The economics of optimal health and productivity in the commercial dairy

D.T. Galligan

Center for Animal Health and Productivity, New Bolton Center, School of Veterinary Medicine, University of Pennsylvania, 302 West Street Road, Kennett Square, PA 19348, United States of America

Summary
Dairy production practices are changing; in order to remain viable, producers must optimise the health and productivity of dairy herds in economic terms. Health care is important in economic terms because disease can substantially reduce the productivity of individual animals. Preventive disease control programmes can thus result in economic gains for the dairy producer. The author describes new approaches to preventing postpartum diseases and dealing with fertility problems which can result from these diseases. Other aspects of dairy production are also changing, employing new technologies where these are judged to be profitable. Innovations include: the use of bovine somatotropin; systematic breeding/culling programmes; new mathematical modelling techniques to determine optimum feed composition and to define optimal growth levels for accelerated heifer-rearing programmes; the use of computers to collect, store and analyse data on animal production and health; and semen selection programmes. Increasing awareness of bio-security is also vital, not least because of the large investment present in dairy herds. Whatever practices are employed, they must offer economic returns to producers that compete with alternative uses of capital. Optimal levels of disease control must be determined for a particular production situation, taking into account not only the economic health of the producer, but also the well-being of the animals.

Keywords

Introduction
Commercial dairies are in the business of producing the raw inputs for use in the production of dairy products. As in any business, dairies desire to see a return on investments and thus have adopted new management strategies aimed to improve economic well-being. The adoption of these strategies has improved the quality and production efficiency of dairies and has provided the consumer with a relatively cheap supply of dairy products. Consumers spend a lower percentage of their income on dairy products than was the case fifty years ago. Production per cow has increased and herds have increased in size to capture economies of scale benefits (Figs 1 and 2). In concert with these changes, the number of producers has decreased, causing many socio-economic changes in agricultural communities (26). Furthermore, consumers are concerned about scientific based production practices and thus have questioned the adoption of emerging technology; public concern about food safety is also increasing.

Environmental stewardship is another issue confronting the commercial dairy. As herds become larger, the environmental impact of dairy farming becomes more visible and is concentrated. Many forms of legislation are emerging that impose constraints, and thus costs, on the production of milk.
Approaches to disease on the commercial dairy

It has long been understood that many diseases of domesticated animals can decrease productivity. The broad dimensions by which disease can affect the productivity of a herd are as follows:

a) reduced productive life (those that die or are culled prematurely due to low production or poor fertility)

b) less accurate genetic selection (true productive capacity is hidden from the selection process)

c) reduced management efficiency (planning in terms of available replacement animals and feed requirements is compromised) (5, 22).

The magnitude of the effect of a disease on these different dimensions varies according to the disease in question. Most of the 'devastating' and zoonotic diseases have been eliminated or brought under strict control by government intervention in order for a viable dairy industry to even exist in a given region. Milder diseases, with relatively milder effects on production, are controlled at the producer level. These diseases can be viewed as economic opportunities for producers when health care programmes exist that offer a favourable return to the producers, relative to other investment options. Hence, on the dairy, the control level of a disease is in competition for resources with other options available to improve herd profitability. If effective and economic health care programmes are not yet defined for a disease condition, the condition is then viewed as part of the inefficiency of production.

Health care programmes can be divided into two broad categories: reactive and proactive. Reactive programmes are those interventions where treatment is given as and when a disease condition occurs in the animal. These approaches are used for conditions that often have minimal effects on current and future productivity, are not contagious to other productive units, have cheap and effective treatments and for which preventive programmes do not exist or are expensive to implement. Milk fever, ketosis and displaced abomasum, when at low incidence levels, are often controlled by reactive interventions. Trends in development of reactive programmes are to improve effectiveness, reduce costs, and develop protocols that allow the producer to deliver the intervention. Reactive programmes have been the backbone of veterinary training and health care services to dairy producers since the 1950s (19).

Proactive health care interventions aim to prevent the occurrence of a disease condition. This type of intervention is ideal when the disease condition has dramatic effects on production or on the productive integrity of other units (infectious disease), or if the condition occurs at a high frequency. Decreasing pre-partum calcium intake or the use of the controversial anionic diets might prevent milk fever at high levels of incidence. Bio-security and vaccination programmes are other excellent examples of the proactive dimension of health care.

