The fat and the lean: review of production and use of milk by pastoralists

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This review examines the role of animal milk in pastoral economies and diets. It then considers project interventions that have sought to increase the supply or commercial value of milk from animals in pastoralist regions. The degree to which pastoralists' diets depend on milk to meet nutritional requirements, either by direct consumption or through exchange for grains, varies across climatic zones and according to animal species, techniques for preservation, market access, and wealth status. Milk supplies are the outcome of the lactation periodicities of the livestock species kept, which are geared to temporal vegetation fluxes, mainly an outcome of climatic conditions. The bulk of detailed studies on pastoral milk production, diet and sales are from eastern Africa. Reference is also made to other pastoral regions of the world where information is available.

Keywords: pastoralism, livestock milk, diet, human nutrition, dairying, East Africa

Introduction

Livestock owners who rely directly or indirectly on their livestock for food and income under an extensive animal husbandry system are considered as pastoralists for the purposes of this review. Seasonality of food supplies, from plenitude to privation, is a feature of pastoral diets globally.[1] In tropical and sub-tropical regions, the major factor influencing milk availability is rainfall, but in the temperate or high altitude regions of the pastoral world, seasonal cold acts similarly to the dry season in warmer climates, by causing temporary cessation of primary production – plants for livestock grazing. Accordingly, pastoralists have strategies for obtaining food which revolve around annual patterns of precipitation, temperature and resulting forage for livestock. Pastoral dietary patterns must accommodate the consequences of seasonal changes in livestock milk supply.

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The review begins by examining the nutritional value of milk and the contribution of milk and dairy products to pastoral diets. We then consider the various factors influencing the role of milk in pastoral diets and household economies, beginning with seasonality of milk supply. How pastoralists allocate milk depends on their climate regime, access to and engagement with markets, commercial demand for meat, milk and other animal products, and the individual pastoralist family wealth status. Within these contexts, pastoralists have a number of choices with regards to how they use milk. Each of these is discussed in turn. Raw milk can be processed into preserved forms and saved for later consumption or sale, there can be a diversity of species or breeds of animals kept (depending on climatic conditions), grain or other foods can be substituted for milk through trading transactions, and lastly, milk can be reserved for the sole consumption by young animals, thus converting milk into meat. The paper discusses some pastoral development interventions which have aimed to increase the milk output of animals, the number of milking animals for families, or the value of milk products through processing and sales. The conclusion notes that the role of milk in pastoral diets and economies has undergone major changes in the last few decades, consequent on rising urban demand for milk and meat, commercialization, and sedentarization.

The evidence base

Livestock milk has been central to the survival of many pastoral societies. The importance of milk among African pastoralists was first documented by social anthropologists in their research in the 1950s and 1960s (Stenning, 1959; Dupire, 1963; Dyson-Hudson, 1969; Spencer, 1965). The extent of pastoralists' dependence on milk and other livestock products, and the reasons behind this, are now well-reported in the literature on pastoralism in East and West Africa. There is much less detailed information on this topic among pastoralists outside of Africa.

Pastoralist communities can be found all over the world, from the mountains of the Hindu Kush and the Andes to the deserts of southern Africa. Globally on the topic of milk, by far the most well-researched pastoralist peoples are the Maasai of Kenya and Tanzania, on whom there are a total of 10 publicly available series of studies. Kenya is also a common research location, with 20 (nearly one-third) out of 67 country-specific studies concerning milk and pastoralism. Several other East African pastoral groups have also been extensively researched regarding livestock milk and production systems; for example, the Turkana of northern Kenya stemming from the STEP long-term research programme (Coughenour et al., 1985; Galvin, 1992; Galvin et al., 1994), and the Boran of southern Ethiopia, with numerous studies by ILCA, now ILRI (the International Livestock Research Institute). In the rest of the world, there have been very few intensive studies of milk from the herds and

flocks belonging to the tens of millions of pastoralists still extant in Asia, the Middle East and South America. This literature search located only 12 studies with any detailed information on livestock milk in pastoralist societies outside Africa. Necessarily, the case studies and examples cited in this review are drawn predominantly from East Africa.

The importance of milk in pastoral diets

The reason why, and the extent to which, pastoralists depend on milk versus meat has been attributed to an efficiency of energy production in converting natural forage to food for humans (Coughenour et al., 1985). Milk is a renewable resource, available daily during certain seasons, in contrast to meat which is available only sporadically when animals are slaughtered, entailing a final product. Livestock milk can provide subsistence for far more people per unit area than any other arid zone production method (Suttie, 2001). Referring to East African grazing systems, it has been calculated that: 'The energy conversion efficiency of milk from pasture is 14%, compared with 3% for meat' (Blaxter, 1962) and 'An efficient herder can obtain over 2.5 times the energy from milk and meat than from meat offtake alone' (Western, 1982 citing Blaxter, 1962).

Contribution of milk products to human energy and nutrient requirements

The nutritional value of milk to humans was repeatedly demonstrated by intervention studies between the two World Wars in which milk provided extra nutrients to those with special physiological requirements; mainly young children and pregnant and lactating women (Darke, 1979). The consensus was that this nutritional policy was highly successful and contributed to a considerable improvement in the health of the nation (Magee, 1946).

Milk is an especially good source of Type II nutrients i.e. those that are needed in a full complement for growth and development (Golden, 1991). The high protein quality of milk is particularly important across the developing world where the cereal-based diet of agriculturalists is often deficient in some of the essential amino acids. The addition of milk to such a diet allows cereal protein to be more fully utilized for growth. The strongest evidence for the association between milk and growth comes from observation (Allen et al., 1992; Allen 1994; Dewey et al., 1995) and intervention studies (Orr, 1928; Du et al., 2004) that have shown associations between the consumption of cow's milk and increased linear growth in children.

Milk is also a good source of important Type I nutrients i.e. those that prevent specific clinical deficiency diseases and that are important for protection against illness (Golden, 1991). These include vitamin C (camel milk particularly), B vitamins such as riboflavin and B6 and calcium. Deficiency of vitamin A and iodine are two of the three micronutrient deficiency diseases

that are of greatest public health significance worldwide. Milk is also a good source of these nutrients.

Many of the components contained in milk have been shown to demonstrate anti-infective properties. Lactoferrin, one of the proteins in milk, exhibits both bacteriostatic and bacteriocidal activity against a range of disease-causing microorganisms, and could improve immunity against infection in children (Shah, 2000; Hoppe et al., 2008).

In contrast to the diets of most populations across sub-Saharan Africa, pastoralists generally have good access to high quality protein and other Type II nutrients in the form of milk and, seasonally, blood and meat. Several studies, starting with those led by Kathy Galvin in the 1980s, noted that these pastoral diets were adequate in terms of protein (providing between 200–400 per cent of daily protein recommended intake in many cases) but were low in energy; the 'protein-rich calorie-poor' phenomenon (Galvin, 1985; Galvin, 1992; Homewood, 1995; Fratkin et al., 1999; Fratkin, 2001).

