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Combating Desertification: The Added Value of the Camel Farming

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Abstract: The combating desertification generally involves water management, sustainable development of crops or control of land degradation. The camel, the most adapted domestic animal to desert conditions, contributes also to combat desertification. By its thirst resistance, its feeding behavior, its digestive physiology and anatomical features, it can survive in the desert region. As multipurpose animal, it allows the desert milieu to provide milk, meat, wool and power in harsh conditions, contributing to consider the desert also as a producing milieu. Moreover, the camel products like milk and meat could be valorized on local or international market. The camel farming systems in future have to integrate all these aspects not only to combat desertification, but also for a sustainable development of the desert.

Key words: Camel, milk, meat, combat desertification, market.

The desert science, named "eremology" (Monod, 1992), has highly changed with the international concern on desertification process throughout the world. Arid areas involved 35% of the emerged lands on the earth. Today, many scientists pay attention to the desert as a complex ecosystem. The desert includes two types of resources (poor resources, but perennial and abundant resources in case of rain, but episodic), so the strategies of desert animal fall into this ambivalent situation. The flexibility and the elasticity are the main animal behavior that make them adapted to desert conditions. The camel is given less importance in combating desertification, which is focused mainly on water resources conservation, soil regeneration, adapted crops to drought or shrub plantation in the arid lands. Yet, the camel could play a pivotal role in the sustainable development of the desert ecosystem and overall in combating desertification (Faye, 2005).

Indeed, the camel, the most important animal domesticated by the mankind in desert ecosystem, is directly confronted to one of the hot-spot regarding the livestock-environment interaction (Steinfeld *et al*., 1999), i.e. the desertification process. It is currently admitted that the camel, being well adapted to such arid environment, is an "environment-friendly" animal and the camel farming system is a low environmental pressure activity (Raziq *et al*., 2008). Yet, the current changes in the camel farming systems are modifying the traditional relationships between the camel and their environment (Faye *et al*., 2012a). Such evolutions have to be taken in consideration to identify the challenges for future development of the camel farming at the global level.

In the present paper, three crucial aspects regarding the place of camel in combating desertification and consequently in sustainable development of desert ecosystems are taken in account: (i) the stakes of the camel to combat desertification, (ii) the added value of the camel for the animal production in arid lands, and (iii) the potential for the economical valorization of the camel production in the desert.

The Camel, an Element to Combat Desertification

The camel is remarkable for its physiological, anatomical and behavioral adaptations. This animal has developed physiological mechanisms for resisting thirst, heat and food insufficiency as well as protein, energy and minerals deficiencies. It has developed in harsh conditions some remarkable physiological abilities which contribute to its reputation. All these features lead to the conclusion that the camel is the main domestic animal able to contribute to combating desertification (Stiles, 1988). Some of those characteristics concerned with the adaptation to desert environment are discussed.

The resistance to the thirst

For the large public, the thirst resistance of the camel is proverbial. The adaptation of

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camel to dehydration tolerance is due to its anatomical characteristics and physiological mechanisms entirely responsible for its survival in environments with poor spatial distribution of water resources. In case of dehydration, the camel develops physiological systems to economize on water through two main mechanisms: (i) decrease of the water loss by decreasing urine excretion, stopping the sweating, slowing down the basal metabolism, varying the body temperature according to the external temperature, and (ii) maintenance of the homeostasis by limiting the variation of the vital blood parameters and by excreting efficiently the metabolic wastes (Bengoumi and Faye, 2002).

This ability has two consequences: (i) the adaptation to water deficits, which makes the reputation of the dromedary also explain why it is one of the domestic species which did not leave its ecosystem of origin except for some import in Europe or North America; (ii) the camel being able to stay several days without drinking water, it can use rangelands far away from the water points, and thus decrease the pressure around them, contrary to cattle and small ruminants that are unable to stay more than 2 days without drinking water and leading to an overgrazing around the water points and sometimes to diseases as botulism (Brown, 2006).

