Impacts of compact calvings and once-a-day milking in grassland based systems.

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ABSTRACT

A sustainable dairy production system relies on decreasing the production costs and improving the farmer's working conditions. Two technical solutions to reach those targets were tested during 3 years within a grass based system : compact calvings to close the milking parlour during one month and once-a-day (OAD) milking. Except in 2003 we managed to limit the amount of stored forages to 2 t of DM per cow per year for the spring calvers. A close calving pattern based on a 3 months period appeared to be more repeatable than a 2 months system. Technical and economical results did not significantly differ between spring and autumn calvings. High genetic merit cows can afford to be milked only OAD during the whole lactation. Both solutions were very effective to decrease working time and improve work organisation on the farm.

INTRODUCTION

A sustainable dairy production system relies on decreasing the production costs and improving the farmer's working conditions. One solution consists in implementing low concentrate systems mainly based on an extended grazing season (Brocard et al., 2000 ; Portier et al., 2003). Dairy producers should also simultaneously manage to decrease the fixed costs (Le Lan et al., 2005). Such a challenge can only be reached by decreasing the amount of stored forages delivered to the herd.
Moreover, milking time represents 50% of the total "compulsory" working time on a dairy farm. A 2 or 3 months compact calving pattern should allow to close the milking parlour at least during one month per year ; compact calvings also appear to be a good solution to improve work organisation as farm sizes increase. Compact calvings are already widely implemented in countries with large grazing herds such as New Zealand, England and Ireland. But it required extra experiments in France in order to improve its "user's guide" for farmers (Brocard et al, 2005).
Finally, French farmers wish to spend less time on their farms. Decreasing milking frequency might free them from a considerable part of their daily mandatory work on farm. This technical option might also lead to a lower energetic deficit in early lactation, even with high genetic merit cows (Brocard et al, 1998 ; Pomiès et al, 2002, Dalley et al, 2007).

1. MATERIAL AND METHODS

1.1. INTRODUCTION TO THE EXPERIMENTS :

Trevarez experimental unit is located in central Brittany (western part of France) in an oceanic wet climate (average rainfall : 1,200 mm per year). The herd is composed of 140 Holstein cows.
Experimental scheme :
The 2002/2005 experimental program was based on 3 axes : a forage system based on 0.5 ha of grazed grass per cow, compact calvings to close the milking parlour one month per year, and once-a-day milking all year long. This program included two experiments : A first one

consisted in comparing two calving periods : autumn - September to November - (A2 group) and late winter - February to April - (LW2 group). A second trial consisted in implementing once-a-day milking during the whole lactation (LW1 group) for late winter calvings.
Animals :
The 3 experimental groups were constituted in 2002. Cows were definitively allocated to one group for the whole 3 years period. Primiparous cows were introduced yearly to replace culled cows. Each group was initially made of 27 cows including 40% of first lactations.
The 151 cows which took part to the experiment were split into 3 parity types named “cohorts” :
- “P” cows which took part only as primiparous cows ;
- “PM” cows which entered as primiparous cows and went on as multiparous cows in the trial ;
- and “M” cows which entered the experiment in 2002 as multiparous cows.
Altogether 80 lactations were fully completed in the A2 group vs 80 in the LW2 group and 73 in the LW1 group.

1.2. FORAGE DIETS

The aim was to deliver the same quality and quantity of forages for the three groups of cows. Rotational grazing was monitored on pure ryegrass or ryegrass-clover associations. Each group was allocated one group of paddocks for good at the start of the experiment. The same grazing management rules were used for the 3 groups of cows (sward heights, key-dates, grass volume…) ; these rules were predefined with a possible adjustment according to grass growths and numbers of grazing days ahead. Forecast and real key-dates of each group are shown in table 1. The heavy draught which occurred during the first year of the experiment led to an early (20th of August, 2003) reopening of the maize clamp.
In the A2 group, the average “100% grazed grass” period lasted 189 days, the “day and night” grazing period 226 days, and the total grazing period 305 days. In the LW groups, the average “100% grazed grass” period lasted 175 days, the “day and night” grazing period 200 days, and the total grazing period 288 days.
Maize silage was delivered to the lactating cows in winter, while dry cows received a mixed grass and maize silage diet.

1.3. CONCENTRATES

Only one energetic concentrate was used in order to simplify diet composition (smashed wheat delivered once a day in the feeding trough). The only nitrogen concentrate used was soyabean (48 % of crude proteins) mixed with the maize silage and delivered at feed trough during the winter ; the nitrogen concentration target was close to 90 g of PDI (intestine digestible proteins) kg^{-1} of DM for lactating cows. The individual concentrate levels were unrelated to dairy productions and the total “wheat + soya” amount was flat and close to 2 kg per cow per day from calving to conception. The yearly total concentrate target was 250 to 300 kg per cow.

