Understanding the environmental impact on animal housing and health

Jamie Robertson, Honorary Research Fellow, University of Aberdeen discusses diagnosis in animals where their living environment is a risk factor

The presence of symptoms of disease does not often signal the arrival of a novel pathogen on a farm. Some examples do exist, such as foot and mouth disease, but the frequency of occurrence is, thankfully, rare. The common situation faced by the practitioner is the arrival of a level of infection in a host animal or group of animals where symptoms become visible, caused by a pathogen that is already on farm. The balance of the dynamic relationship between that existing pathogen and the host defences has turned in favour of the pathogen. The questions that need to be asked are not 'where did that come from?' but 'what has changed to create a more vigorous or more numerous pathogen population, and/or what has created a reduction in immune competence in the host?' Using bovine respiratory disease (BRD) as an example, most farms will show antibody titres to one or more of the main respiratory pathogens, but not all farms will have cattle or young stock with respiratory symptoms.

A focus on pathogens may be a competent part of successful diagnosis, especially if the outcome is the application of a pharmacological treatment or vaccine. The pressure on a practitioner to deliver a successful result in the presence of visible symptoms of illness is not only considerable but backed by decades of relatively successful practice, across many illnesses and many host species. However, if the focus on diagnosis is too narrow, the probability of a sustained improvement in health is reduced, with the additional pressure that treatments may

Factor	Condition	Contribution	Signals to look out for
Moisture	Too much	Supports microbial activity Promotes bacterial growth (some species) Absorbs energy Acts as a transport medium for pathogens Increases slippery floors which causes stress Increases LCT*	Dirty water lying on ground Dirty cattle Damp floors in areas that could be dry Water ingress Leaking drinkers Condensation Staining on underside of roof Animal health problems
Fresh air	Too little	Lack of fresh air: - increases survival time of airborne pathogens - increases concentration of gaseous emissions - can reduce oxygen concentrations	Smell of ammonia, dampness Dark corners – no light, no ventilation Elevated air temperatures Animal health problems
Air speed	Too much	- associated with excessive energy losses - increases LCT*	Animal avoiding certain areas Huddling Hairy coat High intake/low production rate Animal health problems
Air speed	Too little	associated with lack of fresh air	Animals avoiding certain areas Lingering smell Animal health problems
Temperature	Too high	- increased thermal stress/THI** - increased bacterial survival rates	Reduced feed intake Increased sweating Increased respiration rate Increased body temperature Separate/prostrate lying position Fertility problems Animal health problems
Temperature	Too low	- increased thermal stress - reduced immune competence	Huddling Hairy coat Depressed behaviour Animal health problems

Table 1: Environmental factors influencing animal health.
***LCT = Lower critical temperature; **THI = Temperature humidity index**

not be as successful as expected because other significant factors have been ignored. And so we enter a situation where vaccines may not be fully efficacious, or where bacteria become more resistant, or the competence of the practitioner is questioned.

Most of the costly diseases of livestock fluctuate between hidden, chronic, and acute status, and examination of the role of non-pathogenic factors should be part of an obligatory (mental) exercise to, at least, eliminate them from the diagnostic process. Available nutrients? Check. Digestible nutrients? Check. Competent water access and quality? Check. The list of relevant variables is not large and should not be ignored. For example, two areas that are constantly mentioned as important for animal health and spectacularly ignored in reality are biosecurity and hygiene. Both can provide critical control of pathogens leaking from one group of animals to another, and whilst some farms do a good job, most seem to ignore the fact that the quality of either process is completely dominated by the weakest link. The focus may be on the pathogen, but the prevalence of good practice is low. Do we really have to carry out a research project to measure the association between competent hygiene practice in, eg. calf housing and the attrition rate of scours?

