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Review

Leg health of meat chickens: impact on welfare, consumer behaviour, and the role of environmental enrichment

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Abstract. The Australian and global chicken meat industries have benefited from rapid improvements in the efficiency of chicken meat production that have been predominantly achieved through genetic selection, optimisation of bird nutrition and improved bird health. However, this has also resulted in morphological changes in the bird with an increase in the prevalence of leg health disorders. Compromised leg health can cause pain and lameness and bodes poorly for bird wellbeing, bird mortality, and economic returns. There are also implications for the consumer who is increasingly mindful of animal welfare and is demanding more welfare friendly products. Accurate on-farm assessment of bird leg health has challenges due to the diversity of leg disorders and the variety of techniques used to assess their severity and impact. Overall prevalence of leg disorders shows great variability between properties (farms) and flocks. Opportunities to improve bird leg health have been the focus of considerable research which has frequently included an evaluation of environmental enrichment as a means to reduce lameness and improve bird mobility. To this end, currently in Australia, 78% of chicken meat is produced under the conditions of the Australian RSPCA Approved Farming Scheme, which requires perches in the birds' environment. However, the value of perches in providing enrichment and improving bird welfare is unclear. Therefore, this review explores animal welfare and consumer attitudes towards meat chicken welfare, describes leg disorders, outlines techniques for assessing leg health and discusses opportunities to enrich the birds' environment to improve bird mobility and leg health.

Keywords: chicken meat, broilers, animal welfare, poultry diseases, farm management, food production, consumer attitudes, consumer behaviour, lameness, RSPCA Approved Farming Scheme.

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Introduction

Since the 1960s, genetic selection, improved nutrition and increased popularity amongst consumers have resulted in significant growth in worldwide chicken meat production (Robins and Phillips 2011). In 2018 it was projected that by 2022, Australian per capita chicken meat consumption would reach ~52 kg, representing ~45% of total meat consumption (ABARES 2018). The rapid growth rate and low feed conversion ratio of meat chickens have realised relatively low production and resource costs compared with other livestock industries, for example, beef cattle production (Eshel *et al*. 2014; Shepon *et al*. 2016). Due to this, chicken meat products are comparatively inexpensive (Wong *et al*. 2015). This together with chicken meat being considered a healthy alternative to red meat (Wang *et al*. 2010) with high versatility has led to its ongoing popularity (Brunton 2009). However, the genetic selection of birds for high feed efficiency has also lead to morphological changes, including the development of large breast muscle mass. This has induced changes in bird gait (Corr *et al*. 2003*b*, 2003*a*), decreasing their mobility, and increasing the prevalence of leg disorders. These disorders are known to cause pain, which is often expressed as lameness (Danbury *et al*. 2000). Lame birds are reluctant to stand and walk reducing their ability to reach food and water, increasing bird morbidity and mortality, with higher rates of culling and carcass downgrades and condemnation at processing (Corr *et al*. 2003*b*; Bessei 2006; Knowles *et al*. 2008; Shim *et al*. 2012; Kierończyk *et al*. 2017).

Australian consumers are mindful of the welfare of birds grown within chicken meat production systems (Taylor and Signal 2009; Erian and Phillips 2017; Cornish *et al*. 2018). This has driven an increase in the production of more welfare friendly chicken meat products including those accredited by Free Range Egg and Poultry Australia (FREPA) and the Royal Society for the Prevention of Cruelty to Animals (RSPCA) Approved Farming Scheme (Free Range Egg and Poultry Australia 2012; RSPCA Australia 2020). The success of

these Australian schemes is demonstrated through the majority (~78%) of chicken meat products now being produced under these programs (Australian Chicken Meat Federation 2020*c*). Further, there has not been a concurrent increase in the overall retail price of chicken products, which is positive for affordability (Brunton 2009; Australian Chicken Meat Federation 2020*a*).

