Contribution of different farming and forage systems to biodiversity: an example in a PDO cheese area in French mountains.

Gueringer Alain, Orth Dominique, Balay Claire and Landre Fabrice

[a]UMR Métafort, Cemagref Clermont-Fd, alain.gueringer@cemagref.fr; orth@enitac.fr

Abstract: *The Protected Denominated Origin device (PDO) is often presented in France as a model for sustainable agriculture and biodiversity is more and more used to argue PDO device. This research analyzes the links between forage and farming systems, practices and biodiversity in the area of the PDO cheese St-Nectaire in the French Massif central. The specifications for this PDO cheese will change, especially for the feeding of dairy cows. These changes will probably lead to modifications of the stockbreeders' practices and perhaps influence the biodiversity of the PDO area. Our study wants to see which of the present systems would be efficient to provide biodiversity. A statistical analysis characterizes the forage systems of dairy farms in this area as regards their potential impact on biodiversity. Surveys in farms and assessments of floristic, faunistic and landscape diversity permit to evaluate the biodiversity in pastures. These data were used to compare different systems: extensive or intensive, organic or conventional, milk or cheese production systems. Results show that forage systems in the PDO area are more various than usually presented, that extensive and organic ones are generally more interesting for vegetation diversity and that there is no difference between milk or cheese systems. The practices related to the best systems for biodiversity are not really encouraged in the new PDO specification. Links between PDO device and biodiversity are not so obvious and the choices of farmers for future could improve or not their impact on biodiversity.*

Keywords: *Farming systems, Protected Denominated Origin, Forage system, Biodiversity, Pasture*

The question of links between PDO and biodiversity

The aim of the present analysis is to evaluate the biodiversity produced and used by different forage and farming systems on a PDO cheese area in Auvergne (France). It is part of an ongoing research studying how local actors adopt or not this stake of safeguarding the biodiversity, and convey it into actions (BIG-Diva project, part of Diva program "Agriculture, action publique et biodiversité" - French ministry of ecology). In this project, two PDO cheese areas are surveyed. This text presents the results for one, the Saint-Nectaire PDO.

The Protected Denominated Origin (PDO) device is one of the oldest and most important tool of the French policy for quality and origin of agricultural products. The links between the territory and the product, a specific quality, a supposed better distribution of the benefits, are often used to present it as a model for sustainable agriculture. For the justification of this device, new arguments appear: the part played by these official signs of quality as regards the conservation of the natural resources, the landscapes and the biodiversity (Sylvander et al, 2007; Boisvert et al, 2007). However, wild biodiversity is not yet clearly identified as an objective of the PDO device (Camou, 2008).

In such a device the characteristics of the territory are essential and contribute towards the characteristics and the typicity of the product. But PDO specifications are really different from one to the other, and they often concern different sides of biodiversity, more or less linked to the territory: animal breed, microbial diversity in cheese making (Berard et al, 2006)

In this study, we focused on grassland biodiversity. In natural meadows, the flora and the fauna diversity results from the forage practices (harvesting methods, grazing management, fertilisation, etc.) (Le Roux et al., 2009; Plantureux et al., 2005; Dumont et al., 2008). These practices depend on the feeding of the dairy cows which is often an important section of the PDO specifications. Besides, quality of the milk and of the cheese seems to be more or less linked to the flora diversity (Coulon et al, 2003. Martin et al, 2003). Some PDO cheese areas (Beaufort, Comté) are particularly aware of the interest of floristic biodiversity for their products and have begun conservation programs (Hauwy et al. 2005). Since 2007 "flowered meadows" competitions are created in these PDO cheese areas in collaboration with French *Parcs Naturels Régionaux*. In Auvergne, the 5 PDO cheese areas haven't yet followed this movement. Their specifications don't mention grassland biodiversity and include very few elements about forage practices. But the specifications are going to change and the impact of the dairy production on biodiversity could be modified.