An environment-friendly feeding behavior

The camel has a different feeding behavior than the other ruminants. It is a browser rather than a grazer, and it was observed that it can graze a wide variety of plants (Fig. 1) than the other ruminants (except goat) leading to a lower pressure on the floristic biodiversity of the arid lands (Rutagwenda *et al*., 1990). Moreover, due to its special anatomy (long neck), the camel is able to graze at different levels in the pasture ecosystems, from grass to trees with a limited overgrazing (Faye and Tisserand, 1989). Camel can spend more than 8 hours in pasture according to the pastoral resources density. When it grazes during hot day, it would prefer to eat the leaves of trees like *Acacia* up to 3.5 m height for staying under the shade (Fig. 2). Moreover, thanks to its very flexible tongue, it is able to reach the leaves without damaging the branches.

In extensive zone, the camel can move at 1-2 km h^{-1} for grazing. It practices an "ambulatory grazing". But even in case of abundant grasses (after a rain for example), it does not lose the habit to move regularly. Thus, it will consume few grasses in one place consequently, the carrying capacity of a camel herd is evenly distributed in grazing area (Richard, 1985). In a determined milieu, the camel would select the plants richer in salt or in nitrogen, drawing the best part from the poor nutritive rangelands. The camel can consume 2 to 3 kg of forage per hour in favorable season, while in dry season intake may be 1.0 to 1.5 kg. With a comparable metabolic weight, the camel dry matter intake is 20 to 40% less than that of the cow. The camel

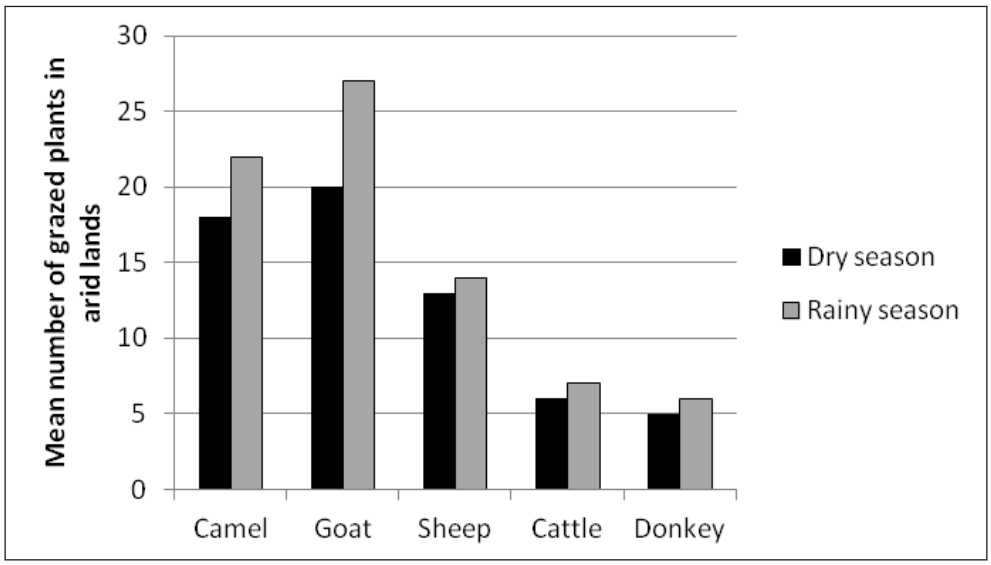

Fig. 1. Mean number of grazed plants in arid lands by different species of domestic ruminants (from Rutagwenda et al., 1990).

in rangelands has a low gregarious instinct, contrary to other ruminants. That makes its guarding difficult, but contributes again to a rational use of pastoral zones by limiting local overgrazing.

