A Nuffield Farming Scholarships Trust Report

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Managing poultry welfare in a transitioning world of technology

James Smaldon

May 2020

NUFFIELD UK

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A Nuffield (UK) Farming Scholarships Trust Report

"Leading positive change in agriculture. Inspiring passion and potential in people."

Date of report: May 2020

Title	Managing poultry welfare in a transitioning world of technology
Scholar	James Smaldon
Sponsor	Three Counties Agricultural Society and McDonald's UK & Ireland
Objectives of Study Tour	1. To identify technology likely to be commercially available for the UK poultry industry in the next decade. 2. To understand various concepts of bird welfare. 3. To establish the implications that technology may hold for the welfare of poultry.
Countries Visited	Canada, USA, Italy, UK, France, Netherlands, Belgium.
Messages	1. Continuous welfare assessment is coming; this can provide farmers with the ability to react to welfare challenges before they become issues, whilst also benefiting consumers with assured verification. 2. Human interaction will continue to be vital within poultry farming. Technology should be embraced which complements, not substitutes, stockmanship. 3. Bird welfare is at risk of falter if technology is not introduced carefully. People tend to trust technology too quickly and lose focus before they should. 4. Over time, the role of stockmanship is likely to move away from manual and towards supervisory, with more time available to care for birds.

EXECUTIVE SUMMARY

Technology permeates throughout our lives, most notably witnessed by the phones we carry around each day in our pockets. It is evident that technology follows an exponential trajectory and that – whether we like it or not – development will be put into autonomous and precision farming. When caring for livestock, farmers hold both an emotional bond with the animals and a social licence with consumers, to look after these animals until their time has arrived to provide us with sustenance.

The clock is ticking, with the continual creep of technological progress within the poultry industry and my worry was that during the initial phases of technology adoption, skills and experience may falter and cause an avoidable drop in the welfare of the birds; there have been instances where Tesla drivers have been seen sleeping whilst driving, and we cannot allow an analogous experience to happen within poultry farms.

I had three interconnected aims for this report: firstly, to discover what precision and autonomous solutions are already or soon to be available to the UK poultry industry; secondly, to understand what exactly bird welfare is, stripping away anthropomorphism and perception bias; and thirdly, to present concepts to help poultry farmers, developers and the wider poultry industry to navigate the waters of technology adoption - improving bird welfare in conjunction with improving productivity.

My findings showed that both precision and autonomous technology can provide benefits to the poultry industry, with a variety of robots, computer systems and revolutionary systems nearing commercial viability. As an industry, perception is critically important and the success or failure in the implementation of technology will determine how the consumer views the industry for decades to come.

Advances in precision and autonomous technology will provide our farms with continuous detailed information so that we can make better decisions. Welfare will be able to be assessed live, allowing the farmer to react when an issue can be identified, not when it presents physical symptoms.

Human connection with our animals is the most important link in the technological chain; we are here to make key decisions, to take responsibility, and to react to situations which cannot be predicted. The role of stockpeople will shift; there will be less manual handling, increased supervision of equipment, and vastly increased time to be actual stockpeople.

During the adoption of technology, novel systems are likely to create a *Welfare Falter* which represents a temporary drop in bird welfare through a lack of competency with these systems. Using the strategies outlined in this report, manufacturers and farmers should be able to minimise the reduction in welfare to an absolute minimum and for the shortest period possible.

In summary, technology is here to stay and, whilst some may resist its adoption within poultry farms, it is better to embrace, learn, understand and share so that farmers, consumers and – most importantly – the birds all benefit.

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Please note that the content of this report is up to date and believed to be correct as at the date shown on the front cover

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1 Personal Introduction

I live in North Devon, with my wife Katie, and am the third generation of the family poultry business. In 1955, my grandfather started with 150 hens and built an enterprise rearing pullets for layer farms until 1981. Since then, the family has been producing fertile hatching eggs for the poultry meat sector, initially for Lloyd Maunder and now for Avara Foods.

I grew up on a small mixed hill farm on the foothills of Exmoor, with the majority of time being spent on sheep and chickens. Most of the sheep were sold prior to the 2001 foot and mouth outbreak and a renewed focus was given to the chickens.

Figure 1: The author James Smaldon

I had been involved with the chickens sporadically during my early life but decided to further my academic career by studying Mathematics and Computer Science at Bristol University and then completed my Masters in Transportation Planning and Engineering at Southampton University.

After university I joined an engineering consultancy, Parsons Brinckerhoff, where I was able to gain a breadth of experience. Within my period at this company, I led the internal *Professional Growth Network* (for engineers with less than 10 years' experience) for the European region in 2013, was part of the management team at the Olympic Transportation Coordination Centre for the 2012 Summer Olympics, and project managed the roll-out of a region-wide document management system for the IT department.

Professionally, a juncture came in 2015 when the family business was set to build a second poultry farm from scratch. The choice was obvious… I left my office job in Exeter for the chance to lead the building of this new farm. Since then, I have been either working in or managing both of the poultry farms: using my data analysis skills to try and optimise the performance of the birds in our care, whilst making their lives as stress-free as possible!

Outside of the poultry, Katie and I have taken on an old Victorian house to renovate, we have a dog to keep entertained and I have become more involved with the NFU – participating in the Poultry Industry Programme in 2018 and engaging with regional and national groups.

I would like to thank the Three Counties Agricultural Society and McDonald's Restaurants for their generous sponsorship and support for my Nuffield Farming Scholarship.

2 Background to my Study

The symbioses between technology and farming have always been at the forefront of my mind. Working alongside Hazel, a valued member of the farm team who has been helping my family since before I was born, has made me evaluate its pertinence and value. She is a stockperson to the core… but hates computers: my dichotomy. She believes that computers *can* provide a lot of benefit to farms, but that it makes workers lethargic and lessens the stockmanship ability of inexperienced people.

I can't disagree with her on these points; I have heard of experienced stockpeople making silly errors due to blindly trusting sensors and not checking things thoroughly enough, and I have seen inexperienced people being unable to problem-solve effectively due to a lack of first principles understanding. Thus emerged my dilemma: I am an advocate of technology on our farms. I can see how technology may result in productivity improvements both inside and outside the poultry sheds, but the main implication of such a technological step-up is that the stockmanship may well decrease and so counterbalance any perceived automation benefits.

In the past few years, technology has become pertinent within various parts of the supply chain, not because it's wanted, but because it's required. The shortage of skilled people to join poultry farms and the recent Coronavirus pandemic has demonstrated the need for labour resilience within our farms. The birds must be cared for and the industry must be able to supply a product to the consumer at the price and quantity that they are willing to pay. Therefore, it is likely that the introduction of new technology within poultry farms will continue at pace.

It didn't take too much thinking for me to arrive at my proposed Nuffield Farming topic: what happens with bird welfare when we increase the level of technology on our poultry farms and what strategies are there to minimise any reduction in their welfare?

3 My Study Tour

3.1 Canada and United States of America – July to August 2019

Both Canada and the USA have extensive research and manufacturing capabilities within the poultry industry. Whilst their ideas for optimal poultry production can be different to those in the UK, there is no doubt that technology will be produced there which will then be available for UK farmers to buy.

3.2 United Kingdom – over several months

The UK has a rich history in animal welfare and academic research. As such, I wanted to ensure I wasn't missing out on individuals and companies to visit that would be a vital step within my Nuffield Farming journey.

3.3 France, the Netherlands and Belgium – January to March 2020

The Netherlands has always been a driver for poultry innovation. It is a country with limited space, and welfare groups that have caused great change within a short period of time. The restrictions imposed upon their poultry farms are the drivers for technological innovation and where benefits can be best observed.

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Editor's Note: A UK Nuffield Farming Scholarship consists of:

(1) A briefing in London.

(2) Joining the week-long Contemporary Scholars' Conference attended by all new Nuffield Farming Scholars worldwide, location varying each year.

(3) A personal study tour of approximately 8 weeks looking in detail at the Scholar's chosen topic.

(4) A Global Focus Tour (optional) where a group of 10 Scholars from a mix of the countries where the scheme operates travel together for 7 weeks acquiring a global perspective of agriculture. (The author of this report participated in a Global Focus Tour).

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The Nuffield Farming Scholarships scheme originated in the UK in 1947 but has since expanded to operate in Australia, New Zealand, Canada, Zimbabwe, France, Ireland, and Netherlands. Brazil, Chile, South Africa and the USA are in the initial stages of joining the organisation.

4 Bird Welfare

'Welfare' is a multi-dimensional concept. It can be said to incorporate both physical and mental health; however the importance of different aspects of welfare varies between individual people. As such, there is no single definition for animal welfare.

Appendix A provides substantive information regarding the development and understanding of bird welfare over the past fifty years.

Editor's Note: The reader is strongly recommended to read the information within Appendix A on page 42 at the end of this report.

Increased understanding of welfare has demonstrated that the emotions of the animal play a key role in their welfare. Additionally, minimising or eliminating negative welfare is necessary, but high welfare can be attained through provision of positive mental experiences for the animals.

Bird welfare can be approximated through qualitative and quantitative measurements through the Welfare Quality Assessment Protocol (see Appendix A) and is optimum when assessed throughout a flock following a combination of stockperson, welfare audit, and processing-plant welfare outcome metrics – all of which could be combined into a single autonomous system.

Bird welfare can be optimised through caring stockpeople; high quality inputs of feed and water; a housing environment designed to encourage play and provide access to the outdoors; and for the genetics of the bird to be optimised, such that the bird is willing to express their natural behaviours.

5 Precision Livestock Farming (PLF)

5.1 Precision livestock farming

Precision livestock farming (PLF) is an evolving field, where animals are continuously monitored to measure their health, welfare, production/reproduction and environmental impact. *Continuous* means that the PLF is measuring and analysing the movements, behaviours and/or environment of the animals every second of every day. PLF should enable farms to be more efficient: to produce output with less input.

The foremost aim for PLF is to provide the farmer with an early warning for any issues that may arise with their animals, and allow them to respond in a timely manner – far more quickly than they would historically have been able to react.

5.1.1 Poultry

Where a single collar may be sufficient for a cow, attaching tags or chips to individual chickens provides three issues: how to attach these at a high volume; how to ensure they are cost-effective; and how to remove them at the end of the flock life. It is cost-prohibitive to tag every broiler bird. For poultry and other livestock in large volumes, it therefore makes sense to monitor the birds through sensors and then react once action is required.

5.1.2 C. I. T. D.

There are four reasons why the implementation of precision technology in farming is more difficult than, for example, car manufacture. These were categorised by Daniel Berckmans (Berckmans, 2017) and are as follows:

- Complex – the complexity of information for a living organism is far beyond the complexity of a rigid, guided process.
- Individually different – living organisms are individually different in their responses to the same stimuli.
- Time-varying – the same living organism is not guaranteed to react in the same way, when presented with the same set of stimuli.
- Dynamic – living organisms change with time. For example, a process that might be suitable for a young chick might not work for an adult bird.

Historically, farmers have managed flocks of chickens by their average; using a bell curve, the standard deviation around the mean will provide an effective way to ensure that 68% of birds are accurately managed, with the remainder either being (if we use feed levels for an example) underfed or overfed.

5.2 Current levels of PLF in UK poultry farms

A huge range of equipment is used within UK poultry farms: for example, within the broiler breeder sector, there are farms with individual thermostats beneath individual fans, which turn the fan on when a specific temperature is reached: whereas other farms use advanced climate computers to incorporate as many sensors as possible to form a model of the poultry shed. If sufficient attention is given, both ends of the technology scale can work very well (more manual equipment will need regular monitoring, whereas the climate computers need to be checked to ensure they are working as intended).

