Animal Husbandry

Animal agriculture has evolved with the growth of the human population from 4 million people 10,000 years before the present (ybp) to the 5.85 billion people that occupy the world today. Domestication of a relatively few of the available mammalian species initially occurred in conjunction with climatic, cultural and societal changes at the end of the last ice age - the Wisconsin deglaciation. Agrarian based communities developed independently around the world, and animal husbandry practices became common. Today, despite tremendous technological advances in genetics (e.g., cloning), physiological manipulations (e.g., artificial insemination) and nutritional provisions (e.g., high quality harvested forages), there are still only a few domesticated species used in animal agriculture, and traditional animal husbandry practices are still universally applied. In 1996, the world population of domesticated grazing livestock was approximately 3.3 billion, an increase of 1.1 billion during the last 5 decades despite a relatively constant total amount of grazeable land. The bulk of this increase during the last half of the 20th century is due to a near doubling of cattle, sheep and goats on the continents of Asia and Africa. The impacts of unmanaged grazing animals have been substantial through the course of human history. The modern principles for proper management of grazing lands developed during this century in response to destructive impacts of unmanaged grazing throughout the world.

Domestication

Domestication is the adaptation by humans of a species resulting in the modification of traits to the extent the species is clearly distinguishable from its native origins. There is evidence that humans first domesticated dogs from wolves over 100,000 ybp (Vila et al. 1997). However, the history of

animal domestication other than canines is generally thought to be much more recent - beginning about 10,000 ybp. Domestication has been documented to have occurred independently at numerous locations around the world from 10,000 to 5,000 ybp (Table 1). Corresponding to this period the world human population has been estimated to have increased from about 4 million 10,000 ybp to 14 million 5,000 ybp. The greatest increases in human population were seen on the European and Asian continents, where domestication (both plants and animals) was being broadly adopted (McEvedy and Jones 1978).

As with the beginnings of agriculture during this period, the appearance of domestication has been attributed to a variety of changing global conditions affecting climate (e.g., deglaciation), culture (e.g., ritual animal sacrifice), and society (e.g., increased sedentary populations). Domestication developed under a wide variety of conditions. For example, domestication occurred in both sedentary and nomadic cultures, in agrarian and hunter-gatherer societies, prior to and subsequent to domestication of plants, and with species with either monogastric or foregut fermentation digestive physiologies. Nevertheless, domestication did not occur in all situations, even when both the conditions and opportunities were optimal (Reed 1977).

Though numerous animal species were tamed during this period (such as elephants in India and hyenas in Egypt), only a few species of mammals were actually domesticated. Ninety percent of domesticated grazing animals in the world in 1996 were either cattle, sheep or goats, and these can be traced to just 3 species - *Bos primigenius*, *Ovis orientalis* and *Capra aegagrus* (Clutton-Brock 1981). Domestication requires at least 30 generations, a period of 100 to 200 years for most of our

domesticated animals. The unique demands of domestication have limited its application by humans to only a few species, but the traditions of animal husbandry were readily conveyed to succeeding human generations. By 5000 ybp communities throughout the world were engaged in common animal husbandry practices such as use of grazing systems, selective breeding practices and spreading of animal manure onto agricultural fields.

In 1996 grazing livestock numbers were estimated at 3.3 billion (Table 2). Domesticated grazers (primarily cattle, sheep, goats, horses, buffalo, mules and camels) were 91% of the total world population of domesticated animals including pigs and poultry (FAO 1996). Since World War II, the world populations of grazing livestock, primarily cattle, sheep and goats, have collectively increased 1% annually. However, this increase of 1.1 billion head during the last 5 decades has been spatially heterogeneous. Cattle numbers have more than doubled in Africa, South America and Eastern Europe - a rate of increase more than 50% higher than the global average. Seventy-seven percent of the global increase in sheep numbers has occurred in Asia. Overgrazing is frequently cited as a principle cause of land degradation on these continents during this century (Dregne et al. 1991).

Grazing Animal Impacts

Grazing refers to the foraging on plant materials that is a characteristic feature of livestock use of pastures and rangelands. Grazing animals have well-documented direct and indirect impacts upon ecosystems beyond simply plant defoliation. These impacts can be manifested at several scales, ranging from that of the individual plant to landscape areas of thousands of hectares. Direct impacts

of grazing include consumption of plant issues, trampling of soil surfaces, disruption of cryptogamic organisms and removal and excretion of nutrients by the animal. Indirect effects include spatial and temporal redistribution of soil nutrients, alteration of numerous plant morphological and physiological attributes, alterations of plant gene frequencies, changes to structural features of plant communities and alterations of water and energy fluxes within the landscape. Impacts can vary tremendously with variations in environmental conditions. The effects of grazing are frequently compounded by the concurrence of other environmental stresses, particularly drought and fire. The impacts of grazing can often be episodic and reflect the occurrence of mitigating site conditions. Often a general understanding of the effects of grazing is not useful to anticipating and predicting grazing effects in specific environments (Vavra et al., 1994).