Much effort has been directed at improving bird welfare, especially leg health, and has frequently involved the introduction of environmental enrichment, for example, the inclusion of perches, within the poultry shed (LeVan *et al*. 2000; Pettit-Riley and Estevez 2001; Bizeray *et al*. 2002*a*; Tablante *et al*. 2003; Nielsen 2004; Groves and Muir 2013; Kaukonen *et al*. 2017*b*; Yildirim and Taskin 2017; Bailie *et al*. 2018). Perches are of particular relevance in Australia due to the uptake of the RSPCA approved farming scheme in which they are compulsory (RSPCA Australia 2018, 2020). Despite this, the ability of perches to improve meat chicken wellbeing, including leg health, remains unclear and requires further evaluation.

This paper provides an overview of animal welfare and the current Australian legislation for chicken meat production together with its impact on consumer attitudes and knowledge of chicken meat products. The most common forms of leg disorders that lead to bird lameness and the methods used to assess leg health in both commercial and research environments are reviewed. Approaches to improving leg health through environmental enrichment are discussed.

Animal welfare framework and assessment

Animal welfare refers to 'the physical and mental state of an animal in relation to the conditions in which it lives and dies' (OIE World Organisation for Animal Health 2018). The Brambell Report in the United Kingdom (Brambell 1965) provided initial guidance on criteria for animal welfare within a freedoms framework where an animal should have the freedom to 'stand up, lie down, turn around, groom themselves, and stretch their limbs'. This report instigated the creation of the Farm Animal Welfare Council that specifically defined the five freedoms as (1) freedom from hunger or thirst; (2) freedom from discomfort; (3) freedom from pain, injury or disease; (4) freedom to express normal behaviour; and (5) freedom from fear and distress (Farm Animal Welfare Council 2009). More recently, a five domains model for animal welfare was devised. This model incorporates elements of nutrition, environment, health, behaviour and mental state with a focus on creating a positive affective state, rather than avoiding a negative one (Mellor and Beausoleil 2015; Mellor 2017).

Protocols for the specific assessment of poultry welfare have been developed utilising these models as a framework. In the United Kingdom, the Welfare Quality Assessment Protocol for Poultry was created (Welfare Quality® 2009), followed by the RSPCA Broiler Welfare Assessment Protocol (RSPCA 2013). Both protocols consolidate validated methods of assessing bird health, outlining procedures to determine bird welfare on an individual bird, flock or farm basis. These protocols are utilised in the Australian chicken meat industry.

Animal welfare legislation and Australian chicken meat production

Within Australia, individual state and territory governments have legislation, which include a broad outline of the minimum welfare standards that must be met for meat chicken production, transport and processing (Animal Health Australia 2019). At a federal level, the Model Code of Practice for the Welfare of Animals (Primary Industries Standing Committee 2001) exists also as a best practice guideline. There are also several optional accreditation programs that producers can elect to follow; the two primary programs are the RSPCA Approved Farming Scheme (RSPCA Australia 2020) and FREPA (Free Range Egg and Poultry Australia 2012). There are other accreditation programs such as organic production, which represent less than 1% of meat chicken produced in Australia (Australian Chicken Meat Federation 2020*c*). When meat chickens are not produced within an accreditation scheme, individual processing companies have requirements that their producers (who act as contractors in this framework) or company farms must meet; however, these are not generally public knowledge. Meat chickens produced in this way are sometimes referred to as being 'conventionally' farmed.

Table 1 compares the three major production systems in Australia's chicken meat industry: conventional, FREPA accredited and RSPCA Approved Indoors accredited. The 'indoors' standard for the RSPCA accredited production refers to the RSPCA approved meat chickens that do not require access to an outdoor range. RSPCA 'free-range' accredited properties also fall under the FREPA accreditation scheme, and are therefore counted under this heading in Table 1 to avoid overlap. Table 1 was produced using statistics from the RSPCA 2018 Impact report (RSPCA Australia 2018) and information produced by the Australian Chicken Meat Federation (Australian Chicken Meat Federation 2020*c*), unless otherwise specified.

