The Therapeutic, Nutritional and Cosmetic Properties of Donkey Milk

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CHAPTER ONE

DONKEY ORIGIN AND DOMESTICATION

Since their earliest domestication about 10,000 years ago, donkeys have been very important for humans (Bough, 2017); this animal has been a help and a companion because it shows great tolerance for hard work, has a strong resistance to disease and requires little looking after. The donkey is an animal strictly correlated to human history; it is possible to find texts mentioning the donkey in literature, in religious books, and in mythology poems. Because they are stoic, slow and sometimes stubborn, donkeys have been considered lacking in intelligence. Throughout human history, the donkey has been there, sometimes revered, sometimes reviled or ridiculed and all too often misunderstood, mistreated or neglected. Donkeys have been a constant presence since the earliest human societies formed. Their greatest use to humans has been as beasts of burden, from ancient Egypt to present-day Africa, bearing every conceivable commodity on their backs or pulled in small carts.

Rock art from ancient Egypt dated to 6000 BC shows wild asses being hunted while later (3000 BC) rock art shows domesticated donkeys transporting goods on their backs, working with humans. Genetic studies have demonstrated that donkeys as we know them today are descended from two lineages of domesticated asses in northeast Africa (Beja-Pereira et al., 2004). Other recent zooarchaeological findings confirmed the theory that the modern domestic donkey (*Equus asinus*) derived from the wild African ass in north-eastern Africa around 6,000 years ago (Kimura et al., 2013). The two subspecies of the wild African ass (*Equus africanus*) are the Nubian ass (*Equus africanus africanus*) and the Somali ass (*Equus africanus somaliensis*). Both asses are still alive today but are critically endangered. The Somali ass is taller, greyish in colour and is characterized by the strong dark stripes on its long legs. In the last two decades, the Somali ass population has decreased by 90%; despite this dramatic loss, they still manage to survive in the wild areas of Somalia, Eritrea and Ethiopia.

The process of donkey domestication is still not completely known but donkeys were most likely first domesticated by ancient cattle herders because of the climatic changes, with lands becoming more arid and rainfall more unpredictable. They have probably been domesticated several times by different groups of herders, while interbreeding between wild and domestic asses has continued throughout the entire domestication process (Kimura et al., 2013). Donkeys were bred as food-producing animals for both meat and milk production but their main use was related to transporting goods. Donkey domestication represents a crucial step in human history, creating a new phase in human populations moving from a sedentary lifestyle to a new society with an economy based on trade.

In the fertile Nile Valley in Egypt, domesticated donkeys were used for all domestic and farming purposes. They were in fact involved in transporting materials for construction sites, goods, food, etc. Close to Cairo, in the archaeological site El-Omary, a predynastic Maadi site in Upper Egypt, the archaeologists found the earliest domesticated donkey bones, dated to approximately 4600–4000 BC, while in the site of Abydos, ten complete donkey skeletons were discovered; the estimated date was around 3000 BC (Rossel et al., 2008). Donkeys were buried in the best area of the north cemetery, confirming that the donkeys were highly considered, as is also indicated by the fact that they were buried close to Egyptian kings in their burial chambers.

The donkey was domesticated before the horse and the camel, and because of their ability to work and survive in hard semi-desert conditions, donkeys greatly contributed to the development of early trade and helped in the formation of more complex civilisations. Donkeys played an important role in all areas of business at that time, transporting foods, opening new routes connecting Egypt with Sudan, Ethiopia and the trading cities of the Middle East, and then from the Middle East they travelled along important trading routes to other regions of the world. At that time Damascus was called “The City of the Asses” because this is wherethe trading and swapping of donkeys took place; traders and herdsmen used to meet along the caravan routes originating from Damascus. Strangely, knowledge about the domestication, spread and use of donkeys is still limited: their arrival in Spain from Africa and from there to other countries in Europe is still not completely understood.

