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Animal Frontiers is published quarterly by the American Society of Animal Science (ASAS), Canadian Society of Animal Science (CSAS), the European Federation of Animal Science (EAAP), and the American Meat Science Association (AMSA). This magazine synthesizes information, through applied reviews, from across disciplines within the animal sciences. Animal Frontiers is provided as a benefit to the members of these societies. The digital version of this magazine is online at www.animalsciencepublications.org/publications/af.
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Introduction

ASAS celebrates 10 years of publishing Animal Frontiers: The Review Magazine of Animal Agriculture

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In July 2011, the first issue of Animal Frontiers was published by an international consortium including the American Society of Animal Science (ASAS), the Canadian Society of Animal Science (CSAS), and the European Federation of Animal Science (EAAP). Development of an international, science-based, open access journal that provided review articles and global perspectives on the complex dynamics associated with the production of animal-sourced foods was an accomplishment in and of itself, but the ability to meet the needs of a diverse community of readers, including scientists, policy makers, educators, and the general public set Animal Frontiers apart from other journals. In 2012, the American Meat Science Society (AMSA) joined the consortium and added a valuable perspective regarding muscle-based meat products and the meat science industry. To keep the journal going (and growing) and maintaining its primary objectives across three publishers, three editors-in-chief, and an increasing number of competing journals, including numerous predatory journals, adds another level of success to the 10-year history of Animal Frontiers!

The first issue of Animal Frontiers was titled “Fork to Farm: The Carbon Footprint” and contained six, peer-reviewed articles addressing the carbon footprint associated with the production of animal-sourced foods (Zinn, 2011). With the completion of volume 10, Animal Frontiers will have published more than 300 articles focused on timely and sometimes controversial topics such as farm animal welfare, use of new technologies, genomics, emerging diseases, global food security, alternative sources of animal-based protein, land use challenges, precision livestock farming, consumer acceptance, the challenge of communicating animal sciences effectively, antimicrobial resistance, meat safety, climate change, reducing the impact of animal production on the water supply, and ethics. Each issue leverages the global scientific community providing a valuable resource. To take advantage of this resource, ASAS conducts a Snack and Fact briefing and distributes hard copies of each issue of Animal Frontiers to Congressional offices in Washington, DC. Issues of Animal Frontiers are also used as required reading in undergraduate and graduate animal science courses in Animal Science Departments throughout the United States. And, many issues of Animal Frontiers provide information for quiz bowl competitions such as the Academic Quadrathlon held at regional ASAS meetings and at the national ASAS-CSAS annual meeting.

In 2019, Animal Frontiers received its first impact factor of 1.984—not a bad start! According to data from Oxford University Press, content engagement (e.g., online views of Animal Frontiers papers) increased more than 4-fold in 2019 compared with 2018 and several articles achieved more than 10,000 downloads and Alt Metric scores above 100. While these are excellent quantitative measures of the success of Animal Frontiers, the future success of the journal will rely on the best scientists from around the world contributing their best work to ensure consumer acceptance, legislation that supports animal production, and an educated workforce willing to supply safe, affordable, and healthy animal-sourced foods to meet the nutritional needs and increased global demand for animal protein.

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Steven A. Zinn was the founding editor-in-chief of Animal Frontiers.

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From the Editor

The future of animal science departments

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“Education is our passport to the future, for tomorrow belongs only to the people who prepare for it today.”

Malcolm X

This issue of Animal Frontiers is envisioned to be a reflection on the future of animal or veterinary science departments in institutions of higher education. The challenges associated with funding for animal research, the maintenance of research and teaching infrastructure, finding and training qualified students for future careers, and educating administrators about the costs and challenges associated with animal research and teaching programs are known across the world. How animal science departments address these issues and others will determine the future. The exercise of imagining the future is critical to shaping it and this issue of Animal Frontiers (Figure 1) encompasses the thoughts about the future from around the world.

