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PROBLEMS OF CALF REARING IN CONNECTION WITH THEIR MORTALITY AND OPTIMAL GROWTH: A REVIEW

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ABSTRACT

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Protection of calves against enteric and respiratory disorders is dependent on the passive immunity that the calf has received, its innate resistance to infection, the burden of infection in the environment and the nutrition of the calf. Superimposed on these, are the effects of management and physical environment.

The plane of nutrition required for dairy heifers during rearing depends on the age at first calving, and for meat animals depends on the carcass weight and fat deposition required at a particular slaughter date in relation to time of birth.

PROBLEMS IN RELATION TO MORTALITY

Introduction

For comparative purposes, it is important that the time span to which mortality rates refer, should be specified. Thus, calf mortality can best be subdivided into:

(a) abortions (still births at ⩽ 270 days of gestation);

(b) perinatal mortality (still births at > 270 days of gestation and mortality during the first 24 h of life);

(c) neonatal mortality (calves born alive that die between 24 h and 28 days);

(d) older calf mortality (calves born alive that die between 29 and 84 days, or between 29 and 182 days).

Under good management conditions in the developed countries, mortality rates in these classifications are approximately as follows:

(a) Abortions: 2—2.5%

(b) Perinatal mortality: 3.5—5.0%

Of these deaths, 85% are due to anoxia and the results of prolonged parturition (Greene, 1978), mostly caused by inappropriate mating, particularly of heifers. The problem arises mainly from the effect of the sire

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and dam on birth weight and musculature, but partly to the size of the pelvic opening of the dam (Menissier, 1975). Cows with difficulties at successive calvings have smaller pelvic openings (Dufour et al., 1981) and a strong correlation has been found for dystokia in Holsteins at successive parities (Thompson et al., 1981). Bull calves and younger ages at calving increase the risk. The dimensions that were most closely related to calving difficulties were the circumference of the head and nose. The role of the hormonal status of the dam and the effect of the prepartum nutrition of the dam is largely unknown, although the incidence of dystokia appears to be greater with overfat animals. Rarely, septicaemia may be the cause of death in calves within the first 24 h of life.

(c) Neonatal mortality: 3%

In this period, septicaemia and enteric disorders caused by particular serotypes of *Escherichia coli.* with or without viral involvement, or by salmonella, particularly *Salmonella typhimurium*, are the main cause of death. The susceptibility of the calf to these conditions is dependent on the passive immunity received from colostrum, the calf's innate resistance to disease, the burden of "infection" in its environment and the quality of the diet given after the colostrum-feeding period. Superimposed on these are the effects of management and the physical environment.

(d) Older calf mortality: 1% (29--84 days or 2% (29—182 days)

This period is dominated by the occurrence of respiratory infections, salmonellosis, particularly *S. dublin*, and bloat arising from the failure of oesophageal groove function in veal calves, or from the use of dry diets containing insufficient long roughage. Internal parasites, causing coccidiosis and helminthiasis are also important, particularly in the period 84—182 days, but these conditions are not considered in this review.

The microorganisms

Septicaemia arising from *E. coli* is associated with the increased virulence and tissue invasion of strains, which produce colicine V (Smith and Huggins, 1976), whereas enterotoxaemic strains that are characteristic of calves are associated with K99 antigen (Ørskov et al., 1975), which allows adherence to the mucosa of the small intestine, and with a heat-stable enterotoxin. Adherence occurs initially in the ileum and gradually progresses towards the duodenum causing stunting of the villi (Bellamy and Acres, 1979; Pearson and Logan, 1979), changes in myoelectrical activity (Burns et al., 1978), increased secretion of water and electrolytes into the lumen (Isaacson et al., 1978) and severe diarrhoea and dehydration. However, various viruses, such as rotavirus, coronavirus and epithelial cell syncytial virus may become established first and act synergistically with *E. coli.* Vaccination of pregnant cows with a vaccine containing K99 antigen may give protection to the calf by inhibiting adherence (Contrepois et al., 1978).

Interference with the balance of *E. coli* and lactobacilli in the small intestine can arise from changes in the composition of the abomasal outflow, or from the use of antibiotics (Weijers and Van de Kamer, 1965). Moreover a build-up of "infection" in a calfhouse may occur when a large number of newborn calves are introduced successively into a building (Roy et al., 1955). The rate of build-up, which is characterized by an increasing incidence of diarrhoea and mortality as time progresses, is associated with the development and dominance of enteropathogenic strains of *E. coli* (Wood, 1955) and is related to (a) the immune status of the calf, (b) the post-colostral diet and (c) probably the air space in terms of cubic capacity per calf and ventilation rate in the calf house.