Fratkin and others have noted that the main nutritional challenge for pastoralists is obtaining sufficient calories, and therefore that most pastoralists supplement their livestock-based diets with grains and sugar to provide carbohydrate calories and to maintain food supply during the dry season and drought when milk yields fall. Several studies have quantified inadequate levels of energy provided by pastoralist diets reliant on milk and animal source foods and have linked this to high levels of child wasting (measured by weight for height). Homewood (1995), in her studies of the Kenyan and Tanzanian Maasai identified high levels of wasting and noted populations surviving on 70 per cent of international recommended energy intakes. Several authors have found energy intakes of pastoralists in northern Kenya ranging from 1,000–1,400 kcal per person per day, only about 50 per cent of the average daily adult requirement, and have linked this to the low body mass indices identified (Little, 1989; Galvin, 1992; Galvin et al., 1994).

However, none of these studies on nutritional status accounted for the different body shapes of pastoralist people when using nutritional indices like body mass index and weight for height. This may have biased the assessment of nutritional status. There is controversy on whether standard criteria for assessing malnutrition can be applied to pastoralist children (usually East African again) since they have particular body types, physiologies and maturation patterns. This question is discussed in *Milk Matters: A literature review* (Feinstein International Center, 2009).

Diversification of livestock species and influence of climate on milk production

Each species of livestock produces not only different quantities of milk on a daily and annual basis, but milk with particular constituents important for human nutrition, as well as having different characteristics affecting

processing. Pastoralists and agro-pastoralists around the world keep a variety of livestock species, many of which provide milk for their owners. A common strategy is to keep several different species of livestock, each with a particular lactation period and length. A well studied instance is that of the Turkana in Kenya, whose camels, cattle, sheep and goats, and even donkeys, each contribute different amounts of milk for humans over an annual cycle, with camels being the most productive (Coughenour et al., 1985; Galvin et al., 1994). As a Tibetan nomad described 'although our yak, sheep and goats all provide milk, the sheep and goats only do so for part of the year (sheep for three months and goats for four-and-a-half months in summer). Only the … female yak give milk year round' (Goldstein and Beall, 1990: 87). Different livestock species also have other milk characteristics such as proportion of fat in the milk (higher in sheep, *Bos indicus* cattle and yak milk), or preservation quality (camel and mare's milk is difficult to preserve).

Climatic conditions govern the type of livestock species that can thrive in an environment – some species such as reindeer, llamas and alpacas have low milk yields and are rarely milked by pastoralists raising these livestock (Blench, 2006). Some factors influencing the species composition of pastoral herds and flocks are constant and related to patterns of precipitation, temperature, soils, topography and resulting rangeland vegetation, while other factors underlying choice of species are variable and include climatic events such as drought or snow disasters. An example is given in the review by Degen (2007) of how the Beja Arab pastoralists of eastern Sudan used to depend for their food mainly on camel milk, but following devastating losses of camels due to droughts in the 20th century have switched to keeping goats and sheep, which are also milked though they provide much less milk than camels.

In general, drier areas support more camels, other types of camelids (as in the semi-arid Andes) and some breeds of goats and sheep. Some of these livestock types provide milk for humans, to greater or lesser degrees; camels in particular are noted as having high milk yields in drier climates. Pastoralists inhabiting regions with more precipitation can raise cattle, horses, buffaloes and yaks, all of which require more water and lush forage but have higher milk yields than pastoral breeds of smallstock (Suttie and Reynolds, 2003).

Several geographical examples illustrate this point. In northern latitudes and very high altitude pastures, pastoralists keep livestock species or breeds that can withstand severe cold over extreme winters, while also producing milk in the warmer months. Other groups prefer animals that are adapted to dry seasons and droughts as in tropical Africa, for example in Somalia, where camels and goats are the dominant pastoral species found in the dry central rangelands. Climate conditions within a region also affect which species is mainly kept by pastoralists: in Somalia, cattle pastoralism is prevalent in the wetter area of lower Juba in the south (Baumann et al., 1993). In an entirely contrasting climate on the high altitude Tibetan plateau of China, pastoralists in the more arid zones keep mainly goats and sheep, while those

in wetter regions concentrate on yaks and cattle, which require more grasses but also provide more milk per animal (Goldstein and Beall, 1990; Nyima Tashi, 2003). Central Asian and Mongolian pastoralists in cold winter climates depend heavily on milk from horses and cattle and from camels in drier regions, while sheep or goats are more rarely milked (van Leeuwen et al., 1994; Swift, 1991).

South American pastoralists in the Andes mountains keep camelids (llamas and alpacas) which are not usually milked, but are adapted to high altitudes and cold weather, while sheep are kept also and provide milk in the rainy season (Mazess and Baker, 1964). In the drier Pacific coastal plains of Latin America, other pastoral groups raise goats which are milked and some of the surplus converted to cheese for sale (Westreicher et al., 2007; Degen, 2007). The Bactrian double-humped camel kept by pastoralists in the Central Asian, western Chinese and Mongolian rangelands produces less milk but with a higher fat content than the dromedary camel which is sometimes kept in adjacent but wetter regions of the same countries (Dzhu-Magulov, 1976; Faye et al., 2008; Khan and Iqbal, 2001). However, although yielding less milk than the dromedary, the Bactrian camel with its thick winter coat is adapted to the seasonal cold where it is endemic (Khan and Iqbal, 2001; Suttie and Reynolds, 2003). The Arabian or dromedary camel is commonly raised by pastoralists in the semi-arid and hot regions of the Middle East, north and east Africa, to provide milk and transport.

Market forces also affect livestock species choices, and as pastoralists adapt to surges in demand for different livestock species, the importance of milk can alter in the pastoral household economy (Al-Najim, 1991; Behnke, 2008;

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Figure 1. Tibetan nomadic woman milking yak

Kerven, 1992). In the case of Mongolia, pastoralists in the last three decades have become more focused on raising goats as there is a ready market for their high-value cashmere, while sheep, cattle and horses, which were traditionally relied on for milk, have not increased as greatly as the national goat flock (Longworth and Williamson, 1993).

Pastoralists' choice of species to rear also varies within communities according to individual family socioeconomic circumstances. Poorer pastoral families may rely more on smallstock – sheep and goats – which are easier to feed and herd, and reproduce faster than large stock, as well as being cheaper to purchase (Degen, 2007; Peacock, 2005). Smallstock however generally produce much less milk per female than the large-sized livestock species that richer pastoralists may be able to keep in their herds, e.g. cattle, camels, horses or yaks. These larger species usually require more capital to acquire and labour to manage and are thus more difficult for poorer pastoralists to own, even though they produce relatively more milk. Choice of species is not only or even necessarily related to their potential milk output. As noted above, climate and market factors also influence pastoralists' decisions on which type of livestock is best suited to their local conditions.

