Enhancing their quality of life: environmental enrichment for poultry

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ABSTRACT Providing environmental enrichments that increase environmental complexity can benefit poultry welfare. This Poultry Science Association symposium paper is structured around four themes on 1) poultry preferences and affective states 2) species-specific behavior, including play behavior and the relationship between behavior, activity level and walking ability, 3) environmental enrichment and its relationship with indicators of welfare, and 4) a case study focusing on the application of enrichments in commercial broiler chicken production. For effective enrichment strategies, the birds' perspective matters most, and we need to consider individual variation, social dynamics, and previous experience when assessing these strategies. Play behavior can be a valuable indicator of positive affect, and while we do not yet know how much play would be optimal, absence of play suggests a welfare deficit. Activity levels and behavior can be improved by environmental modifications and prior research has shown that the activity level of broilers can be increased, at least temporarily, by increasing the environmental complexity. However, more research on impacts of enrichments on birds' resilience, on birds in commercial conditions, and on slow(er)-growing strains is needed. Finally, incorporating farmers' expertise can greatly benefit enrichment design and implementation on commercial farms.

Key words: animal welfare, chicken, environmental complexity, environmental enrichment, turkey

2023 Poultry Science 102:102233
https://doi.org/10.1016/j.psj.2022.102233

INTRODUCTION

The concept of "quality of life" recognizes that animals can have positive and negative experiences (Webster, 2016). Environmental enrichment provides complexity that allows animals the opportunity to make choices that promote their own quality of life. Stimulus-rich environments can improve animal welfare and generate feelings of comfort, pleasure, interest, and a sense of control by allowing animals opportunities to engage in rewarding behaviors, which can include exploration, food searching (foraging), and social interactions (Mellor, 2016). Moreover, environmental enrichment can potentially enhance animals' cognitive development, induce positive emotional states (Anderson et al., 2021a), or improve their ability to utilize resources, adapt to changes, and navigate more complex housing environments (Campbell et al., 2019). These potential benefits are particularly relevant considerations in modern, commercial poultry production systems.

Newberry (1995) defines environmental enrichment as "an improvement in the biological functioning of captive animals resulting from modifications to their environment". The purpose of environmental enrichment includes encouraging species-specific behavior, reducing or preventing the occurrence of abnormal behavior, improving animals' use of their environment, and improving the animals' ability to cope with challenges (Riber et al., 2018). However, there are further factors that need to be considered when attempting to implement environmental enrichment for farm animals. In addition to improving biological function in terms of mental and physical health and ability to express species-specific behavior, the provision of enrichments

Received July 8, 2022.
Accepted October 2, 2022.

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should also result in economic benefits, and be practical to implement (Van de Weerd and Day, 2009). With the transition to cage free housing systems for laying hens, and the focus on improving broiler chicken walking ability and skeletal health, there is a need to identify and implement practical environmental enrichment strategies that will improve poultry resilience, health, and productivity.

This paper is derived from a symposium held at the 2022 Poultry Science Association Annual Meeting in San Antonio, TX, and organized by members of the Poultry Extension Collaborative, Leonie Jacobs, Marisa Erasmus, Shawna Weimer, and Prafulla Regmi. In it, we focus on the benefits and challenges of providing laying hens and broiler chickens with a complex, enriched environment and the impact on welfare in terms of health, behavior, and affective states. The benefits of enrichments on poultry welfare and health will be discussed, as well as to challenges with implementing enrichments in a commercial setting. To address these topics, we have structured this paper around 4 relevant themes focusing on: 1) Poultry preferences and affective states, where we will discuss what affective states are, how affective states in poultry can be measured, and whether we can assess laying hen individual experiences. 2) Species-specific behavior, including play and the relationship between behavior, activity level and walking ability, where we discuss how play can be recognized in poultry, how play can be stimulated in a commercial environment, and how play can be incorporated in animal welfare assessment protocols. Plus, we will review how environmental enrichment and modifications can stimulate active behavior in broilers and discuss which factors to consider when devising enrichment strategies to improve broiler chicken activity and behavior. 3) Environmental enrichment and its relationship with indicators of welfare, building on the reviews of Riber et al. (2018), Pedersen and Forkman (2019), and Estevez and Newberry (2017) and providing an update on scientific literature regarding effects of environmental enrichment on various welfare indicators for broiler chickens. Finally, 4) a case study focusing on the application of enrichments in commercial broiler chicken production, presenting how a large-scale company has engaged producers to practically implement effective environmental enrichment strategies on-farm.

A BIRD'S EYE VIEW: THE IMPORTANCE OF THE LAYING HEN'S EXPERIENCE IN A SUCCESSFUL ENRICHMENT PROGRAM

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Most researchers attempt to understand an animal's welfare through one or more of the 3 basic approaches: nature, function, and feelings (Fraser et al., 1997). Arguably, most research has used the approaches of nature and function, as they utilize validated methodologies that can be reliably employed across research settings. The feelings-based approach, the least studied, encompasses the emotions, affective states, and ultimately the subjective experience of the animal. Until recently, this approach has typically focused on understanding when an animal is experiencing a negative affective state, such as pain, stress, or suffering, and finding solutions to alleviate that state. New methodologies are allowing researchers to now better understand what an animal needs to experience positive affective states, such as contentment, and how to provide for those needs. One potential way to provide for positive affective states may be the provision of enrichment.

What Are Affective States?

The subjective experience of an animal can be thought of in 2 categories: an emotional response and an affective state (Horback, 2019). Emotional responses are discrete events that occur in response to an organism's perception of a specific stimulus, and quickly dissipate when that stimulus is removed. There are 6 core emotions that humans are considered to experience (Ekman et al., 1969); these have been modified to incorporate animal emotions to include seeking, care, play, panic, fear, lust, and rage (Panksepp, 1998). More recently, researchers studying emotional responses in animals have adopted a framework in which the emotion falls on a 2-dimensional spectrum of valence and arousal (as reviewed by Horback, 2019). In contrast, affective states are long lasting moods that result from an individual's accumulated experience (Russell, 2003; Barrett et al., 2007). Affective states may also fall on a spectrum of valence, for instance negative states such as anxiety or boredom, or positive states such as contentment or excitement. As affective states are longer lasting, and often chronic, they may provide a better view into the subjective experience of the animal over time.

Measuring Affective States

Although researchers generally agree on the importance of understanding an animal's subjective experience to a comprehensive assessment of an animal's welfare state, this information is often not considered. This may be because there are currently no objective methods to identify affective states, making them quite difficult to assess. Affective states can, however, be inferred through measures of physiology, behavior, and cognition.