Figure 2: The internal layout of a modern broiler breeder shed. (Photo: author's own)

Figure 3: Modern control systems for a poultry farm. (Photo: author's own)

5.2 Measure, Model, Manage

There are three core components of any PLF system (or a specific PLF technology might contribute to one or more of these core components): Measure, Model, and Manage.

These three components can also be categorised for the human body; sense, think, react. Initially, we need to *measure* what is happening in the world around us and we are able to use our senses to provide sight, sound, touch, smell and taste to allow us to do this. The next step is for our brains to process the information collected and present us with a *model* of our surroundings alongside a single or choice of actions to take. Lastly, our limbs react to the decision that has been made and *manage* the chosen action appropriately.

5.3.1 Measure

The primary issue with existing sensors is that they are not set up to *interact* with each other and there are very few systems that link all these sensors together (although little further analysis is performed).

Video cameras and audio recording have been demonstrated (Rios, 2020) to be the only form of sensor that can completely assess the welfare of birds (as per the Welfare Quality assessment framework).

5.3.2 Model

Modelling poultry can be achieved on multiple levels of analysis: macro (per shed or population of birds), meso (per group of birds) or micro (per bird). Modelling can aim to build a *virtual poultry house* and analyse this before making changes in the real world, or it can work through a series of algorithms (whether static or machine-learning) to make decisions.

The integration of the model is important to ensure that an accurate picture of the housing environment is created; if a key input is omitted, the correct solution may be presented with the information present, but it may be the incorrect solution for the birds in the shed and, in turn, impacting welfare.

5.3.3. Manage

What use is collecting data and generating models if no change can be effected? Currently, the farmer or stockperson effects each change: whether this is a change to the lighting; the feed level; the water pressure; or sets a computer with static values or dynamic values within bounds.

5.3 Chapter summary

- Poultry differ from other animals with respect to PLF systems due to the sheer volume of birds. However, farms in the UK currently have the potential to be highly mechanically automated, ensuring the 'average' bird in a shed receives the specific amount of food, has water available and that the lighting and climate are correct for the development stage of the bird.
- The principle of PLF involves three stages: *Measure, Model and Manage*:

  Measuring is potentially passive and is the data collection stage, whether through temperature, carbon dioxide or other chemical sensors throughout the shed, or video cameras and microphones.

  Modelling takes these measurements, integrates them and produces a simulated shed environment (whether this is a single number or a full virtual representation), to enable actions to be optimised. These models may take the form of discrete values, such as average temperature over a 5-minute period, or may involve complex continuous analysis of an input, such as a video feed with individual chickens identified and tracked.

  Managing is the action or response stage of PLF. When presented with a model, some form of action may be required to benefit the birds' welfare or performance; this may be as simple as increasing the ventilation by a few percentage points, or could be analysis which indicates the early onset of a disease challenge whereby a vet may be required to be contacted.

6 Key Study Visits

6.1 Prof Marian Stamp Dawkins, University of Oxford – Emotional state of animals and OpticFlock welfare assessment

My first Nuffield Farming visit was to Oxford University to meet with Marian Stamp Dawkins. Since the 1980s, Prof Dawkins has been a key advocate for the need to understand the emotional state of an animal in order to consider their level of welfare. She has also been a part of the team that has developed OpticFlock (*Dawkins, Optical flow, flock behaviour and chicken welfare, 2012)*.

OpticFlock uses the changing patterns of light and dark in successive frames to give an indication of behaviour and activity at a flock level. The benefit of OpticFlock is that it is able to be used by a small number of video cameras in the shed, it does not rely upon individual bird movements. It provides real-time data (pragmatically, daily), and helps to detect early signs of mortality, hockburn, footpad dermatitis, lameness, and campylobacter. This is not a system that replaces any form of the stockman's role, but it can act as an additional early warning system to aid the stockperson. The reason that OpticFlock uses cameras is that neither leg tags nor wing tags would be suitable for chickens, as the volume is too high.

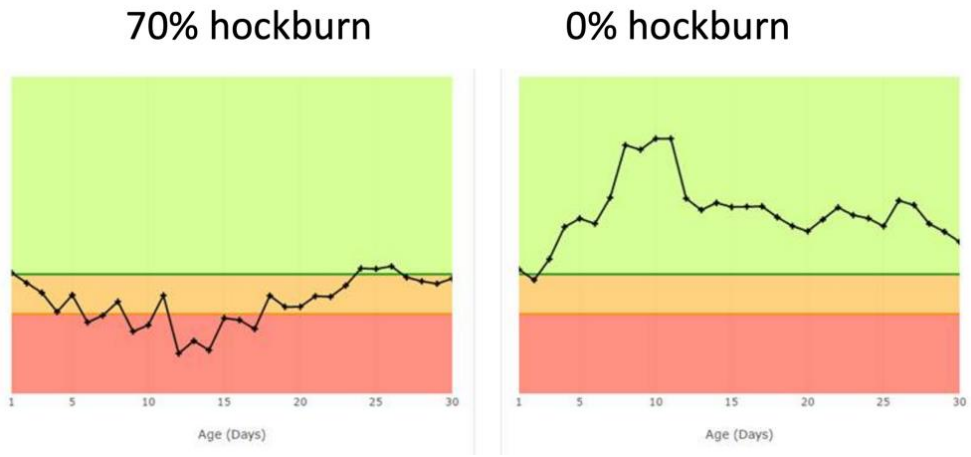

Figure 4: Diagrams showing the progression of two crops of birds, one with hockburn issues and one without, using OpticFlock.

6.2 Dr Martin Zuidhof, University of Alberta – Precision feeding

At the University of Alberta in Edmonton, Canada, I met Dr Martin Zuidhof who has been working to provide individual feeding to chickens. It is a simple concept that has taken years to develop into a fully-functioning project. With Dr Zuidhof's chicken coop, a bird walks up the ramp to the first of two compartments, where it's weighed and, if the bird is already at target weight, they are gently ejected. If they're under the target weight, the bird is allowed into the second compartment, where they're rewarded with some feed. Birds are able to request feed as many times during the day as they want, but once they've hit the target weight, there'll be no more feed available.

Figure 5: Broiler Breeder birds using the precision feeding system.
(Photo: Dr Martin Zuidhof and shared in a presentation with the author)

With this precision feeding system, flock uniformity dramatically increases for broiler breeders; where conventional feeding systems produce around 55% uniformity at 22 weeks old, precision feeding allows for 100% uniformity. They have also seen fertility increase by nearly 4%; gut health improvements since each bird feeds between 5 and 10 times during the day as opposed to conventionally feeding birds once a day; and welfare improvements as individual birds are able to feed when they wish to and so there is less competition and stress for the available feed.

Figure 6: Dr Martin Zuidhof pictured with the author, James Smaldon. (Photo: author's own)

6.3 Agricultural Technology Research Program, Georgia Tech Research Institute – Growout house robot

Whilst in Atlanta, I met with the team at Georgia Tech's Agricultural Technology Research Programme. I spent a fascinating day learning about how people in the processing plant can start being trained on the best cutting technique through virtual reality training; how it may well be better welfare for the birds to Low Atmosphere Stun them at the farm and transport these unconscious animals in climate-controlled lorries to the processing plant (thereby negating the welfare impacts of travel on the bird); and finally, how analysis of the sounds in the poultry sheds can help us to understand welfare impacts and alert the farmer to when they may need to investigate.

Figure 7: The author with members of the Georgia Tech Research Institute. From left to right: Alexander Samoylov, Wayne Daley, James Smaldon, Sim Harbert and Doug Britton. (Photo: author's own)

Colin Usher has been working on the Growout House Robot for a number of years now; whilst it is currently still in the research phase of development, the robot has been developed sufficiently such that it is soon to be developed into a commercial product.

This robot quite literally identifies birds and eggs, constructs 3D models of them and decides how it wants to proceed. It can collect eggs through a suction cup on a robotic arm and can be remotely controlled through a VR headset! I was aware of the possibilities for having school children drive the robot around a poultry house, being able to look around and listen to the birds whilst a) in the safety of their classroom and b) not disturbing the birds in their environment.

Figure 8: A press release photo of the Growout House Robot, developed at Georgia Tech's Agricultural Technology Research Program. (https://gtri.gatech.edu/newsroom/robot-chicken-house)

This robot has a range of sensors that provide accurate mapping of the house environment at bird level to the nearest inch. It also plays chicken with chickens: if a bird doesn't want to move, it'll reverse, wait a couple seconds and then gently nudge the bird. To collect floor eggs, it will periodically navigate around the house and will adjust the frequency of where it goes depending on how many floor eggs it's previously found in that area. In the future, Mr Usher believed that the robot could also automatically assess gait, individual bird weights, and monitor natural behaviours and flock condition.

6.4 Cobb Vantress, Arkansas

Siloam Springs, Arkansas, is the global headquarters of one of the largest poultry producers in the US and one of the largest broiler breed companies in the world. This is no small coincidence, as Cobb Vantress is a subsidiary of Tyson Foods. I spent a few days with Roy Mutimer, the Head of Operations at Cobb (since my visit, Roy has become Managing Director of Cobb Europe).

Roy and I discussed how Cobb is using increasing levels of technology to help manage their research programme and viewed the ability of farms to utilise increasing levels of technology to not only be a convenience, but a necessity in the future; today, millions of dollars are foregone through lost productivity on the lowest 50% of poultry farms. The reality is that computer systems in poultry units are already very sophisticated but most have relatively poor user interface design. An example given to me was that when a member of the Cobb technical team travels to a farm to help them with their flock, this mostly involves training the farm staff on how to use the systems they already have, not to implement anything new. The people managing the birds need to be able to understand and utilise the systems at their disposal. The next generation will take to these systems much more easily than current farm staff; as they have been immersed in a world of tablets and smartphones they will come to see the technology as a prerequisite, not a perk. However, the importance of the transition between the traditional stockperson who solely uses their senses and the young professional who augments their senses with technology cannot be overstated; when issues occur, traditional skills are necessary

and if there is an over-reliance on the technology, an issue could be made far worse than it need have been.

The salient point to our discussions was that farming is about the people, not the animals, but when we look at welfare, we need to completely focus on what the animals want, and not the people. If we could remove a monotonous task such as floor egg collection, this would be beneficial to the people on the farm, but do the birds gain a welfare benefit from regular contact (and therefore familiarisation) with humans? In conjunction with this, if people (within a layer or breeder setting) are not collecting floor eggs, there is a risk that they might choose to spend less time with the birds and therefore pose a risk that the health and welfare of their birds could be compromised. The skills and experience of the farmer or stockperson are vital to the welfare of the bird and so technology within poultry units should move more towards monitoring and intelligence, rather than the removal of labour.

6.5 OptiFarm, Chesterfield

OptiFarm is a relatively new entrant in the UK poultry industry, started by David Speller in 2018. Their aim is to provide 24/7 monitoring of broiler sheds through a remote team who remotely log into farms' computer systems and video cameras every 90-minutes and check that all is well.

