Chapter 13
Ethnoveterinary Practices in the Maghreb

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13.1 Introduction to the Maghreb

The Maghreb is the north-westernmost region of North Africa, comprising mainly Morocco, Algeria, and Tunisia, but also Libya and Mauritania (Fig. 13.1a). However, the Maghreb is a highly diverse and complex region both geographically and historically, which makes it difficult to delimit. The origin of the term Maghreb goes back to the dawn of Islamization (late seventh century to the beginning of eighth century), when the word was used to refer to the lands of newly Islamized North Africa lying west of the Nile. The first Arab geographers and conquerors (late seventh century) used the terms *al-maghrib* or *bilad al-Maghrib* ("the sunset"), and *jazirat al-Maghrib* (the island of the sunset) to refer to the vast area occupied by the Amazigh (Berber) Bilad al-Barbar tribes (Lazhar 2015). In the Middle Ages, *al-Maghrib* continued to designate Islamized North African lands. During the French colonisation of Algeria, Tunisia and Morocco, the Maghreb referred to the well-watered regions of French North Africa, as opposed to the arid regions of the Sahara. After independence, the term was used to designate the three states

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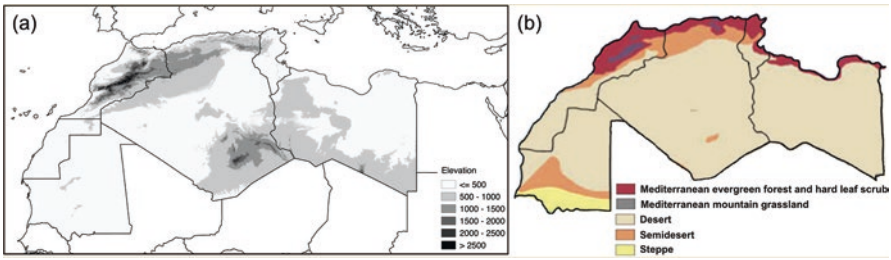

Fig. 13.1 (**a**) North African political and elevation map of Morocco, Algeria and Tunisia (Little Maghreb) as well as Libya and Mauritania (the Greater Maghreb); (**b**) vegetation types in the Maghreb. (Adapted from Wikimedia Commons)

stemming from the French colonisation: Morocco, Algeria and Tunisia. On 17 February 1989, a declaration establishing the Arab Maghreb Union (AMU) was signed in Marrakech for the purpose of economic and political complementarity by the five heads of state of Mauritania, Libya, Tunisia, Algeria and Morocco (Lazhar 2015). To avoid confusion, Morocco, Algeria and Tunisia are called Little Maghreb or simply Maghreb. The Greater Maghreb area includes Mauritania and Libya, acknowledging the geographical proximity and interconnected historical past of the five countries. If not stated otherwise, in this study we use the term Maghreb to refer to the Little Maghreb, excluding Mauritania and Libya.

13.1.1 Physical Geography

The geography of the Maghreb is characterised by the Mediterranean and Atlantic coastlines, the plains of the Atlantic facade, the mountain ranges of Atlas, Rif and Tell, the high plains and arid regions the Sahara Desert and its oases, as well as humanised landscapes including urban and peri-urban spaces (Bellakhdar 2003).

Four geographical areas can be distinguished in Morocco: The Rif, the Moroccan plateau, the Atlas (the High Atlas, the Middle Atlas and the Anti-Atlas) and the Sahara. The Rif contains mountain ranges that are located in the north of the country bordering the Mediterranean. The plateau extends from the southern borders of the Rif chain to the Middle Atlas ranges, and from the Atlantic to the West to Moulouya in the East. It has vast plains and plateaus of low or moderate altitude. The Atlas comprises three massifs: the Middle Atlas chains are oriented from South to West and from North to East, the High Atlas is an East-West barrier making North-South access difficult including the highest peak in North Africa (Djebl Toubqal, 4000 m), and the Anti-Atlas is an ancient massif extended by the Jebel Saghro and connected to the High Atlas by an ancient volcano (Jebel Siroua). Finally, Saharan Morocco is made up of vast stony *hamadas* stretching from the Atlas to Mauritania, reaching the Atlantic (Lazhar 2015).

Algeria is located between the Mediterranean Sea and the Saharan desert, and its varied natural environments are arranged from North to South. Three spaces can be distinguished: coastline, mountains and plains. The Algerian Mediterranean coast has Tellian ranges and steep reliefs that open onto marshy plains. The western Tell is marked by mild reliefs. In the north and central parts of the country, the relief is less dense with open plains leading to the sea. The eastern Tell from Algiers to Annaba is the most mountainous area. The plains are the country's most fertile lands: in the interior of the country, high plains extend up to the pre-Saharan mountains. These high plains are bordered by the Saharan Atlas that extends from West to East. Towards the South, high plateaus extend to the Saharan Atlas. The Algerian Sahara includes sand seas and mountains such as the Mzab (Lazhar 2015).

Tunisia is the easternmost of the three Maghrebi states. It is located at the junction of the eastern and western basins of the Mediterranean, with coastlines to the North and East. The country is bordered by Algeria to the West and Algeria and Libya to the South. The northern and western part of Tunisia is mountainous, which surrounds the plains in the centre of the country. The southern part of Tunisia lies within the Sahara Desert and is composed of large rocky plateaus and oriental dunes (Lazhar 2015).

13.1.2 Climate and Vegetation

The Maghreb has a varied range of climatic conditions, from humid Mediterranean to semi-arid and arid climates. Its western coast has an Atlantic climate contrasting with the humid Mediterranean climate present along the Mediterranean coastline. Towards the interior and along the mountain ranges, the Mediterranean climate is semi-arid and modified by altitude. South of the mountain ranges, which are an effective barrier between the northern and southern areas, the climate is subtropically dry and transitions from semi-arid to desert climate in the Sahara. The Saharan region is characterised by high temperatures and an absence, except in rare cases, of precipitation (Lazhar 2015). From forests to shrublands, steppes and desert dunes, local plants are adapted to the generalised dry and warm conditions (except in the higher peaks and northern coastlines that can be cooler and wetter) and a combination of Mediterranean (to a lesser extent temperate) and Saharan (but also subtropical or Sahelian) floristic elements grow in the Maghreb (Fig. 13.1b).

