Theoretical and empirical studies on farming systems in Spain and Poland

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FOREWORD

An inflexible policy for development of agriculture and rural areas on a national or regional scale has been often ineffective because it has not taken into account the spatially heterogeneity of natural and socio-economic resources of the target area. Much more effective can be a policy that is adequately target to different realities of these areas accordingly with the principle of decentralization of governance, selection of such path-ways and strategies for their development that correspond well to the local demands of the population and to possibilities of an efficient and sustainable use of the resources. Therefore, one of the most important conditions for high effectiveness of EU, state and local government interventions in agriculture and rural areas is their flexibility. Developing and implementation of various options of such interventions should be adequately fitted to the specific types of farming systems existing in the target area. Then, such an intervention strategy would require assessment the diversity and identifying typology of farming systems at the regional and farm levels using both expert or numeric criteria.

The objectives of the monograph are to present some considerations on both general aspects and more detail descriptions of important farming systems existing on rural areas of Spain and Poland. The included papers have been elaborated and presented by participants of the Seminar "Theoretical and empirical studies on farming systems in Spain and Poland" held on 23 May 2011 at Faculty of Agriculture and Biology, Warsaw University of Life Sciences-SGGW, Poland. This Seminar was organized jointly by Faculty of Agriculture and Biology of Warsaw University of Life Sciences, Poland and University of Sevilla, Spain. These papers regard different aspects of agricultural land use with emphasizing of high nature value (HNV) and organic farming systems as oriented to nature conservation. The first one presents a review and analysis of ruminant (cattle, sheep, goats) production systems in Spain. Except description of present state, it contains also an analysis of future development perspectives. The second one is a case study how grazing animals can help to manage and protect grassland habitats in Poland. The next of them shows achievements and new tendencies in grassland management systems with reference to the past and present situation in Poland. Theme of the fourth one is strictly connected to the recent biggest environment problem – the global warming. It presents some technical aspects of mitigations of greenhouse gases emission in cropland management. The main aim of the next paper is to show the usefulness of Technical-Economic Analysis (TEA) in decision-making of farmers, associations and government to increase the viability of farms using also some Spanish examples. The sixth paper presents present state and prospects for development of organic farming in Poland. The last one is a short review of agriculture impact on biodiversity within rural landscapes and methods of it's measurement. Moreover, the monograph contains one practical report on cattle breeding systems in a model large organic farm in Poland.

The knowledge on diversity and characterizing of farming systems met in Spain and Poland presented in this monograph allows to compare their specificity dependently mainly on natural and socio-economic resources, tradition and local policy of rural areas development in the both countries. It could be also a major investment for extension services to establish effective advice and recommendation net to farmers, as well as to all rural actors and society.

Research papers (reviewed)

RUMINANT PRODUCTION SYSTEMS IN SPAIN: SUSTAINABILITY ANALYSIS

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Abstract

The aim of this paper is to show the evolution of Spanish ruminant production and future prospects. Spanish rangelands cover 18.440 thousand ha, 36.4% of the total Spanish surface area. However, Spanish livestock production is practised through intensive systems (pig meat and beef production, poultry production and dairy production, especially cows and ewes). Spanish rangelands are mainly used by beef cattle and meat-purpose sheep and goats. In Spain 9 main Geographical Zones (GZS) can be identified; the Northwest and North Zone, which corresponds to "Wet Spain", and the Southwest and West of Spain endowed with abundant grasslands. The Spanish dairy cattle production, in general is becoming rapidly modernized, although in Spain milk production is making a loss. The main problem in this sector is the low price of milk, which moreover is greatly influenced by large agro food companies. The Spanish dairy sheep production has been highly developed in the last decade by introducing the Assaf breed into intensive farming systems. The *Manchego* cheese (made from sheep milk) is the most important Spanish "Controlled Designation of Origin", and represents 90% of Spanish cheese exports. More than 50% of Spanish goat milk is produced in Andalusia, but only 10% of the milk is processed there. In the sheep and goat meat sectors of Spain most of ruminant farms have abandoned their activity, even after the decoupling of EU aid. The sheep meat sector is currently quite well structured through cooperatives and there are several "Protected Geographical Indications". Finally, in Spain a well-accepted type of cattle, aged 12-14 months, is produced intensively but the viability of this type of production depends essentially on the evolution of animal food prices, as with all types of ruminant production, which also depend on the trade regulations in the EU. In ruminant grazing systems, the evolution of production also depends on the appreciation of benefits (externalities) by the EU and society in general. Other factors, more farmer-dependent, are related to the structuring of each sector and the promotion of quality products. Diversification of farmer activities is another issue to be considered in an effort to reach farm viability.

Key words: bovine, sheep, goat, EU

1. Introduction

Spain, with a surface area of 505 000 km^2 and more than 46 million inhabitants, is the third largest and the fifth most populated country of the EU. The population density (91 inhabitants/km^2), is lower than the most populated countries of the EU: Germany, France, UK, Italy (252, 117, 252 and 199 inhabitants/km^2 respectively). The Gross Domestic Product (GDP) of Spain in 2009 was €1 117 624 million, the fifth biggest of the EU behind Germany, France, UK and Italy. The importance of Spanish agriculture decreased in the second part of the last century, so the current Final Agricultural Production (FAP) is only about 3.5% of the GDP. The Spanish Final Livestock Production (FLP) makes an important contribution to the Spanish FAP (33%) but makes up only 1.2% of the GDP (INE, 2010).

Spanish rangelands cover 18 440 thousand ha, 36.4% of the total Spanish surface area. This large proportion shows the potential to raise animals on grazing systems (Boza, 2006). However, Spanish livestock production is generally practised through intensive production systems (pork and beef production, poultry production and dairy production, especially cattle and sheep). Spanish rangelands are mainly used by beef cattle, and meat sheep and goats. Some dairy farms use rangelands, but additional food is almost always supplied in the manger. As for the fattening animals, they are mainly stabled. In some cases, especially in dairy cattle production, artificial lactation is practised.

Meat (and animals), milk and egg production account for 73%, 18% and 8% of the Spanish FLP respectively. Concerning economic values of pig, cattle, poultry and small ruminant meat production, they reach 44%, 25%, 17% and 11% respectively. Concerning cow, sheep and goat milk production, they make up 85%, 7% and 8% respectively of the total Spanish milk production; the economic values of these productions being 72%, 16% and 12% of the total Spanish milk production value (MARM, 2009).

The aim of this paper is to show the evolution of the Spanish ruminant production and future prospects. In order to place this work in context, a preliminary description is provided of the geographical and agro-climatic characteristics of Spain and of its historical animal production practices.

2. Geographical and agro-climatic characteristics of Spain

Although the climates in Spain are difficult to classify because of their heterogeneity, it is possible to distinguish the following main climate types: oceanic, continental, Mediterranean and Mediterranean mountain. There are also others such as tropical or semi desert climates.

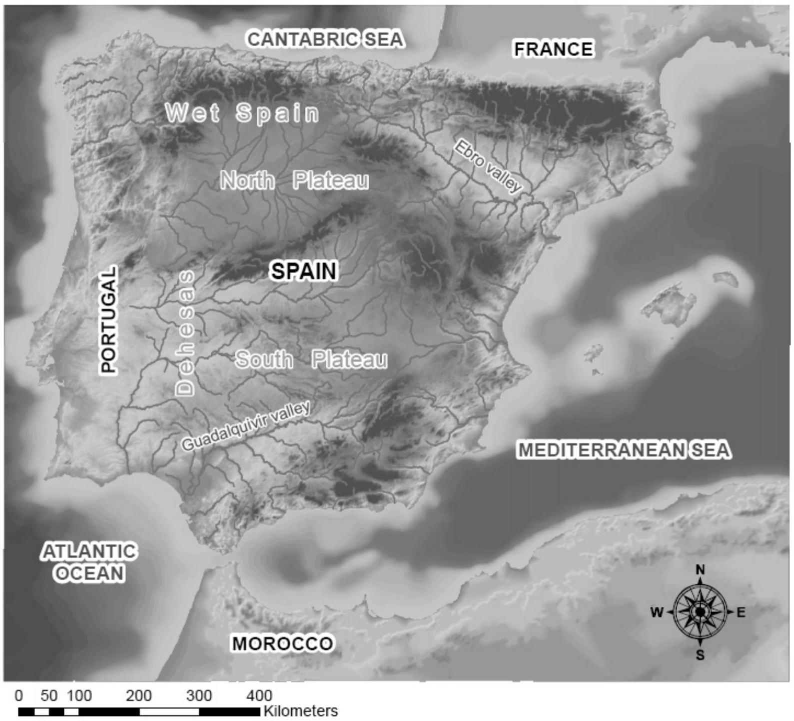

Figure 1. Geographical Zones of Spain (excluding Canary Islands)
Source: CNIG (2011)

In Spain nine main Geographical Zones (GZS) can be identified. They have different climates, orography and soil characteristics, which determine the different agrarian uses (Table 1 and Figure 1).

In Spain there are seventeen autonomic regions that are shown in Figure 2. The main crops and animal productions in each GZS are shown in Table 2. The Northwest and North Zone correspond to "Wet Spain". Consequently in this zone there is abundant grassland and has the most important livestock production in Spain. The other geographical zone with abundant grass is located in the Southwest and West of Spain. This agro ecosystem is of an open woodland type called *Dehesa,* where animals of different meat-purpose species (cattle, sheep, goats and pigs) are farmed extensively (Gaspar *et al*., 2008; Milán *et al*., 2006). In the Guadalquivir Valley (Andalusia), agriculture is very important (cereals, industrial crops and fruit crops) and the animal population in intensive livestock systems (dairy cattle, pigs and poultry) is more predominant than the extensive systems. However in the Guadalquivir Valley, the extensive or semi extensive farms, (cattle, sheep and especially goats, mainly in grazing regimes) are more numerous and they play an important socioeconomic role. Sheep farming in Spain is more important in the Ebro Valley, South Plateau and North Plateau. In the two former, meat-purpose flocks are predominant and in the third zone dairy farming is the most important.

Table 1. Characteristics of Geographical Zones of Spain (GZS)

GZS	MCT	RA (mm/year)	AA (m)	PST
Northwest and North	Oceanic	> 1000	HV*	Acid
Southwest and West	Continental**	500-600	300	Acid
Guadalquivir Valley (South)	Mediterranean**	500-600	100	Mildly basic
Southeast	Arid	< 300	HV*	Basic
East and Northeast	Mediterranean	400-500	HV*	Basic
Ebro Valley	Continental**	400-500	400	Basic
North Plateau	Continental	500-600	850	Mildly basic
South Plateau	Continental	400-600	600	Mildly basic
Canary Islands	Tropical	300-400	HV*	Volcanic

Source: the authors
*There are mountains near the sea; ** There are other influences according to location near Mediterranean Sea or Atlantic Ocean; MCT: Main Climate Type; RA: Rainfall Average); AA: Altitude Average; PST: Predominant Soil Type; HV: High Variability

3. Historical evolution of Spanish ruminant production

The livestock sector is one of the most dynamic parts of the agricultural economy (FAO, 2009). After World War II in all developed European countries, the importance of intensive livestock systems increased. There were several reasons for this increase: a larger urban population, greater purchasing power, lower food prices, and scientific progress in genetics and animal nutrition, especially in pigs and poultry. Until 1960, animal production in Spain was based on local breeds farmed in extensive production systems. From 1960 to 1985 a spectacular transformation occurred in Spain: hills and rangelands in general were ploughed up, leading to a considerable decrease in the population of meat-purpose ruminants, especially sheep and goats (Boza, 2007). At the same time, a new industrial animal production model was born, which used foreign breeds and increasing quantities of food, mostly imported. Spanish society was experiencing strong economic growth, and the demand for animal products increased rapidly. Thus, the Spanish PFG rose from 29 to 39% of the PFA. In this process, people began to show interest in working conditions and in improving their quality of life.

Figure 2. Autonomic Spanish regions (excluding Canary Islands)
Source: CNIG (2011)

However, in the long term, industrial agriculture has proven to have many environmental and sociological disadvantages, in the second part of the 20th Century, this kind of agriculture had clear advantages: that scale of economy was possible and seasonality of the production decreased. The industrial animal production, especially farms for fattening and egg production, were located in the most populated Spanish areas, close to the consumer, namely near the big cities, as was the particular case of the Eastern and Northeastern Zone. This situation led to an active trading of live animals between Spanish regions, from areas with weaned ruminant production (Southwest and West zone and Northwest and North zone) and abundant rangelands, to areas of industrial livestock farming.

In 1986 Spain joined the European Union, when the Common Agricultural Policy (CAP) had begun to change as a consequence of enormous agricultural surpluses. From 1992, milk quotas were effectively applied in the dairy cattle sector, in order to limit the milk production in each country. These quotas limited the expansion of the Spanish milk production, but they also avoided the massive entry of milk from other EU countries, especially France. The Spanish dairy sector was modernized and smaller farms disappeared. In 1999, direct, coupled EU aids were established in sheep, goats and beef cattle. These aids did not limit production, and therefore led to a noteworthy development of these livestock sectors in Spain for a decade (Castel *et al.*, 2010a). By consequence, in some cases, herd sizes increased above sustainable capacity, especially some sheep flocks.

Table 2. Main crops and animal productions in the different GZS

Geographical zones of Spain	Main crops *	Dairy Cows	Meat Cows	Meat Calves	Dairy Sheep	Meat Sheep	Goats
Northwest and North	FC, Legumes	+++	+++	++	+	+	+
Southwest and West	FC		+++	+	+	+++	++
Guadalquivir Valley (South)	IC, FC, OT	++		+		+	+++
Southeast	Vegetables					++	++
East and Northeast	FC, Vegetables	++		+++		+	+
Ebro Valley	FC, Vineyards Vegetables	+		++		+++	
North Plateau	Legumes Vineyards	++	+	++	+++	++	
South Plateau	IC, OT Vineyards	+		+	+	+++	++
Canary Islands	TF						+++

*In all Spanish geographical zones there is significant cereal production. However, cereal production is more important in both Plateaux and the Ebro and Guadalquivir Valleys.
FC: Fodder Crops; IC: Industrial Crops; FC: Fruit Crops; OT: Olive Trees; TF: Tropical Fruits
Source: authors

Since the EU CAP reform, namely the mid-term reform (2003) and the CAP health check (2008), a decoupling process of aid started, to be completed between 2010 and 2012 (the government of each country could decide the speed of the process). This aid was given in single payments to the farmer. In the Spanish case, a partial decoupling took place in the sheep and goat sectors in 2006 and had been completed in both sectors by 2010. Concerning the beef cattle sector, 40% of cattle slaughter aid and 100% of calf slaughter and suckler cow aid will continue until 2012.

Abandonment of farming activity in extensive or semi extensive production systems was accelerated by the decoupling process. It led farmers of small ruminants, especially meat purpose animals, to abandon their activity and go into retirement or switch to another non-agricultural activity. Others focused on maintaining the rural environment (Canali, 2006; De Rancourt *et al*., 2006). Between 1999 and 2007, for each ruminant sector, the number of Spanish farms decreased by about 40% (MARM, 2008b).

Despite the influence of the CAP in the ruminant production trend, the intensification process, which had begun in the last half of the 20th Century, continued (Bouwman *et al*., 2005; Castel *et al*., 2003; Nahed *et al*., 2006; Morand-Fehr *et al*., 2004; De Rancourt *et al*., 2006; IE, 2010; Riedel *et al*., 2007; Pardos *et al*., 2008, Castel *et al*., 2011). The main factors of influence in this process are the following: (i) decrease in grazing areas, due to agriculture intensification and expansion of buildings and roads; (ii) lack of shepherds; (iii) difficulties for grazing in natural or protected areas; (iv) rising land prices (v) acceptable prices, until 2007, of both food purchased and products sold (Castel *et al*., 2010a); (vi) investment support, especially for young farmers.

However, the intensification process began in 2007 with the global crisis of the food industry. This crisis has had two effects on the livestock sectors: the rise in food and energy prices and the stagnation, and even fall in some cases, of product sales prices. Unfavourable sales prices are due to the increasing power of the oligopolies that dominate the food industry: big milk processing and food distribution companies. However, these unfavourable prices had other causes: EU commitments established with the World Trade Organization (WTO) and EU policy evolution (budget limitations), as well as the decrease in consumer demand for animal products.

4. Production, trade and consumption of Spanish ruminant productions

4.1. The Spanish meat industry

Beef production in most EU countries has decreased in the last decade (Table 3). However, global productions in the EU remain more or less constant, taking into account that the number of EU countries in 1999 was 15 and in 2008 had already risen to 27. Therefore, the importance of the EU in global beef production is decreasing. In Spain, in fifth position in the EU beef production, behind France, Germany, Italy and UK, production remains constant, even though it did increase in 2004 and 2005 (Table 3).

Table 3. Evolution of ruminant meat production in Spain and EU (carcasses in tonnes).

Year	Beef		Sheep		Goat	
	Spain	EU*	Spain	EU*	Spain	EU*
1999	661068 (8.6%)	7702509	221327 (20.2%)	1095489	16891 (19.5%)	86628
2004	713886 (8.9%)	8061527	231463 (23.6%)	982232	13373 (14.8%)	90248
2008	661732 (8.2%)	8065744	139853 (15.0%)	932235	8662 (9.5%)	91423

*EU-15 in 1999; EU-25 in 2004; EU-27 in 2008 - *Source: MARM, (2009) ; FAOSTAT (2009)*

The importance of cow's milk production in comparison to beef production has decreased substantially: in 2008, the number of dairy cows reached only 30% of the total number of Spanish cows whereas in 1986 this percentage was 72%. About 25% of beef currently produced in Spain comes from animals of dairy herds, where Holstein is the predominant breed, producing carcasses between 170 and 240 kg. However, most beef produced in Spain (about 60%) comes from animals aged 12-14 months with carcass weights of about 250 kg (MARM 2009). Mothers of these animals are not milked (suckler cows) and in 51% of cases belong to local breeds (Retinta, Asturiana, Gallega, Pirenaica, etc.). These cows are normally crossed with males of foreign breeds (Limousin, Charolais, etc.) in order to obtain calves destined for fattening. In 2009 there were 1 886 731 suckler cows in Spain, 7% less than in 2003 (IE, 2005). These cows are mainly found in *dehesas* (Southwest zone of Spain) and also in the Wet zone of Spain (COAG, 2010). As stated, in Spain, weaned animal production is separated from calf fattening production, the latter being located mainly in the Centre and Northeast of the country. Concerning cattle production in Spanish mountain areas, in the last decade there has been a decreasing trend in dairy cows and an increase in beef cattle (IE, 2009b; Perrot *et al*., 2009). García-Martínez *et al*. (2009) report that the following changes were observed from 1990 to 2004 in Spanish cattle farming systems: increase in size; and great dependence on subsidies; change of productive orientation from mixed beef-dairy to pure beef production; expanded grazing management; reduction of family labour and increase of pluriactivity (off-farm activities such as tourism); reduction of unitary variable costs; and increase in labour productivity. On the other hand, (García-Martínez *et al*., 2011) report that given the situation of partial decoupling of subsidies and existence of an off-farm work market, pluri-activity is of economic interest for the majority of cattle farm groups; furthermore, this trend will be accentuated in times of total decoupling. At the same time, an increase in the price of cereals or a decline in meat prices may lead to a drastic decrease in calf fattening.

Concerning the cattle trade, the number of imported animals in 2009 (597472) was five times the number of exported animals. Animals imported into Spain normally come from dairy herds, particularly France and Romania. As regards the beef trade (Table 4), imports come mainly from Germany, the Netherlands, France, Denmark, Ireland and Poland. Exports go essentially to Portugal, France and Italy. This trade was developed from the end of the 20th Century, but has been decreasing in recent years as a consequence of the current food industry crisis. Beef is considered by consumers as an expensive meat in comparison to pork and poultry. However, Spain is the fourth most important exporting country of the EU, behind Germany, France and Holland, exports being 50% higher than imports (Table 4). This is because the main type of meat produced in Spain comes from an animal aged 12-14 months and is very highly appreciated in Europe.

In last decade the EU sheep meat production has continuously decreased (Table 3). In Spain the situation has been the same, but the decrease has been greater in the last four years as a consequence of several simultaneous processes: aid decoupling, increase in animal food prices, low sales prices, decrease in the consumption of sheep products and presence of animal diseases such as bluetongue. 76% of Spanish sheep meat production comes from animals whose carcasses weigh is about 13 kg, except in the case of lambs traded through the Protected Geographic Indication of *Lechazo de Castilla León* whose carcasses weigh only about 6 kg. The sheep population in 2008 was about 20 million, and has strongly decreased since 2000 when there were about 24 million. In only one year (2008) the Spanish population has decreased by 10.1% (even 26% in Andalusia). The main Spanish meat-purpose sheep breeds are Merina, Rasa Aragonesa and Segureña. Sheep meat imports into Spain come essentially from New Zealand whilst exports go mainly to France and Italy. Exports almost double imports, showing that the quality of Spanish lamb is much appreciated.

Concerning goat meat, as with the beef, the production of almost all EU countries has decreased, although the total remains almost constant due to the incorporation of new EU countries (especially Romania and Bulgaria). Particularly in France and Spain there has been a great decline (12.2% and 19.4%, respectively in the last 10 years). This is basically due to the growing demand for younger animals (Castel *et al*., 2010b). 81% of goat meat production in Spain comes from weaned animals, with 5 kg carcass weight. These low weights, along with the low sale price of young animals, have led to the disappearance of many farms devoted exclusively to meat production. Those that do continue are distributed throughout the central area of the country.

Table 4. Evolution of exports and imports of ruminant products (t) in Spain

Year	Dairy products		Beef		Sheep and goat meat	
	Exports	**Imports**	**Exports**	**Imports**	**Exports**	**Imports**
1999	309395	755340	147681	88900	17786	12397
2004	440611	1061450	259135	153668	20420	10381
2008	474654	1416889	144846	97344	20500	11368

Source: MARM, (2009)

To complete the study of ruminant meat production in Spain, something should be said about the serious health problems found in recent years in the ruminant Spanish sector: first BSE and then bluetongue. There were long periods with many difficulties for the movement of animals which particularly jeopardised the movement of animals from breeding areas to fattening areas. As a result, Spain has attempted to develop calf fattening units in the breeding areas, but with only limited success.

4.2. The Spanish milk industry

Table 5 indicates the evolution of ruminant milk production in Spain and the EU. Concerning milk production, Spain ranks seventh in the EU, behind Germany, France, UK, Holland, Italy and Poland. Spanish cow's milk production, in general, has been modernized; whilst in 1990 there were 207 000 farms with an average of 8 cows per farm, in 2008 the number of farms had decreased 8-fold, with 37 cows per farm (IE 2009a). At the same time, cow productivity has increased greatly to over 8000 l per cow per year and, in some cases, even to more than 10 000 l per cow per year. That can be observed in the results of Typical Farms NET (*Red de Granjas Típicas*) of MARM (Spanish Ministry of the Environment, and Rural and Marine Affairs). This network is included in the International Farm Comparison Network (IFCN) (MARM, 2008b). The Spanish milk quota in 2008 was 6239 thousand t. In the last decade, Spanish dairy cattle production has remained fairly stable, but the Spanish participation in the EU has fallen from 5.0% in 1999 to 4.1% in 2008 as a result of the increasing number of EU countries (Table 5). The most important milk production zone of Spain is the Northwest and North (Wet Spain), with about 80% of farms and about 60% of milk production of Spain. In Dry Spain, covering 75% of the total Spanish surface area, there are 20% of total Spanish farms which produce 40% of total Spanish milk production. In this area, farms, in general, are large and modernized, especially in Catalonia. Naturally, farm dimensions are related to milk quota sizes, so while the average farm quota for the whole of Spain in 2009 was 245 t, it was 480 t in Dry Spain and only 186 t in Wet Spain (IE 2009a).