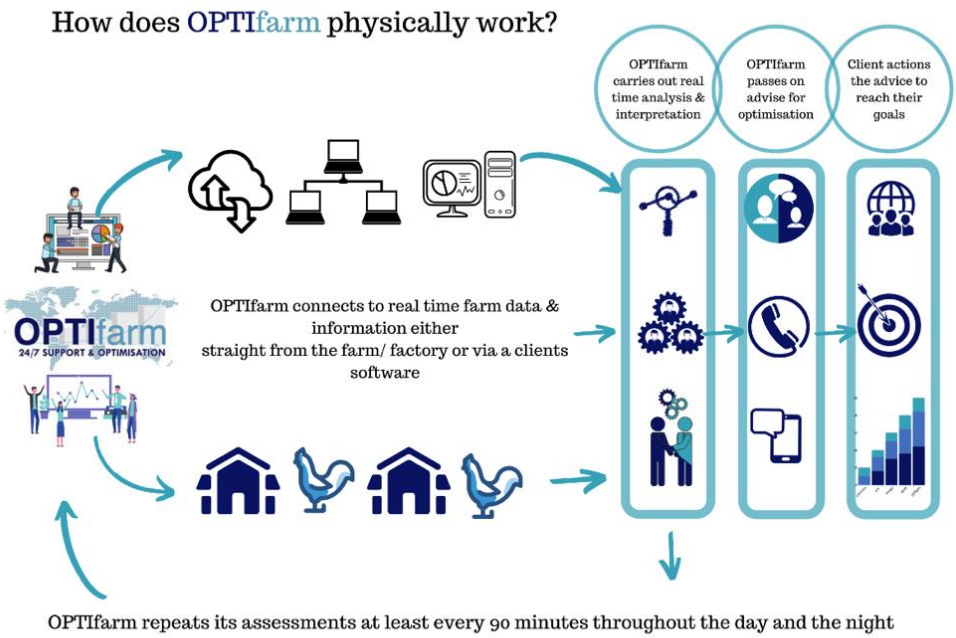

Figure 9: Infographic taken from OptiFarm's website demonstrating their capabilities. https://www.optifarm.co.uk/ (image previously accessed in April 2020, however now unavailable).

I was able to visit OptiFarm's premises and spend the day with Sean McKeown, the Operations Director, as well have a meeting with David Speller. Amongst other subjects, we discussed the adoption of technology onto poultry farms in the UK. The main aim should be the reduction of any

negative mental state and to improve positive mental state where possible, through inputs and housing systems. Integration with the other farm systems is important, as one hand needs to know what the other is doing! In integrating systems, the process should be to observe first, to learn how the shed works and what the stockperson does in a variety of situations, then to simulate what the technology would do (either alerts or changes to within the shed), reviewing these changes and thus assessing whether they would make a difference to the flock's welfare or performance. Only then would you take control of the shed. If a technology is installed and control is passed without understanding its effect on the birds, there is the potential for unnecessary welfare issues.

6.6 Royal Veterinary College, Hertfordshire

I travelled to the Royal Veterinary College (RVC) campus and met with Siobhan Abeyesinghe and Theo Demmers.

Figure 10: Royal Veterinary College Hawkshead campus, located near North Mymms, Hertfordshire. (Photo: author)

Siobhan and Theo have been investigating the use of accelerometers strapped onto broilers and using these, along with easier-to-collect metrics, to hopefully provide early indicators of lameness, disease or other welfare challenges; this is increasingly useful to provide the birds with probiotics at an early stage of a challenge, rather than antibiotics at a later stage. For example, there is increasing research to show low resilience behaviour patterning (e.g. preening being deferred) becoming evident prior to pathological signs. It was noted that these could easily be mapped onto a computer vision technology to provide not only trends over time, but also trends over area.

With respect to autonomy within farming, both Siobhan and Theo agreed that the general public is likely to see it as ethically unacceptable to have a fully autonomous farm. What technology can do is to get the right people on farms; with a reduction in manual handling and the monotonous tasks, the

labour market opens to those who aren't necessarily as physically able. Younger people will come to expect the technology and, if not installed, that will become a barrier. It was noted that "*modern technology and old foxes don't currently mix too well*". A highly automated farm also has the possibility to allow for mental positives which in certain instances we currently cannot provide without the risk of adverse effects to the reliability of production. Light is one of these mental positives as it shows that birds sunbathe in addition to dust bathing. Technology can allow highly motivated natural behaviours, not only in housing design, but also in the interactions with the birds.

Siobhan noted that we don't yet understand those behaviour patterns which are lost due to lack of maternal care. Robotic mother hens could therefore help with sounds to encourage food finding, reduce aggression and, potentially, other behaviours. The chickens will habituate to the robots (like they do with stockpeople) and stress levels are even likely to reduce, as robots are not seen as predators but as non-social novel enrichment.

6.7 Tibot Technologies, France – Spoutnic robot

Tibot Technologies is a relatively small company based in Rennes. I was able to visit them whilst also attending the final EU Feed-a-Gene conference in Rennes.

Tibot produces a poultry robot called Spoutnic. This robot is already being sold around the world for use on commercial farms, which makes it very interesting, as most of the other chicken robots around the world are still in development. The reason that Spoutnic is already available commercially is due to its plug-and-play nature. A farmer can open the box, charge the battery, place the robot in the poultry shed and turn it on; it is that straightforward (unless the farmer wishes to delve into the various settings that can be adjusted!).

Figure 11: The author with Gabriel Laurent (left) and Yanne Courcoux (right) from Tibot Technologies. (Photo: author's own)

This robot does not use any beacons or sensing equipment, but employs the front bumper to assess if there is an obstacle (such as a bird or shed furniture). If so, the robot reverses, turns by a number of degrees (e.g, 15 degrees) and continues. This behaviour allows the Spoutnic to disturb birds on the litter area and helps to reduce floor eggs a lot faster than is usual on commercial poultry farms. Additionally, lights and sounds are able to be emitted from the robot, to provide enrichment and novelty to the birds: this helps to satiate their curiosity within a relatively barren environment.

Figure 12: Tibot technologies' Spoutnic poultry robot. (Photo: author's own)

6.8 Aviagen, Edinburgh

Cobb Vantress is one of the largest broiler breeding companies in the world, the other is Aviagen. Aviagen Europe is headquartered near Edinburgh, Scotland, and so after a short flight, I spent the day with Alan Thomson (European Managing Director), Anne-Marie Neeteson (Global Head of Animal Welfare) and Magnus Swalander (Director of R&D).

Anne-Marie Neeteson started our discussions by speaking of the animal welfare activities within Aviagen, as well as public perception around welfare. We discussed how the slower growing/higher welfare birds do not go together with sustainability and efficiency - quite the opposite in fact. Ironically, the most effective way that Aviagen have found to combine welfare and sustainability is via management principles and feed (feeding the standard Ross 308 broiler chicken on a slower growing feed ration produces very similar welfare outcomes to those of the slower growing breed).

Figure 13: The author, James Smaldon, with Alan Thomson - Managing Director of Aviagen Europe. (Photo: Author's own)

Magnus Swalander then spoke of the research and development within Aviagen since being acquired by the EW Group in 2005. Aviagen is using computer tomography (3D modelling) of chickens to allow for prediction of future breast yield and to scan thousands of chickens per day to help to keep the best birds alive whilst knowing to a high degree of accuracy what their progeny will be like. They use genomics to identify exact parentage and minimise errors, measuring the blood oxygen levels of birds, plus gait scoring to best provide a robust and competitive bird for the global broiler market.

Near the end of our discussions, it was interesting for us to speak of computers within poultry production and their lack of empathy. Stockmanship is crucial to poultry production as there needs to be consciousness. Leading on from this conversation, it was said that those who actively want to use technology on farms will likely see large benefits from it; however, if technology is installed on farms where the farm stockpeople are ambivalent, then there are large risks.

6.9 Hendrix Genetics, Boxmeer, Netherlands

Teun van der Braak is a product manager at Hendrix Genetics in Boxmeer. I met him during my visit to the Netherlands in early 2020. Hendrix Genetics is a global layer breeding company (in addition to swine, turkey and aquaculture breeding) started in 1923.

Figure 14: The author with Teun van der Braak - product manager at Hendrix Genetics. (Photo: author's own)

Teun and I spoke for an afternoon about the intricacies and nuances of layer breeding. I had no idea that the genetic potential of a chicken is more than 10,000 eggs! Hendrix are finding that the best producing hens can lay 575 eggs in 576 days, and are expecting an additional week of production per year of development.

Teun also agreed that, like the broiler breeding companies, Hendrix has been utilising technology within their breeding programme to its fullest extent; the pure line birds have RFIDs, and automatic reviews of grandparent genetic profiles are performed to ensure correct parents (before genomics, they had a 5% parentage error rate which is now down to 0.1%). Again, similar to broiler breeding companies, layer breeding selection trait prioritisation used to be production potential and parent stock efficiency; however now it encompasses 40 traits including product quality, health and welfare and sustainability (the initial two traits now compromise approximately 1/3 of the selection traits).

6.10 Hotraco Agri, Hegelsom, Netherlands

Hotraco Agri are a Dutch company and are renowned within the poultry industry for embracing technology. I met with Frank Schreurs and we discussed Hotraco's place within the future of poultry production.

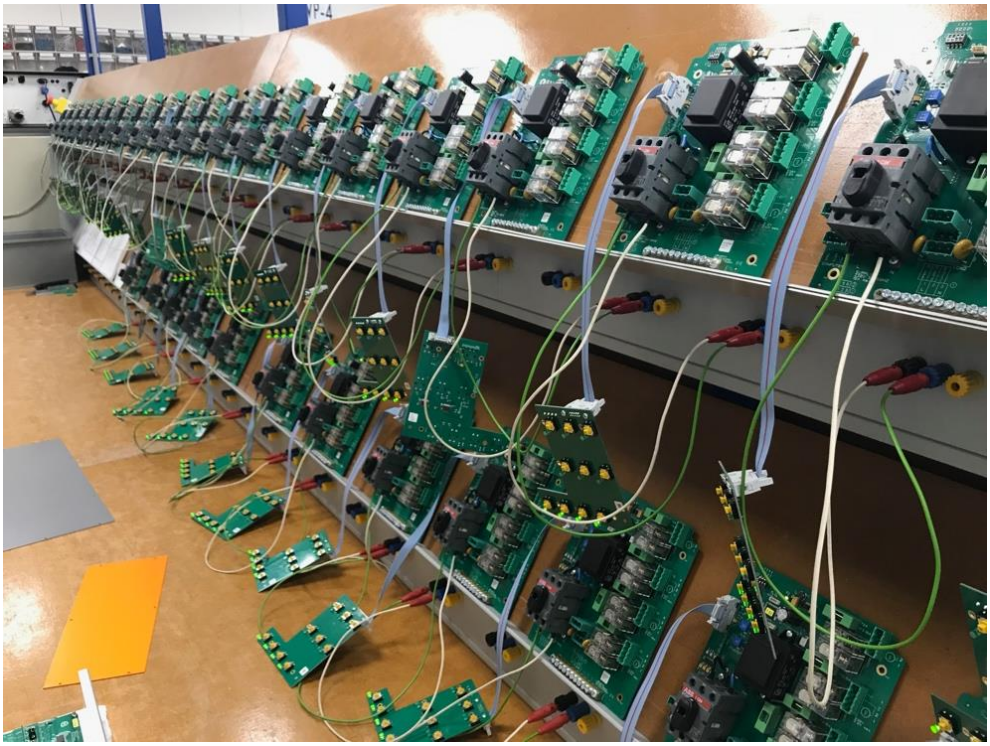

Figure 15: Hotraco Agri circuit boards in production at their manufacturing facility. (Photo: author's own)

Globally, Hotraco's experience is that knowledge of stockmanship is going down; not many people want to work in poultry sheds and so technology has a role in replacing mundane elements of stockmanship.

Frank likened automation within poultry farms to traffic light road junctions – we don't rely on humans to change each light at a junction, as we would have an accident very soon through mistakes. With farms getting bigger in scale, it is necessary to remove the repetitive tasks and allow people to concentrate on the novel tasks and decision making.