Klaus Schwab (2015) first introduced the term the “Fourth Industrial Revolution” to describe the current technological revolution that encompasses the developments in artificial intelligence, biotechnology, genomics, robotics, and other revolutionizing technologies (Schwab, 2015). In 2016, the World Economic Forum (WEF) published a Global Insight Report entitled “The Future of Jobs: Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution.” This publication detailed that the workforce in the technological revolution will need skills including enhanced cognitive abilities (logical reasoning, creativity, and cognitive flexibility) and complex problem-solving skills (critical thinking and decision-making). Social skills (people management, emotional intelligence, and service orientation) and content and process skills were also identified as critical. Other recommendations were to redesign disciplinary education to merge training of the humanities and sciences and create people who are capable of multidisciplinary thinking.

This change in emphasis would improve training in critical thinking and problem solving and allow for continual renewal of the workforce’s skills (Schwab and Samans, 2016). These thoughts are echoed by Dr Stephen Gavazzi (Gravazzi, 2020) who challenges land grant universities in the United States to return to the founding land grant principles and to recognize the importance of a community-based mission for the 21st century. His ideas provide an excellent foundation for articles from Argentina, China, Italy, and South Africa that describe the future of animal science research and teaching programs in these countries.

Workforce training is discussed in the article by Dr Gustavo Jaurena and Dr Maria Boveri (Jaurena and Boveri, 2020) from Argentina. They highlight the need for the incorporation of multidisciplinary training and thinking in the animal sciences curriculum and describe opportunities to embrace technology in information transfer in outreach and teaching. Ruien Grobler and her colleagues (Grobler et al., 2020) describe the dynamic animal sciences programs in South Africa and identify the need for flexibility and embracing technologies in training future animal scientists. The impact of COVID-19 and the need to embrace technology has reinforced the points made by Grobler et al. (2020). Faculty across the world have been forced to learn and incorporate online teaching with only a few days or weeks to prepare. A perspective from some faculty experiencing this rapid, radical change identifies some ideas and challenges for the future is included (Radcliffe et al., 2020). Much has been learned from the COVID-19 pandemic that will be useful and could revolutionize how information is shared: potentially meeting some of the foundational principles Gavazzi (2020) discusses.

The WEF publication (2016) also suggests public-private and cross industry partnerships as change agents and mechanisms by which the talent pool could be increased (Schwab and Samans, 2016). These same themes are found in this issue from contributions across the world. Baldi et al. (2020) describes the growing importance of public-private relationships in research and training in Italy. Animal science research and teaching is also becoming enriched by public-private partnerships in China. Dr. Jingdong Yin and Dr. Zhengpeng Zhu (Yin and Zhu, 2020) highlight the need for these relationships to ensure students are well-trained for the developing, high demand careers in China which require critical thinking skills and multidisciplinary approaches to animal production. As new methods for teaching are developed and used to meet the needs and careers of the future, animal and veterinary sciences must insure the effectiveness of the educational program offered. Accreditation is one way in which animal science programs can identify and address their strengths and weaknesses and assure a common set of learning goals are obtained. One such
program is described by Benson et al. (2020). The principles described in this article provide a process for accreditation of animal science programs.

The similarity of challenges and needs for animal and veterinary training programs identified by the authors in this issue is both striking and comforting. Sharing ideas, successes, failures and preparations for the future such as those in this issue is critical. The talent, creativity and dedication across the global animal science community makes the future of animal science departments bright.

In the middle of preparing this issue of Animal Frontiers for publication, the SARS-Cov-2 virus made many issues for the future take a back seat to other compelling challenges faced by the authors. A primary challenge included moving face-to-face teaching and outreach to on-line platforms immediately, research programs were temporarily curtailed or downsized and people remained in their homes. We are very grateful to the authors who persevered in the submission and review of these articles despite the personal and professional difficulties they faced in their countries and in their personal lives.

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Figure 1. The future of animal science departments.

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Introduction

The year 2012 marked the sesquicentennial celebration of the Morrill Act of 1862 (Figure 1), the congressional action—signed by President Abraham Lincoln amidst the American Civil War—the gave rise to our nation’s land-grant universities. Coupled with two subsequent acts of the U.S. Congress—the Hatch Act of 1877 and the Smith-Lever Act of 1914 (Figure 2)—land-grant universities were assigned a tripartite mission by the federal government: to teach, to conduct research, and to provide service to communities. In the years that were to follow, this three-part mission produced astounding numbers of college graduates, inventions, and discoveries. Land-grant universities wishing to assert the benefits of a college degree must become more efficient, increase teaching excellence, engage with community stakeholders, conduct research that matters, describe how activities impact local needs, and refocus on affordability and accessibility. Additional public investment in animal science research, teaching, and extension activities are urgently needed. Animal scientists should consider how connected they are to the mission of land-grant universities that speaks directly to the 21st century needs of its partners and stakeholders.