Sheep and goat milk production has always been of little significance in the EU CAP. However, this production is quite important in disadvantaged areas of Mediterranean countries. In sheep milk production, Greece, Romania and Italy are the three most important countries, with almost 70% of total EU production. Spain, with about 15% of EU production (Table 5), ranks fourth, slightly ahead of France. In sixth and seventh place are Portugal and Bulgaria, each producing approximately 20% of Spanish sheep milk production. The sheep milk production has increased substantially in Spain in the last decade, especially in the region of Castilla León, where half of the Spanish dairy sheep population is to be found and which provides 65% of Spanish sheep milk production (MARM, 2009). In this region, the average herd size has increased significantly as a result of many new modern farms, with very productive foreign breeds. The following dairy sheep breeds are farmed in Spain: Assaf, Churra, Lacha, Awassi and Lacaune; Assaf, Awassi and Lacaune, being foreign breeds. The dual-purpose Manchega and Castellana breeds are also farmed in Spain for meat and milk production. In the last decade, there has been considerable uncontrolled crossbreeding of local breeds with foreign breeds, especially Assaf,. This breed currently predominates in Castilla Leon (Mantecón *et al*., 2006) whilst in Castilla La Mancha 60% of ewes still belong to the Manchega breed (ASAJA, 2007).

The EU countries with the largest goat population are: Greece, Spain and France. However, in production terms, the order changes: France, Greece and Spain produce more than 80% of EU goat milk. In the last decade, only in two countries of EU has goat milk production increased: 23.5% in France and 15.8% in Spain (Castel *et al*., 2010a). Goat productivity in the EU has increased in general. This was mainly due to the genetic improvement of autochthonous breeds and the improvement of feeding, reproduction and health management (Dubeuf and Boyazoglu, 2009; Sánchez-Rodríguez, 2008; Castel *et al*., 2010a; IE, 2010). The Spanish region with the greatest production of goat milk is Andalusia (44% of the total Spanish production). This region is the first and second European region in goat meat and milk production, respectively. In Spain, there are several goat breeds which are very productive and well adapted to the area (Castel *et al*., 2010a). Therefore, contrary to what occurred in the Spanish dairy sheep sector, very few imports of foreign goat breeds have taken place in Spain. The main Spanish dairy breeds are the following: Murciano-Granadina, Malagueña, Florida, Majorera, Payoya, Palmera and Tinerfeña. Productivity of Spanish goats, ranging from 350 to

700 l per goat and per year, is lower than that of French goats (500 to 900 l per goat and year), but fat and protein proportions in Spain are higher than in France (Ruiz *et al.*, 2009, Bossis *et al.*, 2008).

Table 5. Evolution of ruminant milk production in Spain and the EU (1000 t)

Year	Cattle		Sheep		Goat	
	Spain**	**EU***	**Spain**	**EU***	**Spain**	**EU***
1999	6113 (5.0%)	122850	349 (15.3%)	2283	404 (25.0%)	1613
2004	6384 (4.5%)	141666	410 (18.8%)	2179	479 (26.0%)	1841
2008	6157 (4.1%)	149390	427 (14.7%)	2912	490 (25.0%)	1960

Source: MARM (2009); FAOSTAT (2009)
*EU-15 in 1999; EU-25 in 2004; EU-27 in 2008
**The percentage with respect to EU production is written beside the milk production

Concerning the Spanish trade of dairy products (Table 4), imports are almost three times higher than exports. Spanish milk imports come overall from France and Portugal while Spanish cheese imports come from France, Italy, Holland, Denmark and Germany.

4.3. Consumption of animal products in Spain

According to Martín (2007), from 1987 to 2007, the annual meat consumption per inhabitant has hardly changed in Spain (about 65 kg), as is the case for fresh beef (about 10kg). However the population of Spain has risen approximately from 39 to 45 million inhabitants, therefore the consumption per inhabitant has decreased. The demand for fresh pig meat has increased while the demand for poultry meat has decreased (in 2007 these demands were about 14 and 15 kg respectively). Sheep and goat meat consumption is very low in Spain and has even decreased in the last 20 years from 4 kg to 3 kg per inhabitant and per year. Processed meat consumption has increased somewhat to the current 15 kg per inhabitant and per year. Finally, out of home meat consumption has increased considerably, from 14% in 1987 to 22% in 2007.

Concerning dairy products, consumptions per inhabitant and per year in Spain in 1987 were the following: 124 l of milk, 8 kg of yogurt, 6 kg of cheese and 2 kg of other products; whereas in 2007 consumptions were 94 l, 10 kg, 7 kg and

16 kg respectively. These data show a decrease in milk consumption and an increase in the consumption of yogurt, cheese and other dairy products in general. In most cases, consumption out of the home has increased from 1987 to 2007: from 8% to 16% for milk; from 7 to 13% for yogurt; and from 9% to 16% for cheese. However, in the case of other dairy products, consumption at home has increased (from 61% to 83%).

5. Prospects for ruminant production in Spain

The evolution of ruminant production in Spain is rather uncertain. Farm sustainability is unclear in most ruminant production sectors. For each production sector some internal factors have been shown that are dependent on farm management, and upon which the farmer could act to a greater or lesser degree to improve farming profitability. However, uncertainty about the evolution of the external factors of production systems causes great anxiety and distress in farmers, who must make decisions in the light of many limitations. There are two important, inter-related issues, which greatly affect the evolution of livestock farming: the evolution of the EU CAP and the development of the market. Of course, product sales prices are influenced by the evolution of demand, but they are also affected by changes in consumer preferences and purchasing power. Energy costs in principle are not dependent on the EU CAP, but it can somehow influence bioenergy-related policy. Food prices and product sales prices should in the future be more regulated through the CAP. In order to reach this situation, Spain, together with France and other countries in the central and southern EU, should try to avoid excessive state financing and acquire better control of the internal market and trade with third countries. Concerning this last aspect, it is a necessary requirement that products imported by the EU comply with appropriate regulations and are produced in systems where there are fair labour conditions. Nonetheless, if the EU accepts the market liberalization proposed by the WTO, the risk of not having food self-sufficiency will increase. Food Self-Sufficiency (Soberania Alimentaria in Spanish) is a concept established by an international organization: Vía Campesina in the FAO meeting held in Rome in 1996. Food self-sufficiency is the capacity of each country to define their own agricultural and food policies according to objectives of sustainable development and food security. EU should work in the following ways: (i) to promote contracts between producers, industry and distribution; (ii) to promote safety nets to protect against market volatility; (iii) to promote insurance contracts to cover the risk of natural disasters; (iv) to strengthen the position of farmers in the food chain, for example by supporting the creation of producer organizations, particularly cooperatives; (iii) to make direct payments under the first pillar of the CAP assigned to active farmers; (iv) to link aids in disadvantaged areas to a genuine social and environmental contribution of the farm holdings, for instance fire prevention (Ruiz-Mirazo, 2009), considering this aid as a payment for that contribution (Bernués *et al*., in press). Moreover, the EU should take better care of the financing of investments, as there are many farmers with serious financial problems (MARM, 2010, Castel *et al*., 2011).

Furthermore, the influence of the CAP in the different livestock sectors is described and prospects for each sector are analysed. From 2013, in the beef sector, the suckler cow aid could be continued as well as some support included in quality programmes. However, in order to attain farm viability, facilities and farm management should be improved, seeking a better labour productivity and a better quality of life for the farmer. In the breeding cattle farms, if possible, either individually or collectively, farmers should fatten the weaned calves, rather than sell them, thus seeking a high market value (IPG, guarantee labels, etc.). Concerning calf fattening farms, in general they are very competitive in Spain and only need a small control of animal food prices. In the dairy cattle sector, the milk quota system will end in 2015. The current crisis in this sector is due to different factors: decrease in demand, a spectacular increase in supply due to the French or German surplus, the practice of Spanish distribution companies to use milk as a bait product to draw customers, etc. The end of the quota system may provide an opportunity for young farmers and those who want to expand their production, provided they are competitive. As a further aid, in 2008 the Spanish Government established the regulatory basis for granting subsidies for the overall improvement of the quality of raw milk and its certification. The likely impact of the CAP reform strongly depends on the development of demand for dairy products in the EU (Bouamra-Mechemache *et al*. 2008). In any case, the sector's future will be determined by the progress of the negotiations between the EU and the WTO, as currently, the abundant supply of the exporting countries such as the USA and especially New Zealand causes a fall in milk prices (EU-DGARD, 2009; COAG, 2010). However, the EU is a global leader in the export of dairy products with high added value.

For the sheep and goat sectors, aid has already been decoupled. It is possible that after 2013 aid will be linked to the quality of products and partnership. In the case of sheep meat, the rate of disappearance of farm holdings could be limited through good trading work carried out by cooperatives and associations. However, farm survival will be influenced by the evolution of the quality of life of farming families. As for dairy sheep farms, having achieved very high production levels as a result of intensification, developments will depend largely, as in farming in general, on changes in food prices. However, farmers participating in some way in capital gains resulting from the processing of quality cheeses, have good survival prospects.

As for the goat milk sector, decoupling of CAP aid has had less influence on the abandonment of farms than in the meat sheep and goat sectors. However, in recent years the sector has encountered many difficulties due to the aforementioned high food prices and the existence of very little milk processing in the production area. Milk marketing depends heavily on exports to France, but in the past two years they have fallen by half, as French production has increased. To overcome these difficulties, the Spanish goat sector has been working well recently, with actions related to the following aspects: (i) significant progress in genetic improvement, (ii) the creation of second degree cooperatives for milk marketing, (iii) request for certification marks for cheese and meat, (iv) increase in union activity in the goat sector, although there must be an association for the whole sector, (v) increased farmers' interest in the management of the operation through technical and economic analysis.

Finally, some considerations are provided concerning the whole Spanish livestock production. The Spanish Government is making an effort to support livestock activity. Parallel to aid decoupling process, a set of coupled aids, linked to Articles 68 and 69 of the Regulations 73/2009 and 1782/2003, respectively, have been established in Spain. These aids have supported the dairy sector and the meat sector (sheep, goats and cattle) by promoting partnership, quality and system sustainability. The budget of these aids is small but they have contributed to the maintenance of farms, increasing the income of producers and prioritizing actions to improve livestock production.

However, in order to improve the Spanish ruminant production sector, there are several aspects to be considered in the EU and Spanish Government policies. One of the most important aspects for achieving sustainability of production systems is to improve the contractual relationship between the producers and the buyers of the production companies. A first step in this direction is a binding contract for the regulation of dairy products that has now been established by the EU. Furthermore, farmers that are likely to do so, should try to participate in several production phases, either individually or collectively; for example in the breeding and fattening of cattle, in the milk production and processing of dairy products and in the meat production and processing of meat products. In any case the EU should continue with these actions by establishing and improving the traceability of the productions. Any way to communicate the characteristics of produce to consumers, enhancing its specific quality or linking it to an area, serves to increase the added value of that produce. In this sense, in Spain there are some guarantee marks, but there are also officially recognized quality programmes: 12 Protected Geographical Indications for ruminant meat (9 for beef and 3 for sheep) and 26 Protected Designations of Origin for cheese (IE, 2005; Pacho and Calahorra, 2009). Regarding cheeses, *Manchego* (sheep cheese) has already been underlined, as it represents almost half of the Spanish cheese production with 13.2 million kg in 2007, followed by *Mahon* (cow's cheese, with 16.6%), *Tetilla* (cow's cheese, with13%) *Idiazábal* (sheep cheese, with 8.3 %) and *Cabrales* (Blended cheese: cow, sheep and goat, with 3.9%) (ASAJA, 2007). Concerning exported Spanish cheese, *Manchego* makes up 90% of the total (Valentin-Gamazo, 2007).

Organic production brands are increasingly important to differentiate quality. Within the EU, Spain is the second behind Italy and with Germany on the surface area devoted to organic production. Although Spain is a fairly large organics farmer it is a small organics consumer, and only 1% of household food expenditure is made on organic products. As in other parts of Europe, the organic production of cow, sheep and goat meat, in that order, are the most widely extended in Spain, (Castel *et al*., 2008). The main difficulties of Spanish farmers for organic production are the food prices and lack of marketing channels (Mena *et al*., 2009). To improve organic livestock production it is necessary to establish agreements with organic food producers which are as close as possible to the livestock farm. Other measures for improving organic production, which are valid for any quality product, are the following: (i) attempt to develop segmented and specific organic markets, especially local; (ii) improve training and advice to farmers, both for livestock management and for technical and economic analysis (iii) increase product promotion. These measures could be enhanced through partnerships (for example developing cooperatives) and with institutional support (Castel *et al*., 2008, Perrot *et al*., 2009). But these measures will be ineffective if consumers are not willing to pay adequate prices which will ensure an acceptable profitability for farmers. It is desirable that after the current global economic crisis, consumer behaviour returns to that of a few years ago. Currently, price has become the key factor in the purchase option, so distributor brands (or white labels) have grown dramatically to the detriment of quality brands. Specifically, in the dairy sector, distributor brands cover 50% of liquid milk sales in Spain (Baamonde, 2010).

Reaching improvement objectives in the Spanish livestock industry also depends on social capital (social relationships and bonds) (Bernués *et al*., in press). The livestock structuring facilitates genetic improvement of herds, farmer training and trading improvement (food purchase and product sales). Cooperatives have a key role to play in the farmer and sector organization, but unfortunately, in general, farmers do not have enough confidence in them. Spain has a large number of livestock cooperatives and this decreases their effectiveness. However, currently an important concentration process is taking place. In the sheep sector, the first important cooperative movement occurred in Aragon, where the cooperative OVIARAGON has 1100 members and about 500 000 ewes). Recently, OVISO has been created in Extremadura, with 1700 partners and 870 000 ewes, and

CORDESUR in Andalusia, with more than 1200 members and about 500 000 ewes. These cooperatives collaborate with large food companies who have sites for the classification of lambs. The fattening of these animals is carried out by farmers who have a vertical contract with these food companies (Langreo, 2007; Langreo, 2008). In the case of the cow's milk sector, cooperatives collect 45% of Spanish cow's milk, although only 20% is sold directly; there are some large cooperatives: *Central Lechera Asturiana* COVAP y FEIRACO (IE, 2009a). For the goat milk sector, cooperatives are important particularly in eastern Andalusia (they buy about 30% of production), but they process only a small proportion of milk. Cooperatives, in collaboration with Confederation of Cooperatives (CCAE), work to fetch good prices for selling livestock production. However, unlike in France, the horizontal structuring in Spanish producer unions or organizations is poor (Castel et al., 2010). Moreover, these organizations deal with mainstream agriculture (COAG, UPA and BDA). In some cases there are associations for a specific sector, such as ASOPROVAC for beef or OPL for dairy cattle. Finally, there are some interprofessional associations such as INLAC for the dairy industry and INTEROVIC for the sheep and goat sectors.

To end the presentation of the prospects for ruminant production, it can be said that farm viability will depend on the level of the different attributes of sustainability (Masera et al. (2000), but especially resilience and capacity of adaptation, to address the ongoing problems and challenges that arise (Nahed et al., 2006, Bernués et al., in press). In this sense, the Spanish Government should support adequate research related particularly to traditional livestock systems, which has been rare in recent decades (Zorita, 2001).

6. Conclusions

In the second half of the 20th Century, in Spain, while the country was experiencing economic growth, livestock farming, especially pig and poultry production, rapidly became intensified. But ruminant production was also intensified as a result of the decrease in grazing.

From 2000, despite efforts made by the EU through CAP reforms to stop intensification, this process continued in ruminant production systems. Only the agro food crisis that shocked the world has managed to slow down this trend. In this crisis two elements should be underlined: increasing raw material prices and fluctuations of production sales prices. The EU should be clearer and firmer in their commitments to the WTO.

The livestock grazing production in the less favoured areas of the EU, especially in the mountains, is increasingly difficult. In order to ensure the viability of farms in these areas, production costs should be decreased and added value of productions should be increased. Also, consumers should learn to appreciate the specific quality of products from these zones and the EU and society in general should appreciate the benefits of grazing livestock (externalities).

In the less favoured areas, diversification of production processes and products could increase the sustainability of farm systems, but at the same time, diversification seems to be difficult considering the generalised process of specialization in Agriculture (Bernués *et al*., in press).

Despite sociological and environmental interest of livestock pastoral farms, they only produce a part of the livestock products needed by society. Therefore, EU should also continue to support intensive ruminant production by the control of trade and through an ongoing dialogue with industry organisations.

All types of ruminant production systems need to be well structured (which includes associations and unions) to face the uncertain future even though this uncertainty is partly due to the current worldwide financial speculation and greatly hinders all economic activities.

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GRAZING AT THE PROTECTED AREAS: EXAMPLES FROM POLISH NATIONAL PARKS

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Abstract

Grassland communities in Poland require active protection due to their anthropogenic origin. There are 23 National Parks (NP) in Poland which together cover 1% of the country. Succession is remarkable problem at the national parks with high proportional cover by wetlands. Extensive grazing is a crucial factor which decides about biodiversity in the landscape. At the most of protected areas in Poland cattle and horses are used whereas - in the mountainous region – sheep mainly. These species visibly differ in the way of their preferences for taking various plants and in height of the cut made. Very useful are native breeds like Konik horses or Polish Red Cattle, which are well-adapted to difficult environmental conditions. Grazing at the protected areas, except restoring and maintaining nature values of grasslands also has cultural meaning in order to ensure local tradition continuity.

National Parks in Poland

According to Polish nature conservation act (2004) national park "ranges areas distinctive by special nature, scientific, social, cultural and educational values" at which whole nature as well as landscapes' amenity are protected. The main tasks of national parks are inter alia: to maintenance biodiversity and to restore disturbed habitats or extinct elements of native nature. The whole definition contained in Polish law fulfill conditions determine by International Union for Conservation of Nature (IUCN) for national park. There are 23 National Parks (NP) in Poland (Table 1) which together cover 1% of the country, protect all types of landscape in Poland**.** All of them are part of Natura 2000 network. Habitat types protected in Polish NP are shown in Table 2.

However, the share of forest in the area of Polish Parks is on average about 62% (Tab. 2), grasslands are integral part of the landscape and take part in increasing the biodiversity (especially plants and invertebrates). For example in Gorce NP at the semi-natural grasslands within the forest zone, shaped by several hundred years of extensive pastures management, about 35% of whole flora from this area and almost 50% of plant communities was found (Loch 2009). Among 23 national parks there are some so called forestry park in which forests cover more than 90% of their area (Świętokrzyski National Park, Babiogórski National Park, Stołowe Mountain National Park, Magurski National Park and Roztocze National Park). However, most of the youngest were found in order to protect large areas of grasslands. These are: Biebrza National Park (26% afforested), Narwiański National Park (3% afforested), Warta Mouth National Park (1% afforested). Each of them covers widespread wetlands within which periodically flooded meadows dominate. Except three above-mentioned also Poleski National Park is connected with grassland (non-forest ecosystems – 51% of the PN area). The biggest and the most famous due to its peatland vegetation and many rare birds breeding or resting during their migrations is Biebrza National Park (BbPN) which protects about 60% breeding birds existents in Europe.

Main problems of grasslands protection in National Parks in Poland

Grassland communities in Poland require active protection due to their anthropogenic origin. Traditional management throughout ages led to establishment of ecosystems with great environmental value but dependent of human extensive agriculture within which the presence of animals is inscribed (Pärtel et all. 2005, Rogalski, Warda 2004). Socio-economical changes occurring during last decades brought to progressive abandoning of management at the grasslands which has led to secondary succession in the direction of forest. It especially concerns protected areas where environmental conditions determined people's activities. Remarkable problem constitutes succession at the national parks with high proportional cover by wetlands (Table 3). As presented by Bartoszuk and Marczakiewicz (2006) at the current borders of Biebrza NP almost 21000 ha were mowed in 1962, whereas at first year of the XXI century only 5900 to 11000 ha were used as a pastures or meadows dependent on weather conditions.

The threats for communities situated in river valleys are trespassed reeds and willow-birch thicket (e.g. Bartoszuk 2003, Tomaszewska 1997). Sienkiewicz-Paderewska at all. (2011) showed that the cessation of mowing the meadows in Middle Basin of Biebrza after seven years led to increased number of trees and shrubs as well as enhancement of their coverage in comparison to the part mowed every 2-4 years.

The problem with secondary succession concerns also other Parks in Poland - not only situated at lowlands (e.g. Kampinowski PN in Stypiński, Piotrkowska 1997) but also in mountainous region. For example during last century in Bieszczady NP area of mountain glades decreased to 19% of original value (Kucharzyk 2010) whereas in Pieniny PN forestry on chosen glades increased from 4,04% to 42,16% from the sixties to present time (Zarzycki 2006). Similar changes connected with simplification of species composition and communities structure took places in Tatra NP (Wesołowska 2009).

Table 1. National Parks in Poland

Name of the Park	Year of foundation	Area (ha)*	Location
Babiogórski	1954	3 391	mountain ranges
Białowieża	1947	10 517	lowlands
Biebrza	1993	59 223	lowlands
Bieszczadzki	1973	29 195	mountain ranges
"Bory Tucholskie"	1996	4 613	lowlands
Drawieński	1990	11 342	lowlands
Gorce	1981	7 031	mountain ranges
Stołowe Mountain	1993	6 340	mountain ranges
Kampinoski	1959	38 549	lowlands
Karkonoski	1959	5 581	mountain ranges
Magurski	1995	19 439	mountain ranges
Narwiański	1996	7 350	lowlands
Ojcowski	1956	2 146	highlands
Pieniński	1954	2 346	mountain ranges
Poleski	1990	9 764	lowlands
Roztocze	1974	8 483	highlands
Słowiński	1967	21 573	the Baltic coast
Świętokrzyski	1950	7 626	mountain ranges
Tatra	1954	21 197	mountain ranges
Warta Mouth	2001	8 074	lowlands
Wielkopolski	1957	7 584	lowlands
Wigierski	1989	14 988	lowlands
Woliński	1960	8 133	the Baltic coast
	SUM	**314 484**	

(*data according Central Statistical Office in Poland 2010)

Table 2. Habitat types in Polish National Parks

Habitat	Area (ha)	% of the NP area
forest	190 730	60,7
agricultural land	43 823	13,9
waters	22 749	7,2
lands and ecological use (wetlands)	37 927	12,1
other	19 341	6,1
Total	**314 484**	**100**

(after Mioduszewski W. Poland National Report 2004; modified)

Management in Polish National Park is made difficult by unregulated proprietary connections. Almost 50% of the areas of Biebrza NP remain in private property whereas in Narwiański NP – over 70% (Mycke-Dominko, Górska 2007). Although this proportion is better in elder NP, problem still remains actual. Gradual buying out of land has inhibited by lack of foundings and problems with establishment of lawful owner due to people's migration to other part of Poland or abroad. The mowing of widespread areas, often hardly accessible, require hand-cutting or hand-moving of trees and shrubs, which implicates appropriate manpower and high funds. These problems are particularly noticeable in case of Biebrza NP where Park rent terrain designed for mowing to private businessmen. In spite of using special tracked vehicle with different cutting instrument adjusted to cut and collect mowed vegetation (Zembrowski at all. 2010), problem of secondary succession still exists, moreover management of obtained biomass remains a difficult matter. Although extensive management, in Parks like Biebrza NP, is promoted by payments from agri-environmental schemes (Wasilewski 2003) interest in those among private owners is moderate. Parks in Poland still need accurate stocktaking of grassland communities from the point of view of Natura 2000 in order to apply appropriate protection methods. Since Poland has very small resources of surface water, many grasslands (especially situated at peatlands) are threatened of dehydration (Mioduszewski 2004). Active protection in Poland is cofinanced by European Union programmes supporting environmental and nature conservation projects like LIFE (LIFE country factsheet 2011) as well as by many non-governmental organisations (Mioduszewski 2001, Kucharska, Znaniecka 2005).

