Connecting on-farm studies and experimental results: the batching management in French suckler herds.

4th AFSRE Symposium, Volos, Greece, April 3 to 7, 2000. Workshop n°2

S. Ingrand, B. Dedieu

INRA URH Systèmes Agraires et Développement, Theix, F63122 Saint-Genès Champanelle

Summary

Batches of cows are for the stockbreeder sub-units of management, insofar as their creation is associated with the implementation of specific practices: feeding, breeding, sanitary interventions. The nutritionist's rule is to adjust the food contributions of the diet to cows' nutritional requirements, and then to constitute homogeneous groups according to nutritional requirements. As the farmer has to take account of more or less easily reconcilable and sometimes contradictory constraints, it can be assumed that the assignment of cows to the different batches does not obviously deal with this rule. The questions are then: what are the consequences of batching practices on the elaboration of the animals' performances? What kind of new biological knowledge is required to build models of performances at herd level? We present first a 3-year study combining an on-farm approach to analysing batching management in 81 French beef cattle farms and an experimental approach dealing with the intake level and feeding behaviour of beef cows kept in heterogeneous groups according to their nutritional requirements. Then we discuss about the limits and interests of combining such different approaches.

Keywords: on-farm studies, experimental design, batching practices, beef cows, group feeding, intake

Introduction

Agriculture and more particularly livestock farming systems change under the combined effect of internal and external factors which are so many factors of evolution (CAP, agri-environmental aspects, workforce constraints). For cattle breeding in France, one of the main changes is the evolution of structures: reduction in the number of farms, enlarging those which remain and increase in herd size per worker (Bébin et al., 1995; AGRESTE, 1997). It becomes then necessary to define and develop the following characteristics for breeding systems: simplicity of management, economy in workload, flexibility (capacity of adaptation), security (resistance to risks), while maintaining high animal performance yields compatible with the needs of the meat production sector. The researcher dealing with animal production science, interested either in the practices of farmers or in biological aspects, is then confronted with a dual challenge: 1) to understand and analyse the meaning of the changes and to confront them with biological knowledge, 2) to provide new knowledge and to insert it into tools allowing these changes to be simulated and their consequences to be evaluated. The present study is an illustration of an interactive approach between biological knowledge and on-farm practices (Ingrand 1999).

1. Animal diversity and nutritionist's knowledge

A significant characteristic of livestock farms, especially those involving grazing herbivores, lies in the diversity of the resources mobilised (surfaces, animals). Structuring these resources into functional sub-units by the farmer constitutes a way of managing this diversity. The structuring of the territory and the interventions carried out on this territory have been analysed for grazing systems (Duru et al., 1988; Guerin and Bellon, 1989; Dedieu et al., 1995; Girard, 1995). We consider in the same way that the structuring of the herd into batches is a way of managing the individual diversity of the animals.

The batches are sub-units of management for the farmer, insofar as their creation is associated with the implementation of specific practices: feeding, breeding, sanitary interventions (Ingrand et al., 1993; Girard and Hubert, 1994). Our studies in farms using specialised breeds (Charolais, Limousin) in areas of Central France with extensive grazing land, show the diversity of batching management, either from the point of view of the number of batches managed simultaneously, or of the size and duration of these batches, or of the frequency of interventions to modify their composition (Ingrand and, Dedieu 1996). The differences are not related to the size of the herds, but rather to the structural constraints on the farm. It is in particular the permanent available workforce on the farm which initially determines the number of interventions on the herd throughout the year to modify the batches. These results have been confirmed in ovine suckler extensive breeding systems (Dedieu et al., 1998).

Legay (1997) considers that the definition of a point of view is an essential stage for the study of complex systems. With regard to the management of the diversity of the reproductive females composing a herd, two particular points of view can be considered although there are others (genetics, pathology). The first is the point of view of the farmer, who must take account of more or less easily reconcilable and sometimes contradictory constraints. The question is then: which are the criteria related to the animals used by the farmers to constitute the batches on the year-scale? The second point of view is that of the nutritionist, for whom the categorisation of animals is based on their individual level of nutritional requirements. Feeding being the most expensive item of the variable costs, the objective is to adjust the diet as efficiently as possible to the nutritional requirements of the cows. The distinction of the various categories of nutritional requirements is based on combinations of factors related to the animals (breed, sex, age, production level, body reserves).