Key words: animal science, funding, land-grant universities, research, teaching

Implications

- The tripartite mission of land-grant universities (research, teaching, and extension) continues to produce astounding numbers of college graduates, inventions, and discoveries.
- Land-grant universities wishing to assert the benefits of a college degree must become more efficient, increase teaching excellence, engage with community stakeholders, conduct research that matters, describe how activities impact local needs, and refocus on affordability and accessibility.
- Additional public investment in animal science research, teaching, and extension activities are urgently needed.
- Animal scientists should consider how connected they are to the mission of land-grant universities that speaks directly to the 21st century needs of its partners and stakeholders.

The Land-Grant University Mission of the 21st Century

In 2018, Gavazzi and Gee published Land-Grant Universities for the Future: Higher Education for the Public Good, a book that reported on interviews conducted with 27 presidents and chancellors of America’s public land-grant institutions. These senior administrators were asked to comment on the strengths, weaknesses, opportunities, and threats facing land-grant universities in the 21st century. Analysis of the qualitative data gleaned from the interviews resulted in the development of
seven themes that told a story about the dynamic tensions being faced by the leaders of these public universities, portrayed in dialectical fashion as follows:

1. Concerns about funding declines vs. the need to create efficiencies
2. Research prowess vs. teaching and service excellence
3. Knowledge for knowledge’s sake vs. a more applied focus
4. The focus on rankings vs. an emphasis on access and affordability
5. Meeting the needs of rural communities vs. the needs of a more urbanized America
6. Global reach vs. closer-to-home impact
7. The benefits of higher education vs. the devaluation of a college diploma

In addition to connecting these seven themes to the tripartite mission (teaching, research, and engagement) of the land-grant university, Gavazzi and Gee (2018) borrowed extensively from Robert Greenleaf’s (1970) discourse on servant leadership in order to introduce the concept of the “servant university.” Here, the authors strongly asserted the idea that public institutions of higher learning must place primary emphasis on the stewardship responsibilities they have been given by society to provide for the development and well-being of its communities. Here, the original agreement struck between the public and its colleges and universities—described invariably as a covenant—meant that critical decisions made at all levels of leadership should be filtered first through the lens of what provides maximum benefit for the citizens of each state and for American society at large. Better resemblance to the servant university profile, then, was asserted to be the defining path toward the creation and enactment of a 21st century land-grant mission.

**A Burning Platform for Land-Grant Universities**

In 2011, then Nokia CEO Stephen Elop sent to his employees what has come to be known as his “burning platform” memo (Anthony, 2012). In this communication, Elop recounted the story of a North Sea oil worker who found himself quite literally on an offshore oil platform that was on fire. Faced with almost certain death had he stayed in place, he decided to jump from the platform and into the cold Atlantic waters. Elop wrote that “the man survived the fall and the waters. After he was rescued, he noted that a ‘burning platform’ caused a radical change in his behaviour.”

Here, we see a CEO signaling that his company was ablaze with challenges that required a course of action on the part of his employees that went far beyond what would be considered typical and usual. So, one must ask, are land-grant universities similarly standing on a burning platform at this moment in history? Gavazzi and Gee (2018) would have us believe so, pointing to a growing number of surveys that indicate our country’s citizens increasingly are skeptical about the importance of attending an institution of higher learning (Pew Research Center, 2017; Jaschik, 2019).

In response to this decided decline in public support, Gavazzi and Gee (2018) outlined a clear roadmap—discussed as a “formula for success”—that was designed to increase the public’s appreciation for the return on investment these higher learning institutions offered toward the public good. Nothing else would matter, these authors contended, unless land-grant universities reclaimed their mantle as the “people’s universities.” To do this, these public institutions of higher learning would have to “pick a side” in terms of the seven dialectical themes discussed above. As a result, universities wishing to assert the benefits of a college degree would have to become more efficient, cultivate increased teaching excellence, better engage with community stakeholders, conduct research that mattered, clarify how their university’s activities impacted the needs of local citizens (even amidst internationally based efforts), and
refocus attention on being more affordable and accessible instead of worrying about national rankings.