Our work takes place in this context and we want to identify how far the present forage and farming systems are providing biodiversity in order to discuss the future specifications (ou evolution). . Linking biodiversity to PDO device suppose to know which practices are induced from the PDO specification and are implemented by farmers. So our aim was to characterise different practices systems, related to farming and forage systems, and to evaluate their impact on grassland biodiversity. On farming system, we especially focused on the difference between milk producers and cheese makers, and between organic and conventional farms.

The St-Nectaire PDO, an interesting case to study the links between PDO and biodiversity

The "Saint-Nectaire" is one of the 29 French PDO cheeses made with cow milk. It is produced on average mountains (from 800 to 1800 m elevation), in the French Massif-central. The area is totally included in a protected area, the French "Parc Naturel Régional des Volcans d'Auvergne".

In spite of an area among the smallest of France (1900 km²), it holds the 5th rank of PDO cheese for tonnage. To study the links between forage systems, practices and biodiversity, this PDO device is particularly interesting:

Figure 1. Localisation of the PDO area.

- The milk is mainly produced from natural grassland corresponding to various environments, and biodiversity is often used as a commercial argument. Until now, the PDO specification didn't state anything about harvesting methods and three forage systems are usually distinguished: the first one using hay only to feed the cows, the second one combining hay and wrapped balls, and the third one based on silage. The effects of different practices and of different practices sequences on natural herbaceous vegetation can be compared.

- Home made cheese is important in this area. There are about 900 dairy farms and about one third making cheese. 45% of total tonnage is made in farms by breeders. Our hypothesis was that cheese makers are more sensitive to biodiversity, as they are able to evaluate the effects of their forage practices on the cheese quality.

- Last years, with the climate change and to secure their fodder system most farmers decided to harvest earlier, and adopted wrapped balls. But the specifications for this PDO cheese will change: in particular, silage and wrapped balls will be removed and only dry feed will be allowed. Several points in this new PDO specification seems to favour sustainable farming system (forage self sufficiency, maximum level of fertilisation, hay suppose a later cut, etc.). Consequences on biodiversity may be more various. Anyway, these changes will lead to modifications of the stockbreeders' practices (Farruggia et al, 2009). Several will have difficulties to reconcile these different stakes

An approach combining different analysis scales

Combining different analysis scales, area, farm, plot, vegetation facies, our approach is based on the analysis of the forage systems, the practices of farmers, and the biodiversity in the meadows. Three kinds of data are used:

- Firstly a survey carried out in 2006 by the breeders' organisation with the new PDO specification coming up. The aim of this survey was to know how many farmers should have to change their farming system and to appreciate which difficulties the new specifications would raise to them. Each milk producer located in the area had been invited to describe his farming system. For a statistical analysis to characterize the different forage systems as regards their potential impact on biodiversity, we used 18 variables for 455 farms from this survey (Jean-Pierre, 2008).

- Secondly, surveys in dairy farms to add to the previous one. The objective was to specify the forage systems by analysis of the forage practices, their links with the livestock system and their local adaptation. Values at the scale of the system hide practices adaptations at the scale of the plots (Gueringer et al, 2009). We surveyed 20 farms, chosen in order to grasp the diversity of the farming systems: size, forage system (hay only 10 farms / hay and wrapped balls 7 farms / with silage 3 farms), milk delivery (12 farms) or cheese making (8 farms). In order to evaluate the hypothesis of a lower impact of their practices, we decided to survey all the organic dairy farms in the area (7 farms among which 3 cheese makers)

- A simplified assessment of floristic and faunistic diversity carried out on some of the surveyed farms' pastures. Each farmer was asked to choose three of his plots: two of them had to be typical of his dairy farming system (one only grazed and one mown) and the third one was selected for being the most diversified according to the farmer (grazed or mown meadow). The management of these three plots was precisely described during the survey. The method used to evaluate the biodiversity relies on field observations of landscape elements and simplified counting of flora and fauna (birds, butterflies and orthopterans) based on a physiognomic approach (Orth et al., 2008). The observations permit the calculation of several indicators which values were put in assessment grids. The flora diagnosis has to be done for each vegetation facies of a plot and differentiates the herbaceous vegetation diversity and the additional floristic diversity depending on landscape elements. The fauna diagnosis is carried out for each animal group at the plot scale but birds are only assessed for plots over 5 hectares and butterflies and orthopterans for plots under 5 hectares. The final diagnosis gives a diversity level for each of the five components which is a mark between one (low level) and five (high level) in reference to the regional biodiversity of grassland.