The performance of the herd is built starting from the performances of individuals placed in batches associated with a specific management (food) but also with a specific physical and social environment (counterparts, housing, density...). Thus, the performance built-up at herd level does not result directly from the sum of the performances of each animal considered separately, but depends on the way in which the individuals are associated within the batches. The questions that arise are then: what are the consequences of the batching practices on the elaboration of the animals' performances? What kind of new biological knowledge is required to build models of performances at herd level?

2. Farmer's point of view

The diversity of batching management practices was studied in 81 beef cow farms located in the Limousin (n=34) and Charolais areas (n=47). These farms were rather large (102 calving per year), two-third having a fattening activity (males and/or females) For each farm, a batching diagram was built representing the structuring of the herd in batches throughout the year (Ingrand and Dedieu, 1994). The analysis of the diagrams enables us to identify the animal-related criteria taken into account to constitute the batches.
A batch is defined as a group of free animals in a given place. Thus, according to this definition, tethered animals do not constitute batches. Each batch is characterised by its duration, its size, its composition and by the criteria used by the farmers to assign animals to the batch. For example, the choice of the presumed calving date to constitute the batches at the beginning of winter (batching criterion) generates the existence of early-calving and late-calving batches (composition of the batches). The present study addresses the batching criteria only for the cows after their first calving. The 2-year old heifers are considered only when they are mixed with older cows during the breeding season.
Eleven different batching criteria were identified: calving date, genetics (choice of bulls), the decision to cull (specific batches of animals intended for culling), age of the cows, sex of the calves, "quality" of the animals, drying up, sorting for sale, sorting for replacement, size of the batch (number of cows) and a "miscellaneous" heading (animal with problems, etc).
The frequency of use of each criterion was measured by the number of batches made up by taking the criterion into account divided by the total number of batches. Two cases were distinguished, according to whether the criterion was used alone or associated with others. The analysis concerned the batches created during four sub-periods which are the turn-out to grass (P1), the beginning of wintering (P2),

the grazing period (P3, from April 1 to October 1, except turn-out to grass and beginning of wintering) and the wintering period (P4, from October 1 to April 1, except beginning of wintering and turn-out to grass). A total of 1275 batches of cows were identified (961 and 314, respectively for the Charolaise and the Limousine areas), including 41, 23, 21 and 15 % made up at P1, P2, P3 and P4, respectively. The least proportion of batches made up in winter is explained by the low number of batching operations during this period, but also by the sometimes significant proportion of tethered cows, especially in the Charolais area.

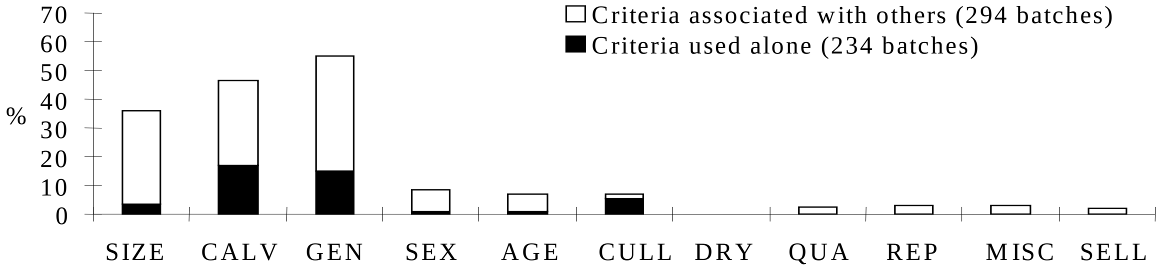

Figure 1: Constitution of batches in beef cow herds (Charolais and Limousin), at turn-out to grass. Proportion of batches built-up for each batching criterion identified.

SIZE:	batch size	AGE:	age of animals	REP:	replacement	CALV:	calving date
CULL:	culling	MISC:	miscellaneous	GEN:	genetic	DRY:	drying off
SELL:	selling	SEX:	sex of calves	QUA	quality of animals		

Batch size, calving date and genetics are the three most frequently used criteria to constitute the batches at turn-out to grass (figure 1), with respectively 36, 47 and 55 % of the 528 batches. The batches built with a single criterion represent 44% of the total, with in descending order (% of the batches with single criterion): the calving date preceding the turn-out to grass (38%), genetics (34%), the culling decision (13%), the batch size (8%). The frequency of association of "genetics" and "calving date" with other criteria is similar. The combinations are more variable with the "genetics" criterion: five other criteria associated against three for the "calving date" (figure 2). The criteria "batch size" and "sex of calves" are in a very large majority of cases associated with "genetics" (82 and 81 % of the batches are concerned).