**A Burning Platform for Animal Science?**

This essay closes with a question: If animal scientists took a good look around right now, would they come to find themselves standing on a burning platform as well? Even a cursory examination of the goals and objectives related to the Innovate 2012 initiative would seem to provide at least some clues to that effect. Perhaps more substantially, the call made by Benson and colleagues (2013) regarding the need for reinvigoration of public investment in agricultural research and development speaks even more directly to an awareness that all...
is not right in animal science land at present. If this indeed is the case, then perhaps members of the field would do well to consider how connected they are to a land-grant mission that speaks directly to the 21st century needs of its partners and stakeholders.
Feature Article

Training the next generation of animal scientists for South Africa

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Implications

• There is a lack of interest in agriculture among the South African youth and agriculture is usually not considered as a career of first choice.
• An increased proportion of black and female students enter the higher education system in South Africa.
• The majority of students come from a nonfarming background with very limited or no previous exposure to agriculture.
• Training of undergraduate students needs to be adjusted to reflect the future demands of the animal science industry without resulting in “academic drift”.
• Future animal sciences programs will see greater incorporation of computer skills and data sciences at an earlier level.

Key words: agriculture, animal science, careers, higher education

Introduction

It is estimated that the world’s population could grow to 9.7 billion people by 2050, with the largest population increase expected in Africa (United Nations Department of Economic and Social Affairs, Population Division, 2019). This population growth will go hand in hand with a parallel increase in nutritional demands, specifically for animal protein. The onus will largely rest on agriculture, and especially livestock production, to meet this increased demand. Agriculture is a major contributor to the South African economy, with animal products contributing 49.2% to the total gross value of agricultural production (Department of Agriculture, Forestry and Fisheries [DAFF], 2019).

In South Africa, agriculture is also a significant provider of employment, especially in the rural areas of the country. The agricultural sector delivers more jobs per Rand invested than any other primary production sector (DAFF, 2016) and plays a critical role in rural poverty alleviation and food security. Furthermore, the agricultural industry in South Africa consists of a combination of medium- and large-scale commercial operations, which produces the majority of the country’s agricultural produce, and smallholder farmers, which are the main source of livelihoods in remote rural areas.

The National Development Plan of South Africa identified agriculture as one of the main drivers for the economy with the potential for job creation and development of rural communities. To bridge the skills gap in the agricultural sector and to promote rural development, the DAFF introduced the External Bursary Scheme in 2004. The DAFF bursary scheme is further used to contribute toward economic growth and job creation and to increase the number of skilled technicians, professionals, scientists, and researchers in the agricultural sector.

Current Situation in South Africa

There is a lack of interest in agriculture amongst the youth of South Africa and, generally, agriculture is not considered as a career of first choice (Terblanché, 2006; Academy of Science of South Africa [ASSAF], 2017). The perception among youth is that agriculture consists of hard labor with low income and with limited space for career advancement (DAFF, 2015).

Within higher education, there are more attractive high-profile study disciplines with ample career options, such as accounting and medicine. There is, however, limited awareness or understanding of the multiple and diverse career opportunities that exist in the agricultural sector, especially alongside the entire market value chain (DAFF, 2015; ASSAF, 2017).

In the past, the majority of students that enrolled for agricultural degrees came from farming backgrounds, with the aim of pursuing a career as a farmer. The majority of these students were also male, while a small number of students were...
female and from urban areas. Since 1994, the demographic profile of students studying agriculture shifted, with increased proportions of black and female students entering tertiary education. An increase in the number of students enrolled in undergraduate and postgraduate degrees at higher education institutions was also seen (Department of Higher Education and Training, 2019). The shift in student demographics and increased enrollments can primarily be attributed to increased access to tertiary education due to government funding, primarily toward the National Student Financial Aid Scheme (NSFAS) and DAFF bursary schemes, as well as the implementation of broad-based black economic empowerment within South Africa, thus creating more job opportunities for black graduates, especially in the public sector.