Vegetation in the Maghreb is rich and diverse, constituting a key resource for the local biota (Bellakhdar 2003). It is characterised by dry forests of evergreen oak (*Quercus rotundifolia* Lam.), cork oak (*Quercus suber* L.), cedar (*Cedrus atlantica* (Endl.) Manetti ex Carrière), pines (*Pinus* spp.), Mediterranean shrublands ("maquis" and "garrigues") and by steppes and grasslands (Fig. 13.1b). Vegetation is scarce in the Sahara, but present in oases and palm groves (*Phoenix dactylifera* L.). In the humid areas of the Moroccan Rif and Middle Atlas Morocco, cedar, fir (*Abies* spp.) and holm oak forests are found and grasslands are abundant in higher altitudes. The Moroccan sub-humid Atlantic area (500–800 m) is under

cultivation of cereals. The arid area of the Maghreb is covered with desert pavement (regs or *hammada*) and sand sea (ergs) (Lazhar 2015). Shrublands, originated and maintained by the degradation of forests, are by far the most diverse and species-rich ecosystems in the Maghreb, known as "maquis" when developed in siliceous soils, and "garrigues" in calcareous ones. Many aromatic plants used medicinally grow in these environments. On siliceous substrates along the Mediterranean coast, *Quercus suber* forests are common, transitioning to *Q. rotundifolia* forests in further inland domains. Various pine species also produce arboreal formations (*Pinus halepensis* Mill., *P. pinaster* subsp. *escarena* (Risso) K. Richt, *P. nigra* subsp. *salzmanii* (Dunal) Franco). In higher altitudes and wetter climates, the beautiful and characteristic *Cedrus atlantica* forests can be found as well as juniper forests (*Juniperus* spp.). Higher up, fir forests are found. In lower lands with maritime influences, *Tetraclinis articulata* (Vahl) Mast. forests are characteristic of the Maghreb while in subtropical climates, endemic argan tree (*Argania spinosa* (L.) Skeels) forests grow. Steppes are found in arid environments and usually have a low biodiversity in contrast with higher altitude grasslands. Saharan ecosystems, although being the least diverse of all, introduce interesting floristic elements to the Maghreb with various species of acacias and other subtropical and Sahelian plants (Bellakhdar 2003).

13.1.3 History and Culture in the Maghreb

Placed at a cultural crossroads, the Maghreb is a land of contact between populations of different origins. The Amazigh (Berbers) have inhabited the Maghreb since at least 10,000 BC (Ilahiane 2006), interacting with populations of the northern Sahara since early times, and later with Phoenicians, Carthaginians, Romans, Hebrews, Byzantines, and Vandals. Some of these peoples had little cultural impact on Maghrebi culture, while others settled down and their influence is still noticeable today. Since the mid-seventh century AD, a continuous movement of Arab populations arrived in the Maghreb at the dawn of Islam, bringing their religion and beliefs, traditions and know-how. However, it was only in the eleventh to thirteenth centuries that the greatest migrations from Arabia and the Middle East occurred due to the rapid growth of Bedouin tribes, who were fleeing from Arabia and Upper Egypt, spreading and settling throughout the Maghreb, from the coastal areas to the Sahara. These migrants progressively settled in desert zones, the steppes and the plains, to the detriment of the Amazigh who were pushed to occupy the inaccessible mountain regions (Bellakhdar 2003). Andalusian populations of Muslims and Jews fleeing Spain after the Iberian Peninsula was conquered by Christians, as well as sub-Saharans from Sudan brought as slaves along the trans-Saharan trade routes also settled in the Maghreb. Finally, in the fifteenth century, the arrival of the Turks from the Ottoman Empire in Algeria and Tunisia, brought Asian and Balkan blood that melted into the local human melting pot. European settlers and colonisers of the

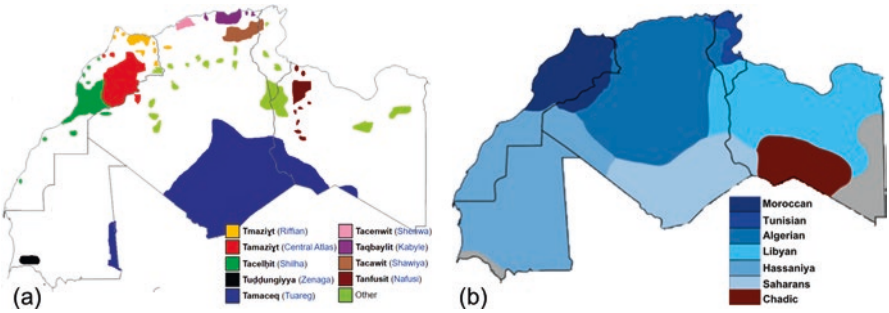

Fig. 13.2 (**a**) Amazigh languages and (**b**) Arabic dialects spoken in the Greater Maghreb. (Adapted from Wikimedia Commons)

twentieth century did not significantly mix with local populations, but their presence had an important impact on culture and lifestyles.

Whilst the Amazigh and the Arab-Islamic cultures were the most decisive elements forging the identity of the Maghreb, from this fusion of human communities an original culture was born, enriched by the multiple contributions from all civilisations that were (and still are), at one time or another in history, in contact with the Maghreb. Such cultural richness is reflected in the linguistic diversity of the region, which includes two major Afro-asiatic languages: Amazigh and Arabic (Fig. 13.2). In the Greater Maghreb, 11 of the 12 Amazigh dialects are spoken including: Tmaziɣt (Riffian), Tamaziɣt (Central Atlas), Tacelḥit (Shilha), Tuḍḍungiyya (Zenaga), Tamaceq (Touareg), Tacenwit (Shenwa), Taqbaylit (Kabyle), Tacawit (Shawiya), Tanfusit (Nafusi), Wargli and Mozabite (Fig. 13.2a). In addition, seven variants of Arabic are spoken in the region, including: Moroccan, Algerian, Tunisian, Libyan, Hassaniya, Saharans and Chadic (Fig. 13.2b).

13.1.4 Pastoral Livelihoods and Animal Husbandry

The most relevant livelihood strategies in the Maghreb include rain-fed and dryland mixed farming systems (arable and pastoral) in northern coastal regions, highland winter fall-fed mixed farming (chiefly in the Moroccan Atlas mountains), followed by semi-nomadic pastoral livelihoods and, in most southern arid regions, sparse nomadic pastoralism. Traditional livelihoods are undergoing profound changes. For example, a trend of sedentarisation is observed throughout the Maghreb, a process that has occurred over centuries. In Morocco, the number of nomads recorded in 2014 stood at 25,274 compared to 68,540 in 2004, a decrease of 63%, representing just over seven nomads per ten thousand inhabitants or 0.07% of the total population (HCP 2018). Nomadic Algerians after independence represented 10% of the population, in 1998 environs 260,000 individuals (1% of the total population)

(ONS-RGPH 1998), and in 2008 their population had diminished to little over 220,000 (ONS-RGPH 2008). Similarly, in Tunisia, nomadic livelihoods have almost disappeared. In 1860, it was estimated that nomads (approx. 600,000 people) slightly exceeded sedentary population, while currently they only represent a small percentage of the whole population (Sandron 1998).

The most important livestock species in the Maghreb are herds of sheep, goats, and camels (especially in the most arid areas), as well as cattle and poultry. According to the existing time series on husbandry stocks from 1961 to 2016 in the Maghreb (FAO 2018), sheep and goats represent by far the most dominant species. With over 25 million caprine and ovine heads in Morocco and Algeria and almost eight million in Tunisia, these are followed by bovine cattle (with a few million heads in Morocco and Algeria, and more than half a million in Tunisia). Chickens (approx. 200,000 animals in Morocco and in Algeria, and half a million in Tunisia), camels (300,000 head in Algeria and 200,000 in Morocco) and horses (200,000 head in Morocco and 50,000 in Tunisia and Algeria) are also important livestock. However, the diversity of species and proportions of domestic animals in the Maghreb have varied over time, affecting the associated ethnoveterinary knowledge. Over the last six decades, the number of Maghrebi ovine and caprine stocks have fluctuated around an annual mean average, except in Algeria, where flocks have significantly increased. For bovine cattle, Morocco and Tunisia have fluctuated slightly, while Algeria has more than doubled its numbers since 1961 (FAO 2018). The number of chickens has constantly been rising since the 1980s in all three Maghrebi countries, and increasing by 16-fold over the last six decades. In non-Saharan Morocco, stocks of horses and camels have diminished since the 1960s (FAO 2018). In Saharan regions, camels have more than tripled over the last six decades. For Algeria, stocks of camels and horses have followed opposite directions, the first increasing with time and the second diminishing, with the divergence occurring from the mid-1980s to the mid-1990s. In Tunisia, camels have had fluctuating populations over the last decades, stabilising from the 1990s onwards, while horses drastically diminished after 1980 maintaining at a low level until the present (FAO 2018).