Salmonella typhimurium has increased in importance relative to *S. dublin* in both the U.K. and France, and the incidence of antibiotic resistance is high (Martel and Fleury, 1979; Threlfall et al., 1979). The commonest lesion is necrotic enteritis in the ileum and in the large intestine (Wray and Sojka, 1978). The apparently lower incidence of *S. typhimurium* in the older ruminant calf, may be associated with the finding that bovine rumen fluid that contains high concentrations of volatile fatty acids has an inhibitory effect on *S. typhimurium* in vitro (Chambers and Lysons, 1979). Mice rather than rats appear to be the most important rodent vector (Hunter et al., 1976), and a lower incidence of salmonellosis has been reported in individually- rather than group-penned calves (Linton et al., 1974).

In respiratory disorders, the relative importance of bacteria, viruses, chlamydia and mycoplasma has not been elucidated, but viruses appear to be established first and exacerbate the effects of secondary bacterial invasion.

Passive immunity

The immunological status of the calf is determined by the quantity of each class of immunoglobulin (Ig) ingested and the time after birth that ingestion occurs. As little as 14 g Ig given within 12 h of birth will protect the majority of calves against a septicaemia (Aschaffenburg et al., 1951), but 300—400 g Ig given within 36—48 h of birth (equivalent to 1.7 kg/feed for four feeds from the first two milkings after parturition) are required to ensure protection against a heavy challenge of infection with enteropathogens. The Ig requirement for protection against salmonellosis appears to be non-specific and about twice that required for protection against *E. coli* (Fisher et al., 1976). With respiratory infections, high serum Ig levels in the first 2 weeks of life have been associated with reduced susceptibility at 2.5 months (Williams et al., 1975).

To prevent bacterial adherence, colostrum must be fed prior to the establishment of the microflora (Logan et al., 1977). Bacteria that are established in the small intestine before the first colostrum feed can be absorbed by pinocytosis in the same manner as for Ig (Corley et al., 1977). Moreover, the presence and multiplication of bacteria may reduce absorption by accelerating cell migration along the villi and reduce "closure time" i.e., the length of time from birth that intact Ig can be transferred into the blood (James et al., 1976; James and Polan, 1978; James et al., 1981). Microorganisms multiplying within the digestive tract may also degrade Ig (James et al., 1976). This finding and also the build-up of "infection" in calf houses may explain why serum Ig levels are lowest and incidence of diarrhoea highest in the spring (Barber, 1979; Vajda and Slanina, 1980; Williams et al., 1980; Boyd and Hogg, 1981) although colostral Ig levels are not affected.

The later that calves are fed after birth, the lower will be their Ig absorption and Ig concentrations in their blood (Stott et al., 1979b). "Closure times" to absorption of intact Ig were reported in 1973 to be 16 h for IgM, 22 h for IgA and 27 h for IgG, and it was suggested then that if colostrum feeding was delayed, a calf might be deficient in IgM (Penhale et al., 1973), which is the Ig of most importance in protection from a septicaemia (Bywater and Logan, 1974). However, recent work indicates that closure occurs at about 24 h for all Ig classes if a calf is not fed. Feeding colostrum shortly after birth promotes earlier closure, and a delay in feeding colostrum, will delay closure up to a maximum of 32 h if calves are first fed at 24 h. Even so, 50% of calves whose first feed was delayed to 24 h were unable to absorb Ig (Stott et al., 1979a).

Attempts to increase time of closure have been unsuccessful, although calves in the presence of their dams, rather than in isolation, appear to absorb more Ig (Selman et al., 1971a; Stott et al., 1976; Fallon, 1978), but very low temperature may reduce absorption (Olson et al., 1980). However, the effect of "stress" in reducing Ig absorption has not been proven (Stott, 1980).

Innate resistance

In theory, calves should ingest more colostrum suckling their dams than is likely to be offered from a bucket, but in practice 32% failed to suckle within 6 h of birth in a study in the U.K. (Edwards, 1982), whilst in the U.S.A., 42% failed to suckle within 12–26 h of birth (Brignole and Stott, 1980). Delays in suckling due to abnormal behaviour of the dam were found to be restricted to heifers. Offspring of older animals with pendulous udders and those that had difficult calvings were likely to fail to suckle. Differences in time of first suckling occurred between the offspring of different sires and low temperatures reduced the calf's desire to suckle.