Overall results: forage system typology and biodiversity assessment

The results for the typology of the forage systems are presented above (figure 1). We distinguish 9 types of systems. The farms are gathered together according to the proportion of various harvesting methods in their forage system, their practices of fertilization, and the difference of intensity they introduce between mown plots and grazed plots in the management of their area.

These results show that combining different harvesting methods, dates of mowing, frequency of cuts, practices of fertilization, grazing management, the forage systems in the PDO area are more various than usually presented. The surveys in farms, thanks to more information on practices, on their adaptation to the different plots and their relation with the livestock, allow a sharper analysis. Looking at the farming system of the 20 farms surveyed, and only for mown areas, we take down 12 different crop sequences, by combination of the different cutting techniques in course of the year. Most farms combine only three, but some up to seven. It results more or less variety of dates of mowing and intensity of exploitation of the meadow for one farm

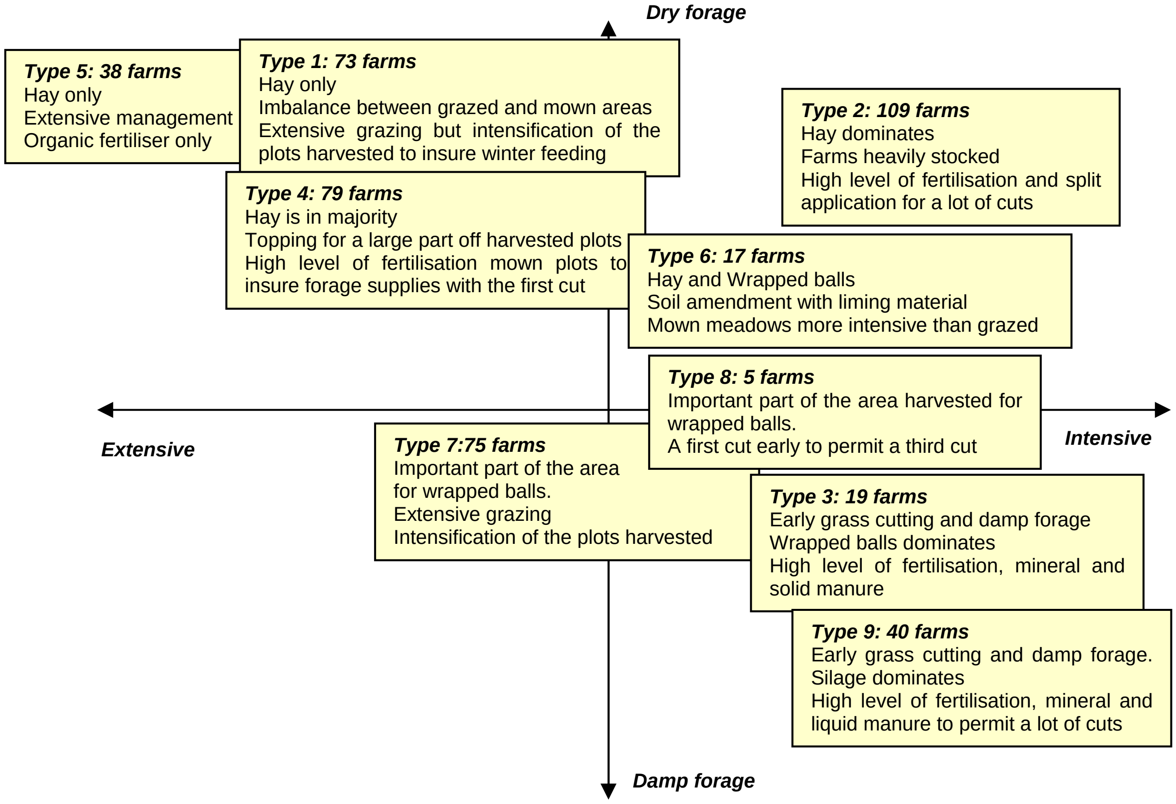

Figure 2. Typology of the forage systems.