The RSPCA Australia scheme is designed to increase the minimum welfare standards in all areas of meat chicken management including provision of feed and water, environmental and housing conditions, stocking density, bird health, and procedures for bird euthanasia, catching, transport and slaughter (RSPCA Australia 2020). At a cost, producers elect to operate within the scheme's guidelines and in return their products are marketed as 'RSPCA approved'. According to the RSPCA, the welfare standards of RSPCA approved products are transparent, well recognised and trusted by 95% of Australian consumers (RSPCA Australia 2011). In 2014, two major Australian supermarket chains introduced RSPCA approved products into their stores and by 2018, 78% of Australia's meat chickens were produced under the scheme, an increase from 13% in 2013 (RSPCA Australia 2018).

FREPA outline the requirements for the production of eggs and chicken meat when the birds have access to an outdoor range (Free Range Egg and Poultry Australia 2012). These standards focus on overall welfare, while specifying management protocols, including light intensity and stocking density. However, FREPA guidelines are not as exhaustive as those provided by RSPCA Australia, for

Table 1. Comparison of Australian chicken meat production systems

Production parameter	Conventional	FREPA accredited	RSPCA approved indoors accredited
% of chicken meat produced in Australia (2020)	Approximately 22%	Between 18 and 20%	Between 65 and 70%[A]
Housing conditions	Sheds with deep litter	Sheds with deep litter	Sheds with deep litter
Access to range	No	Yes	No
Max. stocking density (kg bodyweight/m^2)	28–40	28–30	28–34
Environmental enrichment required	No	No	Perches at 2.7 m/1000 birds
Additional[B] standards for lighting duration	No	No	Max. 18 h photoperiod
Harvest age	35–65 days	35–65 days	35–65 days
Adherence to standards	Internal auditing only	Independently audited	Independently audited
Availability at major Australian supermarkets[C]	Available at some	Yes	Yes
Price of chicken breast fillets 500–1000 g[D]	AU$12/kg[D]	AU$16/kg[E]	AU$12/kg[E]

[A]Figure includes RSPCA approved indoor and outdoor systems, overlapping with FREPA approved percentage of industry.
[B]Beyond Model Code of Practice for the Welfare of Animals (Primary Industries Standing Committee 2001) which requires no more than 23 h of light/day.
[C]Includes Woolworths, Coles, IGA, and ALDI.
[D]Taken from IGA online shopping platform on 5 December 2020 (IGA Australia 2020).
[E]Taken from Woolworths online shopping platform on 5 December 2020 (Woolworths Group Limited 2020).

example not containing specifications for photoperiod nor environmental enrichment. Approximately 20% of Australian chicken meat produced is free range, and grown on FREPA (and often simultaneously, RSPCA) accredited properties (Australian Chicken Meat Federation 2020*c*). As with the RSPCA scheme, FREPA's accreditation program aims to provide consumers with an alternative to products from conventionally grown chickens. Although FREPA does not share the same brand recognition and consumer trust as the RSPCA, consumers do associate 'free-range' products with improved welfare (Cornish *et al*. 2018; van Asselt *et al*. 2019).

Consumer trends towards higher welfare products

There is an increasing awareness by consumers of the conditions in which animals destined for human consumption are grown (Boogaard *et al*. 2006; Cornish *et al*. 2018; van Asselt *et al*. 2019). Further, Australians show an affinity for animal products produced under welfare friendly conditions (Taylor and Signal 2009; Cornish *et al*. 2018). However, although consumers express interest in animal welfare, their understanding of the systems in which animal products are produced is often inaccurate, as has been shown for the Australia meat chicken industry (Brunton 2009). Consumers who believe they have significant knowledge of the welfare of animals within commercial production systems usually have limited knowledge, comparable to that of the general population (Coleman *et al*. 2016). Further, it is not uncommon for consumers who consider themselves well informed, to foster negative attitudes towards commercial animal production and therefore to choose not to consume these animal products regardless of the production process (Coleman *et al*. 2016). In Australia overall knowledge and understanding of the meat chicken industry is consistently low (Taylor and Signal 2009; Erian and Phillips 2017), making it difficult for consumers to interpret specific welfare standards (Taylor and Signal 2009; Erian and Phillips 2017). This is further complicated by the fact that for many consumers consider chicken meat a dietary staple, which may reduce their consideration of bird welfare *per se*, especially compared with perceived luxury or premium meat products such as beef (Brunton 2009; Clark *et al*. 2017). Despite this, consumers do demonstrate concern for meat chicken welfare (Patterson *et al*. 2015), as indicated by the demand for RSPCA and FREPA approved products. This, together with the importance the chicken meat industry places on bird welfare has continued the drive for practical mechanisms for improving bird wellbeing (Australian Chicken Meat Federation 2020*b*).