1.4. HERD MANAGEMENT

The 3 groups of cows calved in a compact pattern in two different periods : autumn (average date : 20^{th} of September) for the A2 group, or late winter (average date : 20^{th} of February) for the LW groups. The compact reproduction protocol (Brocard et al, 2005) was based on the exhaustive recording of all the reproduction events from the calving onwards, on the systematic diagnosis of “problem” cows by the vet (discrete heats, suspicions of metritis) before and during the AI periods, and on the implementation of systematic conception diagnoses. The aim was to group calvings naturally and without use of hormones.

Cows were dried off according to the closing date chosen for the milking parlour (23rd of July for the A2 group, 23rd of December for LW groups), the search for a minimum dry period length of 45 days, and a minimum dairy production of 2 to 3 kg per day.

1.5. SPECIFIC MEASUREMENTS

A specific protocol to assess animal welfare (Brulé et al, 2003) was added during two consecutive years to the usual measurement protocol (Portier et al., 2003). Moreover the daily compulsory work was registered at 4 key dates of the year.

1.6. DATA VALORISATION

Production data were analysed according to a mixed linear model with repeated measures on cows (SAS software). A regression model within each parity group was chosen for each production variable according to the duration of the cow in the experiment and the pre experimental associated variable. An first row self correlation structure was used for within cow differences. Covariates were an estimation of the expected productions.
Health troubles and reproductive performances were analysed the following way :
- binary variables (presence / absence of lameness e. g.…) by a logistic model ;
- census variables through an exponential regressive model (number of AIs for instance) ;
- the risk of non conception was analysed by a survival test (Cox proportional odds model).

Significance levels shown in the paper do not integrate test multiplicity corrections.
The economic analysis was made at the farm gross margin (GM) level and included all the technical results of the experiment. In each group the vet costs were estimated by multiplying the health trouble frequency of the group by the average real cost of each type of health trouble. Estimations were made for an average French farm of 280,000 l of quota and within the economic and forage background of Trevarez experimental farm.

2. RESULTS

2.1. INTAKES

The yearly intakes of stored forages varied from 2.1 to 2.4 t DM per cow according to the group, over the initial technical and economic target of 2 t DM for a system based on 0.5 ha of grazed grass per cow. This has to be related to the draught of summer 2003. The target of 2 t DM of stored forages per cow should be reached in an average climatic year with late winter calving cows. As grazing management rules were roughly the same for all the groups, no difference appeared in terms of forage intakes between the two calving seasons. The OAD cows were delivered less silage at the end of their lactation as their requirements were supposed to be lower. Grass quality and quantity were the same in the 3 groups (Brocard et al, 2005).
The average concentrate levels per cow per year in the groups were the following : 465 kg in group A2, 388 in group LW2, and 332 in group LW1. The difference compared to the expected concentrate levels is related to the early reopening of the maize silage clamp (requiring the delivery of soyabean) in summer 2003.

2.2. MILK PRODUCTION

The lactation curves showed very different shapes, autumn calvings leading to a flatter curve while late winter calvings reached a higher peak (figure 1). Though at the whole lactation scale multiparous cows of the A2 group produced some 300 extra kg of milk compared to the LW2 multiparous cows (table 3).
Only the “P” cows produced significantly more milk (+ 1.6 kg d^{-1}) with a higher fat content (+ 2.8 g kg^{-1}) when calving in autumn (table 4). In the opposite M and PM cows significantly produced a higher protein content in the autumn calving group (+ 1.3 g kg^{-1}).

Compared to the LW2 group multiparous LW1 cows lost 21 % milk per year (table 3). Nevertheless the top third of these OAD cows produced more than 6,000 l of milk per year. All OAD cow cohorts produced significantly less milk per day (- 5.5 to - 6 kg d^{-1}), with higher fat (+ 2.4 to + 3.5 g kg^{-1}) and protein (+ 2.3 to + 2.9 g kg^{-1}) contents, see table 4.

2.3. BODY CONDITION

The average body condition score at calving were close to 3.0 in each group during the 3 years. Body condition losses were relatively low and equal for groups A2 and LW2 (- 0.9 pt), and slightly lower for the LW1 group (- 0.7 pt). OAD led to a higher body condition score at the end of the lactation (2.9 vs 2.6 for group LW2 and 2.5 for group A2).

2.4. REPRODUCTION

A compact calving pattern within a 8 weeks period did not appear realistic in any of the two groups milked twice daily because of the high culling rate it would lead to (table 5) : only 58 to 61 % of the cows were in calf within 2 months. In the opposite, 81% of the OAD cows were in calf within the 2 period.
The main statistic analysis was made on the most pertinent criterion for a compact calving system : the conception rate within a 3 months period. No significant difference among groups appeared through the survival test (probability to be in calf after 3 years in the experiment) made on the parity adjusted data. The only significant difference appeared for one secondary criterion named “days open interval” which was shorter (p = 4 %) for the LW1 group compared to the LW2 group.