Infertility in the dairy herd represents a disease syndrome that sharply contrasts with the two broad dimensions of health care described above and demonstrates the evolution occurring in veterinary health care services. Traditional veterinary reproductive services were based on finding problem cows and treating these animals with the hope of improving fertility. Under this system, all cows were checked for postpartum conditions and those diagnosed with conditions (poor involution and/or infection) were treated or rechecked at a later date. The value of this clinical activity and of the treatments is questionable. Current infusion treatments for uterine infections are highly controversial with mounting evidence demonstrating their ineffectiveness in improving fertility (30). The end result of this form of intervention is ultimately a delay in conception, either due to real biological
pathology, or to management error in delaying the breeding of a proportion of cows that would have conceived.

Systematic breeding programmes (prostaglandin [PG] target programme [9, 25] and Ovsynch [25]), are emerging reproductive interventions that are focused on getting cows pregnant at a faster rate through the systematic use of synchronisation programmes. The focus of these programmes is not to try and find problem animals (via postpartum palpation, or reproductive status checks), but to have a system that ensures a high probability that cows will have the opportunity to conceive. These programmes represent a fundamental change in the philosophy of veterinary reproductive services, which are rapidly becoming integrated into dairy herds.

Figure 3 gives an overview of the target-breeding programme. Cows enter the programme after the voluntary wait and are given a PG injection on a given day of the week (Friday for example). Injected cows are observed for heat on Monday and Tuesday of the following week and bred on signs of oestrus. Approximately 70% of cows should be in heat or coming into heat, however the heat detection efficiency of the farm will determine the proportion bred after this first injection. Cows injected with PG, but not seen in heat are given a second PG injection two weeks after the first injection (Friday again) and bred either on signs of heat or timed bred (72/80 hours after injection). Approximately 100% of cows should be coming into heat after the 2nd injection and thus can be timed bred especially if heat detection efficiency is low. Figure 4 shows the improvement in reproductive performance (higher pregnancy rate) of cows on the target-breeding programme.

Disease and milk production

Diseases can affect production in a number of dimensions as stated earlier. Estimates of the cost of these effects depend on the relative value of inputs/outputs and the system of

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**Fig. 3**
Target-breeding programme: an overview

**Fig. 4**
Target-breeding programme: improvement in reproductive performance

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EED: early embryonic death
PG: prostaglandin
evaluation used. Recent estimates of the cost of postpartum diseases (2, 16) support the statement that diseases can be expensive and are economic opportunities for producers practising preventive programmes (Table I).

### Table I

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mortality</th>
<th>Culling</th>
<th>Milk loss (lbs/kg)</th>
<th>Extra days open</th>
<th>Cost/case (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displaced abomasum</td>
<td>2%</td>
<td>10%</td>
<td>840/391</td>
<td>5</td>
<td>$340</td>
</tr>
<tr>
<td>Milk fever</td>
<td>8%</td>
<td>12%</td>
<td>1,100/499</td>
<td>5</td>
<td>$334</td>
</tr>
<tr>
<td>Ketosis</td>
<td>1%</td>
<td>5%</td>
<td>440/200</td>
<td></td>
<td>$145</td>
</tr>
<tr>
<td>Dystocia</td>
<td>4.1%</td>
<td></td>
<td>1,551/704</td>
<td>33</td>
<td>$379</td>
</tr>
<tr>
<td>NAAAB=5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retained placenta</td>
<td>1%</td>
<td>18%</td>
<td>750/340</td>
<td>19</td>
<td>$285</td>
</tr>
</tbody>
</table>

Postpartum diseases are major components of health care events in the life of a dairy cow (1, 7, 17). Approximately 50% of lactations are associated with at least one postpartum disease and these diseases account for 8% of all disease conditions occurring on a dairy farm (mastitis and lameness predominating). The presence of one postpartum disease increases the risk of infection by another, the animal is also at greater risk from other disease conditions that occur in later lactation. Postpartum diseases tend to occur within three weeks of parturition, suggesting common aetiological factors. Nutritional strategies have been developed for the prevention of most postpartum conditions. Veterinary nutritional services are often first utilised in the correction of one of these problems (8). Commercial producers are interested in these diseases because many of the postpartum diseases can be prevented by sound management practices.

Production level as a causal factor of disease has been suggested. Most studies suggest that increased production is a risk factor for mastitis but not a risk factor for other disease conditions (retained placenta, metritis, ovarian cyst, milk fever, ketosis, abomasal displacement) (17). Bovine somatotropin, a product which increases milk production by 12%-15%, has not been associated with increased disease events.

Increasing milk yields have been weakly associated with reduced fertility. Ferguson reported that first service conception rates decreased by approximately 1% to 3% per 10 pound increase in milk at insemination (10). When 39 herds were stratified by median milk yield, only ten herds had significant differences in first service conception rates between top and bottom production levels. Nebel and McGillard (24) looked at reproductive indices across 4,550 herds and found a weak antagonistic relationship between production and first service conception rates (Fig. 5). Selection for high milk yield has favoured endocrine profiles that support lactation rather than reproduction.