Table 3. Area of non-forest ecosystems in selected national parks at risk of succession

Name of the national park	**The area at risk of succession**	
	ha	**% of the NP area**
Poleski National Park	763.54	7.84
Woliński National Park	1 607.46	14.70
Biebrza National Park	21 572.89	36.43
Warta Mouth National Park	586	7,26

(according to Zembrowski at all. 2010; modified)

Benefits from extensive grazing

Extensive grazing is a crucial factor which decides about biodiversity in landscape. Animals affect vegetation at well-known ways like defoliation, treading, living excreta or transporting seeds (Warda, Rogalski 2004; Bartoszuk at all. 2001, Metera at all. 2010). Influence on the sward is dependent on system of grazing (Isselstein et all. 2007), season, as well as animal species (Guziak, Lubaczewska 2001, Rogalski at all. 2001, Bartoszuk at all. 2001, Metera at all. 2010). Its positive effect manifests in influence on structure of pastures (Scimone et all. 2007): creating of patchiness of the sward by selective grazing and punctual living excreta lead to increased biodiversity of animals species like butterflies, bumblebee, spiders or grasshoppers (Milne 1997, Wallis De Vries et all. 2007, Tallowin et all. 2005, Hoffmann 2002). As shown by Nagy et all. (2001) number of plant species is much higher at the pastures than at the meadows only cut for hay. However, effect of animals on vegetation depends on type of community duration of grazing, stocking rate and local abiotic conditions (Michulnas et all. 1988, Kuiters 2002).

Grazing at National Parks in Poland

During last 20 years livestock density in Poland has been instantly decreased (Jankowska-Huflejt 2007). At the protected areas cattle and horses are mostly used whereas - in the mountainous region – sheep mainly. These species visibly differ in the way of their preferences for taking various plants and in height of the cut made. For example cattle prefer taller grass and other plants than horses which on the other hand tend to choose more fibrous grasses (Bartoszuk at all. 2001). In addition both species as well as sheep were ranked by Bokdam and van Braeckel (2002) among functional group of grazers (as opposed to browsers and intermediate feeders) - large herbivores which are able to digest the plant cell wall fibre efficiently.

Poland is one of 61 countries from among 167 which declared protected areas in relation to conservation of biodiversity at the State of the World's Animal Genetic Resources Country Reports (Rosenthal 2010). Although there is still no scientific evidence that breed has important influence on biodiversity (Rook et all. 2004, Scimone et all. 2007), protected areas can take part in conserving domestic animal diversity (Rosenthal 2010). Also from the ecological point of view native breed could be better adapted to the local conditions than commercial one (Josten 2002). The Polish primitive breed, Konik horses, descendents of tarpan, is useful in extensive grazing at the protected areas not only in their native country (Biebrza NP, Roztocze NP, reserves i.a. Research Station of Polish Academy of Science in Popielno) but also in Netherland (Beije 2002), Belgium and Germany (Cosyns et all. 2001, Rosenthal 2010). Koniks from National Parks in Poland are kept in low stocking rate. The oldest husbandry was founded in 1984 in Roztocze PN (RPN). This region of Poland is meaningful for the history of Konik horses due to the fact that the part of actually living animals of this breed are descendents of population from Zwierzyniec situated in Roztocze (Kownacki 1995). It also has historical values because refuge for horses was situated at the areas where the reserve of tarpan existed in XVIII century (Kotuła et all. 1984). 72% from among 167 ha of the refuge is overgrown by forest (Wlizło, Szwed 2007). Other parts are: Echo ponds (40 ha) and pastures (3.5 ha). Wlizło and Szwed (2007) on the basis of phytosociological research showed that after 20 years of introduction of horses to RPN, vegetation of their habitat is still characterized by high degree of naturalness.

However, in comparison to 1984 there appeared patches with nitrophil plants which give evidence to progressive eutrophication.

The idea of using free-ranging Koniks as a management tool preventing succession on peatlands rose in the last decade of twentieth century. Such husbandries on wetlands are also in France (Carmague breed; Duncan 1983) or Holland (Koniks; Vulink 2002). First trials of Konik horses' introduction to Biebrza wetlands made by Borkowski (2002) showed that the encroachment of scrubs at the management areas was slowed down along with stabilizing and in some cases even increasing key species of breeding bird. Lately potential role of this breed was also affirmed in Bieszczady Mountains where in 2007 reintroduction of Koniks in order to protected areas deserted by people against succession began (Klich 2009). In high density conditions horses preferred willow and rowan whereas birch was avoided. On the other hand research conducted by Chodkiewicz and Stypiński (2011) in Biebrza NP showed that during vegetative season horses avoided successive tree species like *Salix* sp. and such woody species can be preferred by horses only in winter.

Since 2004 husbandry has been led at the Middle Basin of Biebrza NP. Similarly to Roztocze PN horses are kept in a low stocking rate in the refuge. Horses in Biebrza NP most of their time have grazed on the grassland communitites (Chodkiewicz, Stypiński 2010). Their grazing and diet preferences have changed during vegetative season. The basis of their diet during spring and summer are species characteristic for wet and poor communities like *Carex panicea*, *Carex flava* or *Agrostis canina* (Chodkiewicz, Stypiński 2011). Preferring the early stage of growth of *Molinia caeruela* could make them useful at the protection of heathlands in Western Europe where this species is a serious problem (Todd et all. 2000). Chodkiewicz and Stypiński (2011) showed that weather condition has also influence on the diet of Konik horses due to changing proportion between species in communities depending on humidity. Although at both parks Koniks during vegetative season have sufficient nourishment, it is necessary to feed them by hay in winter in order to keep horses in a good condition.

However, the open question remains which attitude is more efficient in active protection on wetlands: grazing by cattle or by horses? Van Braeckel and Bokdam (2002) studied habitat selection by cattle and horses in the Lower Basin of Biebrza NP in order to evaluate their effectiveness in preventing succession of undesirable plants. Although the animals restricted or even stopped developing reeds, they did not restore desired sedges and moss communities. It is also difficult to answer the question: are horses and cattle competitors for habitats or do they niches not overlap? Vulink (2002) showed that there is no difference in grazing selectivity on artificial polders in Holland by these two species. On the other hand Menard et all. (2002) comparing foraging and nutrition of horses and cattle in

European wetlands indicates that horses during vegetative season selected wetter communities and shorter swards than cattle. Their diet on marshes was similar, however cattle ate a wider range of plants, especially dicotyledonous. Menard et all. (2002) concluded that these animals can be used as an alternative tools for management of marshes. The main determinant of using habitats by horses is fulfilling their feeding requirements (Duncan 1983) which also leads to variable use of different communities during the year (Jezierski, Jaworski 2008). The feeding strategy of horses makes them more useful in controlling the vegetation in marshes whereas cattle maintained at high density could be more effective in slowing down succession by eating invasive woody plants.

Cattle grazing in Polish National Parks is important in Parks with wide open areas like (beside of Biebrza PN): Warta Mouth PN, Narwiański PN. Relativly little is known about grazing at these areas. At the active protection of grasslands inter alia Polish Red Cattle is used– native breed which is characterized by very good adaptation to the difficult conditions of marshy pastures (Kucharska, Znaniecka 2005). In Biebrza PN a model WWF project "The happy cows form Brzostowo" is carried out, within which inter alia are used Polish Red Cattle (Kucharska, Znaniecka 2005). Brzostowo is a small village on the left bank of Biebrza river. The basic source of income for farmers at this region is dairy cattle keeping in traditional extensive methods. Meadows adjacent to the village characterize by poor quality but are highly available. The pastures and meadows are breeding habitats and resting places for many rare species of birds (Bartoszuk et all. 2001). According to WWF project over 200 cattle, several horses and a few small flocks of geese during vegetative season stay on the pastures all day long on the right river bank (Kucharska, Znaniecka 2005). Cattle (so called "happy cows") freely cross the river twice a day, whereas horses are in open grazing continuously. Ornithological researches (Kucharska, Znaniecka 2005 cit. Mazurek 2002, Mazurek 2003) showed positive influence of cows on the creation of breeding places for waterfowl (ducks, geese and swans) and, indirect, on reducing the pressure of predators, which could jeopardize nests. Simultaneously cattle did not cause any nest damage. Another positive effect of grazing was preventing secondary succession (van Braeckel, Bokdam 2002). Free-ranging cattle grazing in the peat zone of Biebrza NP preffered mainly *Carex* sp., *Molinia caerulea*, *Phragmites*, *Equisetum fluviatile*, *Calamagrostis stricta* and *Agrostis stolonifera* (Bokdam et all.2002). Diet composed of these species had the digestibility above the minimal level for cattle. Other project conducts by WWF were e.g.: trainings for farmers in order to propagate agri-environmental schemes or the "Ruff Meadow" project within which habitats of aquatic warbler (*Acrocephalus paludicola*) are protected and International Championship in Mowing Wetland Meadows for Nature "Biebrza Haymaking" organized (Kucharska, Znaniecka 2005, Grogyruk, Zub 2006).

The Polish Red Cattle is also a tool for the management on grasslands in Narwiański NP where the positive effects of animals on the communities structure was affirmed (Laskowska, Pruszyński 2008). In comparison to area without presence of animals, in pastures communities there was lower share of rushes species and higher share of species characteristic for fertile habitat. Grazing also was conducive to different species of birds increasing their number. In the Warta Mouth National Park beef cattle is successfully carried in extensive systems even on sward with dominance of *Glyceria aquatica* and *Phalaris arundinacea* which had not been considered earlier as a fodder (Nowakowski et all. 2008). Extensive grazing in Polish NP is also led within framework of projects finance by European Union LIFE Nature fund e.g. Conserving *Acrocephalus paludicola* in Poland and Germany (Aquatic Warbler project) in Biebrza NP and Woliński NP, Restitute and maintain the habitats of breeding waterfowl birds in Warta Mouth NP (Life country factsheet 2011).

The history of grazing in Polish mountains dates back to the 11-14th centuries. In the XIX and first part of XX centuries grazing next to mining industry were the major factors which changed natural vegetation in Tatra Mountains (Piękoś-Mirkowa 1981). Sheep and cattle were grazed mainly in the forests, subalpine bushes with dwarf pine and alpine meadows, only for milking and nights rounded up in enclosures at the meadows. Enclosures were gradually moved which led to even manuring of the whole grassland. Such management resulted in devastation of the forest floor, impoverishment of flora in dwarf pine belts and soil erosion (Michalik 1986b). Grasslands communities, developed as the results of usage, consisted mainly of local species (Pawłowska 1965). The foundation of National Parks, in connection with gradually ransoming private areas, enabled to cease grazing at the protected areas (in Tatra NP in 1978). It was accompanied by protest of local communities for which grazing was part of tradition and heritage (Kucharska, Kuźnicka 2005). Cessation of grassland management (grazing, mowing and fertilization) led to changes in meadows and pastures communities. In 1992 right up to 65-70% of glades in Gorce PN underwent degradation (Michalik 1992). Species reach communities of *Gladiolo*-Agrostietum association have changed after 10-15 years into poor *Hieracio-Nardetum* overgrown subsequently by *Vaccinum myrtillus* and finally *Piceas abies* (Michalik 1986a). Studies of Witkowska-Żuk and Ciurzycki conducted in the areas excluded from grazing during years 1965-1994 in Tatra NP showed that the direction of succession depends on formation of lithospher, height above sea level and it could be modified by natural, local disturbances. In comparison to 1994 grazing enabled growth of higher number of species, however led to decreased number of communities. Finally grazing in Tatra NP has been brought back in 1982 as so called "cultural grazing" in order to ensure local tradition continuity and to support seminatural habitats (Mielczarek 1984). Shepherds are obliged to live in a hut, use regional language, traditional equipments, wear traditional clothes as well as maintain observance and customs connected with pasturage (Mielczarek 1984, Kucharska, Kuźnicka 2005). Only Polish Mountain Sheep and Polish Red Cattle supervised by the Tatra shepherd dog are used in "cultural grazing" (Kucharska, Kuźnicka 2005). Grazing is held only on chosen forest glands and forbidden in forest. It has special meaning for protection of grasslands communities in Gorce NP and Tatra NP. However, extensive grazing does not cause degradation of natural environment, it does not also assure adequate fertilization of pastures in order to maintain the species reach communities (Kaźmierczakowa 1990, Michalik 1992). It has also diverse impact on the invertebrates e.g. grazing reduced number of bumble-bees (Kosior 1990) and snails (Duduch-Falniowska 1990) but had positive influence on species composition of ants (Woyciechowski 1990). Grazing in the mountains has special meaning for protection and maintaining of *Crocus scepusiensis* as well. However, it does not belong to native species of Polish flora, its presence is integrally connected with early spring aspects of glands vegetation in Tatra and Gorce. Kaźmierczakowa and Poznańska (1992) studied two glands: one - excluded from management about 30 years ago and second – at which grazing was restored after a few years of interruption. Without active protection the number of *Crocus scepusiensis* significantly decreased (48.7 per m^2 in comparison to 241,3 at the harnessed gland).

Considering cultural role of grazing, one could not take notice of local products Protected Designation of Origin (PDO). The most famous and most popular is oscypek- type of sheep cheese - descendent from Tatra Mountains, but to the PDO belongs also eg. bryndza podhalanska, redykołka. On list of local products is also narwiański cheese (Lista… 2007). These products take their unique taste from extensive management of grazing and traditional recipe of production.

Since 1993 stud farm of Hucul horses have existed in Wołosate in Bieszczadzki National Park. Hucul horses are primitive breed originated from Ukraine from which they have spread in whole East Carpathians (Krawczyk 1994). Since the meadows near Wołosate are situated at 700-900 m. above sea level, vegetation season begins quite late and so Hucul horses are on pastures only during summer. The problem makes management of dung after winter (Korzeniak, Kalemba 2001). The areas meant for manuring are relatively small, due to the fact that dung is stored in the piles. Such solution has its negative influence on some meadows leading to decreasing of number of species and unify vertical structures of vegetation along with increasing nitrogen content in the top soil level. However, whole husbandry is very important for touristic reasons (horses are useful for mountaineering.

Conclusion

As shown by Van Braeckel i Bokdam (2002) and Metera at all. (2010) grazing is not sufficient in active protection of grasslands. However grazing animals slacken secondary succession, they do not counteract it (Tallowin 2005). It is still one of the most important tools to maintain and restore ecosystems which also has cultural and touristic meaning. Management on protected areas generates questions and dilemmas about preservation and protection of currently existent communities versus restoration of those original ones that ceased to be due to lack of exploitation. The nature value of grasslands is indisputable and further research in the direction of effective methods of their protection is important.

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GRASSLAND MANAGEMENT SYSTEMS IN POLAND

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Abstract

This work shows achievements and new tendencies in grasslands management with reference to the past and present situation. Grassland area has recently decreased but it has been observed first of all in pastures case. Grazing seems not as important for animal feeding (especially dairy cows) as before and grasslands are turned to arable land. The problem of natural succession and lack of utilization causes that about 20 % of permanent grasslands are not harvested for forage production. Hay is still dominated form of forage conservation, silage making starts to be more popular but that system has been adopted mostly in large farms. Grassland yields are about 4 tonnes of dm per ha which means it is below expectations and productivity potential. Grasslands in Poland are treated not only as a source of food for domestic animals but as an important part of landscape and environmental friendly policy. It is probably a challenge for grass farmers in future but some new management systems should be established for different purposes.

Introduction

Polish agriculture is characterised by significant dispersion, as an average size of agricultural holdings is 7,8 ha of agricultural land and more than half of the holdings produce only or mainly for their own use. Poland has adopted the EU policy to improve the quality of food products and we can say that Poland is important European and global producer of agricultural and horticultural produce, as well as products of animal origin. The area of agricultural land is almost 16,2 million ha and consists of 11,6 million (76,6 %) of arable land area , 220 thousands ha (2,1 %) of orchards and 3,3 mln (20,52 %) of permanent grassland.

The quality of agricultural land in Poland is rather poor, poorer in comparison to EU average. High percentage of poor and acidified soils reduces agricultural usefulness of agricultural land. Soil valuation indicator, which is a quotient of conversion hectares to physical farmland is 0,82. It was one of the reasons of abundant land. Fallow land on arable land was a serious problem in Poland (figure 1), but after Poland joined the EU in 2004 the reduction of fallow lands took place (table 2), probably as a result of the application of direct payments per hectare and increase in agricultural land prices. Implementation of good agricultural practice was also important in reduction of fallow land area.

However, arable land is better agriculturally used, permanent grassland is not managed properly.

Table 1. Agricultural land area in Poland (mln ha)

Specification	2000	2005	2008	2009
Total	17,8	15,9	16,1	16,1
Arable land	13,7	12,2	12,1	12,1
Orchards	0,26	0,30	0,33	0,33
Meadows	2,10	2,30	2,30	2,30
Pastures	1,30	0,73	0,67	0,65

GUS 2010 (Statistical Yearbook of the Republic of Poland 2010)

During the last decade the decrease of permanent grassland area (particularly pasture) has been observed, management of grassland is also not as good as it should be and area of abundant land, unutilized meadows and pasture started to be a serious problem. The lack of utilisation seems to be one of the most important issues grassland management in the future (Sienkiewicz- Paderewska and Stypinski 2007)

Permanent meadows and pastures are understood as grass and legumes communities which have been used more than 5 years, they do not include arable land sown with grass as a part of crop rotation. Regarding to EUROSTAT methodology since 2007 agricultural land (arable land, orchards, meadows and pastures) consists of the area in good agricultural condition according to the norms established by the Ministry of Agriculture and Rural Development. The area of grassland is decreasing systematically (Figure 2) also the grassland productivity is below the expectations and potential possibility.

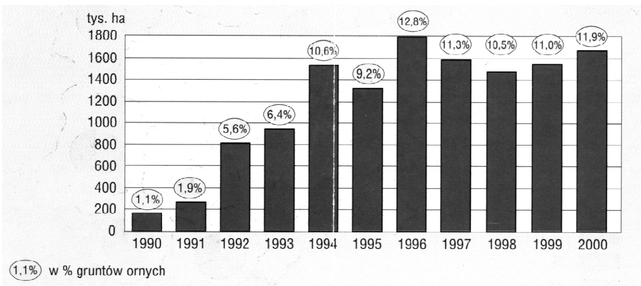

Figure 1. The area of fallow fields on arable land in the years 1990–2000

Table 2. Fallow land on arable land in Poland

	2002	2003	2004	2005	2006	2007
Total fallow land						
In thousand ha	2303	1761	1399	129	984	413
Share in arable land (%)	17,8	13,9	8,6	8,4	7,9	3.5

(Ministry of Agriculture and Rural Development 2008)

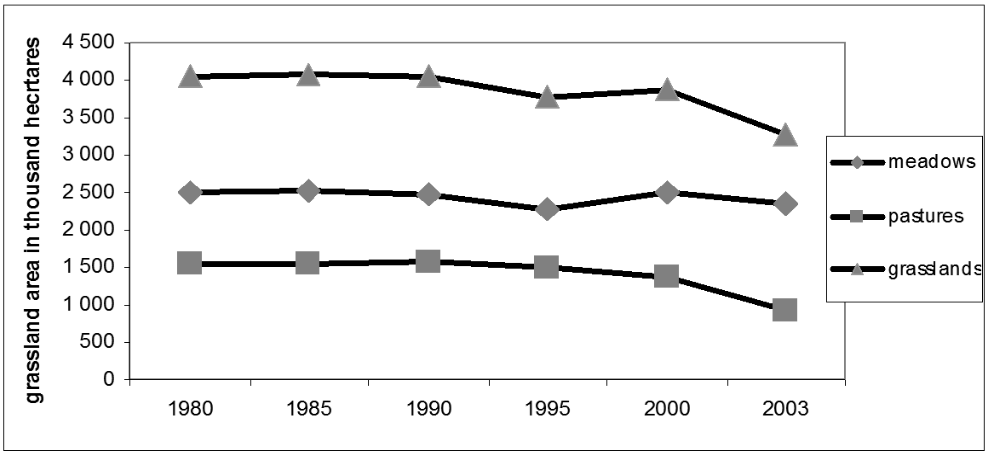

Figure2. Changes in grassland area in the years during 1980-2005
Dm yields (dt ha^{-1})

According to Smit *et al* (2008) it is possible to obtain in Poland the average yield about 4-5 tonnes of dry matter per hectare without the mineral and organic fertilisation (Figure 3). In many field trials the yields about 10 tonnes have been noted but in practice the hay production and dry matter yields are rather low (table 3).

There are many reasons of rather low grassland productivity in Poland. Unfavourable soil conditions accompanied by worse climatic conditions could explain lower agricultural productivity but in the case of grassland management the yields are also connected with animal production and stocking rate. As it was presented by Stypinski *et al* 2009 during EGF meeting in Brno, the number of cattle decreased during last decade from 8 million to 5,5. It was observed in the case of cows (decrease from 3,5 to 2,7) and other farm animals. (Figure 4). Milk yield per one cow increased from 3 453 in 2000 to 4 292 in 2007 and to 4 455 litres per cow in 2009 but it is still considerably lower than in the EU.

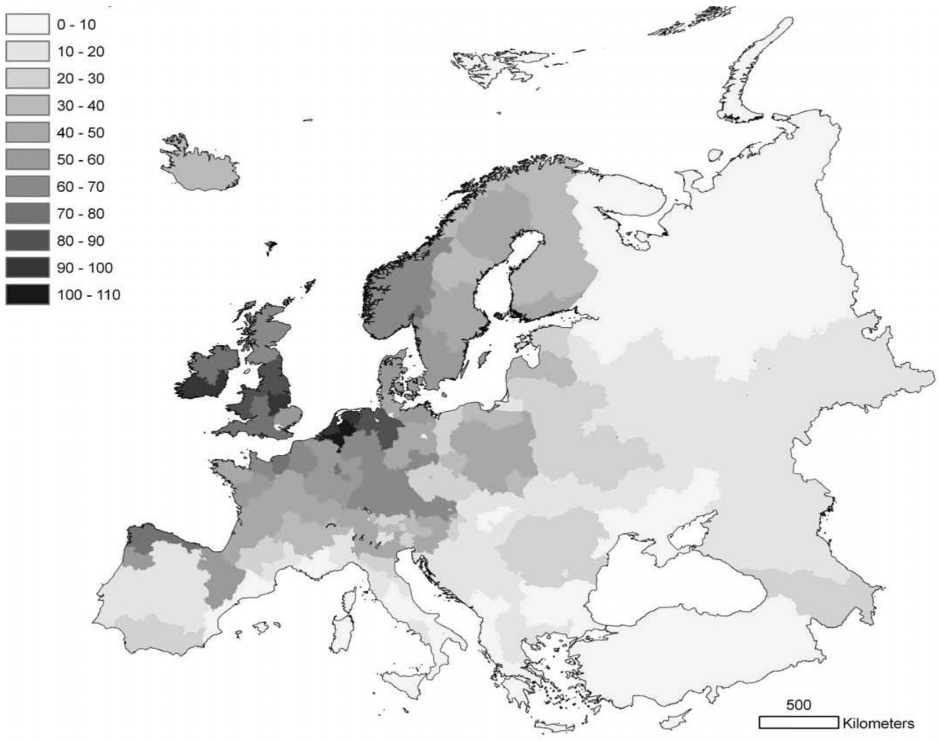

Figure 3. The potential grassland productivity in Europe (Smit *et al*. 2008)

Table 3. The hay production and yields (GUS 2010)

Hay	Production in millions tons of d.m			Yield of dt. ha -1		
	2005	2008	2009	2005	2008	2009
From permanent	13,52	14,40	15,05	39,9	45,2	47,3
grassland	0,04	0,04	0,07	33,3	35,4	36,3
From pulses	1,93	2,15	2,17	46,1	42,2	46,7
From legumes						

It is also necessary to underline that animal feeding has changed during that time. Farmers use more concentrates and maize silage, grassland production seems to be less important and farmers are not interested in increasing grassland yield. Water management and land reclamation are other reasons of lower grassland production. Total area of drainage and watered grassland is 1.79 million hectares so it means that half of grassland needs land reclamation (land reclamation system was built in the seventies and renovation works must be done on many agricultural areas).