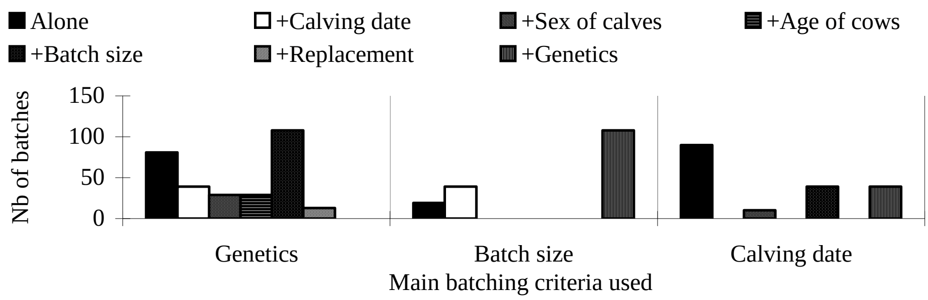

Figure 2: Number of batches composed at turnout to grass with the 3 main used batching criteria, according to other criteria associated.

The batches are only slightly modified during the grazing period and they are generally made up according to a single criterion (60% of the 265 batches). Modifications during the grazing period occur when few criteria were taken into account at the turn out to grass. Then the batches are modified successively according to breeding management, sex of calves, physiological stage of the cows at weaning, etc.

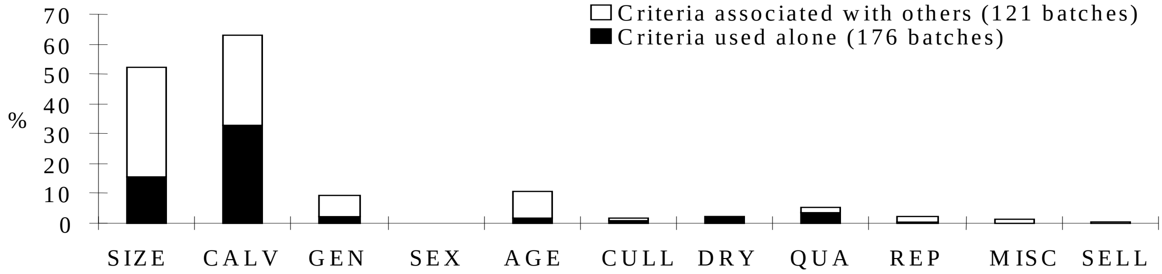

Figure 3: Constitution of batches in beef cow herds (Charolais and Limousin), at beginning of winter. Proportion of batches composed for each batching criteria identified.

SIZE:	batch size	AGE:	age of animals	REP:	replacement	CALV:	calving date
CULL:	culling	MISC:	miscellaneous	GEN:	genetic	DRY:	drying off
SELL:	selling	SEX:	sex of calves	QUA	quality of animals		

At the beginning of winter, the two main batching criteria used are (figure 3): the presumed calving date and batch size, with respectively 63 and 52 % of the 297 batches. A majority of batches are built-up according to a single criterion (59%). This is due to fewer simultaneous constraints to take into account at the beginning of winter than in spring (breeding management, complementation of calves, with an eventual separation of the sexes). Batches are more frequently built-up using a single criterion, either the calving date (56%) or the batch size (26%), which corresponds generally with small pens when cows are loose-housed. The criterion generally associated with others is the batch size which constitutes the link with the total number of batches managed in winter, induced by the configuration of the shed.