Frank's philosophy is that in a world that is antibiotic-free, farming is a new ballgame, as the antibiotic backstop has been removed. Farm management needs to be structured and responsive; not the 'I'll get around to it' traditional-style farming which has been seen for decades. The next level of management is to combine farm information with feed prices and for a feed mill to dynamically adjust the feed ration.

There are three ways to automate alerts, each more dynamic that the previous – either set rigid bounds and alarm when the sensor exceeds these bounds; use the history of the flock, in conjunction with breed expectations to adjust alarm bounds, which alerts the stockperson if the sensor or metric exceeds these adjusted bounds; or the third being the use of deep-learning to understand the past, present and future of the bird and alert if there is the slightest deviation. Equipment will also need to be more precise in order to justify the increased resolution of precision technology. It may transpire that the increase in cost for both measure and manage means that the cost of the technology cannot be financially justified.

However, with increasing automation, where does responsibility for the birds lie? Does it shift towards the computer? Regardless of how much the computer can control, there are always variables such as poor feed or equipment malfunctions that cannot be controlled. To this end, the responsibility of the birds must always be with the farmer. Increased automation means that the first principles of stockmanship aren't necessary for possibly 95% of a bird's life; however, the stockmanship is needed for the last 5% and how do we transition *from manual to auto*? Is the possibility of a *training shed* on each farm viable, with manual controls to ensure that key stockmanship principles are maintained and can be transferred from this small shed to the large ones if needed?

Some people are naturally good stockpeople, some need to work at it and others might never gain good stock sense. To help train the second group, it is reasonable to assume that the 'expert stockperson' role could be separated and provided to farms as a service (similar to OptiFarm, but for stockmanship).

6.11 Wagneningen University & Research, Netherlands

6.11.1 Bastiaan Vroegindeweij – Egg collection robot

Bastiaan works at the StartHub incubator at Wageningen. His family are poultry producers, specialising in the breeding and sale of 17-week old layer pullets. As such, he already had a keen interest in poultry and, with a degree in engineering, it made sense to develop a floor-egg collecting robot.

Figure 16: Bastiaan Vroegindeweij beside his wall of chickens at Wageningen University. (Photo: author's own)

Most farmers think that collecting floor eggs also allows either themselves or the stockperson to inspect the birds as well, but mostly it does not. The robot that Bastiaan developed uses LIDAR (Light Detection and Ranging) to navigate, and path planning algorithms that Bastiaan designed to survey the shed for floor eggs. It was found that a robot that bumps into objects to navigate breaks after a few months of 'abuse', whereas a robot that can see will last a lot longer. Bastiaan joked that their red prototype had not worked so well, as the hens had assumed these robots were cockerels and *presented* themselves for mating (meaning that they wouldn't move out of the way of the robot!).

What they found with the egg collection robot is that the birds were curious of this mechanical toy which provided a novel enrichment as a side-benefit to the collection of eggs. With the reduction of the monotonous tasks, a larger part of a stockperson's day can be directed towards stockmanship, instead of the daily *chores*. In addition, a floor egg robot can stay in the poultry shed all day, whereas a stockperson may walk the sheds 2 or more times per day. Any alerts would therefore be quicker than could be achieved through a stockperson alone.

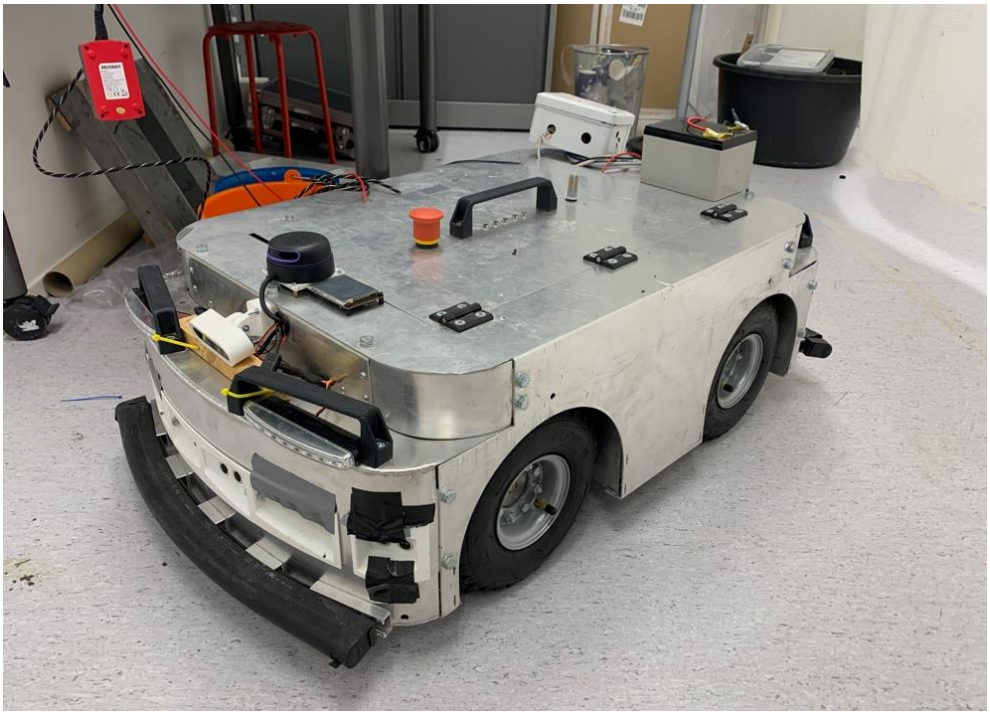

Figure 17: The second-generation prototype floor egg robot collection robot, developed at Wageningen University. (Photo: author's own)

We then went in to discuss the wider impact of technology within the poultry industry. Bastiaan thought that we could get far, but that stockmanship and the consequent understanding of the birds' needs will continue to be superior. It may be that farms can operate with people for five days a week and leave the other two days to the virtual stockperson (in turn, enticing a higher skilled individual to the role).

So what are the benefits of automation? The reduction of human manual handling and also the reduction of risk. Humans are incredibly good at connecting information together, but bad at doing it consistently; computers are the reverse. Where there are monotonous tasks, we should aim to remove the person from the task to improve its reliability; however, when we need to connect a

variety of information together, this is where humans add the most value. We ended by agreeing that a manager held two very distinct roles on today's farms: one as a stockperson and one as a data analyst. In the future, the data analyst role will likely be automated, and the farm manager will become a pure stockperson - able to make key decisions when the data requires a human to make one.

6.11.2 Thea van Niekerk

I was later introduced to Thea van Niekerk who was able to spend a few hours with me sharing her understanding of the behaviour of the chickens in our care, and the implications of technology.

Thea's first view was that there is always something in the shed that is unexpected, so people are needed, first and foremost. We already have a lot of sensors in our poultry sheds and it is the integration and useful interaction of these datasets that will provide a lot of beneficial outcomes.

Whilst RFIDs[1], microchips and leg bands are great within a research setting, Thea suggested that visual and audible monitoring of birds is the best option for commercial sheds, as video cameras that can track individual birds can identify individual and group behaviours, providing the farmer with information previously unattainable. If this video monitoring is combined with a robot that walks the house then 90% autonomy is possible, although the human must be the master connector of information.

Mutilation of farm animals was also raised. In principle, she asked "*why we need to trim beaks in the first place? We should be keeping animals in a place where they do not routinely have injuries, and then adjust the environment accordingly*". It appears that the best farmers who believed that beaks shouldn't be trimmed made it work, whereas the farmers who didn't believe it an option have not seen such success. Any animal industry should work towards removing all mutilations in animals completely.

We can't entirely mimic nature; yet, we can rear birds with the natural skills to be able to express their behavioural repertoire. The ideal would be to have the knowledge of what the birds do and how they interact in areas of 'full freedom' and then work backwards towards a commercial setting. But, how do we assess animal emotions in a scientific way? We can use the welfare quality assessment which also scores fear, as the *fear sphere* assumes that the closer the birds get to the human, the less fear. In the future, this should be augmented with scores for dust bathing, perching and other behaviours indicative of high welfare.

Manual intervention and redundant systems are necessary on any poultry farm (regardless of the level of automation), as we have a responsibility to the animals to ensure they are cared for adequately and not allowed to suffer through equipment failure or our lack of attentiveness through allowing our minds to wander when not actively 'at the helm'. In addition, communication and understanding of where the technology falls short is important, and this 'information' is essential in preventing disaster.

One possibility would be similar to the training wheels on our first bicycles; technology guiding the user within limited bounds to ensure that they do not inadvertently 'fall over'. This guidance could be

[1] Radio-frequency Identification

in the form of alarms being raised much earlier than would normally be expected. Pre-authorisation could then be provided to enable the technology to expand its knowledgebase and reduce the potential for alarms over time.

Any new system on a poultry farm needs to be user friendly; the iPhone is a bestseller not because it was the first smartphone, but because it was the first smartphone that was straightforward for everybody to use; it had a shallower and lower learning curve. To provide this analogy for poultry farms, an advanced technology should ideally be wrapped in a user-friendly shell, which is able to be utilised by each and every stockperson.

6.12 Robert Nijkamp NSch, Zwolle, Netherlands – Windstreek broiler environment

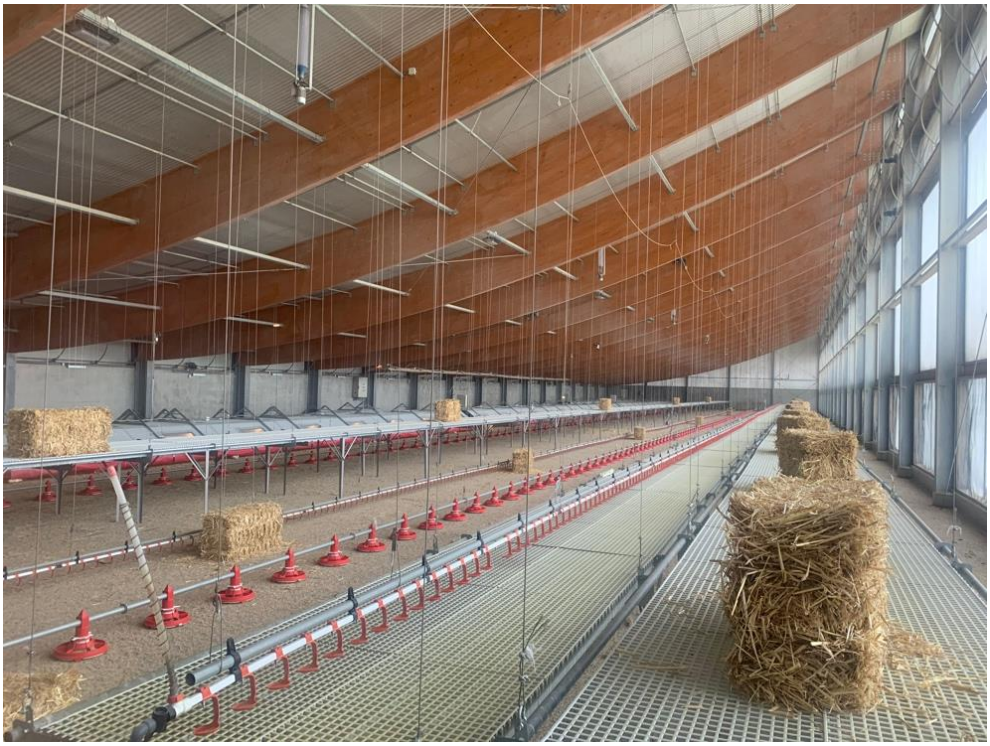

Figure 18: An internal image of the Windstreek broiler shed, during the first days of a new crop. (Photo: author's own)

Robert Nijkamp is a Dutch Nuffield Farming Scholar and built the innovative Windstreek broiler shed concept in 2016. After a Wageningen project to design better poultry housing, the research team took the position that a poultry shed should look at how nature solves issues and not how they would solve them through technical means. This meant that the Windstreek shed doesn't use powered ventilation at all, instead relying upon convection and the birds' own heat to draw fresh air into the shed. During the first ten days, chicks are kept warm under infrared-heated canopies with the ability to wander beyond this canopy area if they wish to do so.

