This includes the Bactrian camel (Faye, 2020). Since 1961, the world camel population has multiplied by 2.9, while it has only increased ×1.6 for cattle. Even in countries experiencing a decline of their camel herd in the 20th century (e.g., China, Turkey, and Central Asian republics), the has been a renewed interest in camel breeding in recent decades. Nowadays, with (source: FAOSTAT, 2022) more than 38.5 million heads (likely an underestimate) the world's camel population represents only 2.4% of the Tropical Livestock Units (TLU).

Due to the high mobility of camels through history, and to the animal's many uses, the selection for specialized traits has only been slightly effective. Roughly, different camel ecotypes are distinguished by their size, their global conformation, their environment, and their coat color. Several investigations, mainly based on morphological measurements, have identified some "breeds," but these are not necessarily confirmed by genotyping studies (Abdussamad et al., 2015). A low anthropogenic selection pressure associated with geographical mixing over a large region has led to a level of phenotypic variability mostly linked to different ecotypes rather than breeds. The domestic camel population has a relatively low structural genetic variability (Burger et al., 2019). Although it was proven that two main genotypes originating from the Arabia Peninsula led to all dromedary camels in the world (Almathen et al., 2016), trans-continental and trans-Saharan trading routes have facilitated gene exchanges leading to a panmictic population at the mitochondrial level (Burger et al., 2019). In Asia, camel movements along commercial routes contributed also to evident admixture between domestic Bactrian camels and dromedaries living in Central Asia, notably in Iran, Kazakhstan, and Russia (Ming et al., 2020). However, thanks to current genome-wide analyses on properly classified populations based on their phenotypes and performances, it might be possible to identify distinct groups and contribute to the emergence of true camel breeds with specialized functions (Al-Abri and Faye, 2019). However, camel biodiversity could also be affected by the new locations of the species.

New Locations

There is a history of importing camels to far-flung places, such as the Canary Islands, Australia, and Southern Africa (Faye, 2020). Camel was introduced to the Canary Islands as a draught animals in the 14th century (Wilson and Gutierrez, 2015), and brought to Australia as working animals in the 19th century (Jones and Kenny, 2010). Although most of this Australian population became feral, there are new efforts to raise them for meat and milk (Fallon et al., 2020).

In the desert of southern Africa, the dromedary camel was introduced also in the 19th century in Namibia by German troops, then later after independence for tourism attractions in some safari parks or commercial farms in Botswana and neighboring countries (Seifu et al., 2019). In Asia, Bangladesh joined the camel countries in 2004 with the opening of a camel dairy farm in Dacca (see https://www.dhakatribune.com/bangladesh/2016/09/12/first-ever-camel-farm, and Wilson, 2019).

However, the most surprising recent introductions have been in the western countries where the environment does not favor a desert animals. Of course, the presence of camel in Europe for agricultural or commercial activities was already established

Figure 5. New camel dairy farm in France (Photo: Bernard Faye).

during the Roman Empire, as mentioned above, and later in the Middle-age in the Southern part of the continent (Spain, France, and Italy), but camels were later limited to zoological gardens and circuses. It was only in the last 30 years that camel farms, including for dairy production, were established in different European countries, such as Sweden, Poland, the Netherlands, Germany, Switzerland, Spain, Italy, and France (Figure 5). Notably, Smits Farm in The Netherlands was the first camel dairy farm implemented in Europe (Smits and Montety, 2009), contributing to the diversification of agriculture activity.

In the United States, the first camels were imported in 1701 by a slave trader, but the first important shipments occurred in the middle of the 19th century for military use in the desert states of the country (Baum, 2011). Today, around 3,000 camels live on private farms as tourist attractions and for dairy production. A consortium of camel dairy farmers sells camel milk and milk products on their online platform "desertfarms" for national and international consumers (https://desertfarms.com) contributing to the rise of the camel milk market all over the world (Konuspayeva et al., 2021).

Camel, Political Conflicts, and Diplomacy

Many recent conflicts in the world have occurred in camel countries (e.g., Western Sahara, Libya, Mali, Niger, Nigeria, Sudan, Ethiopia, Somalia, Yemen, Syria, and Afghanistan among others). These conflicts do not seem affect camel demography but could have indirect impact on the movement and migration of cameleers with their herds, for example from Somalia to Kenya. This migration could contribute to the boosting of the camel dairy industry in Nairobi and other large Kenyan towns (Anderson et al., 2012). Also, after the diplomatic crisis between Qatar and Saudi Arabia in 2020, around 12,000 camels were forced to trek back to Qatar after the Saudi authorities rejected their presence in pastures beyond the borders between the two countries (see https://foreignpolicy.com/2017/06/20/saudi-arabia-deports-qatari-camels-gulf-diplomacy/). Insecurity in some parts of Western and Northern Africa (Mali, Niger Nigeria, Libya) contributes to significant changes in the live camel export routes, as for example from Chad to Libya, forcing the merchants to convey thousand camels to Egypt, passing by Sudan for the meat market. Similar changes occur in the export routes between Niger and Chad as producers must avoid areas occupied by the jihadist group Bokoharam (see https://2009-2017.state.gov/p/af/rls/rm/2016/252357.htm).

