



## **EFFECT OF HERD MANAGEMENT SYSTEMS ON DAIRY COW REPRODUCTIVE PERFORMANCE**

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### **RESUMO**

The objective of this paper is to address the reproductive issues arising from different dairy management systems by describing divergent systems and comparing their reproductive outcomes. In general, cows in zero-grazed (ZG) systems have higher milk production and better energy balance but more of some animal health problems, lower ovarian activity postpartum, reduced oestrous expression, reduced conception success, and higher culling and mortality rates, than cows in pasture-based (PB) systems. Key environmental descriptors affecting reproductive performance within management systems include the type and duration of housing and the pre- and postpartum diet composition.

### **INTRODUCAO**

As the world's population grows global demand for milk for human consumption is predicted to rise by more than 50% by 2050 (FAO, 2011). The FAO states that this demand can only be met by large scale, intensive livestock operations. Dairy farmers have responded by increasing milk production per cow and by increasing herd size. This trend towards herd



expansion will intensify following EU milk quota deregulation in 2015 but then land area will be the new key factor limiting production indicating more producers may adopt confinement systems. This has resulted in intensification of milk production systems worldwide whether they are pasture-based (PB) (e.g. intensive rotational grazing, extended grazing season, high stocking rates) or zero-grazed (ZG) [e.g. total mixed ration (TMR) feeding, genetic selection for increased milk yield, automated milking].

As this intensification has gradually occurred dairy cow fertility has gradually declined internationally to such an extent that it has been predicted that high-performance production systems will become unsustainable by 2020 (Maas et al., 2009). Only a limited number of recent studies have highlighted the association between herd-level management factors and reproductive performance (Bach et al., 2008, Garcia-Ispuerto et al., 2007, Schefers et al., 2010). This systematic review focuses on the effects of management systems on reproductive performance in dairy herds.

### **Dairy herd management systems**

The term management system is used here as a synonym for the farm environment. The hazards within the farm environment which may impact reproductive performance include the housing, nutrition, health, genetic selection and management. The defining characteristics of ZG systems are housing all year round, outdoor access only for loafing, non-seasonal calving, total mixed ration (TMR) feeding and high milk yield per cow. The



defining characteristics of PB systems are grazing for the provision of forage for at least six months of the year with housing for the remainder and seasonal calving. According to a recent report from the EFSA, intensive systems account for 85% of all milk production in the EU (EFSA, 2009a). While only about 10% of world milk production is from grazing systems, pasture grazing is the most common system for managing dairy cows worldwide (Boken et al., 2005). As herd size increases within the EU there has been an increase in the number of farmers adopting a ZG management system (DEFRA, 2011, EFSA, 2009a). Following a review of the relevant literature (Mee, 2012), a synthesis of the main characteristics of these two contrasting management systems is shown in Table 1.

Table 1. Characteristics of zero-grazing and pasture-based dairy herd management systems.

	Zero-grazing	Pasture-based
Synonyms	Barn housed, Confinement, Factory farming, Feedlot, High-input/high-output, High intensity Indoor, Industrial, Intensive, Super dairy, Total confinement	Extensive, Grazing, High forage, Low cost, Low input, Outdoor, Pastoral, Seasonal
Duration of housing	All year round, continuous	None or seasonal in winter
Pasture usage	Loafing/exercise lot used (freestall and drylot) or not used (total confinement)	Grazing $\geq$ 6 months/yr.
Calving pattern	All year round	Seasonal (winter/spring, autumn/winter) or bi-seasonal (split).



Accommodation type	Indoor-loose: Cubicles (freestalls) with various bedding types on a concrete or sand base with slatted or solid passageways (rubber/no rubber) or bedded pens (deep litter, bedded pack, straw yard); Indoor-tied: Tie-stalls (stanchions, tethered). Outdoor - loose: open lot (earthen corral, dry lot).	Indoor: as for zero-grazing systems. Outdoors: Pasture [grasses (ryegrass, alfalfa, lucerne, Bermuda) +/- legumes (clover), rotational or set-stocked] or out-wintering pads/stand-off pads.
Complimentary feed type	TMR <sup>1</sup>	Concentrate or TMR or PMR <sup>2</sup>
Conserved roughage	Maize silage predominantly	Grass silage predominantly
Milk production	High milk volume output/cow	High milk solids output/hectare
Herd size	Large	Small-large
Milking frequency	x2, x3, AMS <sup>3</sup> (robots)	x1, x2

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<sup>1</sup>TMR = total mixed ration, <sup>2</sup>PMR = partial mixed ration, <sup>3</sup>AMS = automated milking systems

Internationally ZG is more common in some countries (e.g. Germany, Israel, Mediterranean countries, North America, The Netherlands,) whilst PB systems are more common in other countries (e.g. Argentina, Australia, Azores, France, Great Britain, Ireland, New Zealand). However, most countries have a mixture of management systems with some types predominating. Management systems are heterogeneous within system, and sometimes between years, and they continue to evolve.