The Windstreek is an example of great shed design that is consumer-friendly. Robert suggested that whilst it cost more than a standard broiler shed, it has generated the same profits over the past 4 years, as there are minimal heating and electricity costs.

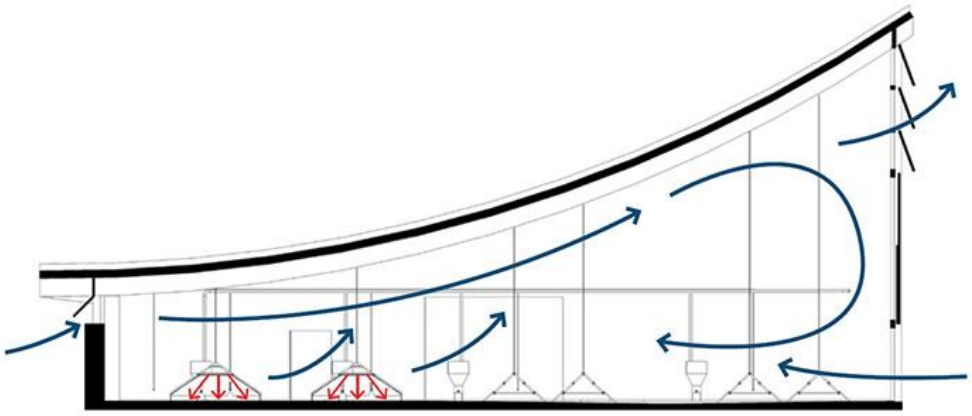

Figure 19: A cross-sectional diagram of how air flows in the Windstreek's naturally-ventilated shed. https://zootecnicainternational.com/field-reports/vdl-agrotech-launches-sustainable-broiler-house-design-called-windstreek/

We touched upon the use of the verified block chain systems Robert is developing to understand more about the welfare of the birds. Robert suggested that poultry farmers and companies need to analyse and combine data more effectively than is currently being achieved. The birds tell us what they want and we need to become better at reading them and to react earlier. It is quite possible that insights can be gained through existing sensors, rather than installing a mass of sensors that effectively 'brute-forces' the answer.

One aspect that was important to Robert is that we cannot measure happiness within birds; we can measure happiness proxies (somewhat similar to humans in fact, if just looking from a distance – is someone laughing or crying?). We can use weigh scale activity, or dust bathing, or human interaction, or another metric to assess the birds' contentment and happiness. The most important thing is that any dashboard should not have an indicator labelled 'happiness' as this is potentially misleading. We can provide a probability that we are achieving welfare aims and provide various approximations that we believe correspond to high welfare, but not the emotions which we cannot know they are feeling.

Editor's Note.

Restrictions imposed because of the COVID-19 pandemic in Spring 2020 meant that the final two of the author's study tour visits needed to be conducted by video-conference. Because of the word count limit imposed by the Nuffield Farming Scholarships Trust on the content in the main body of one of their reports, the text relating to the 2 visits concerned has needed to be transferred to an Appendix: Appendix B on page 48.

The first of these was with Hugo Jansen, who works in Cargill's European Digital Services team and the second to Kate Parkes of the UK's RSPCA. Again, the reader is strongly recommended to read the content of Appendix B.

6.13 Chapter summary

- Across the world, many universities and organisations are investigating PLF to help the global poultry industry to manage chickens more effectively; this research stems from a lack of stockpeople – expected to worsen in the coming decades. A greater demand for the product and increased consumer pressure over welfare also compound the need for effective stockmanship and PLF technology.
- There is widely accepted agreement that PLF should be invested in to complement current stockpeople, and not to reduce the reliance on people within poultry production. However, with an increase in technology, there is a risk that focus will be lost and that the reduction in the role of a stockperson completing manual handling and monotonous tasks will not be succeeded by the increase in stockmanship and supervisory skills necessary. Humans will continue to be the master connectors of information and ultimately responsible for the birds in their care, regardless of what technology is in place.
- In an antibiotic-free world we may soon be entering, technology has the potential to provide insights seemingly unattainable and help us to maintain production levels seen during the period of antibiotic use (as a last resort). These insights may well be obtained through a greater understanding of the birds themselves, and their wants and needs. Modern poultry sheds aim to limit the variables and control the remaining variables; PLF can provide an ability to manage additional variables, thereby allowing poultry housing design to evolve towards a proxy of a 'full freedom' environment for the birds.
- Finally, consumers will hopefully be able to use the verified assurance of *continuous independent welfare audits* to be able to verify the welfare with which their chicken has been raised, and give them the ability to choose and steer the poultry industry.

7 Opportunities and Risks of PLF

There are numerous reasons why technology and advanced systems could be installed in poultry environments: first and foremost, it is that people like gadgets and these novel technologies satiate our own need for fascination and curiosity. But, just because a form of technology is available to install in a farming environment, does not mean that it should be.

7.1 Opportunities

7.1.1 Bird

Poultry farming currently operates on averages; average weight of the bird in a shed of 10,000; average temperature; average feed consumed per bird. There is unlikely to be a bird which conforms to this purely 'average bird'; however, a majority of birds will be 'close enough' to this average to allow for good flock management. PLF provides greater levels of detail and faster response times.

Early warning systems can provide the ability for a drop in bird welfare to be either minimised or the period during which it has dropped to be reduced. If a stockperson can understand that bird 5,283 in Shed 2 requires attention, this presents two benefits over and above existing practices: firstly, that there has been an identification that a bird requires attention, rather than hopefully noticing this bird during one of the floor walks; and secondly, that the stockperson can go directly to that bird or that area of the shed and direct their attention at the earliest possible opportunity to the problem.

The future welfare of poultry will undoubtedly be based on their emotions and our increasing understanding of these emotions. If we can score the inner state of a bird, then we can create quality production environments that are not only commercially viable but also provide an enviable level of welfare. It is likely that this future housing design will use natural solutions where possible and to augment these with PLF to help provide continuous updates to the environment. A future housing solution will incorporate our understanding of how birds behave in a 'full freedom' environment and then provide proxies which correlate with this level of high welfare.

With passive measurement systems such as video or audio, the health of the bird can be continuously assessed and challenges presenting themselves prior to becoming physically obvious (such as a reduction in preening) can be identified. This is likely to be necessary in an antibiotic-free world where pro-biotics or herbal remedies can be used to strengthen the birds' own immune responses.

7.1.2 Stockperson

Technology does not care. Technology does not feel empathy. Technology does not 'think on its feet'. However, technology also doesn't come to work angry, does not fall ill and does not make silly mistakes. The link between human and animal is necessary and absolute.

By providing a *virtual stockperson* in the form of passive sensors to measure the housing environment and provide a *mechanical stockperson* to remove manual handling does not negate the need for

stockpeople, but strengthens the need for them. The stockmanship role is converted from one split between stockmanship, manual handling, supervision of equipment and performance management, to a pure-bred stockmanship and supervisory role. By removing the *not so nice* activities, the birds are also able to associate more positively with humans.

The virtual stockperson augments the senses of the actual stockperson, providing continuous, detailed information that would otherwise be unable to be recorded. In addition, it provides connection since a stockperson on a single farm is complemented with the crowd-sourced knowledge of thousands of farms. This virtual stockperson would need to default to the decision-making of a human and, where it is appropriate, be given pre-authorisation over time for various defined inputs. With a virtual stockperson to augment humans, there is less risk of human error being made during the monotonous tasks.

An updated role for the stockperson with more focus on the welfare of the birds should hopefully provide higher levels of job satisfaction and present an opportunity to professionalise the poultry industry. This is likely to be a necessity for the next generation of stockpeople, as they have grown up with tablet computers, smart phones, and apps for just about anything! They will require technology within poultry farms as a prerequisite, not a perk, but will still need to learn the basics of stockmanship. These basics will likely come through three possible means: either a small training shed (either on the farm or virtual), through traditional applied learning (similar to medical training), or through consultancies of expert stockpeople who mentor, coach and guide young stockpeople.

7.1.3 Farmer

Whilst a vast majority of farmers want to provide the best quality possible to their supply chain or consumers, it is a reality that *the market* determines a price for their product and so farmers wishing to provide a sustainable income for their families are limited by this market price.

Technology presents the opportunity for better profit margins for farms through more accurate forecasting and planning; less waste by providing the right level of inputs at the right times (a reduced environmental footprint as a result); the creation of a baseline of welfare and performance to reduce the foregone productivity of the lowest 50% of farms; and to be able to manage farms with confidence – and potentially for limited periods, remotely – with disruption due to the availability of people presenting less of a risk than it currently is to the welfare of the birds.

7.1.4 Consumer

Technology can provide an 'independent auditor' role, to provide those outside the farm with assurance that the welfare of the birds is not being impinged. In addition, once the continuous and transparent auditing of bird welfare is possible, objective welfare can be proven and perceptive welfare can be dispelled. Welfare is an emotional link between human and animal and anthropomorphism will continue with more people residing in towns and cities, removed from the animals that they consume.

The ability to provide the most choices to the consumer provides them with the ability to choose what they wish to prioritise: price, welfare or the environment? These three priorities are usually at odds

with each other during poultry production, but by providing the consumer with the choice, the decision is removed from the hands of large poultry production companies and responsibility shifted to the consumer.

7.2 Risks

7.2.1 Bird and stockperson

Where interaction between the bird and stockpeople falters, this is likely to cause a drop in welfare of the birds, so I have combined these two levels together to assess the risks.

The major risk of technology within poultry farms is the loss of interaction between birds and their stockpeople. This risk not only hurts stockmanship through a continued decline in skills, it also hurts the bird through the lack of regular acclimatisation to people, thereby increasing the *fear sphere* and introducing unnecessary stress to poultry sheds.

People tend to trust things too quickly that make their lives easier. Focus gets lost and the birds in their care are the ones to suffer when either equipment fails or actions are taken that are wrong, and result in poor welfare outcomes.

7.2.2 Farmer

Whilst the ability to identify and track each individual bird in a shed is a novel and powerful ability, what benefit is it without the ability to provide meaningful change to their lives? The level of detail on the *measure* side should correspond to the level of detail on the *manage* side, so that changes can be effected. To change both adds a lot of cost and may make the virtual stockperson less financially attractive than first believed to be.

Another risk for poultry farmers is similar to that of corn farmers in the USA: race to the bottom for productivity. There is a track record in a variety of industries that when the noble aim of increasing production efficiency and quality on a single farm is able to be expanded to a majority of farms, the cost of production is driven down and farms essentially are required to run with new technology to maintain their business, let alone generate profits.

Data ownership is a relatively recent risk, with few people understanding the full implications: data has value and so farmers should endeavour to retain the ownership of their flock data where possible, selling it to those businesses who wish to aggregate this information and use it for commercial benefit. In addition, if technology companies have servers based *in the cloud*, this increases the risk of catastrophic failure upon a minor loss of connectivity with the farm, or even ensuring the farms are *locked in* to unfair contracts, with few alternatives.

7.2.3 Consumer

Farming is built upon the story of a farmer with their land or animals. Technology not only breaks this emotional connection, but creates the opportunity for companies to create ‘fake meat’ products using technology and thus become equivalent, rather than inferior, products.