Dairy farms convert resources (forages and grains) into dairy products valued by society. Intensive dairy production systems use resources that have competitive uses while extensive practices tend to use inputs with limited alternative uses. The availability and cost of input resources will vary with geography and thus influence the nature of dairy production in a given region. New technologies are constantly emerging in a number of dimensions that will continue to change the nature of the dairy operation. These technologies are evaluated by producers in terms of the economic returns and risk attributes of each, and many are profitable. In fact, the failure to implement these proven technologies incurs a lost opportunity cost to the dairy operation, in the same manner as failing to address a disease issue which limits production. Hence, modern dairying requires the producer to select and integrate an increasing number of inputs into the production system (13, 14, 15). Many of these new technologies are in the form of products available for use on the farm. Type 1 and Type 2 error analysis has been used to evaluate the economic feasibility of product use on the farm (14). This methodology compares the cost of making the wrong decision:

- a) using a product and having it fail, with
- b) the decision to fail to use a product that might have worked.

A brief discussion of current technologies and management strategies that are emerging on successful commercial dairy herds is given below.

### Recombinant DNA technology: bovine somatotropin

A form of recombinant DNA technology is being used in the United States of America (USA) to increase milk production to the order of 12%-15% per cow per day. The product changes the shape of the lactation curve, decreasing the disparity
between milk yields early in lactation with those occurring later, thereby decreasing the value of a day open. Much feared effects on animal health have not been seen in the field application of this technology. Simulation models suggest it is a viable economic investment for most dairies (14, 21). Furthermore, because the economic efficiency emanates from the reduction in maintenance cost of the animal per unit of milk produced, this technology offers a significant approach to dealing with environmental issues.

**Systematic breeding programmes**

As mentioned above, systematic breeding programmes are now being developed and implemented on commercial dairy herds (9, 23). By using new technologies and new strategies, the proper timing of semen placement with ovulation can occur in a routine fashion, improving the pregnancy rate of herds. Because of the relative low cost of implementation and the high value of a cascade of benefits, these technologies are economically lucrative for most producers whose reproductive efficiency is marginal.

**Systematic culling programmes**

Equally as important as efficient breeding procedures is the decision to stop breeding cows because a better investment opportunity exists (3, 4, 11, 18, 20, 27, 31). Current culling programmes on many farms are based on the occurrence of a biological dysfunction that results in the premature removal of an animal. However, in any herd there might exist a population of cows, whose future economic productive capacity is lower than that of a replacement animal or an alternative investment. These animals are 'diseased' and confer a lost opportunity cost to the production system in the sense that a better economic investment exists. Computer models are being developed and implemented in the field to identify these animals and to help producers identify the optimal time for removal.

**Mechanistic ration formulation strategies**

Nutrition is an important area of the dairy operation that affects profitability. It is the largest cost centre in the production of milk (50%-60% of total production cost) and it has direct effects on production, health and reproductive efficiency (8). Mechanistic ration formulation programmes are evolving (e.g. CPM – Cornell Penn Minor – dairy nutrition model) to replace traditional nutrient accounting models (e.g. DairyLP) (12). Traditional ration formulation models used linear programming to find the least cost combination of feeds that fulfill an established nutrient requirement for a given physiological condition (body weight, milk level, reproductive status, etc.). Substantive savings in feed costs, approximately 15%, have been realised on farms using this technology (8). New emerging mechanistic models take advantage of known attributes of rumen physiology to allow greater production responses to feed inputs. In these models, nutrient requirements are dependent not only on the physiological status of the animal, but in addition, are influenced by the physical attributes of the feeds themselves. These models are also attempting to formulate rations for amino acids in a similar manner to ration formulation strategies now employed in swine and poultry production.

**Computer-based herd health record collection systems**

A number of record systems have evolved to record the health and production events of each individual cow within a herd. These systems have improved dramatically and are in widespread use. Furthermore, new data processing methods are allowing for this data to be converted into useful information for decision-making. Not only are computers being used to collect and store data, but also innovative applications of decision science methodologies are being developed to use this information in decision-making on the dairy (3, 4).

**Accelerated heifer-rearing practices**

Average age at first calving is gradually being reduced from a long-standing average of 27 months to 24 and even 22 months (6, 26). New concepts in nutrition are allowing for more rapid gains to be realised (up to 1.8 lbs or 0.82 kg per day) without compromising the productive integrity of the animal. The exact optimal level of growth that can be achieved is controversial but is being defined in dynamic programming models to capture seasonal (feed prices, feed availability) and physiological advantages (onset of puberty, gain-production penalties) (28).

