Contribution of low-input livestock farming to biodiversity conservation

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Challenges

Consumption and production increase

World population is projected to surpass 9 billion people by 2050. Most of the additional people will be based in developing countries, where population is projected to rise from 5.6 billion in 2009 to 7.9 billion in 2050, while the population of developed regions is expected to remain stable (United Nations, 2009). FAO' projects that by 2050, global average per-capita calorie availability could rise to 3130 kcal per day, accompanied by changes in diet from staples to higher value foods such as fruit and vegetables, and to livestock products, requiring world agricultural production to increase by 70 percent from 2005/07 to 2050. Over the past decades, growing demand for livestock products has been driven by economic growth, urbanization and rising per-capita incomes. Meat consumption per caput per year globally is expected to increase from 41 kg in 2005 present to 52 kg in 2050. In developing countries, the effect of the "livestock revolution" that led to fast growth of meat consumption in developing countries and that was mainly driven by China, Brazil and some other emerging economies, is expected to decelerate. However, annual per-capita meat consumption increases from 31 kg in 2005 to 33 kg in 2015 and 44 kg in 2050 are projected for developing countries. Annual per-capita meat consumption in developed countries is projected to increase from 82 kg in 2005 to 84 kg in 2015 and 95 kg in 2050 (OECD-FAO 2009; Bruinsma, 2009, FAO, 2010a). Given that net trade in livestock products is a very small fraction of production, the production projections mirror those of consumption. This implies that much of the projected additional cereal and soybean production will be used for feeding enlarging livestock populations.

Biodiversity impact of livestock production

While the world is projected to need a major increase in production to feed the growing population, it must do so against a challenging backdrop including the decreasing availability of and competition for land and water (including from other land uses such as production of biofuels, urbanization and industrial development); poor soil fertility and reduced access to fertilizer; as well as climate change and biodiversity loss. The most important direct drivers of biodiversity loss are habitat change (e.g. land use changes), climate change, invasive alien species, overexploitation, and pollution (MEA, 2005). Natural wilderness areas are mostly absent in areas of high population density (Groombridge & Jenkins, 2002). Agriculture and livestock production, being the largest land users, thereby contribute to biodiversity loss and ecosystem service changes. FAO (2006, 2010a) provides an exhaustive overview on the land use changes, biodiversity degradation, water pollution and greenhouse gas emissions from the livestock sector. The impacts range from local (e.g. soil and water pollution) over regional (e.g. deforestation, invasive species) to global (e.g. greenhouse gas (GHG) emissions). Reid et al. (2010) provide an overview of livestock- related threats to biodiversity.

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Pasture and feed crop expansion into natural ecosystems have the highest impact on wild biodiversity at all three levels of biodiversity (FAO, 2006) and are global in extent. Livestock grazing occupies 26 percent of the ice-free terrestrial surface and the production of livestock feed uses 33 percent of agricultural cropland (FAO, 2006; 2010a). Direct effects of livestock grazing and trampling on species diversity differ, depending on the long-term grazing history of the ecosystem. In historically old grazing systems, rangeland vegetation and animal grazing have co-evolved, with a certain amount of grazing needed to maintain structural and species diversity. They are usually resilient to livestock grazing (e.g. African savannah). In contrast, systems with recent introduction of grazing are vulnerable to its impact (e.g. Australia) (Reid et al., 2010), especially when introduction of livestock has been accompanied with introduction of fodder species (Hoffmann, 2010a). Management is critical to the biodiversity impact of grazing. While mobile pastoral systems in arid areas make strategic use of landscape heterogeneity and key resources (Behnke et al., 1993), sedentary heavy grazing tends to shift vegetation composition. Water point distribution is important as it influences livestock spatial distribution and density. On the other hand, well-managed livestock grazing can have positive biodiversity impacts (CAST, 2002; Amend et al., 2008; FAO, 2009a,b).