Physiology and Affective States Certain measurable changes in physiology occur alongside emotional responses and longer lasting affective states. Some of the more common measures are heart rate and heart rate variability, as well as physiological measures of stress such as corticoid levels and heterophil:lymphocyte ratios in avian species. Nelson et al. (2020) compared white and brown strains of laying hens to describe genetic differences in fear and stress. They measured corticosterone levels in the plasma and egg albumen, as well as physical asymmetry (a measure to evaluate environmental induced stress during development). They argue that stress response measures can be used as an indication of fearfulness. Ross et al. (2020) examined the effects of an enriched environment on the ability of hens to cope (resiliency) by measuring comb temperature changes in response to a restraint and a novel object test. While these tests are often used to infer an affective state, they do not measure this directly, and can easily be misinterpreted. For instance, while corticoid levels can be measured, they do not relate the valence of the subjective experience, rather just the experience of arousal (as reviewed in Ralph and Tilbrook, 2016).

Behavior and Affective States The interaction of an animal with its environment, that is, behavior, is another proxy commonly used to infer the subjective state of the animal. Vocalizations and other reactions to environments or stimulation that researchers believe to coincide with positive or negative states are generally used in these situations. Behavioral tests such as startle response, tonic immobility, novel object or arena tests, inversion, and human approach are common tests of fearfulness in poultry (e.g., Wichman et al., 2012; Nelson et al., 2020; Ross et al., 2020).

Behavioral measures have generally been used to understand if an animal is experiencing a negative state (such as stress or fear), and using enrichment to decrease that negative state. However, research has also focused on utilizing enrichment to increase the likelihood that an animal will experience a positive state through the use of preference and motivation tests. Laying hens' preferences for perch characteristics and motivation to access perches have been well studied, with the idea that providing access to the preferred characteristics will result in positive subjective experiences. However, preference studies must be carefully designed and interpreted, as they are prone to confounds. There is often conflicting evidence of preference, for example, Duncan et al. (1992) found hens preferred round to rectangular perches, while Chen et al. (2014) found the opposite. Characteristics of perches may also have a ranking in the subjective experience, such as height and material. Hens appear to find height of perch more important than material (preferring height over material; Schrader and Muller, 2009), though this ranking would be unknown unless tested together.

Cognitive Bias Testing and Affective States Another method of inferring an animal's affective state is to examine how that state influences information processing. This method is known as cognitive bias testing (see Horback 2019). Unenriched environments have been shown to elicit negative cognitive bias, and this in turn, is assumed to show an animal is experiencing a negative affective state. Ross et al. (2019) tested hens from enriched and unenriched enclosures and found that enriched hens showed more optimism in their responses to a cognitive bias test. These tests were further complicated by personality traits, however, as only hens considered "exploratory" showed this response. In contrast, Wichman et al. (2012) tested hens from enriched and unenriched enclosures but found no differences in cognitive bias. They attributed this to a lack of perceived difference in housing environments. While cognitive bias testing may provide insight into the valence of an affective state, an improvement from the physiological and behavioral measures, there are current limitations on methodology and understanding of confounds that may interfere with the interpretation of these results.

Can We Assess a Hen's Experience?

It is important to note that all of the approaches to understand the affective state of animals described here infer that state and do not measure it directly. Some approaches provide information about the arousal level experienced, some the valence of that experience. Some tests, particularly cognitive bias testing, are not well validated in general, and especially not validated for avian species.

The relationships between the approaches also need to be explored. Several studies have attempted to understand how measures under these three approaches may be related. Ross et al. (2019) examined startle responses (behavior) and judgment bias (cognition) in relation to enrichments and personality traits, finding the startle response was a more sensitive measure to housing effects than the judgment bias. Paul et al. (2022) housed hens in either generally preferred enclosures (enriched) or generally non-preferred enclosures. They used measures of physiology, behavior, and judgment bias and found that relationships between these measures were influenced by individual preferences, which varied in their study. They also found that some individuals preferred living conditions that differed from the majority of birds. These individual differences are important to consider when generalizing findings back to the overall subjective experience of hens and their welfare. Considerations of social experiences should be incorporated into future studies. Paul et al. (2022) also found that the amount of time exposed to a living environment was important, finding judgment biases were most affected by short-term changes in exposure to different living conditions. This serves as a good reminder that affective states are influenced by experience. Future work should involve better understanding of how that experience may provide for emotional buffering and resiliency of affective states.

PLAYFUL POULTRY: WHAT DOES IT TAKE AND WHAT DOES IT MEAN?

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Play is a widely recognized behavior in mammals but is reported in a limited number of bird orders (Ortega and Bekoff, 1987; Diamond and Bond, 2003) and until recently, has received little attention in poultry. Play can be defined as spontaneous, self-handicapping, non-injurious, non-stereotyped behavior that is energetic but relaxed, occurring in contexts that do not have an immediate survival or reproductive function (Špinka et al., 2001). In poultry, behaviors meeting these criteria in some contexts include worm running (or food running), frolicking (or running with or without wing assistance), wing flapping, and jumping, as well as sparring. When performed in a playful context, these behaviors represent object, locomotory, and social play, respectively. Play behavior is seen in Red Junglefowl (Kruijt, 1964), domestic broilers, and layer chickens (Dawson and Siegel, 1967; Cloutier et al., 2004; Baxter et al., 2019; Campbell et al., 2022), as well as in turkeys (Hale and Schein, 1962). Play can also be seen in other poultry species, but reports are lacking.

Recognizing Play in Poultry

Play behavior is not often recognized as such in the poultry literature. This can be due to ambiguity about whether the behavior constitutes play or not (e.g., turkeys, Sherwin and Kelland, 1998) or perhaps because of an assumption that poultry do not play or concerns about anthropomorphism. It seems that the more that a species resembles humans, the more that scientists are willing to accept that what looks like play is, in fact, play. Thus, the bird play literature emphasizes relatively large-brained altricial birds showing complex play, especially corvids and psittacines (Kaplan, 2020). When reporting on poultry behavior, some authors use neutral terms such as running that can be hard to interpret in relation to play unless the context in which the behavior occurred is clear. Play fighting is more likely to have been mischaracterized as aggression (agonistic behavior) in reports on the behavior of young poultry.