In the Maghreb, the *beldi* and *roumi* dichotomy is used to differentiate what is local from what is foreign, and is widely used to distinguish local animal breeds (*beldi*) from animal breeds that came from elsewhere (*roumi*; Jabiot 2015). As local animal breeds are currently being replaced by more productive, but less adapted ones (Domínguez 2017), this distinction could have important implications in ethnoveterinary medicine. Foreign breeds are sought to develop new products (for example, goat cheese; Jabiot 2015) or increase meat production (Domínguez 2017). Although less productive, *beldi* breeds are considered better for human health and carry cultural meaning, as they are associated with festivities and rituals (Jabiot 2015). There is also the perception that *beldi* breeds will be healed using *beldi* or local remedies, whereas *roumi* breeds may necessitate *roumi* or biomedical therapies (Teixidor-Toneu, *pers. obs.*).

13.2 Ethnoveterinary Knowledge and Practice in the Maghreb

13.2.1 The Documentation of Ethnoveterinary Medicine in the Maghreb

Ethnoveterinary practices have scarcely been documented in the Maghreb, but dispersed information can be found in a range of academic or semi-academic works. Studies are based on fieldwork, academic literature reviews or a combination of both. The core of our literature review consists of 24 sources including 5 books, 1 master's thesis, 6 doctoral theses and 12 journal articles, published between 1926 and 2017. Most books are older sources, whereas all articles were published from 1992 to 2016. Ethnoveterinary medicine is best known in Morocco, while only very limited information exists for Algeria and Tunisia, and none for Mauritania or Libya, to the best of our knowledge. Several studies have been conducted with the Touareg and Sahrawi nomads (e.g., Benchelah et al. 2000; Volpato and Puri 2014; Volpato et al. 2013a, b, 2015) and these populations are often mentioned in regional studies (e.g., Bellakhdar 1997). Information from transhumant pastoralists – and other forms of semi-nomadism – also exists (e.g., Davis 1996; Teixidor-Toneu 2017), but it is scarce.

Articles on the ethnoveterinary medicine of Africa (McCorkle and Mathias-Mundy 1992) and the Mediterranean (Pieroni et al. 2006) provide invaluable background on the beliefs, concepts and practices of ethnoveterinary medicine in the Maghreb (McCorkle and Mathias-Mundy 1992), as well as detailed information about medicinal plants for animal health (Pieroni et al. 2006). North African medicinal plants both for human and animal health have also been documented by Boulos (1983). In Morocco, the seminal ethnographic work by Westermarck (1926) gathers much information on beliefs regarding animal health and documents many ritual treatments. The books by Bellakhdar (2003) and Benchelah et al. (2000) present studies on Maghrebi and Touareg plant use in general. Overall, the focus of these studies was either to discuss the cultural and environmental context of plant use (Bellakhdar 2003; Westermark 1926) and ethnoveterinary practice (McCorkle and Mathias-Mundy 1992), to document the range of medicinal plant diversity used (Boulos 1983; Pieroni et al. 2006) or to both provide a deep ethnographic background and document useful flora (Benchelah et al. 2000).

Two field studies (Merazi et al. 2016; Volpato et al. 2015) and a literature-based study (Viegi and Ghedira 2014) focusing on veterinary ethnopharmacology conducted in the Maghreb were identified. Information on veterinary ethnopharmacology can also be found in a doctoral thesis from the *Institut Agronomique et Vétérinaire Hassan II* (Morocco). Such studies are often based on literature (El Ghalib 2005; El Kaidi 2009; Hamdani 2011; Idrissi 2016), but some have also carried out interviews with the local population (El Ghalib 2005; Fennane 2007). These theses focus on anthelmintic (El Ghalib 2005) and antiparasitic (Idrissi 2016) plants, and on toxic

plants to animals (Fennane 2007; Hamdani 2011). Moreover, ethnoveterinary uses of plants and other products in the Maghreb are mentioned in studies that present local or regional ethnopharmacopoeias for human health, importantly, in the "traditional Moroccan pharmacopoeia" (Bellakhdar 1997). Veterinary plant uses were also identified in a doctoral thesis about medicinal plant use in the High Atlas (Teixidor-Toneu 2017), a regional study on medicinal plants (Bammi and Douira 2002), in phytochemical studies (Houmani et al. 2004; Lindborg 2008), essays on traditional ecological knowledge (Davis 1996), and even foraging and ethnomycology studies (Volpato et al. 2013a, b). We would expect ethnoveterinary plant uses to be mentioned in other studies focusing on medicinal plant use for human health, phytochemistry or traditional knowledge, but this information is scattered and not easily accessible.

13.2.2 Maghrebi Ethnoveterinary Medicine

Farmers and herders in the Maghreb have sophisticated ethnoveterinary knowledge and skills that has been maintained and transformed over generations (Davis 1996). In most African cultures including the Maghreb, concepts of health and illness apply to both animals and people, and often healers that treat humans, treat livestock too (McCorkle and Mathias-Mundy 1992). Human and animal medicine are also related regarding the therapeutic materials used, especially plants, which are often the same for animal and human health (e.g., Mathias-Mundy and McCorkle 1989; McCorkle and Mathias-Mundy 1992; Pieroni et al. 2006). As in human health, two broad aetiologies of disease are simultaneously recognised in the Maghreb, natural and supernatural causes. The former explains illness as a result of a loss of balance in the physical body, often due to an imbalance of the body humours, whereas the latter refers to the actions of sorcerers, gods, genies, evil spirits or to magical procedures (Foster 1976; McCorkle and Mathias-Mundy 1992). These beliefs are widespread in the Maghreb and determine the healing practices that will be used to treat illness (e.g., Greenwood 1981; Teixidor-Toneu et al. 2017). Contrasting with the four humours in ancient Greek medical theory, the humoral pathology in Muslim Africa identifies mainly hot and cold diseases that are treated by remedies of the opposite quality (e.g., Greenwood 1981; McCorkle and Mathias-Mundy 1992). Some of the supernatural beliefs that apply to both human and animal health include issues of sexual cleanliness and purity, or attacks and possession by jinni (Mateo Dieste 2010; Westermarck 1926). Some species may be more vulnerable to some types of illness than others depending on the animal's possession of *baraka*, the beneficial, blessing force from God (Westermarck 1926). Individual animals linked to marabout saints, and some animal species broadly, are perceived to have *baraka*. Sheep, horses and bees are some of the species believed to possess *baraka*, and are particularly sensitive to uncleanliness (Westermarck 1926). This results in differential treatment and species specific ethnoveterinary practices (Westermarck 1926).