Aside from nutrition, from foetal growth to adult immune-competence, the widest area for potential support of animal health are the environmental factors, specifically because they have significant impact on both the hosts and the pathogens. If environmental factors interfere with pathogen survival, there is a direct influence on the available dose of pathogens, and therefore, a direct influence on the probability of causal infection. Using cattle respiratory disease, again, as a broad example, the winter climate of Ireland and most of the UK is significantly supportive of BRD pathogens because the survival rate outside the host is higher at higher relative humidities (RH) than in the low humidities of sub-zero ambient temperatures in winter Europe and North America. Many gram-negative bacteria relevant to animal health are at peak survival rates in the 50-80% RH zone of our normal climate. Fresh air is also a key factor in the survival rate of relevant pathogens, with 100% fresh air having a kill rate that is 10-20 times faster than 50% fresh air.

The impact of the environment on animal productivity and health is indirect (via plant growth, nutrient density, and the influence on pathogen survival, above) and direct (via predictable physiological pathways). The main factors are:

- Temperature;
- Moisture;
- Fresh air; and
- Air speed.

The possible impact of these factors is simply described in Table 1 below (adapted from EBLEX 2013a).

TEMPERATURE

All warm-blooded animals have a ambient temperature zone that causes no additional physiological pressure; the thermoneutral zone. The thermoneutral zone is delineated by the lower critical temperature (LCT), below which an animal has to burn additional energy to maintain homeostasis, and the upper critical temperature (UCT), above which an animal will alter behaviour and reduce food intake. Extended periods out with the thermoneutral zone become inefficient, in terms of productivity, and also

Metabolisability	Live-weight gain	LCT oC		
		100kg heifers of large breed		
		Air speed	Damp bed	
	Kg/d	0.5m/s	2.0m/s	
0.5	0	11.9	20.9	17.9
	0.25	8.2	17.2	14.2
	0.5	3.1	12.1	9.1
	0.75	-4.2	4.8	1.8
	1	-15.5	-6.5	-9.5
0.7	0	14.7	23.7	20.7
	0.25	12.6	21.6	18.6
	0.5	10	19	16
	0.75	6.6	15.6	12.6
	1	2.2	11.2	8.2

Table 2: Impact of diet, growth rate, air speed and moisture on LCT (adapted from Bruce, 1986).

immunosuppressive. This process has been understood for decades and is actively managed in the modern pig and poultry sectors, but has only recently been recognised by the cattle sector.

The LCT of an animal is significantly influenced by its feed intake, dietary digestibility, current health status, genetics, and environmental conditions of moisture and air speed (see Table 2).

The LCT of a healthy dairy calf in the first week of life is in the region of 15-25°C dependant on breed and sex, and so it is totally predictable that all calves born during an Irish winter will be physiologically stressed. So, it is entirely predictable that an animal with a naive immune system, supported only by maternally derived immunoglobulins, will be additionally immunosuppressed, because it is born into an Irish winter.

The solution is to acknowledge the problem as one of energy deficit, and provide a programme of increased energy in the diet, and/or additional support from jackets or quartz-linear heaters, and eradicate additional energy losses to the environment from draughts and damp.

The role of moisture, or specifically, uncontrolled accumulations of moisture, is that it helps to sustain various pathogens outside the host, provides a physical vector, and saps energy. Water on the floor wants to turn into moisture in the air, increasing ambient RH%, and reducing the effective ambient temperature because damp air extracts energy from a warm body faster than dry air. A damp bed can reduce LCTs by 6°C, as well as providing a positive environment for many bacteria and viruses and costing more money for bedding, labour and diesel. Dryness is an achieved target in poultry production, and mostly understood in pig production. The cattle sector has a lot of potential in realising the value of controlling and avoiding excess moisture, so, ensure the drainage and the ventilation is in good shape.

All the environmental factors are independently important, but the conflict between fresh air delivery and air speed management is present across the whole of the UK and Ireland. Keeping the wind out of a livestock building is also a mechanism for keeping control of water ingress, and protecting stock from the hard physiological impact of increased air speed , which sucks energy from any body. However, the ill-designed response to living in a wet and windy climate is a profusion of buildings with solid wall and roof cladding, which may be efficient at keeping the rain out but are also entirely effective in keeping the fresh air out as well. Ironically, keeping the wind out actually increases the accumulation of moisture within a building, because natural ventilation is restricted. The end results are buildings that are colder than they should be (because they are damp), have higher RH% than outside air, and provide an aerial environment that increases the survival time of relevant

pathogens outside the host.

