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Freeing the hens: Workshop outcomes for applying ethology to the development of cage-free housing systems in the commercial egg industry

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ABSTRACT

Throughout the world, most laying hens producing eggs for human consumption are still kept in small, wire battery cages. Ethologists have well documented the behavioural needs of hens, and the way that battery cage confinement thwarts highly motivated behaviour and reduces hens' quality of life. While cage-free alternatives are now being used around the world, the more challenging management in these systems has contributed to the slower than desired uptake that would be necessary for improving hens' welfare. As part of the 2021 International Society for Applied Ethology (ISAE) virtual conference, a workshop was held with the aim to identify solutions to the common challenges. Attendees were given information about cage-free production and then sectioned into breakout groups for discussion. Following the workshop, they were asked to participate in a short survey. Breakout sessions included the topics of stakeholder engagement and further research needs, as well as identification of solutions to the common challenges. Across the two days of the workshop, there were 80 participants, from 27 countries, mostly ethologists (both students and non-students), but including egg producers, and representatives from government and non-governmental (NGO) organizations. Of the 80 participants, 35 completed the survey. Participants generated many insightful and practical ideas in both the breakout rooms and in the survey, but one particularly salient theme was that solutions already exist and what is needed is greater education and dissemination of technical knowledge (half of survey responses from participants in the developed world and 42% of ethologist's responses fit within the theme of established producers assisting new producers or producer education and training). This was further evidenced by the noted success of cage-free producers in a variety of different geographic areas, climates, production scales and in both developed and developing regions. It was concluded that cross-sector collaboration will be necessary to speed up the transition to cage-free housing, with roles to play by the producers' egg buying customers (retailers), end consumers, government and NGOs, and researchers. There are multiple paths forward, with many different approaches possible simultaneously, and the potential to free many more hens from their cages is promising.

1. Introduction

Around the world, cage-free egg production is taking hold in response to animal welfare concerns associated with conventional, battery cage confinement of egg-laying hens. Battery cages—small, wire enclosures, usually holding 5–7 hens—provide very little space (typically 432 cm^2 per hen in the United States; United Egg Producers, 2002) and are barren, restrictive housing systems. Historically, battery cage confinement was one of the original issues prompting the scientific investigation of farm animal welfare (Hughes and Black, 1973).

Ethology research over the past several decades has extensively documented the behavioural needs of hens and confirmed that these cannot be accommodated in cages. Most prominently, cages prevent hens from expressing nest-site selection and the range of nesting behaviour that is physiologically tied to egg-laying. A hen nearing oviposition may inspect 25 or more different potential nesting sites (Freire et al., 1996) and enter several before finally choosing one in which to lay her egg (Meijsser and Hughes, 1989). The physiological mechanism that triggers egg production is the same trigger for laying behaviour, a biological safeguard to ensure the egg is laid in the right place. In motivational analyses, hens will push more weight for access to a nest box than they will for food (Cooper and Appleby, 2003;

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Follensbee, 1992). Additionally, cages prevent hens from foraging, a behaviour that normally occupies over half of a chicken's waking time budget (Savory et al., 1978). Hens prefer to roost at night on an elevated perch (Schrader and Müller, 2009) and, like nesting, this behaviour is highly motivated (Olsson and Keeling, 2000). Dustbathing is also prevented by cage confinement, as the cage floor is wire and loose litter cannot be provided. Dustbathing functions to remove ectoparasites (Martin and Mullens, 2012) and is thought to be motivated by positive affect (Widowski and Duncan, 2000).

Well designed, cage-free housing systems are configured to the behavioural needs of the hens. In a commercial aviary, hens can move between levels, roost on the top tiers at night, and forage and dustbathe in loose litter on the floor during the day. Importantly, hens can select from one of many nest boxes provided (i.e., they can make choices about micro-climate, expressing preferences for less noisy, crowded, or drafty nesting areas, for example). They can also express the appetitive components of nesting behaviour (Duncan, 1998), including nest-site seeking and inspection (Freire et al., 1996). Cage-free floor or single-tier systems, when well equipped, also provide perches, loose litter and nest boxes, fulfilling the behavioural needs of hens.

While furnished (or enriched cages) provide a perch and curtained nesting space, it is difficult to provide the quantity of loose litter that would be effective for dustbathing and foraging (Rodenburg et al., 2005). Further, the height limitations in a furnished cage do not permit elevated perching. For these reasons and because consumers do not well distinguish between different types of cages, animal protection groups do not support furnished cages.

The scientific findings, coupled with growing social awareness, has propelled the issue into corporate and legislative arenas. There are now at least 37 major international brands with global cage-free egg purchasing policies and dozens more at the regional level ("Cage-Free World," 2022). Switzerland banned battery cages in 1992. In the European Union, battery cages have been prohibited since 2012, and some countries banned them even earlier (Luxembourg since 2007, Germany since 2010, and Austria since 2009). A few European countries are phasing out furnished cages as well (including Austria by 2020, the Czech Republic by 2021 and Germany by 2025; German Federal Ministry of Justice and Consumer Protection, 2021). In other regions of the world, various countries and states have enacted prohibitions on cages. For example, in 2012, Bhutan banned battery cages and through the Animal Welfare Act, in 2018 the High Court of Delhi prohibited construction of new battery cage facilities throughout India. New Zealand Code of Practice stipulates the phaseout of all types of cages by the end of 2022 and Australia is in the process of mandating a possible phaseout. In the United States, 10 states ban or restrict the use of cages and many of these also prohibit the sale of eggs from hens confined to cages in other states. The EU is considering a ban of all cages, including furnished cages, in the revision of the EU laying hen directive, with legislation expected to be proposed in 2023.