The spread of donkeys in Africa

According to archaeological findings, it is possible to state that donkeys were in use in Egypt about 3000 years BC, then they spread into the Middle East, Sudan and, later, southern Kenya/northern Tanzania and central Sahara; in all of these contexts, donkeys, together with other domesticated animal species such as bovine and caprine, were associated with human populations (Mitchell, 2017). It is not clear why other species of domestic livestock moved and expanded toward southern Africa during the last centuries BC but donkeys remained behind in north-east Africa. Species such as bovine, ovine and caprine all arrived in southern Africa by passing through the woodland savannas of miombo in south-central Africa (Gifford-Gonzalez, 2000).

The African wild ass, considered the donkey's ancestor, still survives but its subspecies are considered critically endangered. In fact, the Nubian wild ass is now probably extinct while the total number of Somali wild asses has decreased dramatically, with a few surviving only in the Denkalia Desert of Eritrea and the Danakil Desert of Ethiopia (Kugler et al., 2008). Also, the third subspecies, the Atlas wild ass (*Equus africanus atlanticus*), was present in the Maghreb area during the Roman age but is now extinct. Other equid species originated in the eastern, south-central and southern regions of sub-Saharan Africa: Grévy's zebra (*E. grevyi*) in the semi-arid grasslands of Ethiopia and northern Kenya; the plains zebra (*E. quagga*) from south Kenya and South Africa; and the mountain zebra (*E. zebra*) in the western and eastern provinces of South Africa and Namibia.

When domesticated equids moved to the regions south of the Sahara and the Horn, with which they were not familiar, they came into contact with pathogens they had never come across before, as was the case also for bovines (Gifford-Gonzalez, 2000) and dogs (Mitchell, 2015). The susceptibility of domestic horses to diseases originating in the regions south of the Sahara has been investigated in depth; in particular, the expansion of horses in South Africa was dramatically impacted by trypanosomiasis and African horse sickness (Swart, 2010). The same or similar diseases probably affected the expansion of donkeys too.

Trypanosomiasis

More than 30 mammal taxa, including humans and wild and domestic animals, are affected by sleeping sickness; this insect-borne disease has been very well investigated in Africa. The responsible agents are parasitic protozoa of the genus Trypanosoma that are spread mainly by different species of the tsetse fly (*Glossina spp.*); other blood-eating flies (haematophagous) and Trictonid bugs are also involved as vectors of other species (Uilenberg, 1998). Bovines are the preferred target for the tsetse fly (Radostits et al., 2007) even though it is well known that horses are also severely affected by the disease (Namangala & Odongo, 2014). Donkeys are not resistant to this disease either and can register a high mortality rate after being infected. In fact, donkeys, particularly in some regions of Africa (such as southwestern Burkina Faso), show higher frequencies of the disease compared to bovines (Sow et al., 2014).

Three species of Trypanosoma have been identified as the cause of infection in African donkeys:

- *T. congolense*
- *T. vivax*
- *T. brucei*

The most common vectors for the three trypanosomes are represented by *Glossina spp*., currently spread between 14° N and 29° S of the equator. These vectors find the best conditions for their reproduction in the shady bush environment while the mammals living in those areas represent their most common animal hosts. Tsetse-borne infections in donkeys have been investigated. A trypanosomiasis infection rate of 21% has been determined in southern Ethiopia (Kanchula & Abebe, 1997); the rate was very similar to that documented in the same area for horses. *Trypanosoma vivax* was the most common agent in both species.

In another clinical trial performed by Assefa & Abebe (2001), the most common agent of infection was *T. congolense*, as previously determined in other countries such as Kenya and the Gambia (Mattioli et al., 1994). The cited studies basically found that donkeys are greatly susceptible to *Trypanosoma spp*., with the consequent severe diseases caused by that infection (Getachew et al., 2016) and a significantly shorter life expectancy in cases of diffused tsetse/trypanosomiasis infestation (Sow et al., 2014). In Kenya's Lamu Archipelago, the most important limitation of donkey breeding is represented by trypanosomiasis (Burden et al., 2010) while in the Gambia the same infection is responsible for the high equine mortality rate, in both horses and donkeys, exceeding the foals' natality rate significantly (Faye et al., 2001).