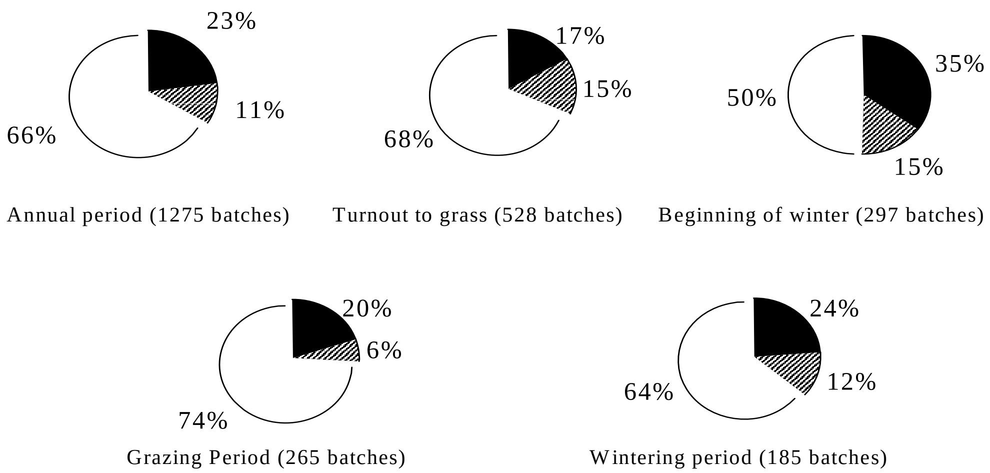

Figure 4: Number of batches built-up with criteria leading to an homoheneity in the within-batch nutritional requirements of the cows (HNR batches), according to the period.

non HNR batches
HNR batches built-up with a single criterion
HNR criteria built-up with several criteria

Among the 11 batching criteria listed, 3 were considered as leading to an homogeneity in the within-batch nutritional requirements of the animals (HNR batches): the calving date and drying off (homogeneity of the physiological states) and replacement (specific nutritional requirements of the young, still growing cows). The "calving date" criterion relates to 84% of HNR batches throughout the year and “drying off” to 40 % of HNR batches during the grazing season. The number of batches built-up with at least one of the three criteria was cumulated and compared to the others according to the sub-periods. Throughout the year, only one third of the batches is supposed to be HNR (figure 4).

They are most frequent at the beginning of wintering with 50% of the total batches concerned. In the other periods, they represent only from a quarter to a third of the total of the batches. Thus, although the calving date is an important batching criterion for the farmers, it appears that the homogeneity of the nutritional requirements is not a characteristic of the majority of the batches.

3. From the farmer to the nutritionist's point of view

Since the homogeneity of within-batch nutritional requirements is not always a priority in farms, we set about an analysis of the capacity of the animals to adapt their behaviour when mixed with counterparts with different nutritional requirements. For the nutritionist, the behaviour is represented by the feeding behaviour and the intake level. Dry and lactating cows, for example, have different motivations to eat (Friend et al., 1977; Metz and Wierenga, 1987). From the farmer's to the nutritionist's point of view, the entity to focus on (the object of research) changes from the batch (management unit) to the animal (biological knowledge unit). For the nutritionist, the group can be defined as well as the batch in the farms: the animals are free to move in a given place, being in social interaction. The "group" entity can be considered as the biological translation of the batch managed by the farmer.

Competition is a major factor of constraint modifying the performances of animals kept in a group, either indoor (Ilan et al., 1979; Morrison et al., 1981; Harb et al., 1985; Ingvartsen and Andersen, 1993; Hindhede et al., 1996; Andersen et al., 1997; Fisher et al., 1997) or at pasture (Blanc et al., 1999). Trials were conducted to measure the effect of the within-group heterogeneity of nutritional requirements on the feeding behaviour and intake level of Charolais cows. These trials were carried out during the winter-period which is a critical phase of the reproductive cycle in "traditional" French systems, as it is the period when the majority of the calving occurs and thus, when the diversity of the cows' nutritional requirements is maximum within herd. To maximise the within-group heterogeneity, some dry and lactating cows were mixed together. The number of troughs was the only source of competition (1 vs 2 cows per trough) and the cows were fed ad libitum with good quality hay. It was assumed that "composition of the group" and "competition at the trough" are, as well as density, the source of more or less strong social constraints for the individuals constituting the batch. The daily variables assessed for each cow in the group were: the intake level, the rate and duration of eating, the feeding pattern and the synchronisation of eating. The individual variability of the adaptation of feeding behaviour within the groups was explored relatively to the main factors identified in the bibliography, i.e. level of nutritional requirements and social rank, and by considering additional characteristics of the animals (size, body reserves, milk yield) to analyse the individual variability of adaptation.

The hypotheses tested were the following: 1) without competition for food, cows with low nutritional requirements will synchronise their eating activity with the cows with higher requirements and will thus have greater daily duration of eating than in homogeneous groups (leading effect), 2) with competition for food, the cows will desynchronise their eating activity, will shift their meals in time and will increase their rate of eating, firstly when they are low ranked and have low nutritional requirements, with a risk of decrease in intake. These hypotheses imply that the social rank and the physiological state of the cow placed in a group influence its feeding behaviour, in addition to the strict effects of the physical constraints undergone within the group. Social rank has a particular status compared to the physiological state as it is expressed relatively to the counterparts. Thus, a dominant cow in a group can be submissive in another group, the question being to know if its feeding behaviour differs in the two situations.