Biodiversity was assessed on 58 plots from 1 to 20 hectares. The floristic diagnosis (landscape elements and herbaceous vegetation) was carried out on 75 vegetation facies as 16 plots had several facies. The fauna diversity was studied on 17 plots for the birds, 22 for the butterflies and 30 for the orthopterans because of the plots' size (over or under 5 ha) and the bad weather conditions in 2008 which needed complementary observations in 2009.

Global results (table 1) show first a high landscape diversity (4.6) for mostly all meadows with the best score for grazed pasture. The results for herbaceous vegetation are more heterogeneous and we have found a wide range of diversity levels leading to an average mark of 3.6 and to a better score for the mown meadows. This is partly due to the fact that farmers had mainly chosen a hay meadow as the most diversified plot of their system and this plot shows generally a higher diversity mark for herbaceous vegetation. Moreover, there is no silage plot in our sample and very few wrapped balls.

For the fauna we have found a lower average diversity than for flora with a score around the medium level for birds (2.8) and orthopterans (3.2) and a quite low level for the butterflies (2.3). The results for birds and butterflies are perhaps due to the cold temperatures of 2008. We can however notice that fauna diversity is always better for grazed plots (table 1).

Table.1. Biodiversity results on the whole sample.

	Number of facies or plots		Average diversity level		
	Mown	Grazed	Mown	Grazed	Whole
Flora-Landscape elements	42	33	4.3	4.9	4.6
Flora-Herbaceous vegetation	42	33	4.2	2.8	3.6
Fauna-Birds	8	9	2.1	3.4	2.8
Fauna-Butterflies	11	11	1.9	2.6	2.3
Fauna-Orthopterans	15	15	3.1	3.3	3.2

Diversity levels : 1(low), 2 (quite low), 3 (medium), 4 (quite high), 5 (high)

Biodiversity and forage systems

As regards to their impact on biodiversity, it appears from the typology that some types have potentially a stronger impact. Their forage system cumulates several practices having an unfavourable impact (dates of mowing, frequency of cuts, practices of fertilization).This concerns types 2, 3, 8 and 9 and 38 % of the 455 farms. On the contrary, other types (1 and 5 gather 24 % of the farms) have practices respecting more biodiversity for each component of the forage system. Lastly, for groups 4, 6, and 7 (38% of the farms), the impact is more complicated to evaluate. They combine practices having different effects, rather positive for some, negative for others.

To study the links between biodiversity and the forage systems described previously, we focused on the herbaceous diversity because this component shows the main differences between plots and is supposed to be strongly influenced by the farming practices. We have assigned each of the 20 farms to a typology group and have compared our field results to the supposed effect on biodiversity of the group (table 2).

Table 2. Forage systems and diversity of the herbaceous vegetation.

Hypothesis on biodiversity	Positive effect expected		Unknown	Negative effect expected			
Forage system	1	5	4	2	3	8	9
Biodiversity results on the 3 plots (one line per farm)	5/ 5/ 5-4	5/ 4-5-5/ 5 ♦★	1-3/ 2/ 4-5	1/3-2/ 3★	5/3/0★	3/5/3-0	1/ 2/ 5-5
	2-5/5/5-5 ★	5/ 5/ 5 ♦	3/4/ 5-5 ♦	0/ 1/ 5			1/3/1-1★
	2/ 5/ 5 ♦	4/ 5/ 5-5 ♦★	1-2/ 2/ 3	1/ 5/ 0 ★			
	2/ 3/ 2-3-4	2/ 5/ 5 ♦	4/ 5/ 2				
		2-3/3-4/3-5♦★					