While play gives the impression that animals are having fun (Špinka et al., 2001), and chickens in a positive state of happiness/arousal can be distinguished qualitatively from those in more negative or depressed states (Muri et al., 2019; Rayner et al., 2020), simply asserting that “the bird looks like it’s having fun, so of course, it is” can be prone to error (Emery and Clayton, 2015). Thus, multiple criteria are used for attributing behavioral events as play to avoid lumping play with similar-appearing behaviors occurring in other contexts (i.e., those fulfilling a current survival or reproductive priority). Accordingly, we need to distinguish playful worm running from food competition or tearing prey apart for consumption, running in a safe context from running to avoid danger (fleeing), and play fighting from offensive or defensive aggression.

Spontaneous play differs from forced behavior and involves diverse movements that can occur in flexible orders. Play bouts are typically short, without carrying through to an outcome such as eating prey, evading capture by a predator, or delivering a wounding peck or scratch. While involving rapid, energetic movements, playing individuals are relaxed enough that they may unexpectedly lose their balance or orientation without ending the play. Playful animals perform self-handicapping movements such as apparently unnecessary rapid turns, tilts and exaggerated leg movements that place them at risk of a temporary loss of control that is then recovered (Špinka et al., 2001). They may also rapidly approach another individual who is at least as big as themselves, rather than confining such “attacks” to those who are likely to be intimidated and retreat. Chases involve role reversals rather than bullying. When carrying a “worm” in a play context, a chicken may run directly into a crowd, peeping, zigzagging, and attracting attention rather than turning away from others, lowering its head, and quickly eating the item (R.C. Newberry, Norwegian University of Life Sciences, Ås, Norway, personal observation). Playful behavior ends immediately when a painful injury occurs, or fear arises.

What Does it Take to Stimulate Play in Poultry?

If a complex and dynamic environment has an enriching effect by stimulating positive emotions and behaviors, it would be expected that more play would occur in such an environment than would be seen in a relatively barren, static environment. There is some support for this prediction in poultry. Holt et al. (2022) found that play (frolicking, sparring) occurred at higher levels in young layer chicks when the environment offered simultaneous choices between litter and perch types rather than a single type of each. Furthermore, Vas et al. (2022) found a positive association between the number of environmental enrichment types provided to commercial broiler chickens and the prevalence of sparring play. Vasdal et al. (2019) observed higher levels of stationary wing flapping and a trend for more worm running and jumping in broiler pens enriched with bales of lucerne hay, peat, and elevated platforms than in unenriched pens. A dynamic environment in which resource variants were changed unpredictably also stimulated sparring play in layer chicks compared to chicks kept in a static environment (Skånberg et al., 2022).

Nevertheless, play is not consistently elevated by the provision of resources intended to serve as environmental enrichments. In Vasdal et al.’s (2019) study, levels of spontaneous running and play fighting did not differ significantly between enriched versus unenriched pens or between areas without versus with enrichments within enriched pens. Moreover, play levels (food running, frolicking, sparring) were comparable in commercial broiler houses with or without platforms, or platforms plus peat (Baxter et al., 2019). Similar results were obtained in a follow-up study in which play levels (frolicking, sparring) did not differ between houses with or without different numbers of suspended platforms (Baxter et al., 2020). In a study comparing play in pens enriched with a peck stone, a suet feeder filled regularly with fresh wood shavings, a hanging weighing scale, and a platform with access ramp versus unenriched pens, Liu et al. (2020) detected no difference in the amount of spontaneous play performed by broilers (running with or without wing-use, stationary wing flapping, sparring). In addition, no difference in play levels (recorded as in Liu et al., 2020) were found between young layer pullets given novel objects each week or provided with perching structures compared to those in control pens (Campbell et al., 2022). In female turkey poults, provision of a "turkey tree" comprising platforms at different heights resulted in levels of wing-assisted running comparable to the control (Lindenwald et al., 2021).

Play is influenced by space availability. This can be seen by looking at the area behind a person walking through a broiler flock, as the birds will frolic and spar in the space temporarily cleared of birds (Newberry et al., 2018; Baxter et al., 2019;2020; Rayner et al., 2020). Liu et al. (2020) used this knowledge to design a "free-space test" whereby the feeder was removed to temporarily create more space in the pen. This disturbance stimulated higher levels of running and frolicking in the unenriched compared to enriched pens, probably indicating that the unenriched birds were more attentive to the change (Liu et al., 2020). Newberry (1999) observed that broilers would frolic into an empty neighboring pen when the gate was opened allowing them temporary access for 3 h daily. This occurred despite a very low stocking density in the home pen (11.6 kg/m^2), suggesting that it was the temporary opportunity to explore the other area that stimulated play rather than a motivation to avoid crowding. Rayner et al. (2020) did not detect a difference in levels of play (worm running, play fighting, wing flapping, jumping, running) between broilers stocked at 27.5 kg/m^2 compared to 31.4 kg/m^2 in either recently disturbed or undisturbed areas of the house. However, across a broader range (28.3−37.1 kg/m^2), Vas et al. (2022) observed increasing levels of running and jumping in undisturbed broilers with increasing space allowance.

While "worm" running can be performed with live mealworms, these prey animals typically stimulate rapid consumption (R.C. Newberry, Norwegian University of Life Sciences, Ås, Norway, personal observation). Playful worm running is more likely to be seen when providing inedible items, especially narrow, lightweight items that can be easily carried (Cloutier et al., 2004), such as small twists of paper, pieces of straw or hay, or coarse pieces of peat. The implication is that this type of play depends upon the availability of such items. Baxter et al. (2021) found that striped red and white paper straw was effective in stimulating worm running during 1-min observations. Liu et al. (2020) stimulated worm running by providing broilers with twisted "paper worms" in standardized 5-min "worm running tests". More worm exchanges, worm running, and worm chasing occurred in the unenriched than enriched pens during these tests.

It is well established in mammalian species that adverse environmental conditions resulting in unpleasant affective states (e.g., feeling hurt, sick, or scared) suppress play (Špinka et al., 2001; Burghardt, 2005). Such studies have not been undertaken in poultry. However, Rayner et al. (2020) observed less play in disturbed areas of the house in a fast-growing broiler strain than in 2 slower-growing strains, and this difference was accompanied by evidence of poorer health in the fast-growing flocks. Similar findings were reported by Baxter et al. (2021) in a comparison of Hubbard Redbro vs. Ross 308 broilers.

What Does it Mean for Poultry Welfare When We See Poultry Playing?

