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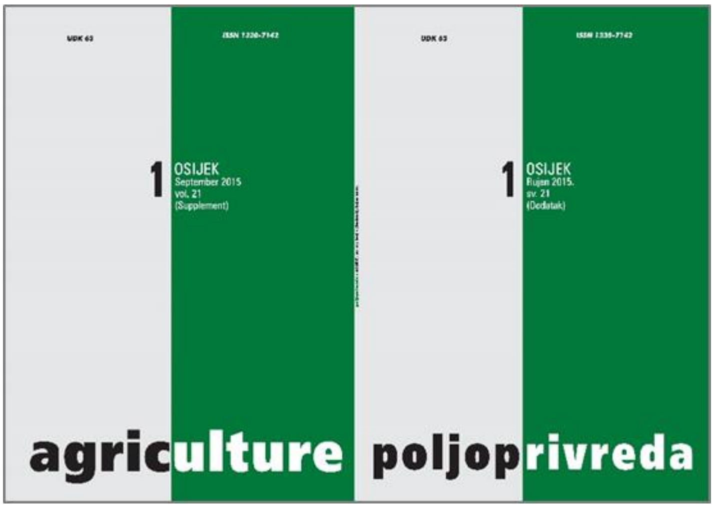

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SUSTAINABLE MILK PRODUCTION IN DIFFERENT DAIRY CATTLE SYSTEMS AND VALORISATION OF ENVIRONMENTAL CHAIN ON THE BASIS OF ADDED VALUE

Cassandro, M.

Scientific review

SUMMARY

Aim of this review is to estimate milk yield and predicted methane emissions added values in local and cosmopolitan cow breeds reared in Italian circumstances. Nowadays it is well known that over the next 50 years, the world's farmers will be asked to produce more food than has been produced in the past thousand years, and in this concern it will be in environmentally sustainable way. The review will higlight the differences between intensive and extensive agricultural systems and this will be discussed and evaluated in dairy cattle production system context. In conclusion, animal genetic resources need to be evaluated not only per unit of output but for other direct and indirect output units related to social and human returns supporting different animal production systems, intensive or extensive ones. The intensive and extensive farming systems are not replaceable to each other, but they should be combined in order to respond to different social and environmental needs, so, to define the best sustainable production system. Moreover, both systems should also consider the modern demands that nowadays agriculture requires as, guarantee for food security. Therefore each system, intensive or extensive, should improve the animal products technological characteristics and at the same time reduce the carbon footprint.

Key-words: substainable systems, animal production, cattle breeds, added values, production and environmental chains

INTRODUCTION

Animal production has been practised for thousands years since the first animal domestication. Humans keep livestocks because they provide food and revenues. Animal's most universal and significant productivity is milk, meat and/or eggs for direct animal owners consumption or for selling to others. Important, but frequently overlooked contributions include transportation, manure, fibre, hides, other by-products, environmental protection and several historical and social traditions. The major factors impacting the classification of animal production systems are based on climate, level of technology, infrastructure, production incentives, political constraints and human resources. For semplicity, two can be the classification of agricultural systems: the Intensive Agricultural Systems (IAS, based mainly on double cropping, crop rotation, crop residue management, erosion control) and the Extensive Agricultural Systems (EAS, based mainly on broad, much variation, inter cropping, strip cropping, involving several different different crops or livestock species).

Over the next 50 years, farmers will be called upon to produce more food than has been produced in the past 10,000 years, and to do so in environmentally sustainable ways (FAO, 2009). An important strategy to increase added value for animal products, to preserve the environment and biodiversity, and to orientate tourism and food consumptions, would be the promotion of connections among the three key factors: breed, product and agricultural system.

Aim of this review is to explore the different effects in which it is possibile to see which contribuition the livestock sector, intensive and extensive, might have in the world modern concept.

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INTENSIVE AGRICULTURAL SYSTEM

This intensive agricultural system (IAS) has produced a large amount of food using green-revolution first generation techniques. Since 1950, increase in global food production has come from increased yield per unit of animal reared or area of crop land, using highly-selected breeds and high-input monoculture, using selectively bred or genetically-engineered crops; high productions using high levels of fertilizer, extensive use of pesticides and high amounts of water and finally a multiple cropping in order to increase the number of crops grown per year in a plot of land.

On the contrary, this intensive system produced an increase of outputs per profit, determined an increase of land and environment pollutions, increase waste runoff that increased nutrients and pathogens in streams, high soil erosion and pesticides concentration, reduced, therefore, animal welfare, food security and overall sustainability of animal production. The intensive agriculture showed that several human intensive agriculture practices can alter native habitats and reduce native biodiversity. However, it has guaranteed a large food security in developed countries.