The three trypanosomes are dangerous in different ways, even if all of them can cause anaemia, lack of well-being and a decrease in working capacity (Burden et al., 2010). Assefa & Abebe (2001) determined that the infection caused by *T. vivax* shows a milder effect compared to that caused by *T. congolense* while the infection caused by *T. brucei* seems to be the strongest for both horses and donkeys, with a consequent high level of mortality (Connor, 1994). In particular, the infection caused by *T. brucei* in some countries, such as the Gambia, is more common in donkeys than in horses (Pinchbeck et al., 2008).

Equine Piroplasmosis

In southern Africa the most dangerous infectious disease for horses is represented by equine piroplasmosis, or babesiosis (Mitchell, 2017). This disease is caused by two infectious agents, *Theileria equi* and *Babesia caballi*. The most common infection is that caused by *T. equi* but there are cases registered in the scientific literature showing that sometimes the two agents work simultaneously (Wise et al., 2013). Both are piroplasmic protozoa belonging to the same phylum (Apicomplexa) of Plasmodium, which is responsible for the well-known infectious disease malaria. Several cases of piroplasmosis have been detected in donkeys in Sudan, Ethiopia and Kenya, but other cases have been registered in horses too (Oduori et al., 2015). When the infection occurs, the clinical symptoms are more evident when the responsible agent is *T. equi* compared to *B. caballi*. The most common symptoms are weight loss, decreased appetite, anaemia, oedema, and abortion; the risks are increased for working donkeys, especially if they are overworked.

For donkeys, equine piroplasmosis has always represented the most important tick-borne disease (Kumar et al., 2009); donkeys were introduced in north-eastern South Africa in the mid-1800s and equine piroplasmosis has caused a high mortality rate in both donkeys and horses since the beginning of the twentieth-century. The results obtained in several clinical trials determined that when donkeys reach regions where equine piroplasmosis is endemic, as they have not adapted and have no resistance to this disease, they are easily infected by ticks, which leads to many deaths in their population, while other equid species such as the zebra can be considered today completely adapted to those areas.

African horse sickness

In sub-Saharan Africa, African horse sickness is endemic; the cause of this disease is a virus belonging to the family Reoviridae, usually spread by two midges of the genus Culicoides, i.e. *C. imicola* and, in southern Africa, *C. bolitinos* (Meiswinkel & Paweska, 2003). Sometimes other vectors can be involved such as mosquitoes and ticks (van Sittert et al., 2013). In the areas in which African horse sickness is widespread, such as eastern, central and southern Africa, the mortality rate is very high, close to the value of 95% (Coetzer & Guthrie, 2004). If infected by this virus, donkeys living in Africa normally display subclinical signs while donkeys living in the Middle East show a significantly high mortality rate, up to 10% (Teshome et al., 2012).

The most common natural host for African horse sickness is the zebra; where this disease is endemic, it did not cause a limitation for breeding, in contrast to the other two diseases previously described.

Donkeys in Asia

Among the Asian countries (Kugler et al., 2008) the largest number of donkeys are registered in China, followed by Pakistan, Iran, Afghanistan, Yemen, Iraq, and Uzbekistan; the Asiatic and the Himalayan donkeys are still wild species and their classification is based on their height and colour. The Food and Agriculture Organization (FAO) has reported three distinct types of Indian ass:

- Indian
- Indian wild
- Kiang

Indian wild asses are widespread in Rann of Kutch (Gujarat) while Kiang asses are popular in Sikkim and Laddakh. They are dark red-brown with white under parts and a patch behind the shoulder. Two different types of donkeys, specifically one characterized by a larger size and a second by a smaller size, are common among Indian donkeys. The colour of the larger donkeys is light grey to almost white while the colour of the smaller ones is dark grey (Bordonaro et al., 2012). In Asia, donkey breeding has three main targets: work, milk and meat production. Work is still the most important target in donkey breeding considering that in Asia these animals are still considered pack animals for transporting loads or people, and are still essential for farm economies in the internal areas of Asia, which are characterized by strong climatic conditions and mountains without proper roads for lorries or cars.

Donkeys in Europe

Donkeys started to spread into Europe probably in 2000 BC, during the Etruscan Age, passing through Morocco to arrive in both Italy and Spain. In fact, in both Spain and Italy rock paintings have been discovered, dating from 2000 BC, in which it is possible to recognize domesticated donkeys being used for agricultural work. In Greece also donkeys have been used for a long time for several kinds of work, mainly in agriculture and for transport. Since that time, donkeys have received different considerations in Europe. In some areas, donkeys were carefully bred while in others the donkey was considered an inferior animal and so received little attention (Dai et al., 2016).

