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EDITORIAL

Bringing livestock back into the fold: Animal research in the *Annals of Applied Biology* - past, present and future

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In a 2019 editorial the journal's previous Editor-in-Chief, the late Professor Simon Leather, announced my appointment as a new Senior Editor responsible for farm animal health and welfare, a subject area which had not featured significantly in the *Annals of Applied Biology* for many years (Leather, 2019). Despite this hiatus in the publishing of applied livestock research in the journal, a look into the archives demonstrates that animals were by no means ignored in the journal's past, but apparently fell out of favour over time, with a plant and crop-based focus predominating.

In this editorial I briefly review the coverage of farm livestock and other vertebrates of interest to agriculture and food production in the journal stretching back to its beginnings more than a century ago, and then comment on how these debates around health and welfare challenges from history continue today. Some of these challenges and opportunities will be discussed later, but the editorial begins by reviewing production animal coverage in the journal's past, both terrestrial and aquatic, while not ignoring some wildlife species that have also featured because of their impacts on agricultural productivity.

The past

The first issue of the *Annals of Applied Biology* in 1914 featured an article on agricultural zoology, where Professor F.W. Gamble highlighted the increasing interest in the application of the subject to actual practice, with special reference to helminthology in relation to animals (Gamble, 1914). Commercial fishing and parasites were also featured early in the journal's history, when Williamson (1919) discussed the distribution and appearance of parasite-infested haddock and cod landed in Scottish ports.

Fish appeared sporadically in the journal in succeeding years, and various aspects of fish biology and pathobiology were covered, particularly the harmful effects of toxins and pollutants, although not specifically in the context of commercial production (e.g. Carpenter, 1925; Lloyd, 1960; Rushton, 1922). Pentelow (1964) provided a commentary on a freshwater fisheries research symposium, and compared the small but growing significance of freshwater fisheries as a food resource in Britain at the time (salmon, eel and trout) to its much greater importance across Africa, Asia and the Americas.

Parasites affecting livestock and causing productivity loss and disease became something of a focal point for the papers published in the journal from the 1920s onwards. Jenkins (1923) described the discovery and study of *Moniezia* tapeworms from the small intestines of sheep killed at an abattoir in Wales, and a subsequent paper made observations on the life history of the parasite (Jenkins, 1924). A series of papers in the 1930s and 1940s then focussed on the sheep blowfly, and efforts to control this important external parasite affecting the welfare of sheep (Angus, Thomas & Williams, 1943; Davies, 1934; Hobson, 1935, 1937, 1941). The disease-causing tick *Ixodes Ricinus* ('castor bean tick') and its impact on ruminants, particularly sheep, was the subject of papers in the 1940s, with a particular focus on sheep dipping in arsenic solutions as a control method (MacLeod, 1947; Milne, 1943, 1945). Continuing on a tick theme, in more recent decades Gray and Lohan (1982) described a field sampling method for *Ixodes ricinus* in the context of better understanding the epidemiology of babesiosis (redwater fever) in cattle in Ireland, one of the diseases that this species of tick transmits to livestock.

Veterinary entomology was the subject of a review paper by Beesley in 1964, where arthropods of veterinary importance in Britain were summarised and a range of hosts considered, and mention was made of blowflies, ticks, lice, mites and warble flies affecting variously sheep, cattle, pigs and poultry according to the species of arthropod (Beesley, 1964). This review paper followed on from a narrower focus on the effects of three organophosphate insecticides used to kill arthropods infesting livestock, and the paper noted the toxic side-effects which were possible in mammals (Beesley, 1963). Mammalian pest control was considered when Phillips (1955) compared field methods of rabbit control on a 300-acre farm in Wales, and Houston (1978) investigated the motivations of hooded

crow attacks on young lambs, suggesting that crows only attacked weak lambs or those that were already dead rather than targeting the healthy, fit ones.

Early discoveries and scientific opinions on viral diseases of animals were reviewed by Arkwright (1923). The paper reported that around 48-50 animal viruses were on record at that time. A "virus disease" was defined by Arkwright as 'an infective disease which can be transmitted experimentally, though it is not due to any known protozoon, spirochaete or ordinary bacterium, but can be transmitted by a liquid containing only very minute particles'. Notable viral diseases of livestock which the paper covered were foot and mouth, rinderpest, swine fever and influenza. Arkwright, before the development of powerful microscopy and advanced laboratory isolation techniques and deeper epidemiological understanding, correctly identified: the high transmissibility of some viruses; the presence of a carrier state for diseases such as foot and mouth; the importance of insect vectors for certain viral diseases; and the importance of isolation and destruction of infected animals for disease control. The high transmissibility potential of an animal virus was typified in the first British myxomatosis outbreak in wild rabbits described by Armour and Thompson (1955). The paper reported how this novel disease was first confirmed in October 1953 and subsequently spread over a very wide area, despite intensive control efforts seeking to limit the spread. The authors correctly postulated that the rabbit flea (*Spilopsyllus cuniculi*) was a vector for the disease in rabbits.