As a consequence of the high efficiency of Australian chicken meat production, the retail price of chicken meat has not increased in recent years (Australian Chicken Meat Federation 2020*a*), despite the increase of welfare friendly production systems. In 2013 when only 13% of meat chickens were grown under the RSPCA approved farming scheme the average consumer retail price across all chicken meat products was AU$5.56/kg. In 2018, 78% of chicken meat was produced within the RSPCA approved farming scheme, and at a similar time the 2017 average consumer retail price was AU$5.34/kg (Australian Chicken Meat Federation 2020*a*). However, the dilemma for consumers is that when the products produced by the more welfare friendly systems tend to be higher priced than products from the conventional systems; consumers are often reluctant to pay for the higher welfare product (Taylor and Signal 2009; Clark *et al*. 2017; Erian and Phillips 2017). Schröder and McEachern (2004) identified this as the consumer two-persona theory; consumers may support the production of meat with high welfare standards but are not prepared to pay the higher price for that product. Hence a balance between the cost associated with achieving a higher level of welfare throughout production is critical for the overall success of welfare focused schemes (Carrigan and Attalla 2001), as has been experienced in Australia. Understanding consumer attitudes and the public's behaviour towards the meat chicken industry is an area with significant opportunities for investigation. However, if chicken welfare can be improved without significantly affecting price, 'willingness to pay' studies may be redundant.

Lameness: common manifestations and impact on broiler welfare

Throughout the chicken meat industries compromised leg health is acknowledged as a welfare concern and its improvement is a priority (Cobb-Vantress 2021). Although poor leg health can have a variety of causes and manifest as several disorders, the common clinical sign is lameness (Pines and Reshef 2015; Nicol *et al*. 2017). Lameness impacts the five freedoms, particularly the bird's ability to reach food and water, and to be free from pain (Kestin *et al*. 1992; McGeown *et al*. 1999; Danbury *et al*. 2000). The main leg health conditions that result in lameness in meat chickens include bacterial chondronecrosis with osteomyelitis (BCO), bone deformities such as tibial dyschondroplasia, rickets, and leg asymmetry, and contact dermatitis (Pines and Reshef 2015).

BCO is an infectious leg disorder in meat chickens that is often observed as femoral head necrosis (Dinev 2009; Wideman 2016). The condition is commonly caused by *Escherichia coli*, but coliforms or environmental pathogens such as *Staphylococcus* spp. may also be involved (Thorp *et al*. 1993; Dinev 2009). In a recent Australian report BCO was observed in ~28% of on farm culled birds (the percentage of the flock that was culled was not reported), hence its impact on bird welfare and farm costs is apparent (Wijesurendra *et al*. 2017).

Lameness is also experienced by birds as a consequence of leg deformity from conditions such as tibial dyschondroplasia (TD), rickets and leg asymmetry. TD is a failure of bone development resulting in an un-mineralised mass of cartilage at the proximal, or less commonly, distal, end of the tibiotarsus (Dinev *et al*. 2012). In some studies, with up to 24% of birds exhibiting TD lesions, its economic cost can be substantial (Pines *et al*. 2005; Dinev *et al*. 2012). Rickets, considered a potential precursor to both BCO and TD (Dinev 2012), is also a developmental condition often associated with inadequate dietary ratios of calcium, phosphorus, and vitamin D (Thorp 1994; Dinev 2012). Leg asymmetry is also caused by bone deformation, degeneration or a combination of both (Pines and Reshef 2015).