While there is growing uptake of cage-free egg production internationally, there are challenges, which have slowed its adoption. Cage-free systems require a greater level of knowledge and management skill, slightly modified hen nutrition, specialised rearing conditions for pullets, and more hen vaccinations to ensure a healthy flock that produces to expectations. While the scientific community has done good work cataloging the common challenges, this has created a bias in the literature where the problems are emphasised, but well-functioning, cage-free operations are less well documented. This situation has been exploited to slow policy change. There is a need to focus on solutions involving a variety of relevant stakeholders: ethologists, who are well positioned to address the challenges through research and innovation, egg producers, who have valuable experience that cannot be found in the scientific literature, and international animal protection Non-Governmental Organizations (NGOs), who overview global developments and can act as a link between professionals and a wider public. The aim of this paper is to map and analyze the solutions for a broader uptake of cage-free systems proposed by these three stakeholder groups in a joint workshop at the ISAE congress. These insights could be used in practice to foster a global transition to animal-friendly, ethologically sound husbandry systems for laying hens. In addition, topics on which more research is needed will be identified.

2. Materials and methods

2.1. The 2021 ISAE congress and cage-free egg workshop

The theme of the 54th Congress of the International Society for Applied Ethology, held virtually in August of 2021 was "Developing animal behaviour and welfare: Real solutions for real problems." As part of the Congress programme, Humane Society International (HSI), an NGO non-profit charity working to protect all animals, held a workshop titled "Freeing the Hens: Applying Ethology to the Development of Cage-Free Housing Systems in the Commercial Egg Industry." The goal of the workshop was to generate solutions to the common challenges in cage-free egg production, with the aim of encouraging more wide-spread adoption of high-welfare systems meeting the behavioural needs of hens.

2.2. Generating solutions

The workshop lasted two hours, with the first hour for presentations and the second hour consisting of small group breakout sessions and overall synthesis. Workshop attendees were provided with solution examples, ranging in scope from complex (whole new housing designs, e.g., the Kipster system) to simple—such as adding ramps between the levels of a cage-free aviary to reduce the rate of bone fractures (Heerkens et al., 2016) or adding wire A-frames to prevent smothering in corners (Fig. 1) with an emphasis on one specific challenge (feather pecking behaviour, which can be especially problematic in large group sizes). Workshop attendees were informed that approaches to manage feather pecking in cage-free systems should be targeted both at pullet rearing and at the adult laying phase (de Haas et al., 2014a, 2014b). In a study in Dutch commercial flocks, de Haas a, b) et al. (2014) found that managing fear and stress sensitivity and litter supply were two crucial factors in preventing feather pecking and feather damage in adult hens. Flocks that were fearful of the caretaker as pullets were found to have more feather damage as adult hens, indicating that investing in a good human-animal relationship is worthwhile. As a second main factor, the availability of good quality litter (dry and friable), both during rearing and lay, is crucial in preventing the birds from redirecting their foraging behaviour to the feathers of flock mates. Environmental enrichment with roughage and pecking stones can help to reduce problems with feather pecking once they develop. Various advisory tools are available for housing and managing cage-free flocks in the best possible manner

Fig. 1. Photo of a practical, low-cost solution to preventing smothering and piling of hens at the entrance and corners of an aviary housing system. Photo credit: Humane Society International, 2018.

and producers are advised to make use of these tools. In the EU, the Best Practice Hens project (European Union, 2021) is aiming to make best practices available for farmers that are interested to make the transition from cages to cage-free systems. An example of a best practice is ensuring a smooth transition between rearing and laying environment, both regarding design of the housing system and management practices.

Commercial-scale, cage-free production is well established in the developed world. The United States is over 30% cage-free production (U. S. Department of Agriculture, 2021), Europe is over 50% cage-free (EU Market Situation for Eggs, 2021) and in Australia, over 60% of major supermarket grocery chains egg sales are cage free (Australian Eggs Limited, 2021). However, the potential for cage-free egg production in the developing world is less well documented. Workshop attendees were given a successful case study from India, the Happy Hens farmer cooperative, founded in 2010 ("Happy Hens," 2022). Happy Hens has a simple model, building a community of free-range farmers to not only offer an alternative to battery cage eggs, but to contribute to food security by boosting rural economies. Partner farmers average just two acres and often supplement income from eggs by growing semi perineal fruit trees in the area where the hens range outdoors. The enterprises are family owned and largely run by women. Happy Hens provides training at their Humane Farm Animal Care certified farm, beginning at the brooding stage, and offering guidance for key factors including space, nesting areas, perches, drinkers, feed, breeds and other basics based on the programme's animal welfare standards. The farms are decentralised, located around the urban perimeter so the eggs arrive fresh to urban consumers. By selling to high-end retail outlets in the cities, Happy Hens can offer a guaranteed price to the famers, a win-win for both the rural communities and the animals.

2.3. Breakout discussions and analysis

After the attendees received initial information from the presentations, given by an HSI representative, an ethologist, and a farmer of the Happy Hens initiative, they were invited to participate in small breakout groups for discussion. Attendees could preselect their preferred breakout group, from one of the three topics:

1) Overcoming the challenges of cage-free egg production
2) Collaborative opportunities to facilitate the transition to cage-free systems
3) Identification of remaining research needs, and next steps for the ethology community

Each breakout room session lasted 30 min, beginning with open discussion and then the moderators asked participants to give input on the designated topic. The workshop was given twice, on August 2 and August 3, 2021, to accommodate different time zones. Participants were informed that the session would be recorded and that while responses were anonymised, that they would be used for this subsequent publication. Key findings from the breakout sessions are summarised and described in the results section (but were not analyzed formally from transcripts).