Applied livestock nutrition has not featured much in the journal over the decades. Hammond (1945) briefly overviewed the relationship between the genetic make-up of animals and their associated pests and diseases, and also linked in the importance of nutritional status using the example of dairy cows and their lowered resistance to disease when fed on deficient diets. A review by Campling (1977) of the feeding value maize for pigs, cattle and sheep, suggested an increased risk of metabolic diseases such as ketosis and displaced abomasums in dairy cattle when there was an over-reliance on maize silage in the ration.

In what could be classified in the 'miscellaneous' category, the genetic improvement of sheep through selective breeding was the theme of Crew's paper on fleece quality in certain wild and primitive breeds of sheep in Scotland (Crew, 1921). Measurements were made of hair and wool fibres and microscopy photographs presented from the various species with a

view to comparing to domestic breeds. Finally, returning to the theme of blowflies to conclude our review of the past, in a quirky aside from the same year's journal volume R.A. Wardle from the University of Manchester (Wardle, 1921) looked at a later stage of the food supply chain, and considered the frustrating problem of how to prevent the flies from contaminating meat products in butchers' shops and fishmongers!

The present

Since the relaunch of applied farm animal health and welfare research in the journal in 2019, a number of papers have been published covering a range of themes. Łagowski et al. (2020) presented evidence from laboratory genotyping methods to demonstrate how the routine administration of a commercial vaccine against the dermatophyte *Trichophyton verrucosum* to calves resulted in clinical cases of dermatophytosis (ringworm) on a number of farms in Poland. This phenomenon had previously been described in the scientific literature, but rarely. The results of the laboratory analysis revealed that dermatophytes isolated from the skin lesions on the vaccinated cattle had an identical electrophoretic profile with the vaccine strain and different from the reference strain of *Trichophyton verrucosum,* showing that the vaccine was causing clinical disease in a small percentage of vaccinated animals.

Animal nutrition science has featured in three papers also published recently. Shirmohammadi et al. (2020) tested the effects of three different heating methods - roasting, microwave irradiation and steam flaking – compared to no processing on the ruminal and post-ruminal nutrient degradability and starch granule morphology of barley grains (*Hordeum vulgare*). They found that heat processing can enhance both the ruminal and post-ruminal utilisation efficiency of barley as a ruminant feed source, resulting in a higher total tract digestibility. Field emission scanning electron microscopy (FESEM) images provided visualisation of the effects on the surface of starch granules resulting from the various treatments, and the subsequent attachment of ruminal microbial colonies.

A unique and highly significant review paper by Woodgate and Wilkinson (2021) describes the animal by-product rendering systems which were poorly understood until research became vitally important in the aftermath of the bovine spongiform encephalopathy (BSE) epidemic beginning from the mid-1980s in the United Kingdom (UK). The disease and its

control became an issue of global significance for both animal and human health, and the key process parameters of rendering systems needed to be investigated and fully elucidated to guide future European Union legislation on the inactivation of transmissible spongiform encephalopathies (TSE). Providing a fascinating historical overview of the rendering industry, the use of meat and bone meal in animal feeds, and the emergence of BSE as a clinical entity, the paper then goes on to describe the subsequent investigation and refinement of rendering system processes and TSE inactivation trials. The paper also traces the legislative and policy developments right through from the early years of the BSE crisis to the present, and considers the future market for modern processed animal proteins (PAPs) in animal feeds.

Finally, Saati-Santamaría et al. (2022), seeking to further understanding of chicken gut microbiota-host interactions, conducted a study to analyse the bacteria contained within the faecal microbiota of medium-slow growing Redbro chickens in the first 4 weeks after hatching. They demonstrated that the diverse microbiota found in the excreta did not vary significantly over this early life period, but the genus *Lactobacillus* predominated, followed by *Clostridiales* and *Bacteroidales.* The authors hypothesised that *Lactobacillus* present could be largely controlling fructose and mannose metabolism.

The future

It is important to understand the past to contextualise both the present and the future, and it is to the future that I now turn my attention. Papers featuring livestock have already been published again in the journal after a long hiatus, but given the breadth and depth of vitally important subjects within applied farm animal health and welfare, there is room for significant expansion in the output of high-quality papers with global appeal. With a rapidly increasing global human population, there is a need to produce food in greater quantities and more efficiently, but always sustainably from limited and competing resources. Livestock agriculture is a crucially important part of the global supply chain feeding the world's human population (Eisler et al., 2014), but there are ongoing challenges to be faced and overcome in livestock production while ensuring food security, resilience and public health (Anon, 2013; FAO, 2009; Thornton, 2010). Despite the challenges, there are also opportunities, and applied scientific research is needed to harness these opportunities to do

things differently - more efficiently and sustainably - while influencing agricultural policy making to initiate and enact change (Gill, Garnsworthy & Wilkinson, 2021).