Birds with reduced mobility are also more likely to exhibit lesions and infections associated with contact dermatitis on the footpad, hock, and breast (Sørensen *et al*. 1999; Haslam *et al*. 2007; Groves and Muir 2016), but the incidence of contact dermatitis can be significantly increased by poor litter quality (Kaukonen 2016). Not only does contact dermatitis and any associated infections impact bird health and welfare they can also result in carcass condemnation (Hashimoto 2013).

Due to the variety of leg health conditions, difficulties in the assessment of leg health, and continual progress in poultry breeding programs that select for improved leg health (Lawrence *et al*. 2004; Dawkins and Layton 2012; Cobb-Vantress 2021), it is difficult to accurately determine the prevalence of leg disease in meat chicken flocks. Not surprisingly, reports on individual leg health conditions show high variability in their incidence among both properties and flocks (Haslam *et al*. 2007; Allain *et al*. 2009). Farm management, housing type, and environment are also likely contributors to this variability, together with non-skeletal metabolic conditions that reduce bird activity, for example, broiler ascites syndrome (Wideman *et al*. 2013). However, a comprehensive study which incorporated data from 50% of UK producers identified that by 40 days of age, 27.6% of birds had impaired locomotion, whereas 3.3% were unable to walk (Knowles *et al*. 2008). Similar levels of compromised bird mobility have also been reported more recently (Kaukonen *et al*. 2017*b*).

Techniques for assessing leg health in meat chickens

Common leg health assessment techniques are presented in Table 2. Some of the techniques included are broad, identifying signs of poor leg health such as reduced mobility or altered gait of the live bird, whilst others identify specific manifestations that are known to have welfare implications, such as the presence and severity of TD at post-mortem. Techniques can be performed individually or together, with some suitable for use on farm or in processing plants. Others may require expensive equipment - for example latency to lie - or software to analyse - for example optical flow - making them more appropriate for a research context. Although the list is not exhaustive, the listed techniques are frequently referenced in literature addressing leg health in meat chickens.

Reduction of lameness through environmental enrichment

Enriching the environment in which an animal is held is designed to promote its physical and mental stimulation, thereby improving its health and welfare (Dawkins 2008; Riber *et al*. 2018). In the context of commercial animal production environments, enrichment is any element that the animal is motivated to engage with, promoting natural behaviours and improved biological functions (Riber *et al*. 2018). While the modern commercial chicken shed meets the fundamental needs of the bird for feed, water, and contact with other birds, it is a relatively bare environment with minimal enrichment (Riber *et al*. 2018). A variety of stimuli including panels, perches, barriers, and straw have been evaluated for enriching the environment of conventionally reared meat chickens in relation to activity, behaviour, health and welfare.

Perches have become increasingly common as a form of environmental enrichment in Australia's meat chicken industry, predominantly due to their inclusion in the requirements for RSPCA accreditation (RSPCA Australia 2013). A 'traditional perch' is an elevated structure that a bird can easily access and rest on (LeVan *et al*. 2000; Bizeray *et al*. 2002*a*). Perching is an instinctive behaviour separating the bird from the ground and when in the wild from ground-dwelling predators, with highest perch usage recorded at night (Olsson and Keeling 2002). Currently the Australian RSPCA Approved Farming Scheme requires 2.7 m of perching space per 1000 birds from 7 days of age provided at a height that is readily accessible to the birds (RSPCA Australia 2020). The RSPCA code does not dictate the structural materials nor perch design, hence, it is difficult to determine how much variety there is within Australian chicken meat facilities. Fig. 1

Table 2. Common leg health assessment techniques and their suitability for research or commercial environments