13.3 Overview of Documented Ethnoveterinary Knowledge and Practices in the Maghreb

13.3.1 Types of Practices and Diseases Treated

Ethnoveterinary practices aim to keep animals healthy either by preventing illness or by curing it. They may use therapeutic materials, notably medicinal plants, as well as ritual and prayer, especially to local saints (Westermark 1926). Ethnoveterinary practices are also used traditionally to improve the quality of animal products such as milk and dairy products or meat. For example, in the High Atlas salt is fed to animals to increase the strength and flexibility of sheep and goats' guts, a desired quality during butchering (Teixidor-Toneu, *pers. obs.*). Illness is diagnosed in African ethnomedicine by identifying the most salient symptoms (McCorkle and Mathias-Mundy 1992). Symptoms are often the basis to classify diseases, but epidemiological and supernatural factors are also considered. Thus, local disease classifications rarely have a one-to-one correspondence with biomedical concepts. Ailments considered "supernatural" will most often be treated by ritual than those considered "natural" (Foster 1976; Westermark 1926).

A wide range of natural ailments is treated by ethnoveterinary medicine in the Maghreb, with digestive and respiratory conditions being amongst the most common. Diarrhoea and flatulence are most common amongst sheep and goats (Fennane 2007). Internal and external parasites are also commonly treated by traditional veterinary medicine (El Ghalib 2005; Idrissi 2016). In the region of Sidi Bel Abbes (Algeria), Merazi et al. (2016) reported that diarrhoea, respiratory issues, loss of weight, skin problems and musculoskeletal ailments are the most common among livestock. In camels and cows, ethnoveterinary practices exist to treat difficult delivery, external parasites and mastitis (Davis 1996). The most commonly reported camel diseases by Sahrawi populations are sarcoptic mange, dermatomycosis, respiratory infections and mastitis (Volpato et al. 2015).

According to supernatural beliefs, animals may become sick because they have transferred the disease from another person or animal, becoming ill because they were the recipient of someone else's ailment (Westermarck 1926). Animals are also vulnerable to attacks and possession from jinni, who are believed to interfere in both human and animal lives. Villot (1888 in Westermarck 1926) documented that local populations believed some jinni would only attack animals, and that sometimes whole flocks would become victims. Furthermore, sexual cleanness and menstruation of the person feeding or milking an animal is believed to affect animal health, causing disease, and ethnoveterinary practices are in place to avoid illness (Westermarck 1926).

13.3.1.1 Preventive Practices

Rational use of space, dietary prescriptions and beliefs about the supernatural world are among the most important preventive practices. Herders have in-depth knowledge about range ecology from fodder availability, grazing conditions, and the health of their herds, which they mobilise to take decisions about resource use (Davis 1996; Fig. 13.3). This is instrumental in making rational choices on how to use local resources that ultimately play an important role on the herd's health. While it is difficult to distinguish between the pharmacological and nutritional effects of some fodder plants with multiple phytochemicals that have an apparent medicinal effect (Pieroni et al. 2006), herding strategies have an impact on health by avoiding the build-up of dirt and disease agents in camps, grazing areas and water sources (McCorkle and Mathias-Mundy 1992). Specific movements of the herds can also avoid seasonal disease threats, or disease-bearing pests and wildlife, as well as being used consciously to provoke mild infections that confer immunity (McCorkle and Mathias-Mundy 1992).

Leading herds to graze the most nutritious pastures will also improve the herds' health, and dietary complements are also often given to livestock. Dietary supplementation contributes to well-nourished animals that are healthier and more resistant to parasites. For example, Ishelhi farmers in the High Atlas have specific knowledge about fattening diets that can be fed to livestock in particular moments (e.g., before selling) or life stages, such as during pregnancy (Teixidor-Toneu, *pers. obs.*). An important aspect of ensuring quality fodder resources is managing the reproduction and breeding of livestock, along with adapting the number of animal heads (Davis 1996), ultimately important implications for the herd's care.

Prevention of illness is also achieved through particular practices aimed at avoiding supernatural harm. For example, to prevent evil eye, special care and protection is granted to mares and fowls, cows and calves after birth, during set a number of days (Westermarck 1926). Other supernatural beliefs are less easily linked to the prevention of physical illness, but were widespread in the Maghreb. It is believed

Fig. 13.3 Sheep and goats grazing summer alpine pastures in the High Atlas, where transhumant movements make use of different altitude grazing areas during different times of the year. (Photo by Irene Teixidor-Toneu)

that a person giving barley to horses, mules or donkeys should be clean, and among the Andjra tribe menstruating women should not milk cows, sheep or goats, or the animal would become diseased. In parts of Morocco, it was believed that unclean people should not walk among sheep or they would die, neither visit beehives to prevent bees from becoming ill or producing small amounts of honey (Westermarck 1926). Ridden by an unclean rider, a horse will get sores on its back, which may happen to mules too even if they do not have *baraka* (Westermarck 1926). If an animal is possessed by jinni (supernatural beings), identified in the way it moves its head showing obvious signs of giddiness, it will be slaughtered to prevent the attack from spreading in the flock (Westermarck 1926).

Box 13.1 Fodder Plants and Their Role in Health: Camel Husbandry Among the Saharawi

In addition to the medicinal properties of plants, common forage plays a crucial role in animal health and reproduction. As shown by Volpato and Puri (2014) amongst Saharawis, the presence or absence of certain feed plants may significantly influence the healthy growth and development of camel herds (Fig. 13.4). Through a free-listing exercise with 46 Sahrawi (men and women), the cultural domain of *martaa lbal* ("camel forage") was described by Volpato and Puri (2014). Of the hundredth ethnotaxa belonging to 31 botanical families, the most culturally relevant species were *Acacia tortilis* (Forssk.) Hayne (Fabaceae), *Nucularia perrinii* Batt. (Amaranthaceae), *Astragalus vogelii* (Webb) Bornm. (Fabaceae), *Panicum turgidum* Forssk. (Poaceae), and *Stipagrostis plumosa* Munro ex T.Anderson (Poaceae), and the most mentioned families comprised Asteraceae and Fabaceae (with 12 species each) followed very closely by Amaranthaceae (11 species). A quarter of these species were mentioned as influencing the production of camel's milk or its flavour, while others were considered healthy when mixed with other plants, but that can create certain disorders if eaten alone (e.g., *Anabasis articulata* which causes diarrhoea and colic). Worth mentioning also are the relatively high number of species rich in salt (especially Amaranthaceae), the significance of protein rich plants (chiefly Fabaceae) and the predominance of the consumption of vegetative parts, but also in some cases of reproductive organs. Such diversity of plants and plant parts consumed, as well as if they are consumed fresh (or to a lesser extent dry) also allows for the availability of fodder for most of the year, if not all. Volpato and Puri's (2014) analysis of the camel forage free-lists indicated that nomadic experience and, to some extent, age were the most important factors underlying the differences among informants. Interestingly, men and women differed little in their knowledge scores. This research clearly shows the relevance of ethnobotanical knowledge to pastoralists, and the high number of species mentioned indicates the rich diversity of potential resources, the significance of a varied diet to cover different seasons and stages of plants, as well as the consequences of changing livelihoods in ethnobotanical knowledge.