### Housing versus pasture



In comparing whole farm management systems inevitably there is confounding of effects with, for example, higher milk production per cow in ZG compared to PB systems and differential veterinary dairy herd fertility service provision (Mee, 2010). Thus reproductive outcomes are due not just to management system *per se* but to the effects it has on cow health and lactational and reproductive physiology.

It is generally accepted that milk production is higher in ZG than in PB systems (by up to 20%), (Davis et al., 2006). This may be explained by greater dry matter and energy intake and lactation persistency and length in ZG systems (Davis et al., 2006). Negative energy balance [plasma glucose, insulin, non-esterified fatty acids, body condition score (BCS) loss and body weight loss] is higher in PB compared to ZG systems (Boken et al., 2005, Fontaneli et al., 2005). In addition, pasture use is associated with lower levels of some important production disorders, e.g. lameness and mastitis (Boyle and Rutter, 2013).

#### *Dairy cow reproductive performance*

A UK contemporaneous comparison of a ZG and PB system using 363 lactations from 229 cows on the same farm revealed that while the pattern of luteal activity postpartum was 'better' (earlier onset, longer luteal phases, shorter inter-ovulatory intervals, and less frequent delayed ovulation) in the PB system, reproductive performance (number of luteal cycles needed to become pregnant, conception characteristics, gestation length) was poorer (Pollott et al., 2008). The differences in luteal activity were entirely explainable by the differences in energy balance characteristics of the two systems. A recent Irish study using



46 spring-calved cows has shown that the oestrous behaviour of cows in a ZG system differs significantly from that in a PB system. There was a higher frequency of standing to be mounted, mounting other cows and ano-genital sniffing in PB compared to ZG cows (Palmer et al., 2012). As a consequence of these differences, efficiency of oestrous detection was significantly higher in PB cows, irrespective of the method of oestrous detection employed (visual observation, tail paint, radiotelemetry), though accuracy of oestrous detection did not differ between treatment groups. In addition, the intervals between calving and oestrus were longer in the ZG treatment (Palmer et al., 2010). These findings are supported by the results of a North American study with 36 cows which showed that PB cows had a significantly higher peak plasma progesterone concentration (in the first postpartum cycle), had a significantly higher estrus intensity (number of mounts received) and had a significantly higher pregnancy rate than ZG cows (Boken et al., 2005). However, management system had no effect on calving to onset of luteal activity or first estrus, duration of first estrus or number of services per conception. In agreement with these peak progesterone data, Bilby et al., (1998) found that progesterone clearance was lower in PB cows in New Zealand than in ZG TMR-fed cows in North America. A Danish study in 2,144 herds found significantly higher odds of metritis in ZG compared to PB herds (Bruun et al., 2002).

In a Dutch epidemiological study in 3,904 herds relating herd environment to herd fertility using principal component analysis, high intensity herds had a shorter interval from calving





to first service but a lower first service conception rate (Windig et al., 2005). Supporting this result, in a recent Croatian study with 860 cows early pregnancy loss rates (day 32-86 post insemination) were significantly higher in a ZG (11%) compared to a PB system (5%) and were associated with increased BCS loss and higher milk yield (Zobel et al., 2011). These results are in agreement with an earlier study in two Hungarian herds where PB cows had a higher fertility index and shorter calving interval than ZG cows (Beri et al, 1995b). Recent Danish research in 391 herds comparing ZG and PB systems concluded that cow mortality was lower in PB herds (Burow et al., 2011). In addition, the risk of mortality decreased with increasing number of hours on pasture. PB systems also had lower culling rates than ZG systems (Washburn et al., 2002, White et al., 2002).

In contrast to these results, a four-year study on a university farm in the USA did not find any significant differences in reproductive performance between a ZG and a PB system though 10% less Holstein-Friesians in the ZG survived until a subsequent lactation compared to in the PB system (Washburn et al., 2002). In addition, a North American study of 17 herds showed no relationship between conception rate and housing type (PB and ZG), (Dransfield et al., 1998). In support of these results, a semi-quantitative risk assessment carried out by the European Panel on Animal Health and Animal Welfare concluded that the risk of suffering reproductive or metabolic disorders was independent of the housing system (cubicle, tie-stalls, straw yards or pasture) (EFSA, 2009b). No conclusions were drawn from the scientific report of the panel which reviewed these systems. It is concluded that luteal



and oestrous activity is higher and metritis, early embryonic mortality and cow culling and mortality rates are lower in PB compared to ZG systems. However, there are conflicting data on effects of management system on conception metrics.