Assessment technique	References	Pre-/post-mortem	Subjective/ objective	Suitability/limitations	What does the assessment identify?
Gait scoring	Kestin *et al.* (1992); Webster *et al.* (2008); Welfare Quality® (2009); Aydin *et al.* (2010); RSPCA (2013)	Pre-mortem	Subjective	Suitable for on farm, though labour intensive and difficult at high bird density	Impacted mobility
Latency to lie	Berg and Sanotra (2003)	Pre-mortem	Objective	Possible to perform on farm, though a set-up and space is required and the procedure is labour intensive	Impacted mobility
Optical flow	Dawkins *et al.* (2017)	Pre-mortem	Objective	Still a novel technique, optical flow analysis requires significant equipment, therefore unsuitable on farm.	Normality of flock movement; impacted mobility.
Footpad dermatitis scoring	Welfare Quality® (2009); Michel *et al.* (2012); RSPCA (2013)	Pre- or post-mortem	Subjective	Suitable on farm and in processing plants	Poor litter quality and/or impacted mobility
Hock burn scoring	Welfare Quality® (2009); RSPCA (2013); Groves and Muir (2016)	Pre- or post-mortem	Subjective	Suitable on farm and in processing plants	Poor litter quality and/or impacted mobility
Breast plumage cleanliness scoring	Welfare Quality® (2009); RSPCA (2013)	Pre-mortem	Subjective	Suitable on farm	Poor litter quality and/or impacted mobility
Breast blister scoring	Welfare Quality® (2009)	Pre- or post-mortem	Objective	Suitable on farm and in processing plants	Poor litter quality and/or impacted mobility
Leg asymmetry scoring	RSPCA (2013); Toscano *et al.* (2013)	Pre- or post-mortem	Subjective	Suitable on farm and in processing plants	Leg bone asymmetry due to deformation or degeneration.
Tibial dyschondroplasia scoring	Groves and Muir (2017)	Post-mortem	Subjective	Suitable on farm and in processing plants in recently culled birds or mortalities	Tibial dyschondroplasia
Observation of detached femoral caps or BCO	Packialakshmi *et al.* (2015)	Post-mortem	Objective	Suitable on farm and in processing plants in recently culled birds or mortalities	Detached femoral caps or BCO
Bone ash percentage calculation	Hall *et al.* (2003); Tablante *et al.* (2003)	Post-mortem	Objective	Unsuitable for a commercial environment – time, labour and equipment requirements too great	Degree of bone mineralisation

Fig. 1. Three examples of perches used in commercial broiler facilities.

highlights some examples of perch structure and design that are used.

Research on the use and benefits of perches for meat chickens has generated varying outcomes. There is contention around the level of bird engagement with perches, with several groups reporting a maximum of only 3% of the population observed perching at any given time (LeVan *et al*. 2000; Pettit-Riley and Estevez 2001; Norring *et al*. 2016; Kaukonen *et al*. 2017*b*). Does this level of engagement fit into the classification of enrichment? Higher rates of perching can be induced by increasing bird stocking density but this may be at the detriment of other bird welfare or production factors such as thermal comfort, gait score or growth rate (Pettit-Riley and Estevez 2001; Dawkins *et al*. 2004). Perches have been found to increase the birds' behavioural repertoire including social and playful behaviours, and a reduction in fearful behaviour (Ventura *et al*. 2012; Bailie and O'Connell 2015; Ohara *et al*. 2015; Yildirim and Taskin 2017). However, the effect of behaviour on physical bird welfare is difficult to interpret in the absence of physiological outcomes. Hence, both behavioural and physiological measures are recommended in future assessments of perches and their effect on the bird.

The physiological impact of providing meat chickens with access to perches has shown some benefits for bird leg health, including improvement in gait scores and bird latency to lie (Groves and Muir 2013; Yildirim and Taskin 2017). Further, the reduced prevalence and severity of contact dermatitis in birds with access to perches is most likely due to less frequent contact with litter (Ohara *et al*. 2015; Kiyma *et al*. 2016; Karaarslan and Nazlıgül 2018). However other studies have shown negative physiological implications of perches including decreased levels of bone mineralisation (Nielsen 2004; Karaarslan and Nazlıgül 2018). There are also conflicting reports of the impact of perches on bird stress when assessed through heterophil : lymphocyte ratios (Heckert *et al*. 2002; Ohara *et al*. 2015). However, cooled perches have been shown consistently to reduce heat stress (Estevez *et al*. 2002; Hu *et al*. 2019). Further, preliminary data provides some evidence that perches can improve meat quality by reducing breast inflammation and increasing breast meat yield (Kiyma *et al*. 2016; Velo and Ceular 2017). However, numerous studies have not identified repeatable consistent physiological benefits of perches (Su *et al*. 2000; Tablante *et al*. 2003; Bench *et al*. 2017; Bailie *et al*. 2018; de Jong and Gunnink 2019). Some of these inconsistencies may be attributed to the wide array of experimental and perch designs used and therefore the combined findings from these studies should be treated with some caution. Further, to validate the use of perches as a tool of environmental enrichment for improving meat chicken leg strength and welfare more closely controlled research is required.