FAO (2007) reported that animal production in the future needs for urgent action because of the wise management of the world's animal genetic resources, in order to guarantee the food security and the environmental protection. The world's population is expected to increase in the next forty years from 6.2 billion to 9 billion people. It is clear that more people will require more meat, milk, eggs and other livestock products. A wide portfolio of animal genetic resources will be crucial in adapting and developing the world's agricultural production systems so increasing the resilience of our food supply.

In particular, nearly all of this population increase will occur in developing countries, the urbanization will continue at an accelerated pace and about 70 percent of the world's population will be urban (compared to 49 percent today). Income levels will be many multiples of what they are now. In order to feed this larger, more urban and richer population, food production (net of food used for biofuels) has to increase by 70 percent and annual cereal production will need to rise to about 3 billion tonnes from 2.1 billion today. Annual meat production will need to rise by over 200 million tonnes to reach 470 million tonnes.

Summarizing, the IAS is an agricultural production system characterized by high use of input such as capital, labour and chemicalfertilizers relative to land area. Agricultural intensification has been the dominant response to population growth, as it allows producing more food on the same amount of land. Intensive animal farming practices can involve very large numbers of animals raised on limited land requireing large amounts of food, water and medical inputs. Intensive livestock farming provides opportunity to capture methane emissions which would otherwise contribute to global warming. Once captured, these emissions can be used to generate heat or electrical energy, thereby reduce local demand for fossil fuels. Factory farming is the process of raising livestock in confinement at high stocking density, where a farm operates as a factory being a practice typical in industrial farming by agribusinesses. The main products of this industry are meat, milk and eggs for human consumption.

EXTENSIVE AGRICULTURAL SYSTEM

The extensive agricultural system (EAS) is a system of farming carried out on very large holdings with a high reliance on technologies and local biodiversity. Moreover, the EAS is based on relatively low input and low yields compensated by the very large area cultivaed. Decisions taken by the farmer, or the corporation, are of great importance. The EAS can define a better system than IAS because it pursue the conservation of a state of armony between human and land (Knight and Riedel, 2002). The idea of Leopold, reported by Knight and Riedel (2002) is to describe the land, as it is not merely soil; it is a source of energy flowing through a pyramidal circuit with he soils at the base t and above their plants and animals. Food chains are the living channels which conduct energy upward; death and decay return it to the soil.

Summarizing, the EAS is an agricultural production system that uses small inputs of labour and capital restriceted to the land area farmed or grazed. Nomadic herding is an extreme example of extensive farming where herders move their animals to use feed from occasional rainfalls. Animal welfare is generally improved because animals are not kept in confined conditions. Moreover, extensive livestock farming provides opportunity to produce low methane emissions per unit of metabolic body weight or per hectar, and the main strategies of extensive system is to valorize local genetic diversity and make profit with a reduction of costs of production and with an increment of added values of its products (Cassandro, 2013).

INTENSIVE AND EXTENSIVE ANIMAL PRODUCTION SYSTEMS

In the specific sector of animal production the intensive and extensive systems can be defined as follows:

- Intensive systems are based on smaller acreage, fewer animals, cosmopolitan breeds, more input costs per individual animal, more labor, more often, sell for higher prices (often purebred/seedstock operations).
- Extensive systems are based on larger acreage, more animals, local breeds, fewer input costs, less labor, less often, sell for lower prices (often crossbred commercial herds).

Differences in how we assess the impact of intensive and extensive systems might be evaluated based on:

- added values for dairy chain by intensive and extensive systems;
- added values for environmental chain comparing greenhouse gas emissions generated by intensive and extensive systems.

A comparison of added values for milk yield and predicted methane emissions from local cows and intensive systems reared in Italian circumstances could be used as an example of how we can assess the impact of the intensive and extensive systems in different circumstances. Market-oriented strategies to payment systems that include milk yield added values of could enhance profitability and interest in rearing and safeguarding of extensive systems based on local animal genetic resources; but, not all countries can apply these market strategies. Therefore, other strategies to enrich milk production added values of might be based on the differences in greenhouse gases emissions among the production systems and breeds. Indeed, local animal genetic resources are expected to reduce the greenhouse gases emissions because of their lowest metabolic body weight, respect to high selected animals, or because their larger use of pasture providing a carbon sink effect. The impact of livestock species reared in different production systems is showed in Table 1 in terms of greenhouse gas emissions.