Biodiversity results: marks from 1 (low level) to 5 (high level), 0 for missing data
3 marks per farm separated by " / " : Typical grazed meadow / Typical mown meadow / most diversified meadow (grazed or mown)
Several marks per plot (separated by "-") when several vegetation facies in the plot
♦: organic farming system , ★cheese producer

Taken as a whole and looking at the typical meadows, the hypothesis on biodiversity we proposed can be accepted as the groups expected to be positive for biodiversity show mainly high level of biodiversity and the groups expected to be negative show low level.

However it doesn't work for all typical plots and the most diversified meadows can sometimes have a high diversity level although the farming system seems to be quite intensive. A further study based on a second meeting with each farmer gives elements to explain the difference between plot diversity and global forage system. The main elements are: plot location with higher practice intensity for the nearest one, natural environment features which limit diversity despite extensive practices (wet conditions for example) or increase it due to soil heterogeneity, history of the plot as the vegetation assessed is inherited from the former practices. So we get still variability within the system due to the specific place and characteristics of the plots although there is a general trend linked with intensification of the practices.

Biodiversity and cheese production

There are cheese makers in each group of the typology, but 75 % of them are divided in three types only. We find about 25 % of cheese makers in each type 1, 2 and 4 and in each one, they are about half of the breeders. For these three types, hay predominates in the forage system. But the intensification levels are various, and the potential impact on biodiversity may be really different.

In our farm sample we have 8 cheese producers (3 organic) and 12 milk producers (4 organic). When considering the cheese producers' forage system we can notice that they are equally divided into systems supposed to be positive or negative for biodiversity and the plots' diversity confirm these hypothesis (table 2). When comparing the biodiversity results of milk and cheese producers we have only found a significant difference for the herbaceous vegetation. The multiple comparison tests have shown that the difference was due to the harvesting method (grazed or mown) and not to the farming system (table 3).

Table 3. Average diversity level of the plots for milk and cheese producers

	Mown		Grazed		
	Milk producer	Cheese producer	Milk producer	Cheese producer	P-Value
Flora-Landscape elements	4.5[a]	4.4[a]	4.9[a]	4.8[a]	0.397
Flora-Herbaceous vegetation	4.1[b]	4.2[b]	2.5[a]	3.1[a]	0.0005***
Fauna-Birds	2.2[a]	2.5[ab]	4.0[b]	3.0[ab]	0.110
Fauna-Butterflies	1.9a	2.5[ab]	2.6[ab]	2.7[b]	0.109
Fauna-Orthopterans	3.7[a]	3.7[a]	4.1[a]	4.3[a]	0.513

Diversity level from 1 (low level) to 5 (high level),
P value of the variance analysis : *** : P < 0.001 , ** : P < 0.01 , * : P < 0.05

However when considering the mean values obtained for each system we can notice that they are slightly higher for the grazed pasture of the cheese producers although not significantly different. Figure 3 also shows that cheese producers have no poorly diversified herbaceous vegetation (under level 3) for the mown meadows on the contrary of the milk producers. Nevertheless, these observations cannot confirm our hypothesis of higher diversity for the cheese producer's meadows.

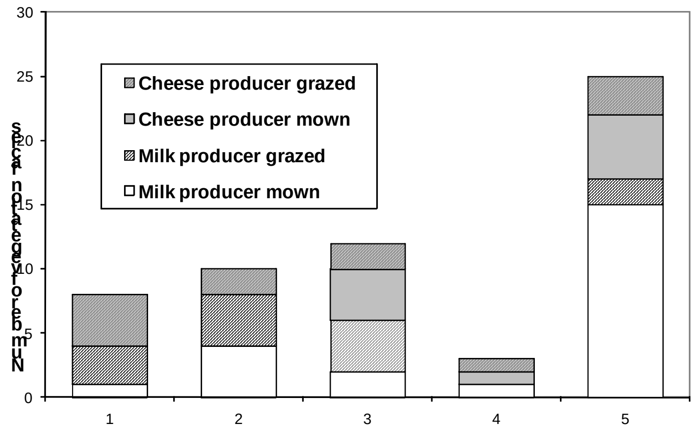

Figure 3. Herbaceous vegetation diversity for milk and cheese producers.