Some centuries later, Romans spread the donkey further into Europe during their war campaigns: following and working with the Roman soldiers, donkeys reached the northern countries of Europe such as Hungary, Germany and Great Britain. Strangely, after the fall of the Roman Empire, donkeys disappeared again in most of the northern European countries. In contrast, the use of donkeys remained very important in agriculture in all the Mediterranean olive and wine-growing areas and, because of their surefootedness, donkeys were still being widely used until a few decades ago as pack animals in mountain areas in several European countries. During the Middle Ages, donkeys were reintroduced in Central Europe by monks and were used in agriculture, for transport and for supplying milling grains (Kugler et al., 2008).

Donkeys arrived in England with the Roman invasion of Britain in AD 43 but they were not popular in the UK until after the second half of the 16th century. In Ireland, donkeys were not common until the mid-17th century when Oliver Cromwell removed horses from that country, forcing the Irish to turn back to donkeys as working animals. In the 16th century, the Spanish conquerors introduced donkeys to the new continent of South America.

Conclusions

Even in recent years, the donkey does not often receive much esteem compared to most other livestock species; it can surely be considered still today an undervalued animal. The African wild ass is the ancestor of the current domesticated donkey; evolution took place in semi-arid environments with poor food sources and limited access to water. The donkey has been and still is used in several areas around the world for rural work (Burden & Thiemann, 2015).

Evaluating the donkey's archeozoological findings in the Pastoral Neolithic areas of East Africa, it has been established that domesticated donkeys were bred both in southwestern Kenya and in northern Tanzania starting in the first millennium BC.

Donkey diffusion from East Africa toward South Africa has been limited by several infectious diseases, particularly trypanosomiasis. During the entire pre-colonial times, the donkey was not present in South Africa; this absence can be explained by the presence of a deterrent or barrier in the lands located between South Africa and East Africa. That barrier was the donkey's susceptibility to the diseases endemic in those regions. The impact on donkeys of diseases such as trypanosomiasis, equine piroplasmosis and African horse sickness can be better evaluated in further veterinary studies, together with the study of the effects and origins of other diseases that are equally spread by insect vectors, such as equine infectious anaemia. The donkey is one of the domesticated native ungulates from Africa; for this reason, its absence from southern Africa must be further investigated in order to better understand the role of infectious diseases in this peculiarity.

The donkey cannot be considered a small horse; it is a different species, with many important differences and requirements that should be noted and appreciated. In recent years there has been renewed interest in donkeys by the scientific community involved in studying animal biodiversity, with the specific aim of preserving some donkey breeds from extinction. The exploitation of donkey milk as a functional food for human nutrition has contributed to the rediscovery of the donkey as a food-producing animal. Most of the studies performed with the aim of evaluating donkey milk quality have been carried out in Italy, even if some data are also available on the donkey milk obtained from Chinese and Balkan breeds (Martini et al., 2018). In addition, due to the increasing global spread of food allergies (Polidori et al., 2015), consumers have started looking for so-called "natural milk", characterized by good taste and useful in the treatment of some conditions such as cow's milk protein allergy (CMPA).

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CHAPTER TWO

DONKEY HUSBANDRY

The total number of donkeys all over the world is about 44 million (**Table 2.1**), mostly in developing countries (Polidori et al., 2016). The exact classification is as follows:

Kingdom: *Animalia*

Phylum: *Chordata*

Class: *Mammalia*

Order: *Perissodactyla*

Family: *Equidae*

Genus: *Equus*

Species: *Equus asinus africanus*

The scientific name for the donkey is *Equus asinus asinus* according to the principle of priority normally used for scientific names of animals; this name was determined by Linnaeus in 1758 (Orhan et al., 2012). In 2003, the International Commission on Zoological Nomenclature established that if the domestic species and wild species are considered subspecies of each other, the scientific name of the wild species has priority. This means that the proper scientific name for the donkey is *Equus africanus asinus* when it is considered a subspecies, and *Equus asinus* when it is considered a species.