A Digestive Physiology Adapted to Low Nutritive Resources

The digestive physiology of the camel is entirely turned to the valorization of poor nutritive resources. It has been mentioned above, its tolerance to salt and consequently, its ability to eat halophyte plants, which are unpalatable for the other herbivores (Yagil, 1985). Based on this capacity, it has been suggested to raise fodder under saline water irrigation (Breulmann *et al*., 2007). Many digestive features, as the ruminal flora, the nitrogen recycling or the slow transit (Al-Jassim and Hogan, 2012) allow the camel to increase the ratio of forage consumed and production by a better forage use efficiency than other ruminants. Even though the microbial population is qualitatively the same, the cellulolytic activity of the bacteria is much more important in the camel forestomach and the retention time of solid particles in the forestomach is much longer. The evolution of these two parameters is responsible for a better digestion of organic matter and of the cellulosic fractions of the diet. Due to better buffered digesta, the addition of large amounts of starch to a forage-based diet has no negative effects on microbial cellulolysis usually observed in ruminants. Furthermore, camels excrete less nitrogen in the urine and efficiently recycle urea via the mucous wall of the forestomach. This economy of nitrogen allows them to maintain a minimal production of microbial proteins when dietary nitrogen is insufficient. As a consequence, the digestibility in camel is 4 to 5% more efficient than in other ruminants receiving the same diet (Jouany, 2000). Furthermore, thanks to the slower transit of feeds in the digestive tract of camel, the seeds rejected in the feces could increase their germinating power better than for other ruminants in arid lands and promote the spread and regeneration of the desert plants (Trabelsi *et al*., 2012). It is facilitated by the ambulatory behavior of the camel in rangelands.

All these physiological features contribute for a better valorization of the arid lands characterized by forage of low nutritive quality and a better resistance to face the climatic changes marked by regular droughts (Faye *et al*., 2012c). In the recent drought in the Horn of Africa, it was observed that farmers who had switched their camel flock to cattle flock had lower capacity to cope with the crisis. Most of the cattle died, but camels not only survived, but continued to provide marketable produce to the farmers in spite of the food shortage (Bonnet and Faye, 2000).

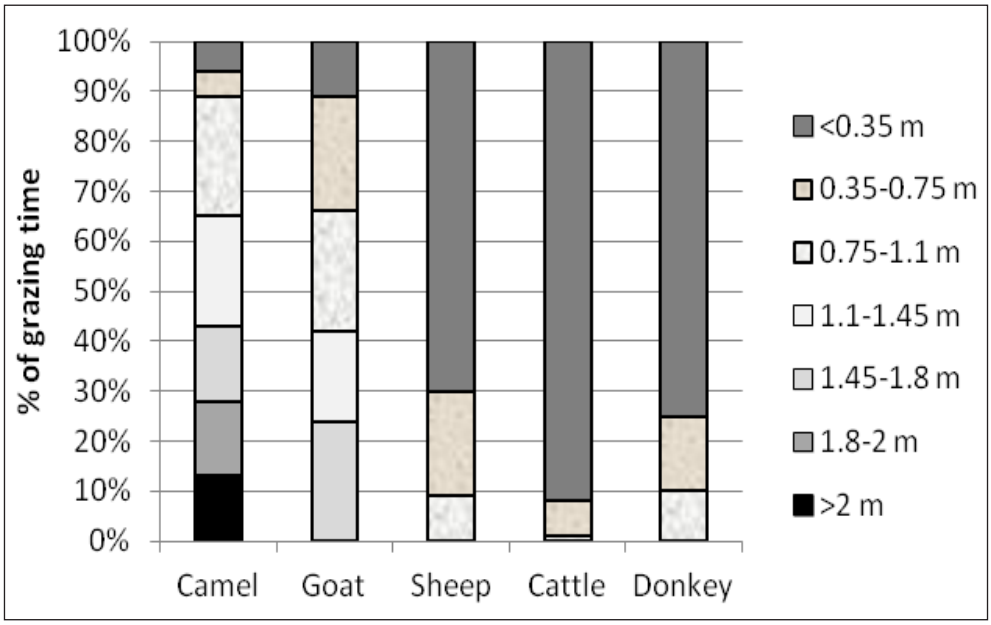

Fig. 2. Percentage of grazing time according to the height of vegetation for domestic ruminants in arid lands.

Finally, as the camel is adapted to less frequent watering, able to move and take resources with caution, and also because it has soft feet devoid of hoof, provoking a less aggressive walking for the soil compared to herbivores with hooves, the overgrazing is rarely observed in traditional camel farming system. In consequence also, in spite of the low level of desert resources, the camel is able to produce under harsh conditions by protecting its environment.