Biodiversity and organic farming

When considering the 7 organic farms in table 2 we notice that they were mostly in the extensive systems of the typology, but herbaceous vegetation diversity can be low on some plots due to reasons explained previously. To further investigate the effect of this farming system on biodiversity we have compared the organic and conventional plots for all the biodiversity components. We have distinguished grazed and mown plots as we know their diversity level is different (table 1). We have also checked that there was the same proportion of "most diversified plots" in organic and conventional systems.

Variance analysis and multiple comparison tests (LSD test) were performed to compare the diversity levels of the 4 combinations (table 4).

Table 4. Average diversity level for conventional and organic plots.

	Mown		Grazed		P-Value
	Conventional	Organic	Conventional	Organic	
Flora-Landscape elements	4.6[ab]	4.3[a]	4.8[ab]	5.0[b]	0,20
Flora-Herbaceous vegetation	3.8[b]	4.7[c]	2.3[a]	3.7[b]	0***
Fauna-Birds	2.6[a]	2.0[a]	4.0[b]	2.8[ab]	0,03*
Fauna-Butterflies	1.6[a]	2.3[ab]	2.5[b]	2.8[b]	0,03*
Fauna-Orthopterans	3.7[a]	3.7[a]	4.2[a]	4.2[a]	0,55

Diversity level from 1 (low level) to 5 (high level),
P value of the variance analysis : *** : $P < 0.001$, ** : $P < 0.01$, * : $P < 0.05$

Results have shown no significant effect of farming system and practice on diversity level of landscape elements or orthopterans. The variance analysis has been significant for birds and butterflies but the multiple comparison tests showed that differences were between grazed and mowed plots rather than organic or conventional treatment. On the contrary we have found a highly significant effect for the diversity of the herbaceous vegetation which is due to the farming system. Considering grazed or mown plots, the mean diversity level of organic plots was more than one point higher (table 4). When looking at the indicators used to obtain the diversity of the herbaceous vegetation (species, colours, flowers) we noticed that they were all higher for the organic plots and significantly different for 5 of the 7 indicators.

We can conclude that organic farming seems to have a more positive impact on the vegetations' diversity than conventional one. When comparing the agricultural practices of both systems we have found that the absence of mineral fertilization could be an explanation (Jacquemyn et al.,2003) although the total amount of fertilizers (N, P, K) was the same for organic or conventional plots. We have also observed less stoking rate on organic grazed plots even if the difference is not significant (Ollf and Ritchie, 1998). Moreover we can see a tendency for the mown organic meadows to be harvested later (58 %) than the conventional ones (35 %) which is favourable to biodiversity (Critchley et al., 2007).

Biodiversity and the new PDO specifications

Our results cannot completely succeed in getting a precise idea of the biodiversity produced in the Saint Nectaire PDO dairy systems as we study only three plots per farm which doesn't cover the whole diversity of the practices. Moreover the 20 farm surveys cover only 7 of the 9 farming system types. Nevertheless, we show some trends which are important to consider for biodiversity conservation in the PDO area especially with the new PDO specifications.

We have found that the intensive farming systems, which are well represented in the area, lead usually to low biodiversity for their typical meadows even if they can also have some more diversified meadows left due to the characteristics of the plots. It's particularly important to encourage these systems to keep on the diversity between their different plots and even within the plots when different vegetation facies are present. The intensive systems based on silage or wrapped balls (type 3, 8 and 9) will have to change as these harvesting methods won't be allowed in the future. It will be an advantage for grassland biodiversity but only if they are not replaced by barn dried hay or acid treating which still allow an early cutting of the meadow and is nowadays used by the intensive systems based on hay (type 2). These techniques could spread and go against biodiversity safeguarding.