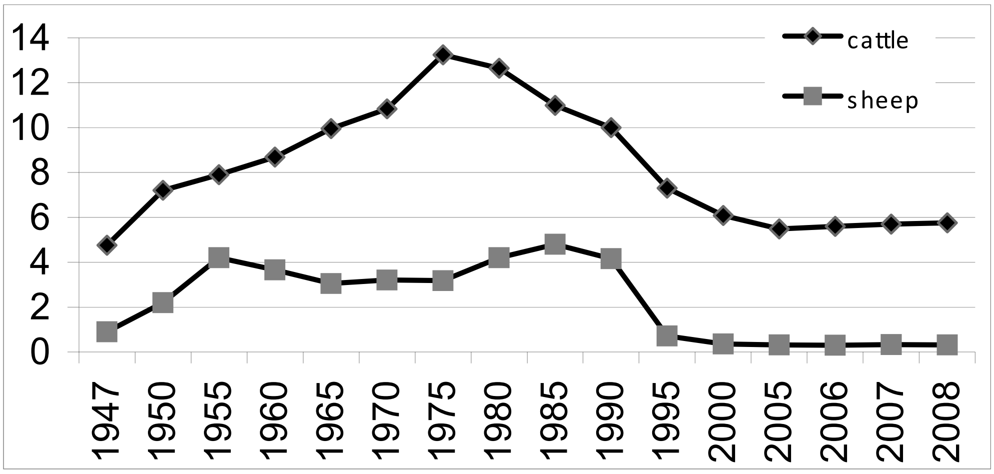

Figure 4. Number of cattle and sheep (in millions)

Grassland management

Polish grasslands are used mostly as meadows, the area of grazing decreased significantly since 1997 (Zastawny and Jankowska-Huflejt 1999) and this process is still going on. It is connected with the intensification of forage production and rather low level of mineral fertilization which is about 100 kg NPK per one hectare of grassland. Meadows are cut once or two times per year and it is estimated that about1/3 of meadows area (500-800 thousands hectares) is not cut each year. The official data do not include no-utilized grasslands, only set –aside arable land area data are published (around 30-50 thousand of hectares during last five years in Czech Republic, more than 1 million hectares in Poland), but we are able to estimate that about 20 % of permanent grasslands are not harvested for forage production in Czech Republic, 600 thousand of hectares in Poland (18 % of total grassland area) and probably even more in Slovakia. (Stypinski *et al* 2009). It could be the reason of serious degradation of our grassland, natural succession process is often observed particularly on the area of less favourable agricultural conditions (LFA). The majority of grass biomass is taken in hay form, silage making is not as popular as in the West European countries. (Zastawny and Jankowska-Huflejt 2000, Zastawny *et al* 1997). It is estimated that in 1995 year only

2,6 % of total biomass from grassland was used as silage, 72,4 % was dried and about 25 % was used as zero-grazing in directly feeding. That situation has improved recently and on the base of data from 2010 it is estimated that silages amounts to about 30 % of total forage production in Poland, but hay is still dominating in fodder production structure (about 60 %) and unfortunately the quality of hay is not good enough, it is known that in hay making technology quality depends mainly on the weather conditions .The progress in fodder conservation and implementation of big bale technology is observed mainly in large farms keeping 20 or more animals, but it should be mentioned that 40 % of individual holdings keep only one or two cattle. Since the time of preparation for EU accession, and because of the need to make adjustments of cow sheds to sanitary and veterinary requirements concentration of breeding has been observed (the Ministry of Agriculture and Rural Development 2008) but still 58 % of holdings keeping cattle have 1-4 animals which produce milk exclusively for the holdings use. In large dairy cattle farms the changes in fodder area are also observed. The permanent grassland are used less intensively whereas the increase of maize for feeding (silage) is observed (table 4) contrary to legumes area which has decreased rapidly.

Table 4. Sown area in thousands hectares of fodder crops in the year 1990-2010

Specification	1990	1995	2000	2005	2010
Total fodder area	2005	1087	913	840	930
within					
Perennial legumes	782	441	328	86	60
Root plants	206	143	126	40	32
Maize for feeds	325	133	162	330	420

Pasture utilization and grazing systems in Poland

In Poland several different grazing systems are used in practice. Each system can be described by some advantages and disadvantages and the decision which system to choose is sometimes very difficult. It depends on soil and climate conditions, technical possibilities but also on farmers' knowledge, experience and expectations. Very extensive "free grazing" system is used mainly in the mountains area in sheep breeding and husbandry. On lowlands this system is sometimes used for cattle, but it is not effective method f cattle feeding. Indicator of grass utilization is below 60 % which means it is not possible to be used in dairy farms but it could be interesting in the area with high ecological value in the Landscape Parks or National Parks.

Much more popular old Polish system is keeping animals chained. It is very often typical for small holdings with 1-2 cows. This system is very time consuming but it could be effective if farmers follow some basic rules of that management. In many farms, especially in large dairy farms paddock system is very common and some modification of that traditional rotational system are also observed (like strip grazing or continuous grazing). One of the basic questions in that system is the number of paddocks and sward height which allow to start grazing According to Wasilewski (1994 a, b) a very good animal daily gain can be obtained in treatments with only 4 paddocks. In the past more paddocks were recommended (8-12) but it increased the cost of pasture investments and in some situations could be difficult in maintaining in the small farms. It should be underlined that even good pasture sward fulfils only part of animal feeding needs and allows to produce about 20 kg of milk per day per cow. In higher production using supplementary food is absolutely necessary. In Poland there is a big difference between pasture potential and practical implementation. Farmers very often do not pay enough attention and effort to pasture management, on the other hand some good milk producers prefer keeping and feeding animals indoor instead of letting them graze on pastures. The area of pastures has recently decreased in Poland and the similar problem is observed in other European countries so the question "to graze or not to graze? " is still very important in grassland management (Van den Pol-van Dasselaar A, et al. 2008) . Probably grazing is not very attractive now for large milk producers but it is very important in beef and sheep production. It also plays very important role in horse breeding and management on sensitive and protected area. Animals are also important landscape elements, so it is difficult to imagine Polish agriculture without grazing animals and without pastures at all.

The environmental role of grassland

One of the most typical features of Polish grasslands is an unusual diversity of flora and fauna that results from a vast range of habitats. Most of the Polish grasslands are semi-natural, man-influenced ecosystems. They persist because of farming. Long-lasting man's influence on the one hand, and many natural features on the other ,result not only in a high biodiversity but in high stability too. (Stypiński *et al.* 2006) The significant ecological role of meadows and pastures is emphasized in many publications. In the same time many authors focus on a large number of factors that endanger semi-natural grasslands. Few of them such as floods, erosion and succession are natural process, but the main reasons for grassland transformation and degradation are the human influences (i.e. renunciation of utilisation, drying up, burning euthrophisation). Elimination of them is one of the most important tasks concerning maintenance and protection of grassland biodiversity. Rather extensive use of grassland in Poland (but also in other counties in our region) is one of the key factor for biodiversity stabilization

(Stypiński *et al* 2009). Maintaining of present status of grasslands and introduction of agro-environmental programs and agreements is one of the solutions for sustainable development and it seems to be a good challenge for grass farmers. Environmental friendly policy is one of the important tools of Common Agricultural Policy, but in grassland protection and utilisation it needs some specific models or system of grassland management. Agro-environmental programmes connected with grassland are mainly based on intensification of grassland management (late term of the first cut, limiting fertilization and stocking rate, keeping of strips with different harvest plant to ensure continuous source of food and hide for birds and other animals) (Stypiński e*t al* 2009). The practical realization of those agro-environmental programs is not easy however, because of many reasons. One of the most important is the situation on the milk market. The milk production in Eastern and Southern Europe is still moving from grassland to arable land (Roeder *et.al* 2007). The similar trend is observed in Poland and even extra agro-environmental substitutes do not cause more farmers being interested in grasslands which are not attractive from economical point of view like arable land. As a result grasslands are exposed to many threats even in the area of National or Landscape Park (Sienkiewicz-Paderewska D. and Stypinski P. 2009).

Conclusions

Most of the Polish grasslands are semi-natural ecosystems. It means there is a serious risk of succession and grasslands can be changed into woodlands or scrublands. Polish grasslands are used in rather extensive way and their production is below the potential possibilities. During last decade decrease of grassland area is observed, particularly pastures have decreased from 1.5 millions hectares to about 700 thousands hectares in the last years. The average grassland yield in Poland is still rather low (about 4 tonnes of dry matter per hectare per year) due to low fertilisation and rather extensive management. Hay production still dominates, but the system of making silage, particularly big plastic bale system has started to be more popular. It is not possible to treat grasslands only as a source of animal forages because grasslands play important role in biodiversity, environmental protection and conservation. It could be a challenge for Polish grasslands but specific management systems must be adopted on grasslands located on ESA and LFA. Agro-environmental program seems to be interesting solution on grasslands but their implementation is rather difficult and probably more research and advisory work with farmers must be done to keep grasslands stability and to preserve grasslands habitats for future generation. Global changes and new tendencies in Common Agricultural Policy of EU are also important for future of Polish grasslands and grassland management. It is rather difficult to predict now the direction of those changes but probably the environmental role of grassland will be in the future much more important than forage production.

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A MITIGATION OF GREENHOUSE GASES EMISSION IN CROPLAND MANAGEMENT

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Abstract

The global temperature is expected to increase even 5°C till the end of this century. Anthropogenic emission of greenhouse gases is mostly responsible for this situation. It is very important to search for ways to mitigate the global climate change. Agriculture is a major emitter of greenhouse gases, especially nitrous oxide and methane but there are agricultural practices which may mitigate GHG emission. One of them is improved cropland management. The aim of this paper, is the attempt to assess global warming potential in different cropping systems based on collected references. The three systems considered here are, conventional tillage system, reduced or no-till system and organic system. The assessment is based on measured and calculated carbon sequestration potential, methane flux, nitrous oxide flux and energy consumption in these systems.

1. Introduction

The global temperature is increasing. It is largely caused by human activity. Fossil fuel burning, deforestation, land use provoke the growth of greenhouse gasses (GHG) concentration in the atmosphere. From year 1900 global GHG emission expressed in CO_2-eq have risen more than 70%. Based on different models which depend on future world economic growth it is predicted that the temperature can increase even up to 5°C in the next 90 years in comparison to current situation (Figure 1) (IPCC, 2007).

The main CO_2 emitter is electricity and heat sector. They were responsible for 41 % of global GHG emission in 2008. Next are transport and industry. Agriculture also plays a major role in GHG emission. Greenhouse gases like CH_4 and N_2O are emitted mostly in agriculture (Figure 2). Agricultural nitrous oxide accounts for about 60% and methane for about 50% of global anthropogenic emissions. Most of N_2O comes from fertilizers and manure applied to soils and most of CH_4 comes from enteric fermentation. CO_2 emissions accounts for the smallest portion of GHG emission from agriculture. It is mostly emission from agricultural energy use. The total greenhouse gases emission from agriculture is around 6 $GtCO_2$-eq/yr and adds around 14% to world global emission.

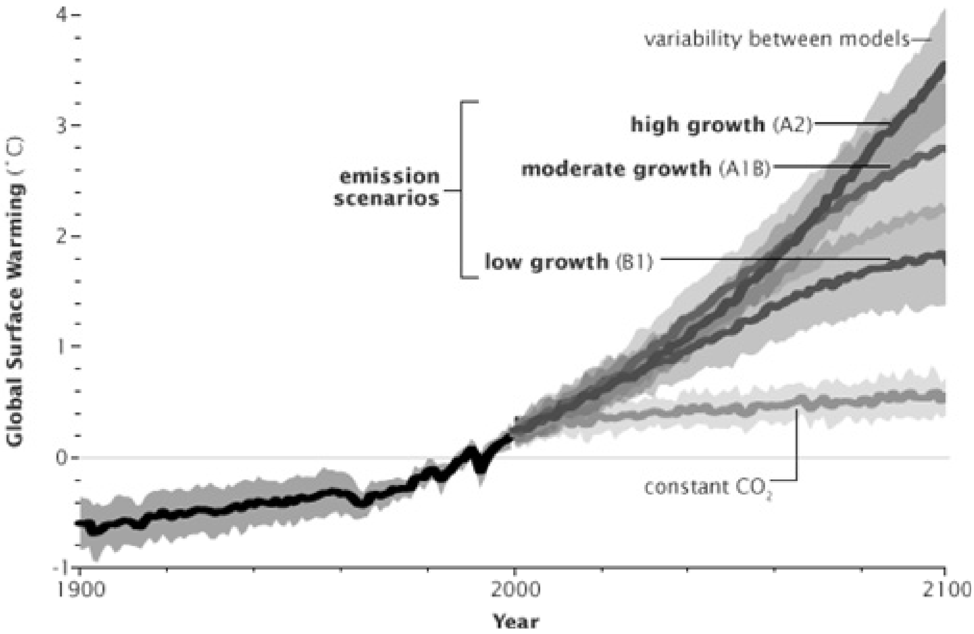

Figure 1. Global surface warming prediction. Solid lines indicate multi-model global averages of surface warming (relative to 1980–1999) for different scenarios of world economic growth A2 (high growth), A1B (moderate growth) and B1 (low growth). Shading denotes the ±1 standard deviation range of individual model annual averages. The orange line corresponds to situation where CO_2 concentrations stay the same as in year 2000 (IPCC, 2007).

For comparison purposes the CO2-eq was introduced. It allows comparison of global warming potential (GWP) of different particles. GWP of 1 CO_2 particle is equal to 1 CO_2-eq, effect of 1 CH_4 particle corresponds to 25 CO_2-eq and 1 N_2O particle to 298 CO_2-eq.

The sources of different greenhouse gases in agriculture are as follows:

• CO_2 is released largely from microbial decay or burning of plant litter and soil organic matter,

• CH_4 is produced when organic materials decompose in oxygen-deprived conditions, from fermentative digestion by ruminant livestock, from stored manures, and from rice grown under flooded conditions,

• N_2O is generated by the microbial transformation of nitrogen in soils and manures, and is often enhanced where available nitrogen exceeds plant requirements, especially under wet conditions.

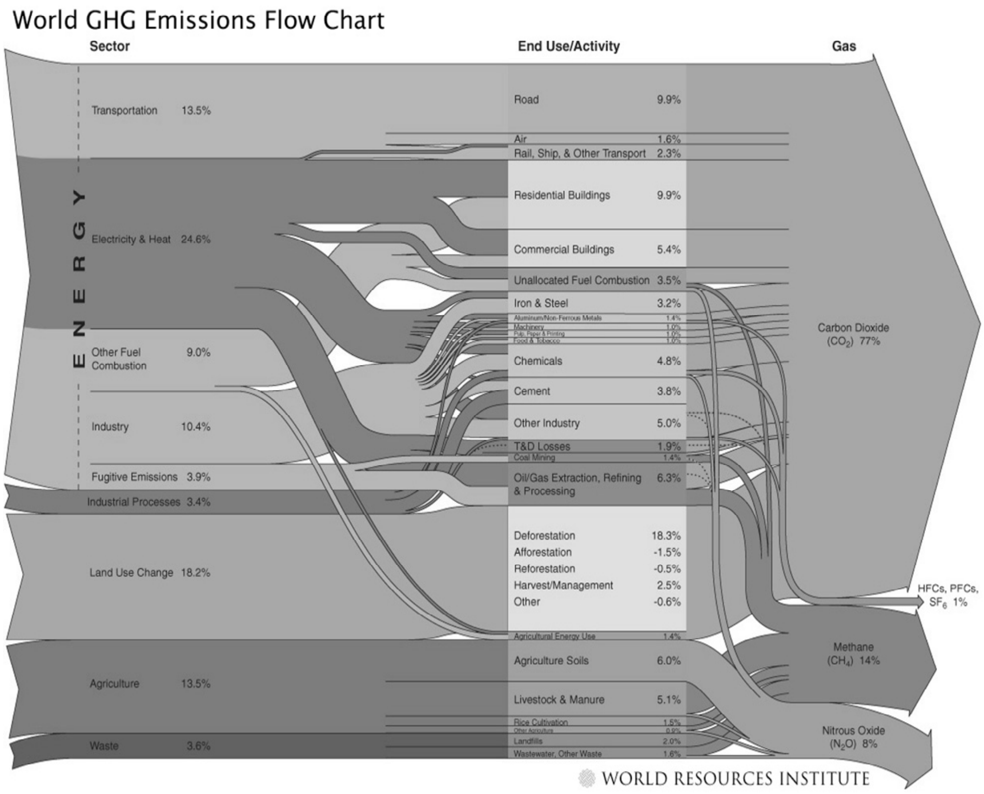

Figure 2. World GHG emission flow for the year 2000.

Annual GHG emissions from agriculture are expected to be higher in coming decades due to rapid increase demand for food, especially for meat in diet of people from developing countries. Figure 3 presents historic estimation and prediction for changes in nitrous oxide and methane emission in different parts of the world. However, studies show that improved management practices and new technologies will be a key to reduce GHG emissions per unit of food (or of protein) produced.

There are many ways to reduce influence of agriculture on the global climate change. Agricultural practices that may mitigate GHGs are as follows (IPCC, 2007b):

- improved cropland management,
- improved grazing land management/pasture improvement,
- improved management of agricultural organic soils,

• restoration of degraded lands,

• improved livestock management,

• improved manure/bio-solid management,

• bio-energy production.

All the mitigation options and the greenhouse gases they affect together with reduction potential are presented in graph below (Figure 4).

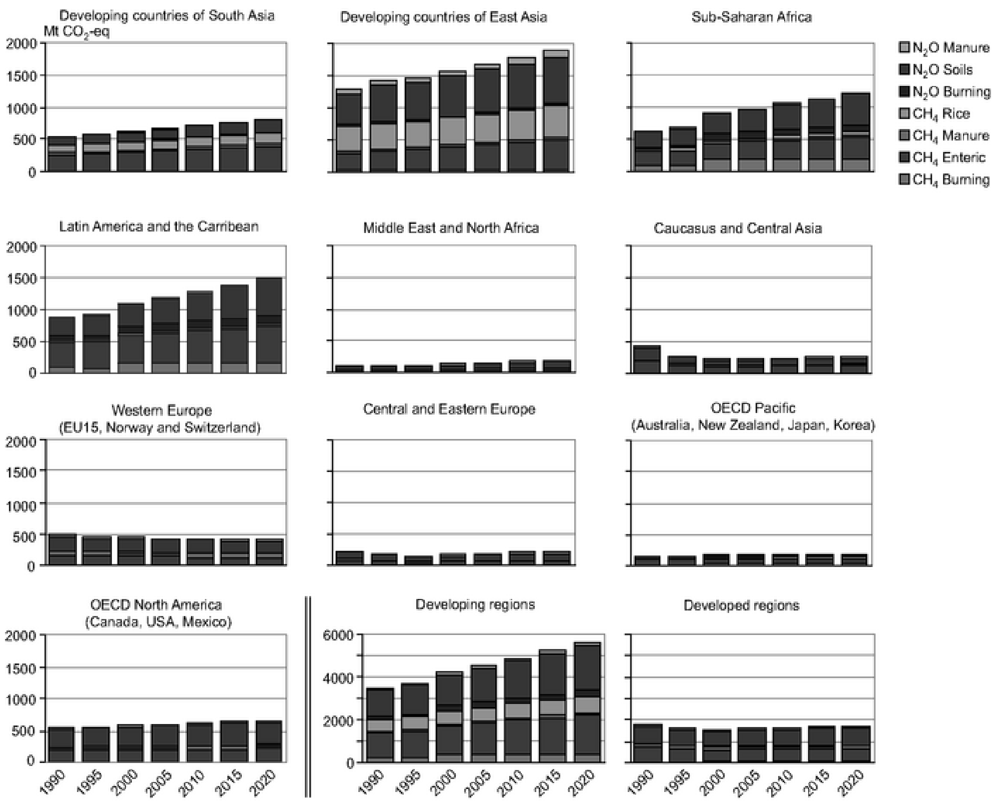

Figure 3. N_2O and CH_4 emissions in agriculture - historical estimation and projection from 1990 to 2020 for different regions in the world (IPCC, 2007).

The main focus of this article is cropland management which is indicated by the first bar in the graph above (Figure 4). According to FAO (The Food and Agriculture Organization of the United Nations) total agriculture area covered 4884 Mha and accounted for 38% of total world area in 2008. The main area was devoted to pastures (3357 Mha, 69%), then to arable area (1380 Mha, 28%) and the rest to permanent crop (146 Mha, 3%). The graph above informs that in the cropland management only CO_2 and N_2O gases emission can be reduced but there is the greatest opportunity to mitigate GHG emission in agriculture among other options (Marland et al., 2001). This is due to the fact of carbon sequestration potential, possibility of reduction in energy and N-fertilizers use.

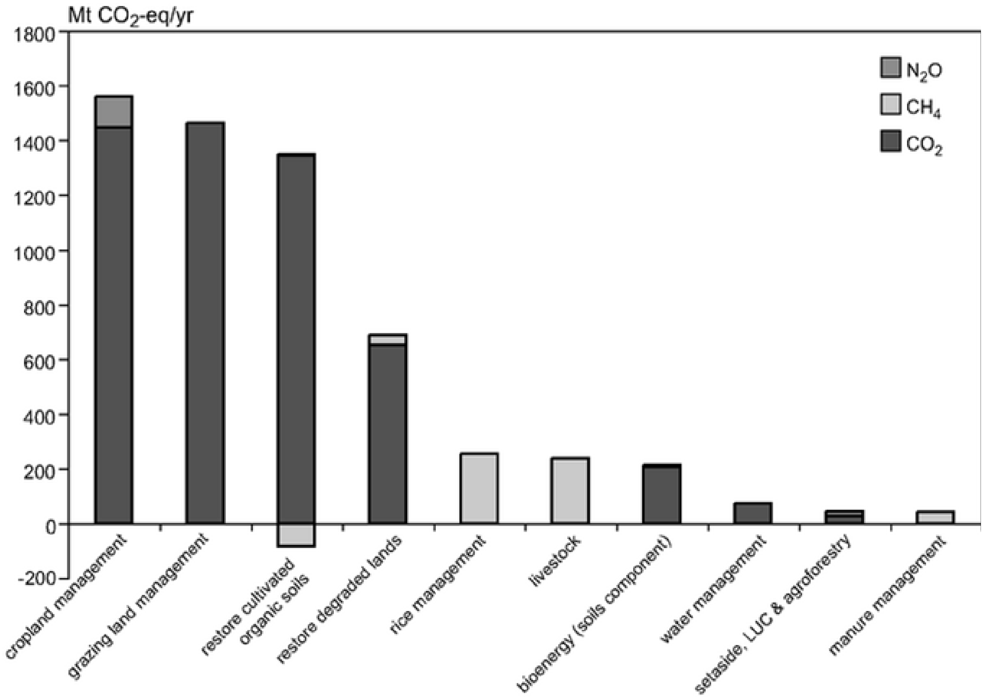

Figure 4. Global technical mitigation potential by 2030 of each agricultural management practice showing the impacts of each practice on each GHG (IPCC, 2007b).