Herbivory is a natural process that can have complex impacts in natural settings (Collins et al., 1998); however, unmanaged grazing by livestock can have extreme and negative effects on ecosystems at local, regional and continental scales (McNaughton, 1993). There is evidence of damage to grazing land resources because of past overgrazing by livestock on most continents. Frequently, these damaging effects are seen in a relatively short time period, often just within one or two decades. Given the arid and nutrient poor conditions of many of our global grazing lands, recovery of these lands can be slow or nonexistent (Schlesinger et al., 1990). It is now increasingly recognized that some environments, such as those with highly erodible soils or inherently low primary productivity, may not be suitable for grazing by domestic livestock. However, managed grazing has shown to have beneficial or negligible effects in many environments (Heitschmidt and Stuth, 1991).

Managed Grazing

Managed grazing is any situation where the array of grazing behaviors displayed by an animal is under some degree of management control. Most often the level of control is at a pasture scale, which can vary from less than one hectare in humid climates to over 10,000 hectares in arid climates. Key factors for management control are the timing, frequency, intensity and duration of grazing (Trlica and Rittenhouse, 1993). Each of these controlling factors can have significant effects upon the structure and function of grazing land ecosystems. The most commonly examined controlling factor is intensity of grazing use, but impacts of other factors, such as season of use and spatial distribution of grazing animals are well recognized and management principles are well articulated (Holechek et al., 1997).

A grazing system is any type of management program where the key factors of grazing are controlled to some degree. Grazing systems fall into four broad categories - true nomadism, semi-sedentary, transhumant and sedentary (Williams, 1981). Variations within each category are numerous, but each system is characterized by some level of management over one or more of the main controlling factors. It is important to recognize that grazing systems have evolved during the past 10,000 years, plant-vertebrate interactions have occurred over millions of years. Though grazing systems have been developed to either minimize livestock effects or to mimic the historical grazing behaviors of native herbivores, there is no evidence that any one specific combination of control factors (ie., a specific system) has intrinsic advantages over other combinations/systems to either compensate for prior mismanagement or dramatically improve resource conditions. The benefits of particular systems are often found in the level of increased human involvement in land management which

accompany their deployment. Secondary benefits associated with implementation of a system, such as improved animal distribution associated with watering tanks, or restricted growing season defoliation due to construction of new fences to conserve more sensitive areas, are frequently observed.

Today, grazing management is evolving towards achieving desired resource conditions rather than trying to recapture some prior existing state (Westoby et al., 1989). This change is occurring both in developed countries that have placed an emphasis on multiple uses of grazing land (ie., functioning to provide forage for livestock, habitat for wildlife, conserved watersheds for high quality water supplies and open spaces for recreational adventures) and in less developed nations where livestock production is a key component of subsistence agriculture. A future issue is whether grazing animals can be used as tools for managing landscapes while also providing agricultural products. Management objectives could include a variety of goals such as increased native vegetation diversity, improved watershed functions, decreased use of harvested forages, and biological control of introduced plant species. These objectives require managed control of grazing by livestock in order to minimize or negate effects of grazing.

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Table 1. General timeline (years before present) of domestication[1] of animals used as livestock[2].

years before present	species and locations
10,000	sheep and goats in southwestern Asia
9,000	cattle, sheep and goats in southeastern Europe
	pigs in Asia, Europe and the Far East
7,500	alpacas or llamas or both in Peru
6,000	wild asses in northern Africa
5,000	Bactrian camels in Turkmenistan region
	horses in Asia
	water buffaloes in southern China
2,500	rabbits in Europe

[1] Numerous species have been tamed and exploited but cannot be regarded as domesticated. Some of these events predated domestication, including reindeer herding 15,000 ybp in Siberia.

[2] Adapted from Clutton-Brock (1981).

Table 2. World population numbers (millions) of the primary domesticated grazing animals in 1948-52 and in 1996 by continent.[*1]

	Cattle		Sheep & Goats		Horses, Asses & Mules		Buffalo		Camels		Total	
	1948-52	1996	1948-52	1996	1948-52	1996	1948-52	1996	1948-52	1996	1948-52	1996
World	759	1,320	1,059	1,722	127	120	81	152	9	19	2,035	3,303
Western Europe	100	170	143	141	22	5	1	<1	0	<1	266	316
Eastern Europe[*2]	56	118	92	144	14	n/a	0 [*3]	<1	0	<1	162	262
North & Central America	114	165	51	32	20	22	0	<1	0	0	185	219
South America	135	300	142	110	26	23	0	2	0	0	303	435
Asia	242	431	279	795	32	46	79	147	3	5	635	1424
Africa	94	198	205	386	13	19	2	3	6	14	320	620
Oceania	20	37	145	176	1	<1	0	0	0	0	166	213

[*1] FAO 1956, 1996.

[*2] Reported as USSR in 1956, and separated as Eastern Europe in 1996.

[*3] 0 = none reported.