These programmes substantially reduce costs of rearing heifers, in addition to reducing the environmental pollutants which are a by-product of heifer rearing. Furthermore, by reducing heifer rearing cost and thus animal replacement cost, costs associated with diseases that have an increased culling component are also reduced. Contract rearing of heifers is becoming popular as a way of focusing management expertise on both the milking and the replacement herd. In areas where high land values restrict expansion, producers can move the replacement herd to distant regions and thus increase the milking herd density per acre.

**Semen selection programmes**

Approximately 70% of dairy cows in the USA are artificially inseminated with semen from bulls from commercial insemination centres. With the advent of systematic breeding programmes, the use of semen is likely to increase as timed breeding increases in frequency.

Control of semen cost will determine the number of breeding attempts that can be made for a cow and thus influence reproductive strategies and culling policies. Linear programming in the selection of bulls has been used to substantially reduce the cost of semen per breeding (case application realised a 52% reduction in semen cost) (15).
Bio-security

Bio-security is becoming an increasingly important issue in commercial dairying due to a number of factors. First, commercial herds represent a substantial investment in capital that must be protected from the occurrence of devastating disease outbreaks. Failure to implement appropriate vaccination programmes resulted in bovine virus diarrhoea (BVD) outbreaks with significant mortality in dairy herds in Canada and Pennsylvania. In 1996, a survey of producers in Pennsylvania revealed that only 20% of dairy cattle were appropriately vaccinated for BVD.

An additional reason for increased interest in bio-security issues is the need for dairy herds to expand periodically. As milk prices continue to decline relative to the cost of inputs of production, producers must expand to maintain net farm income. Additional production units are either raised internally or purchased. A major obstacle to expansion by the purchase of animal units is the risk of importing new diseases to a herd.

Increasing consumer concern regarding food safety, warrants an increased responsibility on the part of the producer to follow defined animal husbandry practices that minimise the risk of disease occurrence. This concern has increased as communication of food safety problems has become more pervasive and as human health issues have been associated with animal diseases (e.g. Johne's disease and Crohn's disease) (29, 32). Consumers are demanding that animal products not only have certain quality attributes but that the production processes used minimise the risk of food safety hazards.

Conclusion

In summary, commercial dairy producers are constantly searching for new investment opportunities to improve or maintain the economic viability of dairy operations. The opportunities exist in many dimensions, from controlling a disease, to using new technologies, to the computer algorithms that determine appropriate culling strategies.

New technologies will continue to emerge, especially in the areas of biotechnology and information management. Successful producers will accept these changes, selecting the appropriate combination of investment opportunities that will maximise economic returns for a selected level of risk (13). Commercial herds that fail to embrace economically efficient changes will have difficulties in maintaining a viable operation. Consumers will continue to enjoy cheaper and safer dairy products.
Economía de la optimización sanitaria y productiva en la ganadería lechera industrial

D.T. Galligan

Resumen
Los métodos de producción lechera están cambiando; para asegurar su viabilidad, los ganaderos deben optimizar, económicamente hablando, el estado sanitario y el nivel de productividad de sus rebaños lecheros. En términos económicos, la atención sanitaria es importante porque ciertas enfermedades pueden mermar sustancialmente la productividad de un animal. De ahí que los programas de prevención de enfermedades puedan redundar en beneficios económicos para el productor. El autor describe nuevos sistemas para prevenir enfermedades puerperales (postparto) y tratar ciertos problemas de fertilidad derivados de esas enfermedades. Hay otros aspectos de la producción lechera que también están evolucionando, con la incorporación de nuevas tecnologías cuando se considera rentable. Entre otras innovaciones se observan las siguientes: el uso de somatotropina bovina; la aplicación de programas sistemáticos de selección y descarte; nuevas técnicas de modelización matemática para determinar la composición idónea de las dietas y definir niveles óptimos de crecimiento en programas de cría acelerada de terneras; el uso de ordenadores para obtener, registrar y analizar datos relativos a la producción y la salud de los animales; y la aplicación de programas de selección de semen. No menos importante es la creciente sensibilidad existente en torno a cuestiones de seguridad biológica, sobre todo considerando las cuantiosas inversiones que absorben hoy los rebaños lecheros. Con independencia de los métodos que se apliquen, éstos deben ofrecer al ganadero beneficios económicos capaces de competir con otros usos alternativos del capital. Para cada contexto pecuario concreto debe determinarse el nivel óptimo de control sanitario, teniendo en cuenta no sólo la salud financiera del ganadero sino también el bienestar de los animales.

Palabras clave
References