The loss of connection between the consumer and their farms (through national integrated supply chains instead of 'the local farm') creates conspiracies about how animals are produced. As Frank Schreurs said: "*Trust comes by foot and runs off by horse*".

7.3 Chapter summary

- Precision Livestock Farming presents many opportunities at each level of detail within the supply chain, from the end consumer to the individual bird. Benefits include the speed and detail of information, the continuous nature of sensors - never needing to rest or even to blink - and the transparency and integrity that this information provides to each link within the chain.
- However, stockpeople may lose focus and trust the technology to perform actions too reliably and thereby instigate avoidable welfare issues. Also, a race to the bottom would see farms *needing* to invest in increasingly costly technologies without the benefit of additional welfare or profits, but to maintain access and competitiveness within a mature market.

8 Technology Adoption Strategies

8.1 Change management

Change can occur on a large scale (industry-wide) or small scale (on a single farm). It is important to note that when reviewing new technology and bird welfare, change at the farm level – with direct interaction with the birds – is most important.

There are a number of barriers to stockpeople effectively utilising the technology at their fingertips: first and foremost is the training and ability to use the equipment. This ability usually comes through having to use it or it being easy to use, rather than voluntarily learning how to use it.

8.1.1 The Dunning-Kruger Effect

The Dunning-Kruger effect is a cognitive bias in which people wrongly overestimate their knowledge or ability in a specific area. It was found that "*those with limited knowledge in a domain suffer a dual burden: Not only do they reach mistaken conclusions and make regrettable errors, but their incompetence robs them of the ability to realise it*" (Dunning & Kruger, 1999).

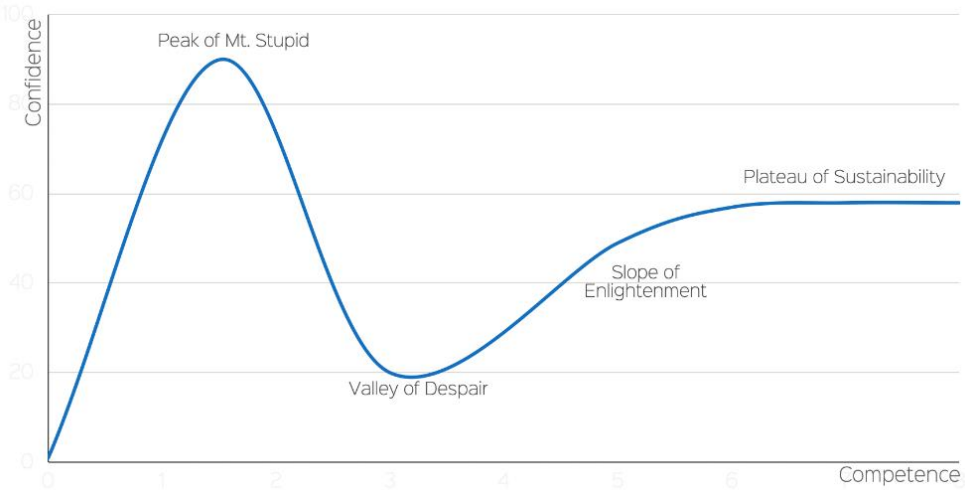

Figure 20: A graph showing the Dunning-Kruger Effect. Author's own representation of graph: https://josephparis.me/my-articles/lessons-from-mt-stupid/

Where previously ignorant in a particular field, people tend to over-estimate their knowledge in this field when they have a small amount of knowledge. It is only through continued use and additional knowledge that they understand what little they actually knew. It is reasonable to understand why people trust technology and lose focus, as they believe that they understand exactly what is happening; in reality, these stockpeople will not have experienced most of the issues that a technology can raise and it is only through experiencing issues and learning from them (how to respond and how to avoid them in the future), can they learn to use them most effectively.

8.1.2 The four stages of competence

The stages of Dunning-Kruger can also be referred to as one of the four stages of competence (Mind Tools, 2016):

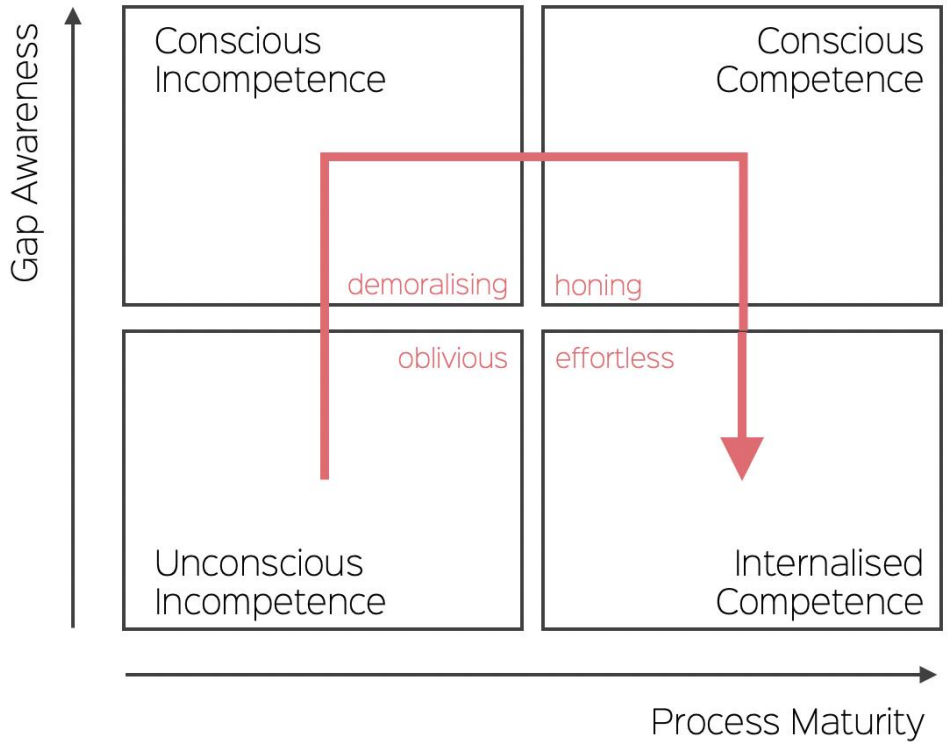

Figure 21: The matrix of Conscious Competence, incorporating the emotional effect on the person. Authors own representation of matrix: https://www.mindtools.com/pages/article/newISS_96.htm

With respect to poultry stockmanship and the increase in technology, this matrix can be modified as the following:

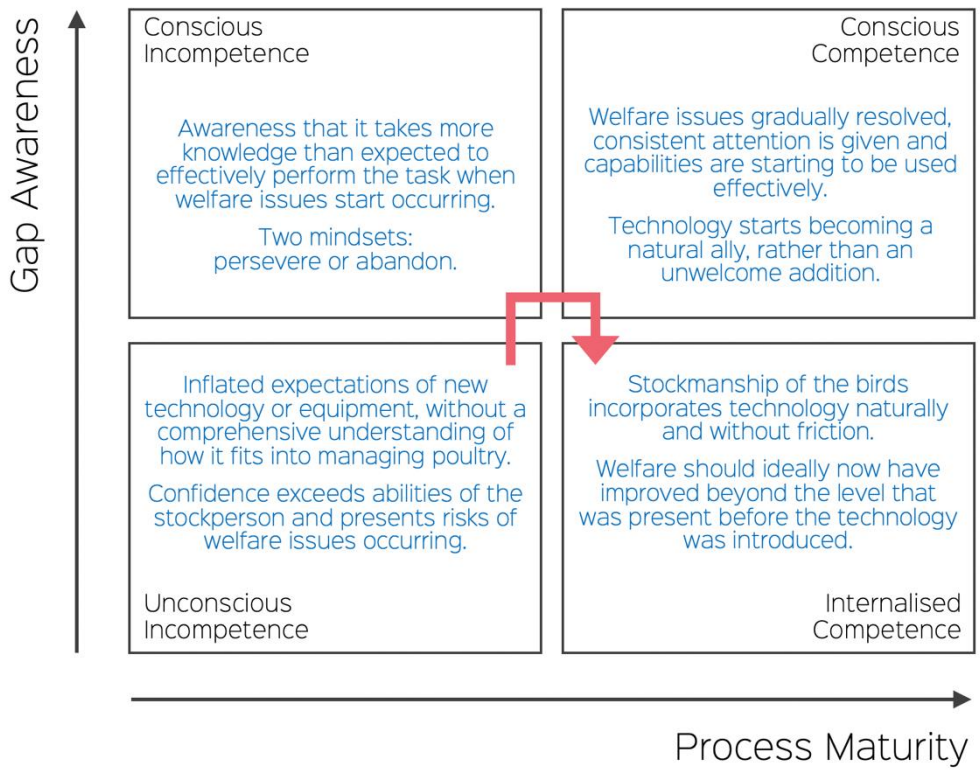

Figure 22: The matrix of Conscious Competence, revised for poultry stockmanship
Author's own interpretation of Conscious Competency matrix

8.1.3 The 'Welfare Falter' risk

The unskilled period of competence (both unconsciously and consciously) is where there is a true risk that the welfare of the birds can drop. The aim for the introduction of a new technology is to make this drop in welfare as shallow as possible (the ideal is to remove it altogether) and to shorten this drop as much as possible.

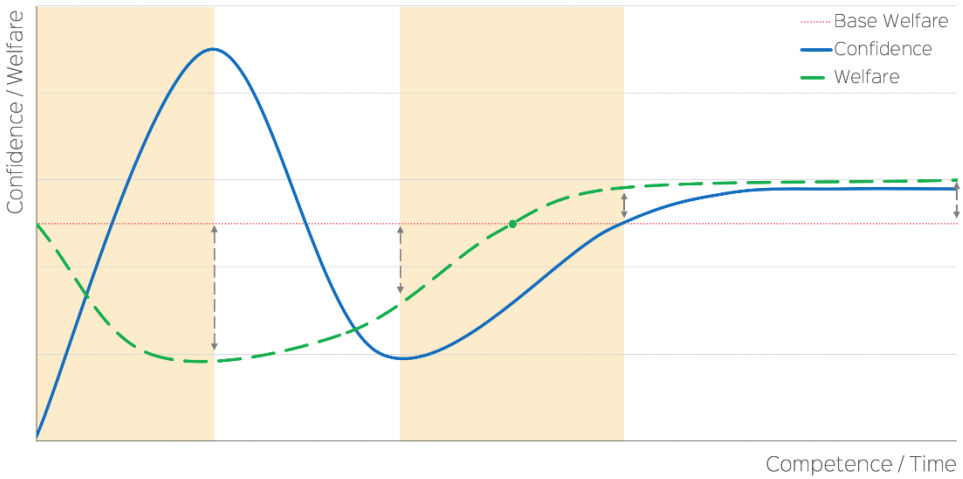

Figure 23: Graph showing the 'Welfare Falter' experienced by birds when stockpeople progress through the stages of competence. (Photo: author's own).

The drop can be referred to as the 'Welfare Falter' and needs to be addressed whenever equipment or technology will have a direct interaction with the birds (this includes computers which calculate feed levels and ventilation rates situated outside the sheds).

8.2 Strategies to minimise the falter

There are a variety of ways to make the welfare curve shallower and shorter: these are outlined below.

8.2.1 Demonstrate benefits to the birds

If a technology is imposed on stockpeople, it is likely that it will be met with resistance and the unskilled period will be extended. Demonstrable benefits also sharpen the developers to provide a solution to a problem, rather than trying to find the problem after the technology has been developed!

8.2.2 Make the right action the easiest one

The user interface of any technology should ideally be designed such that any person should be able to logically choose the correct action with the shortest number of steps (there is a reason why the emergency power cut-off button is usually big and red – it is the easiest to spot and press in an emergency!).