Greenhouse gases contribute to climate change which in turn increases the risk of biodiversity losses. The livestock sector is a large producer of greenhouse gases (GHGs). Eighteen per cent of global GHG emissions are attributed to livestock – via land use and land-use change (directly for grazing or indirectly through production of feed crops), manure management, and enteric fermentation (FAO, 2006a, 2010). Many of the environmental changes that are already occurring as a result of human activities and those that are likely to occur in the future as a result of climate change are incremental, but they are cumulative and may eventually materialize in environmental crises. The IPCC has warned of 'tipping points' where damage due to climate change occurs irreversibly (Lenton et al., 2008). Thomas et al (2004) estimate that 15 to 37% of species will be threatened by extinction by 2050 through changes in species range and distribution, population size, disease pattern and species invasion. Especially sensitive are marginal ecosystems (rainforest, high altitude, low fertility, marine etc).

Intensification of agricultural systems, coupled with specialization in breeding and the harmonizing effects of globalization and zoosanitary standards, has led to a substantial reduction in the genetic diversity within domesticated animal species (MEA, 2005). FAO (2007a) indicates that the risk for breed survival in the past century was highest in regions that have the most highly-specialized livestock industries with fast structural change and in the species kept in such systems. Globally, about one-third of cattle, pig and chicken breeds are already extinct and currently at-risk (FAO, 2010b).

Pollution and contamination in intensive production areas, and nutrient concentration in extensive grazing systems also have impacts on biodiversity (FAO, 2006), mostly at regional scales. Fertilizer and manure (N, P) run-off lead to eutrophication and algae bloom, damage aquatic species (e.g. coral bleaching) and, in the worst case, cause biologically dead zones in water systems. Pollution related increases in soil fertility result in the out-competition of N-sensitive plants.

Invasive alien species are another pathway how livestock affects biodiversity (Hoffmann, 2010a). Feral pigs, goats and rabbits are classified among the top 100 world's worst invasive alien species (Lowe et al., 2000). Linked to the introduction of livestock species was the concomitant introduction of alien plants, often to improve fodder quality of native rangelands. The IUCN/SSC Global Invasive Species database lists 95 invasive plant species, many of which were introduced as livestock improvement crops and later invaded natural grasslands, out-competing native grasses and decreasing biodiversity. Grazing livestock in turn contributes to seed dispersal and triggers habitat changes that facilitate invasions. On the other hand, livestock can become a victim of alien plant invasions in pastures, driving pasture expansion and land-use change (Reid et al., 2010).

The impacts of high and low external input production systems on different levels of biodiversity, from the gene to the ecosystem, are not consistent, due to the complex biological interactions between livestock and their production environments and the high trophic level of livestock in the food web. Usually, the effects of land-use change and GHG emission that affect natural biodiversity at global level go in the same direction. From the global level point of view, high-external input systems may have advantages as regards their lower GHG emissions per unit product, with positive indirect impacts on land-use and global natural biodiversity. However, at regional and local level, habitat and species diversity tend to be higher in low external input systems. Besides natural resources endowment and socio-economic data, societal choices also depend on cost-benefit ratio as well as farmer personal preferences (Hoffmann, 2011).

Solutions to reduce the biodiversity impacts of livestock production

Trade-offs are likely to occur between achieving the Millennium Development Goals' targets and the targets of reducing the rate of biodiversity loss (Hoffmann, 2011). However, potential synergies between the various internationally agreed targets relating to biodiversity, environmental sustainability, and development exist (Herrero et al., 2009). Strategic Priorities 5 "Promote agro-ecosystems approaches to the management of animal genetic resources" and 6 "Support indigenous and local production systems and associated knowledge systems of importance to the maintenance and sustainable use of animal genetic resources" of the Global Plan of Action for Animal Genetic Resources, the internationally agreed framework for the management of livestock biodiversity (FAO, 2007b), also aim at co-benefits.