Table 1. Impact of livestock species reared in different production systems on greenhouse gas emissions (Cassandro et al., 2013)

	Ruminant Species		Monogastrics species	
Greenhouse gas emissions	Extensive grazing	Intensive systems	Traditional systems	Industrial systems
CO_2 emissions from land-use change for grazing and feed-crop production	---	-	ns	--
CO_2 emissions from Energy and input use	ns	--	ns	--
Carbon sequestretion in rangelands	++	ns	ns	ns
Methane emissions from digestion	---	--	ns	--

Legend: - = negative effect; + = positive effect; ns=not signficant effect; the number of minuses are proportional to the efffect on the greenhouse gas emissions

ADDED VALUE FOR DAIRY CHAIN

The definition, in a broad sense, of the added value (AV), can be the difference between the final selling price of a product and the direct and indirect inputs used to manufacture it. Therefore, the AV can be defined as the measurement of increment of gross value for a product made following a specific process. In dairy chain the AV can be calculated as difference between value V (the price value of final product, e.g. value of cheese produced by 1 kg of milk) and value K (the price value of input, e.g. value of 1 kg of milk used as fluid milk). Therfore, if the AV is positive, the product has added value, whereas if the AV is negative, the product has reduced value. In other terms, if the AV is greater than the cost of the process if is profitable, otherwise, the process is not profitable. Using a study of Cassandro (2013), the intensive systems (IS), namely Holstein Friesian, Brown Swiss, and Simmental, produced 9.2 kg/d ($P<0.05$) more milk compared with extensive systems (ES), namely Burlina, Rendena, Reggiana and Valdostana Red Pied. Fat percentage was significantly ($P<0.05$) higher for IS (3.89%) compared with ES (3.56%), whereas not significant differences were found for protein percentage and somatic cells count. Regarding body weight, IS were 213 kg ($P<0.001$) heavier than ES. Table 2 reports the added value per kg of milk yield estimated using standard milk and cheese prices adopted in Italy including cheese yield (Bozza, 2007). The average added value for milk yield was 0.15 ± 0.03 Euro/kg and it was lower for IS than ES (0.13 vs 0.17 Euro/kg; $P<0.05$). Hence, the milk yielded by ES is more suited to be destined to cheese production comparered with milk from IS. However, in terms of lactation yield the comparison between IS and ES can change due to the higher longevity of IS compared with ES. The added value for 305-d lactation yield showed that on the average, the added value was 813.7 ± 106.2 Euro, and it was higher, but not statistically significant, for IS than ES (893 vs 754 Euro; NS).

Table 2. Added value per kg of milk yield and per 305-d lactation of different livestock systems (Cassandro, 2013)

Livestock system	Value of cheese, €/kg	Value of milk yield, €/kg	Added value, €/kg	Added value, €/305d
Intensive:				
- Holstein Friesian	0.502	0.399	0.103	918
- Brown Swiss	0.569	0.423	0.146	950
- Simmental	0.553	0.425	0.128	810
Extensive:				
- Burlina	0.552	0.393	0.159	706
- Rendena	0.565	0.393	0.173	822
- Reggiana	0.574	0.411	0.162	835
- Valdostana Red Pied	0.576	0.387	0.189	654
Average ± SD	0.556 ± 0.025	0.404 ± 0.015	0.151 ± 0.029	813.7 ± 106.2
lsmeans of Intensive vs Extensive systems [1]			0.13 vs 0.17 P<0.05	893 vs 754 NS

[1] One way ANOVA using as fixed effect the livestock systems grouping in two levels (Extensive and Intensive); NS = not statistically significant

ADDED VALUES FOR ENVIRONMENTAL CHAIN COMPARING GREENHOUSE GAS EMISSIONS BY INTENSIVE AND EXTENSIVE SYSTEMS

In the environmental chain the AV may be defined as the minimum air pollution due to enteric methane emissions. Methane emissions contribute significantly to the greenhouse effect having many times the global warming potential of carbon dioxide (IPPC, 2001; Kebread et al., 2008). Among human activities, the FAO (2006) declared that the agriculture sector accounts for 22% of the total greenhouse gases (GHG) emissions and 3% is due to livestock sector (Cassandro et al., 2010). In Italy, cattle breeds account for 78% of the total GHG emissions from livestock species; 54% is produced by dairy cattle and 24% by beef cattle. Typically, 2 to 12% of the gross energy intake in cattle is lost through eructation of methane (Johnson and Johnson, 1995). As methane concentration in the atmosphere is increasing, there is a strong interest in developing strategies to reduce its emissions, particularly from the livestock sector. A mitigation action to reduce the emission might be possible by improving the breeds with the highest AV for environmental chain that can be defined as the GHG emission per 1 kg of milk yield or metabolic weight. In this case the AV is a measurement of an environmental mitigation and might be used as a new brand of the breed for a valorization project.