The study of the link between herbaceous vegetation diversity and the forage systems show also that less intensive systems are generally more interesting for preserving biodiversity. The new Saint-Nectaire PDO specifications will limit nitrogen fertilization (less than 60 mineral unit per ha and than

130 for the total) which is positive towards biodiversity. However, at the same time, the need of fodder self-sufficiency and the fact that all heifers will have to be born and reared in the area could also encourage some of the extensive systems to increase their fertilization or stocking rate.

Our global biodiversity results show also the high level of landscape diversity in the Saint-Nectaire PDO area. Landscape elements are particularly important for supporting both floristic and faunistic diversity as they work as islands able to keep or restore biodiversity (Söderström et al.2001). Unfortunately, landscape elements are not taken into account in any French PDO specifications (Camou, 2008). To avoid their decreasing it would be interesting to introduce the maintenance of these elements in the specifications.

Considering the farming systems, we found no difference between milk or cheese producers for biodiversity. One reason could be that they have the same specifications with no special measures when producing cheese so that we have found a wide range of forage systems, more or less intensive, among them.

On the contrary, as expected, organic farming seems to lead to higher biodiversity for the herbaceous vegetation. These results can be related to the organic specifications and in particular the absence of mineral fertilization which induces generally a later growth of the grass and therefore a less intensive utilization of the meadows. There are however few dairy organic producers in the PDO area and this system is not specially supported within the PDO organization.

Finally, it's not easy to anticipate whether new PDO specifications will or not improve biodiversity in the St-Nectaire area. We have both measures which are in favor of biodiversity and new requirements which could lead to intensification. Moreover, it will depend on the farmers' choice. Surveys show that some of them would prefer to leave the PDO device as the evolution of their system would require too important efforts. Other seems to have more adaptability depending to the part of silage or wrapped balls in their forage system. There are also 40 % of the farms which combine dairy cows with another herd (mainly succkler cows, sometimes sheep) which give them more adaptability according to the CAP payments they receive.

In conclusion, links between PDO device and biodiversity are not so obvious

Combining different scales (territory, farm, plot, facies) and different level of approach (PDO specification, farming system, practices sequences, etc.), relationships between cheese PDO specification and biodiversity are complex.

Firstly, PDO specifications allow a large diversity of practices systems and sequences, even intensive ones which don't respect grassland biodiversity. Second, at the scale of one farm, the average level of biodiversity may mask important differences from one plot to the other, according to the local adaptations introduced by the breeder.

Safeguarding biodiversity through PDO device suppose to insert in the PDO specification measures or practices more directly linked to biodiversity. Of course it's a real challenge to find a balance between social and economical objectives and biodiversity conservation.

In this work, we surveyed farms under PDO specifications, and farms under organic farming specifications which are not linked to the territory. Biodiversity results for vegetation are better for the second ones. Some ideas may be found on organic farms.

Finally, at the scale of the whole area, biodiversity depends on all the farms using the territory. In our case, around 60 % are dairy farms concerned by PDO, most of the others are suckling systems, generally less intensive than dairy ones. Besides, a large part of this mountainous area is also used as summer pasture by farmers coming from other areas. It means that the biodiversity of the PDO area is also produced by other farming systems.

References

Bérard, L. and P. Marchenay (2006) Local products and geographical indications : taking account of local

knowledge and biodiversity, *International Social Science Journal, Cultural Diversity and Biodiversity*, n°187, pp109-116.

Boisvert, V. and A. Caron (2007) *Compétition entre les normes dans la construction de marchés pour la biodiversité*, in joint congress of the European Regional Science Association (47th congress) and Association de Science Régionale de Langue Française (44th congress), Paris 29 Aug-2 Sept 2007

Camou, R. (2008) *Appellation d'Origine Contrôlée France et Biodiversité*, CNASEA, 9p.