Starting to reduce the livestock sector's biodiversity impacts at the demand side, a modification or reduction of meat consumption with a shift from ruminant to monogastric meat may reduce the climate change and land-use related impacts due to the latter's better feed-conversion ratio (FAO, 2010a). In future, the separation of meat production from live animals, through in-vitro meat, or meat substitution by other protein-rich foods can be envisaged.

At the supply side, intensification, productivity increases and waste reduction in all production systems will improve the resource efficiency of livestock production and thereby pressure on natural biodiversity. To reduce the impact on natural biodiversity from high external input production systems, the focus should be on reducing land use changes and emissions associated with feed production. This also goes along with a shift from ruminant to monogastric livestock species (FA), 2010a). Due to the already high productivity in these systems, the options for further improvement are limited, however, frontier research in breeding and feeding could make a difference.
In low external input production systems, various opportunities for productivity gains, including options for climate change mitigation, exist. However, it may easily happen that local breeds, which are usually fed on roughage and/or crop residues and have low output in single food products, are considered inefficient if efficiency is just considering output of marketable food products. The pressure to increase efficiency may thus disadvantage local breeds, especially of ruminants, thereby exacerbating the current trends of economically driven breed loss (FAO, 2009c, 2010b; Hoffmann, 2011). On the other hand, there are huge potentials to increase productivity of local breeds that could easily be achieved with improved feeding and within-breed genetic improvement (FAO, 2010c).

Another issue in the assessment of "efficiency" that links the global to the local level impacts of livestock on biodiversity is that of human-edible food needed to produce one unit of livestock source food, taking account of species' different ability to use forages that cannot otherwise be used by humans. Generally, countries with very intensive grain-based livestock production systems have a human-edible protein output/input ratio of below or near one, while countries with a predominance of low external input grazing ruminants have considerably higher ratios, meaning that they add to the overall supply of protein (CAST, 1999). This food-feed competition can be reduced either by producing a larger share of the world's livestock products within forage grazing and low external input mixed systems, leaving more plant protein to be eaten by humans, or by recycling more crop residues and waste products, including agro-industrial by-products, through animals. This would favour the return of herbivore livestock species to forage-based diets and land-based production systems and might offer new opportunities for local breeds (FAO, 2009a). Besides more research in breed-vegetation-soil interactions, especially in semi-arid pastoral areas, a supportive political and economic environment will be needed.

At regional and local level, where habitat and species diversity is directly influenced by livestock production, the multiple products and services of livestock, especially in low external input systems, play an important role, and co-benefits between different objectives can be expected. The use of local breeds and the introduction and maintenance of extensive grazing systems contribute to agricultural biodiversity and conservation of agricultural landscapes as well as food security (FAO, 2009b).

In agricultural systems, livestock often 'mimicked' the role of wild large herbivores in controlling vegetation. Traditional farming and associated land management practices have produced a range of semi-natural environments that favoured a variety of wild fauna and flora, with high heterogeneity and a mixture of spatial and temporal land uses, including the presence of 'neglected' areas. Local animal breeds are getting recognized as part of culture and landscape, and as attractive for tourism. As many traditional farming landscapes are now protected, Amend et al. (2008) asked what types or proportion of agro-biodiversity might be included within a protected area.

The European Council Habitat Directive, in its Annex 1 (European Union, 1992) lists habitats that are considered as being of importance for their biodiversity value. To implement the Habitat Directive, the EU Biodiversity Action Plan established more than 26000 Natura 2000 sites, corresponding to 18% of the EU (27) territory. In addition to protected areas, EU agri-environment measures aim to support public goods such as high nature value grasslands with high structural heterogeneity.
Although there is some evidence that local adapted breeds exert pressure on vegetation different than exotic breeds due to their feeding behaviour and grazing ranges, there is generally little research in special adaptation of local breeds or ecosystem functions linkages. An indication on the situation of rare or endangered breeds inside and outside the Natura 2000 sites is still missing (Diana, 2011).

