Aligning health and welfare principles and practice in organic dairy systems: a review

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This review provides an assessment of research findings into the current practices and standards and the principles and aspirations for organic dairy production, with respect to the health and welfare of the dairy cow. The relationships between the four main factors: management, environment, genetics and nutrition and their impact on the health and welfare status of organic dairy cows are considered. The concept that good animal health and welfare is more than merely the absence of disease, with behavioural aspects of health and welfare such as physiological and psychological needs, is also discussed. These factors are inter-related and important in all dairy systems, irrespective of whether the system is organic, low-input or intensive. Incidences of individual clinical and sub-clinical diseases that are recorded in conventional dairy systems also occur in organic dairy systems, with infertility, lameness and mastitis being the major problems. However, the magnitude of the incidence of many of these diseases may be either lower or higher in organic systems due to different management practices and the standards defined for organic milk production that, for example, prohibit the routine use of conventional medicines and require the feeding of high-forage diets. In relation to different systems, it is important to note that contrary to a common assumption, good welfare does not necessarily occur with more extensive systems. The type of organic system (self-sufficient, purchased-feed) also has the potential to have a major influence on the incidence of health problems and the reproductive status of organic dairy herds. Health status is also influenced by environmental and welfare factors, including the method of rearing replacement animals, type of housing and the geographical and climatic conditions of individual farms. Overall, this review identifies where conflicts arise between current practice and the organic principles and standards, and aims to provide suggestions to bring about further improvement in organic dairy health and welfare.

Keywords: organic milk production, dairy cows

Implications

The aim of this review is to provide an overview of research conducted into the health and welfare status of organic dairy cows and to how to better align practice with the principles and standards of organic farming to bring about further improvements in dairy cow health and welfare.

Introduction

The ‘principles’ and standards of organic agriculture, as defined by the International Federation of Organic Agriculture Movements (IFOAM) and within EU Regulation EC2092/91 as amended (EC1804/99), state that livestock should be managed with special care for their health and welfare. Management strategies should also satisfy the animals’ behavioural needs, and not merely avoid cruelty. The Farm Animal Welfare Council (2005) refers to this as ‘positive animal welfare’. In 1946, the World Health Organization defined health as ‘a state of complete physical, mental and social well-being and not merely the absence of disease’ (WHO, 1946). The main objectives for organic livestock production (EU Regulation EC, 1991 as amended (EC, 1999)) that are relevant to health and welfare in organic dairy production include:

- To keep animals in good health and increase their ability to resist infection, parasites and metabolic disease through excellent husbandry practice and health planning;
- To keep animals in ‘natural’ systems, balancing production levels with their health and welfare needs;
- To provide ‘natural’ living conditions, allowing access to pasture whenever possible, to allow the expression of
innate behaviour according to the physiology of the animal;
- To maintain a 'closed' system when possible, including maintaining a self-replacing herd, and reducing reliance on external inputs;
- To limit animal health problems by selecting appropriate (traditional or local) breeds, using high-quality feeds, providing regular exercise and keeping the correct stocking density;
- If an animal becomes sick or injured, despite all measures for prevention, preference is given to homeopathic or herbal approaches.

In both conventional and organic herds, the main challenges to health are lameness, mastitis and infertility, with all three multi-factorial problems associated with the majority of cows being culled from the herd (Lotthammer and Wittkowski, 1994). The incidence of these three issues in organic or conventional dairy systems is briefly covered here. However, the impact of the four main factors: management, environment, genetic, and nutrition on these health and welfare issues in organic dairy cows are covered in the relevant sections. In particular, lameness and mastitis provide challenges to achieving better welfare standards for dairy herds, irrespective of whether they are under conventional or organic management, with mastitis control more problematic for the organic farmer due to the restriction on the routine use of antibiotics. It is difficult to draw definite conclusions as to whether the incidence of these health problems is greater in either organic or conventional dairy systems, because of the variation (in scale, milk yields, management system and so on) that exists among both organic and conventional farms, resulting in disparity between research findings comparing organic and conventional systems. There are a multitude of causes that can contribute to the incidence of lameness, with large individual variations in severity occurring between farms due to differences in environment and the standards of husbandry applied. In a comparison of conventional and organic dairy herds, Rutherford et al. (2009) reported the average incidence of lameness to be statistically lower on organic farms (16.1% v. 21.2%) but with large differences between the levels of lameness on the individual farms that were recorded in both groups. Overall, the paper showed that the major factors influencing lameness were age at first calving and length of the summer grazing period and as the organically managed dairy systems had longer grazing seasons and a higher age at first calving this meant that, on average, the organic farms had lower lameness.