Regional variation in the role of animal milk in pastoralists' diets

There is considerable inter-ethnic group variability in dietary intake and intra-ethnic group variability by season. In the past, many studies, mostly from East Africa, have noted the important contribution that livestock milk has made to human energy and nutrient requirements. This level of contribution has been found to vary considerably between ethnic groups and by season, with groups such as the Masaai, Rendille and Turkana of Kenya and Tanzania, the Borana of southern Ethiopia and the pastoralists of Koch county in south Sudan seen to consume more than 50 per cent of their dietary energy in the form of milk and milk products (Barasa et al., 2008; Galvin, 1992; Galvin et al., 1994; Lindtjørn et al., 1993; Homewood, 1995;). For groups such as the Turkana, studies in the 1980s have noted more than 90 per cent of dietary energy came from milk during the rainy season (Galvin et al., 1994):

> Agro-pastoralists such as the Awlad Hamid in northern Darfur in the Sudan, have a diverse diet. … Camel milk and milk products only constitute about 20–25% of the food energy of the diet [Holter, 1988]. Malian Tuareg (Kel Tamasheq) pastoralist diets include millet and rice, milk and meat, with milk and cereals consumption varying by season [Wagenaar-Brouwer, 1985]. (Little, 1989)

> [Among the Borana, in Southern Ethiopia] … the diet was based mainly on milk and milk products. Children under 5 years of age had, on average, milk for 2.3 meals per day. However, the true amount of milk consumption was probably higher as young children were often observed drinking milk between meals. (Lindtjørn et al., 1993)

Pashtun nomadic pastoralists in southern Afghanistan were recorded in the 1970s as consuming some 3 kg per day of buttermilk for six months a year from their flocks of sheep and goats, while wheat bread provided the main source of calories throughout the year (Casimir, 1988). Ghee and dried cheese were consumed in the cold period when fresh milk was less available.

Whilst many of the studies cited above are now more than two decades' old, there is some more recent evidence that suggests that milk and animal products in the diets of some pastoralist communities remain relatively important. In cattle-keeping communities in South Sudan, milk accounted for up to 30 per cent of total energy intake (Muchomba and Sharp, 2006) and among Nuer agro-pastoralists milk accounted for 50 per cent of the total energy intake of children aged less than five years (Fielding et al., 2000). The Rendille Sedentarization project discussed below demonstrates the importance of milk in the diets of pastoralist children in northern Kenya (Fratkin et al., 2006). At the household level, milk is a particularly important food for children and children have been noted to receive preferential treatment in terms of milk consumption (Barasa et al., 2008):

> In Shinelle, Somali Region Ethiopia, milk is a very important part of the pastoralist and agro-pastoralist diet, and from a young age children are given [animal] milk. The proportion of children over 6 months that had consumed milk during the previous day was between 68% and 94%. This consumption pattern is related to livestock condition and migration of animals causing poor food security at that time (SCUK, 2007a).

The importance of milk in pastoral diets is also changing, due to the opportunity cost of pastoral labour, and especially female labour which is required for milking animals, as other income options expand. There is also a suggestion that at least for some economic segments of pastoral groups, there has been a decrease in animal numbers relative to the humans reliant on them, such that animal milk supplies per person have declined: 'The Borana [in southern Ethiopia] today are in a state of considerable change that has been induced primarily by a long-term decline in the per capita supply of cow's milk, the traditional dietary staple. This imbalance has resulted from steady growth in the human population in combination with density dependent fluctuations in cattle population' (Coppock, 1993).

This trend of an imbalance between an expanding human population, combined with shrinking access to rangeland leading to a decline in the human/livestock ratio, is more recently noted for some East African pastoralists (Homewood et al., 2009; Sandford, 2006).

Seasonality of milk supply

Livestock milk production is geared to the animals' reproductive cycles, which in pastoral systems is often related to temporal changes in forage

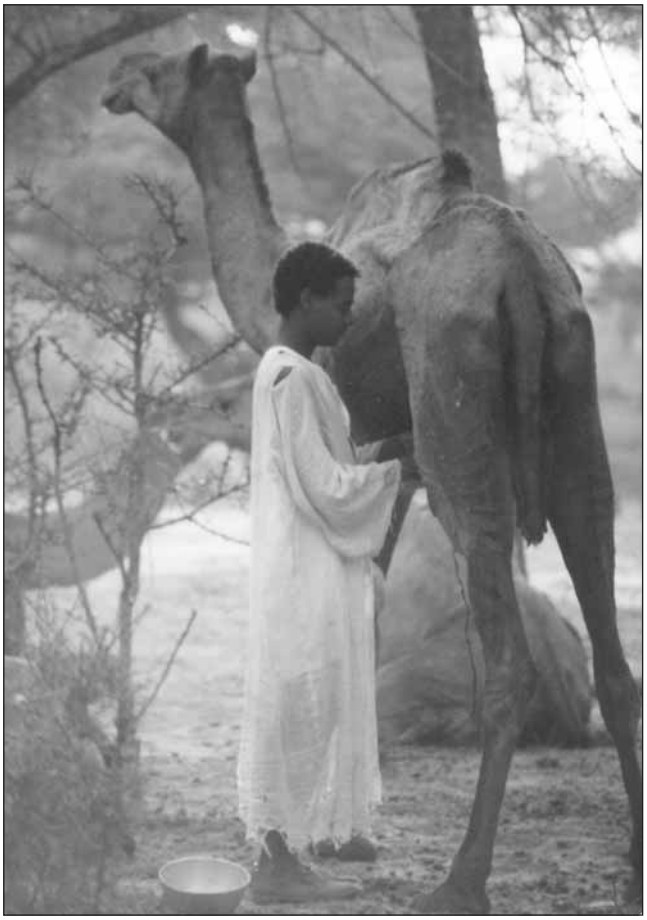

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Figure 2. Baggara Sudan nomadic man milking camel

supply. At the beginning of the rains in the tropics or in spring time after the cold winters in high latitudes and altitudes, a flush of new vegetation results in an increase in livestock milk output, often resulting from the birth of offspring. 'The biological cycle of the herds has a direct influence on the stock-breeders' diet as do their pastoral practices' (Bernus, 1988: 324). In both tropical and temperate climates, there are regular seasons of higher and lower forage quality and quantity, resulting from patterns of precipitation and temperature. Where livestock depend on natural pastures and their feed is not supplemented, these seasonal fluctuations of natural forage have a strong effect on milk supply (Coughenour et al., 1985; Nicholson, 1984). Writing about Boran cattle in southern Ethiopia, Nicholson (1984) noted that 'in pastoralist cows … the major influence on production is the season. New grass following the onset of the rains causes a rapid rise in milk production

at almost any stage of lactation while the dry season severely depresses milk yield' (Nicholson, 1984). Thus, in parts of eastern Africa, the double rainfall seasons per year often allows year-round milking, which means eastern African pastoralists can survive more exclusively on milk, compared to pastoralists in other climatic regions. A single season of rainfall in the West African semi-arid zones means that the Sahelio-Sudanic pastoralists have relied less than east African herders on livestock milk, and more on agriculture, hunting and fishing (Western and Finch, 1986). In regions with cold winters, such as the Tibetan plateau, 'just as summer is the time of dairy plenty, winter is the time of meat abundance' (Goldstein and Beall, 1990: 96).