The Desert Productivity: The Added Value of the Camel

The camel is able to provide livelihood in the desert ecosystem. The economic evaluation of the camel rearing in the desert is important. Indeed, traditionally used as pack or riding animal, the camel is also a milk and meat producer, as well as an auxiliary of the farmers for various farm operations. Recently, in the Sahelian countries a diversification of the camel use has been observed for example for ploughing, which is already common in India and Pakistan (Rathore, 1986), and other farm activities (ploughing, harrowing, seeding, etc.). These activities have become very common even in regions where camel was not traditionally used by the farmers (Vias *et al*., 2004). The extent of drought in such countries has contributed to the expansion of the area under camel farms. This shows the role of camel in the ability to maintain rural activities in poor ecosystem and to increase, not only the animal productivity in the desert, but also the agricultural activities in the desert regions. Regarding two main productions, milk and meat, according to FAO statistics, the camel annually provides at global level 1,720,000 t of milk and 356,000 t of meat, i.e. less than 1% of the total milk and meat produced in the world. However, in some arid countries of the Horn of Africa or Near-East, the camel productions could represent up to 10% of the animal production (Fig. 3).

Milk productivity

Regarding milk production, in some arid countries, camel milk parlours are emerging around big cities in order to satisfy the growing urban demand for camel milk. For example, in Niger, around Agadez, or in Mauritania, around Nouakchott, small or large dairy plants have motivated dairy camel farming by collecting camel milk in nomadic camps (Faye *et al*., 2003). The estimates of milk yield in camel, available in the literature, mention the milk yield within lactation or in a year. In most of the cases, the authors did not specify if the yield includes the part consumed by the young camel, which represents about 40 to 75% of the milk produced. Last, the number of milkings may change according to the circumstances and the producer's habit, and could have an effect on the whole production. So, a high variability

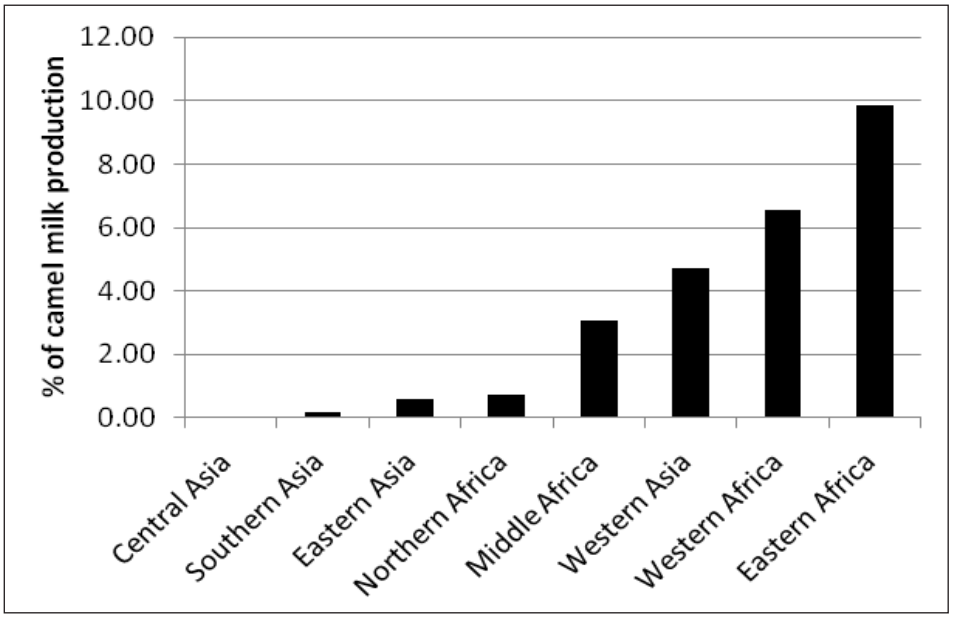

Fig. 3. Part of the camel milk (in %) in the total milk production in different regions of the world (Faye and Bonnet, 2012).

exists in the literature, and comparisons are not easy (Faye, 2008). Globally in Northern Africa, the milk production at lactation level varies between 320 to 4000 L (Faye, 2008). Similar results are reported in camel farming from the Horn of Africa (Schwartz, 1992; Zeleke, 2012) and from Western Africa (Chaibou and Faye, 2003; Saley and Steinmetz, 1998). Higher milk production are reported in Middle East, Central and Southern Asia with extreme values between 650 and more than 12000 L. The Dromedary camels have better milk potential than Bactrian camel (Konuspayeva *et al*., 2008). In India and Pakistan, milk yield between 2000 and 6000 L were reported (Khanna, 1986). Especially in Pakistan on an average milk yield of Punjabi camel is reported to be 4260 L (Khan and Iqbal, 2001) and even more (Raziq *et al*., 2008).