Similar to the problem of lameness in organic herds (Rutherford et al., 2009), the incidence of mastitis varies widely between organic herds. Studies of organic and conventional herds has shown an average incidence of clinical mastitis that is either slightly lower or similar in the lower yielding organic herds than the average for conventional herds but with both an increased level of somatic cell counts (SCC) (indicating sub-clinical mastitis) and incidence of mastitis during the dry period in organic herds (Hovi and Roderick, 1999; Weller, 1999; Sato et al., 2005; Fall et al., 2008). Infertility is a major reason for culling in many herds, with similar average calving intervals recorded in conventional and organic herds (Haskell et al., 2007).

The use of pharmaceuticals in organic systems

Pharmaceuticals, such as antibiotics, may be used under organic standards and under the advice of a vet, if they are the best way to reduce suffering, save life or restore health. Organic standards aim to prevent animal products that may have been affected by pharmaceuticals from entering the food chain and the emphasis in the standards is on withdrawal periods for medicines and removal of organic status from livestock rather than preventing their use when required by an animal. For example, organic standards state that if livestock are treated with pharmaceuticals for more than three courses of treatment within 1 year or for more than one course of treatment if their productive life cycle is less than 1 year, the animals concerned or their produce may not be sold as ‘organic’ and the livestock must undergo conversion back to organic status (subject to agreement from the inspection body). However, organic standards have been the target of criticism in the farming press (Andrews, 1991), due to a restriction on the routine use of antibiotics and anthelmintics. This may be due to a misinterpretation that the restriction is against their use on a routine prophylactic basis rather than their use as and when required. Furthermore, criticism may be due to the potential time delay between the onset of sub-clinical disease and the visible clinical signs/diagnosis, with concerns that the animal’s health and thus welfare is compromised in the period in between. The exact point at which a sub-clinical disease starts to cause ill health and compromise welfare is impossible to define. Applying the WHO definition of positive health, then even a sub-clinical infection is not in agreement with the aspirations of organic principles. However, if an animal is to be allowed to acquire immunity to an infection to which it is likely to be exposed to throughout its life, then some exposure to the infection is required to elicit an immune response and to develop this natural protection. However, whilst it is the intention to maintain animals in an environment that allows them an optimal chance of maintaining their health status (through good nutrition, management and genetic selection), unforeseen circumstances can disrupt the system, resulting in a disease outbreak.

To avoid animals suffering from the effects of a sub-clinical infection, the dilemma is whether it is better to give a prophylactic treatment or not. Is animal welfare less compromised if animals are able to avoid unnecessary treatments with veterinary medicines? For example, gastrointestinal tract (GIT) parasites are a real and immediate threat to ensuring the welfare and health of dairy cattle and, in particular, replacement dairy heifers. Organic livestock standards allow for animals to be treated for parasites in the case of a known problem/diagnosis under supervision.
Man from a qualified veterinarian. However, it is important to recognise that GIT parasites could cause significant subclinical discomfort and pain to an infected animal prior to a confirmed diagnosis. Certainly, the routine use of anthelmintics is not a sustainable management tool for controlling internal parasites in either conventional or organic livestock systems. Both overuse and inappropriate use of anthelmintics has led to the emergence of parasites that are resistant to anthelmintic treatment (Jackson and Coop, 2000). Organic standards encourage the use of grazing management strategies, such as mixed or alternate grazing (Marley et al., 2006) to control internal parasites. Alternative approaches currently being used and developed include the use of vaccination (Dominguez-Torano et al., 2000), nematophagous fungi (Larsen, 1999), genetic selection of hosts with natural resistance/resilience (Beh and Maddox, 1996), dietary supplementation (Coop and Kyriazakis, 2001) and the use of alternative forages (Marley et al., 2003 and 2005).

The impact of the four main factors: management, genetics, nutrition and environment on health and welfare in organic dairy cows are now covered, with a separate section for each.

Management factors

Health planning
In the UK, health planning is compulsory for farmers wishing to obtain organic certification. The focus of 'positive health' is to devise health plans that actively promote health rather than relying on chemical prophylaxis to support bad management or exploitative farming practices (Hovi et al., 2004). An analysis of the key principles of health and welfare plans and planning and details of how health and welfare plans are promoted and implemented by British governments, industry quality assurance and organic certification bodies has been covered in a recent review (Nicholas and Jasinska, 2008). This review highlighted that whilst farmers often undertake health planning to prevent or reduce disease problems, many farmers regarded health plans as a paper exercise that are more for the benefit of others. As proposed by Nicholas and Jasinska (2008), a simplified health plan may be a way to implement and encourage the practical application of health plans as part of a whole farm management plan on both conventional and organic farms. The main principles of animal health and welfare planning identified included, for example: to identify the current disease status, ensure bio-security, monitor health data records, to obtain veterinary involvement, to aim to reduce the use of veterinary medicine, to explicitly address animal welfare, to encourage the use of preventative management and to make health plans available to all staff working with livestock.