In East Africa, a seasonal increase in vulnerability to human malnutrition has been recorded during the dry season when livestock pasture becomes scarce, which limits the availability of livestock milk for human consumption (Fujita et al., 2004). However, seasonal fluctuations in nutritional status are noted to vary considerably by pastoralist ethnic group. Studies among the Turkana and Datoga (Kenya and Tanzania respectively) document only a moderate decline in anthropometric status in the dry season, despite significant seasonal variation in rainfall and food availability (Sellen, 2000; Shell-Duncan, 1995). The Rendille and Ariaal studies in Kenya describe less variability in nutritional status during the dry season among pastoralists compared with their settled counterparts, and suggest that in these communities, seasonal changes in food availability is not a significant determinant of nutritional status (Fratkin et al., 1999; Fujita et al., 2004). A more significant decline in nutritional status by season has been noted among the Fulani and Tamasheq in Niger (Loutan and Lamotte, 1984; Wagenaar-Brouwer, 1985), the South Turkana ethnic groups (Galvin, 1985; Little, 1989) and the Somali pastoralists in Ethiopia (SCUK, 2007a).

Pastoralist decisions on milk allocation

Milk from livestock can be used in a multiplicity of ways to support a pastoral family. By enquiring how livestock milk is allocated, we can distinguish several categories among pastoralist groups having different degrees of dependence on livestock milk. The first division is between pastoralists who process milk into relatively stable preserved foods with high energy and/or protein, namely hard cheese, butter, ghee, etc., versus those who consume milk fresh or moderately processed and more perishable e.g. soured, buttermilk and yoghurt. Another major division is between pastoralists who manage multiple animal species, each with different seasonal lactations, such that milk supplies for humans can be stretched out further over a year, versus pastoralists who herd only one or two species with strong seasonal lactations, leading to large fluctuations in milk supply for humans. A third difference occurs between pastoralists who also grow some crops at least in some years, or have ready access to crops. Some pastoralist groups inhabit climatic regions in which crop agriculture is impossible due to aridity or cold temperatures, and have to trade for those

foodstuffs not provided by their animals. For these peoples, milk products can be substituted for grain via markets. Fourth, pastoralists may have the choice of converting animal milk into meat, by allowing young animals to take all their dam's milk. Cross-cutting these categories are three other variables; individual family wealth status, market proximity, and degree of commercialization. These major categories and noted trends are represented in Table 1, and evidence about each is then presented.

Processing, preservation and sales

One of the choices pastoralists can make is whether to convert some of the raw milk into some form of preserved dairy product such as cream, cheese, butter or ghee (separated butter fat):

> Dairy production is a biologically efficient system that converts large quantities of roughage, the most abundant feed in the tropics, to milk, the most nutritious food known to man. As Walshe et al. [1991] pointed out, where there is access to a market, dairying is preferred to meat

Table 1. Pastoral deployment of livestock milk to redress seasonal variability in food supplies

Milk deployment	*Climate*	*Wealth*	*Market access*	*Commercialization*	*Trend*
Processing for preservation	Necessary in hot climates. Cold climates suitable.	If sufficient milk, small herd owners can retain food for lean seasons or to sell.	Can be sold if markets available.	Private and project investment in dairying.	Consumer demand increasing.
Diversification of livestock species	Species and breeds must be adapted. Variety of species spreads milk supply.	Smallstock more economic for poorer owners.	Some species more easily marketed.	Changing demand for meat, milk and animal fibre products.	Smallstock increasing, but less milking.
Substitution of milk with grain	Trading dairy products where crops not grown.	Poorer families gain more calories, richer families want varied diets.	Markets must be accessible.	Higher prices for dairy products.	Increasing substitution of grain.
Conversion of milk to meat through animal growth	All climates.	Wealthier families gain more income.	Greater market access encourages meat production.	Private investment in meat production and export.	Increasing sales for meat.

> production since it makes more efficient use of feed resources and provides a regular income to the producer (de Leeuw et al., 1998, citing Walshe et al., 1991).

The transformation of milk into dairy products can help to deal with seasonal gluts of milk. These periods of plentiful livestock milk supply occur under two completely different climatic regimes; during the wet season in semi-arid tropical regions and during summer in temperate regions. By processing fresh milk into more stable dairy products, pastoralists can preserve valuable nutrients for consumption or sale during lean seasons – the regular dry periods in tropical climates and regular cold winters in temperate climates (FAO, 1990). Writing about pastoralists in Sudan, Warda et al. (1998) note that:

> The bulk of milk in the country is produced by nomadic herds of cattle and these produce a glut of milk supply in the rainy season which extends in central Sudan for 3–5 months. The surplus milk thus produced is fermented by souring into one or other of certain dairy products.

Products such as butter or ghee, yogurt and cheese not only prolong the value of milk but also change its nutrient profile. Butter and ghee are a concentrated source of energy containing approximately 800 kcals per 100g, whilst the protein component of milk has been completely removed in these products (Platt, 1962). Such 'milk fats' are a valuable mechanism for increasing the energy density of diets.

Processing milk into hard cheese also increases the energy and fat soluble vitamin density of the product by roughly a factor of between 5 and 9 (USDA,

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Figure 3. Boran Ethiopian women selling milk

2008). Unlike the transformation into milk-fat, transforming milk into hard cheese also increases the density of protein and minerals such as calcium (USDA, 2008). Both soft cheese (of the type often produced from milk in the developing world) and yogurt maintain a very similar nutrient profile to milk (Platt, 1962; USDA, 2008; Warda et al., 1998).

Fermented milk products such as yogurt have been consumed by people for centuries around the world and a number of health benefits have been associated with them (Heyman, 2000). Probiotic (or beneficial) bacteria, either present in milk or added at the time of fermentation, multiply during the fermentation process and will promote the growth of probiotic bacteria in the gut. Such bacteria have been shown to improve intestinal microbial balance and may decrease the incidence and reduce the severity of illness such as diarrhoea (Shah, 2000).

A general pattern noted by other reviewers (e.g. Blench, 2006) is that preservation of milk products is more characteristic of Asian pastoralists than African, though some West African and Sudanese pastoralists have well-developed techniques of preserving milk (Bernus, 1988; Warda et al., 1998), and in East Africa, Somali pastoralists have been trading ghee for centuries (Swift, 1979).

A pastoral calculation of alternative benefits for deploying milk is illustrated in a case from Peru:

> Goat production for cheese making is better developed along the coastal area … than in the Andean region. Of interest, milk is more valuable to the farmer for cheese production than for goat production. It was calculated that 11.5 kg milk is required for the increase in body mass of

Michael Wadleigh

Figure 4. Milking Maasai goats, Tanzania

> 1 kg in a kid. The 11.5 kg of milk [converted to cheese] brings in more income than the 1 kg of meat, and therefore, kids are often slaughtered early.' (Degen, 2007)

Growing demand for milk products in urban areas has also motivated pastoralists within range of towns to sell more milk, noted several decades ago (Sikana et al., 1993). For example, a recent case is reported for Maasai pastoralists raising their livestock near the large city of Nairobi, among whom 17 per cent of total household income (comprising 30 per cent of total livestock income) was derived from sales of milk (Radeny et al., 2007). Camel pastoralists in Kenya, Kazakhstan and Mauritania have responded to an upsurge in urban consumer demand for camel milk, by selling milk to new dairy companies (FAO, 2008).