Coulon, J.B., Rock, E. and Y. Noël (2003) Caractéristiques nutritionnelles des produits laitiers et variations selon leur origine *INRA Productions Animales,* 16 (4), 275-278

Critchley, C.N.R., Fowbert, J.A. and B. Wright (2007) Dynamics of species-rich upland hay meadows over 15 years and their relation with agricultural management practices, *Applied Vegetation Science* 10: pp 307-314

Dumont, B., Farrugia, A., Garel, J., Bachelard P., Boitier E. and M. Frain (2009) How does grazing intensitiy influence the diversity of plants and insects in a species-rich upland grassland on basalt soils ?, *Grass and Forage Science*, 64, 92-105.

Farrugia, A., Parguel, P., Hulin, S., Reuillon, J-L., Pomiès, D., Beaumont, B., Rioud, G., Hauwuy, A., Veysset, P. and B. Martin (2009) En filière fromagère AOP, les conditions de production dans les cahiers des charges et leurs conséquences pour les exploitations *Fourrages* n°199, pp311-329

Gueringer, A., Rapey, H., Houdart, M., Bigot, G., Josien, E. and F. Landré (2009) Adaptability through spatial management: a case study of livestock farms in the Massif central (France), *Outlook on Agriculture*, vol 38, n°2

Hauwy, A., Fleury, P. and P. Poccard (2005) *Une agriculture s'appuyant sur la biodiversité des écosystèmes prairiaux et microbiens : l'exemple des zones de montagne des Alpes du Nord, avec des systèmes laitiers destinés à la production de fromages typés*, Conférence internationale Biodiversité : Science et gouvernance, Paris, 4 p.

Jacquemyn, H., Brys, R. and M. Hermy (2003) Short term effects of different management regimes on the response of calacareous grassland vegetation to increased nitrogen. *Biological Conservation*, 111, pp 137 -147

Jean-Pierre, J. (2008) *Pratiques agricoles et biodiversité des prairies : une relecture des systèmes fourragers en zone AOC Sait-Nectaire*, LaSalle ISAB, Cemagref Clermont-Fd, 43 p.

Le Roux, R., Barbault, J., Baudry, F., Burel, I., Doussan, Garnier E., Herzog F., Lavorel S., Lifran R., Roger-Estrade J., Sarthou, J.P., Trommetter, M., (2009) *Agriculture et biodiversité. Valoriser les synergies. Expertise scientifique collective,* Editions QUAE , 177 p.

Martin, B., Buchin, S. and C. Hurtaud (2003) Conditions de production du lait et qualités sensorielles des fromages *INRA Productions Animales,* 16 (4), 283-288.

Ollf, H. and M.E. Ritchie (1998) Effects of herbivores on grassland plant biodiversity. *Trends in Ecology and Evolution*, 13(7) : 261-265.

Orth, D., Balay, C., Bonafos, A., Deleglise, C. and P. Loiseau (2008) Proposition d'une démarche simple pour évaluer la diversité floristique d'une prairie permanente, *Fourrages* n°194, 233-252.

Plantureux, S., Peeters, A. and D. Mc Dracken (2005) Biodiversity in intensive grasslands : effet of management, improvement and challenges, *Agronomy research* 3(2), 153-164.

Söderström, B., Svensson, B., Vessby, K. and A. Glimskär (2001) Plants, insects and birds in semi-natural pastures in relation to local habitat and landscape factors, *Biology and Conservation* 10, 1839-1863.

Sylvander, B., Isla, A. and F. Wallet (2007) *A quelles conditions les dispositifs de gestion des Indications Géographiques Protégées peuvent-ils être considérés comme des biens publics contribuant au développement durable*, in joint congress of the European Regional Science Association (47th congress) and Association de Science Régionale de Langue Française (44th congress), Paris 29 Aug-2 Sept 2007.