NSFAS provides loans and bursaries at all public universities to eligible students from poor and working-class families to enable access to higher education and training. The DAFF bursaries enable young people from poverty-stricken rural communities with excellent academic achievement to further their studies in one of the identified scarce skills in agriculture, forestry, and fisheries. Subsequently, the number of students, females included, pursuing agricultural degrees increased. It is, however, debatable if the DAFF bursary scheme initiative is successful in uplifting the candidates from rural communities since the majority of students studying agriculture currently come from an urban, nonfarming background with very limited or no previous exposure to agriculture and farm animals.

Implementation of the Skills Development Act (Act 27/1998) in support of the South African Qualifications Authority Act (SAQA Act 58/1995) provides an institutional framework to devise and implement national, sector, and workplace strategies for learnerships that can lead to recognized occupational qualifications. The purpose of these acts is to provide a platform where the skills of the workforce can be improved and to ensure that critical, scarce skills, especially those needed in the agriculture industry, are addressed in a timely manner. The implementation of AGRI-SETA bursaries whereby agriculture producers (primary and secondary) can be subsidized with funding from the government for the employment and further in-service training of agriculture graduates is one of the results of the Skills Development Act.

In South Africa, the majority of agricultural training is provided by universities of technology, private colleges, and Technikons, who offer degrees in various disciplines related to livestock and crop production. These institutions emphasize vocational training for management, community development, and extension services, which reflects in the degree programs offered. These degree programs are orientated toward Bachelor of Agriculture (BAgric) and Bachelor of Technology (BTech) degrees focusing on animal production, farm management, land reform, and food security. These degree programs are viewed as terminal degrees and will not be discussed further.

In South Africa, there are eight universities offering agricultural degrees specializing in animal science from a first-degree level, with the majority of universities also offering Masters and PhD qualifications (Table 1). The structuring of animal science degree programs in science-focused faculties within universities has resulted in an increased focus on science and research, both during undergraduate and postgraduate training (ASSAF, 2017). Animal science degrees presented at first-degree level include a 3-year Bachelor of Science (BSc) degree and a 4-year Bachelor of Science in Agriculture (BSc Agric) degree, both with specialization in animal science (Table 1). These universities focus primarily on training animal scientists for the commercial livestock industry.

### Animal Science Curriculum

The BSc and BSc Agric degrees start to build the scientific knowledge of students at a first-year level and, usually, all BSc students have a similar curriculum based on science-related modules. These modules include physics, chemistry, biochemistry, molecular biology, genetics, and mathematics or statistics. At first-year level, an introductory module to animal science is presented, with more specific subject-related modules only presented from second-year level. At second-year level, students are introduced to animal production systems with specific focus on monogastric and ruminant species. During the third and fourth year of study (BSc Agric degrees), modules are presented to facilitate knowledge and understanding of the scientific principles of animal science. These modules include specialized and applied subject matter related to animal physiology, nutrition, genetics, breeding, and management of livestock species. The curriculum is also structured to incorporate the entire value chain of livestock production systems and to be in line with the demands from the livestock industry. At the undergraduate level, training primarily

| University         | 3-year BSc | 4-year BSc Agric | BSc Honors | MSc Animal Science | PhD Animal Science |
|--------------------|------------|------------------|------------|--------------------|--------------------|
| Fort Hare          | X          |                  | X          | X                  | X                  |
| Free State         |            | X                | X          |                    |                    |
| KwaZulu-Natal      |            | X                |            |                    |                    |
| Limpopo            | X          | X                | X          |                    |                    |
| Pretoria           | X          | X                |            |                    |                    |
| Stellenbosch       |            | X                |            |                    |                    |
| Venda              | X          |                  |            |                    |                    |
| Zululand           | X          |                  |            |                    |                    |

BSc, Bachelor of Science; BSc Agric, Bachelor of Science in Agriculture.
focuses on ensuring that students obtain critical thinking skills and practical knowledge that they will be able to apply in the workplace. Practical training sessions involving livestock start at a second-year level and mainly entail species and discipline-specific lectures and sessions (Figure 1).

Universities presenting animal science programs mainly use experimental farms for both practical training and research purposes. The University of Venda, for example, has a feedlot, piggery, and both broiler and layer production units for practical demonstrations and research. Although there has always been cyclic opening and closing of different production units on university experimental farms, there is a general downward trend in the diversity of permanent production units and animal numbers, despite increasing student numbers. Cyclic variation in production units is mainly according to research interests at the time, while the downward trend is the result of excessive running costs and the lack of human capital to manage large production units. Many experimental farms are, therefore, effectively moving away from keeping permanent large herds/flocks on the farm. Instead, animals are often acquired for specific research and training purposes whereupon completion of the project/course the animals are marketed to avoid the costs of maintaining large herds/flocks over time.