Play is associated with activation of dopamine (desire) and opioid and endocannabinoid (pleasure) mechanisms in laboratory rat brains (Siviy and Panksepp, 2011). While studies on the neurobiology of bird play are lacking, birds have dopamine and opioid receptors in equivalent brain regions (Emery and Clayton, 2015) and have been reported to show endocannabinoid activity in relation to singing (Riters et al., 2019). Play in rats involves learned anticipation as indicated by conditioned place preference for locations previously associated with play (Trezza et al., 2009). Birds also show conditioned place preference related to reward (Riters et al., 2019). These findings support the hypothesis that plays reflects a joyful affective state in poultry.

However, it is unclear to what extent levels of play reflect welfare prior to the playful expression. For example, in rats, play is stimulated when given temporary access to a social partner following social isolation (Siviy and Panksepp, 2011), and chickens show elevated play when temporarily given access to more space (e.g., Liu et al., 2020). Lundén (2022) did not detect a difference in play levels of hatchery-stressed and control chicks when offered novel objects despite evidence that hatchery-stressed chicks exhibited a chronically more negative judgment bias (Hedlund et al., 2021).

There are also questions about the extent to which play experience has future fitness benefits. It is hypothesized that play provides "training for the unexpected", whereby individuals learn how to recover from unexpected loss of control (Špinka et al., 2001). If so, it is not surprising that play is a feature of young animals including chickens (Baxter et al., 2019; Rayner et al., 2020) and turkeys (Sherwin and Kelland, 1998), and declines as they gain experience. At the flock level, higher play levels were associated with higher body weights and lower mortality in broilers (Newberry et al., 2018), suggesting that higher levels of play may promote fitness. In contrast, more playful mice exhibited higher state anxiety and less willingness to explore when older (Richter et al., 2016). Therefore, caution is needed in interpreting play in relation to welfare.

Incorporating Play Into Welfare Assessment Protocols

When making comparisons across individuals, flocks, or treatments, several factors must be considered to avoid comparing apples with oranges. First, we need to compare birds of the same ages or developmental stages. Second, play takes up only a small proportion of the daily time budget and can only be seen when birds are active. Third, results vary depending on whether the birds are disturbed or undisturbed. Fourth, if birds are stressed, for example, by placing them in a test arena, play is likely to be suppressed. Fifth, there are likely to be sex differences in play that have not yet been explored in poultry. The development of algorithms to automate data collection from video cameras would greatly facilitate the collection of data on spontaneous play under undisturbed conditions. This would enable sufficient observation time for robust comparisons, with enough data for separate evaluation of object, locomotory and social play.

In conclusion, similar to the situation in other agricultural animal species (Lawrence et al., 2018), a dearth of literature on play in poultry illustrates a bias toward research on negative aspects of welfare (mortality, injuries, disease, stress, and negative affective states) at the expense of positive welfare. Until recently, there has been a view that play represents "luxury behavior" that is, at best, irrelevant to commercial production or at worst, something to be discouraged to avoid "waste of energy". With increasing realization that positive affective states contribute to quality of life and may have an important role in mitigating stress (Kaplan, 2020), there is a need for a better understanding of how to interpret play as an indicator of welfare across all species of poultry. While an absence of play indicates a welfare deficit, research is needed to understand how much play is needed for optimal quality of life, how to achieve such levels, and how to monitor their achievement.

STIMULATING AND MODIFYING BROILER BEHAVIOR BY PROVISION OF BIOLOGICALLY RELEVANT ENVIRONMENTAL ENRICHMENT

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The activity level of broiler chickens decreases with age, as the time budget is increasingly taken up by resting, that is, sitting or lying inactively on the floor (Baxter et al., 2019; Norring et al., 2019; da Silva et al., 2021). Even some types of active behavior will often be performed in less physical strenuous manners. For example, feeding, which is normally performed by domestic fowl in a standing position, may be performed while sitting (Weeks et al., 2000). This is more pronounced in individuals with walking deficiencies, even just moderate, than in birds with no or minor walking deficiencies (Weeks et al., 2000; Riber et al., 2021). Thus, part of the decrease in activity level can be explained by deterioration of walking ability. However, the barren and homogeneous environments that broilers typically are kept in, where the quality of the flooring material is deteriorating with broiler age, may contribute to the decreasing activity level. The aim of this section is to review how to enrich or modify the environment of broilers to stimulate active behavior and to discuss which influencing factors to consider.

Environmental Complexity That Increases Broiler Activity

One approach found to be successful in terms of increasing activity is to force broilers to travel longer distances to obtain essential resources, that is, feed and water. This can be achieved by increasing the distance between feed and water lines (Reiter and Bessei, 2009; Bach et al., 2019), by placing barriers in the environment (Bizeray et al., 2002), or by scatter feeding as opposed to trough feeding (Jordan et al., 2011). Barriers have other benefits to the welfare of the birds. They increase the complexity of the environment and provide the opportunity of resting in an elevated position. Furthermore, a more even distribution of broilers within the space available has been found when placing barriers under experimental conditions, resulting in fewer disturbances of resting birds (Ventura et al., 2012). Although scatter feeding has been demonstrated to stimulate more locomotion and foraging in broilers, their growth is negatively affected and feed waste is likely to be considerable (Jordan et al., 2011).

Another approach to increased activity levels of broilers is to provide environmental enrichment that stimulates active behavior, such as foraging, dustbathing, and locomotion. This can be point-source elements promoting foraging and/or dustbathing such as straw bales, highly valued feed items (e.g., roughage, insects, mealworms), and different dustbathing substrates. Some studies have investigated single types of point-source enrichment (e.g., Pichova et al., 2016; Bach et al., 2019), whereas others have examined effects of combining a range of enriching elements, often targeting different behavioral motivations (e.g. Vasdal et al., 2019; de Jong et al., 2021; Mocz et al., 2022).

One example of point-source enrichment is scattering of feed items. Scattering of whole wheat in the bedding as a supplement to the feed in the feeding troughs has been found to have no effect on the level of activity (Bizeray et al., 2002; Jordan et al., 2011; Pichova et al., 2016). In contrast, scattering of mealworms, considered to be highly valued by broilers, instigated more foraging activity in the period immediately after being provided, but not at later observation periods (10−30 min later: Pichova et al., 2016; 2 h and 5 h later: Wood et al., 2021). Pichova et al. (2016) suggested that frequent provision of high-value feed items would be more effective. This was indeed supported by Ipema et al. (2020b) who examined the effect of providing black soldier fly larvae at different frequencies and portions on the activity level of broilers and found that the largest amount combined with the highest frequency of larval provisioning resulted in the most prominent increase in activity.