Despite being displaced by conflict, camels have had a role in diplomacy. One of the most fervent defenders of diplomacy by the camel was the former president Muammar Ghaddafi of Libya, who brought camels to the many heads of state in the world, from South Africa to Peru (Wilson, 2013). One could mention also the camel given by the president of Mali to the French President François Hollande after the French military operation against a jihadist group in 2013, even if the animal was later consumed in Mali (see https://www.nytimes.com/2013/04/10/world/europe/hollandes-camel-a-gift-from-mali-becomes-tagine.html).

Camels and New Identities: A Camel for the Weekend?

The image of the large camelids is still ambivalent. A camel can be regarded as an animal of the past in search of modernity, often between "marginalization and idealization"

Figure 6. A camel herd for the weekend in Saudi Arabia (Photo: Bernard Faye).

(Faye and Brey, 2005). Traditionally, the link between man and camel is strongly imbued with a deep and sincere emotional relationship as they face hardships together in extreme environments. But in their original cradle, are dromedaries and Bactrians still "ships of the desert?" Nowadays, the deserts of Arabia and the Middle East are crisscrossed by highways and the Bedouin ride 4 × 4 vehicles. Lines of trucks have replaced caravans to transport goods from one city to another.

The "oil boom" in the States of the Gulf region could have led to the decline of the camel population, especially since this economic boom resulted in rampant urbanization (between 1961 and 2018, the proportion of urban dwellers in the total Saudi population increased from 32% to 84%). Yet, despite the competition with the truck and its low-cost fuel, the number of "desert ships" has continued to grow. That is because the camel has found other ways of development (dairy farms, feed-lots, races, and beauty contests). Despite this evolution, the camel remains an emblematic animal. Printed on the banknotes of most desert countries, the camel's statues are present in public squares or at the entrances of cities—as any totem animal would be. In fact, the camel is seen as a central element of Bedouin culture and, as such, it is the object if not of veneration, at least of special consideration.

Beyond the image of an animal allowing the man of the desert to be in harmony with his environment (Breulmann et al., 2007), the dromedary is a central element of the Bedouin, nomadic, rural identity. Although now urban dwellers, many Arabs in the Gulf or other countries spend weekends in tents among the camels that they still possess under the care of a shepherd often of foreign nationality (Figure 6) (Faye, 2016).

Even depending on the comfort of cities, the urban dweller of the Middle East recognizes himself in camel breeding. The dromedary is part of his roots, sometimes of his youth or that of his parents or family members. Under the veneer of urbanity, there is a barely sleeping cameleer always ready to spend time in the desert. In Saudi Arabia, these weekend cameleers, more or less integrated into the market, represent nearly a third of the camel farms (Abdallah and Faye, 2013).

Conclusion

Thus, the continuous expansion of the large camelids that we are witnessing is not only a matter of geography but also of purpose. Less and less "ship of the desert," the camel appropriates productive functions (milk, meat, wool) more important than before and especially more modernized, while maintaining its links with the men of the desert, even if they settle in solid houses. Starting from the Arabian Peninsula and Central Asia, large camelids have gradually conquered all the deserts of the Old World and have now found more comfortable latitudes in terms of food and water resources. The enthusiasm that we are expressing today for the animal and its products may well expand its conquest of the world. However, such an expansion of the species also raises questions for managers and researchers concerning the adaptation of this species in these new ecological and economic contexts.

Conflict of interest statement. None declared.

About the Author

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Bernard Faye, veterinarian, specialized in tropical veterinary medicine, PhD Paris University and HDR Montpellier University. Stayed in Africa for 8 years (Ethiopia, Niger) for research and development activities (1975–1983) before joining the National Institute of Agricultural Research (INRA) as director of the Ecopathology Laboratory. Joined CIRAD (Centre for International Cooperation in Agricultural Research for Development) as Head of Animal Productions Program (1996), then as Scientific project manager (2007). Starting interest in camels in Ethiopia in 1975, studying mineral metabolism. Gradually, through his multiple research programs in cooperation and his international network of camel scientists (North, Western and Horn of Africa, Middle-East, India, Central Asia, Latin America), he founded the International Society for Research and Development on Camelids (ISOCARD). At present chairman of ISOCARD and vice-chairman of the French Federation of camelids farming. From 2010 to 2015, working in Saudi Arabia as an FAO consultant in a camel research center. At present, emeritus researcher at CIRAD and independent international camel expert. Author of more than 450 scientific publications, 340 communications in national and international conferences, 45 books and chapters in book, 210 technical reports, and 12 scientific editions. **Corresponding author**: bjfaye50@gmail.com

Website: http://camelides.cirad.fr and http://www.isocard.net

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