2.5. HEALTH AND WELFARE

The average health troubles frequency over the 3 years period is shown in table 6 (151 cows, 242 lactations). The main statistic test was made on the total health troubles frequency : no significant difference was found. But the OAD multiparous (PM + M) cows of the LW1 group developed significantly more mastitis than in the other groups (p = 9%) but “in the same time” less cases of lameness (p = 7 %).
In terms of welfare Brulé et al. showed in 2003 after two series of experiments on groups LW1 and LW2 that OAD milking might lead to some kind of “discomfort’ in early lactation few hours before morning milking. This “discomfort” vanishes quickly during the lactation as cows manage to adapt to the decrease in the milking frequency both physiologically (udder state, less milk losses) and in terms of behaviour.

2.6. CULLED COWS

Whatever the group the culled cows had a significant higher genetic merit (+ 1 kg d^{-1}) than the ones which stayed in the experiment (this difference even reached 2 kg in the LW2 group which had the highest culling rate). The culled cows of the LW1 group required a shorter fattening period (- 10 days, see table 7) thanks to their better body condition at the end of the lactation. As they were heavier and had a better conformation their sale price was higher than for the LW2 culled cows sold in the same period. The main culling reasons were mastitis for the LW1 group and infertility for the LW2 and A2 groups.

2.7. WORKING TIME

The yearly compulsory working time (WT) reached 1,800 hours for both groups with two daily milkings (for an average quota of 280,000 l). The compact calving patterns led to a strong monthly organisation of work (Brocard et al, 2005), see figure 2. The same figure applies for the late winter calvers with a start occurring 5 months later. Milking time represented some 68 % of the daily WT for both these groups.

Turning to OAD milking reduced the time spent milking to 57 % of the WT. Tasks which are proportional to cow numbers had then an increased contribution (housing management and feeding). Though 27 % extra cows were required to produce the quota, the OAD system led to a decrease by 17 % of the total yearly WT (table 8).

2.8. ECONOMIC IMPACT

The late winter calving system required 3.7 extra cows and 5.5 extra hectares to produce the same quota (see table 9) than the autumn calving system. The farm gross margin did not significantly differ from one system to the other. The dairy GM was higher by 8 € per t of milk for the LW2 group thanks to a higher beef by-product and lower feeding costs. There was no real impact of the calving season on the housing costs.

Though higher cow numbers (+ 12 cows) the LW1 group milked OAD kept variable costs under control (feeding costs below 45 € per t of milk). The higher milk price and beef by-products led to a higher dairy GM by 2,730 €. The increase in the forage area (+ 6.1 ha) decreased the crops area. Hence the farm GM difference was not significant. The potential increase in the investments might be related to the housing of the 12 extra cows required : a close spring calving pattern leads to culled cows in winter, meaning less requirements in terms of cows housing. Finally, the higher cow number must also be consistent with the environmental regulations (European Nitrates Directive, other national regulations…).

3. DISCUSSION

The heavy draught of summer 2003 led to a higher intake of stored forages than predicted (target : 2 t DM per cow per year) for a grass allowance of 0.5 ha per cow ; this level was nearly reached in 2004 thanks to less extreme climatic conditions. No difference in terms of dry matter intakes were recorded among the two calving periods we compared because of the common grazing key dates and rules (the sward heights observed did not lead to a change of that part of the protocol).

The compact calving protocol (Brocard, 2005) implemented was considered as very satisfying by the herdsmen ; such a management appeared very rational in relation to the monthly work specialisation it led to. But such a calving scheme requires the production of heifers with an age of 24 months at first calving. With Holstein high genetic merit cows a compact calving system based on a 3 months period appeared more repeatable than a 2 months system.

Finally this experiment confirmed that OAD milking can be achieved during the whole lactation on grass based systems with low feeding costs. No consequence on animal welfare was recorded as during our first experiment on OAD milking (Guéguen, 2003), or as reported by Tucker in 2007. A good initial cell counts situation remains compulsory before starting OAD milking. The decrease in the working time reached 17 % but more important for the farmer is the increased flexibility OAD milking leads to. The surveys made on Breton farms show that farmers are implementing OAD with very different options (in summer, in early lactation, at the end of the quota period…) according to their personal requirements (Michaud et al, 2007).

CONCLUSION

Within the forage system we studied none of the two calving seasons we tested appeared to be clearly technically or economically better than the other. Only climatic conditions (good grass growth in summer or not) and the farmer's personal choices in terms of holidays will help him choose among the 2 calving seasons if he dares to try compact calvings. For one dairy factory there might be complementary seasonal deliveries by farmers making different decisions (production of summer or winter milk). Turning to once a day milking - at least in early lactation - can really make it easier to reach the grouping targets.