In Near-East and Middle East, especially in the Gulf countries, where intensive camel farming occurs, the milk productivity is higher. For example, in Kuwait, a good, a medium and a poor camel dairy farm in 350 days can produce 9030, 3185 and 805 L milk, respectively (Ibnoaf, 1987). In Emirates, in intensively managed camel dairy farm, having more than 300 lactating camels, the total milk production is reported to be more than 3000 L per lactation (Nagy *et al*., 2013). In Saudi Arabia, some camel breeds (like Majaheem) are known for their high yield potential producing, up to 5000 L per lactation (Almutairi *et al*., 2010).

In Central Asia dromedary Arvana breed could produce up to 5400 L per lactation (Cherzekov and Saparov, 2005). Yagil *et al*. (1998) asserted that yield up to 8200 L, even 12000 L in intensive conditions is possible. Bactrian camels seem to have a lower milk potential. The average milk yield of these camels is only 800 to 1200 L. In China, the total lactation yield varies between 500 and 1254 L (Faye, 2008).

Thus, the productivity potential of camel seems higher than for cow in similar climatic and feeding conditions. In Ethiopia for example, *Afar* pastoralists which rear cattle and camel simultaneously, got an average daily milk yield of 1.0-1.5 L with *Afar* cow and 4-5 L for *Dankali* camel. According to Schwartz and Dioli (1992) in the Horn of Africa, the milk productivity related to live weight of the animal was higher in camel (250 kg/Tropical Livestock Unit/year) than in small ruminant (220 kg) and Zebu cattle (100 kg). On an average, camel is among the high yield dairy animals (Fig. 4).

Meat productivity

In spite of the marginal place of camel meat at the global level (0.13% only), this production increased at a rate of 2.8% from 1961 to 2009. During the same time, the mean camel carcass weight at the global level increased from 180 to 200 kg indicating either a slight increase of the meat productivity, or an increase of the mean age at slaughtering. In consequence, the camel meat production increased at global level, both due to the higher slaughtering rate and to the mean weight of the carcasses (Faye and Bonnet, 2012). Moreover, contrary to camel milk, which is confined to local market, camel meat is available in regional markets. However, the export is mainly achieved through live animals

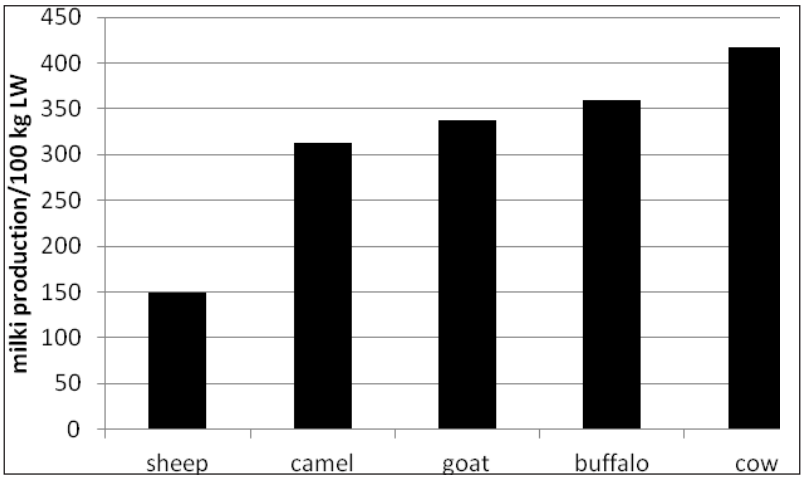

Fig. 4. Milk productivity average (in l/100 kg life weight) of different dairy species (based on world population).

rather than carcasses. The main camel exporting countries are in the Horn of Africa and in Sahel, while the importing countries are mainly the Gulf States and Northern Africa.