The main results obtained according to the treatment and the physiological state (i.e. the nutritional requirements) of the cows are shown in table 1. Heterogeneity and competition for food disrupted the feeding pattern, especially for dry and submissive cows. Lactating cows had the most stable feeding behaviour whatever the treatment because of their high motivation to eat (Metz, 1975; Metz and Wierenga, 1987). Dry cows displayed more variable adaptation to feeding. With competition for food, they reduced their intake when in homogeneous groups, with the dominated cows greatly decreasing their feeding time. They increased their intake when associated with lactating cows, the social rank having no longer any effect. In all cases, the energy balance remained largely positive. Finally, the nutritional requirements appeared to be determinant compared to the social rank to explain the effects of treatments (competition and homogeneity) for cows kept in groups. This is in accordance with the results obtained with dairy cows (Friend et al., 1977), despite the higher social reactivity of beef cows (Le Neindre and Sourd, 1984) and their lower nutritional requirements.

Table 1: Between treatment comparisons: homogeneous (Hom) vs heterogeneous (Het) groups, without (NCmp) vs with (Cmp) competition for food.

Within group Nut. Requirements Level of treatment	Homogeneous Hom vs Het	Homogeneous NCmp vs Cmp	Heterogeneous NCmp vs Cmp
Nb cows	12	12	12
Variable measured			
Duration of intake (min/c/d)			
Dry cows	284 vs 293	**290 vs 259**[1]	287 vs 274
Lactating cows	334 vs 350	-	295 vs 284
Rate of intake (g/min)			
Dry cows	52 vs 51	49 vs 52	40 vs 46
Lactating cows	46 vs 44	-	56 vs 59
Nb short meals (/d)[2]			
Dry cows	**7,7 vs 10,4**	**9,1 vs 10,5**	**9,2 vs 10,9**
Lactating cows	**9,3 vs 11,1**	-	9,9 vs 10,2
Nb long meals (/d) [3]			
Dry cows	1,3 vs 0,7	**1,1 vs 0,8**	1,0 vs 0,8
Lactating cows	1,3 vs 1,3	-	1,0 vs 0,8
Synchronisation of eating[2]			
Dry cows	**3,2 vs 2,9**	**2,7 vs 2,2**	**2,1 vs 1,7**
Lactating cows	**3,6 vs 2,8**	-	**2,0 vs 1,7**
Intake level (kg/c/d)			
Dry cows	14,5 vs 14,8	**14,1 vs 13,4**	**11,4 vs 12,6**
Lactating cows	15,3 vs 15,4	-	16,2 vs 16,5

[1] bold values: difference statistically significant ($P<0.05$)
[2] short meals: < 60 min; long meals: >= 60 min
[3] number of cows eating simultaneously

4. Discussion

The discussion will focus on the methodology used in each part of the work (surveys and trials) and on the advantages and disadvantages of conducting studies simultaneously in two areas of research.

4.1. On-farms studies

The results of the first part of this work are based on data collected with a same tool: the batching diagram. The data treated are qualitative (batching criteria) and were collected using sporadic surveys. They were not verified by direct measurements or observations of the animals. These elements constitute limits to the interpretation of our results insofar as the same batching criterion cited by several farmers can cover various situations. For example, the within-batch variability of the physiological states for batches made up at the beginning of winter according to the calving date may not be the same (with an equal number of batches) in a farm where the calving dates are grouped over two months and in a farm where the calving dates are spread out over all the winter. Moreover, even if the "calving date" criterion is not cited by the farmer in the first case, the batches will anyway be homogeneous according to the physiological state of the cows, whatever the batching strategy of the farmer at the beginning of winter. However, our sample of farms includes as a whole 1275 batches of multiparous cows, which seems to be sufficient to draw some valid conclusions concerning the within-batch heterogeneity of the physiological states of the cows.
We didn't either analyse the determinants of the batching practices, i.e. the underlying reasons for the farmers' choices, such as they expressed them. From this point of view, the present work can be considered as a preliminary study. Some more focused analyses are now conducted to explain farmers practices with respect to batch composition in a context of high quality meat production, which

suppose to control the animal diversity as well as possible. Former studies have shown that structural elements (buildings, field pattern, workforce) have a significant role on the one hand on the number of batches made up and the frequency with which these batches are modified (Ingrand and Dedieu 1996), and on the other hand on the assignment of these batches over the farm territory during the grazing season (Dedieu et al., 1997). These last authors emphasised the link between the choice of batching criteria at turn-out to grass and the field pattern, either for monitoring constraints (late calving near to the farmstead, cows having the oldest calves on distant pastures, etc), for breeding management considerations (young heifers far from "undesirable" bulls), or for the workforce reasons (cows having male calves which receive concentrates near to the farmstead).