2. Materials and methodology

In the article there are different components of global warming potential compared. Based on collected literature three cropping systems were compared. The systems considered here are: conventional tillage system (CT), reduced or no-till system (NT) and organic system (OT). The assessment is based on measured and calculated carbon sequestration potential, methane flux, nitrous oxide flux and energy consumption in these systems. The balance of GWP can be expressed according to the equation below:

$$GWP = \Delta Soil\ C + N_2O\ flux + CH_4\ flux + Energy\ Use$$

The GWP balance includes the on-farm practices and the production and transport of inputs. When the GWP value is greater than zero then there is contribution to global climate change, when it is less than zero then there is the global climate change mitigation potential. Studies report that global warming potential from agriculture can be lower than zero. The results can be use to draw conclusions regarding global climate mitigation opportunities.

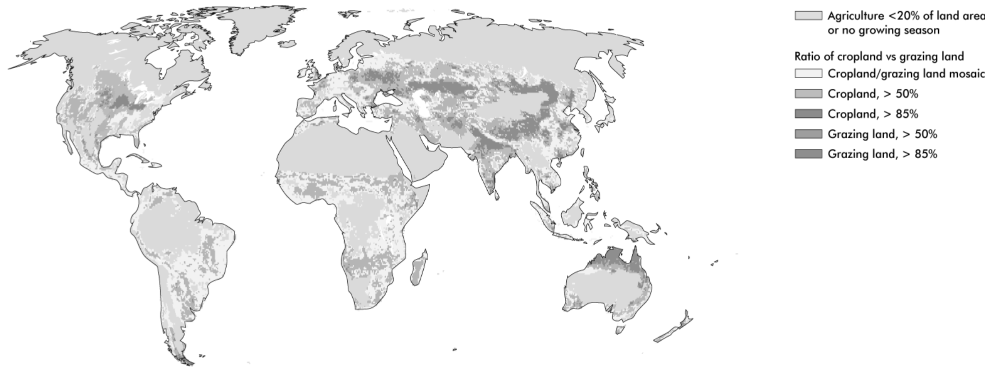

Figure 5. Pictoral view of agriculture land use distribution - croplands and pasture land from UNEP (United Nations Environment Programme).

2.1. Carbon sequestration - ΔSoil C

$$GWP = \Delta Soil\ C + N_2O\ flux + CH_4\ flux + Energy\ Use$$

The amount of soil organic carbon (SOC) in soil depends on soil texture and previous and current cropland management (Robertson and Paul, 2000). Clay soils have more SOC than other soils. Clay prevents organic matter from decomposition. The amount of SOC can be around 1% in sandy soils up to 100% in wetland soils.

Studies show that tillage can go far towards soil organic carbon losses through enhanced erosion and decomposition (Madari et al., 2005). Therefore reduced or no-till cropping system can result in soil carbon gain. However, studies also denote that soil carbon obtained in no-till system is lost quickly after just one tillage event (Grandy and Robertson, 2006)

$$\Delta Soil\ C \text{ in NT systems} > \Delta Soil\ C \text{ in CT systems}$$

There is very little data on soil organic carbon in organic agriculture systems.

2.2 .Nitrous oxide flux

$$GWP = \Delta Soil\ C + N_2O\ flux + CH4\ flux + Energy\ Use$$

As far as N_2O flux is considered adopting reduced or no-till may increase N_2O emission but it is also possible that it will have no effect on nitrous oxide flux. This depends on the soil type and climate of the place where reduced or no-tillage is applied (Smith and Conen, 2004), (Helgason et al., 2005), (Li et al., 2005), (Cassman et al., 2003).

$$N_2O \text{ flux in NT systems} \geq N_2O \text{ flux in CT systems}$$

In case of organic system the emission from the soil can stay the same or be lower than in conventional tillage system. This is due to the fact that no synthetic fertilizers can be used in organic farming system. There are some studies which report no difference in N_2O flux in organic and conventional systems (Robertson and Harwood, 2000), (Kramer et al., 2006).

$$N_2O \text{ flux in OT systems} = N_2O \text{ flux in CT systems}$$

Some studies report that nitrous oxide emission is lower in organic system in comparison to conventional system (Dalgaard et al., 2002), (Flessa et al., 2002).

$$N_2O \text{ flux in OT systems} < N_2O \text{ flux in CT systems}$$

The benefits from nitrous fertilizers can be offset by higher N2O flux from soils, especially when the supply excess crops demand for nitrogen and CO2 emission from their production. Therefore more efficient use of N fertilizers can reduce N_2O and CO_2 emission.

2.3. Methane flux

$$GWP = \Delta\text{Soil C} + {}_{N2O} \text{ flux} + \text{CH4 flux} + \text{Energy Use}$$

Many studies report that tillage system has no influence on methane emission (G. P. Robertson and Harwood, 2000). It can be seen in the graph below (Figure 5). The methane flux does not differ in the different cropping systems (conventional, no-till, low chemical input and organic). The difference were reviled only in comparison between cropping systems and forest sites (successional). For that reason it is not taken into account in comparison between deferent cropping systems and for later use the GWP equation can be written as follows:

$$GWP = \Delta\text{Soil C} + N_2O \text{ flux} + \text{Energy Use}$$

2.4 Energy Use

$$GWP = \Delta\text{Soil C} + N_2O \text{ flux} + \text{Energy Use}$$

Reduced energy use means less fossil fuel use and less CO_2 emission. In reduced and no-till system less energy is used for the tillage process. It also helps to restore soil organic carbon because of more crop residues is left on the surface of soil. However, no-till management requires more herbicides usage for weed control purposes. Herbicides production also requires energy. Nevertheless, the balance shows that there is less energy use in reduced tillage systems.

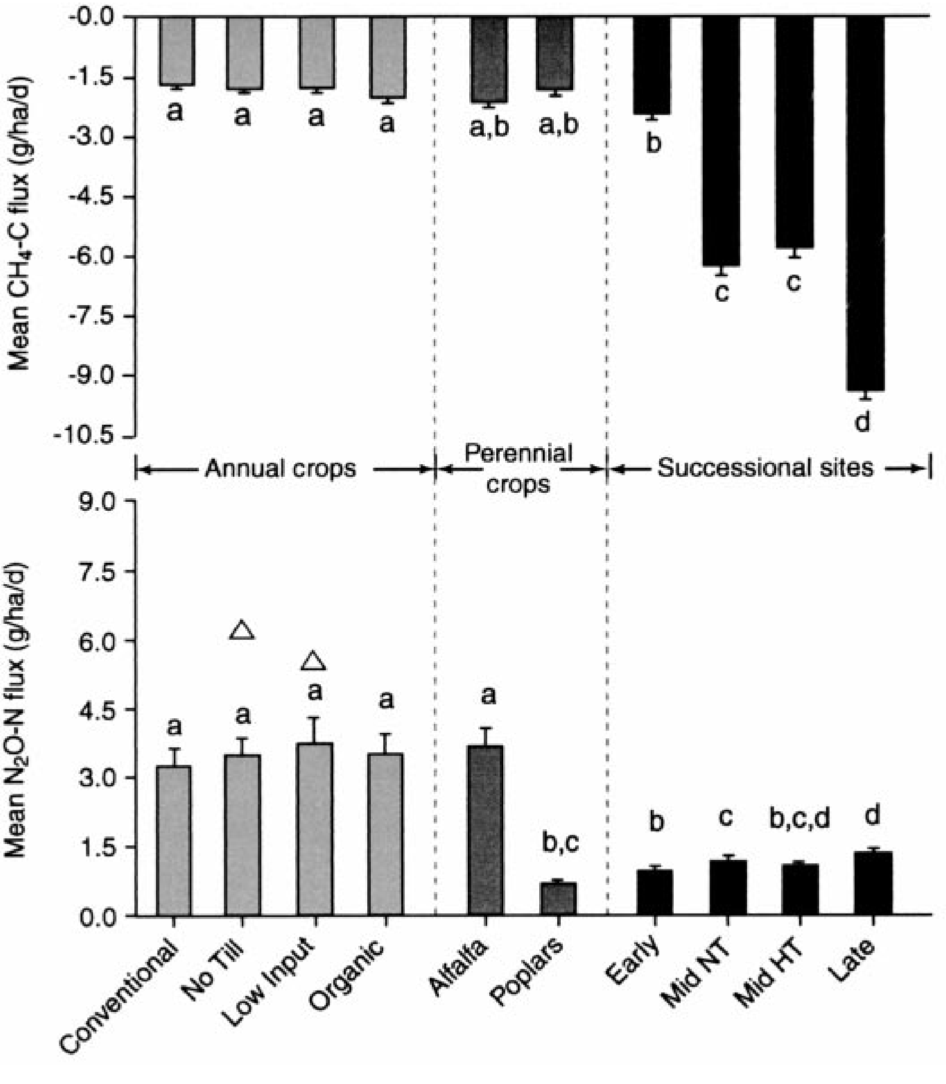

Figure 6. CH_4 oxidation (top) and N_2O production (bottom) in annual and perennial cropping systems and unmanaged systems. Annual crops were managed as conventional cropping systems, as no-till systems, as low-chemical input systems, or as organic systems (no fertilizer or manure). Mid-successional systems were either never tilled (NT) or historically tilled (HT) before establishment. The same letter in the graph indicates no significant difference among measurements.

energy use in NT < energy use in CT

In organic system greater tillage is needed as there is no possibility to use synthetic pesticides and fertilizers. Many studies report lower energy use in organic cropping system than in conventional cropping system (Dalgaard et al., 2001). There are not many results regarding the comparison between organic and reduced tillage systems.

3. Conclusion

Agriculture has a potential to mitigate global warming. There is a number of ways to mitigate the global climate change in agriculture. The crop management is one them giving the highest GHG reduction option. The overview of literature points that reduced tillage has higher potential of soil carbon storage than conventional soil management. The N_2O flux is the smallest in organic systems and there is no significant difference in CH_4 flux in different tillage systems. The balance of energy use is lower in reduced or no-till systems.

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TECHNICAL-ECONOMIC ANALYSIS IN LIVESTOCK FARMS: A TOOL TO ATTAIN VARIABILITY

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Abstract

The main aim of this paper is to show the usefulness of Technical-Economic Analysis in decision-making of farmers, associations and government to increase the viability of farms. Characteristics that should have indicators have been defined and the main aspects of methods used for collecting field data have been presented. The necessity to have collaboration from any type of farmer association has been underlined. Experiences using Technical-Economic Analysis in livestock farms at local, regional, national and international level have been reported. A process has also been described which explains how to go about putting a Technical-Economic Analysis method into practice within a given area; it first being necessary to characterize and classify farms according to production system types. Next, results of three papers, which concern goat grazing production systems in Andalusia (Spain), have been explained as a Technical-Economic Analysis pattern used in livestock production systems. Finally, uses of indicators in assessing the sustainability of livestock production systems have been presented.

Key words: indicator, monitoring, on-farm assessment, decision-making, sustainability

1. Introduction.

Technical-Economic Analysis (TEA) is a tool that can be used to study the working of livestock farms. It allows the researcher to assess farming management, productivity and profitability and then develop strategies to improve them. TEA is built with indicators which allow us to understand complex situations and quantify and simplify phenomena (International Institute for Sustainable Development, 2009). Nahed *et al*. (2006a) report that in order to assess any livestock production, variables should be identified and indicators should be selected, picking up data from different events and results concerning production activities. But, other complementary technical, sociological and economic aspects should also be considered, in order to compare analytic results of different farms. These aspects influence the determination of the minimum possible values for each indicator, as there are no absolute thresholds (Dubeuf, 2001).

Indicators can be used for different objectives: (i) to supply previous information of production systems, (ii) to assess the production systems in specific external conditions taking into account possible changes of these conditions, (iii) to compare results with established objectives, (iv) to compare a production system in different places or conditions, and finally, (v) to analyse possible trends of production systems (Gallopín *et al*., 1996).

The most important characteristics of indicators include the following: (i) they must be reproducible, easily measured and objectively verifiable, (ii) calculations to obtain indicator values from data should be easy, (iii) both farmers and technicians should be involved in designing and measuring them, (iv) measurements of indicator values should be repeated over time, (v) they must be sensitive to changes in the system, and (vi) it should be possible to analyse the relationships with other indicators (Claverias, 2000).

Agricultural systems should always be assessed using simple indicators, however, reality is complex, and it is sometimes difficult to evaluate a set of indicators (Andersen *et al*., 2007). It is therefore important to select appropriate indicators for the analysis of issues to be assessed in each system.

The technical-economic analysis methodology is highly developed for intensive livestock systems, such as poultry, swine and dairy cattle, for which there are standardized indicators to assess productivity. In less intensive systems, such as suckling calves, goats and sheep, this analysis is less developed. These systems are linked to the use of pastures which complicates the analysis. The lack of TEA on these systems, together with their diversity, means that there is a lack of information upon which actions can be taken to improve their performance.

In the EU there are many methodologies for technical-economic indicators. These methodologies have been developed by both public and private agencies with different objectives. In Andalusia (South of Spain), a group of researchers from the *Universidad de Sevilla* (U.S.) and the *Instituto Andaluz de Investigación y Formación Agrarias* (IFAPA) are collaborating with continuous and reliable information systems of small ruminant livestock from Andalusia. Based on this information, the researchers wish to develop a definitive TEA of these systems. Information is obtained with the collaboration of various agencies of the Andalusian sector of small ruminant breed associations, cooperatives, agricultural unions and the government, and for discussion of the methodology and results, researchers work together with international networks. The TEA in small ruminants have provided researchers with abundant scientific information, especially on grazing systems (Ruiz *et al*., 2008, Ruiz *et al*. 2009b, Castel *et al*., 2011). It has also led to a significant transfer of results to the productive sector.

The aim of this paper is to show the usefulness of TEA in the decision-making of farmers, associations and the government to increase the viability of farms. Achieving this aim is based on the results of work undertaken by the authors and by several groups located in different Spanish regions and the EU. Another aim of this paper is to show the use of other, non technical-economic indicators, in assessing the sustainability of livestock production systems.

2. Purpose of the TEA in livestock farms

According to Bockstaller *et al*. (1997), in recent decades the development of indicators at the international, national, regional, and local or field level has become an essential matter to provide tools for the evaluation of production systems. Accurate technical and economic information is useful for each farmer to manage the farm. Farmers' associations can help to improve the performance of each farm by comparing the technical and economic results of all farms. Finally, the government may use the information to better design strategies to assist and regulate every sector. Thus, the purpose of the TEA is different for a farmer, an association of farmers or the government, although the flow of information can either be bottom-up (farms to government) or top-down.

The length of this analysis varies, although one year is considered usual. The farmer can relate the economic result of this period with the management actions carried out in the farm, and improvements can be made in the next period. But TEA is an ongoing and durable process and results of several years show the farm’s evolution. Seeing this evolution, some technical management or trading organization decisions can be taken by farmers to improve economic performance (Santamaria, 2009). One important issue is the analysis of changes in production or trading factors. On the one hand, consequences of changes planned by the farmer can be analysed and, moreover, consequences of external changes that have taken place in the sector or in society can be studied, for instance in EU CAP or market regulations, both in relation to purchases of raw materials and to production sales.

Today the farmer is often in a cooperative, a breeding association, an animal health association or a union. Any association may be used to pick up data for technical-economic analysis, at the least possible cost. Pooling of data from all farmers allows them to make mutual comparisons and significant conclusions can be drawn to offer farmers appropriate advice. Holdings data can be compared with those of other holdings of the analysis group, but can also be compared with data from groups of the same area, other areas or regions or countries. Many experiences in this regard have been carried out in all livestock species, having obtained satisfactory results (Agudo *et al*., 2010). Also, different aspects such as food, health and marketing can be jointly managed, based on the analysis results of a group of farms. In some cases, a proposal to improve a group of farms can be made, for example through feeding differentiation taking into account the level of grazing or animal productivity

Concerning governments, some of them, regional or national, have established methodologies to carry out the TEA within some livestock sectors to obtain reference information (Bossis *et al.*, 2009). Generally data is collected through associated bodies. Based on the analysis results some policies and plans for improvement of livestock sectors can be better designed by governments. There are also international networks where results of different countries are compared; this is the case of the International Farm Comparison Network (IFCN) for dairy cattle (Deblitz, 2005) or the FAO-CIHEAM Network for small ruminants (Toussaint, 2002). It seems that in the new CAP of the EU, indicators will play an increasing role because in the future, the use of standardized indicators of production costs are likely to be indispensable when establishing contracts between industries and producers.

3. Keys of TEA in livestock farms

In order for TEA to work properly, certain aspects must be considered, some of which have already been mentioned but will be developed in further detail. First, collected data should be reliable. For this, selected farmers must take this seriously and have a real interest in the partnership. Requests should be made to the suppliers of raw materials and purchasers of produce to supply data on farmers who are working in the analysis. Thus, concerning feed, data supplied by the marketing companies may refer to the type of food supplied, quantities and prices. In the case of companies buying the production, data may refer to the quantities sold and their quality, for example fat and protein for milk. Errors often occur in data collection, which are readily detectable by farm advisory experts. It is essential to carry out a review of the data as soon as possible to correct any flaws in the methodology.

Data collection can be performed using two different methodologies: a retrospective analysis and monitoring. In the retrospective analysis, the information is collected at the end of a period, usually one year. The monitoring consists of more or less continuous collection of data over the period, usually every month or every two months. The data are taken primarily by farmers, but farms are visited by the technician overseeing the process at a frequency that depends on farmer effectiveness. Obviously, except for areas in which, as mentioned, it is easy to obtain the annual record (food purchases and sale of productions), the information through the monitoring method will be of higher quality than that obtained by the retrospective analysis. Areas with more changes throughout the year are the most interesting for the use of the monitoring method, for example animal headage, feeding management (especially when based on grazing) and reproductive management. Other aspects such as labour may also change, but these changes are less frequent.

Concerning indicators, they should be selected according to animal species and to the production capacity of the farms studied, or taking into account their production objectives. In general two types of indicator can be used: simple indicators, resulting from the measurement or estimation of an indicative variable, and composite indicators that are obtained from several variables or by aggregation of simple indicators (Girardin *et al.*, 1999), examples of which will be presented later.

4. Experiences using TEA in livestock farms

In this paragraph different experiences in the use of indicators for the ATE in different parts of the EU will be presented. These experiences were classified according to the application level indicators: local, regional, national and international.

4.1. Experiences at the local level

The use of technical-economic indicators by an association of farmers is common. In Spain, some cooperatives and breed associations collaborate with universities and research centres to improve farming through the TEA. These analysis results are then used to advise farmer partners. Next, some experiments carried out by associations and universities in Spanish farms sheep and goats will be presented.

Table 1. Evolution of technical-economic indicator values in meat sheep farms of Aragon

Indicator	2002	2003	2004	2005	2006
Number of ewes	718.9	750.5	765.0	760.0	773.5
Prolificacy	1.32	1.34	1.34	1.31	1.35
Sold lambs per ewe and year	1.23	1.26	1.26	1.19	1.28
Meat incomes per ewe and year (€)	78.25	81.63	82.61	78.60	77.19
Feed costs per ewe and year (€)	48.99	50.72	54.50	50.91	52.32
Gross margin per ewe and year (€)	36,50	32,15	30,37	28,27	25,03

Source: Fantova et al. (2008)

Oviaragón is a cooperative of the meat sheep production sector located in the region of Aragon (Northeast Spain). Since 1992 a TEA has been conducted in this cooperative through a group of associated farms and in collaboration with the

University of Zaragoza. In the early years TEA results were used for the classification of farms and to analyse their progress. Subsequently, specific studies have been carried out to identify relationships between different aspects of farm management and economic margins. The following studies conducted recently are noteworthy: Fantova *et al*. (2008 showing the decline in agricultural profits from 2002 to 2006 (Table 1), Santander *et al*. (2005), showing the influence of the rate of abortions in economic performance, and Fantova *et al*. (2007), showing the influence of feed costs and staff productivity in the economic margins.

As for goat milk, authors of this paper have been working since 2001 mainly in grazing production systems, collaborating with goat breeder associations and other sector bodies. Despite being in decline, goat production grazing systems have an enormous sociological and environmental importance. Seeking solutions to improve these systems is an important objective of this work. The main weaknesses found by authors in the Spanish grazing systems that have been studied, are related to the bad feeding management, where, sometimes animals walk too far when pastures do not offer enough grass and, other times when the quantity of hay provided in the trough is not enough (Ruiz *et al*., 2008). When systems are more intensified, too much concentrate is supplied in the trough (Ruiz *et al*., 2010a). In order to base the results obtained by the authors on data increasingly more accurate and reliable, work is being done to improve the monitoring methodology of TEA that, is particularly interesting on grazing farming systems. Another objective of the authors has been to make it possible to conduct a joint analysis of data from goat farms in different areas of the Mediterranean Basin. To this end, indicators have been used that are common to different countries, although it has sometimes been necessary to make adjustments. Collaborations have resulted in joint work between Spanish authors and authors of several countries: France (Ruiz *et al*. 2009a), France and Italy (Ruiz *et al*., 2009b, Table 2) and Morocco (Chentouf *et al*., 2009).

4.2. Experiences at the regional level

At the regional level, an experiment conducted in Italy through the Regional Association of Sardinian Farmers (ARAS) is described. The ARAS includes farmers of various livestock species: milk and meat cattle, dairy sheep, milk goats and pigs. Services given by ARAS are diverse: from management of the herd books of local breeds to a laboratory for analysis of livestock products. The ARAS uses only technical information of farms and not economic information. Technical assistance is available to numerous groups of farmers, the assistance for each group (of 50-60 holdings) being led by a veterinarian and an engineer. In total 5342 farms are controlled by the ARA, mainly dairy sheep, with a total population size of 1 416 731 head.

Table 2. Technical-economic indicator values for each dairy goat grazing farm typology of the Mediterranean Basin

Indicator	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total farm area (ha)	53.0 (±7.7)	150.0 (±22.7)	368,2 (±69.8)	86.8 (±37.0)
Cultivated pasture area (ha/goat)	0.26 (±0.04)	0.03 (±0.01)	0.08 (±0.02)	0.06 (±0.03)
Goats present (n)	112.9 (±14.9)	184.2 (±18.1)	540.3 (±45.4)	117.4 (±24.6)
Forage supply (kg/goat)	232.7 (±41.8)	89.16 (±12.3)	51.1 (±15.4)	398.8 (±36.4)
Milk income (€/goat)	185.1 (±55.2)	106.5 (±15.0)	153.4 (±16.2)	318.8 (±67.5)
Feed cost per goat (€/goat)	82.8 (±15.7)	50.7 (±5.5)	64.4 (±7.1)	129.1 (±17.1)

Source: Ruiz et al., 2009b

Technical data from partners are picked up by technicians from associations who, after carrying out a TEA, use the results to advise farmers. A set of technical indicators for each species has been developed by the ARA, which in the case of sheep and goats are related to reproduction and to milk production. The information collected from the farm is available to the farmer through a database (Data Warehouse) that is accessible on the Internet.