Agri-environment payments from the European Union Rural Development Programme (RDP) support the rearing of local breeds indigenous to the area and in danger of being lost (Council Regulation EC 1698/2005 and 1974/2006). Both Regulations allow for specific measures for the conservation of genetic resources in agriculture at national or regional levels. However, Signorello and Pappalardo (2003) showed that previous EU RDP measures were not as effective and efficient as expected in conserving breeds at risk.

Well-managed livestock grazing can have several co-benefits (Amend et al., 2008; FAO, 2009a,b). For example, improved grazing management leads to reduced rangeland degradation, improved vegetation biodiversity and, depending on aridity, improved soil-carbon sequestration which may partially offset GHG emissions from other components of the production process; it also has a favourable impact on livestock productivity (CAST 2002; Smith et al., 2007; FAO, 2009a; 2010a). However, usually only the value of rangeland as a source of forage supply for grazing livestock has an economic market value. The absence of market values for the other ecosystem services results in low incentives for the conservation of their provisions to the public. It is thus important that policies are implemented to provide appropriate incentives and benefits in support of the provision and conservation of ecosystem services. Also institutional problems such as land-use rights and secure access to resources need to be solved to enable the diverse and often marginalized livestock keepers in dry and sub-humid lands to partake in decision making and develop and adopt improved rangeland management practices.

With regard to the development of niche markets for local breed's products, it is often the production system associated with the breeds, rather than the breed itself, that results in higher prices. Not only the genetic characteristics of traditional breeds contribute to taste and structure of the meat but also the vegetation consumed the slow extensive production system, or special processing of meat or cheese.

Conclusion

There is no question that demand for animal products will continue to increase in the next decades and a further push to enhance livestock productivity across also production systems is needed to reduce the global level environmental footprint of livestock production. However, many of the required new technologies will accelerate the structural change of the sector towards more intensive systems and thereby the loss of animal genetic diversity.

Arguments in favour of low-input breeds are based on the multiple products and services they provide, mostly at regional and local level. Firstly, their ability to make use of low-quality forage results in a net positive human edible protein ratio. Secondly, under appropriate management, livestock kept in low external input mixed and grazing systems provide ecosystem services. Thirdly, as a result, and linked to local breeds' recognition as cultural heritage, linkages to nature conservation need to be further explored and strengthened.

Improved capacity to predict the consequences of changes in drivers for biodiversity, ecosystem functioning, and ecosystem services, together with improved measures of biodiversity, would aid decision-making at all levels (MAE, 2005).

It can be assumed that contracting public budgets will require clear monitoring of outputs and outcomes for future payment for environmental schemes. Therefore, more research in both the livestock and ecosystem functioning and their interaction would be needed, including public databases for breed genetic and phenotypic data, their performances in different production environments, and in breed-vegetation-soil interactions. FAO's efforts to implement production-environment descriptors in its global breed database in DAD-IS (FAO/WAAP, 2008) is a critical step in this direction, but country-level research to provide data is needed. Baselines and indicators would need to be developed to allow for monitoring and underpin incentive mechanisms. Wätzold & Schwerdtner (2005) noted that issues related to the cost-effectiveness of biodiversity conservation policies had not been prominent in European conservation research and policy-making, and stressed the need to integrate knowledge from ecology and the economic analysis of policy instruments. The Economics of Ecosystems and Biodiversity (TEEB) initiative recognized the need to develop tools to properly value ecosystem goods and services and to determine the cost of biodiversity loss. It aims at making better use of economic incentives for the sustainable use of ecosystem services (TEEB, 2010).

Science can help ensure that decisions are made with the best available information, but ultimately the future of biodiversity will be determined by societal choices. Policy instruments are required to stimulate implementation of a portfolio of options that include changes in consumer behavior, the development of niche markets and labeled products as well as the fostering of sustainable livestock agriculture and food production.

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