Table: 2.1 World distribution of donkey population.

Continent	**Donkeys**
Asia	15,000,000
Africa	9,700,000
Middle East	9,220,000
South America - Caribbean	8,164,000
Europe	1,500,000
North America	52,000
TOTAL	**43,636,000**

Source: Bougler et al., 2005.

In the past centuries, “ass” was the most common name for the donkey. It is used in the King James version of the Christian Bible, where donkeys often play an important role, mainly in the Old Testament. Between 1784 and 1785, the term "donkey" was used for the first time. From the 18th century, the term “ass” has been gradually replaced by “donkey”, probably as the former has become a 'bad' word (Fairman, 1994). A jenny is a female ass or donkey. In Ireland, the word jennet is used for a hinny, a cross between a jenny and a stallion; this use followed Irish immigrants to North America, even though in Canada the word "jennet" is often used instead of "jenny." Another alternative name for a jenny in the past was "she-ass" while an intact donkey male is sometimes called a "jack" (Fairman, 1994).

Mules are the result of a cross between a male donkey (jack) and a female horse (mare), there are an estimated 15 million in the world; hinnies are the result of breeding between a jenny donkey and a stallion horse. In both cases, the hybrids showed better physical and mental traits when compared with the parents, according to the well-known “hybrid vigour” (Proops et al., 2009). Mules possess 63 chromosomes in their nucleus, an intermediate value between the 62 chromosomes in donkeys and 64 in horses (Osthaus et al., 2008). In **Table 2.2,** the number of chromosomes of each equine species is shown.

There is not a proper animal breed definition that can be used in all cases. From a genetic point of view, breeds are usually represented as populations of animals that share similar traits that are transmitted from generation to generation. By this definition, breeds can be considered a useful “bank” of genetic resources.

There are over 189 donkey breeds all over the world according to FAO's Domestic Animal Diversity Information System of June 2011. These breeds vary in body weight and size, ranging from 80 to 480 kg as regards body weight, and a wither height ranging between 64.2 cm of the smallest breed (Mediterranean Miniature Donkey) and 170 cm of the tallest breed (American Mammoth Jackstock).

Table 2.2: Chromosome number in the equine species.

Species	**Chromosomes**
Equus caballus (domestic horse)	64
Equus asinus (domestic donkey)	62
Equus hemionius (Asiatic wild ass)	56
Equus burchelli (plain zebra)	44
Equus grevji (imperial zebra)	46
Equus zebra (mountain zebra)	32

Source: Modified by Proops et al. (2012).

Actually, 60 breeds of donkeys are classified in Europe; the most represented are listed in **Table 2.3,** but this is not very accurate. In fact, of the 60 breeds recorded, 2 are considered extinct, 5 are synonymous, and only the past consistency is reported for 6; the consistency is reported but no description of phenotype or photos are provided for 5; and for 14, no data are reported. Finally, a more or less accurate morphologic description and updated consistency are described only for 28 breeds (Camillo et al., 2018). The following criteria have been established by the Food and Agriculture Organization of the United Nations (FAO) to classify the degree of endangerment of a breed:

- Extinct: no sires or mares for breeding remaining
- Critical: mares 100, sires 5
- Endangered: mares 1000, sires 20
- Not at risk: mares >1000, sires >20

Using these criteria on the 28 European breeds, 7 are in critical status, 20 are endangered, and only 1 is not at risk. The use of donkeys in Europe has basically four main targets: use in agriculture as working animals, use for meat and milk production, and use for social activities (pet therapy); nowadays, a new possible use is represented by their use for tourism and leisure (Camillo et al., 2018).

Table 2.3: Main donkey breeds reared in Europe.

Country	Breed	Consistency
Croatia	Littoral Dinaric	2,150
France	Ane de Provence	271
	Ane Normand	221
Italy	Ragusano	2,481
	Martina Franca	1,086
Portugal	Burro de Miranda	1,400
Spain	Catalana	957
	Zamorano-Leonés	1,338

Source: Modified by Camillo et al. (2018).