Substitution of milk for grain

The exchange of dairy products for grains or other starchy food is one of the key elements of pastoral strategies to fulfil their caloric needs. This kind of exchange has been historically documented and can be found in widely differing cultural and physical environments (see Swift 1979 for one of the first descriptions of this exchange in Africa, in the case of Somalia; also Kerven, 1986).

Studies in Africa by the 1980s on five pastoral populations (Baggara, Fulani, Maasai, Tuareg, and Turkana) had recorded 'that pastoral diets show considerable among-population variation and that this variation is dependent both on degree of cultivation vs. pastoralism and patterns of trade and exchange' (Little, 1989). Among Asian pastoralists in high altitudes, there is similarly a range of dependence on cultivation of grains and starchy foods, while trade of pastoral with agricultural products is long-established (Suttie and Reynolds, 2003; Casimir, 1988). For Iranian and Afghan nomadic pastoral groups, milk products have not only been a dietary staple, along with wheat bread, but also one of the principle traded goods with settled agriculturalists, allowing pastoralists to obtain high-calorie grains and other foods (Black-Michaud, 1986; Casimir, 1988; Ferdinand, 2006).

In parts of Africa, a number of contemporary factors appear to be reducing dependence on milk, while dependence on cultivated or purchased cereals is increasing as the main staple in some areas. This trend was noted earlier in a review on pastoral dairying in Africa (Sikana et al., 1993). Over the past 20 years some studies of pastoral production systems have clearly shown that, whilst animal products remain important, it would be difficult for pastoralists to subsist without grains and sugar and that as observed in East Africa, these commodities were purchased by pastoralists in increasing amounts during the last decades. This tendency can be attributed to several reasons, discussed further below in the sections on commercialization, wealth and sedentarization.

In Borana, southern Ethiopia for example, grain purchased with the sale of livestock products met over 30 per cent of dietary energy requirement (Cossins and Upton, 1987), while more recently, in Somali Region of Ethiopia, milk production was noted as the most important source of revenue, being 66 per cent of total income (Barrs, 2000). Sales peak in the wet season and both wealthier households and households closer to the market have been noted to sell or exchange considerably more (in quantity) than others (Holden and Coppock, 1992). This is a calorifically-efficient pastoralist strategy, since grains will provide more calories per unit weight than raw milk, often at a lower market cost (Kerven, 1987). In the development context, caution is needed prior to making interventions. Development agencies should first calculate, as pastoralists inevitably must, whether the family as a whole may benefit more from some milk products being sold in order to obtain greater overall nutritional value in the form of higher calorie foods.

Conversion of milk to meat: commercialization, markets and pastoral wealth

There is a distinction in the domestic economies and diets between pastoralists who directly rely on their animals for most of their food – milk and meat (and blood) – compared those who raise animals solely or primarily in order to sell the live animals or their products – principally milk, skins and fibre. Increasingly, the distinction is becoming blurred, as formerly subsistence-oriented pastoralists have become more engaged in commercial markets. These two kinds of producers may live and raise their livestock side by side in a single community. How a pastoral producer responds to market opportunities has much to do with their status in terms of herd or flock wealth, family labour and capital availability. The broader framework of changes in national and international market demand, and official policies or subsidies for particular species also encourages or dampens commercial responses by pastoralists.

New market potential and rising prices for live animals can lead to subsistence milk-surplus systems being reconfigured to commercial live animal enterprises (Behnke 1983, 1987, 2008; Kerven 1992; Fratkin 2001; Swift 1979). As portions of a pastoral group become richer, with growing herds and tighter market integration, consumption of animal milk becomes less economically optimal, since milk deflected to humans depresses the growth of young animals being raised in readiness for the market. Pastoral families who own larger numbers of lactating animals can afford to let their livestock's offspring take more milk which transforms into faster-maturing and heavier animals; describing Sahelian pastoralists, Bernus remarks 'Only the rich stock owner can allow the young animals to suckle freely during the months following birth' (1988: 325). Wealth creates more wealth.

In contrast, pastoralists with very few animals may decide that the best option is to deprive the livestock offspring of more milk in order to extract a small amount for human consumption, whether at home or for sale. Holden et al. (1991) found that among the Borana, improved access to a dairy market reduced the proportion of milk allocated to calves in these households. The authors conclude that their results support a causal relation between factors of proximity to market, dairy sales and risk to calf health for poorer households. This has been observed by livestock scientists to lead to a cycle of poverty – ill-fed young animals mature more slowly to reproductive age (so the herd or flock does not expand as fast) and are weaker and more susceptible to drought, cold and disease:

> If poor households have fewer consumption options and therefore rely disproportionately on their livestock for milk (and/or blood), their livestock are likely to become weaker and exposed to greater risks during drought. Sieff [1999] and Upton [1986] each observe that East African pastoralists with large herds milk 35–45% of their cows, while those with small herds milk 65–75%, which in times of stress adversely impacts calf growth and survival (Lybbert et al., 2004).

The human owners of small herds or flocks, however, are able to provide a little milk to their families, including children:

> Traditional subsistence pastoralists in East Africa tend to keep large herds, milk cattle in preference to eating them, and subject them to long foraging treks. Milk must be available in sufficient quantities to sustain calves to weaning age. The surplus is available for human consumption. Offtake that deprives calves, though benefiting the pastoralist in the short-term, will impair herd replacement and growth rate in the long-term (Western and Finch, 1986).

In Somali Region, Ethiopia, a high proportion of cattle milk is converted to ghee for consumption or sale, with wealthier households converting substantially more than poorer households (Nori et al., 2006; SCUK, 2007a).

The pan-African review by Sikana et al. (1993) documented the transformation in the economic value of milk, finding that the role of milk diminished in pastoral diets undergoing commercialization, especially among poorer households. Better-off households with a calorifically sufficient diet can afford to view milk as a source of protein, while calorifically insufficient households view milk as a source of calories and, as a result, practice higher rates of milk off-take for sale to purchase cereals for consumption. Because of this greater dependence on milk income, the management strategies and milking practices of poorer pastoralists differ from those of richer households. They often live nearer to watering points, despite range being of poorer quality, and water animals more frequently as a strategy to maximize milk output.

Generally, only pastoralist families with a relatively larger number of livestock are able to transform surplus livestock milk into a preserved dairy

product for later home consumption and, if markets exist, also sell some dairy products to obtain other desired goods. Otherwise if a family has few animals and no other income sources, it may be more economic for them to consume any extra milk at home, and, if markets exist, sell some dairy products in order to obtain higher-calorie carbohydrate foods such as grains.

Pastoralist wealth status and milk intake

The influence of economic status on milk intake and nutritional status of pastoralist people is debated in the literature (Galvin, 1992; Galvin et al., 1994; Fratkin et al., 1999; Homewood, 1995; Sellen, 2003; Shell-Duncan and Obungu Obiero, 2000). It is likely that this influence has changed over the time period in which researchers have been observing these phenomena. A strong ethos of sharing milk across wealth strata, as described by Homewood (1995) several decades ago, has diminished when pastoralists have gained more market opportunities, as discussed elsewhere in this article.