Collaboration with industry in research and training is becoming more important and has the advantage of not only limiting the costs of training animal science students but also has the potential of bridging the gap between science and industry. An example of such collaboration that is underway is the joint venture between the University of Pretoria and the Animal Feed Manufacturers Association (AFMA) in building a feed mill for research and training purposes. The day-to-day operations of the feed mill will be run commercially, while training will involve specific courses regarding feed mill management and hosting training sessions for BSc Agric graduates from other universities, as well as a research focus in collaboration with universities and the formal feed industry. Alternative options used to alleviate the costs of experimental farms are the use of well-managed private farms, as well as farms under government control. While the latter is less expensive, it is more limited in availability. The Outeniqua research farm under the management of the Western Cape Government is an important example of a government farm that is often used by universities like Stellenbosch for research and training.

Students benefit by participating in practical training with live animals, especially for anatomy and physiology modules. However, the availability of cows is limited by the large number of students and the number of practical sessions required to master the required skills, as well as ethical and welfare constraints. A recommended alternative to using live animals and slaughtering animals for dissections is to use model animals or organs (Figure 2 and 3). Added advantages from implementing this alternative are increased animal welfare and the health and safety of both animals and students. Different types of animal simulators and models are currently available. “Breed n Betsy” was developed as an education tool for practical teaching of the internal reproduction anatomy of a cow, as well as allowing students to practice skills that are used in pregnancy testing, artificial insemination, and embryo transfer. Some models work on the basis of virtual reality where a student can sense the feel of a rectal palpation. A study by Bossaert et al. (2009) suggested that “Breed n Betsy” cannot fully replace training in live cows but may be valuable to the classical teaching method by accompanying practical training on live cows.

Synthetic organs that are life-like, dry, and durable specimens allow students access to competently prepared and long-lasting study material (Figure 3). These synthetic organs are used to improve the quality of teaching and learning anatomy and are especially useful for anatomical regions or organs that are difficult to dissect and/or visualized. The synthetic specimens can either be used with no wet dissection of a specific organ or it can be used as supplemental study material before dissecting actual organs or animals. Many studies recommend using these organs in conjunction with wet dissections for teaching anatomy (Latorre et al., 2007).

Use of computer software programs to formulate diets and model animal production performance efficiency are some of

Figure 1. Practical training of students at the undergraduate level on (A) pig production systems and (B) wool quality and classification.
the most useful tools for training animal science students. While the training of undergraduate students in animal nutrition is less dependent on physical resource capabilities, limitations in the numerical and biochemical skills of students hamper the proper integration of theoretical and practical knowledge in the utilization of software programs. Furthermore, limitations in terms of laboratory space for chemical analysis training of undergraduate students could be partly overcome by the use of near-infrared spectroscopy (NIRS) as a method of feed analysis. The traditional training method of postgraduate students in animal nutrition has become expensive from a financial and time-consuming point of view but is also very challenging from an ethical stance. While the substitution of live animals with alternative in vitro methods for the determination of feed digestibility does have some advantages on hand, the compromises in student training cannot be overlooked. It is evident that the traditional teaching and learning of modern animal science students cannot be fully replaced by alternative methods and/or models. However, the need for students that have the cognitive and mathematical capabilities to work with large data sets and use various software models to accurately predict feed properties and animal production performance will become more critical in the future.

Training students in animal breeding was primarily based on quantitative genetics but, since the development of DNA technology and advancements made in genomics, molecular genetics has also been incorporated in the animal science curriculums. Breeding programs focusing on data-led practices, both from quantitative and a genomics approach, to make well-informed decisions have become the norm. The existing animal science programs in South Africa have limited exposure to data science and much greater focus will have to be placed on mathematics,
statistics, and computer science skills in the future. Recognizing this need, the University of the Free State started incorporating basic data science concepts in the third- and fourth-year curricula of BSc and BSc Agric students (Figure 4). Introductory courses in R and SAS for data management, mining, and analysis have done much to provide learners with some exposure and experience in these areas. A much more promising observation can be made at the postgraduate level on a national stage with most universities, including bioinformatic analysis of large data sets for Masters and Doctoral studies. However, training opportunities are lacking, and a lot of time is spent teaching students the required techniques. In addition, students spend many hours studying and teaching themselves. Unfortunately, the percentage of students pursuing a postgraduate degree is significantly lower compared to those completing the undergraduate programs (Figure 5).