If a particular task is behind a multitude of steps, one of three outcomes may occur: users dislike the technology because it adds needless effort to their day, users find an alternative way to complete their task (potentially bypassing the technology completely), or users do not perform the task at all.

8.2.3 Back up the backup

When caring for live animals, farmers take absolute responsibility for their animals' welfare. Failures in mechanical or electronic systems are avoidable through backup systems. A new technology should ideally provide a plan for the eventuality that either the stockpeople are unable to use it effectively or that the technology itself does not behave in an expected or consistent manner (both potentially compromising the birds' welfare).

8.2.4 Staged release of capabilities

Where the technology is capable, a large learning curve can be segmented into smaller, shallower learning curves through the staged release of capabilities. The technology will initially be limited, with only basic settings available, but this ensures that advanced settings are not played with and so create a completely avoidable welfare issue.

8.2.5 Manage expectations

Equipment and technology are usually sold with the aspiration that they can do everything, but usage of the technology often brings the realisation that it is not quite as it was sold.

This is most self-evident in car sales, where the car salesman will exude confidence that a particular model is perfect for the potential purchaser; whereas, if a mechanic with no benefit to be gained in the sale is asked, a truer picture of the benefits would emerge. Potential users of a technology need to know especially what it cannot be trusted to perform; computers cannot be blindly believed and need human checks to show that the information they provide is the reality within the shed.

8.2.6 Embrace early adopters

Early adopters are champions of any technology adoption. They are likely the people who will actively make it work as they will put the time and effort into moving through the stages of competence most quickly. Early adopters are likely to share their mistakes and engage with developers of the product to ensure that it is not just 'good enough', but that it provides real benefit for the farm.

Early adopters are usually the strongest sponsors of the product and will naturally sell it if they believe it will benefit other farmers; conversely, if they are unable to see an appreciable benefit from the technology, the traction of the adoption of the technology is likely to slow and stutter. The best approach for technology manufacturers to take is to demonstrate the success stories of the technology and allow potential purchasers to visit farms where this technology is working successfully and to hear from the farmers how well they have been able to integrate it into their daily routine.

8.2.7 Provide training

Making the right action to take the easiest one is straightforward to some and difficult to others! By providing training to the direct users of the technology, progress is made along the stages of competence.

Training could take the form of a virtual poultry shed, where known issues can be simulated, or short videos of how the various parts of the technology work could be viewed. Otherwise, training could take place within a live environment, so that people could witness real-life operation of the technology. There is nothing better than stockpeople using the technology and having an expert on the technology coaching them throughout the operation to help them avoid pitfalls. This could include remote monitoring of the system, so that if potential issues are picked up before they occur, then the farm can be contacted and the issue averted.

Checklists are a handy tool to complement training, to remind people of the various tasks that need performing. Various aspects might be new and so may be forgotten very easily without repetition and reinforcement.

8.2.8 Make sure the initial setup is done right

Each shed on each farm is different. A farm with four seemingly identical sheds will produce differing flock results and therefore a new technology should be set up by somebody who is an expert. This technology should be calibrated and then those calibrations be validated throughout the initial flock, to provide confidence that setup has been done correctly.

8.2.9 Understand where the best and worst performing farms differ

There is a reason why some farmers consistently gain the best results and others consistently languish in the bottom quartile of results. An Aviagen study proposed two reasons: commitment, and attention to detail.

A 'passive' technology such as a virtual stockperson has the capability to add a 'committed and highly attentive' member to the farm team and may enlighten the farm as to the reasons behind the poor results. Conversely, an 'active' technology may be as poorly used as other equipment on the farm, and provide zero appreciable benefit to the farm as the attention to detail is lacking and so welfare may drop further than it might already have.

8.3 Chapter summary

- Technological change is similar for most industries, but at differing paces. The stages of competence cannot be skipped, but can be made as rapid as possible; this helps to minimise the *Welfare Falter* in both magnitude and time. A variety of techniques can be employed to aid developers of new and novel technologies and to ensure that their products – assuming they are beneficial to the bird and solve a problem within the industry – can permeate through the industry and raise the wholesale basal level of welfare.

9 Conclusions

1. Continuous welfare assessment has the potential to identify welfare challenges whilst they are occurring (and maybe prior) and allow the farmer to react.

2. In addition to stockmanship, genetics, environment and inputs are also vital for the provision of high welfare.

3. The level of detail should be similar across the 'measure, model, manage' process, otherwise issues may be identified with no way to effect change.

4. Human interaction is vital to poultry farming to ensure responsibility for the welfare of the birds, as well as to be master connectors of information; to react to issues which cannot be predicted; and to maintain an emotional connection to the animals on our farms.

5. The role of stockpeople will shift: less manual handling, less risk of human error - in contrast to more problem solving and more stockmanship.

6. Understanding of poultry will increase and so more environmental variables will be able to be managed within a poultry shed. This may enable a shift towards providing a closer proxy to nature for the birds.

7. Data handling and analysis competency is still at the early stages on poultry farms. This will increase over time, but gradual introduction of new technologies will benefit younger stockpeople, who may already be *au fait* with how technology works.

8. Independent welfare audits will provide confidence to consumers, if it is applied correctly. Linking assurance schemes to minimum welfare values may reduce confusion whilst providing assurance.

9. The *Welfare Falter* occurs when new or novel technology is introduced on a farm. The welfare of the birds will temporarily drop during the early stages of competence and then recover – hopefully exceeding the previous baseline of welfare.

10 Recommendations for the industry

1. Do not assume that people can be reduced or removed. Technology needs to complement and augment people, not be a substitute.

2. Developing technology is usually done by those with an intrinsic understanding of technology. Farming is usually done by those with an intrinsic understanding of animals. There are very few people where these two fields overlap. Technology must be developed to:

    a. be familiar to those with limited technology understanding.
    b. make the easiest action, the correct action. Preferred actions should not be hidden beneath menus.
    c. Provide visibility to the full capabilities (whether immediately or through progression) of the technology and provide everyday analogies to aid understanding.

3. *Welfare Falter* can be mitigated through a number of strategies:

    a. bring stockpeople on the journey, as opposed to imposing technology upon them,
    b. provide training for people to understand what they *don't know*, so that focus is retained, and
    c. Embrace early adopters and help them progress through the stages of competence.

11 After My Study Tour

I have gained a tremendous amount from my Nuffield Farming Scholarship. In the past two years, I've been given the opportunity to connect with some truly exceptional people within the poultry world and to look beyond what I know and towards what I now know that I don't know!

I have written articles in the NFU Poultry publication and have spoken at local NFU meetings, the Three Counties Farming Conference and the Northern Broiler Conference. I was intending to speak at the South West Chicken Association's annual conference; however, the COVID-19 pandemic has meant that this event has been postponed.

As a direct result of my Nuffield Farming scholarship, I know I have a substantial amount of information to share, not only with my family business, but with the local farming community and wider poultry industry to help change the industry for the better.

Finally, and one key point above all others, the Nuffield Farming Scholarship has demonstrated to me that farming is full of people wanting to help others. There are many kind people wanting to push farming forward whilst respecting the animals in our care.

James Smaldon

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Please see Appendix A overleaf

14 Appendix A

14.1 Bird welfare definitions

The Five Freedoms have had a significant impact on animal welfare internationally, although recent research and greater understanding is now demonstrating the shortcomings within this widely used framework.

14.1.1 Five Freedoms

The *Brambell Five Freedoms* came about as a result of The Brambell Report (1965), under which animals should have: "the freedom to stand up; lie down; turn around; groom themselves; and stretch their limbs" (Brambell, 1967). The Farm Animal Welfare Council in the UK refined Brambell's concept in 1979 and came out with the revised *Five Freedoms* (Farm Animal Welfare Committee, 2009) for animal welfare. These 'five freedoms' are that animals should have:

1. **Freedom from Hunger and Thirst**: by ready access to fresh water and a diet to maintain full health and vigour.
2. **Freedom from Discomfort**: by providing an appropriate environment including shelter and a comfortable resting area.
3. **Freedom from Pain, Injury or Disease**: by prevention or rapid diagnosis and treatment.
4. **Freedom to Express Normal Behaviour**: by providing sufficient space, proper facilities and company of the animal's own kind.
5. **Freedom from Fear and Distress**: by ensuring conditions and treatment which avoid mental suffering.

Since their inception, the 'five freedoms' have become internationally recognised indicators for animal welfare; however, increases in scientific understanding of the freedoms and of animal welfare in general has shown that they do not capture the "more nuanced knowledge of […] biological processes".

14.1.2 Emotions

What do animals *feel*? Much of animal welfare science has concerned itself with an animal's ability to suffer and feel pain, and more recently their ability to experience positive emotions. David Fraser at the University of British Colombia noted that "*People use many different criteria in judging what constitutes a good life for animals and how animals ought to be treated. In recent decades, ethical concerns about the quality of life of animals have increasingly become the subject of public policy and controversy*" (Fraser, 1997). One such controversy within the poultry sector is that of the 2016 Plofkip (translated to 'exploded chicken') Campaign in the Netherlands, which resulted in all major Dutch supermarkets changing to a slower-growing broiler chicken.

In 2008, Marian Stamp Dawkins provided a succinct criterion to assess good animal welfare: "*whether the animal was healthy*" and whether it "*had what it wanted*" (Dawkins, The Science of Animal Suffering, 2008). The first criterion is obvious – if the animal is in good health this is universally accepted as an indicator for good welfare. The second criterion is equally essential; the environment and conditions provided must empirically been proven to be positive for an animal's mental wellbeing. Since animals cannot tell us what they want, this determination can be achieved through choice testing, where the animals are given two choices and are assumed to choose the option that brings them a more positive experience i.e. enhancing their welfare.

The idea that the animal should choose their environment leads to determining which natural behaviours are essential to good animal welfare. Natural behaviour is not solely responsible for good animal welfare, as there are some natural behaviours (e.g. the presence of a predator) that would bring negative welfare. Enrichments that aren't *technically* natural could be found to provide a suitable environment comparable to the animals' natural environment and provide them with the ability to express natural behaviours. A key point contended by Prof Dawkins: "We should not, therefore, base the science of animal welfare on the assumption that we understand consciousness or can decide which species are or are not conscious" (Dawkins, Animal welfare with and without consciousness, 2017).

14.1.3 Five Domains

In 2017, David Mellor proposed an alternative to the Five Freedoms; the *Five Domains*. This revised model has four physical domains – Nutrition, Environment, Behaviour and Health – as well as a fifth domain for the *mental state* of the animal. The first four domains can each affect the mental state domain both positively and negatively. For example, feeding level would be within the nutrition domain, with a lack of feeding producing the negative mental state of hunger. A complete overview of the five domains model can be found in (Mellor, Operational Details of the Five Domains Model and Its Key Applications to the Assessment and Management of Animal Welfare, 2017).