2.4. Post-conference survey and analysis

At the end of the breakout session, participants were given a link to the survey. The survey asked participants to provide basic demographics (i.e., about their occupation and country of residence) and then asked a few open-ended questions regarding the content of the workshop. Human ethics approval was not necessary, as no personal information was collected. On the survey itself and in the email accompanying the survey, participants were informed that their responses would be anonymised and used for this publication. Two of the open-ended questions (Question 7 and Question 10) generated enough quality answers to be considered for further descriptive analysis. These questions were:

Question 7. The theme of the 54th Congress of the ISAE conference is "Developing animal behaviour and welfare: Real solutions for real problems." While cage-free egg production permits hens to display their behavioural needs, the system comes with its own set of animal welfare challenges. What ideas or solutions did you contribute during the breakout session, or what idea or solution presented by other participants resonated with you? (Referred to as "cage-free solutions" question in the remainder of this paper.).

Question 10. Describe any final thoughts on the best way forward for establishing cage-free production as an industry-wide norm. (Referred to as "way forward" question in the remainder of this paper.).

An initial review of the survey answers revealed that they could readily be grouped into different themes, which the corresponding author identified. For these two questions, three observers blind to all the demographic information in the survey, categorised the individual respondents' answers into the themes. For the question on cage-free solutions, the 5 themes identified in the participants' responses are given in Table 1. For the question on the way forward, the 6 themes are given in Table 2.

Categorizations were binary, either a survey response fit under the theme, or it did not (each theme was marked a "1" or a "0" by the observers for each respondent's answers). Each answer could be counted under more than one theme and every answer fell into at least one theme unless it was not applicable (because the respondent didn't answer the question). For the question on cage-free solutions, a score of "0" was assigned if no solutions/ideas were offered and only challenges were given. If a respondent left an answer blank, it was assigned a "0." When in doubt, observers were generous with awarding answers with a "1."

If at least two out of three observers agreed an answer fit into the same theme, the answer was considered as falling into the category and was used in the subsequent descriptive analysis.

3. Results

3.1. Participation

Over both days of the workshop, there were 92 total participants. However, some people attended both workshops so there were 80 unique attendees.

More detailed demographics are only available from the post-conference survey. Thirty-five participants completed the survey, with 24 self-identified as ethologists (69%) and 11 as non-ethologists (31%). Eleven people marked both ethology and animal science and one marked both NGO and ethology. Of the non-ethologists, 2 were government employees, 4 were animal scientists, 1 was an egg producer and 1 was a representative of an NGO. There were 15 students (43%) and 20 non-students (57%). Participants were from the following regions: Africa (2), Asia (7), Oceania (2), Europe (16), North America (6) and Latin America (2). Participants could be classified into developed (24 participants, 69%) versus developing regions (11 participants, 31%) following the Guidelines of the ISAE Council (2020) (developing regions were Eastern Europe, Africa, the Middle East, Asia apart from Japan, and Latin America (Guidelines for the International Society for Applied Ethology, 2020)).

Table 1
Response themes identified for Question 7 on cage-free solutions.

Specific technical or practical solutions
Ideas for providing education or advice to farmers
Ideas for collaboration and communication between different stakeholder groups
Conceptual solutions (big ideas that need further evaluation or emphasis) or ideas for additional research or implementation of results
Marketing or economic solutions

Table 2
Response themes identified for Question 10 on the way forward.

Work through multiple stakeholders/ levels/ disciplines
Educate/ motivate consumers
Have established cage-free producers/ regions assist new producers or producer communication/ training
Tackle specific management challenges or larger consequences of cage-free production (environmental or social)
Provide economic/ marketing solutions or support and/or research funding
Enact laws/ policy or expand certifications

3.2. Breakout room results

3.2.1. Breakout room 1: overcoming the challenges of cage-free egg production

A summary of the challenges and solutions identified during breakout room 1 is presented in Table 3.

A key point of discussion in breakout room 1 was that to solve the problems, their root causes need to be uncovered. For example, to truly solve the problems with feather pecking and piling or smothering, the underlying causes of these behavioural anomalies must be better understood. A case in point is that while blocking off the corners of the house to prevent smothering may help control flock mortality (see Fig. 1), this fix does not reveal the root of the problem, the original cause of the piling behaviour. This concept overlapped with the third breakout room topic, research needs. The question, "Why does it happen on some farms but not others?" was raised, noting the variability between flocks. It was agreed that the goal should be to treat the root cause of the behaviour rather than to simply mitigate the outcome. In other words, the goal is to address the motivation to perform the behaviour in the first place, rather than react to the behaviour itself and this may require continuing research.

Another overarching outcome of breakout groups 1 and 3 was the identification of breed or hen genetics as a key factor for addressing many challenges at once (feather pecking, keel bone fractures, good range use, etc.). Similarly, pullet rearing conditions can improve (or worsen) many of the challenges identified. One potential solution that was raised was marketing and certification schemes should expand to inspect the rearing conditions of the hens—there is a need for these programmes to include the rearing phase in their animal welfare standards. Some already do have modules for the rearing phase, and these should be utilised.

Given that the early rearing environment was identified as an important area of focus, several ideas were raised related to this theme. The idea of mixing older and younger animals was raised as a potential method to curb feather pecking and the concept of producing more resilient flocks through the provision of a more complex environment, including novel, changing enrichments early in development were explored.

In terms of overcoming economic challenges, some other notable solutions that were identified included the use of crops in addition to hens in range areas, for example growing fruit trees. Attendees noted that this solution provides dual benefits, both increased crop income for the farmers and natural protection and shelter for the hens. The hens can also serve as a natural form of insect control for the fruit trees and there could be slight benefits to soil health from chicken manure on the range, although this would need further investigation.

3.2.2. Breakout room 2: collaborative opportunities to facilitate the transition to cage-free systems

Breakout room 2 focused on stakeholders and collaborative efforts necessary to realise the transition to cage-free housing systems for laying hens. Participants first identified the relevant stakeholders and then discussed which stakeholders should collaborate with each other, the aims of these collaborations, and possible challenges (Fig. 2). The key stakeholders mentioned were farmers, citizens (particularly consumers of eggs), researchers and universities, governments, retailers, and animal protection and welfare NGOs.