Fig. 13.4 Camels from nomadic populations grazing in the Igourdan *agdal*, Moroccan High Atlas. (Photo by Ugo D'Ambrosio)

13.3.1.2 Curative Practices

Similarly to traditional human medicine, Maghrebi curative practices in animals range from the use of therapeutic materials (discussed below) to surgery and rituals including prayer and offerings. Internal ailments are often treated with beverages and foods, and fumigations are used for colds and other respiratory problems. The treatment of external parasites includes removal by hand when possible, driving livestock through rivers to wash them, lighting smudging fires and fumigating with medicinal plants the animals themselves, as well as the camps (McCorkle and Mathias-Mundy 1992).

Prayer and offerings to local saints were common in the early twentieth century. Westermarck (1926) observed that the Ulad Rafa tribe had two veterinary saints: Sisi Ali Stwan and Sidi Mhammed s-Snhaji. If a cow or ox died of disease, one of its shanks with the hoof was deposited at the one of the shrines to prevent the death of other animals and the promise of a sacrifice was made to the saint if this hope was fulfilled. Similarly, among the Igliwa tribe, when a flock of sheep or goats was afflicted by an epidemic, it was taken three times around the shrine of the patron saint in Aglu, and one of the animals was sacrificed (Westermarck 1926). In this way, the slaughter of an animal may serve to preserve the health of the rest of the flock.

Surgery is practiced in many African ethnoveterinary traditions to care for wounds, but also in obstetrics (McCorkle and Mathias-Mundy 1992). Both vegetable fibres and animal hairs are used to suture wounds (Davis 1996; Wolfgang and Sollod 1986). In Morocco, there are accounts of successful surgery to help cows during delivery. Davis (1996) documented the case of a female veterinary healer who made a mid-ventral incision with a knife extracting the live calf from the

labouring cow, and closing the incision with agave fibre. The Touareg from Niger can remove infected or abscessed tissue successfully (Wolfgang and Sollod 1986). Surgery is also employed to castrate animals, and this is often performed during the dry season, when there are less chances of infection (McCorkle and Mathias-Mundy 1992).

Bone setting is also common in the Maghreb and bonesetters (called *jbar*) treat animals and humans in the same fashion (Bakker 1992). In the High Atlas, subsistence sheep and goat pastoralists are all capable of treating animal fractures. Goats are more often wounded due to their climbing habits, and sometimes sheep, and rarely donkeys and mules, are also injured. Animals are taken care of at home, where they will rest for up to 3 months in the case of the most serious injuries (Ait Baskad, *pers. comm.*). Finally, another common practice in the Maghreb both in human and animal medicine is cauterisation, used to treat a broad range of ailments (McCorkle and Mathias-Mundy 1992).

13.3.2 Therapeutic Materials for Resources

In Africa, there is empirical evidence for the efficacy of over 30% of the ethnobotanical therapeutic materials for resources (Ibrahim et al. 1984; McCorkle and Mathias-Mundy 1992; Niang 1987). Medicinal plants seem to be amongst the most common, or at least best documented, means of treatment. Medicinal plants are used in the Maghreb because they are perceived as effective, easily available and free or not expensive compared to pharmaceuticals (Fennane 2007; Merazi et al. 2016). Currently, pharmaceuticals may simultaneously be used with plants. Plants are harvested from the wild or cultivated by the farmers themselves or bought raw or processed (Fennane 2007). In Tunisia, medicinal plants used for veterinary purposes are often common and easily available (Viegi and Ghedira 2014), but in southern Morocco, some pastoral nomads travel long distances to obtain specific medicinal plants to treat their livestock (Davis 1996). Herbal remedies are used internally and externally, prepared in a myriad of ways: as infusions, decoctions, powders, drops, fumes, pastes and ointments (McCorkle and Mathias-Mundy 1992). In Morocco, plants are often prepared in multi-species mixtures as infusions, decoctions and macerations and these beverages are administered to sheep and goats using a feeding bottle (Fennane 2007). For example, against ovine diarrhoea, Fennane (2007) documented the use of water with sugar or fermented milk with corn flour, and young animals are fed a beverage with powdered henna. Many preparations are used against ovine flatulence, from the use of just lemon juice, olive oil or a mixture of the two (salted or not), to more complex preparations. For example, a mixture of henna, eucalyptus and absinthe leaves is macerated in the leftover water from olive preserves and given to the animals until healing (Fennane 2007). Other practices to treat flatulence include pulling the tongue out to aid the animal eliminate gas or to pour warm water on the animal's back followed by over feeding (Fennane 2007).

Animal parts are also used for ethnoveterinary purposes. These can be used as amulets, as well as fed or applied on the sick animal. A widespread practice in Morocco is to use dried weasel (called *fart el-hil* or *ibn-'irs*) as medicine for horses and mules; it is burned and the animals are made to inhale the smoke when they have colic (Bellakhdar 1997; Westermarck 1926). A horse that has a cold can be made to inhale the smoke of the skin and bristles of a hedgehog, burned under his nose (Westermarck 1926). Among the Ulad Buaziz, a piece of camel skin was tied around the neck of a calf that had vermin troubles (Westermarck 1926).

Whilst most diseases are treated using the local products and biodiversity, commercial products are also employed, including commercial pharmaceuticals and less conventional products. Mateo Dieste recalled that in 1998 he "was in a house in a small mountain village during a wedding and a man showed up asking for a Coke. The hosts did not have any, and the man replied that a Fanta would also do, so they gave that to him. He said that it did not matter one way or the other, since it was for the donkey who had gastric problems" (*pers. comm.*).

Through a literature review we have documented 489 different ethnoveterinary medicinal uses for 183 plant species and nine fungal, animal and mineral materials. Latin plant names cited in the various sources were cross-checked with The Plant List (TPL 2013) and The Catalogue of Life (Roscov et al. 2018) to identify accepted taxa names. An overview of these results is presented, but the studies reviewed have different research aims and methodologies, which makes the information documented in them hardly comparable (Ellen and Puri 2016).

13.3.2.1 Common Ethnoveterinary Plant Families in the Maghreb

From our review, 56 plant families have been documented in total in ethnoveterinary practices in the Maghreb. The most commonly used families for ethnoveterinary purposes in the Maghreb are Asteraceae, Cupressaceae, Lamiaceae, Fabaceae and Amaranthaceae. Overall in the Mediterranean, Pieroni et al. (2006) found that the families Asteraceae, Lamiaceae, Fabaceae and Apiaceae were most commonly used for ethnoveterinary purposes. Whilst the Asteraceae, Lamiaceae and Fabaceae are always amongst the most used families for human health, not only in the Maghreb (e.g., Bouasla and Bouasla 2017; Fakchich and Elchouri 2014; Miara et al. 2018; Teixidor-Toneu et al. 2016) but also across the Mediterranean (e.g., González-Tejero et al. 2008; Rigat et al. 2007), plants from the Cupressaceae and Amaranthaceae families are not used so often to treat human diseases.