Globally, the camel farming systems are not very well organized to ensure regular camel meat supply. However, there is a traditional (and efficient) farming system for fattening camels in pastoral areas of Eastern Africa (Somalia, Ethiopia, Djibouti, Sudan), but intensive feed-lots are not yet well developed, except in some parts of Northern Africa. For example in Tunisia fattening camel calves workshops are now encouraged to reach quickly a body weight of 250 kg at slaughtering to meet the camel meat demand (Khorchani *et al*., 2005). However, in many cases, camel meat is rather a by-product of the dairy production. Pastoral system is still the most common way for camel meat production. The regional market is sometimes disturbed by health concerns such as the ban by Saudi Arabia (one of the main importing country) after the Rift Valley Fever outbreak in Ethiopia and Somalia in the year 2000 (Aklilu and Catley, 2011). However, the modernization of the camel production for supplying more meat, especially for growing urbanized market is on the way, and the export of camel stock to satisfy this market at regional level has a high opportunity for developing pastoral camel farming systems in the Sub-Saharan countries.

Moreover, due to its expected dietetic quality (Kadim *et al*., 2008), the camel meat could have a preference, especially in well-educated urban middle classes. Moreover, under changing climate and desertification in some countries, the camel production would increase and more area might come under camel farming. And finally, the extensive farming system could guarantee the production of environment-friendly meat. Thus, the conditions exist for an increasing contribution of camel in the meat supply at world level. However, this progress will be possible only with an improvement of the meat productivity which is low in this species compared to the other domestic animals. Such development requires an efficient market, a better control of veterinary services and a better communication on the dietetic and nutritive quality of camel meat (Faye, 2012).

However, the role of camel in the desert is not limited to their primary production. Combating desertification doesn't regard only the ability of desert to deal with "zootechnical productivity" (Chaibou and Faye, 2005), but also with the ability of camel producers to market their produce.

The Desert Valorization: The Added Value to Camel Produce

The camel is the main domestic species which helps human survival in desert conditions. Camel is considered to balance between the milieu (the desert or arid lands), the available resources (poor but usable for camel production) and the human economy and wellbeing. It is an essential element of the pastoral ecology and economy. In some countries, it is also a source of tourist attraction and desert discover. However, the camel products like milk, meat and wool are self-consumed in most of the cases. For example, in Saudi Arabia, the part of self-consumed camel milk is estimated to be 61% (Faye *et al*., 2012b). In consequence, camel rearing was poorly integrated to market. The growing urbanization and the increased demand for camel products from consumers less connected to Bedouin life have precipitated the market development for the camel products, especially milk, which was formerly regarded as a gift for the visitors.

The market integration of the camel products

Nowadays, widely appreciated for human consumption, camel milk and meat could be commercially promoted, especially in urban areas. The "multi-purpose" camel (Hjort af Ornas and Ali-Hussein, 1993) is a guarantee for valorizing the products of the desert. However, the increasing integration of camel rearing into market has to take in account the consequences of this development on the environment and social organization of camel production. The camel has obviously good stakes regarding the quality of its products. Camel milk and camel milk products like fermented milk are acknowledged for their dietetic and even medicinal properties (Konuspayeva *et al*., 2004). The fermented milk as *shubat* (Kazakhstan), *gariss* (Sudan) or *zrig* (Mauritania) are appreciated for their probiotic virtues. The valorization on the local or regional market is linked to the desert, as the cheese "caravane" promoted by the dairy plant in Mauritania. Camel meat is also known to provide high quality protein with low cholesterol content to

the consumers (Kadim *et al*., 2008). Moreover, considerable efforts have been made for preparing new milk and meat products (Farah and Fisher, 2004; Konuspayeva *et al*., 2012). Due to the supposed or proved benefits of the camel products, their prices in the market are generally high. The camel productions appear rather profitable, although the hygienic conditions could be improved in many cases (Eberlein, 2007). In several countries, camel dairy plants are being installed, contributing to the emergence of powerful value chain leading to a rational organization of camel milk producers, to the integration of camel sector in the national livestock economy, and to the development of a distributors' network (Abeiderrahmane, 1997). In Central Asia and in Middle-East, fermented and pasteurized camel milk and camel meat are available in supermarkets.