Several studies have explored other forms of environmental enrichment including panels, platforms, straw bales, light and string. Vertical panels that were expected to increase activity through increased environmental complexity were found to decrease bird activity (Cornetto and Estevez 2001). Birds with access to platforms have demonstrated improved gait scores and a reduced prevalence of TD in addition to a decreased fear response, suggesting that platforms may improve both bird physical and emotional welfare (Norring *et al*. 2016; Kaukonen *et al*. 2017*b*, 2017*a*; Tahamtani *et al*. 2018; Baxter *et al*. 2019). However, as with perches, results with platforms have been inconsistent. Bailie *et al*. (2018) reported that although platforms were preferentially chosen by birds over perches, implying behavioural benefit, no physiological benefits were evident. When mesh grids or perches were provided, birds preferred mesh grids (Malchow *et al*. 2019). However, Wideman (2016) reported a correlation between mesh grids and an increased prevalence of BCO, which indicates that mesh grids may not be suitable as environmental enrichment for meat chickens. Other forms of enrichment including nylon strings hung from feeder lines, projection of erratic lights onto shed floors and dispersion of whole wheat amongst the litter have not consistently demonstrated significant changes in bird behaviour or improved leg health (Bizeray *et al*. 2002*a*; Bailie and O'Connell 2015; Riber *et al*. 2018). In comparison, other forms of environmental enrichment such as the provision of natural light and dispersion of straw bales throughout the shed have been correlated with lower gait scores and longer latency to lie (Bailie *et al*. 2013; Baxter *et al*. 2018) and could be worthy of further evaluation.

Bird activity and leg health

The relationship between bird activity and leg health is complex and has been shown in many studies (Bizeray

et al. 2002*a*; Rodriguez-Aurrekoetxea *et al*. 2015; de Jong and Gunnink 2019; Vasdal *et al*. 2019). In some cases, environmental enrichment has stimulated bird activity (Bizeray *et al*. 2002*a*; Rodriguez-Aurrekoetxea *et al*. 2015; Pichova *et al*. 2016), whereas at other times, there was no effect (Norring *et al*. 2016). Unfortunately, a concurrent assessment of elements of bird physiology (for example bird mobility or leg conditions such as TD or contact dermatitis) to deduce possible outcomes of increased bird activity through environmental enrichment are not always undertaken. In cases where they have been assessed, clear outcomes were not always evident (de Jong and Gunnink 2019; Vasdal *et al*. 2019). When assessing physiological changes as a result of altered bird activity through environmental enrichment other factors that may also alter activity, for example diet and lighting (Bizeray *et al*. 2002*a*), may confound the results (Newberry *et al*. 1985, 1986, 1988; Su *et al*. 1999; Bizeray *et al*. 2002*b*). Hence, closely controlled conditions that change bird activity in response to specific environmental enrichment are required to provide insight into the mental and physical stimulation induced by the enrichment; physiological assessment will be required to determine whether the activity shift improves bird health and welfare.

Conclusions

Leg health is an important welfare consideration for the meat chicken industry. In Australia, accreditation schemes, such as the RSPCA Approved Farming Scheme, are designed to ensure the conditions in which birds are grown, including farm management practices and enrichment of the housing environment, meet a minimum welfare standard. The increased popularity of chicken meat products produced within accredited welfare friendly schemes with Australian consumers has been reinforced by the relative low price of chicken meat. For an accurate assessment of bird leg health, consistent assessment techniques need to be used across the industry. Opportunities to improve chicken leg health are being actively pursued through farm management and environmental enrichment. However, studies addressing the direct physiological impacts and welfare implications of different forms of environmental enrichment, including perches, require further evaluation under industry relevant conditions.

Conflicts of interest

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