The consumption of donkey meat and, especially, milk is increasing in both developed and less developed countries even though the donkey is not widely considered as a food source. In the areas of Africa where the donkey originated – Kenya, Somalia, and Ethiopia – donkey meat consumption is more or less tolerated, depending on the local food tradition, while in some other African countries their traditional cuisine shows several courses based on donkey meat. China is the country with the highest donkey meat consumption in the world while Italy is the consumer of the most donkey meat in Europe (Polidori et al., 2015). Donkey milk is also receiving a lot of attention by the scientific community because of its nutraceutical properties, especially compared to dairy cow milk, and for its similarity with human milk chemical composition (Salimei & Fantuz, 2012; Brumini et al., 2016; Aroua et al., 2019). These nutritional characteristics contribute to the high cost of donkey milk, which is very expensive compared to the cost of dairy cow milk in many countries (Charfi et al., 2018).

Donkey digestive physiology

Vegetable fibres represent the basis of the diet for herbivore animals. Non-ruminant herbivores include a wide number of species, such as hippopotamus, hamster, horse, zebra, donkey, kangaroo, and some primates in which microbial activity happens first in a sacculated stomach ((Van Soest, 1994). Equids are considered herbivores with the ability to co-exist with bovids in tropical ecosystems like Africa. Some scientists think that the different digestive systems of equids and bovids could drive the two species to adopt different foraging systems (Hintz et al., 1978). Compared to equids, the digestive system of ruminants permits these animals to extract more digestible dry matter from medium quality forage, using a forage classification based on their fibre content. On the other hand, the equid's digestive system permits the extraction of dry matter from forages richer in fibre because the passage rate is higher in their digestive system. People working with donkeys know that although the donkey and horse are very close in the general classification, there are great differences in their physical traits and feeding behaviour (Burden & Thiemann, 2015). The ancestors of the domestic donkey used to dedicate 14 to 18 hours per day to foraging, covering distances of 20 to 30 km daily. They evolved as browsers as well as grazers, able to survive on the lignin-rich, low energy, fibrous plants they were able to find in their daily migrations (Smith & Pearson, 2005).

The donkey is a hindgut fermenter and had an evolution that permits the moving of fibrous plant materials through the gut at all times. Donkeys are more efficient at digesting nutrient-deficient fibre compared to horses. Considering a comparison between maintenance energy requirements in donkeys and horses, they are significantly lower in donkeys, with levels ranging between 50-75% of the requirements for a horse with a similar body weight (Smith & Burden, 2013). Feeding trials showed that the daily intake of dry matter per day for the donkey's maintenance is about 1.3-1.8% of their body weight. Surprisingly, donkeys are also able to accurately compensate their water intake when drinking after a period of water deprivation (Jerbi et al., 2014); the mechanism that regulates this physiological behaviour is not completely clear but it is supposed that it is related to the usually good body condition scores for a donkey even if only poor-quality feeds are available.

Donkey and horse metabolisms have never been deeply investigated and compared. Both donkeys and horses are hindgut fermenters; for this reason, they show a better glucose tolerance compared to foregut fermenters such as ruminants. Insulin sensitivity is similar in donkeys and in adult horses, having similar body condition scores; this situation is particularly interesting when donkeys are compared to adult ponies, which are generally characterized by lower levels of insulin sensitivity when compared to both donkey and adult horse groups. The energy requirements for maintenance per kilogram of body weight are higher in donkeys compared to ponies, but donkeys, in relation to their body weight, spend less energy per metre travelled compared to ponies (Smith & Burden, 2013). This greater locomotive efficiency can be explained by the larger proportion of "endurance" muscle fibres in donkey muscles; these fibres are able to use metabolic energy in a more efficient way and, compared to sprint muscle fibres, fatigue appears more slowly (Burden, 2012).

The microbial activity of the donkey gut has not been deeply investigated. One study suggested that the microbial cellulolytic activity in the caecum is higher in donkeys compared to ponies (Tisserand, 1989). Diet obviously affects gut flora; horses that have adapted to a hay diet are reported to digest fibre more efficiently than horses that have adapted to a grain diet (Smith & Burden, 2013). A better microbial adaptation would be expected in donkeys because they normally receive higher-fibre diets compared to horses.