Farmers were seen as key stakeholders as they would have to invest in the new system and to manage the animals in this system in practice. These two themes bring challenges which require collaboration with other stakeholders. Regarding the management of hens, farmers who operate cage systems often seem to lack knowledge of the behavioural repertoire of chickens. Therefore, on the one hand, they may not see the need for housing systems that allow the hens to engage in various behaviour. On the other hand, farmers may also fear how to deal with or how to manage this behaviour. To overcome this, collaboration should be facilitated with experienced farmers, who already keep flocks in cage-

Table 3
Summary of challenges and solutions identified in breakout session 1 "Overcoming the Challenges of Cage-Free Egg Production".

Challenge	Solution
Feather Pecking, cannibalism and beak trimming to avoid it	Rearing with loose litter, pecking enrichments (banana trunk given as an example from Malaysia), genetics, nutrition and better identification of root causes
More difficult management	Training and education; better dissemination of information already available
Smothering	Block off areas where smothering occurs, including corners and overused nests; identify root causes (more research needed)
Avian Influenza	Vaccination, conditional outdoor access (i.e., temporary confinement when there is an imminent threat); trees may help (further research needed)
Hens not using the outdoor space provided to them, or not using other provided resources	Rearing conditions; genetics; redesigning outdoor (or other) spaces to be attractive to the birds; providing early access; providing safe access outdoors by including cover on range areas
Keel bone fractures	Breeding/genetics, perch placement/ adjustment (especially in aviary systems) and early access, ramps in aviaries, housing system design
Land shortage/scarcity	Integrate free-range production with fruit tree cultivation, orchards, or willow so land has dual use and therefore greater productivity; using indoor barn/aviary systems (which have relatively small building space requirements) rather than free-range (cage-free doesn't have to be free-range)
Cost to farmers (investment costs, depreciation of current cage equipment)	Selling into a niche market; stable purchasing relationships; support from buyers with long-term purchasing arrangements; other stakeholder support (such as financers or investors); educating consumers so they know what they are paying for; improved producer margins; staff satisfaction (who stay longer, reducing training costs)
Additional labour associated with e.g., litter management and egg collection	A benefit for job creation; an asset in the developing world, where labour is readily available
Choosing the wrong system then stuck with the decision	Clear vision/direction of where we want to go, communicated well
Permits for outdoor production (to regulate pollution)	Policy adjustments to better accommodate free-range production
Producer perceptions/willingness and generational resistance	Successful case studies; farmers teaching farmers; regionally specific examples; tailor the advice to the specific situation (by size, scale, and geography); obtain buy-in through education/outreach, and government involvement
Lack of training/knowledge/skill in how to manage cage-free flocks	Training and course work on the basics; certificates to demonstrate skill/ competence

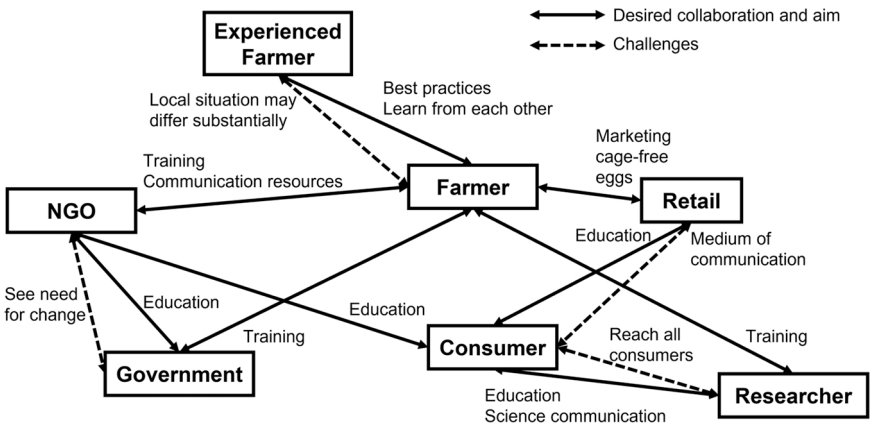

Fig. 2. Overview of stakeholders, desired collaborations between stakeholders, and aims and challenges of collaboration identified during breakout room 2: "Overcoming the challenges of cage-free egg production.".

free systems. One participant mentioned a successful initiative where a delegation of farmers from Canada, who kept hens in furnished cages, visited farms with cage-free systems in Switzerland and exchanged experiences with the local producers. An advantage is that farmers seem to more readily adopt recommendations shared by colleague farmers than those presented in rather abstract scientific papers or by scientists. Successful farmers can be used to inspire other farmers and people from the industry. However, a challenge that can arise with such collaborations is that the local situation in countries with a high proportion of cage-free systems may differ substantially from that in countries with a high proportion of cage systems. In Bangladesh, for instance, there is a high demand for animal proteins, but it is also a very densely populated country and the availability of land is a limiting factor. An option may be to seek collaboration with countries with similar demographics that have already transitioned to cage-free systems.

Collaborative efforts also seem necessary regarding investments in the new housing systems. In Nigeria for instance, farmers have invested in battery cage systems and now lack capital to invest in a new cage-free system. The participants of the breakout room agreed that consumers need to pay more for eggs produced in cage-free systems to give farmers an incentive to transition and allow them to work economically. Therefore, education of consumers is essential. They need to know where the eggs they are buying are coming from, and why they should choose eggs from cage-free systems. A system like the EU has, where egg codes for specific housing systems are printed on the egg, could be recommended to increase transparency for consumers.

One participant, a university researcher, was actively engaged in science communication and workshops for consumers. However, only consumers already interested in the topic may join such workshops and it may be difficult to reach a broader public. It was mentioned that both NGOs and (applied) universities offered training for schoolteachers on laying hen behaviour and housing systems. This was seen as very efficient, as children would pass on what they have learned to their parents, who in turn may change their purchasing behaviour.