Please see chart overleaf

Physical/Functional Domains

Survival-Related Factors

Situation-Related Factors

1: Nutrition

Restrictions on:	*Opportunities to:*
Water intake	Drink enough water
Food intake	Eat enough food
Food quality	Eat a balanced diet
Food variety	Eat a variety of foods
Voluntary overeating	Eating correct quantities
Force-feeding	

2: Environment

Unavoidable/imposed conditions:	*Available conditions:*
Thermal extremes	Thermally tolerable
Unsuitable substrate	Suitable substrate
Close confinement	Space for freer movement
Atmospheric pollutants: CO_2, ammonia, dust, smoke	Fresh air
Unpleasant/strong odours	Pleasant/tolerable odours
Light: inappropriate intensity	Light intensity tolerable
Loud/otherwise unpleasant noise	Noise exposure acceptable
Environmental monotony: ambient, physical, lighting	Normal environmental variability
Unpredictable events	Predictability

3: Health

Presence of:	*Little or no:*
Disease: acute, chronic	Disease
Injury: acute, chronic: husbandry mutilations	Injury
Functional impairment: due to limb amputation; or lung, heart, vascular, kidney, neural or other problems	Functional impairment
Poisons	Poisoning
Obesity/leanness	Body condition appropriate
Poor physical fitness: muscle de-conditioning	Good fitness level

4: Behaviour

Exercise of 'agency' impeded by:	*'Agency' exercised via:*
Invariant, barren environment (ambient, physical, biotic)	Varied, novel, engaging environmental challenges
Inescapable sensory impositions	Congenial sensory inputs
Choices markedly restricted	Available engaging choices
Constraints on environment-focused activity	Free movement
	Exploration
Constraints on animal-to-animal interactive activity	Foraging/hunting
	Bonding/reaffirming bonds
	Rearing young
Limits on threat avoidance, escape or defensive activity	Playing
	Sexual activity
Limitations on sleep/rest	Using refuges, retreat, or defensive attack
	Sleep/rest sufficient

Affective Experience Domain

5: Mental State

Negative	*Positive*
Thirst	Wetting/quenching pleasures of drinking
Hunger (general)	Pleasures of different tastes/smells/textures
Hunger (salt)	Pleasure of salt taste
	Masticatory pleasures
Malnutrition malaise	Postprandial satiety
Bloated, over full	Gastrointestinal comfort
Gastrointestinal pain	

Negative	*Positive*
Forms of discomfort:	*Forms of comfort:*
Thermal: chilling, overheating	Thermal
Physical: joint pain, skin irritation	Physical
Physical: stiffness, muscle tension	
Respiratory: e.g. breathlessness	Respiratory
Olfactory	Olfactory
Auditory: impairment, pain	Auditory
Visual: glare/darkness eye strain	Visual
Malaise from unnatural constancy	Variety-related comfort

Negative	*Positive*
Breathlessness	Comfort of good health and high functional capacity
Pain: many types	
Debility, weakness	
Sickness, malaise	
Nausea	
Dizziness	
Physical exhaustion	Vitality of fitness

Negative	*Positive*
Anger, frustration	Calmness
Boredom, helplessness	Engaged, in control
Loneliness, isolation	Affectionate sociability
	Maternally rewarded
Depression	Excitation/playfulness
Sexual frustration	Sexual gratification
Anxiety, fearfulness, panic, anger	Secure/protected/confident
Neophobia	Likes novelty
Exhaustion	Energised/refreshed

Figure 24: The Five Domains model. https://www.researchgate.net/figure/The-Five-Domains-Model-modified-from-12-The-examples-provided-for-the_fig1_319020431

14.1.4 Welfare Quality Assessment Protocols

The Welfare Quality® started in 2004 and was the largest ever European research project on animal welfare. The final output of the initial Welfare Quality project was twelve areas of concern (Welfare Quality, 2009):

Table 1: Author's own representation of Table 2 within Welfare Quality (2009, October 1)

Welfare Principles	Welfare Criteria
Good heeding	1. Absence of prolonged hunger
	2. Absence of prolonged thirst
Good housing	3. Comfort around resting
	4. Thermal comfort
	5. Ease of movement
Good health	6. Absence of injuries
	7. Absence of disease
	8. Absence of pain induced by management procedures
Appropriate Behaviour	9. Expression of social behaviours
	10. Expression of other behaviours
	11. Good human-animal relationship
	12. Positive emotional state

The next step was to construct an assessment tool applicable to poultry (broiler chickens and laying hens individually), providing the ability for a welfare score to be calculated (Welfare Quality, 2009). A single welfare score can be calculated through a bottom-up approach, shown on next page:

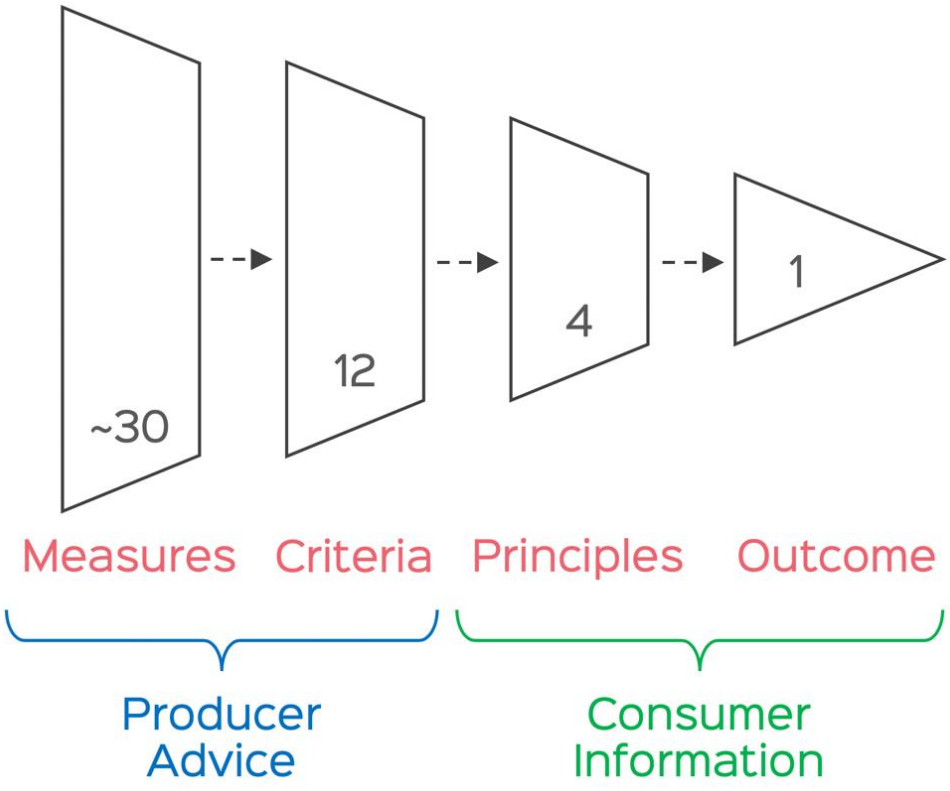

Figure 25: Use of the Welfare Quality scoring system to arrive at a single welfare score. Authors own representation of Figure 3 within Welfare Quality (2009, October 1)

It was found (Jong, 2012) that on-farm welfare scores correlated closely with slaughter plant measures such as foot pad dermatitis, hock burn and cleanliness; however, there could be no benefit to the birds' lives if welfare-outcome scores were solely used.

14.2 How can we measure bird welfare?

On poultry farms, there are several ways that we can assess the welfare of the birds in our care. Firstly – and foremostly – is the stockmanship ability of the people on the farm. Those with experience and skill are able to assess the welfare of the animal and provide immediate attention to those animals that require it. People also have empathy and care for animals, so it is often a predominant desire to provide the best environment and conditions possible for the birds.

Qualitatively measuring the welfare of animals each day is preferable to the end-of-life assessment of 'iceberg' quantitative indicators. These outcome-based welfare indicators are performed once per flock and so if there has been an issue with the welfare of the birds, it is only future flocks that will benefit from lessons learnt. However, if the quantitative welfare-outcome assessment provides a reasonable metric for on-farm welfare, then these iceberg indicators can help to build a picture of the farm and to enable comparisons to be drawn to corresponding farms.

It would be straightforward to combine the qualitative and quantitative assessments into a single welfare measurement (such as the Welfare Quality assessment protocol, outlined in the previous section); however, this also lacks the continuous oversight of the flock, or the ability to pre-emptively stop welfare issues from occurring in the first place.

The final method to measure welfare is through automated systems. These can not only provide quantitative indicators of welfare, but can also provide them at all times that animals are within our care and, as such, would allow for welfare-compromising issues to be addressed immediately, thus improving the overall welfare of the animals. The immediate issue with automated systems is that they do not care; they do not feel empathy and ignore any issues that they have not been programmed to identify.

14.3 How can we optimise bird welfare?

Once birds are within our care, we must provide them with the best treatment and attention that we can reasonably provide. Other than stockmanship, there are three other pillars which needs to be considered for any particular flock:

14.3.1 Genetics

Modern poultry breeds have been genetically selected to provide advantageous traits for their industry. Yet, this selection can bring the potential for welfare issues directly associated with the breed, regardless of the level of care provided at the farm level. For broiler breeders, the incidence of hunger is a potential welfare issue; for broilers, the growth rate has the potential to cause issue with birds' legs; and for layers, the quantity of eggs produced can increase the incidence of keel-bone damage through a lack of calcium.

14.3.2 Inputs

Provision of the best possible feed and water quality would ensure that nutrition requirements are met (given the correct level of feed is provided and water volume is available).

14.3.3 Environment

The housing design and operation is crucial to bird welfare. It is generally assumed that birds with outdoor access have a higher welfare to those indoors. The lighting, equipment layout (and setup), enrichment options and daily routine provide ways to improve the welfare of birds with minimal effort.

Please see Appendix B overleaf : Details of the final 2 visits of the author's Study Tour

15 Appendix B

Details of the final 2 visits of the author's study tour, conducted by video-conference due to the COVID-19 lockdown restrictions in Spring, 2020, are:

15.1. Hugo Jansen, Cargill Digital Services, France

When this team looked at the poultry meat sector, they saw two opportunities: the first of these is to detect walking patterns and ability by tracking animals through the shed and assessing the individual birds' homogeneity with the average of the shed. If there is low variation, the flock can be seen as being largely healthy, but if there is a high variation this could indicate issues.

The second opportunity is that of audio recording within poultry sheds. There is great interest in trying to find a way to identify and measure the 24-26 different vocalisations that chickens make. If an algorithm could be developed to measure these and analyse them, we may gain an insight into chicken behaviour that may precede that of physical issues or benefits.

When it comes to promoting better welfare, there are currently no reliable, continuous *and* independent indicators for bird welfare on farm, only at the processing plant (the *iceberg* indicators). Digital technology can work to dispel myths and conspiracies of modern poultry farming and better inform the consumer about what they are purchasing.

For the consumer, transparency will provide unemotional information and allow the consumer to choose the chicken which meets their priorities, whether these are ethical (animal welfare), environmental (lowest greenhouse gases) or economic (cost).

15.2 Kate Parkes, RSPCA

The second of my remote meetings was with Kate Parkes, Sector Manger of Pigs and Poultry at the RSPCA. Kate has recently been instrumental in the 'Eat, Sit, Suffer, Repeat' campaign, investigating the welfare outcomes of standard broilers vs. slower-growing broilers. For the RSPCA, it's not necessarily about how long an animal lives, but the quality of life the animal has whilst it's in our care.

Our conversation started by considering technology vs. people in the poultry industry. Kate expressed a keen view that technology shouldn't be replacing the skills of people that are built up through experience and should be *complementary* to those skills. Kate emphasised the benefit of early warning indicators for the stockperson, to minimise any potential drop in the welfare of the birds. She noted that this is likely to change the roles on poultry farms from manual to managed, and that the industry needs to ensure there are enough skilled stockpeople with softer skills to help train others.

We also considered how consumers view poultry production. She noted that people like the idea of *Old MacDonald* chickens, running around the farmyard, and to shift this perception is a massive challenge. Most technology for poultry farms would only widen this perception chasm. Qualitative

welfare scoring might actually create confusion for consumers, as a well-managed standard bird may have a welfare score higher than a badly-managed 'higher welfare' bird. It would get tricky and may need assurance to set minimum welfare scores along a scale, rather than providing individual bird welfare scores at the supermarket.

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