4.3. Experiences at the national level

The Institut de l'Elevage (IE) is a French organization dedicated to experimentation and development in various livestock sectors: cattle, sheep, goats and horses. The IE is led by various professional associations in these sectors, which is organized in 4 departments: genetics, regional actions, farming techniques and quality of products and economics. The regional actions department is responsible for livestock reference networks to provide advice and foresight. Each livestock species has its own network. In the case of goats, the network collects data from the five major goat-farming regions of France: Poitou-Charentes, Rhône-Alpes, Centre, Midi-Pyrénées and Pays de la Loire. The data collection is carried out by different French goat sector bodies, syndicates, milk recording institutions, agricultural offices, etc. The data collection and analysis have been unified by a computer program, called BTE / GTE Logicap, and hence, since 2002 a national annual analysis has been carried out for goat farms (Bossis *et al.*, 2008). In goat production, there are two levels of TEA made by the IE: (i) the Technical-Economic

Balance, where a balance is calculated by subtracting the feeding costs from the milk incomes, because incomes from milk and cheese explain about 85% of total income, and feed costs are the main expense of the holding, and (ii) the Technical-Economic Management, where the gross margin is calculated taking into account all income and expenses of the goat farm.

The technical data collected by the IE are grouped into several sections: farm and herd sizes, workforce, feeding management, milk production (Bossis *et al*., 2008). The TEA is made by IE in order to study the evolution of French goat farming systems at both regional and national level (Table 3). But, as in the case of the ARA, results are used by field technicians as an advice instrument to farmers. Moreover, some educational documents are drawn up by IE in order to help improve the situation of farmers; these documents are also a source of information for industrial bodies and the regional and national government.

Table 3. Technical-economic indicators for goat farms of three French regions: Poitou-Charentes, Loire and Bretagne, according to feeding management.

Indicator	Corn silage	Hay	Dehydrated and straw
Goats present (n)	289	268	302
Milk production (l/goat)	865	872	899
Milk income (€/goat)	565	508	492
Feed cost (€/goat)	173	216	263
Gross margin (€/goat)	324	312	268

Source: Bossis et al. (2009)

4.4. Experiences at the international level

At the international level there are networks that regularly show the technical and economic results of a particular livestock sector. For example the International Farm Comparison Network (IFCN) is an international network providing policy advice by applying internationally harmonized methods of data collection and analysis (Deblitz, 2005). Likewise, the IFCN develops a global research network connected with agricultural economics researchers in order to obtain a better understanding in farming production worldwide. In the case of the dairy milk production, the Dairy Research Centre belongs to the IFCN, and coordinates scientific work and provides professional management for the network. Dairy farmers benefit from learning about their competitiveness in a globalized dairy world. Moreover, they have access to information about alternative production systems. This network uses indicators for comparative studies such as: milk production per cow per year, number of cows per farm, the relationship between prices of 1 kg of milk and a 1 kg of concentrate, etc. (IFCN, 2009).

On the other hand, FAO-CIHEAM Sub-Network for sheep and goat production systems is a forum for the development of technical-economic and other sustainability indicators, and is also a meeting point to present the results of the indicator implementation in sheep and goat Mediterranean production systems (Table 4). The Subnetwork proposes a basic set of indicators in several languages which can be used in several countries to compare data collected in each zone by a common TEA (Toussaint *et al*., 1999). The heterogeneity of the production system and the difference in levels of difficulty to pick up data in different areas make it necessary to structure indicators in the following levels: (i) Level 1 which considers the minimum descriptive elements to identify the production system structure, (ii) Level 2 which considers quantitative data, (iii) Level 3, which includes more detailed measures, both quantitative and qualitative, which explain some results of previous levels and (iv) Level 4 which includes certain necessary data in the special studies (Toussaint, 2002). FAO-CIHEAM technical-economic indicators (Level 2) are placed in the following groups: surface area, workforce, animal structure, technical results (reproduction, feeding, production and transformation) and economic results (expenses, incomes and margins). Furthermore, there are other indicators related to the production system environment to determine the geographical, socio-economic and socio-political situation.

Table 4 shows results of FAO-CIHEAM technical-economic indicators for different goat production systems of the Mediterranean Basin.

5. Use of TEA in livestock production systems research

Numerous scientific papers are available on animal production systems where indicators are the work basis. Important issues are dealt with in these papers such as production system characterization and evolution, farm classification according to different production systems, relations of farm management aspects with economic results, production system sustainability evolution, etc.

5.1. Characterization and evolution of production systems and farm classification

Characterization and evolution of production systems and farm classification according to different production systems (clusters) are the first step in production systems research. This process can also highlight which variables most determine the good management and profitability of farms. Some of these variables are then integrated within technical-economic indicators to be used in TEA.

Table 4. Results of FAO-CIHEAM technical-economic indicators for different goat production systems of the Mediterranean Basin

Mediterranean Region	Total area (ha/goat)	Number of goats	Feed (kg)		Milk (l)
			Concentrate	Forage	
Andalusia (Spain)	0.73	353	278	52	334
Canary Islands (Spain)	0.41	122	319	331	472
North Morocco	0.34	31	147	0	118
Andalusia (Spain)	-	180	343	231	403
Andalusia (Spain)	0.31	382	392	198	410
Poitou-Charentes (France)	-	277	-	-	766

Source: Ruiz et al. (2008), Escuder et al. (2006), Chentouf et al. (2009), Sánchez et al. (2006), Mena et al. (2005), Jènot (2006)

The choice of variables for characterization depends on the production system management and objectives, as with other factors, but depends overall on the characteristics of information that can be found in farms and in the farm environment. When information is scarce, qualitative variables are mainly used, for instance type of farm activities, characteristics of rangelands, type of feed supplied, presence of infrastructures, animal performance, type of reproduction management (Castel *et al*., 2003, Riedel *et al*., 2007, Castel *et al*. 2011). However, whenever possible, quantitative variables are used, as they are more accurate. In fact, quantitative variables are the most used by researchers for conducting multivariate analysis: Milán *et al*., 2006 and Gaspar *et al*., 2008 in dehesa agro-ecosystems, Ruiz *et al*. 2008 in dairy goat systems and Pardos *et al*., 2008 in meat sheep systems. However, when a qualitative variable is important, it should be included in the analysis. The more frequent quantitative variables used in livestock production system multivariate analysis are related to the following aspects: surface area size, flock size, animal density, workforce, feed supply and productivity, among technical variables, and incomes, expenses and margins, among economic aspects. Frequently, economic variables are statistically correlated with technical variables and consequently do not have be included in multivariate analysis. The purchased feed price and the production sales price are determinant variables for economic analysis but, taking into account their low variability coefficient, habitually they are not included in multivariate analysis (Hair *et al*., 1998). Therefore, economic variables, in general, are less important in multivariate analysis than technical variables.

An example of the first step for beginning a technical-economic analysis can be found in the Podlasie region of Poland (Castel *et al*. 2010b). As a result of characterization and classification of farms in this region five farm clusters were obtained (Table 5). In this case, several important variables related to diversification of farmer's activities and to culture or cow productivity have been used (milk production is the main activity in the region). In the near future, a technical-economic analysis can be made in this Polish region. In order to do so, some more technical variables should be used, which are related to feeding, reproduction and animal health management, and economic variables should also be used, related to prices of purchased feed and to sold products.

Table 5. Values of considered variables (mean and standard error) for farms in the whole studied area in the Podlasie province (Poland) and for each cluster

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
No. persons in the farm household working off-agriculture both on- and off-farm	0.4 (±0.1)	0.2 (±0.1)	0.8 (±0.1)	0.2 (±0.1)	0.4 (±0.1)
Number of persons per 10 ha in the farm household working in farm-agriculture	1.2 (±0.1)	1.6 (±0.2)	1.6 (±0.2)	0.6 (±0.0)	1.0 (±0.1)
Farm area (ha)	19.5 (±1.6)	19.5 (±1.9)	10.7 (±1.3)	47.0 (±4.1)	20.1 (±1.1)
Proportion of fodder crops arable areas (%)	35 (±3)	67 (±4)	2 (±2)	39 (±10.2)	28 (±2.9)
Dairy cattle density (LSU/ha AA) +	1.3 (±0.1)	2.6 (±0.2)	0.3 (± 0.1)	1.5 (±0.2)	1.5 (±0.1)
Contribution of commercial feeds (%)	18 (±4)	34 (±6)	3 (±1)	20 (±4)	16 (±2)
Yield of cereals (ton/ha)	4.0 (±0.1)	4.6 (±0.2)	3.6 (±0.1)	4.2 (±0.1)	3.9 (±0.1)
Milk yield per cow (l/year)	5152 (±266)	6747 (±320)	4930 (±253)	6429 (±341)	6151 (±167)
Contribution of agricultural production to total farm household incomes (%)	87 (±5)	94 (±2)	66 (±7)	96 (±2)	88 (±3)
Contribution of non agricultural activities to total farm household incomes (%)	13 (±5)	6 (±2)	34 (±7)	4 (±2)	12 (±4)
Contribution of crop production to total farm incomes (%)	34 (±5)	2 (±1)	62 (±9)	14 (±4)	8 (±2)
Contribution of livestock production to total farm incomes (%)	66 (±5)	98 (±1)	38 (±8)	86 (±4)	92 (±2)

Source: Castel et al., 2010b

In order to obtain data from these variables any Polish body could collaborate, especially the Podlasie Center of Extension Services and also the

Agency for Restructuring and Modernization of Agriculture (Podlasie Regional Office and Poviat Bureaus), that works in the Podlasie region.

5.2. A pattern of TEA use in the livestock production systems research process

As a pattern of TEA use, a research process in goat production systems of Andalusia (Spain) is shown through results of three papers written by authors of this work: Ruiz *et al*. (2008), Ruiz *et al*. (2009b), Castel *et al*. (2010a). Ruiz *et al*. (2008) made an adaptation of the FAO-CIHEAM method (Toussaint 2002), which is applied to intensive small ruminant systems and to grazing systems. Indicators involved in the classification of goat production systems in Andalusia through multivariate analysis are related to system size (surface area and number of animals), productive factors (indoor feeding and labour) and milk yield. Three clusters were obtained from the analysis (Table 6). Furthermore these authors, from data of a farmer association, made a characterization and diagnostic of Andalusian dairy goat farms. One of the most important conclusions to improve the economic viability of these systems is that pasture resources must be correctly utilized and the varying seasonal production of grasses must be taken into account, thus leading to more appropriate indoor feed planning.

Table 6. Technical-economic indicators in pastoral dairy goat Andalusian farms

Variables	Cluster 1 Small area farms	Cluster 2 Large area farms	Cluster 3 Farm less dependent
Total area per goat	0.31 (±0.10)	0.85 (±0.10)	1.28 (±0.26)
Brush area per goat	0.23 (±0.07)	0.61 (±0.13)	0.99 (±0.16)
Total labour per 100 goats	0.93 (±0.15)	0.47 (±0.06)	0.75 (±0.05)
Goats presents	189.2 (±27.6)	546.6 (±69.5)	302.9 (±95.9)
Concentrate consumed per goat	260.0 (±35.4)	363.6 (±26.6)	160.2 (±57.8)
Forage consumed per goat	76.6 (±26.3)	55.4 (±22.0)	1.1 (±1.1)
Net energy from grazing (%)	55.6	49.4	77.5
Milk produced per goat	328.5 (±33.4)	463.2 (±29.9)	366.1 (±53.4)
Proportion of milk produced in autumn	10.3 (±2.5)	15.0 (±2.3)	10.4 (±1.7)

Source: Ruiz et al. (2008)

Concerning methodology, due to the variation between farms and the seasonal nature of pastures and of milk production, adjustments to some FAO-CIHEAM indicators had to be made. The most important new indicator used in this work was *Net energy from grazing*. This indicator has been included in later works of FAO-CIHEAM (Toussaint *et al*., 2009, Toussaint *et al*., 2010).

In the work of Ruiz *et al*. (2009b), grazing farms of different Mediterranean countries (Spain, France and Italy) were characterized and classified, seeking common improvement strategies. The indicators chosen were those commonly used by partners which are calculated in similar ways or are comparable after a small modification. A total of 21 indicators were chosen and grouped into six categories: surface area, labour, herd, feeding, production and economics. After a cluster analysis, four groups of farms were obtained (Table 7). The determinant technical indicators for the farm classification are those related to cultivated pastures, farm size and use of forage. Through a contingency analysis conducted between the obtained groups and the region where the farms are located a tendency is observed for Spanish farms to be placed in cluster 3, whereas Italian farms would belong to cluster 2, and to a lesser extent, to cluster 1, and French farms would belong to cluster 4, although, again to a lesser extent, could also match cluster 1.

Table 7. Technical-economic indicators in pastoral dairy goat Mediterranean farms

Variables	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Total farm area (ha)	53.0 (±7.7)	150.0 (±22.7)	368.2 (±9.8)	86.8 (±37.0)
Proportion of natural pasture area (%)	39.2 (±3.2)	74.5 (±6.8)	77.1 (±6.2)	81.9 (±6.2)
Cultivated pasture area per goat (ha/goat)	0.26 (±0.04)	0.03 (±0.01)	0.08 (±0.02)	0.06 (±0.03)
Goats present	112.9 (±14.9)	184.2 (±18.1)	540.3 (±45.4)	117.4 (±24.6)
Concentrate per goat (kg/goat)	249.6 (±23.1)	171.2 (±27.6)	283.6 (±31.0)	221.6 (±28.6)
Forage supply per goat (kg/goat)	232.7 (±41.8)	89.16 (±12.3)	51.1 (±15.4)	398.8 (±36.4)
Milk sold per goat (liters/goat)	333.5 (±59.7)	213.8 (±24.1)	316.6 (±31.0)	482.3 (±74.5)
Difference between milk income and feed cost per goat (€/goat)	102.2 (±41.4)	55.8 (±13.2)	89.0 (±11.5)	189.7 (±56.5)

Source: Ruiz et al. (2009b)

Results of Ruiz *et al*. (2009b) show that there is a wide diversity in dairy goat grazing farms studied in France, Italy and Spain, especially in feeding management. The main weaknesses found are linked to the grazing and feeding management and to the low productivity of goats which both have repercussions on the economic benefits obtained. Research is to be encouraged on the nutritional utilization of rangelands and pastures, and transfer of results to the livestock sector should be facilitated. Concerning the productivity of goats, work should be carried out to improve it, but without overlooking the balance between hardiness and productivity.

Finally, Castel *et al*. (2010a) based on the available technical-economic information, described the present situation and future prospects for goat production systems in Spain. This work shows that changes of socio-economic, technological and agricultural policies of the European Union (EU) have sharply influenced the evolution of these production systems. Table 8 shows results of technical indicators in Spanish goat farms obtained from monthly monitoring in two types of system, those in which goats are permanently confined and those where goats are kept on pasture with different grazing times. Basically farmers take advantage of natural pastures, although they also use cultivated forage fields and agriculture residues. Goats are supplemented indoors, basically with concentrate and forage. In intensive production systems, the most productive Spanish breeds are used. Animals of these breeds can express their maximum productivity in these systems.

Table 8. Average yearly values of technical indicators of Spanish goat farms obtained from monthly monitoring.

Indicators	**Stabled systems**	**Grazing systems**		
Farms studied	7*	8**	21***	18****
Breed	Murciano - Granadina	Malagueña	Canaria	Payoya
Number of goats per farm	179	382	122	353
Grazing surface per goat (ha)	-	0.31	0.32	0.73
Labour per 100 goats (YWU[a])	0.74	0.69	-	0.71
Feed concentrate per goat (kg)	343	392	319	278
Fodder per goat (kg)	288	199	331	52
Milk produced per goat and year (l)	487	440	473	389

Source: * Sánchez et al. (2006), ** Mena et al. (2005), *** Escuder et al. (2006), ****Ruiz et al. (2008)
[a] YWU: year worker unit

The success in results of this Andalusian research team is due to the collaboration of farmer's associations to collecting data in farms. But this success is also due to the knowledge that researchers have acquired concerning the goat sector and to their good relations with goat sector bodies and with international research groups.

6. The use of indicators in assessing the sustainability of livestock production systems

Currently, a number of requirements related to the environment, animal welfare, product quality, product safety and rural development are demanded by society for farming production. These requirements together with the need for economic efficiency in farming production give rise to the concept of sustainability. Consequently, in recent years many methodologies and indicators have been developed concerning the assessment of farm systems sustainability: Arandia *et al.* (2009), IDEA (2003), Several authors (2001), Several authors (2006), and numerous works have been published related to this issue: Coffey *et al.* (2004), Nahed *et al.* (2006b), Galán *et al.* (2007), Peacock and Sherman (2010) in general aspects, and Napolitano *et al.* (2009) and Phythian *et al.* (2011), at animal welfare level. For environmental impact assessment, several types of indicator can be distinguished. Bockstaller *et al.* (2009) point out three groups: the first consists of simple indicators based on one or a simple combination of variables obtained by survey, data bases and are not directly measured, the second group includes indicators based on calculation and integrating more than one type of factor, e.g. farm practices and soil conditions, and the third group includes indicators based on one and several measurements, e.g. biodiversity indices. Also in environmental aspects, Niemeijer and Groot (2008) established a conceptual framework for selecting environmental indicator sets. The most commonly used environmental sustainability methodologies are related to energy balances and the carbon footprint. The energy balances method has been used for example in meat sheep systems by Benoit and Laignel (2007 and 2010) and by Pervanchon *et al.* (2002) in agro-ecological production. The carbon footprint method which take into account all sources of greenhouse gas emissions, including animals, cropping, fertilizer, and manure, is currently the most used (because it is an easy and intuitive method), therefore, it has been used by numerous authors (Thomassen and Boer, 2005). However, Capper *et al.* (2009) use a modification of the carbon footprint method which takes into account some corrections in the negative influence of livestock production (Steinfeld *et al.* 2006). Also, Life Cycle Assessment (LCA) is a method regulated by ISO that conveys the environmental impact of products. LCA of milk production has evaluated environmental issues such as greenhouse gas emissions, resource utilization and land use change (Yan *et al*, 2011).

Concerning indicators for sociological sustainability assessment, researching in recent years has also been important but less so than in the case of environmental indicators. Van der Ploeg (1994) established the Styles of farming methodology which confer great importance to the workforce factor. Mas de Noguera (2003) conducted interesting work on sheep production system sustainability in Castellón (East of Spain). A robust set of indicators has been built by these authors among which the sociological indicators can be underlined. Malkina-Pykh and Pykh (2008) have also worked on sociological indicators, particularly in quality-of-life indicators at different scales.

Animal welfare is considered a part of sociological sustainability. In this issue, Phythian *et al.* (2011) propose animal-, resource-, and management-based indicators to analyse on-farm sheep welfare. On the other hand, organic production systems are a natural tendency towards sustainability (Darnhofe *et al.* (2007), whose evaluation should include all possible aspects of the production system: productivity, environment, sociology, etc. (even animal welfare and quality and safety products) (Müller-Lindenlauf *et al*., 2010). Some authors have studied differences between organic and conventional farms (Nauta *et al*., 2006, Rozzi *et al*., 2007).

Considering the broad sustainability, the Framework for Assessing Natural Resource Management Systems Incorporating Sustainability Indicators (in Spanish, MESMIS) proposed by Masera *et al.* (1999), is a widely used methodology which was used by some authors of this article in a study of Andalusian dairy goat systems (Nahed *et al*., 2006b). In this study, five attributes were considered: productivity, stability (including reliability and resilience as they are closely related), adaptability (or flexibility), equity and self–management. Authors are working on expanding the list of indicators to better assess certain environmental (Nahed *et al*., 2009) and sociological aspects (Ruiz *et al*, 2009c).

Several scientists, including those involved in the Livestock Farming Systems (LFS) Working Group of the EAAP, have driven interdisciplinary research in animal production systems in order to improve farm sustainability (Gibon 1999). However, the number of methodologies developed in recent years in the sustainability issue is high, making it difficult to exchange analysis results between different authors. Some authors have attempted to compare different methodologies (van der Werf and Petit, 2002) and others have tried to integrate different indicators. In this way, Murgueito *et al.* (2003) integrated two types of indicator: an indicator of diversity and an indicator of the carbon footprint, thus making the sustainability analysis easier. Arandia *et al.* (2009) established the NAIA methodology which includes all aspects of sustainability (productivity, environment and sociology). This method confers importance to aspects such as autonomy (in different senses of animal production systems), the amount of labour, quality of work activity, quality of life of the farmer's family, the diversification of farmers' activities, the relationship between agriculture and landscape features, etc.

To conclude this work, an important idea arises: as the negative aspects of livestock to the environment are evaluated, one of the main challenges today is to value the positive contribution of livestock to society (externalities), in addition to providing high quality food (Ruiz Mirazo *et al*., 2009, Guzman *et al*., in press). These contributions can include the determination of the population in difficult areas or, in the case of pasture-based livestock systems, fire prevention (Ruiz-Mirazo *et al*, 2009), maintenance of landscape (Gibon, 2005) and High Nature Value (HNV) farming (Caballero, 2007, EUROCARD, 2009). To assess these contributions, indicators are being developed by several authors to measure the so-called externalities of livestock production systems.

7. Conclusions

Technical-economic analysis is increasingly necessary because of the general increase in price variability, of both purchased factors and sold productions.

Technical-economic analysis applied to the livestock production is mainly developed in intensive systems. However, in recent years some research teams are working in pasture-based systems.

Results of technical-economic analysis in a region or a country are clearly useful for Governments in order to establish development policies. Likewise they are useful for EU Common Agricultural Policy.

To develop the technical-economic analysis in a new area the collaboration of an association is necessary in order to control the data collection from farmers. The monitoring method is better than the retrospective method.

Technical-economic analysis is conducted through indicators. In order to compare results for different areas, regions or countries, a homogenization is sought by researchers of different teams. In this way, several networks have been created for analysing different livestock sectors.

In recent years, requirements in different aspects of sustainability (environment, animal welfare, product quality, product safety and rural development) are demanded by society. By consequence, many methodologies and indicators have been developed concerning the assessment of farm system sustainability.

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CURRENT STATE AND PROSPECTS FOR DEVELOPMENT OF ORGANIC FARMING IN POLAND

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Abstract

The popularity and prevalence of organic farming in Poland is lower than the average in the European Union Member States, despite that fact that this type of farming is rapidly developing in the European Union. It is only in the year 2005 that the total area of agricultural land has exceeded 1%. The studies on this type of agricultural system have shown that the fundamental problems impeding the dynamic development are as follows: low consumer awareness, lack of efficient national and international distribution of organic products and high prices charged for organic products. Polish legal regulations which have been in force before and after joining the European Union, however, do not constitute barriers to the agricultural system.