### **Variations in accommodation within housing systems**

In both PB and ZG systems there is variation in the type of accommodation provided when cows are housed. The studies reviewed here describe the effects of these variations during the housing period.

#### ***Cubicle versus tie-stall housing systems***

The incidence of some clinical animal health problems (mastitis, teat injuries and ketosis) is lower while the incidence of others (poor claw health, SCC) is higher in cubicle compared to tie stall systems (Simensen et al., 2010). Many, (Simensen et al., 2010, Lof et al., 2007, Eriksson et al., 2006), though not all (Bruun et al., 2002, Kinsel et al., 1998), studies show poorer reproductive performance in tie-stall systems compared to cubicle house systems. It is concluded that good reproductive performance can be achieved in either tie stall or cubicle management systems.

#### ***Cubicle versus loose housing systems***





It is generally accepted that the incidence of clinical lameness and of leg injuries is higher in cubicle compared to loose housing, for example, in straw courts or compost-bedded pack barns (DEFRA, 2003, Lobeck et al., 2011). Attempts to improve reproductive performance in loose housing by separating cows for one month after calving failed but milk production did increase in primiparous cows (Ostergaard et al., 2010). A recent study was carried out in Ireland on low cost winter housing systems comparing uncovered or covered loose out-wintering pads with cubicle housing. Type of accommodation did not significantly affect reproductive performance (O'Driscoll et al., 2007). It is concluded that there are insufficient studies comparing cubicle and loose housing to determine their effects on reproductive performance.

### ***Tie-stall versus loose housing systems***

Loose housing has a more positive influence on postpartum ovarian activity than tie-stalls with a greater incidence of atypical progesterone profiles and longer interval to first ovulation in the latter (Petersson et al., 2006). In addition, higher milk yields and greater longevity have been found in cows housed loose compared to those in tethered systems (Bader et al., 1987). However, Coleman et al., (1985) reported a higher incidence of retained fetal membranes and of culling for low production in open lot compared to stanchion systems. It is concluded that luteal activity may be better in loose housing compared to tie-stalls but there are insufficient data comparing reproductive performance.

### ***Floor surface in cubicle housing***



Wet and slippery flooring is associated with poorer reproductive performance (Przewozny, 2011) hence alternative floor surfaces have been tested to improve cow health, welfare and reproduction. A recent study by Kremer et al., (2010) found that cows on rubber flooring had an earlier onset of oestrus postpartum and superior reproductive performance to those on concrete flooring. In contrast, an earlier study by Boyle et al., (2007) found a negligible beneficial effect of rubber flooring on heel erosion and differences in behaviour but no effect on other claw lesions or on oestrous expression or on reproductive performance. The authors emphasised the importance of floor friction coefficient in expression of standing oestrous behaviour, a point made by other authors also (EFSA, 2009a). While soft flooring materials within the cubicle have been associated with increased milk yield, and fewer incidences of clinical mastitis, teat lesions and removal of cows, data on reproductive performance are lacking (Ruud et al., 2010). It is concluded that while floor surface affects reproductive performance, there are conflicting results on the benefits of rubber passageway flooring.

### **Variations in feeding practices within management systems: reproductive performance**

There is a substantial and growing corpus of literature on the effects of various feeding regimes on reproductive performance of dairy cows in different management systems.

#### ***Stocking rate at pasture***



The effects of SR or pasture intake on reproductive performance have not been widely investigated. Two studies have shown the benefit of high pasture intakes (unrestricted access or 11.9 kg pasture DM/cow/day) prepartum on postpartum reproductive performance (shorter post partum anovulatory interval) in heifers and in cows (Burke et al., 2007, Chagas et al., 2006).

Three recent studies have, in general, shown no effect of postpartum SR at pasture on reproductive performance across the range from 1.6 to 4.3 cows/hectare (McCarthy et al., 2011, Baudracco et al., 2011). However, Ryan and Mee (1994) reported a longer calving to conception interval for cows on tight compared to lax grazing (4 vs 8cm postgrazing height) and McCarthy et al., (2011) showed higher late embryonic mortality at low SR (2.5 cows/ha). Recently Macdonald et al., (2011) commented that cows/ha may not be the most robust measure of SR and that comparative SR (kg of cow body weight at a standard BCS/tonne of feed DM) may be more meaningful. It is concluded that these studies show that for all-year-round grazing systems, maximising pasture intake precalving benefits reproductive performance but that unless pasture intake is severely restricted, postpartum SR has negligible effect on reproductive performance.