Calf management
The principles of organic farming encourage dairy farmers to rear calves under a system that is as close to ‘natural living’ as possible. Under natural conditions, mothers would leave calves in a group from about 2 weeks of age, whilst they graze nearby (Webster, 1994) and weaning would be introduced gradually at approximately 6 to 8 months

Summer mastitis (mainly caused by Actinomyces pyogenes (previously Corynebacterium pyogenes) and Streptococcus dysgalactiae pathogens) is a risk for herds with an autumn or a year-round calving pattern as the timing of the dry period has an influence on the incidence of mastitis during lactation (Cousins et al., 1980; Roberson et al., 1994). The incidence of this type of mastitis rises dramatically during July to September, as flies cluster around the teat orifice causing considerable irritation (Blowey and Edmondson, 1995). This type of mastitis is painful with cows suffering from a high temperature, stiff hocks and lameness and also leads to permanent udder damage, the risk of increased culling and financial loss. Smith et al. (1985) reported that 50% of mastitis cases during early lactation were attributable to intra-mammary infections that occurred pre-calving. In organic herds where the routine use of long-acting antibiotics is prohibited, the risk of subsequent infections in the lactation is increased. Avoiding the grazing of fields that are adjacent to habitats frequented by flies and the use of teat sealants is essential (Klocke et al., 2006) to minimise the problem in organic herds.
(Phillips, 1993). The main welfare implications for rearing calves under current dairy practice, some of which apply to both conventional and organic dairy systems, are: isolation from their mothers and conspecifics, reduced space allowances, barren unnatural environments and poorer nutrition as diets are based on reconstituted milk (Broom, 1991; Le Neindre, 1993). Whilst the organic standards within some individual EU countries do, the current EU organic standards do not state a requirement or provide guidance on the best time to separate dairy calves from their mothers despite the potential impact of this factor on both the short-term and the long-term performance, health and welfare of both animals. Most organic dairy farmers, like conventional farmers, remove calves from their mothers within the first day of life. In some countries, for example, on some farms in Finland, calves are allowed to remain with their mothers until 3 or even 11 weeks old. It has been shown that short-term suckling can have benefits in terms of performance, udder health and the behaviour of both calf and cow when compared with systems separating calves from their mothers immediately after birth (as reviewed by Krohn, 2001). More recent studies support this evidence as restricted suckling (30 min twice daily) reduced abnormal sucking behaviour and increased live-weight gain in calves and increased milk yield, influenced milk composition and improved udder health in cows (Froberg et al., 2007; Wagenaar and Langhout, 2007). Barriers to the introduction of natural suckling systems include the weaning stress when cow and calf are separated after 3 weeks and the loss of marketable milk. Another option is the use of nurse cows, where calves are introduced to a foster cow and is able to be reared alongside two to three other calves. Research indicates that these multiple suckling systems were less stressful than single suckling systems for rearing dairy replacements as weaning could be more gradually introduced (Wagenaar and Langhout, 2007). Farmers need to be encouraged to accommodate an attitude change to the use of these novel rearing systems within organic herds, and standards could recommend their consideration as pressures increase from consumers to provide ‘natural’ rearing systems.

Organic standards require that calves are not weaned before they are 12 weeks old. In some instances, calves with a high birth weight or achieving a high daily live-weight gain may reach a live weight of over 100 kg, the weight at which calves are typically weaned in conventional systems, earlier than 12 weeks old. Restricting the weaning time to a specific age rather than to either a specific weight or age, may mean that animals kept under optimal management systems may be ready to be weaned (and require more forage and concentrates than is provided) earlier than 12 weeks. Whilst it is recognised that good welfare is not merely evident from a good production response, research comparing early weaning (3 to 7 weeks) showed no effect of weaning age on daily intakes or live-weight gain in dairy calves (Winter, 1985; Kehoe et al., 2007), indicating that early weaning was not detrimental to calf development, at least in the early stages. However, the effects of early weaning on the development, health and longevity of a dairy cow needs to be considered if we are to achieve the full aspirations of organic dairy systems. Typically, information on rearing dairy calves is extrapolated from studies into beef cattle and is therefore based on short-term economic considerations rather than the long-term productivity of dairy heifers. Research into the lifetime performance effects of different heifer rearing systems is needed to determine the best approach for weaning both conventional and organic livestock.