Broilers prefer sand and peat over other materials (Arnould et al., 2004; Shields et al., 2004; Shields et al., 2005; Toghyani et al., 2010; Baxter et al., 2018a).

Therefore, it has been suggested that allocation of these materials can stimulate broilers into increased activity (Shields et al., 2004). However, Shields et al. (2005) could not demonstrate a higher level of activity in broilers on sand compared to broilers on wood shavings. Similarly, Baxter et al. (2018b) found no increase in general activity in unenriched areas on commercial farms when providing broilers with peat dust baths in combination with elevated platforms. In contrast, Arnould et al. (2004) found a higher foraging activity in broilers with access to sand in addition to wood shavings compared to broilers only having a bedding of wood shavings.

A more radical change in the environment is to provide access to a covered veranda or an outdoor area where a wider range of elements, such as natural weather conditions (including sunlight), vegetation, different flooring materials, and insects, in addition to more space may stimulate active species-specific behavior. Although not all broilers venture outside (Dawkins et al., 2003), the broilers staying indoor also benefit due to the decrease in indoor stocking density when part of the flock is outdoors. However, comparative studies of the effect of veranda and/or outdoor access on activity are scarce and usually confounded with genotype (e.g., Bergmann et al., 2017). Dal Bosco et al. (2014) observed less resting in broilers having access to a range with sorghum (i.e., a tall grass) as compared to an open short grass range. In general, active behavior appears to be performed mainly in the veranda or outdoor range, whereas resting is performed mainly indoors (Ruis et al., 2004; Fanatico et al., 2016).

Factors Impacting Broilers' Use and Benefit From Enrichment

The extent to which broilers exploit and benefit from the environmental enrichment depends on a range of factors, which have to be considered before implementation in a poultry house. As for any animal species, the enrichment provided needs to be biologically relevant to be effective (Newberry, 1995). Examples are found in the literature where types of enrichment provided are only used by the birds to a limited extent due to lack of relevance (e.g., strings: Arnould et al., 2004; Bailie and O'Connell, 2015; Taylor et al., 2022).

For point-source types of enrichment, concern has been raised whether the amount, the number of locations, and the frequency of provisioning are sufficient to truly function as enrichment for the entire flock (Vas et al., 2020). On the other hand, a patchy distribution creates functional spaces that require the broilers to move between them to get access to highly preferred resources for different motivated behaviors. This way, some types of enrichment that may not directly involve active behavior, for example, panels, elevated platforms, or other structures promoting resting, may indirectly stimulate activity as the broilers have to perform locomotive behavior to access the resources. However, so far this remains speculation, as it has not been demonstrated, for example, in studies providing platforms for broilers (Bach et al., 2019; Baxter et al., 2020).

When providing outdoor access, the ranges have to be found attractive by the broilers for high use to occur. Trees and bushes are preferred to open short grass habitat, even if being more distant from the house (Dawkins et al., 2003). Presence of tall vegetation such as trees, bushes, and sorghum as well as artificial shelters in the range has been documented to increase time spent in the range and distance ventured from the house (Dawkins et al., 2003; Dal Bosco et al., 2014; Fanatico et al., 2016). This is also reflected in the forage intake, where broilers having access to ranges with sorghum have been estimated to ingest more plant material in total and from areas further from the house than birds from open short grass ranges (Dal Bosco et al., 2014). Shelter in terms of artificial structures, for instance A-frames, appear to be less preferred to natural vegetation such as trees and bushes (Stadig et al., 2017).

Among the factors not directly related to the enrichment are genetics, stocking density, and light intensity. Genetics play a major role in the activity level exhibited by broilers, where for example, fast growth rates may hamper the use of enrichments, but variation may also exist within genotypes of similar growth potential (Almeida et al., 2012; Dawson et al., 2021). De Jong et al. (2021) showed that although the fast-growing genotype used the enrichment less than the slower-growing genotype, the positive impact on overall activity level was similar for both genotypes. Different genotypes vary in their propensity of being fearful, but research has shown that this may not necessarily impact how the genotypes exploit available enrichment (Lindholm et al., 2017). High stocking densities result in reduced locomotor activity (Leone and Estevez, 2008), that is, the space allowance influences the possibility and the effort needed to approach and utilize enrichment, implying that high stocking densities likely reduce the positive influence of enrichment on activity levels. Indeed, reduced usage of enrichment has been found with increasing stocking density (Ventura et al., 2012). Similarly, the lighting condition can be expected to influence the use, and hence impact, of enrichment as it is known that the light schedule and intensity that broilers are exposed to affect their activity level (Blatchford et al., 2009; Schwean-Lardner et al., 2012). Indeed, housing broilers with enrichment in combination with natural light increased activity as compared to housing broilers either with enrichment and no natural light or in unenriched conditions (de Jong and Gunnink, 2019). Likewise, Arnould et al. (2004) speculated whether the lower light intensity where the enrichment (strings) was placed accounted for the low use of the enrichment.

In general, it remains to be confirmed that the enrichment provided increases the total activity over 24 h, that is, that the effect observed (typically an increase or no effect) is not simply due to a change in the activity pattern that the method of data collection is unable to detect. For example, broilers housed at low light intensities have been observed to show less pronounced differences between the light and dark periods, that is, to change their activity pattern, but little overall differences were found in the time budget as compared to broilers housed at higher light intensities (Alvino et al., 2009). Failure in registering differences in activity levels due to methodological constraints may explain why some studies report improved walking abilities when enrichment is provided, despite an inability to demonstrate effects on activity levels (e.g., Baxter et al., 2018b).

In conclusion, the activity level of broilers can be increased, at least temporarily, by increasing the environmental complexity. Under standard and stable housing conditions, but with enrichments added, the increased activity level gained is likely an expression of the housing conditions better meeting the behavioral needs of the broilers. Further benefits are improved health, for example, fewer leg problems (reviewed by Pedersen and Forkman, 2019), decreased fear levels (Baxter et al., 2019; Anderson et al., 2021b), and performance of more positive behavior such as wing-flapping (Vasdal et al., 2019). Thus, solid evidence exists that provision of environmental enrichment increases broiler welfare by allowing expression of natural behaviors, improving health, and benefitting affective states. Challenges remain to be overcome, including how to ensure that all birds have access to enrichment, at which frequency to renew or provide enrichment, and what amount of enrichment to provide.