4.2. Experimental device and protocols

At the winter-period level, the results thus do not allow us to evaluate the animals' global performances as they can be assessed by the farmers, especially their reproductive performances. So, the experimental process was focused on modifications in feeding behaviour and then on the intake level of the cows, which are considered by nutritionists to be components of the beef cow's performance (such as milk yield and variation in body reserve).
In all the tests, the cows were fed ad libitum using hays of equivalent quality. The main reasons were 1) an harmonisation of the experimental conditions over the three years of trials, and 2) a non limited situation from the point of view of the food allowance throughout the day. Situations where the feeding resource becomes limited makes it necessary to take into account the relationships between the manner of constituting the batches and the feeding practices associated to each batch, which is another subject of research.

4.3. Implications of linking the two approaches simultaneously

As far as we are concerned, two main limits can be identified by linking on-farm and experimental studies closely in a same work, limited in time and in workforce. The first one is the lack of thoroughness in each approach. In the present study, this concerned on one hand the analysis of the determinants of the batching practices of farmers, i.e. the analysis of the mode of reasoning involved when batches are constituted, and on the other hand a thorough analysis of the mechanisms involved in the modifications on the feeding behaviour of cows kept in groups. The second limit, not independent of the previous one, deals with the "academic character" of the work, especially for the experimental part of the work. Hence, in the present study, trials were conducted with cows kept in groups, to fit with the problem to solve (within-group homogeneity) and with "real" situations observed in farms. This procedure led us to take individual data, associated with each cow, as statistical units, despite the fact that they are not independent. This leads to considering the best way to manage such research involving several disciplines. Our purpose, according to the definition of Bonneval (1993), was to promote more interdisciplinarity rather than multidisciplinarity, when the collaboration between several disciplines leads to "real interactions, i.e. to a reciprocity inducing mutual benefit". Our experience tends to indicate that this aim can be achieved when the work involves some specialists from each discipline, but also some people being the interface between the disciplines.

However that kind of approach enabled a closer link to be made between biological knowledge, i.e. the nutritionist's knowledge in the present study, and farming system research, i.e. between techniques and practices. This generated some reciprocal questions which could be useful to progress on how to analyse the relation between cause and effect concerning practices and animal performances. Thus, the within-group heterogeneity suggested in private farms by the surveys implies a modification of the nutritionist's point of view by testing other situations than those considered in current models for feeding cattle. Conversely, on-farms studies (surveys, monitoring) might be reconsidered by taking into account the variation factors identified experimentally, i.e. for in-group management, the composition, the management and the environment of the group. More generally, the challenge could be defined as constructing tools for simulating situations including constraints and variability, i.e. situations which do not obviously fit with some standard recommendations, but taking into account non-normalised practices. Finally, what is perhaps most interesting is to take advantage of the synergy between several points of view on the same problem (figure 5).