Donkey feeding

The usual diet for donkeys is based on crop residues and mature bush grasses of reduced nutritive value because of the poor nitrogen content and the high fibre content (Pearson et al., 2001). In order to determine the intake of nutrients donkeys can receive from both poor- and good-quality forages, it is necessary to determine their feed consumption and their digestive process when they receive feeds *ad libitum* and when they receive a restricted ration. Donkeys consume less dry matter per day compared to ponies when they receive moderate or poor-quality roughage diets, meadow hay and barley straw, respectively (Pearson & Merritt, 1991). Consequently, the passage of digesta in donkeys' gastrointestinal tract is slower, so donkeys show a higher apparent digestibility of both organic matter and fibre fractions compared to that determined in ponies. The better apparent digestibility of nutrients by donkeys when they receive forage diets compared with nutrient digestibility in ponies permit donkeys to compensate very positively for their reduced feed intake (Pearson et al., 2001). Donkeys normally show a "ruminant-like" behaviour, with long feed retention times in the gastrointestinal tract, reduced feed intakes and better apparent digestibility of nutrients. In a bad situation, characterized by a limited forage supply, donkeys normally show better efficacy in adsorbing available nutrients compared to ponies (Janis, 1976).

During the winter or pregnancy and the following lactation period, donkeys may require dietary supplementation with hay or haylage in order to receive extra energy. Hay or haylage for donkeys must be chosen carefully and must be different to forages prepared for horses and other livestock; in fact, if forages are too rich, they can create in donkeys a dietary upset or laminitis. It is more convenient to give late-cut hay or haylage, high in fibre and low in sugar, to donkeys. When late-cut hay is not available, high fibre haylage can be used because sugar levels have been reduced through partial fermentation. During the last three months of pregnancy and, later, during the first three months of lactation, donkeys should receive ad libitum hay or haylage (Chiofalo et al., 2005).

During the lactation period, donkeys show a small but quite constant daily production (Polidori et al., 2009; Chiofalo, 2011). Production level is influenced by several aspects, such as lactation stage, milking technique, presence of the foal, and the foaling season (Salimei et al., 2004; D’Alessandro & Martemucci, 2012). In particular, during milking, the presence of a foal and the stage of lactation influence milk fat and protein content, while lactose content is normally constant during lactation with no relationship with donkey breed, milking time and stage of lactation (Guo et al., 2007; Alabiso et al., 2009).

Donkey's production system

Extensive system

Donkeys are allowed to graze freely throughout the day in the fields, drinking and resting when and where they desire. This is basically synonymous with grazing in the wild where a donkey’s behaviour is related to the season and resource availability. It is well known that donkeys can survive on a very poor diet without clinical or metabolic disorders and are tolerant of a number of infectious pathogens and pests that cause clinical diseases in ruminants and mycotic infections that are prevalent in the tropics. Even though donkeys belong to the same family, equids, colic is not as frequent as in horses (Orhan et al., 2012). Extensive systems are very common in tropics, particularly in harsh conditions.

Mixed and small-case system

Donkeys are still represented as a small number of working animals for small-holder rural dwellers; they are basically used as pack animals (Yilmaz et al., 2013). Donkeys are kept mainly for draught and transport in a free-range system, periodically alternating resting periods with specialized tasking. These systems are diffused throughout sub-Saharan Africa.

Semi-intensive system

The feeding system of donkeys is based on daily grazing and some limited supplemental feeding in the late evening; animals spend part of the day on the field and the whole night in the barn. This is the typical situation in farms where donkeys have been integrated with other livestock, like dairy production in Kenya (Mattioli et al., 1994). Electric fences may be used to check and limit the grazing areas, a useful tool for pasture management strategy.

Intensive system

Also called zero grazing, the intensive system describes a certain number of stabled donkeys receiving a diet based on a mixture of forages (hay and straw principally) and concentrate foods, with a supplementation of vitamins and salts. This can be seen in dairy herds, feedlots and, simply, with the group of young animals (Moehlman, 1998). Nevertheless, under traditional management, tethering is mainly a system for isolating or confining a donkey rather than a management tool used with a peculiar production target.

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