Collaboration of farmers with the retail sector is also essential as the retailers can help them to market the cage-free eggs and to inform consumers. In Taiwan, for instance, retailers visit farms and produce small video clips of the hens there, which are then presented on screens next to the cage-free eggs in the supermarkets. Less costly alternatives may be to print QR-codes on the egg packages which lead to the website of the producing farm, or to put small flyers with pictures of the hen housing conditions in the packages.

Besides educating consumers, NGOs are considered important collaborators for the government. An example from Latin America was mentioned where the governments are often not well informed about the behavioural needs of farm animals. Educating the government does not only seem important to develop stricter animal welfare regulations, which could facilitate the transition to cage-free systems, but also to encourage the government to provide training and funding opportunities for farmers.

In conclusion, the participants of breakout room 2 saw the transition to cage-free systems as a multi-stakeholder task with a key role of education and exchange of information.

3.2.3. *Breakout room 3: research needs*

Breakout room 3 focused on remaining research needs. One area that was discussed was the pullet rearing phase, as this is a crucial period for behavioural development of the birds. Further research into providing or mimicking maternal care could be important. For instance, supplying pullets with dark brooders has been shown to have a lot of potential to reduce feather pecking in pullets (Gilani et al., 2012; Jensen et al., 2006). Other aspects may include environmental improvement with other maternal stimuli, such as olfactory cues or sound cues (Edgar et al., 2016). A second topic identified was the quality of the free range. By providing cover in the free range, preferably by providing natural vegetation, free range use can be stimulated and hens have shelter to protect them from predators and averse weather (Bestman et al., 2019). However, it was also discussed whether expanding the number of farms with free range access is realistic and desirable for large-scale egg production. For instance, the crisis with high pathogenic avian influenza in Western Europe – that kept free-range and organic hens indoors for eight months in 2020 and 2021—illustrated that free range access can be problematic in densely populated areas (both with humans and animals). Alternatives that need to be investigated further include covered verandas or indoor foraging areas with ample daylight (Gebhardt-Henrich et al., 2014). Examples of the latter can be found in the innovative Rondeel and Kipster systems in The Netherlands. These types of foraging areas can still provide the hens with very good opportunities for foraging, dust bathing and sunbathing, while reducing the health and biosecurity risks. Rana et al. (2021) recently showed that laying hens prefer UV light for these behaviours.

Some specific challenges were discussed as well. The first one was the topic of piling and smothering in laying hens, a behaviour where birds flock together in a given area of the house or the free range and where birds at the bottom of the pile may suffocate (Barrett et al., 2014; Rayner et al., 2016). This is a topic that has been investigated relatively sparsely until now. Only for preventing nest smothering some practical advice exists (leaving the curtains of the nests at the end of the row open at the start of the laying period). Another topic is the social impacts of large group housing, including damaging behaviour. On this topic, a lot of research has been conducted (see de Haas et al., 2021 for a review), but still a lot of attention is needed to translate this knowledge to commercial practice and further trials in commercial situations may be needed. This is especially true for countries where a transition is taking

place from beak-trimmed flocks to flocks with intact beaks. Also keel bone fractures were mentioned as a major concern. Further research should investigate improving housing structures to prevent keel bone damage. However, the recent findings regarding the relationship between keel bone fractures, hen weight, egg weight and age at onset of egg laying are promising (e.g., they demonstrate that raising the age at which onset of lay occurs lowers bone fractures) but need to be investigated further (Thøfner et al., 2021). Apart from behavioural problems, attention should also be given to stimulating positive behaviour, such as dustbathing. More broadly, research is needed on environmental variation and how that interacts with the needs of individual laying hens in a flock. As not all animals are equal or behave equally, the environment should cater for all types of birds to optimise their welfare (Rufener et al., 2018). When designing the system, we should also think about the most suitable bird for a given system. For instance, although white hens were originally bred for the cage environment, they do remarkably well in cage-free systems and seem better able to navigate the three-dimensional system than brown layers. Heerkens et al. (2016) kept brown and white groups of hens in a complex three-dimensional environment and found a lower incidence of keel bone fractures in the white birds compared with the brown birds. On the other hand, brown hens seem to perform better in free-range and organic systems and to show more foraging behaviour in the free-range and to range further from the house (Bestman et al., 2019).

Secondly, the main tools that need to be developed were discussed in breakout group 3. Here, participants indicated that there is a need for Precision Livestock Farming (PLF) technology for tracking and automated management. For research, tools for individual tracking in group housing will be very important. Given the relatively small body size, the similarity between individuals and the large group sizes in practice, probably a combination of tracking methods will be needed to achieve this (Ellen et al., 2019). For instance, behaviour could be recognised automatically using computer vision and a Radio-Frequency Identification (RFID) tag or visual marker on the bird can be used for identification. These tools hold great promise for the development of welfare monitoring on commercial farms and could support management. At the same time, from the perspective of human-animal relationship and good quality management, PLF technology could and should not replace inspection visits of the flock by a human caretaker. The technology should be seen as additions to the toolbox. Data from behavioural monitoring could also be integrated with other sensor data, such as data from environmental/climate sensors and from feed and water intake.

When developing these research approaches, we should not only think about novel production systems, but also about scenarios to improve laying hen welfare in existing or low-cost systems. It may not be realistic in all countries to invest in large-scale aviary systems. In those cases, research should also develop advice for smaller farms with basic floor housing or single-tier systems. This approach was also taken when developing a management guide for cage free systems in Vietnam (de Haas et al., 2020). To make real progress, it is pivotal to get farmers 'on board' early on and to connect with geneticists, retailers, industry, policymakers, NGOs and data scientists.

A final discussion point in breakout room 3, was that research should be translated to end users. The translation of science into practical, usable information and technical solutions is key to its adoption, and this is a role for various stakeholders in including science writers for trade publications, NGOs (which often employ scientists) and auxiliary egg industry players such as breeding companies and equipment manufactures.