The prominence of plants from the Cupressaceae family is due to the popular use of tar (*qtran* in Arabic; Fig. 13.5) to treat various veterinary diseases, most prominently skin and intestinal issues (Boulos 1983; Bellakhdar 1997; Lindborg 2008). The three most common tar plants in the Maghreb are Cupressaceae: *Juniperus oxycedrus* L., *J. phoenicea* L. and *Tetraclinis articulata* (Vahl) Mast. (discussed below). *Juniperus thurifera* L., as well as the Pinaceae *Cedrus atlantica* (Endl.) Manetti ex Carrière, *Pinus halepensis* Mill. and *P. sylvestris* L., are less popular but also used. When Cupressaceae and Pinaceae plants are not available,

Fig. 13.5 Tar sold in the Marrakech spice market made from *Juniperus oxycedrus.* (Photo by Ugo D'Ambrosio)

plants from other families are sourced (e.g., *Acacia gummifera* Willd., *Eucalyptus globulus* Labill. and *Olea europaea* L.; Lindborg 2008).

The salience of mineral-rich species from the Amaranthaceae family is due to the well-documented husbandry and ethnoveterinary practices in the Sahara Desert where these species are abundant. Amaranthaceae plants are mostly used by Sahrawi and Touareg people as fodder and medicinal plants for camels and dromedaries (Bellakhdar 1997, 2003; Benchelah et al. 2000; Volpato and Puri 2014; Volpato et al. 2015).

13.3.2.2 Plant Species Commonly Used in Maghrebi Ethnoveterinary Medicine

One hundred and eighty-three plant species, five fungi, one animal and one mineral were documented with veterinary uses in the Maghreb. Approximately half of this diversity had been reported only once in literature sources, but several plant uses were documented across various studies. The most important ethnoveterinary plants in the Maghreb based on the variety of uses documented and number of sources documenting them are summarised below (in alphabetical order).

Acacia tortilis (Forssk.) Hayne (Fabaceae) [Syn. *Acacia raddiana* Savi].

Vernacular names: *L-herrob, talh, talha.*

Acacia tortilis is one of the most important fodder plants for camels and dromedaries, especially during hot and dry periods when few other green food sources are available (Volpato and Puri 2014). Mixed with other animal foods, Sahrawi

people give it to camels as a fattening dietary supplement (Volpato et al. 2015). The plant also has medicinal properties. In the Moroccan region of Btana, it is believed that eating this plant treats *l-gesh*, a gastrointestinal disorder in dromedaries caused by the ingestion of sand (Bellakhdar 1997) or dew (Volpato et al. 2015). Sahrawi people use it ground and applied topically to help cicatrisation and mixed with sugar and olive oil to treat diarrhoea (Volpato et al. 2015). A decoction of burned leaves or a plaster prepared with water and coal obtained from this plant's bark are used topically to treat sarcoptic mange (Volpato et al. 2015).

Allium cepa L. (Amaryllicadeae).

Vernacular names: *Besla, azalim.*

In Morocco, onion is used to treat coryza, the inflammation of the mucous membranes lining the nasal cavity, usually causing a running nose and nasal congestion, as well as eye problems among cattle and against external parasites (El Ghalib 2005; Idrissi 2016). Sahrawis use it to treat camels' post-partum prolapse, abortion, mastitis and camelpox (Volpato et al. 2015). It is also used to treat cough in camels by heating onion in oil which is then given as a dietary supplement once a day for 2 or 3 days or until the animal gets better (Volpato et al. 2015).

Allium sativum L. (Amaryllicadeae).

Vernacular names: *Thoum, toum, touma, tiskert, tissert.*

Garlic is used across North Africa and the Mediterranean for multiple purposes in veterinary medicine (Bellakhdar 1997; Boulos 1983; Pieroni et al. 2006). In Algeria, the bulbs are used mixed with olive oil against intestinal worms in cats, and in Morocco mixed with human urine as a digestive for cattle (Pieroni et al. 2006). Sahrawis use the heated or fried bulbs topically to treat post-partum prolapse and mastitis in camels (Volpato et al. 2015).

Artemisia absinthium L. (Asteraceae).

Vernacular names: *Shiba, shajrat meryem, shibat lajouz.*

Absinth is used much like the more common white wormwood (*Artemisia herba-alba*). In Morocco and Algeria, it is used to treat flatulence, intestinal worms and other gastrointestinal problems (Davis 1996; El Kaidi 2009; Pieroni et al. 2006). In the Mitidja region in Algeria, it is also believed to treat nervous diseases (Pieroni et al. 2006). It is also used against insects (El Kaidi 2009).

Artemisia herba-alba Asso (Asteraceae).

Vernacular names: *Shih,'alala, ghoreid, ifsi, tizrit, zeri, zezzeri, izeri, ifssi, abelbel, odessir.*

Artemisia herba-alba is the most important North African antihelmintic plant (Boulos 1983; Fig. 13.6), and is also commonly used for other purposes. The essential oil of white wormwood is antiseptic, and is used against parasites and insects (Boulos 1983; El Ghalib 2005; El Kaidi 2009). The plant is fed as an anthelmintic for sheep in the Algerian regions of Mitidja and Djelf (Houmani et al. 2004; Pieroni et al. 2006), and among the Aarib tribe in the south of the Draa valley, Morocco (Davis 1996). The Aarib also use it with *Peganum harmala* L. to treat lung and nasal worms by burning the two plants together as a fumigant (Davis 1996). In the area of Essaouira (Morocco) and other parts of Morocco, it is used to treat gastrointestinal problems among goats (El Ghalib 2005; Fennane 2007). Sahrawis heat

Fig. 13.6 Fresh *Artemisia herba-alba* Asso harvested in the Moroccan High Atlas. (Photo by Irene Teixidor-Toneu)

the plant with barley peels and use it topically to treat camel mastitis (Volpato et al. 2015). A decoction of the plant is fed to treat "bees' diarrhoea" and as a smudge used as an acaricide in bee hives (Pieroni et al. 2006). The meat from goats and sheep that have fed on this plant is highly appreciated in the Maghreb (Bellakhdar 2003; Fennane 2007). A saying among the Beni Guil herder tribe of the Moroccan Dahra plateau speaks of its quality as medicine and fodder "The halfa grass helps walking, the white wormwood helps fighting and the wild orache is better than barley" (Bellakhdar 2003).

Calotropis procera (Aiton) Dryand. (Apocynaceae).

Vernacular names: *'Oshar, baranbakh, kreka, kurunk, torsha, tourza, tawarza.*

The bark and latex of this plant are used across northern North Africa to treat animal lepra and scabies (Boulos 1983; Bellakhdar 1997). The Touareg mix carbon made from the wood of *Calotropis procera* with butter to treat scabies in dromedaries (Voinot 1904 in Bellakhdar 1997). In Tunisia, the bark and latex are also used to treat scabies in camels and goats (Boulos 1983). Sahrawis use it to treat mange, but also as a nutraceutical plant (Volpato et al. 2015).

Haloxylon scoparium Pomel (Amaranthaceae) [Syn. *Hammada scoparia* (Pomel) Iljin].

Vernacular names: *Rremt, remeth, assay.*

A decoction of this plant is mixed with tobacco juice to treat scabies in Morocco and Tunisia (Bellakhdar 1997; Le Floc'h 1983 in Viegi and Ghedira 2014). This is also one of the common ethnoveterinary plants for camels used among Sahrawis (Volpato et al. 2015). In the Sahara, the plant is used to treat snake bites and scorpion stings by squeezing the juice on the bite, or boiled and used as a wash (Volpato et al. 2015). To treat camel-pox and broncho-pneumonia, a fumigation with the branches is done repeatedly in front of the camel. In this disputed territory, it is also used to

treat *aulisis* (salmonellosis), *mhaz* (respiratory infections) and *buguashish* ('Kraff' disease) (Volpato et al. 2015).