Extreme dairy breeds, such as the Jersey, Guernsey and Ayrshire, seem to be more susceptible than Friesians to *E. coli* and salmonella infection (Osborne et al., 1978; Wray and Sojka, 1978; Muller and Ellinger, 1981). Friesian and Jersey calves have been shown to have a higher efficiency of absorption of Ig than have Red Danish calves (Kruse, 1970) and Friesian × Ayrshire calves were more efficient than Ayrshires in absorbing Ig from

Ayrshire colostrum (Selman et al., 1971b) and Holsteins were more efficient than Ayrshires in absorbing total Ig from Holstein colostrum (Baumwart et al., 1977). Breed differences in efficiency of digestion of post-colostral diets (Roy et al., 1970) may be due to differences between breeds in the amounts of digestive enzymes (Ternouth et al., 1976). Associated with the marked decrease in susceptibility to enteric infections as calves grow older is an increase in gastric acid production and in digestibility of protein (Ternouth et al., 1976).

Comparative breed resistance to respiratory infections differs from that of enteric infections, Ayrshire and Hereford × Friesian calves being more resistant to respiratory infections than Friesian and Jersey calves (Roy, 1971).

Nutrition

The composition of the diet fed after the colostrum feeding period may affect the incidence of enteric disease. The severity of the effect will depend on the immune status of the calf in relation to the burden of infection in the environment (Roy, 1975). "Severely" heat-treated milk and non-milk proteins, which do not coagulate in the abomasum may result in reduced gastric acid secretion (an important protective barrier to the multiplication of *E. coli*) (Tagari and Roy, 1969), reduced gastric enzyme secretion (Williams et al., 1976), reduced proteolysis with increased escape of undigested protein into the duodenum (Tagari and Roy, 1969) and reduced pancreatic enzyme secretion (Ternouth et al., 1974, 1975). In the U.S.A., but not in Europe, milk powders are classified so that "mildly" heat-treated powder can be selected for use in milk substitute diets. To be satisfactory for the neonatal calf, skim milk used in milk substitutes should contain at least 0.17 of the N as non-casein N. The value for raw milk is 0.25 and for UHT sterilised milk (135°C for 1–3 s) is 0.11 (Roy, 1980b).

It appears that whey protein, in the form of whey protein concentrate, which normally passes rapidly out of the abomasum can be well tolerated by the calf. The production of whey protein concentrate has been possible because of new developments in process technology, e.g., reverse osmosis and ultrafiltration.

Diarrhoea in suckled calves has been associated with changes in the composition of whole milk, as a result of dams grazing particular pastures (Shanks, 1950), or being sufficiently calcium-deficient to prevent the coagulation of their milk in the calf's abomasum (Johnston and Maclachlan, 1977).

Gastric stasis, followed by diarrhoea, may occur from allergy to the proteins, glycinin and β-conglycinin in soyabean flours (Kilshaw and Sissons, 1979). However, only a proportion of calves appear to become sensitised (Kilshaw and Slade, 1980). The oligosaccharides of soya flour may also be detrimental to the calf. Both problems can be overcome by the extraction of soya flour with hot aqueous ethanol.

Diets containing a low fat concentration (10 g kg^{-1} dry matter) cause increased incidence of diarrhoea in comparison with diets containing a high-fat concentration (Roy et al., 1970). Although gastric proteolysis is not affected, pancreatic enzyme activity is reduced by low-fat diets (Ternouth et al., 1974, 1975). Diarrhoea arising from low-fat diets may be caused by fermentation in the large intestine, similar to that produced by diets containing too much soluble carbohydrate. The maximum amount of hexose equivalent (glucose (g) + lactose (g) $\times$ 1.05) that should be included in a high-fat diet is about 12 g kg^{-1} live weight (Roy, 1980b).

Ruminal bloat may be associated with cold-milk feeding or the inclusion of some non-milk proteins in the diet, and appears to be due to failure of oesphageal groove function and resultant passage of the diet into the rumen. Fermentation of carbohydrates, e.g., supplementary glucose or those present in vegetable protein sources may cause abomasal bloat. The claim that the use of acidified milks reduced the incidence of diarrhoea has not been proven.

Weaning at a young age, i.e., 5 weeks rather than at a later age, and the physical environment, e.g., a low relative humidity at a high environmental temperature and a high relative humidity at a low environmental temperature, may all increase the susceptibility of calves to respiratory infections (Roy et al., 1971; Roy, 1973). In contrast a very high dry matter concentration in a milk substitute to achieve very high growth rates (1.57 kg day^{-1}) and a high carcass fat concentration may increase the susceptibility to respiratory infections and the risks of dehydration (Stobo et al., 1979).