3.3. Post-conference survey results

Tables 4 and 5 show categorizations of responses into themes for the questions on cage-free solutions and the way forward respectively by respondent groups. Response themes and groups of respondents were described separately above. The tables show the percent of the respondent groups' answers fitting into a theme as determined by agreement between at least two of the three blind observers; we show the number of responses fitting the theme in parentheses. For example, of the 24 ethologists surveyed, responses by 13 of them fit the "Specific technical or practical solutions" theme, representing 54% of that group.

While the low sample size and lack of independent answers precluded statistical analysis, some general observations can be made. For the question on cage-free solutions (Table 4), responses fitting into technical and practical solutions were mentioned most widely among all respondent groups. Ethologists and those from 'developed' regions provided answers that fit under the themes producer education, conceptual/research and marketing/economic at a higher rate than non-ethologists or those from 'developing' regions. Both students and non-students provided answers fitting all themes at similar rates (percentages).

For the question on the way forward (Table 5), all groups identified producer communication at a relatively high rate (percentage), with the exception of the 'developing' region group, compared to other themes. We also observed that ethologists respond with suggestions that generally fit all themes, while non-ethologists' responses fit the multiple stakeholder theme at a lower rate and the 'developing' region groups' responses fit the producer communication and marketing/other economic themes at lower rates. As with the question on cage-free solutions, students and non-students responded to the question on the way forward with answers that fit all themes at similar rates, with the possible exception of students offering suggestions fitting the marketing/other economic theme at a lower rate.

4. Discussion

Several notable outcomes and solutions were identified in the workshop. A key observation was that many of the solutions are already available and what is missing is good dissemination of existing information and guidance (as identified in the breakout room discussions and in the survey answers to both the questions on cage-free solutions and the question on the way forward). There is a need for more training, advice, and education. With the right management, cage-free egg production is already working well in many regions of the world (some

Table 4
Survey response themes into which answers from the question on cage-free solutions were grouped. (Question 7 asked about ideas or solutions contributed during the breakout session, or ideas or solutions presented by other participants that resonated.).

Response themes	Ethologists (24)	Non-ethologist (11)	Students (15)	Non-student (20)	Developing country (11)	Developed country (24)
Specific technical or practical solutions	54% (13)	55% (6)	60% (9)	50% (10)	55% (6)	54% (13)
Ideas for providing education or advice to farmers	33% (8)	9% (1)	20% (3)	30% (6)	9% (1)	33% (8)
Ideas for collaboration and communication between different stakeholder groups	17% (4)	9% (1)	13% (2)	15% (3)	9% (1)	17% (4)
Conceptual solutions (big ideas that need further evaluation or emphasis) or ideas for additional research or implementation of results	58% (14)	18% (2)	47% (7)	45% (9)	27% (3)	54% (13)
Marketing or economic solutions	21% (5)	0% (0)	20% (3)	10% (2)	0% (0)	21% (5)

Table 5
Survey response themes into which answers from the question on the way forward were grouped. (Question 10 asked participants to describe any final thoughts on the best way forward for establishing cage-free production as an industry-wide norm.).

Response themes	Ethologists (24)	Non-ethologist (11)	Students (15)	Non-student (20)	Developing country (11)	Developed country (24)
Work through multiple stakeholders/ levels/ disciplines	29% (7)	9% (1)	20% (3)	25% (5)	18% (2)	25% (6)
Educate/ motivate consumers	21% (5)	27% (3)	27% (4)	20% (4)	27% (3)	21% (5)
Have established cage-free producers/ regions assist new producers or producer communication/ training	42% (10)	27% (3)	33% (5)	40% (8)	9% (1)	50% (12)
Tackle specific management challenges or larger consequences of cage-free production (environmental or social)	13% (3)	9% (1)	13% (2)	10% (2)	9% (1)	13% (3)
Provide economic/ marketing solutions or support and/or research funding	25% (6)	18% (2)	13% (2)	30% (6)	9% (1)	27% (7)
Enact laws/ policy or expand certifications	13% (3)	27% (3)	13% (2)	20% (4)	27% (3)	13% (3)

countries, such as the Netherlands, have had cage-free production for over 20 years). Cage-free systems need to be presented in a way that encourages uptake. Reports of feather pecking and cannibalism, while very real and important, can cause hesitation and prevent new producers from making the investment in cage-free systems. Workshop attendees confirmed there is a need for more collaboration between scientists and farmers and to improve knowledge transfer. In some cases, egg producers prefer to learn from their peers, experienced cage-free farmers, and this may be an additional way to improve knowledge transfer.

The answers to the survey questions largely reflected the conversations that took place in the breakout rooms. Many solutions were generated, and no challenge was raised that could not be overcome with innovation, collaboration among stakeholders, support for producers, or with continued refinement of the systems already working well through additional research, which will likely continue to lead to improvements. As indicated by the survey results (the question on cage-free solutions; Table 4), many of the suggested solutions were technical and practical, for example, one practical solution given was matching the rearing and laying environment as closely as possible. While this is an obvious solution to many ethologists familiar with the importance of behavioural development, it is not a widely known concept for producers who may be new to cage-free farming and are more experienced with rearing chicks in cages. Thus, it is not surprising that ethologists provided answers fitting under the theme of producer education. For the survey question regarding the way forward for promoting cage-free production, many potential paths were identified. These could be (and are being) advanced simultaneously by many different stakeholders working in collaboration throughout the world.

Another key observation to come from the breakout sessions and the survey results was that the solutions will depend on the scale of production and the type of system. Smallholders in the developing world may need more advice on basic nutrition and veterinary health, while large-scale, cage producers need more assistance with managing the behaviour of large cage-free flocks with thousands, or tens-of thousands, of birds. Solutions may also vary by region. For example, humidity control is more of a concern in hot, tropical regions of the world, while northern climates may require supplemental heating. However, general principles of cage-free production are global, with all systems requiring loose litter, nesting space, and perching, and concepts such as proper lighting techniques to discourage floor eggs are universal.