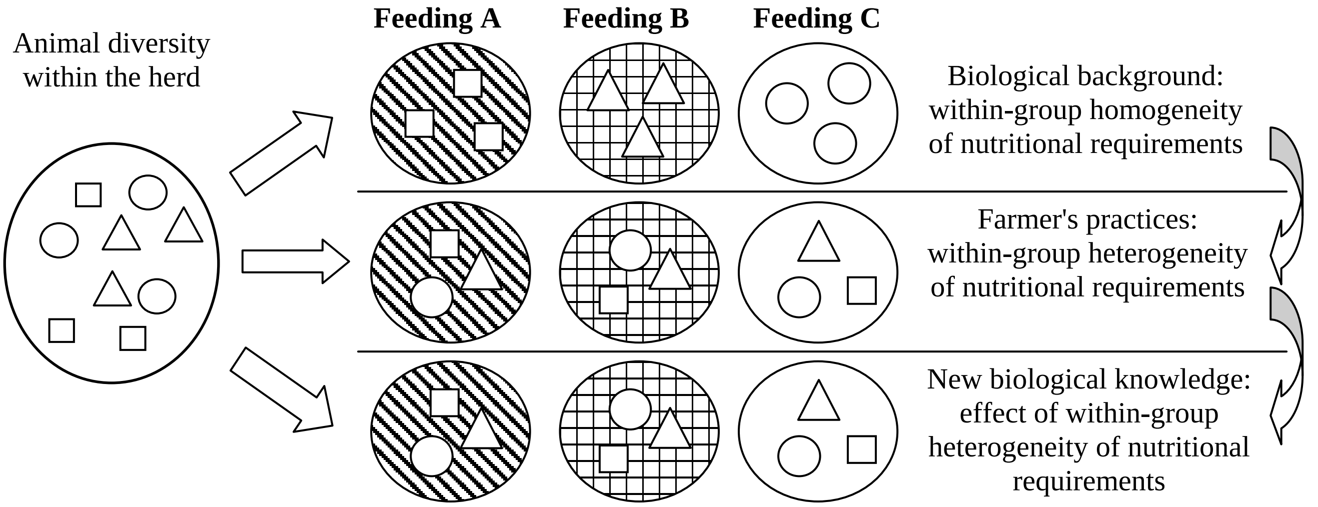

Figure 5 : From feeding recommendations to the management of feeding = from homogeneity to heterogeneity of within-group nutritional requirements.

Conclusion

We showed that farmers do not consider it as a priority to constitute homogeneous batches according to the nutritional requirements of the cows. The question in the nutrition research area was then to analyse the performances of the animals kept in these batches and to re-consider the validity of the individual-based models when animals are in interaction with some counterparts which have different and variable nutritional requirements. We also showed that 1) the question of the composition of the batches is not specific to the winter period, 2) compromises are carried out by farmers at turn-out to grass, 3) the composition of the batches at pasture is not independent of their size and their duration. We do not consider that this is evidence a priori to take into account these questions in an animal performance modelling process. It involves firstly studying the reality of the practices in farms (i.e. the batches of cows are heterogeneous in terms of nutritional requirements), and secondly to take it into account in the modelling process by connecting decisional to biological sub-models.
Conversely, the experimental step leads to many questions as to the manner of analysing the functioning of the herd and the process of livestock performance build-up: which variables to measure? Which level of precision? Which level of organisation (animal, batch, herd)? How to connect these different levels? Our results do not allow all these questions to be answered, initially because they relate to only one category of performance, i.e. the intake level and its components, which involve only short-term mechanisms of regulation (compared to the regulation of body reserve which allows the variation of intake level to be compensated and smoothed out). Some lines can however be drawn. The more significant point is that group composition has no effect as such on the performance of the beef cow (characterised by a low production level) and that it is necessary to take into account the interaction between the composition of the group, the management of the group and the environment of the group.

References

AGRESTE, 1997. Enquête sur la structure des exploitations agricoles. Principaux résultats 1990-1993-1995. La Statistique Agricole. Données chiffrées. Agriculture n° 97. 202 p.

Andersen, H.R., Jensen, L.R., Munksgaard, L., Ingvartsen, K.L., 1997. Influence of floor space allowance and access sites to feed trough on the production of calves and young bulls and on the carcass and meat quality of young bulls. Acta Agric. Scand. Sect. A, Anim. Sci., 47, 48-56.