Reflecting on the papers from the archives of *Annals of Applied Biology*, the issues dealt with decades ago still have resonance today. Obviously our knowledge and understanding of these issues has expanded, sometimes exponentially, but the challenges caused by animal disease and infestation and compromised health and welfare continue. For example, parasites and their impact on animal health and food security remain as salient in the 21st century as they were in the 20th, further complicated by the increasing development of parasite resistance to therapeutic veterinary pharmaceutical products, particularly anthelmintics (Ahuir-Baraja et al., 2021). This increasing resistance problem hinders our ability to treat livestock to kill the external and internal parasites causing health and welfare problems, and makes applied research and new husbandry methods and technologies as relevant as ever (Fitzpatrick, 2013). Veterinary entomology, situated at the nexus of animal, human and environmental health, remains a highly important subject (Mullens et al., 2018). Illustrating this triad of interactions, while MacLeod (1947) reported almost complete agreement globally that arsenic solutions were regarded as the most effective tick-killing substance of the time, it is notable that subsequent discovery and classification of arsenic as a Group-A human carcinogen has highlighted a significant environmental and public health challenge due to heavily contaminated soils and groundwater sources around historical livestock dipping vat sites (Sarkar et al., 2007). As with parasite control, similar resistance challenges exist and are increasing for antimicrobials in the treatment of bacterial infections with implications for animal and human health (Magouras et al., 2017), meaning that increasing research and field efforts are being expended to improve animal health and welfare while improving antimicrobial stewardship on farms through optimal use (Gozdzielewska et al., 2020). Understanding the role of the 'people factors' affecting animal disease control and animal welfare is increasingly important if change is to be enabled (Redfern, Sinclair & Robinson, 2021; Robinson & Epperson, 2018).

Continuing with the theme of animal health, the viral epizootic diseases reviewed by Arkwright (1923) remain a significant global problem today, apart from rinderpest, which was declared eradicated in 2011 (Roeder, Mariner & Kock, 2013). Avian influenza continues to infect wild and domesticated poultry across the world, providing a significant human

health challenge as well as producing animal health and economic consequences (Peacock et al., 2019). Over the last 10-15 years African swine fever has become a notable epizootic disease in European and Asian domesticated and wild pig populations, and research into the disease continues to expand (Dixon, Sun, & Roberts, 2019).

Although applied livestock nutrition research has rarely featured in the journal over the years, the importance of this subject area increases with the ongoing drive towards better economic, environmental and public health outcomes from livestock agriculture (Eisler et al., 2014; Hatcher et al., 2021). Particularly interesting here is the growing attention being paid to the gastrointestinal microbiome and its role in nutrition and health (Kogut & Arsenault, 2016; Pajarillo et al., 2021). Animal genetics, or 'constitution' to adapt Hammond's concept (Hammond, 1945), are also important in the context of production efficiency, disease and animal welfare. The feasibility of selectively breeding livestock and fish for host resistance to disease, and therefore reduced susceptibility, is showing exciting potential (e.g. Tsairidou et al., 2019), but there is room for expansion of this field into new areas focussing at the population level and aiming to solve problems which require holistic solutions (Doeschl-Wilson et al., 2021; Rosendal & Olesen, 2022).

Last, but not least, applied animal welfare and behaviour research have an important place in this global debate around the sustainability of livestock and food production. Animal welfare did not have the same focus or attention paid to it through the history of this journal as it does today, but it most certainly has a place in its future. Fascinating developments and discoveries are being made across all livestock species involved in domestic agriculture and across the stages of the supply chain (e.g. Charlton & Rutter, 2017; Dawkins et al., 2021; Grosse-Kleimann et al, 2021). Much more remains to be revealed as efforts continue to understand animal behaviour and improve animal wellbeing, with higher welfare and precision livestock approaches to farming continually being developed which are better for animals, but also can future-proof the viability of livestock farming (Eastwood, Edwards & Turner, 2021; Gómez et al., 2021; Mota-Rojas et al., 2020; Vaintrub et al., 2021).

As a Senior Editor, I welcome quality submissions demonstrating applied farm animal research across all of these areas, bringing livestock back into the *Annals* fold in the 21st century; building upon the animal publications of more than one hundred years of history, but very much focussed on the future.

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