A clear outcome of the workshop was identification of the need to define positive welfare attributes rather than focusing solely on elimination of negative welfare states. A vision is needed of where we want to go, the ideal system for animal welfare. For example, in free-range systems, the ideal is to have good pasture with trees and real foraging opportunities rather than a barren, degraded landscape. Related to this is the concern that animal welfare guidelines may erode over time to the bare minimum. This can happen when producers do not have the financial support required to achieve high welfare systems. Consumer and corporate buying power can help. Egg buying customers are positioned to provide the resources producers need to achieve the expected level of welfare, but a good understanding of the issue is necessary to drive and sustain higher price points for cage-free eggs. A key time to influence busy consumers, juggling different food shopping priorities (price, convenience, environmental impacts, etc.), is at the point of sale, when they are choosing between options and need a reminder that cage-free production is an issue about which they care. Retailers can also play an important role by, for instance, only selling table eggs from cage-free systems, as has happened in The Netherlands.

In breakout session 1, the idea of raising mixed flocks, with both young chicks and adult, mother hens, was raised and discussed. Several studies show an impact on the behavioural development, feed preferences and fearfulness of chicks (Shimmura et al., 2010). The presence of a mother hen can also help reduce the development of feather pecking (Riber et al., 2007; Rodenburg et al., 2009), possibly through mediating fearfulness and facilitating behavioural synchrony (Edgar et al., 2016). However, the problem of biosecurity concerns, with older animals a potential source of infection for younger birds, could be prohibitive. Multi-age flocks could be a future solution, depending on the trajectory of veterinary medical advances. Another potential solution could be to provide an artificial substitute for the mother hen, such as a dark brooder, which mimics specific characteristics of the mother hen, such as warmth and shelter. These ideas were also discussed in breakout room 3, where it was stressed that the pullet rearing phase is essential to prepare for the later laying period. A stimulating rearing environment and a seamless transition between rearing and laying environment seem critical factors for success in cage free systems.

In breakout session 1, the idea of producing more resilient laying hen flocks through increasing environmental complexity in the rearing period was proposed as a potential solution. A changing (rather than static) early rearing environment can positively influence neurological and physiological development, with substantial benefits for the health and behaviour of adult birds. Even simple, novel enrichment objects during the rearing phase could help birds better adapt to change (Campbell et al., 2019). More variable environments increase opportunities for animals to make choices, increasing their sense of control, which is an important way to reduce stress (Wiepkema and Koolhaas, 1993). For example, research comparing newly hatched chicks reared in either a 'No-Choice' environment (with only one perch and litter type) or a 'Choice' environment (with four different perching and litter options) revealed that birds raised in the environment with choices demonstrated greater exploratory behaviour, had better natural immunity and lower fear and stress responses. Overall, the chicks with behavioural options had better coping abilities (Nazar et al., n.d.). There is a rich research opportunity to further develop these concepts and turn them into practical advice for farmers. This also links to the discussions in breakout room 3, on the added value of a free range or a covered veranda. These areas supply the birds with a more varied environment and increased opportunities for foraging and exploration. Earlier access could be beneficial for younger birds, and conversely, more enriched rearing conditions for young and very young chicks could increase the

use of range areas for older birds, helping them to better realise the full benefits. For regions where providing free-range access may be problematic, for instance due to lack of space or the threat of avian influenza, a covered veranda may be considered, and would be a safe area for younger birds to explore.

In breakout room 3, it was agreed that more research is needed on the topic of smothering and piling in cage free systems, as still relatively little is known about this behaviour. Fortunately, currently several projects are being conducted on this topic, also focusing on research in commercial flocks (for example, Winter et al., 2021). On feather pecking and cannibalism, already a lot of scientific knowledge exists, but an effort should be made to transfer this knowledge to the commercial sector. To do that successfully, more studies should also be conducted on commercial flocks. Best practices of farmers that are successful in controlling issues such as smothering and feather pecking can help other farmers to successfully make the transition. Welfare monitoring and welfare assessment tools may also help the industry to make progress. Tools for automatic monitoring of behaviour are developing, both for research purposes and for application in commercial practice. These may help to provide the farmer with early warning tools in case behavioural patterns are deviating from normal and allow the farmer to take action at an early stage.

In breakout room 2, stakeholders were identified which need to be involved to transition to cage-free systems and to realise the ideas developed in breakout room 1. The participants mentioned farmers, citizens and consumers, researchers and universities, governments, retailers, and animal protection and welfare NGOs. Fernandes et al. (2019) identified four stakeholder groups that are critical to the success of initiatives to improve farm animal welfare in general. These groups include the industry sector, which subsumes producers and retailers, but also processors, exporters, industry consultants and veterinarians. The second group is described as the community sector including animal protection NGOs and other community representatives, but not citizens or consumers as such. Further essential stakeholders are the research and the government sector (Fernandes et al., 2019). Similarly, Swanson et al. (2011), invited representatives from the retail, animal welfare, consumer, and egg producer sectors to their workshop on discovering the underlying values and priorities of different stakeholders regarding future sustainable egg production. In addition, they also recruited participants from the environmental and food safety sector (Swanson et al., 2011).