Key words: organic farming, organic food, organic consumer awareness, law regulations, Poland

Introduction

Initially in many countries the driving force for the development of organic farming, different to other agricultural systems, was caused by consumers' demand for organic products. Currently the organic production is defined as the fastest growing sector of agriculture, particularly in highly developed countries. This is mainly due to state funding provided for various development programmes (Komorowska 2006, Nasalski, 2006). Komorowska (2006) lists also other reasons for growing farmers' interest in the development of organic farming, such as: the willingness of active participation of farmers in the environmental protection, lifestyle changes, eagerness to improve animal health, higher prices of organic products. In Poland from the end of World War II until 1998 the development of organic farming was very slow. The first organisation of organic farmers, i.e. Organic Food Producers EKOLAND, was established in Przysiek near Toruń on the 1st of September 1989. At that time the number of organic farms was only 27 and in the next 8 years it increased to 417 (Ekoland 2007, WIJHARS 2011). To begin with it was down to the farmers to judge the usefulness of this type of farming but later on organic farmers organisations appointed special committees of inspection, certification and internal control (Łuczka-Bakuła, 2006).

The demand for organic food is increasing both in the USA and the European Union where the leading role is played by the Scandinavian countries. According to the consumers in the 1980s, the most relevant features of food products were: external appearance, including size, colour, number of defects, and packaging. Nowadays the consumers interests are focused not only on commercial criteria, but also on health properties, such as health and safety, food produced without addition of chemicals and pesticides, and ecological aspects, including products produced in an environmentally friendly way (Bałtromiuk, 1999, Kucińska, 2009). Organic food satisfies all of these requirements (Rembiałkowska, 2007). One of the factors strengthening the position of organic food on the market is the increase in demand for the products (Sławiński and Sadowski, 2005). The major factors that influence the demand for organic foodstuffs are: rise of ecological awareness in society, development of lifestyle diseases (cancers and allergies), increase in the well-being of the population and fear of food scandals such as BSE. It is also important to establish specialized institutions in order to make business contact with Polish and foreign customers (Sławiński and Sadowski, 2005; Kucińska, 2009).

Poland is a country where historical and political circumstances are prohibiting dynamic growth of consumers' awareness. Even though the area of full organic farms grew from 25000 hectares in the year 2000 to 222000 hectares in 2009, it still has less than 1.4% share in the whole agricultural land area (GIJHARS, 2010). The newest raport of GIJHARS, (2011) revealed the area organically cultivated in 2010 was approximately 520 thous. ha. (comprised of 308 thous ha fully organic and 212 thous. ha in convertion), that means that share of organic agricultural area in total arable land in Poland accounted for about 3.3%.

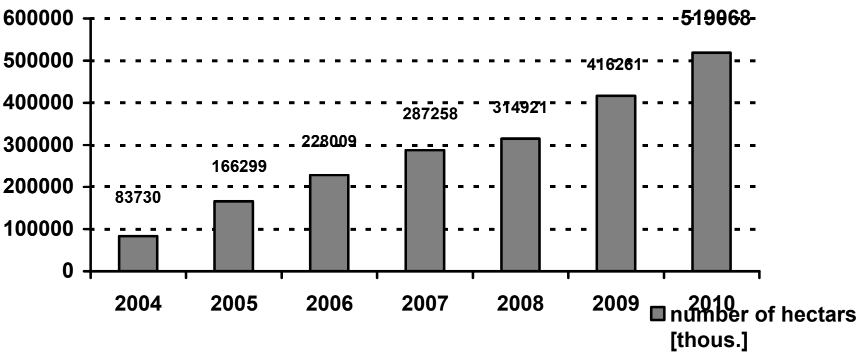

Fig 1. The area organically cultivated in 2004-2010 in Poland (hectars)
source: GIJHARS, 2011.

Even though Polish market has seen a noticeable growth of organic food supply, the demand for this type of food products still remained at a relatively low level. The dynamic development of organic farming system is only possible due to the fact that the average area of organic farms size in Poland exceeds 12 hectares and is greater by 4 hectares than the average for all farms in Poland. The growing number of food processing plants indicates the development of organic agriculture in Poland. However, it should be stressed that the increase to 293 in the year 2010 was at a level of 5.8% and compared to the year 2009 was significantly lower, when it reached 17.4% (GIJHARS 2011; MRiRW, 2008; GUS 2009).

Organic food safety and quality of selected features

Although organic farming is commonly accepted in the whole world as an agricultural system which can solve problems with food safety, the conventional farmers widely claim that organic products may contain more mycotoxins and hazardous microorganisms e.g. Salmonella, because of the prohibition of the usage of pesticides (Vijver et al., 2006, Knura et al., 2006). A number of studies conducted in various European countries including Poland do not support this theory (Bavec and Bavec, 2006; Champeil et al,. 2004; Dasko et al., 2006; Fookes, 2001; Jończyk, 2006; Plochberger, 1989; Vijver et al., 2006; Velimorov et al., 1992; Czerwiecki et al., 2002; Gonazáles-Osnaya et al., 2007; Schollenberger, 2003). In the research work of the Institute of Soil Science and Plant Cultivation (State Research Institute) in Pulawy (Jończyk, 2006) there were no differences detected in the amount of mycotoxins contained in grains from neither organic nor conventional farming systems. In actual fact organic grains were slightly less contaminated by these substances. Furthermore, the studies on the quality of animal products Schenweis et al. (2005) found significantly lower levels of total zearalenone (ZEN + alpha + beta-ZEL-ZEL) in bile samples of pigs fed with wheat grain which were derived from organic farms in comparison to the amount of toxins in bile samples of pigs fed with the same variety of wheat but cultivated within the conventional system (Scheneweis, 2005).

According to numerous European studies carried out by Velimorov (1992), Plochberger (1989) or cited by Rembiałkowska (2000, 2006, 2007) Shmidt (2006), Dasko (2006), Bavec (2006) there is no doubt that foods derived from organic agriculture are characterised by a significantly higher content of dry things such as sugars, minerals (especially iron, magnesium and phosphorus), valuable amino acids, vitamins (C and group B) and the so called plant secondary metabolites such as phenolic acids, which not only play an important role in the defence system of plants but also have a beneficial effect on human health. Currently there are studies being carried out on the use of organic foodstuffs in the diet of people during the time of reconvalescence from various types of cancer (Vijver, 2006; Willer, Yussefi, 2004). Moreover, studies conducted in Poland, for instance by

Institute of Soil Science and Plant Cultivation (State Research Institute) in Pulawy (Jończyk, 2004), or at WULS - SGGW (Rembiałkowska, 2000, 2006), as well as in other European countries (Bavec and Bavec, 2006; Dasko et al., 2006; Willer Yussefi, 2004) show that organic food contains fewer nitrates and pesticide residues than products from conventional agriculture. The same authors emphasise that this is not clear that the samples of organic foods are always better than the food from conventional farming. This view is also supported by Gawrońska - Kulesza citing the results of research conducted during the 90s. (Gawrońska-Kulesza, Leart, 2004). Ensuring food safety is not only through the control of the production process which takes place at organic farms but also through the control of foodstuffs in accordance with applicable regulations.

Ecological awareness of consumers in Poland

Consumer research conducted in Poland after the year 2000 showed that half of respondents did not know the meaning of the term 'organic food'. They either never came across this particular word or defined that word incorrectly. The other half of respondents shown familiarity with organic food but only 23% were actual consumers of that food (Pilarski, Grzybowska, 2002, Kucińska 2009). Research conducted by Żakowska - Biemans (2004) and Kucinska (2009) showed that the term 'organic food' is already known to more than 70% of respondents but some of them, about 30%, are still defining it incorrectly.

Consumers of organic foods are dominated by people aged 45 (account for 57% of respondents) and those between the ages of 46 - 65 years (31%). An important factor in the context of purchasing organic food is also gender. The research work of Łaguna and Żuchowski (Łaguna, Żuchowski, 2000) showed that women constitute 63% of all customers.

Consumers of organic food are mainly people who have graduated from high schools or universities. The buyers of organic products mostly live in cities with more than 100000 citizens. They usually have small families (approximately 2 persons) and are mainly office workers, managers, students or professionals. Economic status of consumers of organic food products is described as good.

Consumers consider the following features of organic products to be important: healthy nutritious, nice flavour, appropriate colour, freshness and naturalness (for appearance and shelf life) (Kucińska 2009, Pilarski and Grzybowska 2002).

Most Poles are buying organic products in specialized stores. Others are buying directly from farmers (at the farm, at the marketplace or at the grocery retail network) (Pilarski and Grzybowska, 2002). Organic foodstuffs are purchased each day by approximately 8.2% of respondents, 41.1% - once a week, 23.3% - once a month and 27.4% - less than once a month (Pałasz, 2003).

According to Kucińska (2009) and Pilarski and Grzybowska (2002), people familiar with the term "organic food", but not consuming it, were not buying the products for the following reasons: too small selection, too high prices, difficult access to sales, lack of confidence in the control system and labeling.

Ongoing research (Zakowska-Biemans, 2005) revealed three main reasons for the lack of interest in buying organic food: the availability of organic foods, the availability of information about this kind of food and places to sell it, and too high prices for organic food, which significantly affects the reduction of consumer interest in this type of product.

Legislation in relation to organic farming

In order to protect the rights of consumers interested in organic food and organic farmers from unfair competition clear and uniform standards regulating organic farming were established (Gutkowska and Zakowska-Biemans, 2002). The dynamic development of organic farming in the whole world and consequently the appearance of the risk of introduction to the trade of false organic products has created the need for standards to regulate the production, inspection and labelling of food produced organically (Wicker, 2003). The most important role in creating the legal framework for organic farming was played by the International Federation of Organic Agriculture Movements – IFOAM. The activities of IFOAM became the starting point for international legislation on organic food (Krupińska and Molenda 2001). In European countries, such as Britain, Denmark, Austria, Sweden, Switzerland, the association of organic farmers set up their own systems of standards and labelling of organic products long before government regulations came into force. The labels were widely recognized and the consumers trusted them which is one of the reasons for the current buoyant market for organic products in those countries (Willer and Yussefi, 2004).

Regulations in relation to organic farming in the European Union and in Poland

The highest-ranking legal act on organic agriculture in the current European Union are two major regulations and several complementary regulations. The basic regulations are *Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91) (EC,2007)* and *Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control. (EC, 2008).*

This regulation applies to anyone who is involved in production, preparation and distribution of live or unprocessed agricultural products, processed agricultural products intended for human consumption, animal feed, vegetative propagating material and seeds for cultivation and yeast. It states that hunting and fishing of wild animals shall not be considered as organic production. The above regulations are a "cap " to other legislations already in force in this area. Therefore, the rules need to comply with organic agriculture rules, basic, general and additional ecological rules.

The regulation came into force as a result of earlier reforms of the Common Agricultural Policy (CAP). By the end of the 1980s the earlier point of agricultural policy was introduced which was to generate productivity of agriculture and to ensure self sufficiency of the European Community in food production. The intensification of agriculture based on the existing system of intervention in the agricultural market of the Community has led to a problem of surplus production. This in turn necessitated further reforms such as promotion, food quality as well as integration of environmental protection with agriculture (Guillou and Scharpé, 2000).

This regulation must be implemented immediately in its entirety using the powers of the national law in each EU country. This also applies to all laws supplementing and expanding the original regulation (Velimorov et al., 1992).

The growing interest in organic farming policy and consumption in Poland caused a need for state regulation. After two attempts of trying to impose a law on organic farming in the years 2001 and 2003 there is now in force the Act of 25 June 2009 on organic farming (OJ 2009, No. 116, item. 975), (http://dokumenty.rcl.gov.pl/items.jsp?id=396). This Act is supported by the Act of 24 October 2008 which amends the Law on commercial quality of agri-food and certain other laws. This is due to Agricultural and Food Quality Inspection (IJHARS) acting as a supervisor of organic farming in Poland.

Prospects for the development of organic agriculture in Poland

Organic production constitutes an enormous chance for the development of numerous medium and smaller, non-specialised farms. Various conditions, such as the type of climate, the type of soil, social and economic conditions mean that agricultural production in many Polish regions is close to organic anyway. However, the need for financial, educational and organisational support for organic production as well as improvement in the organisation of the distribution of organic products is evident.

Education on organic farming

According to Runowski (1996), Lampkin (2002) and Caporali (2004) one of the major factors determining the development of organic farming is the propagation of knowledge on this agricultural system among consumers, producers and adolescents. For a number of years people from big cities are distancing themselves from nature. This situation leads to disappearance of the tight connection between human being and nature which in turn causes lack of understanding and sensitivity to the natural environment. Most European countries have introduced special educational programmes in schools to re-establish those links. In Poland projects for raising environmental awareness of children and adolescents are being realised (Runowski, 1996).

Referring to Lampkin (2002), Caporali (2004) and Runowski (1996) dealing with organic farming requires a wide knowledge on the following factors: environmental changes, varieties of animal breeds and plants, standards and law regulations, selling and effectively promoting organic foods, etc. Moreover, the theoretical knowledge needs to be supported by practical applications. Regarding Runowski, only the interrelation of traditional knowledge and science makes it possible for organic farming to develop and to achieve its goals (Runowski, 1996). Therefore, in many European countries in addition to numerous specialist training sessions for farmers there are also university programmes available on organic farming. Thanks to the European exchange programme Socrates-Erasmus (www.sggw.waw.pl) the students from Poland (e.g. from Warsaw University of Life Sciences have the opportunity to study organic agriculture at many foreign universities for instance in Denmark (University of Copenhagen), Germany (Kassel University), Italy (University of Torino oraz University of Viterbo), Great Britain (University of Aberystwyth), France (ISARA), the Netherlands (Wageningen Agricultural University), Finland (University of Mikkeli) or Slovenia (University of Maribor).

In Poland the studies on the level of education of organic farmers are carried out by Kucińska (2007, 2009, 2010) and Runowski (1996). On the basis of the results of this research it can be concluded that the organic farms are managed by relatively young people (the average age of the farmer was 41 years old) with higher than average educational level within agriculture. The respondent organic farmers have graduated from secondary schools and universities more often than the conventional farmers, but they did not necessarily study subjects connected with agricultural science. The majority of farmers have long experience in managing the farm, though in the case of managers of organic farms, the length of experience is slightly shorter than for conventional farmers (Kucińska et al., 2009).

Labelling in organic farming

Organic farming could not have existed without appropriate, legally regulated labelling of products, which allows consumers to distinguish them from many others products on the market. The special logo is a sign of guarantee for the consumer that the product has a high quality and fulfils all the requirements pointed out in the regularions. The legislation ensures that the special labelling cannot be applied to the products not meeting the standards and can lead to the prosecution of any farmer or processor who uses the logo illegally to take advantage of it, for instance to receive a higher price for their product (Michelsen, 2001; Pades at al., 2002; www.ekoland.org.pl).

Despite the fact that the logo guarantees the required quality, in some situations it may not be helpful in the development of organic farming but instead it may become an obstacle because in the past certification bodies and other organisations have introduced their own logos. Therefore, the multitude of labels and also certification programmes may have contributed to the slowdown in trade of organic products. The new organic production logo of the European Union is an official one since the publication of the Regulation (EU) No 271/2010 of 24 March 2010 in Official Journal of EU dated 31 March 2010. The logo symbolises the marriage of Europe (the stars derived from the European flag) and Nature (the stylized leaf and the green colour) (ec.europa.eu, 2011b).

Certification and accreditation system in organic farming

A well-designed certification system ensures the reliability of products and builds the consumer confidence.

According to “Notices From Member States No 2009/C 72/04” concerning list of bodies or public authorities charge of inspection provided for in article 15 or regulation (EEC) No 2092/91 published in the Official Journal of the European Union on 26th of March 2009, the systems made operational in each of the Member States are indicated as follows:

A: System of approved private inspection bodies

B: System of (a) designated public inspection authority(ies)

C: System of designated public inspection authority and approved private inspection bodies.

In Poland the third option with 10 units accredited to carry out inspection and certification of organic farms is obligatory.

The system of controlling organic farming is as follows:

Country	Type of system
Austria, Belgium, Bulgaria, Cyprus, Czech Republic, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Portugal, Romania, Slovakia, Slovenia, Sweden, United Kingdom	A
Denmark, Estonia, Finland, Latvia, the Netherlands	B
Luxembourg, Malta, Poland, Spain	C

Prepared by ec.europa.eu, 2011 a.

Regardless of the control system in each country, each Member State should respect the requirements of the European standard EN 45011 with regards to all individuals performing the audit (ec.europa.eu, 2010).

Continuance or the introduction of financial assistance to the certification expenses, which the farmers have to cover, is extremely relevant for the future of organic agriculture. The studies carried out in Denmark and Great Britain (Michelsen, 2001; Pades at al., 2002) have shown that the subsidy encourages producers who want to convert their production system on their farm from conventional to organic. hat the relationship between accreditation and certification bodies has significance for the organic farming system. What is relevant is not only the supervision, but also the close cooperation between these entities because it reduces cost and avoids unnecessary bureaucracy. The cooperation between the bodies also improves the quality and effectiveness of the certification and inspection system (Rundgren, 2000; Michelsen, 2001; Pades at al., 2002).

The work in the area of control creates the best possible robust system. It is also important that the inspection and certification system is not overloaded with unnecessary bureaucracy (Willer and Yussefi, 2004).

Role of financial support for organic farming

Many authors agreed that financial support is indispensable especially during the conversion of the production system on the farm. At that time, the farmers bear a considerable financial outlay on the introduction of organic production methods (adjustment to the requirements of the Act) which is accompanied by, among others, reduced crop yields and augmented expenses and labour costs. At the same time, the farmers cannot sell their products as organic and obtain a higher price for them (they do have the possibility of labelleling their products as "during a conversion period"). Financial support in a further phase is also very crucial because it allows the farmer to develop themself and to improve the farm. Support also means safety. Farmers are more eager to experiment and to convert their farms in the knowledge that they have adequate financial provision. However, the amount of financial support must be reasonably calculated to ensure that there will not be an excess of supply on demand leading to organic food surpluses and falling prices and, in this situation, the farmers themselves lose out (Rudgren, 2000; Kucińska and Golba, 2007; Kuś, Jończyk, 2007; Kucińska et al., 2009; Kucińska, Staroszczyk, 2010; Kucińska, Brzezina, 2010).

Conclusion

To conclude it should be ascertained that organic farming plays a vital role in achieving the idea of sustainable development and implementation of national environmental policy objectives including the fulfilment of Polish international obligations. It is worth to emphasise that introduction of organic farming system, especially in regions with low degree of industrialization aids organic production. As claimed by Szymona, the increase in the number of organic farms in Poland is too slow (Szymona 2006). However, organic farming has the potential to become a significant part in the development of Polish agriculture. For that reason it is desirable that the area of organic farms is increased to a average EU level. Constantly growing demand for organic products in the EU and in ather countries, mainly in the USA, is an evident prospect for the progress of organic food industry in Poland. The production of this type of foodstuff will be the most profitable export in the direction of Polish agricultural products to the EU (Komorowska, 2006; Szymona, 2006).

Legal regulations in force in Poland are sufficient for the development of organic agriculture. The most significant issues are as follows:

- lack of a well-organized distribution system for organic food
- insufficient efforts at the level of provinces have been taken in order to increase the demand for organic food
- lack of knowledge about organic food among consumers
- high prices of organic food.

Summary

In Poland the development of organic agriculture is dynamic; however, the total area of organic farms has just exceeded 3,3% which is less than average in other countries of the European Union. Research suggests that the main obstacles

to the development of organic farming are the shortage of properly educated consumers, the lack of an efficient distribution system for organic products in Poland and abroad and too high prices of organic food. Regulations established before and after joining the European Union, in spite of some shortcomings, are not a barrier for the development of organic farming.

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BIODIVERSITY AND CROP DIVERSITY: ITS ASSESSMENT AND IMPORTANCE IN DIFFERENT SCALES OF SUSTAINABLE FARMING SYSTEMS

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Abstract

A biodiversity decilne is a one of most important problems of present word. The paper is divided by trhree parts. The first is a short description of conception of biodiversity, their division and levels of description. The second treats piositive and negative impact of agriculture on biological diversity. The last mentioins a most common biostatistical devices used to description of biodiversity on different organization levels.

1. Biodiversity

1.1 Problems with biodiversity

One of most important problems of present word is a protection of biological diversity. The general consensus about importance of biodiversity from Earth and human race is undoubted. Moreover, negative impact of human civilization is strong proofed. Nevertheless this consensus, the terminus "biodiversity" is very imprecise. The most general definition says, that biodiversity is degree of variation of life forms (Hawksworth 1996, Soule & Wilcox 1980). For sake of a fractal nature of life (Brown et all 2001, West et all 2009) (complexity on a lot of organization levels and scales), biodiversity could be described on a few organization levels. We can find:

- Genetic diversity (interspecies). It's describe variation among specimens of singular species, both phenotypic and genotypic. (Campbell 2003)

- Species diversity. Most common interpretation of biodiversity, stated by number of species (or higher taxa) in habitat. Beyond a simple species number, it includes their abundance. Some ecologists, narrow the biodiversity to species diversity, presented as an combination of species number and relative abundance, down. (Krebs1997)

- Landscape diversity. It's describe a complexity of ecological landscape by variation of its forms. Mostly it's presented as proportion of different types of habitats in a landscape.

- Functional diversity. More complex than species diversity. It's include ecological function of organisms and connection between them.

The biodiversity (especially species diversity) could be consider on different scale. Quite good shown it a Whittaker's system of α-β-γ-diversity presented in table 1 (Whittaker et all. 2001) . But we need remember, that the units are only symbolic. There are any natural borders between them.

Table 1. Whittaker's system of α-β-γ-diversity.

Level	Diversity	
	inside	between
Ecosystem (habitat)	α	β
Landscape	γ	δ
Biome	ε	ζ

Source: Whittaker et all. 2001, modified

1.2 Role of biodiversity

Biodiversity plays a key role for nature and human population. It is strongly related to ecosystem productivity (Yachi & Loreau 1999) and stability (Tillman 1996, Tillman et all. 1998, McCann 2000). A quality of ecosystem is connected with it stress resistance. On a population level, genetic variability decreases probability of species extinction. (Newman & Pilson 1997)

For human population and economics, biodiversity have too significant meaning. First of all, diverse, undisturbed ecosystems have a large potential to absorption of pollution and carbon dioxide (Wehrmeyera & Tyteca 2009). It links directly with human's healthy. Another important role of nature is a source of different goods and materials. It belongs to remember, that only a few part of wild organisms is yet investigated. It is estimated , that only about 10% species has a scientific name (May & Beverton 1990). Biodiversity has esthetic, cultural and ethic value too.

Role of biodiversity in agriculture requires special note.

1.3 Human impact on biodiversity.

The human populations render a drastically negative impact on a biodiversity. It is evaluated, that species extinction rate is 100 to 1000 times higher as in pre-human rate(Pimm et all. 1995). On the rate of tropical rainforest deforestation it is estimated, that up to 30 % of existing species could be extinct since 2010 (Chapin at all. 2000, Pimm & Raven 2000).

Biodiversity decrease by following ways:

- Overexploitation. It is a direct reason to extinction or decreasing of abundance some economically important species. Probably the first victims was a members of megafauna extincted after last ice age (Burney & Flannery 2005).
- Habitat destruction. Probably the most common recent reason of global extinction. It's an effect of land use changing. Natural habitats are replaced by agrocenosis or buildings. The fig.1 shows changes of land use in last 300 years. The number of species is a simple function of area occupied by their habitat (Connor & McCoy 1979).
- Invasive and introduced species. Especially habitats with high level of endemism are vulnerable on species invasion. One of spectacular example is introduction of nile perch (*Lates niloticus*) I to Victoria Lake. After them, number of species of endemit *Haplochtominae* cichlids decreases about 80% and biomass about 90% (Witte at all. 1991).
- Environment pollution.
- Climate change.
- Food web destroying. Extinction of one species, that fulfilled a important role in ecosystem involves disappearing of species linked with them (Koh 2004).