The camel meat market is regional and lead to important flow of live camel stock, especially from the Sub-Saharan countries and Horn of Africa to northern Africa and Arabian Peninsula as mentioned above. So, the pattern for camel meat economy appears different than for milk, which remains integrated into local market only. The sustainability of such market is dependent on two main aspects: the security and the health constraints. The camel stock market for export is widely "informal" (no official declaration) and if the commodity channel is well organized, the economical importance of this market is not well known (Aklilu and Catley, 2011). This lack of official implementation contributes to the insecurity all along the trade routes, especially in countries where local conflicts occur (especially in the Horn of Africa). Regarding health aspect, disease is of particular concern when camels are forced to live outside their natural habitat. In many countries, the veterinary services are poor to prevent or manage camel diseases. Mange, trypanosomosis, plant poisoning or tick infestations are common. Emerging diseases provoking high mortality are also regularly described (Faye *et al*., 2012c; Roger *et al*., 2000). Because of the increased risk of transboundary diseases in camel, the World Animal Health Organization (OIE) in Paris has constituted one ad-hoc group of experts on camel diseases for establishing rules and standards (nomenclature of diseases, diagnosis kits, references lab, etc).

Those specific products could be proposed in international market for their nutritional value addition. Anyway, this international valorization needs at first recognition by the international standard organization based on the characterization of the milk products and production mode of camel products.

The Social Dimension of the Camel in the Desert Societies

The social role of camel in the nomadic way of life and beyond in all the pastoralists' societies from Africa, Central Asia and Middle-East is widely undermined by the scientists and development agencies. As for other livestock in low input systems, camel is a symbol of the social prestige of the owners, a capital for ensuring the well-being of their family, and, due to its remarkable resistance to drought, a security face to the climatic changes as it was observed in Sahelian countries (Faye *et al*., 2012c). Its role in the securization of the pastoralist systems is making it happen by the shift from cattle to camel in farming systems confronted to the aridification of the milieu, even among traditional cattle breeders like *Wodaâbe* in Niger or *Massaï* in Kenya (Potkanski, 1999). Because of its longevity and low reproductive performance compared to small ruminants rather regarded as "coin purse", the camel is really the long-term capital for the nomadic family. Thus, it contributes to the poverty alleviation by (i) the food security (it can provide milk and meat for self consumption), (ii) the securization of the long-term capital, (iii) the contribution to the diversification of the incomes in livestock systems including a multi-activity of the family, (iv) the ability to be included in market economy at local or regional level, and (v) the contribution to solidarity network among the pastoralists (Faye, 2009).

In spite of the constraints to the production in harsh conditions, the consumption of camel products could be an important part of the human nutrition (Fig. 5 and 6).

Moreover, the "traditional life" in the desert is regarded as a "harmonious, symbiotic relationship with the environment" (Breulmann *et al*., 2007), the pastoralists managing their fragile rangelands without over-exploiting them (Olsvig-Whittaker *et al*., 2006). This proximity to the nature including the emotional links with the camels could be maintained in spite of the changes in the farming systems to intensification (biotechnology of the reproduction, irrigated production of feedstuffs, milking machine, feed-lots). In spite of the new