ENVIRONMENTAL ENRICHMENT FOR BROILER CHICKENS – ARE THERE BENEFICIAL EFFECTS ON WELFARE?

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Effective environmental enrichment, that is, enrichment that is actually used by the chickens and which has no harmful effects, contributes to the welfare of broiler chickens through stimulating activity and species-specific behaviors, and may contribute to the experience of positive emotions (Estevez and Newberry, 2017; Riber et al., 2018). Much research has focused on the actual use of the enrichment by the chickens and the effect of the various types of environmental enrichment on broiler chicken behavior. In addition, environmental enrichment may also have positive effects on other welfare indicators than behavior (Riber et al., 2018; Pedersen and Forkman, 2019). This may be a direct effect caused by the enrichment itself. For instance, when providing perches, chickens are less in contact with the litter, which may reduce the prevalence of contact dermatitis on the feet and hocks (de Jong et al., 2013). But the effect can also be indirect. For instance, environmental enrichment may stimulate broiler activity, which will in turn improve walking ability, as it has been suggested that there is a relationship between lameness and activity levels in broiler chickens (Kestin et al., 1992; Bizeray et al., 2002).

This section builds further on the reviews of Riber et al. (2018) (including studies from 2000 to 2018), Pedersen and Forkman (2019) (including all studies until February 2016) and Estevez and Newberry (2017), and will provide an update on scientific literature regarding effects of environmental enrichment on various welfare indicators in broiler chickens since then. Studies are not always in agreement regarding what can be considered as environmental enrichment. For example, Pedersen and Forkman (2019) also included reduced stocking density, a larger distance between feed and water and various light aspects (light program, light intensity) as environmental enrichment. Estevez and Newberry (2017) focused on increasing environmental complexity, either by various structures, providing outdoor ranges, and visual enrichment through lighting. Riber et al. (2018) included increased environmental complexity but did not include light as enrichment. Here we considered increased environmental complexity, either through adding structures or by providing an outdoor range, as environmental enrichment. In addition, we briefly discuss the potential effect of daylight entrance in the house in combination with environmental enrichment on welfare indicators, as daylight increases environmental complexity by variation in light intensity and light spectrum and thus can be regarded as visual enrichment. Environmental complexity will create microenvironments within the production house facilitating the broiler's adaptive behavioral responses (Estevez and Newberry, 2017), can stimulate activity and species-specific behaviors, and contribute to the experience of positive emotions (Estevez and Newberry, 2017; Riber et al., 2018). If, at the same time, the risk for welfare problems such as leg health problems can be reduced with increasing environmental complexity, it may also have economic benefits outweighing the costs of applying the enrichment and stimulate implementation in practice (Estevez and Newberry, 2017). With respect to effects of environmental enrichment on welfare indicators other than behavior, leg health is frequently assessed while other indicators such as feather cleanliness or scratches have not received much attention until now.

Perches

Perches may meet the need of the broilers to rest on an elevated structure. However, the actual use of perches by broiler chickens varies and is especially reported to be low in fast-growing broiler chicken strains due to physical constraints. Slower-growing strains are usually better able to perch, but studies on the effect of perches on various welfare indicators are mostly limited to the effects of perch provision on welfare of fast-growing strains. If well used, broiler chickens are less in contact with litter when resting on the perch, which may reduce the risk for contact dermatitis (footpad dermatitis, hock burn, and breast irritation). Moreover, they may increase broiler activity and exercise (e.g., jumping on and off the perch) which may have positive effects on bone and muscle development, and thus improve walking ability. In the reviews of Riber et al. (2018) and Pedersen and Forkman (2019), few studies found that perches could decrease footpad dermatitis and improve tibial morphological characteristics, although not all studies found such effects. One more recent study indeed suggested a negative correlation between perch use and prevalence of footpad dermatitis and hock burn in fast-growing broiler chickens (Matkovic et al., 2019). Although perches are used in commercial fast-growing chicken flocks, the usage is reported to be low (e.g., Bailie et al., 2018; de Jong and Gunnink, 2019; Phibbs et al., 2021) and it has been suggested that elevated platforms with ramps are better suited as elevated resting place for both fast- and slow(er)-growing chickens (de Jong and Van Wijhe-Kiezebrink, 2014; Bailie et al., 2018).

Elevated Platforms

Riber et al. (2018) indicated that elevated platforms could stimulate locomotor activity in broiler chickens, and therefore, improve leg health, although by that time limited scientific evidence was available. More recent studies indeed indicate a positive effect of elevated platforms on welfare indicators. Malchow and Schrader (2021) provided elevated platforms at different heights, accessible with a ramp, and observed improved walking ability and less footpad dermatitis in male slower-growing broilers but not in male fast-growing broilers. In another study of the same author the positive effects on walking ability in a slower-growing strain were confirmed (Malchow et al., 2019). In both studies, negative effects of the platforms on feather dirtiness were found. This could be explained by chickens sitting under the platforms and having dirty back feathers (Malchow et al., 2019). Yang et al. (2020) observed a positive effect of mesh platforms with ramps provided to fast-growing chickens on footpad dermatitis, likely because the chickens were less in contact with litter. However, they did not find any effect on cleanliness and walking ability. In contrast, others did not see any positive effect of elevated platforms on welfare indicators such as walking ability, cleanliness, footpad dermatitis, leg deformities, tibial morphology and strength, or muscle developments (Bailie et al., 2018; Baxter et al., 2020; Pedersen et al., 2020; Tahamtani et al., 2020). Tahamtani et al. (2020) observed less footpad dermatitis when providing platforms of 30 cm height, but observed a worse gait score in the same treatment. However, they indicated that overall good gait scores were found in that particular study and indicated that further investigation was needed.

Bales

Straw, hay or other bales are frequently used in commercial practice and may serve various functions; when intact, they provide an elevated resting area; cover and structure in the house, and they increase opportunities for explorative behavior (Estevez and Newberry, 2017; Riber et al., 2018). In the reviews of Pedersen and Forkman (2019) and Riber et al. (2018) a positive effect of bales on walking ability was suggested. More recently, Tahamtani et al. (2020) did not find any effect of straw bales on leg deformities, walking ability, cleanliness, and prevalence of scratches, but observed a negative effect on footpad dermatitis. In the same study, no effect of bales on leg pathologies, tibial morphology and tibia strength was found (Pedersen et al., 2020) as compared to some other treatment groups (control or with other types of enrichment). In commercial practice, straw, lucerne or hay bales are often used, but these can be firmly pressed and difficult to manipulate, especially for young broiler chickens, as long as the strings or wraps are not removed (I.C. de Jong, Wageningen Livestock Research, Wageningen, the Netherlands, personal communication). In these systems, bales may thus not be suitable to stimulate exploration during the entire rearing period and merely serve to structure the open space and provide an elevated resting area.