Farming systems
Self-sufficient dairy systems aim to maximise the utilisation of (home-grown) forage in the diet and feed a reduced quantity of purchased concentrate feeds. As a result, many herds in self-sufficient systems fed above the minimum 60% forage in the total diet required by the organic standards, even during the early-lactation period. A key factor in their success is the provision of high-quality forage for grazing and conservation. The total quantity of concentrate feeds (cereal grains, pulses) that can be produced on the self-sufficient organic farm determines the quantity available for feeding per cow and on most farms this quantity is too restricted. In general, these systems are more challenging to manage in relation to herd health and welfare standards, as there is less flexibility to balance diet, health and herd performance. Extended grazing within self-sufficient systems may increase the exposure of livestock to gastro-intestinal parasites, which may increase the incidence of parasitic infections (Ruest, 2002) unless a successful rotational grazing system is employed (Larsson et al., 2006). The incidence of lameness has been found to be lower in some herds using self-sufficient systems when compared with more intensive systems (Weller and Bowling, 1999). This may be due to high-fibre forage diets reducing acidosis and laminitis due to improved rumen stability, although the neutral detergent fibre (NDF) concentration in pasture-based diets may need to be higher than 30% to achieve this (Lean et al., 2008). This factor also depends on the DM of the forage as studies have shown that diets with a DM below 25% led to an increased number of heifers with both white line and sole lesions (Offer et al., 2001 and 2003). Therefore, the DM content of the forage in the total diet is as critical in organic systems as the proportion of concentrates in the diet of conventionally fed dairy herds. Haskell et al. (2007) reported similar levels of metabolic disorders in conventional and organic herds; however, the incidence of these disorders, such as ketosis, may increase when systems aim for self-sufficiency (Vaarst et al., 2004; Weller, 2006). However, research has also found that changing to self-sufficiency on unsuitable farms can increase the risk of poor animal welfare because of nutritional deficiencies. Other studies suggest that the incidence of clinical ketosis is generally lower in organic herds compared to conventional herds (Vaarst and Enevoldsen, 1994; Krutzinna et al., 1996) despite the potentially high risk of problems because of the limitation...
on the quantity of high-energy feeds (i.e. concentrates) in the total diet. These findings may have been due to differences in the breeds compared between organic and conventional systems (Hörning, 2006). However, Kjeldsen et al. (1999) showed that the lower milk production in organic herds could be explained by a lower level of feeding as there was no difference in the genetic potential between organic and conventional herds.

Organic dairy farmers managing a purchased-feed system feed a higher quantity of concentrates in the diet (Weller, 2006), with many purchasing all the concentrate feeds to allow a higher stocking rate (1.5 to 1.7 cows/ha) and maximise milk output per hectare. In these systems, there is the opportunity to adjust the type and quality of the individual concentrate feeds purchased to meet changes in the energy and protein concentrations of both the conserved and grazed forages. This option is particularly useful during seasons when climatic conditions have led to forages being harvested at below optimal quality and offers the opportunity to balance diets and prevent nutritional deficiencies. This type of system may also ensure that the reproductive performance of the dairy herd is satisfactory, avoiding the need to raise extra replacements due to infertility problems in the herd (Weller, 2006). By avoiding the risk of metabolic disorders, the system also reduces the risk of predisposing cows to other problems. However, while purchasing concentrate feeds has these benefits for the health status of the herd, feeding a higher level of concentrate feeding may lead to an increased risk of acidosis, depending on the method of feeding and quantity of starch in the concentrates. If complete diets (total mixed rations) are fed, then the rumen pH will remain relatively constant. However, if the concentrates are fed only twice daily, there is a potential risk of significant fluctuations in the rumen pH and the risk of acidosis, due to the excessive production of lactic acid that is absorbed into the blood stream that then leads to reduced blood supply to the foot and lameness problems (Chamberlain and Wilkinson, 1996; MDC, 1997).

**Access to pasture**

The organic principles and aspirations aim for organic dairy systems to be managed as a ‘natural system’. The increasing costs of production are leading many farmers to consider the merits of keeping cattle outside for a greater proportion of the year (e.g. extended grazing systems) or out-wintering non-lactating cattle for the whole winter period (e.g. brassica-based systems). Whilst these grazing systems offer benefits in reducing production costs, there are implications for the health and welfare of the cattle, including the hardness and suitability of dairy breeds. These systems require additional labour input to ensure that grazing areas are managed effectively and animal health and welfare are not compromised. Factors requiring consideration include: the provision of suitable shelter to ensure that livestock are protected from exposure to extremes of temperature and avoidance of over-poaching of the ground. The latter can increase dirtiness around the udder and cause subsequent infections (Christiansson et al., 1996).

Cattle will acclimatise to colder weather by growing longer, thicker coats with reduced hair shedding to provide better insulation against lower temperatures, but the coat must be clean and dry to allow protection to the cow (Webster et al., 1970; Brick, 1998; Tarr, 2006). While UK winters are not normally associated with extreme cold, temperature per se is not an accurate measurement in relation to the response and hardness of cattle out-wintered, as the accumulated effect of the wind chill factor, rainfall and state of the ground all increase the loss of body heat from the cow. In two reviews, Johnson and VanJonacker (1976) and Sharma et al. (1988) reported that to maintain good health the ‘comfort zone’ for dairy cows was temperatures between 2°C and 22°C. Beef cattle are frequently out-wintered and are more adaptable to changes in climatic conditions compared with dairy breeds, due to their higher body condition scores and thermal insulation (Webster et al., 1970; Wright and Russel, 1984). Conversely, high summer temperatures and heat stress in UK dairy herds results in reduced fertility and financial loss (Farm Animal Welfare Council (FAWC), 1997), with Holstein cows being found to be less tolerant of high temperatures than Jersey cows (Bakke, 2003). As the target conception date for many organic dairy herds occurs during the periods of warmer weather, heat stress needs to be considered when implementing a strategy to improve cow welfare.