PROBLEMS IN RELATION TO GROWTH

These are concerned with the selection of the most economic plane of nutrition required for a particular form of production. Except for veal production, calves should be weaned on to dry food at the youngest age possible to achieve a low mortality and the desired weight gain. For the dairy heifer, the optimum plane of nutrition will be dependent on the age at puberty that is required for a particular calving age. For the meat-producing animal, the optimum plane of nutrition will depend on the intended date of slaughter in relation to the date of birth, the desired weight of carcass, and the desired degree of fat deposition.

The relative economic efficiency of size of breed, in relation to feed availability and protein metabolism (Roy, 1980a), for milk or meat production has yet to be established.

Dairy heifers

Prediction in the calf stage of subsequent milk yield, composition, fertility and longevity has not been achieved. Very high growth rates during the rearing of heifers, particularly arising from the use of high-cereal diets, can be detrimental to subsequent lactation. It is not known to what extent this detrimental effect is associated with changes in metabolic hormone concentrations in the blood, particularly of growth hormone and insulin, with changes in rumen fermentation patterns leading to a high proportion of propionic acid, and with increased fat deposition in the udder. Nor is it known whether the detrimental effect occurs during any particular period during rearing, i.e., before puberty, between puberty and conception or during gestation, or whether very high growth rates during all of these periods may have an adverse effect.

The effect of environmental factors, such as light, on feed conversion efficiency, growth (Peters et al., 1978) and age at puberty (Roy et al., 1980) is still largely unknown.

Meat animals

Cattle seem unable to compensate for low growth rates during the first 3 months of life (< 10 g kg^{-1} body weight per day), and thus cannot catch up in weight during the first year of life (Wardrop, 1966). Although after scaling for mature weight (Taylor, 1980), little differences occur between beef breeds in carcass composition at the same stage of maturity, it is not known whether there are discrete classes of muscle:bone ratio for dairy and beef cattle.

Large gaps in knowledge exist in the factors controlling food intake in growing cattle. For instance, greater dry matter intakes may be achieved by pelleting concentrates with roughages rather than by giving them separately (Thomas and Hinks, 1982).

CONCLUSIONS

From this brief review is should be clear that problems of calf mortality and ill-health dominate the field of calf rearing. However, the establishment of optimum growth curves during different periods of life for particular forms of milk and meat production using specific breeds in particular farming systems and economic and environmental conditions is clearly going to be an area of increasing importance in the future.

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RESUME

Roy, J.H.B., 1983. Revue sur les problèmes de l'élevage des veaux en relation avec leur mortalité et leur croissance optimale. *Livest. Prod. Sci.*, 10: 339—349 (en anglais).

La protection des veaux contre des troubles digestifs ou respiratoires dépend de l'immunité passive que le veau a reçue, de sa résistance innée aux infections, du taux d'infection du milieu ambiant et de la nutrition du veau. S'y ajoutent les effets du ménagement des animaux et du milieu physique.

Le niveau de la nutrition nécessaire des veaux d'élevage dépend pour les génisses laitières, de l'âge du premier vêlage et, pour les animaux de boucherie, du poids de carcasse et de l'état d'engraissement recherchés à un âge à l'abattage donné.

KURZFASSUNG

Roy, J.H.B., 1983. Probleme der Kalberaufzucht unter besonderer Berücksichtigung der Mortalität und des Wachstumsverlaufes; eine Literaturübersicht. *Livest. Prod. Sci.*, 10: 339—349 (auf englisch).

Schutz von Kälbern vor Erkrankungen der Verdauungs- und Atmungsorgane ist abhängig von der passiven Immunität des Kalbes und von seiner angeborenen Widerstandsfähigkeit gegen Infektionen, von der Infektionsbelastung seiner Umwelt und von seiner Ernährung. Die Auswirkungen von Management und der Umwelt sind diesen Faktoren übergelagert.

Die erforderliche Aufzuchtintensität ist bei Färsen der Milchrassen vom Alter beim ersten Kalben abhängig. Bei Tieren für die Fleischproduktion sind das beabsichtigte Schlachtkörpergewicht und der gewünschte Verfettungsgrad am Zeitpunkt der Schlachtung, unter Berücksichtigung des Geburtstermins, massgebend.