Live Insects

Live insects can promote locomotory and foraging behavior, which can in turn have positive effects on litter quality and thus contact dermatitis and walking ability. Two studies were performed by Ipema et al. (2020a; 2020b) using black soldier fly larvae. In the first study, the highest proportion of live black soldier fly larvae (10% of daily dry matter intake), and fed 4 times per day, reduced hock burn but not footpad dermatitis, and resulted in a better gait score (Ipema et al., 2020b). In a follow-up study, no effect of black soldier fly larvae provision (5 and 10% of diet, with different feeding methods and frequency) on walking ability, footpad dermatitis, hock burn, tibia morphology, and tibia strength was found while litter quality was worse for the highest amount of larvae. Broilers were housed in small pens at relatively high stocking density which was suggested to be the cause of absence of any effect on welfare parameters, although some positive effects on activity and foraging behavior were found (Ipema et al., 2020a).

Other Enrichments

Few studies considered other types of environmental enrichment and their effects on welfare indicators in fast-growing broiler chickens. Laser beams, 4 times per day during four minutes (Meyer et al., 2019), a robot vehicle (Yang et al., 2020), and roughage did not improve welfare indicators in broiler chickens (Pedersen et al., 2020; Tahamtani et al., 2020), while for roughage it was indicated that there might be a risk for wetter litter and as a result contact dermatitis (Riber et al., 2018). Vertical panels showed to have a beneficial effect on leg muscle width although other welfare indicators were not affected (Pedersen et al., 2020). Colored balls or a mirror stimulated activity and had a positive effect on footpad dermatitis and hock burn (Zahoor et al., 2022). Dark brooders simulate the hen and provide a warm and dark resting place. Broilers provided with a dark brooder until d 14 of age showed less footpad dermatitis as compared to the control group without brooders (de Jong et al., 2022).

More Complex Environments

A covered veranda or outdoor range potentially offers a more complex environment to broilers, offering variation in environment, climate, and light. As reviewed by Riber et al. (2018), studies showed contradictory results with respect to the effect on welfare indicators in systems with outdoor ranges, which was likely linked to the condition of the outdoor area and the actual use by the broilers. Interestingly, Taylor et al. (2020) found a relationship between range use and welfare, with better welfare scores with higher range use. In literature often systems are compared where the provision of an outdoor area or veranda is confounded with breed (Sans et al., 2022; de Jong et al., 2022) which makes it impossible to determine the exact contribution of the outdoor area or covered veranda to broiler welfare. Environmental complexity can also be increased by applying various types of environmental enrichments which may have several functions, such as elevated resting areas combined with materials stimulating dustbathing and/or exploratory or foraging behavior. Recent studies showed that these more complex environments can have positive effects on welfare, which might be related to stimulation of various behaviors including locomotor activity. A combination of elevated platforms and straw bales reduced footpad dermatitis and hock burn in fast-growing broiler chickens housed at 2 stocking densities (31 and 41 kg/m^2). At the highest density enrichment also improved walking ability (Mocz et al., 2022). Also a combination of elevated platforms, straw bales, and laser projections reduced the prevalence of footpad dermatitis, which was suggested to be related to increased activity in the enriched housed broilers as compared to a control environment without enrichment (da Silva et al., 2021). A combination of elevated platforms, increased distance between food and water, live insects, and barrier perches did not affect footpad dermatitis, hock burn, and gait score in both fast- and slower-growing broilers (de Jong et al., 2021; Guz et al., 2021), but positive effects were found on tibial biophysical characteristics in both breeds (Guz et al., 2021). A combination of perches, elevated platforms, and combined structures had a positive effect on footpad dermatitis in fast-growing chickens (Spiess et al., 2022). Under commercial conditions, a combination of peat, lucerne bales, and elevated platforms improved gait score in fast-growing chickens (Vasdal et al., 2019). Similarly, a combination of various enrichments (bales, peat, elevated structures) for fast-growing broilers in a commercial environment reduced the number of broilers with scratches and was also associated with lower mortality, fewer rejections at the plant, and a better overall welfare score as compared to environments with single enrichments (BenSassi et al., 2019). In slower-growing broilers, a combination of elevated platforms and lucerne bales reduced footpad dermatitis (I.C. de Jong, Wageningen Livestock Research, Wageningen, the Netherlands, personal observation).

When environmental enrichment (bales, perches) in a commercial house with fast-growing broilers was combined with natural light from windows, activity was improved as compared to flocks with enrichment without natural light, or without enrichment and natural light, but this did not affect leg health indicators (de Jong and Gunnink, 2019). In contrast, Bailie et al. (2013) found better gait scores when natural light and straw bales were provided in a commercial environment. As natural light causes more variation in light intensity and spectrum, it potentially can increase broiler activity which may in turn be beneficial for other welfare indicators such as walking ability. However, more research on the effect of natural light in combination with enrichment is needed.

An area that deserves further attention in research in broiler chickens is that greater environmental complexity may also have beneficial effects on resilience and make the birds less vulnerable for disturbances such as diseases. For example, in pigs it was shown that with enriched housing the susceptibility to infection was reduced (van Dixhoorn et al., 2016), and studies indicate that also in layers resilience might be increased in a complex environment (Zidar et al., 2018; Campderrich et al., 2019).

Concluding Remarks

Although studies indicate that environmental enrichment can be beneficial for broiler chickens with respect to other welfare indicators than behavior, these effects are not always found. Especially leg health (including bone strength, walking ability and contact dermatitis on feet and hocks) has been included in studies and can be improved with environmental enrichment. The apparently contradicting results between studies can be explained by factors such as pen/house size, the type and material of enrichment and how this is used by the chickens, and the quality of the litter and house climate. For instance, with impaired litter quality, it is more likely that well used elevated resting areas can reduce the prevalence of contact dermatitis on feet and hocks, as broilers are less in contact with the litter. In case litter quality is good, there will be little contact dermatitis in the flock and any beneficial effects of elevated areas as enrichment are less likely to be found. It is advised to perform more research under commercial conditions as environmental conditions and enclosure sizes largely differ from experimental conditions, so that effective environmental enrichment programs for commercial practice can be developed with beneficial effects on welfare, for both fast- and slower-growing broilers. Especially for slower-growing strains, studies on effective environmental enrichment are lacking.