Bébin, D., L'Herm, M., Liénard, G., 1995. L'extensification avec contrat ? Evolution de quelques exploitations d'élevage bovin Charolais du centre de la France. Fourrages, 142, 107-130.
Blanc, F., Thériez, M., Brelurut, A., 1999. Effects of mixed-species stocking and space allowance on the behaviour and growth of red deer hinds and ewes at pasture. Appl. Anim. Behav. Sci., 63, 41-53.
Dedieu, B., Josien, E., Chassaing, C., Chabosseau, J.M., Willaert, J., 1995. Répartition des activités agricoles sur le territoire de l'exploitation: le cas de l'élevage allaitant en zone herbagère. In M. Duru et E. Landais (Eds) *Pratiques d'élevage et systèmes fourragers*, INRA SAD, 22-29.
Dedieu, B., Chabanet, G., Josien, E., Bécherel, F., 1997. Organisation du pâturage et situations contraignantes en travail: démarche d'étude et exemples en élevage bovin viande. Fourrages, 149, 21-36.
Dedieu, B., Chabosseau, J.M., Willaert, J., Benoît, M., Laignel, G., 1998. L'organisation du travail dans les exploitations d'élevage: une méthode de caractérisation en élevage ovin du Centre-Ouest. Et. Rech. Syst. Agr. Dév. 31, 63-80.
Duru, M., Fiorelli, J.L, Osty, P.L., 1988. Proposition pour le choix et la maîtrise du système fourrager. I- Notion de trésorerie fourragère. Fourrages, 113, 37-56.
Fisher, A.D., Shiels, P., O'Kiely, P., Enright, W.J., 1997. The effect of restraint and diet on the behaviour of housed beef heifers. Agricultural Research Forum, 251-252.
Friend, T.H., Polan, C.E., McGilliard, M.L., 1977. Free stall and feed bunk requirements relative to behavior, production and individual feed intake in dairy cows. J. Dairy Sci., 60, 1, 108-116.
Girard, N., Hubert, B., 1994. Modélisation à base de connaissances de systèmes d'élevage en région méditerranéenne. In J.B. Dent, M.J. McGregor, A.R. Sibbald (Eds) *Livestock farming systems: research, development socio-economics and the land manager*, Wageningen Pers, EAAP Publication 79, 291-300.
Girard, N., 1995. Modéliser une représentation d'experts dans le champ de la gestion de l'exploitation agricole. Stratégies d'alimentation au pâturage des troupeaux ovins allaitants en région méditerranéenne. Thèse de doctorat. Université Claude Bernard, Lyon 1, 234 p.
Guérin, G., Bellon, S., 1989. Analyse des fonctions des surfaces pastorales dans des systèmes de pâturage méditerranéens. INRA Et. Rech. Syst. Agr. Dev., 17, 147-157.
Harb, M.Y., Reynolds, V.S., Campling, R.C., 1985. Eating behaviour, social dominance and voluntary intake of silage in group-fed milking cattle. Grass Forage Sci., 40, 113-118.
Hindhede, J., Sorensen, J.T., Jensen, M.B., Krohn, C.C., 1996. Effect of space allowance, access to bedding, and flock size in slatted floor systems on the production and health of dairy heifers. Acta Agric. Scand. Sect A, Anim.
Ilan, D., Bleiberg, M., Holzer, Z., Levy, D., Folman, Y., 1979. The effect of floor space allowance on feedlot performance and on behaviour of Israeli-Friesian male cattle. Livest. Prod. Sci., 6, 307-312.
Ingrand, S., Dedieu, B., Chassaing, C., Josien, E., 1993. Etude des pratiques d'allotement dans les exploitations d'élevage. Proposition d'une méthode et illustration en élevage bovin extensif. Et. Rech. Syst. Agr. Dév. 27, 53-71.
Ingrand, S., Dedieu, B., 1994. An approach of batching management practices as a contribution to the study of livestock farming systems. In *Livestock farming systems: research, development socio-economics and the land manager* (J.B. Dent, M.J. McGregor, A.R. Sibbald Eds), EAAP Publication n°79. Wageningen Pers. 353-356.
Ingrand, S., Dedieu, B., 1996. Diversité des formules d'allotement en élevage bovin viande. Le cas d'exploitations du Limousin. INRA Prod. Anim., 9, 189-199.
Ingrand, S., 1999. Constitution des lots de vaches dans les élevages allaitants. Effets de l'hétérogénéité des besoins nutritionnels sur le niveau d'ingestion et le comportement alimentaire. Thèse Doct.-Ing.. INA-PG. 262 p.
Ingvartsen, K.L., Andersen, H.R., 1993. Space allowance and type of housing for growing cattle. A review of performance and possible relation to neuroendocrine function. Acta Agric. Scand. Sect. A, Anim. Sci., 43, 65-80.
Legay, J.M., 1997. L'expérience et le modèle. Un discours sur la méthode. Collection Sciences en questions. INRA Paris, 111 p.

Le Neindre, P., Sourd, C., 1984. Influence of rearing conditions on subsequent social behaviour of Friesian and Salers heifers from birth to six months of age. Appl. Anim. Behav. Sci., 12, 43-52.

Metz, J.H.M., 1975. Time patterns of feeding and rumination in domestic cattle. H. Veenman et B.V. Zonen (Eds), Mededelingen Landbouwhogeschool Wageningen, 66 p.

Metz, J.H.M., Wierenga, H.K., 1987. Behavioural criteria for the design of housing systems for cattle. In *Cattle housing systems, lameness and behaviour* (H.K. Wierenga et D.J. Peterse Eds). Martinus Nijhoff Publishers. 14-25.

Morrison, S.R., Lofgreen, G.P., Prokop, M., 1981. Effect of floor space allotment and animal group size on beef cattle performance. Transactions of the American Society of American Engineers, 24, 450-451.