Juniperus oxycedrus L. (Cupressaceae).

Vernacular names: *Taqqa, tiqqi, taga, 'ar 'ar, tamberbout.*

This plant is mostly used to produce cade oil, which is a very popular remedy in Maghrebi veterinary, as well as human medicine (Bellakhdar 1997, 2003; El Kaidi 2009; Le Floc'h 1983 in Viegi and Ghedira, 2014; Lindborg 2008; Idrissi 2016). It is used topically against scabies (Bellakhdar 1997; Idrissi 2016) and other skin diseases (Bellakhdar 1997; Le Floc'h 1983 in Viegi and Ghedira 2014; Lindborg 2008; Viegi and Ghedira 2014), as well as against insects and intestinal parasites (Idrissi 2016; Le Floc'h 1983 in Viegi and Ghedira 2014; Lindborg 2008). In the region of Ouazanne, Morocco, the fruits are macerated in alcohol together with soap powder and used internally as a digestive (Pieroni et al. 2006).

Juniperus phoenicea L. (Cupressaceae).

Vernacular names: *'Ar 'ar, ayfs, ammes.*

This plant is also used to produce tar and used in similar ways as cade oil: to treat intestinal parasites and skin diseases (Bellakhdar 1997; Lindborg 2008). In southern Morocco, treatments made of this juniper are used to treat both uterine prolapse and retained placenta (Fine 1990 in Davis 1996). In Algeria, leaves are used in decoctions to treat respiratory diseases among horses, sheep, goats and cattle (Pieroni et al. 2006), and in the region of El Haouz, Morocco, juniper is considered a good bee plant that contributes to the hives' health (Fennane 2007).

Nucularia perrinii Batt. (Amaranthaceae).

Vernacular names: *Askaf, tassak.*

This is the best fodder plant and most important salty plant for camels in Saharan regions. Sahrawis believe that it provides salt, strength and body-mass to camels and improves the quality of camel milk (Volpato and Puri 2014; Volpato et al. 2015). However, if the plant is the only pasture available to camels during the drought months, mange develops quicker (Volpato et al. 2015). As it is the case for many other salty plants, grazing this plant is believed to be an effective treatment for camels and dromedaries against *l-gesh* (gastrointestinal problems related to the ingestion of sand or dew) and *l-homsi* (a respiratory ailment; Bellakhdar 1997). In dromedaries and camels, this plant has a depurative effect (Bellakhdar 1997) and treats intestinal parasites (Volpato et al. 2015). Used as a smudge and fumigant, it treats skin ulcers from camelpox (Volpato et al. 2015). Sahrawis also use it to treat *buguashish* ('Kraff' disease) (Volpato et al. 2015).

Peganum harmala L. (Nitrariaceae).

Vernacular names: *Harmel, himhim.*

Fumigation with the seeds of *Peganum harmala* is used as a sedative for horses in the Moroccan region of El Haouz (El Kaidi 2009; Fennane 2007). They are also used to help cicatrisation of infected wounds (El Kaidi 2009). Sahrawis heat the seeds in oil and use the mixture topically to treat diseases as diverse as strokes and abscesses in camels (Volpato et al. 2015).

Ruta chalepensis L. (Rutaceae).

Vernacular names: *Fijel, aourmi, issin, zent, issel.*

This plant is used to help delivery and treat flatulence in cattle, sheep and goats (El Ghalib 2005; El Kaidi 2009; Idrissi 2016). In cattle, it is also used to treat persistent fever, and in horses to remove intestinal parasites (El Ghalib 2005; El Kaidi 2005; Idrissi 2016). It is also used against insects and worms in sheep (Idrissi 2016).

Tetraclinis articulata (Vahl) Mast. (Cupressaceae).

Vernacular names: *'Ar 'ar, azuka, imijjed.*

This Cupressaceae plant endemic from Morocco is used in similar ways to juniper species. Tar produced from old or dead wood to treat dermal diseases and skin problems, including scabies, inflamed wounds and external parasites (Bellakhdar 1997; Boulos 1983; Le Floc'h 1983 in Viegi and Ghedira 2014; Lindborg 2008). It is also used to treat internal parasites (Lindborg 2008). Sometimes tar is used in combination with cauterisation (Teixidor-Toneu, *pers. obs.*).

Thymus vulgaris L. (Lamiaceae).

Vernacular names: *Z'atra, toumss, Azouknii, tazakum, tazerkaahla.*

This plant is considered to have antiparasitic, tonic and antiseptic effects in Morocco (El Ghalib 2005; El Kaidi 2009; Idrissi 2016). A decoction of the inflorescences is used topically in cattle, goats and sheep to heal wounds, mouth and udder inflammations in the region of Ouezanne (Pieroni et al. 2006). It is also used against various gastrointestinal diseases including intestinal parasites in rabbits, to enhance digestion in cattle, and intestinal inflammations in poultry (El Ghalib 2005; El Kaidi 2009; Idrissi 2016).

Trigonella foenum-graecum L. (Fabaceae).

Vernacular names: *Helba, tifidas.*

The seeds of fenugreek are used as dietary supplements to enhance the quality of the hair of cattle, goats and sheep in Morocco and to fatten the animals before they are sold in Algeria (Pieroni et al. 2006). Sahrawis also used it as a dietary supplement for camels, but not during pregnancy, as the acidity of the seeds could cause abortion (Volpato et al. 2015). In Tunisia, the seeds are used as a purgative (Le Floc'h 1983 in Viegi and Ghedira 2014). Sahrawis also use this plant to treat diarrhoea, indigestion and colic (Volpato et al. 2015).

Box 13.2 Toxic or Medicinal? Ethnobotanical Knowledge on Seeking or Avoiding Toxic Plants

Many toxic plants are used medicinally in small quantities or topically (McCorkle and Mathias-Mundy 1992), or can be eaten as fodder (Volpato and Puri 2014). For example, Touareg populations from Niger believe ingestion of *Balanites* sp. is responsible for a disease among small ruminants with fever and jaundice as symptoms, but they use oil extracted from these plants to treat livestock skin diseases and external parasites (Wolfgang and Sollod 1986).

Toxic plants documented in the works of Fennane (2007) and Volpato and Puri (2014) belong to 24 botanical families. Whilst Asteraceae and Fabaceae are the two most prominent families with toxic, as well as medicinal plants,

Euphorbiaceae species are also commonly mentioned. In the Moroccan regions of El Houz and Essaouira, *Ricinus communis* L. (Fig. 13.7), *Gladiolus italicus* Mill., and *Eryngium ilicifolium* Lam. are plants most commonly cited as toxic when animals ingest them (Fennane 2007). *Ricinus communis* is nonetheless used by Sahrawis topically to treat strokes, mastitis and udder inflammations in camels (Volpato et al. 2015).