**Housing**

The majority of organic herds are housed during the winter period in either cubicle housing or straw-bedded yards. A failure to ensure that the cubicles are suitable for the herd will increase the risk of injury, including teat damage, as large cows using cubicles of an inadequate size will have difficulty when lying, entering and rising (Blowey, 1994). In addition to the design of the cubicles, the cleanliness of the passage ways and loafing areas is also important as the build-up of slurry will lead to lameness problems, such as digital dermatitis, requiring the use of antibiotics to achieve effective control (Roderick and Hovi, 1999; Laven and Lawrence, 2006). While organic standards state the minimal space required per animal, depending on breed and age, the relationship between stocking density and the frequency of bedding renewal and cleanliness is of equal importance. The risk of injury can be influenced by the type of bedding (Livesey et al., 2002), with straw, sawdust, paper, mats, mattresses and sand being recommended within organic standards. Compared with loose housing in straw-bedded yards, the incidence of lameness and leg damage was shown to be higher in cows housed in cubicle sheds (Rowlands et al., 1983; FAWC, 1997; Haskell et al., 2007). However, straw-bedded yards provide an ideal environment for pathogens. If straw moisture content is too high, a rapid increase in the temperature of the bedding and an increased risk of Escherichia coli and Streptococcus uberis infections can result (Ward et al., 2002). The risk of
Husbandry and stockmanship
Undesirable handling, transport conditions and stockmanship can have negative consequences for livestock. Farmers and consumers as it can seriously damage the welfare, productivity, product quality and profitability of farm animals (as reviewed by Hemsworth and Coleman, 1998; Maller et al., 2005; Hemsworth, 2007). Negative interactions with humans are associated with reduced milk let-down and subsequently milk yield in dairy cows (Rushen et al., 1999; Breuer et al., 2000; Waiblinger et al., 2002). Chronic and acute stress responses, traumatic incidents, injuries and death are also more prevalent in cows, heifers and calves that have been incorrectly handled (Breuer et al., 2003). The standards for organic production cover the necessity to satisfy the needs of animals by handling and transporting them with due care to ensure freedom from fear and distress and stipulate strict welfare standards regarding the rights of animals to enjoy freedom from fear and distress. It is envisaged that with the tendency towards a higher number of animals per stockperson, the impact of correct stockmanship will become increasingly important as dairy cow herd sizes continue to increase within the industry. In light of this, the standards may need to recommend the number of animals per stockperson for organic dairy systems and to state that all stockpersons should be suitably trained to better meet the principles of organic farming and ensure that a high level of animal health and welfare is maintained.

The principles of organic systems may not be conducive to the use of automated (robotic) milking parlours as compared with the recommended application of excellent husbandry skills and good stockperson to animal relationships. Potential implications for the health and welfare of dairy cows kept in automated milking systems include increased risks of failure for clusters to attach to teats correctly (Miller et al., 1995), although Vliegher De et al. (2003) found no significant difference between conventional and automated milking on teat skin and teat end condition. The risk of health problems going undetected in an automated milking system needs careful consideration. On the one hand, automated systems may improve the detection of sub-clinical problems, such as the combined use of automated milking with an automated lameness detection system (Pastell and Kujala, 2007) or an online detection system for sub-clinical mastitis (Nielen et al., 1995; Hovinen et al., 2006). Alternatively, an atypical health or disease problem, or an injury that would be easily observed by a stockperson, may go undetected for a longer period in an automated system. Guidelines on the use of automated systems and the requirement for good stockmanship in these systems are needed to avoid risks to dairy cow health and welfare.

Dehorning
The principles of organic farming do not support the use of mutilations, such as disbudding or dehorning, to support intensive farming methods. The dilemma with regards to dehorning is whether the horn itself is a potential health and welfare risk or whether it is regarded as an integral part of the animal, required to allow an animal to express its innate social behaviour (Menke et al., 2003). Certainly, the process of dehorning is a source of stress and pain in the animal (Stafford and Mellor, 2005; Mounier et al., 2007), particularly if performed without anaesthesia or analgesia (Hewson et al., 2007). In practice, in the UK, disbudding with a hot iron is preferred to dehorning and it is advised that this should be performed before cattle reach the age of 2 months (FAWC, 2006). Organic standards do not permit the disbudding of calves after 3 months of age. It has been shown that the application of caustic paste is acceptable in cattle up to 7 days old (Stafford and Mellor, 2005) but anaesthesia is required if cattle are dehorned after this period (Faulkner and Weary, 2000). Vickers et al. (2005) showed that dehorning with caustic paste, combined with a sedative, resulted in less pain to calves than dehorning with a hot iron combined with a sedative and a local anaesthetic. Recommendations for the best practice to reduce pain and distress when disbudding calves should be part of the organic standards. One route to avoid this problem completely would be the breeding of polled dairy animals. Polledness is a dominant autosomal genetic trait (Stookey and Goonewardene, 1996) that appears in all offspring of homozygous polled bulls. There are no performance restriction as polled genes are not linked to production or behavioural traits (Goonewardene et al., 1999). There is large scope to undertake new research programs to develop DNA tests that identify homozygous/heterozygous animals for poll genes that would assist faster introgression of the polled condition into beef cattle populations (Prayaga, 2007). Similar approaches, such as microsatellite mapping of poll genes (Georges et al., 1993), could be applied to the dairy breeds, but further work may be required with dairy bulls as polled sires are rare in many breeds, including Holstein (approximately 1%).