What has the industry done to protect our livestock? Clad the whole structure in tin (because it is cheap), paint it a dark colour so that it exacerbates the diurnal variation in ambient temperatures, and provide no holes in the roof to ensure airborne moisture remains trapped in the structure. There should be absolutely no confusion; the physical conditions described above will exacerbate virtually all livestock health and production issues. There is tremendous potential to improve. There is considerable free guidance material available on cattle building design issues (DairyCo 2012, EBLEX, 2013b). There is also a need to change attitudes towards buildings, from opinions to objective descriptions. Tin cladding may be 'cheap' to buy, but is expensive if it does not provide a competent environment for the livestock. For example, competent inlet and outlet areas for any building housing any stock can be defined using simple mathematics to give bespoke answers, based on published science and available guidance. However, the industry, including government bodies, still advise that ventilation should be 'adequate', with the end result that even new buildings for cattle are erected that are not fit for purpose. Just because there are holes in the roof and walls of a building does not mean the subsequent ventilation will be competent.

STOCKING DENSITY

Stocking density is often cited as a significant or potential contributor to animal health problems. In a broad analysis, the space between two animals must have a critical role in disease transmission. Infectious bovine rhinotracheitis (IBR) is much more likely to be transmitted cow-to-cow during a 60-minute stance in a collecting yard than in a field. Assessment of a health problem must always include stocking density, and it is not uncommon for stocking density to be considered at least part of the causation of many chronic health issues. Subjective assessments of livestock systems, therefore, may easily lead to conclusions that include overstocking as a problem, followed by possible solutions that include putting fewer animals in a space. Few farmers appear willing to take that option, and not surprisingly, health problems continue.

However, the animal health assessment process utilised by farmers and professionals is seldom fully objective, and subsequent diagnosis is often weakened as a result. The reality is that our livestock live in systems with many variable components, and for efficient production there is a requirement for all the components to be competent. An objective assessment of a cattle system, and overstocking in particular, should start with objective descriptions. If there are 100 cattle in a building 30m x 20m, the stocking density is $6m^2$/animal. Standard texts can inform us for straw-based or slatted floors, for different liveweights of stock, whether $6m^2$/head should be competent. If the evidence on farm is that the stocking density is not competent, any assessment should question the possible reasons for this, starting with an analysis of the physical environment. The amount of space available is not the prime factor; it is the quality of the available space (control of moisture, fresh air, air speed) that are the prime factors. The result is that the practitioner, making a correct diagnosis, is able to guide the client towards practical solutions that may include drainage, ventilation, feed space, lying space, etc.

Animal numbers per farm are likely to increase, adding to the pressure of overstocking. The risks of infection will also increase, but this does not have to mean an increase in disease prevalence. The pig and poultry sectors have also learned the hard way that to maintain production they have to do as many of the production steps as correctly as possible. There is little success in adopting a vaccination programme if the environmental pressures are reducing vaccine efficacy by a factor of four, for example. We need to set achievable targets on individual farms, and then pursue them ruthlessly.

MOISTURE

Animal systems process large volumes of water that may be clean to start with but, which becomes dirty once exhaled or excreted. The target is to prevent moisture accumulation within a building, and the design requirement is competent drainage and ventilation. The former is not a given, and if a system has poor floors, inadequate slopes and/or drainage channels, the floor will be substandard forever, until it is changed.

Similarly, ventilation, where the design function is twofold:

- Removal of airborne dusts, gases, heat, moisture and airborne pathogens/commensals;
- Introduction of fresh air through oxygen delivery system.

The simple fact is that a system cannot have the latter (fresh air delivery) until the former (air exhaust) takes place. Thus, the removal or release of exhaust air has to take place before 'ventilation' can occur. The mechanism behind ventilation is simple; a force is required to provide air movement, and, in a naturally ventilated cattle building, the force is provided by pressure differences around the building. For 80%-90%+ of the year, the required force is provided by the wind, which creates areas of high and low pressure around every structure, and exhaust air is sucked or forced out of a building, to be replaced by an equal volume of clean air from outside.