### ***Concentrate supplementation in pasture-based systems***

Where concentrate supplementation has been practised precalving in PB systems low-fed cows tended to have better reproductive performance (onset of ovarian activity, ovulation detection rate, embryo mortality) than high-fed cows (Cutullic et al., 2011, Fahy et al., 2005)



though this is BCS-dependent (Adrien et al., 2011). In a review of the literature on dry period feeding in PB systems, Mee (2008) concluded that grass or grass-silage alone resulted in an earlier onset of ovarian cyclicity and better reproductive performance than forage plus concentrate supplement.

A series of experiments have been carried out on the effects of concentrate supplementation after calving at pasture on reproductive performance. In general, these studies have failed to show a benefit of such supplementation, irrespective of cow genotypic merit for milk production, on reproductive performance (Coleman et al., 2009, Horan et al., 2005, Horan et al., 2004). Supplementation levels varied from 350 to 2,000kg of concentrate/cow/lactation. However, Fulkerson et al., (2001) found that while cows fed higher levels of concentrates (0.84 and 1.7 tonnes/cow/lactation) had an earlier onset of ovarian activity postpartum and higher submission rates, they also had lower first service conception rates than those fed lower levels of concentrates (0.34 tonnes). This was supported by Jonsson et al., (1999) who showed that the probability of ovulation postpartum was higher in high-fed pluriparous cows (2,000kg concentrates/cow/lactation) but not in primiparous cows. It is concluded that these studies show that postpartum luteal activity is better in cows on low-feed regimes prepartum and on high-feed regimes postpartum and that conception success is generally not affected by concentrate feed level postpartum where pasture allowance is adequate.

### ***Concentrate supplementation in zero-grazing systems***



Similar to the results from PB systems, data from ZG systems show that increasing the energy density of the precalving diet (grass silage supplemented with concentrates or straw or a TMR diet offered during the dry period) is not beneficial for reproductive performance and can be detrimental (longer calving to onset of luteal activity, greater number of services/conception) (Keady et al., 2001). Such outcomes have led to the theory of limit feeding during the entire dry period and avoidance of luxury feeding to prevent over-conditioning at calving by feeding a low energy-high fibre TMR precalving (Beever et al., 2006). There is some evidence to support the effect of this controlled-energy diet feeding regime on reproductive performance using straw-based (Mee, 2008) or grass silage only (Fahy et al., 2005) diets precalving.

Earlier studies showed no benefit of high concentrate supplementation in complete diets offered postcalving for the complete lactation (2.5 tonnes) on reproductive performance (Pryce et al., 1999, McGowan et al., 1996). Reduced reproductive performance on high concentrate diets was entirely due to increased milk production. More recently the theory of feeding an insulogenic diet ('cycling diet'; e.g. high starch) in early lactation and a lipogenic diet ('mating diet'; e.g. low starch, high fat) prebreeding has been posited to reduce the calving to onset of luteal activity interval and to improve embryo development and conception success, respectively. While Garnsworthy et al., (2008) showed detrimental effects (delayed post-ovulatory progesterone rise) of a very high starch diet (230 g/kg DM), lower levels of dietary starch 160-180 g/kg DM) and fat (<44 g/kg DM) had a positive effect



on ovarian function. These results were not replicated recently by Gilmore et al., (2011), hence there is a need for larger scale confirmatory studies.

It is concluded that these results suggest that high feed levels during the dry period or postcalving in ZG systems are not beneficial to reproductive performance but that limit feeding precalving and altering postcalving dietary energy source may have a positive effect.

Whilst there are numerous studies showing effects of specific components of the diet (e.g. fat, protein, microelement and vitamin supplements, (e.g. McNamara et al., 2003, Mee, 2011), body condition score (e.g. Buckley et al., 2003), and the aberrant metabolism of modern dairy cows' somatotropic and gonadotropic axes on dairy cow reproduction, these are not management system-specific and so have not been reviewed here.

## **Conclusions**

Given the heterogeneous nature of both ZG and PB systems, comparisons between them in dairy cow reproductive performance need to be treated with caution. However, in general, cows in ZG systems have higher milk production and better energy balance but more of some animal health problems, lower ovarian activity postpartum, reduced oestrous expression, reduced conception success, and higher culling and mortality rates, than cows in PB systems. Key environmental descriptors affecting reproductive performance within





management systems include the type and duration of housing and the pre- and postpartum diet composition.

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