Genetic factors
Yield potential
The type of cow and her genetic merit in relation to milk yield, disease resistance and fertility of cows are key factors in meeting the health and welfare standards required by both the standards for organic milk production and the criteria defined to meet the quality assurance standards of milk production. Correct breeding and selection of appropriate dairy breeds should be viewed as a preventative health strategy for organic dairy systems. Breeding cattle with a good, lifetime milk yield, rather than the short-term
high-yielding traits that have previously been selected, may help to fulfil the aspirations of organic dairy production. The trend for high percentages of dairy cows to fail to reach their third lactation is an unacceptable loss for both conventional and organic dairy systems, with the average UK annual culling rate in the dairy industry at approximately 29% (MDC, 1999). Klenke (1989) studied conventional and organic herds in Germany and found little evidence that longevity is significantly higher in organic herds (average 5.85 and 5.43 years for organic and conventional, respectively), although Krutzinna et al. (1996) found that the longer a farm had been in organic management, the longer the productive life span of the dairy cows (as reviewed by Boehncke, 1997). Whilst economic factors drive many dairy systems and put stresses on modern-day dairy cows, a true cost of the requirement to replace cows within less than three lactations needs due consideration. More recently in the UK, dairy cows selection traits have reduced the emphasis on production rates (to 45%) and increased the emphasis on health, welfare and fitness traits, reflecting both the farming industry and wider consumer demand to strive for higher animal welfare standards, as well as the impact of these traits on profitability (Sandoe et al., 1999).

Within the UK, and some European countries, organic milk production has been dominated by breeds selected for intensive systems where a high proportion of concentrates are fed in the diet. Currently, Holstein–Friesian breed of high genetic merit contributes more than 92% of the UK’s dairy cow population (Moorby et al., 2003). Walsh et al. (2008) reported a negative genetic correlation between increasing milk yield and the incidence of health and fertility traits with Holstein–Friesian herds. While the Holstein–Friesian produces higher milk yields compared with breeds of a lower genetic merit, this has not been accompanied by an increase in feed intake. This has led to an increased risk of negative energy balance, metabolic stress due to abnormal physiological function and other problems (Veerkamp et al., 1995; Nielsen, 1999; Weller and Bowling, 2004). While the breed is predominant in organic herds, other more traditional breeds (e.g. Ayrshire, Jersey and Shorthorn) and crossbreds also contribute to organic milk production in the UK. In other countries, traditional breeds are selected for organic systems. For example, in Switzerland, breeding programmes have (with Brown Swiss, and Swiss Red and White breeds) improved the compatibility between genetics and the system of management (Bapst, 2001).

Disease resistance
Genetics can greatly affect the incidence of three main health and welfare problems in dairy cows: lameness, mastitis and infertility. The incidence of lameness in organic herds may be influenced by breed, with Holstein–Friesian cows appearing to be more prone to lameness either due to their white hooves compared with breeds with black hooves (Peterse, 1985; Webster, 1993; Roderick and Hovi, 1999) or heavier bodyweight when compared with lighter breeds (e.g. Ayrshire, Guernsey and Jersey) (Radostits and Blood, 1985). Bakke (2003) reported that Jerseys, Norwegian Reds and Swedish Red breeds are more prone to milk fever. The critical balance between genetic merit and fertility problems was found by Snijders et al. (1997) who found a higher incidence of failure to conceive and more cows culled for infertility in high genetic merit cows. For cows with high milk-yield potential, failure to meet their optimal nutrient requirements resulting in either clinical or sub-clinical health problems has to be recognised as a welfare problem. A main factor to consider in the aim of minimising disease problems is heterosis or hybrid vigour. Brotherstone et al. (2003) reported the positive benefits of cross-breeding on SCC in milk. The recent inclusion of health traits in the classification of bull breeding programmes should help to improve the health status of both conventional and organic dairy herds in the UK. If future organic standards included thresholds on acceptable levels for specific health ailments, the selection of suitable breeds and types within individual breeds could have a greater influence on the management of organic dairy systems.