The major design flaw in Irish and UK cattle-housing systems is that there are many 100% solid walls, especially on the prevalent wind direction side. The irony is that the prevalent wind direction can supply a free and dependable ventilation system for maybe 40-50% of the year, if inlet design is sensible. Solid roofs provide zero outlet, whilst solid walls deliver 0% fresh air. The requirement is a sidewall design that allows adequate air movement but minimises water ingress as well as controlling sir speed. Irish cattle housing has an urgent need for Yorkshire boarding, because properly designed and installed, it allows fresh air in, reduces air speed, and keeps rainwater out. Note that many think that space boarding, a single line of boards with gaps between each board, is Yorkshire boarding. It is not, and space boarding will allow 20ft of rain into a building in wet and windy conditions. Yorkshire boarding is two parallel lines of boards with gaps, but the gaps in each row of boards are offset so that the weather cannot enter a building (see EBLEX 2013b).

SOLUTIONS

So, where are the answers? Some of the available guidance on the design parameters for livestock systems has been available for years, and two examples for cattle building systems guidance are freely available online. The guidance is nearly all science based, so there is no need for lengthy discussion against dogmatic objections. A rapid system assessment with due consideration of the potential weather conditions at relevant times can focus on the original four environmental parameters of moisture, fresh air, air speed and temperature (eg. EBLEX 2013a). If these are not probable physiological stressors on the host/s, or significantly beneficial to pathogen survival, then the environmental component of the livestock system is not likely to be a health issue. However, years of appliance of the rules of physics to naturally ventilated cattle buildings in the UK indicates that, on ventilation capacity alone (the competence to deliver fresh air), around 50% of all cattle buildings are not competent.

The two building design guides cited above contain a simple method of providing an accurate calculation of the inlet and outlet areas needed to provide competent ventilation for any number and live weight of cattle within a set space. However, a simple rule of thumb can be applied on farm that can give an immediate assessment of ventilation competence:

- Oulet area in the ridge per adult or hard growing cattle = 0.1m^2/head;
- Inlet area (sidewalls) needs to be minimum of 2x outlet area, optimum 4x outlet area.

Thus, 100 cows in a shed need a ballpark figure of 100x0.1m^2, or 10.0m^2 outlet in the roof. And the inlet area, ideally spread across the two sidewalls, needs to be a minimum of 10m^2 x 2 (20m^2) or an optimum for productive growing/adult cattle of 40m^2. Assessment can be made on the spot with no more equipment than a tape measure and some mental maths.

STACK EFFECT

The importance of the hole in the roof is simple, for when the wind speed is below 0.5m/s, or a building is for any reasons shielded from wind passing in one side and out the other, the building will not be competently ventilated by the wind. At that point building design uses the known parameters of the stack effect to drive the ventilation. Predictable quantities of energy (sensible heat) pass from the livestock to the surrounding air, which then increases in temperature compared with the wider ambient air temperature outside. Warm air rises, and as long as there is adequate outlet area in the roof, the warmed, damp, dirty air leaves the building, to be replaced at the sidewalls by an equal volume per second of clean air. Simple, and with no running costs.

The assessment of an animal host/pathogen/environment system must always consider amongst other parameters the competence to remove contaminants and provide fresh air:

- Are there holes in the roof and the sidewalls?
- Are the holes big enough?

The practitioner has an educational role here, and one where there is conflict with the builders (who patently do not know the rules of animal physiology or relevant physics) and even professional advisors (hence the new prevalence of Ventair sheeting). A rapid assessment of a building clad with Ventair on the sidewall would show that with 100 cows in a building 30m long, the 10m^2 of outlet needs to be matched with a balancing 20-40m^2 of inlet in the sidewalls Ventair has a porosity of 4.5%, which means that a 30m-long building would need more than 7m height of sidewall to give the minimum inlet (30m x 7m x 0.045 = 9.45m^2). The maths are clear, the physics are proven, and the epidemiological evidence of the impact of poor quality environments on health problems has been growing for years. There is substantial potential to improve animal health by improving the system environment (Robertson, 2015).

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