The accidental consumption of toxic plants can produce a loss of coordination, buccal and skin afflictions, hypersalivation, constipation, a stop of the rumination, and flatulence, sometimes followed by the death of the animal in absence of treatment. Intoxications are most common among cattle, but also among sheep and goats and to a lesser extent, camels. Herders and farmers have a deep knowledge on plant toxicology: from what ailments are the result of ingesting toxic plants, toxic quantities, and for which species, age group or sex they are toxic (McCorkle and Mathias-Mundy 1992). Adaptation of grazing patterns and avoidance of certain species when feeding animals are two of the practices that manage toxic vegetation.

Fig. 13.7 One of the most toxic plants in the region, *Ricinus communis* (High Atlas, Morocco). (Photo by Ugo D'Ambrosio)

13.4 Concluding Remarks

There is a wealth of ethnoveterinary knowledge in the Maghreb that both men and women hold. Whether there is a common cultural heritage in the Maghreb regarding ethnoveterinary medicine is not known as available evidence is scattered and barely comparable. In a comparative study across the Mediterranean, Pieroni et al. (2006) found very few shared ethnoveterinary taxa, and they concluded that there was no shared Mediterranean ethnoveterinary heritage. However, a common pool of plants was observed between Morocco and Algeria (Pieroni et al. 2006), and we have also identified similarities in beliefs, practices and plant use through our literature review.

Contrary to common claims, herders in the Maghreb have the knowledge to control the various aspects of farming practice including livestock health, and women, as well as men, participate both in the caring practices and in decision-making processes regarding livestock. In fact, women are often more knowledgeable about animal health than men (Davis 1996; Merazi et al. 2016). Davis (1996) observed that among the transhumant, camel-rearing Aarib tribe in the Draa valley (Morocco), women had better ethnoveterinary knowledge and that they performed much of the work with camel livestock, also acting as animal healers (Davis 1996). Women diagnosed and treated various animal ailments, preparing and administering the botanical treatments, as well as removing parasites, helping with new-borns and sometimes performing surgery (Davis 1996).

Whilst in much of the Mediterranean, ethnoveterinary practices may be getting lost, in the Maghreb they are still being used (Pieroni et al. 2006). Nowadays, some pastoralists and farmers use pharmaceutical, government-sponsored veterinary treatments, alongside traditional animal health care. This was already observed two decades ago in southern Morocco (Davis 1996), but it is still the case among Ishelhin transhumant pastoralists in the High Atlas (D'Ambrosio and Teixidor-Toneu, *pers. obs.*). However, ethnoveterinary practices have their limitations: the diagnosis can be inaccurate, the preparation of remedies can be inconvenient and time consuming and pharmaceuticals can be more effective than local remedies (for example, in the case of antibiotics; McCorkle and Mathias-Mundy 1992), with some authors observing that this knowledge may be lost soon (Merazi et al. 2016).

13.5 Future Directions

Ethnoveterinary medicine is a fast developing area of ethnopharmacological investigation (Heinrich et al. 2009), but there continue to be important knowledge gaps in the Maghreb. Several studies have previously noted the lack of ethnoveterinary research in the Mediterranean and North Africa. Pieroni et al. (2006) called for further work in the Mediterranean basin, but this was not achieved in the last decade. This is also the case for North Africa in general and the Maghreb in particular, as has been illustrated with our literature review. To the best of our knowledge

ethnoveterinary practices in Libya and Mauritania have never been documented. In the Little Maghreb, besides an in-depth study on camel health among the Sahrawis (i.e., Volpato and Puri 2014; Volpato et al. 2013a, b, 2015), information on ethnoveterinary practices is scattered, incomplete and outdated. The classic work by Westermarck (1926) focusing on beliefs surrounding ethnoveterinary practices is almost a century old. It is expected that these would have changed with the European colonisation and decolonisation process (e.g., Davis 2006), the spread of globalisation (e.g., Domínguez 2017), increased availability of veterinary alternatives and enhanced schooling (e.g., Teixidor-Toneu et al. 2017).

Besides the many gaps in ethnoveterinary research in the Maghreb, most of the studies do not accurately report on their data collection methods, both regarding traditional knowledge and information on the therapeutic materials used. Only a few articles clearly state their data collection and analysis methods, providing in-depth information on ethnoveterinary practice, but others do not have clear methodologies and only provide anecdotal data. Many sources do not present the ethnographic context; hence it is not possible to know if practices and remedies documented are particular of a group of people or specific to a region. Half of the sources we reviewed do not provide any information on the methods used for botanical plant identification and only two authors collected voucher specimens and deposited them in registered herbaria. To develop this field of knowledge on a regional scale, ethnoveterinary data collection should be carried out systematically, following international standards (e.g., Heinrich et al. 2009; Weckerle et al. 2018), and ideally cover the breadth of cultural diversity present in the Maghreb, as well as all the main livestock animals.

In the future, the research process, methodologies used and sample material identified need to be fully documented. First, ethnoveterinary studies should follow ethical guidelines (e.g., the International Society of Ethnobiology Code of Ethics, ISE 2006), be reviewed and approved by a relevant ethics committee, and obtain the necessary permits for conducting the research (as well as for collecting and transporting botanical specimens; Heinrich et al. 2009; Weckerle et al. 2018 and references therein). Every field study should accurately document botanical diversity, collecting herbarium specimens and depositing them in herbaria, evaluate how knowledge is distributed among the studied society (including differences between common and specialist knowledge), and provide an understanding on the socioeconomic and cultural context (Heinrich et al. 2009; Weckerle et al. 2018 and references therein). Ethnoveterinary medicine is part of a complex, culture-specific system of thought which forms local knowledge and gives local meaning. Thus, it is necessary to consider and explain emic concepts of plant properties, their modes of use and the ailment categories for which they are used. It is important that future research presents a comprehensive view of ethnoveterinary medicine without a priori drawing emic distinctions or only focusing on the remedies used without providing the necessary ethnomedicinal context. Local disease categories may be remarkably different to biomedical ones (McCorkle and Mathias-Mundy 1992) and describing the symptoms of diseases is most helpful to later identify ailments described in the biomedical sciences.

As it is occurring in many other parts of the world, ethnoveterinary medicine appears to be changing or even disappearing, and yet is an overlooked aspect of local ecological knowledge in the Maghreb. While various aspects and contributions of local ecological knowledge are mobilised to improve the livelihoods of the diminishing pastoral populations in the region, to the best of our knowledge ethnoveterinary knowledge is not being documented. This lack of documentation also hinders our understanding of change at regional spatial scales (Zent and Zent 2004; Saynes-Vásquez et al. 2016), as well as within local populations (i.e., intracultural variation of knowledge; Hanazaki et al. 2013), which have proven to be very informative for sustainable development.

In addition to its theoretical relevance, further research in ethnoveterinary knowledge could also have multiple applications from local to regional levels, including a minimisation of concentrated feed and the use of synthetic medicines, with the revitalisation of other sustainable practices linked to livestock and animal rearing. In addition, most relevant plants could be studied in greater pharmaceutical detail for the prospection of healthier therapeutics based on the profuse indigenous traditions and lore documented herein. Thus, to revert the loss of such ethnoveterinary practices and to improve the corpus of knowledge surrounding these practices we suggest that a systematised regional research program would be needed, including the variety of environments and cultural backgrounds found in the Maghreb. Such programs could be led by academic institutions (botany and veterinary university schools in collaboration with anthropology and linguistics departments), along with other relevant organisations to have a more holistic view of ethnoveterinary knowledge, practices and beliefs in this understudied region.

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