Longevity
Longevity is a factor in dairy herds that has both benefits and disadvantages. Benefits include improved welfare standards associated with the cow having a longer productive life, while the disadvantages include the lower immunity and higher risk of disease occurrence with older cows. It is also generally considered by farmers that younger cows have a superior genetic merit. Optimal age limit lifetime efficiency is achieved by cows with a productive life of six lactations (Webster, 2000; Moorby et al., 2003). However, the major change in the last 30 years has been to select cows for higher milk yields, including changing the type of cow that is managed in different dairy systems from Friesians and other breeds to the Holstein, leading to a decline, in the last 30 years, of the average herd life of a cow from 4.76 to 3.44 lactations (Moorby et al., 2003). The issue in many European organic dairy systems is to ensure a high average milk yield, leading to the culling of a high number of low-yielding animals during their first lactation. This point is clearly illustrated in the results of a study of organic dairy herds in Denmark where the average annual culling rate from herds was found to be 40% (Kristensen and Pedersen, 2001). Low culling rates and the maintenance of herds with three or more lactations lead to more efficient systems, with lower culling rates and a better ratio of productive to non-productive cattle. However, older cows have been found to have markedly higher SCC in their milk compared with younger cows (Weller and Davies, 1998), indicating a higher level of sub-clinical mastitis due, in many cases, to Staphylococcus aureus, which can be easily transmitted between cows. Therefore, in some herds, older cows are culled to reduce the average SCC and to gain a maximum price for the milk. Problems with older cows that increase the risk of mastitis infections include the reducing udder support and increasing problem of pendulous udders and also the increased teat size and
more relaxed sphincter muscles in many cows (Seykora and McDaniel, 1985). This demonstrates that whilst longevity has welfare benefits, in relation to herd health it may have detrimental effects.

Nutritional factors

Balancing energy and protein

For organic farmers, the introduction (as from 1 January 2008 in the UK) of standards requiring all ruminant diets to be 100% organic, will increase pressure to use home-grown feed. Using forage compositional analyses is essential to ensure that the nutritional requirements of dairy cows are met. Organic dairy systems are often referred to as high forage–low input systems and have the advantages of allowing animals to have access to pasture and a minimum of 60% of DM intake to be fed as forage. Based on organic principles, livestock diets should be in a form that allows an animal to carry out its natural feeding behaviour and meet their digestive needs and should also provide for high-quality products rather than maximising output. However, failure to maintain the correct energy-to-protein balance in the diet, resulting in the intake of excess protein, affects the fertility of the dairy cow, as discussed later in this section.

High-protein diets may also cause peri-parturient problems including retained placenta, metritis and ovarian cysts (Barton et al., 1996), an increase in the number of services/conception and impaired embryo survival (Chamberlain and Wilkinson, 1996). Organic spring-calving herds often use grass/white clover pastures, including grazing both reseeded leys and permanent pastures for grazing. By early July, forage protein is above the cow’s nutrient requirements and can reach 25% by the autumn, leading to poor protein utilisation by the cow and the risk of fertility problems (Weller and Cooper, 2001). When herbage supply is plentiful, a preference for clover rather than grass further increases protein intake. For a high-yielding cow receiving a concentrate supplement that has a high-energy/low-protein value, the diet will be balanced, but for cows not being fed concentrates the protein content of the diet may be too high. These risks should be considered when non-pregnant cows graze protein-rich swards of either fertilised ryegrass or grass/clover mixtures and do not receive a high-energy feed. Grazing swards with a high (greater than 19%) crude protein concentration can reduce reproductive efficiency and increase lameness compared with diets of 16% (Butler et al., 1993; Heur et al., 2000). Baker (1980) and Mayne et al. (1988) showed that implementing a leader/follower grazing system (where high-yielding cows are placed in the leader group and have access to grazing areas one day ahead of a lower-yielding follower group) can reduce the risk of metabolic disorders common in high-yielding cows during early lactation.

Minerals and trace elements

Milk is an excellent source of calcium, phosphorous, riboflavin (vitamin B2), thiamine (vitamin B1) and vitamin B12 and a valuable source of folate, niacin, magnesium and zinc in human diets (Food Standards Agency (FSA), 2002). The removal of milk from a farm potentially results in a net flow of these elements from the site, which either needs to be replaced in the form of fertilisers or in feed. A principle of organic systems is to reduce reliance on external inputs, including mineral, trace element and vitamin supplementation. Ideally, the mineral and trace element status of the farm and livestock should be determined and appropriate measures should be taken to avoid emergency remediation. The aim of the standards is to prevent the use of these supplements so as to stimulate production rather than maintain health. The standards allow the use of straight mineral and trace element additives without prior permission provided that justification, such as forage or soil or blood analysis, can demonstrate a deficiency. Potentially, novel management practices, such as using different forages may be a more sustainable option to ensure that these nutrients are made bio-available to the dairy cow. Chemical
analysis of certain forages, for example chicory (*Cichorium intybus*), has received attention due to its higher trace element content (Clark, 1995), with preliminary results from grazing trials indicating that, in comparison to ryegrass, chicory significantly increased the copper, cobalt (vitamin B12) and selenium status of grazing ruminants (Marley, 2001). Organic systems aim to increase the diversity in the pasture species in grazing swards, and using specific forage species to improve the mineral and trace element status would be closely aligned with organic principles. The risk of hypomagnesaemia occurring during the spring period, when cows graze lush grass swards grown with high inputs of nitrogen and potash fertilizer, is a problem in many conventionally managed herds. However, in organic systems where the primary N input for crop production is white clover, the incidence of hypomagnesaemia has been found to be lower (Weller and Bowling, 2000) and may be attributed to lower N inputs and the higher magnesium concentration of white clover compared with the levels found in grass. The same may be true for other minerals, trace elements and vitamins. However, there have been few studies into the effects of different pasture species on the mineral and trace element status of organic dairy cows and into the long-term sustainability of this approach to prevent deficiencies.