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Table 1 : Mean grazing key dates over the 3 years period

	forecast	achieved
turning out	01/02	20/02
night outside	01/03	31/03
clamp closed	01/04	07/04
clamp reopened	15/10	30/09
night inside	15/11	04/11
end of grazing	10/12	10/12

Table 2 : Intakes of stored forages (t DM cow $^{-1}$ year^{-1})

	year 1	year 2	year 3	mean
A2	2.7	2.4	2.2	2.4
LW2	2.8	2.1	2.1	2.3
LW1	2.4	2.0	1.9	2.1

year 1 : A2 = 2002/03. LW = 2003

Table 3 : Non adjusted dairy production of multiparous cow

Group	lactation length (d)	dry period length (d)	Peak kg d^{-1}	milk (kg)
A2	304	77	33.0	7.315
LW2	299	83	37.2	6.982
LW1	296	71	30.6	5.533

Figure 1 : Non adjusted dairy production of multiparous cows

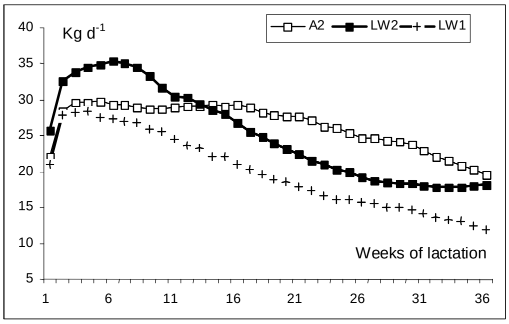

Table 4 : Dairy production by cow cohort (differences on 1 and 1.6* years and p values)

	difference A2-LW2		difference LW1-LW2	
	P cohort	PM and M cohorts	P cohort	PM and M cohorts
for a presence of :	1 year	1.6 year	1 year	1.6 year
milk kg	1.6 *(0.02)*	1.2 *(0.18)*	-6.0 *(0.0001)*	-5.49 *(0.0001)*
fat content g kg^{-1}	2.8 *(0.04)*	1.6 *(0.13)*	3.5 *(0.01)*	2.4 *(0.01)*
protein content g kg^{-1}	0.8 *(0.17)*	1.3 *(0.004)*	2.9 *(0.0001)*	2.3 *(0.0001)*

** average duration of cows in the experiment*

Table 5 : Reproduction performances (151 cows, 237 lactations)

non adj. data	C- 1st heat int. (d)	C – 1st AI int. (d)	C- concept int. (d)	conception rate 1st AI %	concept within 2 months %	concept within 3 months %
A2	41	80	102	39	61	78
LW2	47	79	98	34	58	72
LW1	42	78	87	58	81	85

C = calving ; int. = interval

Table 6 : Frequency of health troubles per year

for 100 cows	A2 group	LW2 group	LW1 group
total health troubles incl.	170	172	214
reproduction	33	21	22
mastitis	64	79	143
lameness	36	24	5

Table 7 : Characteristics of culled cows

	% cows	fattening period (d)	Carc weight (kg)	Price €
A2 group	34.5	46	280	611
LW2 group	42.7	48	293	649
LW1 group	36.5	36	306	665

Figure 2 : Working time per month (A2 group)

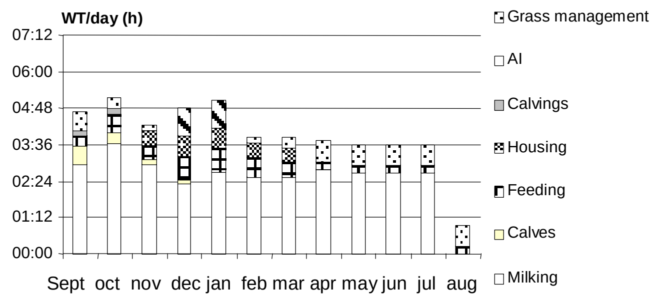

Table 8 : Total yearly working time (WT)

	LW1	LW2	LW1-LW2
Number of cows	57	45	+ 27 %
Yearly WT (h)	1490	1800	– 17 %
WT/LU/year	19h15	29h40	– 35 %

Table 9 : Main economic indicators

€	LW2	A2-LW2	LW1-LW2
Milk sold (l)	280,000	-8,100	-11,200
Number of cows	44.6	-3.7	+12
Forage area (ha)	39.3	-5.5	+6.1
Milk price t^{-1}	278.5	+10.2	+21.1
Beef product	18,193	-3,888	+4,850
Cows feeding cost for 1,000 l	38	+4	+ 6
Dairy gross margin	69,360	-2,322	+2,734
Farm gross margin	69,360	-333	+532