> Maasai women have to partition milk between their human dependants and their calves. There is powerful motivation to invest in calves any milk apart from the bare minimum needed for people. The careful husbandry of milk supplies and the low importance attached to hunger probably account to some extent for the striking similarities of consumption and nutritional status within and between the two communities. (Homewood, 1992)

> The ethos of sharing milk also acts as a levelling influence between households, and household composition (which includes poor dependants as well as lineal descendants of the household head) and may mean that the variation in energy intake, expenditure and resultant nutritional status is greater between individuals within a household than between households. (Homewood, 1995)

Other earlier studies of the Borana in Ethiopia that have investigated wealth and nutrition status found family wealth position played a significant role in decisions around milk off-take (Alemu et al., 1993; Holden et al., 1991; Lindtjørn,). Holden et al., (1991) examined the interaction of wealth, household milk allocation, and the nutritional value of pastoral diets. They found that poorer families have higher rates of milk off-take, with the milk increment being sold to purchase cereals for human consumption.

A study of maternal depletion syndrome among the Rendille of northern Kenya found that consumption of milk is highly influenced by economic status, with poor women having 2.3 times higher risk of low intake as compared to economically sufficient women. Save the Children UK have also observed an increasing prevalence of nutritional wasting with decreasing wealth. Factors associated with greater wealth were increased milk consumption, improved dietary diversity and health (SCUK, 2007a).

When pastoralists make these calculations on how to divide and use the milk from their animals, there is another crucial factor in their decision making, which is the social value of milk and dairy products. Rather than sell or consume surplus milk products, pastoralists often use lactating animals or their milk products to maintain social ties within and between communities. In some pastoral societies, there are cultural prohibitions on selling milk products, which must be kept for hospitality and sharing between group members (Bernus, 1988). These practices are well-documented (for earlier work, see Bush, 1995; Sikana et al., 1993; Sikana et al., 1994;). For some pastoralists, the future social insurance gained by sharing milk between group members may outweigh an immediate financial gain from selling their dairy products. Likewise, children of pastoralists often have informal access to livestock milk products from other families in their social group.

Impact of sedentarization on milk production and use

There is a global trend for mobile or nomadic pastoralists to cease moving, either partially or completely settling with their animals (Galvin et al., 2008). This trend is linked to many factors: increased pastoralist participation in markets, changes in government support to pastoralist systems, (e.g. in the former Soviet Union), official settlement policies (as in communist China), a greater desire among pastoralists to avail themselves of social services, impoverishment, loss of grazing land, climatic disasters and other causes, all of which are now quite well documented.

As pastoral herd management practices are changing, so are their diets, and so is their health related to nutrition. There are some detailed studies of how settlement alters the contribution of milk in the pastoral diet and the impact of these changes on the health and nutrition of pastoralists.

Sedentarization of pastoralists has two main effects on their supply of animal milk: firstly, settled pastoralists may have less access to lactating animals which are herded at a distance from settlements; secondly, if animals are moved less to seasonal pastures but do not receive supplementary feeding, their milk production decreases.

Some work has documented that, as a result of settlement, there is an improvement in nutritional status among children and adults due to an increase in commercial opportunities, improvements in child care practices and better access to health care. A case study by Ensminger (1991), on the economic transformation of the Orma of Kenya, found increased residence in market centres and agricultural commercialization associated with improved nutritional markers (weight for height) for adults and male children, though not for female children.

However, whereas settlement may hold some opportunities, these can be at the expense of herd productivity, and in particular, milk yields. A comparative study of milk yields carried out among the Ngok Dinka of Sudan indicates that milk production in migratory herds is about 50 per

cent higher than in sedentary herds during both the wet season and the dry season (Niamir, 1982).

By far the largest work that has examined the consequences for pastoralist nutrition of sedenterization is that of the Rendille Sedentarization Project in northern Kenya, which ran for several years in the mid-1990s (Fratkin et al., 1999). By comparing the diet, nutritional status, fertility and morbidity of women and children in nomadic and sedentary communities, they were able to show, quite conclusively, that child nutrition and growth patterns were worse in the sedentary communities in comparison with the nomadic control group. What clearly differentiated the nomadic from the sedentary communities was the consumption of milk. Based on 24-hour dietary recall the project was able to show that children in the nomadic community consumed on average over 10 times as much milk (3.2 versus 0.3 cups) as children in the settled community. It was particularly during the dry season that the sedentary communities had significantly more malnutrition and significantly higher levels of anaemia and infection such as diarrhoea. This study suggests that the pastoral nomadic diet, particularly one dependent on camels' milk, offers children better resistance to the pressures of drought and supports findings that the subsistence base of mixed-species pastoralism is superior to sedentary alternatives with respect to child health (Nathan et al., 1996).

Other studies have noted similar findings. Children of settled Bedouin in Jordan in Lebanon and Syria had a poorer nutritional status than both the nomads living under the same environmental conditions and the semi-settled agro-pastoral populations (Baba et al., 1994). In 2006, Grobler-Tanner found that mobile pastoralists with animals in Turkana, Kenya, were comparatively better off than those who had settled and were dependent on food aid, trade and begging in urban and peri-urban areas (Grobler-Tanner, 2006).

Strategies for increasing and stabilizing pastoral livestock milk supply

Concern for the plight of pastoralist peoples subjected to climate disasters such as droughts or snow storms, and a realization that negative political and economic forces have impoverished some pastoral groups, has led donor agencies and national governments to seek ways of improving the food security of pastoralists. Milk is an obvious focal point, since it is known that many pastoralists have relied on livestock milk not only as a dietary staple but also as a means of trading for other foods. This review discusses some development programmes which have sought to increase or stabilize livestock milk supplies, through different interventions. The interventions can be grouped as follows, and examples of each are given below. Detailed impact assessments of these interventions, which might describe outcomes related to change in livelihood security or nutrition, are rarely publicly available:

- Increase the number of milking animals available to pastoralists in the lower wealth categories with few or no livestock.
- Improve the nutrition of lactating animals in seasons when animal forage is insufficient or of poor quality.
- Improve livestock health so as to increase their milk supply.
- Introduce or promote different livestock breeds so as to prolong the seasonality of animal milk supply.
- Introduce methods of preserving or selling milk in less perishable forms in pastoral societies where these technologies are unknown but are used by other pastoralist societies.

The research reviewed here also suggests several other ways to improve pastoral food security, though not often attempted by outside agencies:

- Reduce the cost to pastoralists of obtaining high calorie food supplies (e.g. grains and other starches) so as to alter the terms of trade between dairy and farm products i.e. less dairy produce has to be exchanged to gain the same amount of farm products.
- Encourage mobile livestock husbandry as this augments animal milk yields, compared to sedentary livestock, unless receiving high quality and expensive supplementary feed.