Environmental factors

**Effects of herd size and hierarchy on health and welfare**

Organic principles require that animals are allowed to express their innate behaviour to meet their psychological and physiological needs. As dairy cows are naturally a herd animal, social behaviour can greatly influence the health and well-being of an individual cow. In the wild, bovines would form strong relationships with members of their herd and develop a natural hierarchy. In extensively farmed cows (i.e. beef), the social bond of cow and calf is life-long for female offspring, whereas for most males, it lasts until they leave the herd (either 10 or 18 months) (e.g. Napolitano *et al.*, 2005). Whilst domestic dairy cows do have some opportunities to develop strong bonds within the herd, given the short longevity and subsequent high turn-over of animals within the herd, the development of a natural herd structure within modern dairy herds may be compromised. Organic principles encourage the use of a closed herd and breeding replacements. This principle offers an opportunity to integrate animals to overcome the socially compromised modern day dairy cow. First-calf heifers and recently introduced cows are often submissive and larger cows, older cows and cows with more seniority in a group are often more dominant (Harb *et al.*, 1985). To overcome any restrictions resulting from the lack of a natural and secure herd hierarchy, handling and housing facilities should be fit for purpose and the size of the herd (Petherick and Phillips, 2009). Limited space is a main reason for aggression among cows (Miller and Woodgush, 1991) and the design of housing, feeding troughs and access to water should be modified to prevent submissive cows from being unable to meet their needs. Social problems usually occur at housing but also occur at grazing when fields are strip-grazed rather than set-stocked or rotationally grazed. Social hierarchy may alter the time of feeding, time spent lying down, access to water and the time spent ruminating by an individual animal, as dominant cows inhibit the activities of submissive cows (Proudfoot *et al.*, 2009). Numerous studies have shown that social dominance is particularly critical during feeding periods (Miller and Woodgush, 1991; Thomson *et al.*, 1991; Grant and Albright, 2001; Huzzey *et al.*, 2006). Chamberlain and Wilkinson (1996) found conflicting views on the merits of dividing a herd into sub-groups based on either milk yield per cow or the separation of heifers from cows. Krohn and Konggaard (1979) concluded that separating a herd into sub-groups was beneficial for first-lactation heifers that are kept separate from the rest of the herd as they spent 10% to 15% more time eating and recorded 20% higher intakes. Grant and Albright (2001) reported that moving cows between groups had a negative social effect that lasted for 3 to 7 days. Stacking density is an important factor in organic dairy systems, with a direct link to welfare problems, specific diseases and herd performance. While organic standards clearly define an acceptable stocking density on a farm to be 1.7 cows/ha or less, this can be misleading. For example, a farm allocating a significant proportion of the total land area to growing crops may have a low stocking density for the farm but a high density for its dairy enterprise when managed on a relatively small land area.

**Conclusions**

The key factors affecting the health and welfare status of dairy herds are the management regime within the individual dairy system, the genetic merit of the cow, the nutritional quality of the diet and the social environment within which the animal is kept. These factors are inter-related and important in all dairy systems, irrespective of whether the system is organic, low-input or intensive. Incidences of individual clinical and sub-clinical diseases that are recorded in conventional dairy systems also occur in organic dairy systems, with infertility, lameness and mastitis being the major problems. However, the magnitude of the incidence of many of these diseases may be either lower or higher in organic systems due to different management practices. Contrary to a common assumption, good welfare does not necessarily occur with more extensive systems. The type of organic system also has the potential to have a major influence on the incidence of health problems and the reproductive status of organic dairy herds. Health status is also influenced by environmental, husbandry and welfare management, such as the method of rearing replacement animals, type of housing and both the geographical location and climatic conditions on the individual farm. Incremental improvements to the current health and welfare status of dairy cows in both conventional and organic systems may
be restricted due to the current economic constraints within the dairy industry. However, it is important to note that in any herd, the failure to maintain both a good health status and high welfare standards has the potential to affect the financial margins that can be achieved and increases the risk of the enterprise becoming financially non-viable.

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