Interestingly, studies combining various enrichment types under (semi) commercial conditions show beneficial effects on various welfare indicators. As these potentially better meet the needs of the birds by providing more opportunities for various natural behaviors, these may increase broiler resilience and for example make them less vulnerable to infections. This area deserves further study.

CASE STUDY: ENGAGING THE FARMER IN POULTRY ENRICHMENT

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At Perdue Farms, we aimed to develop an effective animal care program, thus we started to build it based on our experience with the No Antibiotics Ever (**NAE**) program which was launched in 2004. We had developed a USDA Process Verified Program (**PVP**) for animal care in 2009 based on National Chicken Council (**NCC**) welfare standards, and we incorporated additional points that we deemed important.

Lessons From Organic Operations

In 2011, we purchased Coleman Natural, a USDA-certified organic company. This exposed us to a new level of animal husbandry that was also very competitive to the results we were seeing in our nonorganic operations. We were exposed to windows, enrichments, more space and engaged farmers. We spent time learning about the program and how we could bring that kind of animal husbandry into our NAE programs. We were so impressed with how engaged the Coleman farmers were on the birds' welfare and health, which was obviously driving results. One thing we did hear from the farmers was about the performance of the enrichments and the chickens' interaction with them. The farmers complained about the enrichments being too heavy to move, hard to store and the chickens did not use them enough. One thing we did not hear from the farmers was that the enrichments were completely useless; however, they needed to be improved.

For an effective animal care program we decided to include the farmer, because they spend the most time with the birds. If the farmer believes and understands why we need to do something and, even more importantly, if we can get their perspective on it, it will be more effective. If it makes the farmer's job easier and it is better for the birds that is a win/win solution.

Involving the Farmers

As part of our journey of continuous improvement in animal care, we were exploring ways to enable our chickens to exhibit their natural behaviors. We wanted to improve our chickens' environment and allow them to do what they do naturally- act like chickens. So, we decided to ask the experts – the farmers. Beginning on June 1, 2018 we launched the "New Chicken Enrichment Contest" and engaged our farmers to build a better enrichment. We had over 30 submissions and they were judged internally to get the top 5. The top 5 enrichments, along with the families, were brought to Salisbury, Maryland where a panel of 3 outside judges (Temple Grandin, Professor of Animal Science Colorado State University, Richard Swartzentruber, Family Farmer and Maja Makagon, Assistant Professor of Animal Science at UC Davis) determined the winner. The winner received a $5,000 cash prize and the runner up received a $2,000 prize. Both families were also invited to attend our 2019 Animal Care Summit in Salisbury. The winning enrichment was a 'carpenter bench' (Figures 1 and 2) providing broiler chickens with an opportunity to perch at an elevated place, and hide or rest in a secure place.

Figure 1. The winning enrichment, the carpenter bench, in the Perdue Farms "New Chicken Enrichment Contest".

Effective Enrichment Strategies in Practice

In summary, what did we learn from this contest? We need to include the farmers in enrichment programs, as they spend the most time with the birds, and have a great perspective of what is good for the birds and good for the farmers. From the chickens' perspective, they

Figure 2. The winning enrichment in the Perdue Farms "New Chicken Enrichment Contest" after multiple generations of use.

want to get off the litter and up high. They also like to hide under things, they want to be level, and they want to feel safe. From the farmers' perspective, enrichments should be easy to manage and store. In addition, if the enrichment adds to the operation efficiency and farmers see the birds use it, this all makes it worthwhile for the farmer. Currently, we have added enrichments to all our NAE free-range operations, which include the winning enrichment from the contest.

CONCLUSIONS

Environmental enrichment can greatly influence the welfare of poultry, including health, behavior, and affective states. The birds' experiences matter most when exploring effective enrichment strategies. Evaluating birds' affective experience is relatively novel, yet methods are available to assess enrichment efficacy from the birds' perspective. Individual variation, social dynamics, and experience can impact the outcomes of these novel methods to determine birds' evaluation of enrichments, and further research is needed to get a better understanding of the complexity in affective states.

As one indicator of positive affect, play behavior can be a valuable indicator of effective enrichment strategies, yet play has been understudied or in the past miscategorized in poultry research. With increasing realization that positive affective states contribute to quality of life and have an important role in mitigating stress, researchers, and industry stakeholders need a better understanding of how to interpret play as an indicator of welfare in poultry. While an absence of play indicates a welfare deficit, research is needed to understand how much play is needed for optimal quality of life, how to achieve such levels, and how to monitor their achievement.

When considering environmental enrichment strategies for poultry, the relationships among bird behavior, health, and activity level need to be considered, particularly for broiler chickens. Broiler chicken activity decreases with age which could in part be because of a deteriorated walking ability. Based on a review of the literature, some effective strategies for improving behavior and activity levels include scattering feed, providing straw bales, highly valued feed items, dust bathing substrates, or access to an outdoor area (with natural vegetation). Factors impacting enrichment efficacy include genetics, stocking density, and light intensity. Overall, the activity level of broilers can be increased, at least temporarily, by increasing the environmental complexity.

Besides behavioral benefits of effective enrichment strategies, there can be direct and indirect benefits for other aspects of broiler chicken welfare, although results are not always consistent. Perches and or platforms may benefit bone and muscle development and reduce contact dermatitis. Bales may improve walking ability yet results are not consistent. One study reported benefits of feeding live insects on contact dermatitis and walking ability. Balls, mirrors, or dark brooders reduced contact dermatitis prevalence. Providing a complex environment, for instance an outdoor range, could benefit welfare outcomes depending on range use. Combining enrichments, such as platforms, bales and other items (insects, laser lights) may improve bone strength, walking ability or reduce contact dermatitis, scratches, or mortality. More research on the impacts of enrichments on birds' resilience, on birds in commercial conditions, and on slow(er)-growing strains is needed.

For enrichment strategies to be truly effective, not only bird experience, but also farmer experience needs to be considered. Involving those people that spend most time with the birds provides a valuable resource to determine which enrichments will actually be used by the birds, and which will actually be implemented by the farmers. In a case study, one company incorporated farmers' knowledge in an enrichment program for broilers. Based on experiences with organic production systems, an enrichment program that purposefully included farmers' know-how has resulted in the use of multiple enrichment items in all of a company's free-range broiler chicken operations.

DISCLOSURES

The authors have no conflict of interest.

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