Increasing the number of milking animals

The most widely-spread development programme aimed at increasing poor people's access to milking animals is Heifer International. The programme's basic approach is 'passing on the gift' of animals donated by the project to members of a community, who agree to pass on some of the offspring to other community members. Heifer International now works in more than 50 countries of Africa, Asia, North and South America, including with a number of pastoralist groups. Among groups formed by Rendille and Samburu pastoral women in northern Kenya, supported by Heifer International and other donors, each pastoral woman received a milking camel. With further support, camel dairy enterprises were established by women's groups (Lemunyete, 2002). In Asia, Heifer International works in China, India and Pakistan, countries with sizable populations of pastoralists in the semi-arid regions. For example, Heifer projects in China work with Tibetan and Mongolian pastoralists. While Heifer International projects are evaluated by an independent organization, no information could be found that describes any impacts of these projects on pastoral nutrition or other livelihood outcomes (Heifers Measure of Success, 2005).

A more direct approach is the provision of more animals to pastoralists, and this has occurred most commonly (or at least is well documented) through 'restocking' projects. In pastoralist areas of Africa, these projects have been implemented as part of a post-natural disaster rehabilitation strategy (Aklilu and Wekesa, 2002; Burns and Suji, 2008; Heffernen et al., 2004; Hogg, 1985)

or as a means to assist the reintegration of returnees back into pastoralist communities (Catley and Blakeway, 1997; SCUK, 2007a; Wekesa, 2005).

Some evaluations and studies indicate that when restocking is carefully designed, there is a benefit of increased milk supply for pastoralists. For example, interviews with restocked pastoral households in northeast Kenya 18 months after the receipt of livestock noted that, 'During the wet season an average of 12 sheep and goats were lactating per beneficiary family [recipient of restocking], each one producing a daily average of 1 litre of milk, and 7 litres of milk available for daily home consumption. Whereas in the dry season an average of 8 shoats were lactating each producing an average of 0.5 litres of milk daily, and 2 litres of milk was available for daily home consumption' (Lotira, 2004).

The provision of livestock has also been used as a means to assist the reintegration of returnees and internally-displaced people in pastoral areas. Working in Somali agro-pastoral areas in Ethiopia in the mid 1990s, Save the Children UK provided sheep and goats to 616 female-headed returnee households. A preliminary evaluation noted that, 'Those respondents whose sheep and goats have delivered told the team that on average, sheep produce about 500 ml of milk whereas goats produced 800 ml. About one third of milk is given to children in the breastfeeding stage (goat milk only) and the rest is used for home consumption. After the breastfeeding stops, almost all the milk is left for children' (SCUK, 2007b).

Improving the nutrition of lactating animals

For some years, research has been carried out on how to improve the quality of pastoralist livestock feed sources, particularly at the International Livestock Research Institute (formerly the International Livestock Centre for Africa, ILCA). This organization has produced detailed information on how to increase milk production through better animal feeding (Leng, 1999). However, the costs and benefits must be carefully assessed before recommending that pastoralist families should obtain supplementary feed for their animals in order to increase their milk supply. Since this type of analysis has often not been carried out by researchers, the likely impacts cannot be assessed.

There is limited information available on the impact of technical improvement projects on production of livestock milk. Well rehabilitation, better water supply and livestock feed banks have been associated with healthier and more productive livestock in Niger; for example, livestock feed banks were established under community management as a means to make livestock feed available and affordable during drought (Burns and Suji, 2008). Concentrate feed, wheat bran, cotton seed and salt were used, and during an impact assessment, informants associated use of the feed banks with healthier and more productive livestock, and specifically mentioned milk production as a benefit. Between 40–50 per cent of this milk was consumed and the rest was sold or given away as a gift.

During a drought in 2008 Save the Children US implemented a supplementary feeding project in Borana, Ethiopia, based on 10 feeding centres with 6,750 cattle (Bekele and Tsehay, 2008). Two of the centres were assessed in detail and 48.6 per cent (191/393) of cows either returned to milk production, or began milk production following the birth of calves while in the feeding centers. These results were compared to the performance of cows outside the feeding centres, where lactation ceased.

Improving livestock health

The supply of livestock milk is greatly affected by livestock health and disease. This has rarely been quantified under pastoral conditions. Alternative perspectives on the impact of livestock diseases on milk supply are provided by pastoralists themselves, and include both qualitative and quantitative estimates. For example, the use of participatory methods has enabled pastoralists to define their own indicators of disease impact and compare different diseases. In Somaliland the indicator 'Disease reduces milk yield' was one of 26 indicators identified by herders when comparing livestock diseases (Mohammed, 1993), and pastoralists in South Sudan (Barasa et al., 2008; Catley et al., 2001), Tanzania (Catley et al., 2004) and Ethiopia (Rufael et al., 2008) have all included a milk loss indicator in their descriptions of important livestock diseases.

Using participatory methods in South Sudan, Nuer herders estimated milk losses in cattle due to acute foot-and-mouth disease at 1.6 litres per day (95 per cent CI 1.20, 1.95 litres per day) for an average of 14 days; this represented a 62 per cent fall in production in affected cows during the period of clinical disease (Barasa et al., 2008).

Pastoralists can assess the value of disease control against indicators such as milk production, and can estimate absolute reductions in milk off-take per milking by disease. Pastoralists are well aware of the multi-factorial nature of milk production and can describe the relative importance of factors such as rainfall, pasture and conflict for milk supply compared with livestock diseases.

Veterinary interventions have been one of the most commonly used approaches to improve food security in pastoral areas, both in development and relief projects. Various evaluations of veterinary projects make either very general qualitative statements about milk production, or state that the assessment of disease impact on milk production was not attempted (Groot, 1997). Only one formal study was found on the impact of veterinary interventions on milk production. Conducted in northern Kenya, the study compared production variables in two camel herds with and without a veterinary programme (Simpkin, 1985). The mean milk yield over an entire lactation period was 1,146 litres in treated camels (n=26) compared with 687 litres in non-treated camels (n=16). The mean length of lactation was 13.1 months in treated camels and 9.4 months in non-treated camels. This finding indicates

that a comprehensive veterinary programme can improve milk production both in terms of the volume of milk supply and the duration of lactation. Although valuable as a rare example of herd monitoring, the small sample size reflects the practical difficulties of this kind of research.

During the last 10 years or so, various NGOs have assessed the impact of community animal health workers (CAHW) projects in pastoralist areas. The reports provide qualitative insights into impact, and to varying degrees, describe and attribute project activities to changing livestock disease impacts and milk supply or consumption (Abebe et al., 2008; Admassu et al., 2005; Dejenu, 2004; Nalitolela and Allport, 2002).

Introducing different breeds

In a project in Kenya, new breeds of milk-meat goats were distributed to pastoralists in Kajiado (Siamba et al., 2003). Pastoralists acquired the Kenya Dual Purpose Goats (KDPG) for milk production and cross-breeding with the local small East African and Galla goats to improve production levels. Measured over a year, the average daily milk production of 700 ml from KDPG in pastoral flocks was higher than for its crosses in this study. The crosses of KDPG with local goats had an average of 500 ml per day, were which was significantly superior to the local goats with just over 100 ml daily production. Moreover, the pre-weaning survival rates of the crossbred dual-purpose goat did not differ significantly from the indigenous goats, indicating that the KDPG and the crosses were as adapted as the indigenous goats. They were, however, more productive in terms of milk production and growth.