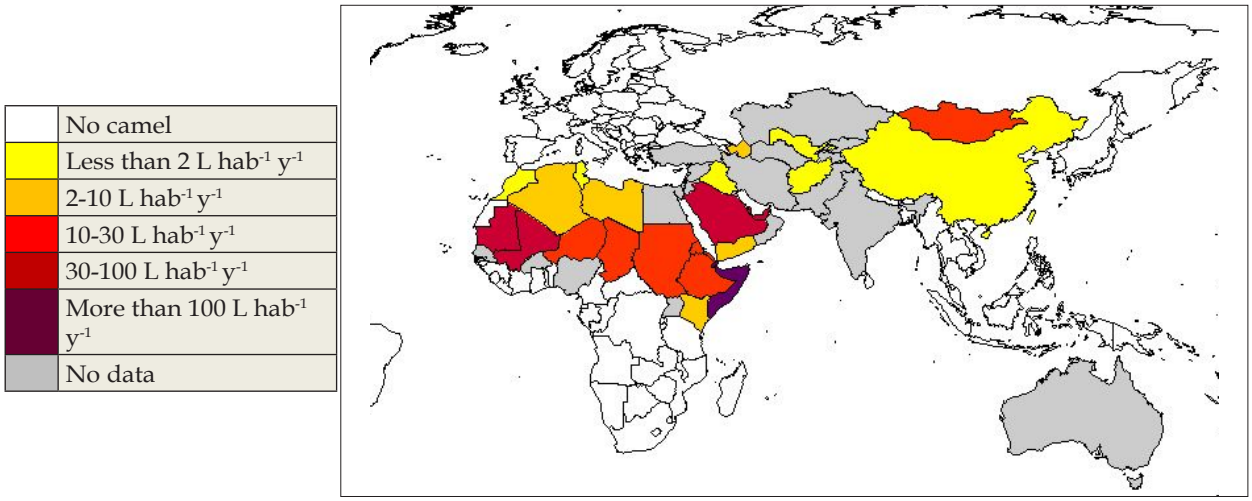

Fig. 5. Camel milk consumption (in L hab^{-1} year^{-1}) in the world (Faye and Bonnet, 2012).

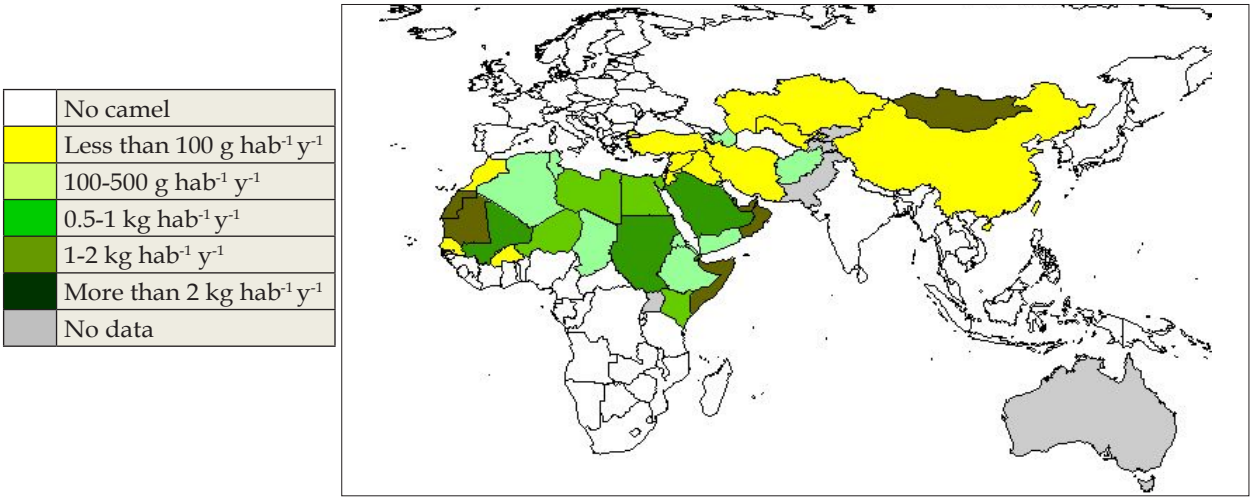

Fig. 6. Camel meat consumption (in kg hab^{-1} year^{-1}) in the world (Faye and Bonnet, 2012).

standard of life developed in Middle-East, the search for the quality of life, by passing for example the week-end under the Bedouin tent surrounded by the camel herd, is still expected by the recently urbanized people. The challenge of the new camel farming systems based on the intensification of the management and production would be to maintain this relationship.

Conclusion

In combating desertification, the place of the camel is stated at three levels: first by its anatomical and physiological characteristics which contribute to the use of the desert milieu without excessive pressure if the camel demography is controlled properly; second, because thanks to camel, it is possible to regard the desert as a producing zone, especially animal protein of high quality for local consumers; and third, because the camel products not only milk, meat but also wool and power, could be valorized in local, regional or international markets contributing to the valorization of the desert areas of the world. Thus, the desertification combat has to contribute to the promotion of the camel sector because the camel farming is one important component of the sustainable development of arid lands. New camel farming systems could emerge by proposing products with high added values in term of quality and of economical interest for a market more and more sensitive to the ecological conditions of production.

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