The participants in breakout room 2 agreed that collaboration between the stakeholders identified is key for a successful transition to cage-free systems for laying hens. Stakeholder involvement was identified in the survey questions as well, and ethologists, in particular, saw this collaboration as a way forward. None of the stakeholders, however, were thought to be able to bring about this change on their own. This is in line with previous findings. Vanhonacker et al. (2012), for instance, emphasise the importance of creating a conception of animal welfare, which starts from public perceptions and integrates the opinions of further stakeholders, such as producers, retailers, animal welfare organizations and representatives from the animal or veterinary sciences. Regarding the sustainability of different laying hen housing systems, a more formalised stakeholder network in the form of a public-private partnership was proposed and completed successfully (Mench et al., 2016). The authors stress the role of a non-profit intermediary, which facilitated the public-private partnership and was also responsible for communicating research results and engaging in consumer research (Mench et al., 2016). In the present breakout room discussion, it was suggested that animal protection and welfare NGOs might take up the role of such a facilitator. NGOs were seen to have the potential to mediate between stakeholders, for instance by providing communication material to farmers, educating consumers, or convincing local governments of the need for change. Similarly, Fernandes et al. (2019) consider the usefulness of a facilitator in collaborative stakeholder networks as multiple ideas and values are present in such networks, which makes it necessary to plan for disagreement and conflict among stakeholders in advance.

Regarding the global transition to cage-free systems for laying hens, the question arises whether such formalised multi-stakeholder networks are always necessary. In regions in which some producers have already transitioned to cage-free systems and in which a market for cage-free eggs is developed, it would be more important to facilitate collaboration between these experienced farmers and farmers who still operate cage systems. The collaboration of sub-groups or individuals within a certain stakeholder group to improve animal welfare has hardly been addressed in the scientific literature and previous studies have mainly focused on multi-stakeholder collaborations in one specific country (Swanson et al., 2011). Producers in distant regions of the world can learn from each other, particularly with the growing popularity of virtual events, and with the added benefit of not being competitors. A further aspect raised by the participants of breakout room 2 was that the local situation in different countries or regions may differ substantially, which would make it impossible to simply adopt approaches developed in other regions of the world. However, globally available animal welfare certification programmes are proving the opposite—that very few changes are necessary to adapt basic standards in multiple countries. In breakout room 3, the importance of not only transitioning to cage-free systems, but also guaranteeing high welfare standards in these systems was a point of discussion, and this is where comprehensive certification programmes can help.

Regardless of the local situations, all participants of breakout room 2 agreed that consumers have to pay more for eggs from cage-free systems in order to compensate farmers for the additional production costs. However, previous studies have shown that most consumers do not consider animal welfare at the supermarket shelf (Clark et al., 2017). Therefore, different ideas on how to educate consumers on the welfare consequences of certain housing systems for the animals were developed during the breakout room and echoed in the survey responses. The idea of Research institutions or NGOs organising workshops on laying hen housing systems for consumers was challenged by the notion that this would only reach already interested consumers, but not a wider public. Similar to Fernandes et al. (2019), participants mentioned the retail sector as an important collaborator because of its close connection to consumer perceptions and demands. Presenting cage-free housing systems through different media, for instance video clips or pictures directly in the supermarket could help all consumers to make informed purchasing decisions. Another interesting option mentioned was to provide education on animal welfare already in schools with the aim to not only educate future customers, but also to pass knowledge to the children's parents who may change their purchasing behaviour. The effectiveness of educational programmes on animal welfare for farm animals has also been highlighted in the literature (Burich and Williams, 2020; Hawkins and Williams, 2017).

As pointed out in breakout room 3, animal welfare is a value on its own, however there are many other benefits of cage-free production such as work satisfaction of farmers and greater societal acceptance. As identified in results of the survey question asking participants to describe their thoughts on the best way forward for establishing cage-free production as an industry-wide norm, these added benefits could help propel higher welfare housing across many of the themes identified, such as in communication with producers or the advancement of laws or policies.

One salient topic that was not thoroughly raised and discussed in the breakout sessions or the survey responses was the issue of sustainability. While the term, sustainability, can encompass concerns about animal welfare (Keeling et al., 2019), it is often focused on environmental aspects. Although land use was mentioned often, there are further impacts to consider around emissions and efficiency. Compared to other animal-based products, egg production has relatively low GHG emissions as well as acidifying pollutants, eutrophication and land use (Poore and Nemecek, 2018). However, given the pressures on food production,

and the environmental sustainability goals of some food companies to reduce their overall carbon footprint, the impact of a transition from cages to cage-free housing systems will have to be tackled to better ensure loose housing systems persist. Resource use per egg produced may be higher in cage-free systems (due, mainly, to greater feed and housing inputs; Dekker et al., 2011), but recent research is demonstrating the importance of feed composition and manure management as key factors in life cycle analyses. For example, in a 2021 comparison of different types of egg production systems in Canada, organic (cage-free) systems had the lowest GHG emissions compared to battery cages, enriched cages, single-tier barns, aviaries and free-range systems, largely because of the feed composition (Turner et al., 2022). The potential for cage-free systems to perform well on environmental impacts is a rich area for further exploration.

Around the world, cage-free production is already successful, on every scale, from smallholder villages with free-range production in developing regions, to large, commercial aviary systems, supplying millions of eggs per day to major retail end users. Many ideas floated in the workshop, such as breeding for resilience and providing (artificial) mother hens, are already present and practiced by some producers, with great potential for further adoption. Although there is already a lot of knowledge and experience regarding cage-free systems, there is a need for further research on continuing challenges, particularly those identified in breakout room 3. However, the need for ongoing research should not preclude the continued spread and adoption of higher welfare, cage-free housing systems, which will continue to be refined with new knowledge and technical advances. As there are many resources available, or that could be available, to support the transition from cages, the future is promising for freeing the hens and transitioning to cage-free production.

CRediT authorship contribution statement

Sara Shields led the organization of the workshop at the 2021 ISAE Congress and the drafting of the paper. Bas Rodenburg was a speaker at the workshop, led a breakout session, and contributed to the drafting of the paper. Mona Giersberg led a breakout session at the workshop and contributed to the writing of the manuscript. Paul Petersan helped organize and run the workshop, led the survey work and contributed to the writing of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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