Cassandro et al. (2013), using an indirect method, predicted the methane emissions in different cattle breeds, that can be assumed as intensive and extensive systems. The predicted methane production of 16.28±3.24 MJ/d with a maximum value of 21.23 MJ/d for the IS based on Holstein Friesian and a minimum of 12.53 MJ/d for ES based on Valdostana Red Pied on the average are reported in Table 3. The average of ES showed better AV than average of IS for environmental chain, because of lower predicted methane production (13.90 vs 19.46 MJ/d; $P<0.01$). In terms of methane emission per kg of milk yield, the average value was 0.9059±0.1098 MJ/d with a maximum value of 1.1029 MJ/d for ES based on Valdostana Red Pied and a minimum of 0.7309 MJ/d for IS based on Holstein Friesian. Not significative differences were found between ES and IS for daily methane production per kg of milk yield (0.9627 vs 0.8301 MJ/kg/d; $P>0.05$). Moreover, in terms of methane emission per kg of metabolic weight, the average value was 0.1378 ± 0.0063 MJ/kg with a maximum value of 0.1488 MJ/kg for IS based on Holstein Friesian and a minimum value of 0.1283 MJ/kg for ES based on Valdostana Red Pied. The ES showed better AV than IS for environmental chain, because of lower predicted methane production (0.1339 vs 0.1424 MJ/kg; $P<0.05$).

Table 3. Added value (AV) for environmental chain, expressed as predicted methane emission (MJ/d) in absolute value, as predicted methane emission per kg of milk yield and as kg of metabolic weight (Cassandro, 2013)

Livestock system	Methane, MJ/d	Methane/Milk yield MJ/Kg/d	Methane/Metabolic Body Weight, MJ/Kg
Intensive:			
- Holstein Friesian	21.33	0.7309	0.1488
- Brown Swiss	18.22	0.8552	0.1416
- Simmental	18.82	0.9041	0.1383
Extensive:			
- Burlina	13.37	0.9185	0.1368
- Rendena	14.31	0.9174	0.1353
- Reggiana	15.38	0.9120	0.1354
- Valdostana Red Pied	12.53	1.1029	0.1283
Average ± SD	16.28 ± 3.24	0.9059 ± 0.1098	0.1378 ± 0.0063
lsmeans of Intensive vs Extensive systems [1]	19.47 vs 13.90 $P<0.01$	0.8301 vs 0.9627 NS	0.1424 vs 0.1339 $P<0.05$

[1] One way ANOVA using as fixed effect the livestock systems grouping in two levels (Extensive and Intensive); NS = not statistically significant

CONCLUSION

Animal Agriculture is an important aspect of human life since the beginning of the world. A major constraint to the adoption of improved innovations in animal agriculture is the land use system which should be based on modern extensive system in respect to intensive system. The present intensive system in agriculture of the developed countries has created an overexploitation and general mismanagement of resources. Land use and rangeland policies that guarantee a low environment impact will enable farmers to propagate fodders and control breeding of their animals. All these improved management practices will ensure sustainable animal agricultural development.

Analyses on added value for dairy chain was better on extensive systems than intensive systems, so, cheese yield is preferred for extensive systems to milk fluid production which is more appropriate to intensive systems. Similarly, analyses on added value for environmental chain, showed that added value is better with extensive systems in respect to intensive systems. Hence, extensive systems showed to cope better with mitigation of predicted (CH_4) emission in absolute value and per unit of metabolic weight than for unit of milk. Knowing that CH_4 emission per unit of metabolic weight might be considered as a measure at net of the selection effect, while the CH_4 emission per unit of milk yield is a measure at gross of the selection effect, this study showed that livestock systems have a dual role not only in food production, but also in the provision of public good objectives including, biodiversity and landscape values as well as diffuse pollution to environment. Therefore, the comparison of different livestock systems should be evaluated in terms of environmental efficiency and not only in term of economic efficiency. Livestock systems need to be evaluated not only per unit of output but for other direct and indirect units of output related to social and human returns, valorizing added values for cheese yield and environment mitigation including other social and public goods, as territory preservation, consumer habits, turists requests as well as history and cultural aspects of link between breed and food. In conclusion, the intensive and extensive farming systems are not alternatives to each other, but must be combined in order to respond to different social and environmental needs. Both systems must still be considered the modern demands that nowadays agriculture requires as guarantee for the food security, improving the technological characteristics of animal products and reducing the carbon footprint.

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