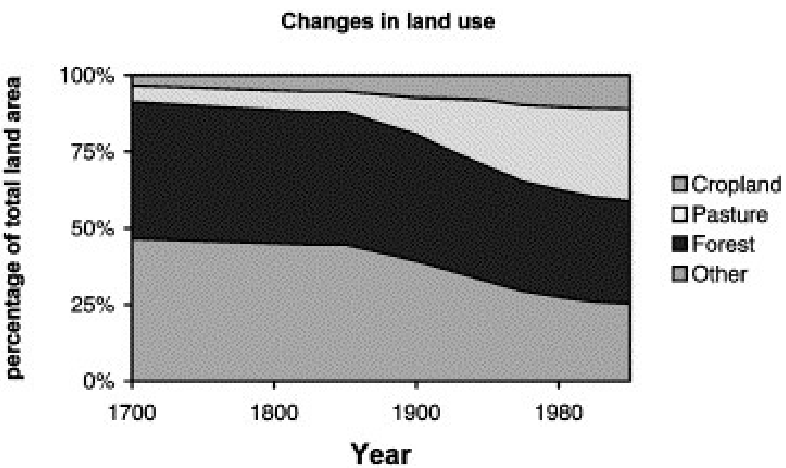

Fig. 1. Estimated changes in land use from 1700 to 1995
Source: Lambin at all. 2001

2. Impact of agriculture on biodiversity.

2.1 Agriculture as a specific biomanipulation

From ecological point of view, we can consider agriculture on specific form of a specific way of ecosystem's manipulation. The natural habitats are actively transforming into a specific ecosystem type named agrocenosis. They are fully controlled by human and regulated to maximizing yield. Agrocenosis have some characteristic attributes (Altieri 1999, Connor et all. 2011):

- Species diversity is extremely decreased. Whole ecosystem is managed to maximal growth of one (or a few) crop species.
- The abundance of the attendant species is reduced by different manipulations including direct extermination (pest and weed control).
- Food webs are maximally simplified. Consuments (or high order consuments by animal production) are eliminated.
- A matter turnover in ecosystem is open. From one side a large part of organic matter is removed from agrocenosis (as a yield). Other side the lacks are compensate by fertilization.
- In general, a crop species and a part of according species are not native in local landscape.

Due to scale, agriculture is one from most of important factor of anthrpopressure (human impact).

2.2 Negative impact.

The simplest negative impact of agriculture in nature and biodiversity consist in destroying of natural habitats by replacement of agrocenosis. In 2000 year about 1,5 billions hectares of ice-free land was used as cropland and about 3 billions hectares as a pastures (Rudel et all. 2009).

Additionally, recently changes in a farming systems are strictly connected with decreasing biodiversity of agrocenosis. The intensive methods of weeds and pests control provides to decreasing of abundance of the most species (Tscharntke 2005).

Otherwise we can observe decreasing of genetic variability of crop species. The local cultivars are replaced by a lot of patented (Di Falco & Chavas 2006).

The indirect negative impact of agriculture consist on migration of chemicals to natural habitats. The chemicals used in agriculture we can divide on to two groups: fertilizers and pest controllers (Geiger et all 2010, Simon et all 2009). Extremely danger is an effect of eutrophication of water bodies and pit bogs by excess of fertilizers (mainly nitrogen and phosphorus) eluded from crop fields. The indirect negative impact of agriculture consists on migration of chemicals to natural habitats. The chemicals used in agriculture we can divide on to two groups: fertilizers and pest controllers (Geiger et all 2010, Simon et all 2009). Extremely danger is an effect of eutrophication of water bodies and pit bogs by excess of fertilizers (mainly nitrogen and phosphorus) eluded from crop fields. (Smith et all. 1999).

Effect of pest control is the most intensive directly in to agroecosystems. Diversity of crop attendant species is strongly negative correlated with number of field manipulations. Species number decreasing is significant both in pest or weeds groups and neutral or eligible species (McLaughlin and Mineau 1995, Filippi-Codaccioni et al. 2010).

2.3 Positive impact.

The most important positive impact of agriculturae on a biodiversity consist on a increasing a landscape diversity (Benton et all. 2003). Agrocenosis are completely new habitats, connected with a new species (Duelli and Obirst 2003).

Extremely important role on biodiversity increasing plays low intensity farming systems with permanent crops or semi-natural pastures. For example, in western part of Europe natural grassland habitats are absent except some alpine meadows. All these species-rich ecosystems are created by recent or past animals pasturage (McDonald et all. 2000, Klimkowska et all. 2007). Another example are orchards with semi-natural understory vegetation like Mediterranean olive plantations.

Non-cropfield elements as borders, shrubs, wetlands or water bodies plays very important role ob biodiversity. They increases significantly landscape diversity. Except them, they could be a ecological island or refugees for many group of species. Role this kind of landscape elements could be not overestimated (Dauber et al 2003, Hendricks et all 2007).

3. Role of biometry.

The important role of biometry by investigation of impact of agriclutarae on biodiversity consist on measuring of biodiversity. Because of imprecisely definition and multi-level nature, describing of biodiversity demands a developing a lot of measures.

3.1 Species diversity.

The most known level of biodiversity. The simplest way to describe a species diversity is a species number. By simple comparison we can evaluate species loss on a defined area. An interesting method to evaluate potential species loss is using a Species – Area Relationship (He & Legendre 1996). This is an exponential relation describing a species number on a given area. When we draft these relationship, we can calculate species loss after destroying a particular part of natural habitat, for example by replacing it on an arable land. Most known are these calculations for deforestration of tropical rainforests (Whitmore & Sayer 1992, Plotkin at all. 2000).

But species diversity is not only a species number. The extinction of species is prelude by decreasing of abundance. To evaluate these processes we need more developed measures of species diversity (Krebs 1989). The most known are diversity indices, witch combine species number and a relative abundance. In ecology, most popular are two: Shannon – Wiener index (Shannon 1948) and Simpson index (Simpson 1949). Recently, their usefulness in ecology is discussed, but there are still widely employed because of a simplicity (Ulrich 1999) . Another advantage consist on a possibility to use their to measure a diversity of different units. That's mean, we can use the same formulas to calculate biodiversity on different levels. We must noticed here, that Shannon Index wasn't developed for ecology but adapted from mathematical theory of information.

$$H' = \sum_{i=1}^{n} p_i \ln p_i \qquad D = \sum_{i=1}^{n} p_i^{\,2} \qquad p_i = \frac{n_i}{N}$$

Where:

p_i – proportion (relative abundance) of i-th species

n_i – individuals number of i-th species

N – number of all individuals (all species)

The more involved methods to describing a species diversity based on a Relative Abundance Distributions still waiting on wide adaptation.

Recently, for EU environment policy was developed an index to measure biodiversity decreasing: Abundance Species Loss. It is very simple to calculate but need more theoretical background.

3.2. Genetic diversity.

The known problem is a decreasing a crop diversity. To describe it, we can use two ways. The first is a simpler. We can treat a cultivars as a species and use this same methods as by species diversity. It is possible to operate of cultivar numbers and Shannon or Simpson index. The fundamental disadvantage of these way re problems with definition and description a cultivars.

The second way is using methods known from population genetics (Nei 1978).

3.3 Landscape diversity.

Very important biodiversity level by debate on influence of agriculture is a landscape diversity. On this level we can observe some positive aspects of this kind of human activities. (Farino 1998). A special form of landscape diversity is a agriculture land use diversity or crop species diversity. It concentrate only on agrocenosis and it could be expressed by Shannon or Simpson index calculated on area of different crops (or another agriculture land uses like grasslands, woods, fishponds or wastelands). It could be calculated on single farm level or on administrate unit level (Gozdowski et all. 2008, Jaskulski & Jaskulska 2011).

3.4. Functional diversity.

A base for analyzing a functional diversity is a describing of wood web or interaction web. To this aim, we need recognize and evaluate power off all ecological interactions between species inhabiting an ecosystem. Often, except individual species, are investigated a guilds or another group of similar species. The foot web analysis based on mathematical graph theory (Bersier et all 2002, Sugihara et all. 1989, Thompson & Townsed 2005).

We can compare proportion of edges (interactions) to nods (species), number of edges, nods, find nods with extremely large number of species (key species) and extremely few (specialist). Moreover, the food web is divided onto a trophic levels. It enables to analyze a food chain lengths and share of multilevel species (omnivores).

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Voice of practice

AFFECT LONGEVITY BY BREEDING!
WHAT MATTERS ARE THE RIGHT GENES!

Postler G.

(translation from German – Irmina Pelc)

But what are the right genes? And how can you breed them? What does the farmer, the breeder want anyway?

According to surveys among practitioners, they generally desire an unproblematic, productive, long living cow. However, the breeding went far away from this desire in recent decades. How did that happen?

Breeding is a very old cultural achievement of the mankind. After millions of years of natural selection of the nature, in the frame of evolution, our ancestors began to domesticate wild animals. This domestication began with the oldest domestic animal species around 16,000 years ago. An intense selection took place in the classical animal breeding within the last two centuries and in the recent decades these efforts were accelerated by bioengineering. The era of one-sided breeding on high productivity begun.

Efficiency at any price has, of course, its price.

In the case of animal breeding the consideration of the efficiency improvement relativize itself when considering high productive animals from 1870 till 1900, which already during the grazing season with exclusive grass-feeding gave 30-35 kg daily milk yield and were capable with additional feeding to achieve 45-50 kg. The responsible genetics at that time was already there. What would make these cows comfortable with the current feeding and care? A major difference is in any case, what is now called the productive lifespan. Our ancestors would shake their heads in disbelief learning that the average life of the West German cow is 2.7 years.

20% of the cows end their life at the butcher, because of sterility and infertility, about 15% due to udder diseases and about 10% on account of claw and limb disorders. On the basis of an "animal husbandry" decision less than 20% of cattle have to leave the farms. All other exits are due to illnesses and they are often assisted by shorter or longer time of problems and costs.

This productive lifespan of 2.7 years has a significant impact on the profitability of dairy farming:

1.On average, resulting from the short period of use a total lifetime production of dairy cows turns out by about 15,000 to 18,000 kg of milk. The average age at first calving is about 30 months and results in rearing costs of approximately 1.300 € to 1.400 €. This must be apportioned to the overall lifetime production, and therefore, it affects each liter of milk very strongly. Doubling the average lifetime production to over 30,000 kg of milk has led to a decrease by half of the cost burden on the part of the rearing costs.

2. Productive lifespan of 2.7 years means only about 2,7 calves per cow and life. So on the female side stays only about 1,3 heifers, which have to replace their mother after her short life. Therefore, a selection on the female side can hardly be still held.

Fig 1: Tyrol Grey Cattle Family

The breeding of cow families is still more disappearing in the background, and together with it the peasant-oriented farming. The breeder allows the breeding to be taken out of his hand. Everything is focused on bull selection. It is said that "the bull is the half of the herd". However, at least the other half are the cow families on the farm of the breeder. The breeders know everything about these cows, they can estimate them, they know those with whom they would like to continue breeding. In contrast, what do they know about a bull from a glossy catalogue?

The one-sided high productivity breeding has also other implications. What has to be accounted for on the side of the efforts and costs, if one wants to provide these high-productive animals with adequate treatment and care, are still increasing costs of concentrated fodder, rising costs of treatment as well as the high management expenses. It does not go any longer without this intensive care, otherwise animal welfare would not be fulfilled in case of many animals. In recent decades, animal breeding in combination with feeding has also led to changes in the body of cows – they have become significantly larger and heavier. Therefore, many animals do not fit any longer in the stables which are 30 years and older, which in turn leads to an increased culling rate among cows. Cows with body weight of 900 kg and more are not uncommon. By the productivity comparison with lighter cows they do not show off better in terms of kg milk per kg of body mass. The pure milk yield without additional key data says relatively little about the economics of a farm and should always be seen in relation to what was said above.

What should be changed in this situation? How does the natural cattle management look like?

Criteria of nature-friendly breeding:

a) breeding objectives in the sense of natural laws, evolutionary relationships

b) selecting stable constitution as a basis for each special productivity

c) compliance with biologically functional relationships

d) taking into account positive and negative characteristics between relationships

e) consideration of genotype-environment interactions

f) improving the health, productive lifespan and lifetime production

Nature always selects in terms of maximum abilities to survive on the basis of a good constitution and adaptability. This guarantees that an organism can maintain itself and through the reproduction it contributes to the survival of the species. A stable constitution (health and fitness) describes the so-called secondary characteristics, to which for a long time science referred to as "for breeding not workable", because they have a low heritability (heredity). As a result of total exclusion of breeding of these traits from all breeding programs, they were completely neglected. This neglect led over the past years and decades to the continuous deterioration of cow’s constitution and overwhelmed animals in terms of their productivity. As a consequence, many cows leave the herd to an increasing extent, because of disorders in these secondary characteristics (fertility, udder health, hoof health, etc.). If for example VW had improved over the past 40 years the engine of the VW Beetle and had it “bred” from 34 hp to 200 hp, then nobody would be surprised when the transmission (metabolism) would fail or the wheels (claws) would fly off. Breeding must always consider the entire animal, including its environment. Manipulation in one place has always an impact on other features.

Cows are running animals, mammals and ruminants. These conditions must be taken into consideration in the keeping (cow barn with a run for running animals), feeding (feeding ruminant-oriented), and in the bill of the breeding.

Mammals are divided into male and female gender. This sexual dimorphism is genetically and hormonally determined. The excess of female sex hormones results in the formation of secondary female sexual characteristics, including reproduction and lactation. By an excess of male sex hormones, it is typical for a male skeletal figure to have larger and stronger muscles. Breeding and selection of the cows producing a lot of milk achieves in the same time well-muscled bulls.

The opposite happens when the error is made by selecting bull with the "dairy character", who embodies a female type. The hormonal uniqueness is in this way violated. A similar situation occurs when an attempt to unite in the female milk and meat in the form of exaggerated male musculature.

The cow is a mammal: milk from cows, meat from her sons!

If this relationship is not respected, then it leads to a hormonal shift. As a result, strong muscles appear in those parts of a cow body where they are less desirable e.g. strong musculature inside the thigh, which pushes the udder down and causes the damage to the udder and the udder suspension. The simultaneous deficiency of female hormones causes poor widening of the cervix (estrogens) and weakened travails (oxytocin) and as a consequence to difficult delivery. All in all, it leads to poorer fertility.

The function determines the shape!

Formalistic ideas towards the exterior lead, if they are not affiliated with functional biological contexts, to false assessments and thus disadvantage individuals and species.

Functionally, a slightly bowed back line with pronounced sacrum and tail ensures a swing back line of the spine during walking and running, which spreads forces between forehand and backhand.

A non-functional back line through the position of the back limb loads additionally a claw. This false load leads to a false non-physiological claw abrasion on the balls, which manifests itself sooner or later in hooves problems. The cow puts the most weight on the claws' walls, and thus uses off the weight-bearing edge more strongly than the balls. The wall of the claw is harder and grows faster, resulting in a physiological deterioration. This functionality has been selected by evolution over millions of years and led among wild animals to a perfect interplay between deterioration and re-growth.

The exterior should be better taken into account only there, where a biologically positive relation to life and productivity of the animal is considered together with relationships between characteristics and natural ability to function.

The high lifetime production as the basis of breeding

High lifetime production is the foundation of dairy cattle breeding and the result of a long, productive life. Cows, which have achieved a high lifetime production, must stay healthy, fertile, metabolically stable, strong in production and unproblematic (with good character).

Such animals are usually not very conspicuous. They do not usually show very high productivity in their first lactations. They are late mature. They increase their production according to their capacity without showing overwhelming efficiency as they are still growing, and thus building their ability of a higher forage intake. Finally, the breeder is surprised about that cow that was so unremarkable, but now stands in her sixth lactation, has always taken well up and her production is correct. In terms of breeding, it is interesting for a breeder to identify that even her mother, grandmother and side relatives have been reported on the high lifetime production.

Table 1. Example of the cow with a good increase of production and high productivity over the lactations. This cow was always unproblematic and earned her place in the barn multiply (ADR, 2009).

Beispiel für eine Kuh mit guter Leistungssteigerung und hoher Leistung über viele Laktationen.
Diese Kuh war immer problemlos und hat sich ihren Stallplatz mehrfach verdient.

1. Laktation	5.938	200	3,37	184	3,09
2. Laktation	7.529	247	3,29	236	3,13
3. Laktation	10.124	330	3,26	308	3,04
4. Laktation	10.167	354	3,48	299	2,94
5. Laktation	10.910	394	3,62	328	3,01
6. Laktation	9.764	369	3,78	329	3,37
7. Laktation	11.450	412	3,62	349	3,05
8. Laktation	10.878	375	3,45	322	2,96
9. Laktation	10.509	352	3,35	308	2,93
10. Laktation	11.275	392	3,48	339	3,01
11. Laktation	11.065	415	3,75	338	3,05
Durchschnittsleistung: 11/12,5	**9.746**	**342**	**3,51**	**299**	**3,07**
Lebensleistung:	**122.641**	**4.302**	**3,51**	**3.769**	**3,07**

Abb. 38:
Salome, geb: 01.10.1981
V: Templin
Züchter: Anton Demmel

A successful breeding on lifetime production requires the frequent occurrence of high lifetime productions within cow families as a criterion of a high probability of inheritance of this feature. The related animals of such families (lines) are not mated between each other in order to reach high probability of "functional homozygote" with hereditary factors from both parents. This leads to a corresponding characteristic development (good constitution, health, fertility, readiness for the long time production) and means that a cow from an appropriate lifetime production family must be mated with a bull from a different lifetime production family so that both positive sides are united in their descendants!

In the breeding program of the "Working Group on Cattle Breeding for Lifetime Production" (*ger. Arbeitsgemeinschaft für Rinderzucht auf Lebensleistung*) three lines (now in between additional new lines of lifetime production), in which very high lifetime production occur, are bred in the form of line rotation with each other. In this method of mating the dreaded effects of inbreeding reach no dangerous levels, and the security of inheritance is improved from generation to generation.

The basics of cattle breeding on lifetime production are applicable not only for all breeds of cattle but also for other farm animals.

Advantages of a longer period of use and lifetime production:

1. Better selection intensity by more offspring;

2. Reducing costs of herd renewal;

3. Because of lower rearing costs lower production cost per liter;

4. Adult cows have a higher fodder intake capacity and produce at their optimum possibilities;5. A grown herd structure is achieved, when it consists of approximately 1/3 youths, 1/3 medium and 1/3 older animals;

6. Fewer cows must be replaced annually, therefore, there are less hierarchy fights, the herd is stable, therefore quiet, which is especially a big advantage for herds of horned animals;

7. Reduced veterinary costs by animals of strong constitution;

8. Increase of the company's profit margin per cow by rising to ninth lactation.

The table clearly shows an increase in profit till the ninth lactation, with simultaneous and continuous efficiency improvement. This means that most farms give away or lose the essential part of the profit due to the short productive lifespan, which is currently about 2.2 to 2.7 lactations (national, race-dependent average).

Table 2: Efficiency and Longevity (Gerstädt, 1996)

Lactation	Share% BRD*	Standard lactation kg Milk€/cow	DB**	Profit of the farm €/cow/lactation
1	32	6.299	1.307,-	164,-
2	24	6.650	1.541,-	228,-
4	11	7.077	1.705,-	372,-
5	7	7.193	1.751,-	415,-
6	4	7.261	1.813,-	475,-
7	2	7.304	1.845,-	493,-
8	1	7.315	1.862,-	512,-
9	0,6	7.326	1.870,-	535,-
10	0,5	7.292	1.831,-	563,-

Germany (Bundes Republik Deutschland) ** Gross margin

Finally, the possible impacts of increased production length on several factors will be demonstrated by a model calculation.

Effects:

1. A productive lifespan of 4,7 years means 38.500 kilograms more milk.

2. For the quota 5,6 cows less are kept.

3. The productive lifespan of 4,7 instead of 2,5 years gives 770 kg more milk yield per animal per year.

4. The productive lifespan of 4,7 results in double lifetime production of 32.454 kg.

Overall, an improvement in the productive lifespan and lifetime production means substantial increase in profitability!

Overview

Meanwhile, there is hardly a breeding organization that talk about lifetime production and productive lifespan. The implementation on closer examination is left on the side of wishes as in the foreground still stands the high production achieved with great effort, which often do not seem to understand the relationships.

In German-speaking countries Arbeitsgemeinschaft für Rinderzucht auf Lebensleistung – ("Working Group on Cattle Breeding for Lifetime Production") was founded over 28 years ago. Together with some sister organizations they consistently and successfully apply this breeding approach. The Stanisław Karłowski Foundation and its farm in Juchowo, are the part of the Working Group. The two basic herds of HF and Brown Swiss created there are selected according to long lifetime production and long productive lifespan. This is the only situation in the world, where the two lifetime production herds can be developed and observed in the same conditions and scientifically examined.

Table 3: Model calculation for the period of use and herd average production (Postler, 2002)
Assumption: a) milk quota of 300,000 kg with 50 cows,
b) efficiency improvement from lactation to lactation,
c) first lactation production 5.500 kg,

Lactation	Production	2,5 J ND*	3,15 J ND	4,7 J ND
1	5.500	40 % (20 cows)	25 % (12,5 cows)	15 %
2	6.000	20 % (10 cows)	20 %	15 %
3	6.400	15 % (7,5 cows)	15 %	10 %
4	6.800	10 % (5 cows)	15 %	10 %
5	7.200	10 % (5 cows)	10 %	10 %
6	7.500	5 % (2,5 cows)	10 %	10 %
7	7.800		5 %	10 %
8	8.000			10 %
9	8.000			5 %
10	8.000			5 %
Total production		306.750 kg	320.750 kg	345.250 kg
Avarage cow/year		**6.135 kg**	**6.415 kg**	**6.905 kg**
Avarage LL/cow**		**15.338 kg**	**20.207 kg**	**32.454 kg**

* Productive lifespan
** Lifetime production

In the year 2000 a European Meeting on Lifetime Production took place during which criteria for the selection of lifetime production bulls were developed. It was decided to select bulls based on this set of criteria and issue a joint lifetime production bulls catalogue. The first bull catalogue appeared in October 2000 and it is updated regularly.

Through the project "Natural Service Bulls and Cow Families" the experiences of breeding on lifetime production were applied to the Simmentaler cattle (*ger. Fleckvieh*) and Brown cattle (*ger. Braunvieh*) and own breeding lines were selected and as a result a separate catalogue for lifetime production of Braun cattle and Simmentaler bulls was created.

The lifetime production bull catalogues are available to all interested breeders and can be purchased through the Arbeitsgemeinschaft für Rinderzucht auf Lebensleistung (“Working Group on Cattle Breeding for Lifetime Production"), or Forschungsinstitut für ökolgische Tierzucht und Landnutzung, FIT e.V. (“the Research Institute for Organic Animal Breeding and Land Use”).

To sum up, breeding for lifetime production is:

- ethically defensible
- ecologically sustainable
- economically successful

It makes breeding fun!

Arbeitsgemeinschaft
für Rinderzucht
auf Lebensleistung

FIT
FORSCHUNGSINSTITUT
für ökologische Tierzucht
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