A programme working with Karamojong pastoralists in Uganda (Dan Church Aid, 2007) bred local female goats with higher yielding dairy species purchased from South Africa. Goats bred by the project produced at least one litre of milk per day, which the members either consumed or sold to raise money for other domestic needs.

Not only goats but cattle breeds with higher milk yields have been introduced to pastoral groups, in the case of an indigenous pastoral development organization in Kenya. The Mainyoito Pastoralist Integrated Development Organization in Kenya has embarked on upgrading the local East African Zebu through cross breeding with a higher breed such as Sahiwal (good for both beef and milk production) so as to yield a higher market price faster than the local breeds and also increase the production level of milk (MPIDO, 2007).

Introducing methods of preserving or selling milk products

Most pastoral societies in the Middle East and Asia have traditional technologies of using surplus animal milk to make into preserved forms of milk. This is rarer in pastoral sub-Saharan Africa, though is practiced by Fulani and Arab pastoralists in the Sahel and Sudan, and Somali pastoralists. Preserving the

nutrient qualities of milk provides fat, protein and calories for pastoralists during seasons of low milk yield and permits potential income generation. Several development interventions and commercial ventures have sought to improve the technology of milk preservation, as well as create a market for a pastoral dairy product. For example, the Trace Foundation works with pastoralists on the Tibetan Cheese Project:

> Extending traditional methods and techniques by making a new kind of cheese, would enrich the nomads' unique way of life, in which dairy production already plays an important role … the sale of milk has the added benefit of increasing the productivity and value of yak herds. … Trace Foundation provided training in milk hygiene, herd management and common disease recognition to families … adjoining the cheese factory. In turn, the nomadic families, whose children study at the school, provide milk and other support for the school. (Trace Foundation, 2007)

However, this review could not find any detailed research on the impact of these dairying interventions specifically on the production or consumption of milk products by pastoralists.

Several studies reviewed here have commented on the role of dairy marketing (i.e. the sale or exchange of milk) as a survival strategy particularly for poorer households. In Somalia, a well-organized camel milk trade to supply the capital Mogadishu started in the early 1970s and was described by Herren (1990), who found that in the collection areas, 'The pastoral producers have geared their production and movements to the milk chain, so that in most camel-owning households, milk sales dominate in their total cash income'. The development of a pastoral-urban milk trade in Somalia is more recently described by Nori (2006).

The potential to develop processing and markets for camel milk as a source of income for pastoralists is endorsed by FAO (Food and Agriculture Organization) and has been commercially successful in several countries having pastoralists that keep camels. The FAO see a great potential for camel milk marketing. A camel milk factory in Mauritania was a pioneer in this field, with supplies from nomadic Mauritanian camel herders (FAO, 2008). In northern Kenya a camel milk factory is working with pastoralists who supply camel milk which is processed into a number of dairy items for sale (New Agriculturalist, 2006).

Conclusions

This review has noted a number of constants as well as changes in the production and use of livestock milk by pastoralists worldwide. The chief constant feature is the seasonal irregularity of milk supply, as livestock species raised on pastures without supplementation will either cease or reduce their

lactation in seasons of low pasture output. To maintain their dietary intake, pastoralists have resorted to various methods including: processing milk products to conserve protein and fat; diversifying the species or breeds of animals kept, so as to stretch out lactation periods; substituting grains or other foods in their diets by exchanging milk products; or, by forgoing the consumption of milk products and diverting milk to young animals raised for the market.

Examples in this paper are drawn largely from East Africa (including Ethiopia and Somalia), where the majority of research studies and development programmes has been implemented. Reference is also made to case studies from pastoral societies in the Middle East, Asia and Latin America.

Looking back over the evidence accumulated in the past few decades, certain trends are evident. The first is that the role of milk has changed in some pastoralist livestock systems; from being a principal or major source of food for domestic consumption and distribution within a pastoral community, milk has diminished in the diets of some pastoralists, though often remains a crucial source of food, particularly for young children. There are several reasons why the role of milk has altered in some but not all pastoralist systems. The rising consumer demand for meat as incomes rise in less-developed countries has led pastoralists – particularly those with more animals – to switch from taking milk for use within the pastoral society, to nurturing young animals which can then be profitably marketed. Calves and lambs benefit from getting more milk, while their owners can buy alternative foods.

Consumer demand has also risen for dairy products, encouraging pastoralists to convert some of the milk yield to a saleable commodity, rather than being consumed directly. For poorer pastoralists, this is often a process of 'trading protein for calories'. One of the early characterizations of pastoral diets in East Africa was 'protein-rich but calorie-poor'. Milk is a higher protein but lower calorie food than grain; processing milk into butter or ghee results in a high energy resource but requires large amounts of milk and is expensive in terms of labour. Processing milk into types of cheeses preserves the protein but has the same drawbacks as above. Semi-conserved items such as buttermilk have a short shelf-life and do not last into seasons of low milk supply. If a pastoralist family does not have enough animals or other food sources (e.g. crops) to sustain the family's energy requirements, then measures must be taken to make up the caloric deficiency. Since protein-rich animal source foods are much appreciated in many societies, there will be a ready market for these milk-based items, provided they are affordable.

With the income from selling or trading live animals or dairy products, pastoralists both rich and poor have been able to substitute milk in their diets for more grains. Global economic factors also account for some of the observed changes in the role of milk in pastoral societies. One of these factors is the improved transport infrastructure that allows previously isolated pastoralists to travel more easily to markets to sell their live animals or dairy products and return with other foods, often imported. Improved transport

links are both a cause and a consequence of a tighter articulation between pastoral producers and wider markets. From having to be self-sufficient by relying on the bounty of the herd or flock, pastoralists in many regions now have choices on what to eat, depending on price, season and availability.

Practical assistance to pastoralists who lack sufficient food security, whether following climate disasters or because of poverty due to having few animals can be grouped into three categories:

- augmenting the milk output per animal by various means, including veterinary attention, improved feed or water supplies, or introducing new breeds;
- increasing the number of milking animals;
- raising the value of milk, through introducing techniques for preservation or stimulating sales of dairy products.

There are other less direct ways to strengthen pastoral food security, which may or may not affect animal milk production. Schemes such as 'food for work', income diversification, live animal marketing and water point construction, can all positively contribute to more balanced and adequate pastoral diets. From a nutritional perspective, it remains important that pastoral children in particular should continue to have access to milk products, which have been shown to have many beneficial health and developmental effects. But this applies equally to children in urban areas and in some cropping systems, where access to protein foods may be minimal. Enabling pastoralists to sell more dairy products, at prices they find attractive, could also benefit non-pastoral peoples if they are able to purchase pastoral dairy products.

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Notes

1. The review stems from a comprehensive study 'Milk Matters' (Feinstein International Center, 2009) on the contribution of human and animal milk to nutrition among pastoral children, carried out by Save the Children USA and the Feinstein International Center at Tufts University, USA.

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