The BSc Agric degree is equivalent to a 3-year degree plus an honors degree. During the fourth year of the BSc Agric degree, students are enrolled in a research methodology module, where students are specifically introduced to research methods and scientific writing. This module is also employed as preparation for prospective students who might be interested in pursuing a postgraduate qualification (MSc Agric degree). Although, the postgraduate qualifications in animal science offered at traditional universities are primarily research based, the execution and level of scientific interaction of these studies differ widely and contribute toward much skepticism and debate on the application thereof in practice.

The differences in focus areas of undergraduate student training are also reflected in postgraduate research and training, whereby some South African universities will focus more on animal production-related aspects and others more on pure scientific content. In general, postgraduate animal science training is research focused and does not include much course work, while little integration between the various disciplines occurs. A lack of understanding the differences between interdisciplinary versus multidisciplinary research might contribute to the compartmentalization of research outputs experienced in the past and needs to be addressed for future training of postgraduate students.

**Professional Career Development**

Across the eight public universities that offer animal science degrees, an increasing number of students graduated with an undergraduate degree over time (Figure 5). The total number of students obtaining an MSc degree has remained relatively constant, while the number of PhD students increased slightly since 2013 (Figure 5). The majority of the animal science graduates were from the universities of the Free State, Pretoria, and Stellenbosch (Higher Education Management Information System [HEMIS], 2017). It is important to note that South African universities, in general, have no “active tracking” systems in place to monitor student employment and career development after graduation. Therefore, it is difficult to establish any link between the increases in graduated candidates as illustrated in Figure 5 and the successful placement of candidates within the formal workforce.

To practice as an animal scientist in South Africa, animal science graduates are required by law (Act 27/2003) to register at the national legislated regulatory body of the South African Council for Natural Scientific Professions (SACNASP). According to the SACNASP guidelines, students that obtained a 4-year BSc degree or a BSc Honors degree, together with relevant work experience, qualify to register as a professional natural scientist, whereas a 3-year BSc or BAgric degree allows only registration for candidate and certificated membership. Registration at SACNASP ensures that only registered persons may practice in a consulting and advisory capacity and that persons practice strictly within their area of competence. Both the South African Society for Animal Science and the World’s Poultry Science Association are voluntary associations with SACNASP and ensure that registered animal scientists continue to engage in academic activities by means of a continued professional development program. The validity and purpose

![Figure 4. A computer lab where students learn to perform data and statistical analysis at the University of the Free State.](https://academic.oup.com/af/article-abstract/10/3/NP/5876091/5876091)
of these continued professional development programs are open for debate. However, they serve as a platform to ensure that graduates engage in continuing education with exposure to new developmental changes in practice. Furthermore, due to legislative issues, students seeking employment in the formal animal feed market need to be registered by SACNASP before they are considered.

Future Considerations

As the research demands of the animal science industry continue to change to more sophisticated technology and approaches, individuals filling these positions will increasingly come from nonagricultural backgrounds. The current demographics of the undergraduate population in South African universities reflect this trend. Training of undergraduate students needs to be adjusted to reflect the future demands of the animal science industry, without resulting in “academic drift” influenced by third party stakeholders. Since a large proportion of tertiary education is primarily subsidized by the government in South Africa (i.e., NSFAS bursaries), universities will also need to adhere to the demands of the national government to address the shortages of critical skills within agriculture. While the introduction of more private tertiary training institutions will not be a direct threat for public tertiary institutions, especially at the postgraduate training level, it must be viewed with caution since private and public institutes compete for a similar student pool, while private institutions are less exposed to political interference and instability.

While the formal employment markets will remain relatively constant in terms of the needs for discipline specialists, a wider range of new opportunities will emerge for the creative animal scientist student that is capable of working across discipline fields and capable of adopting new problem-solving techniques in the 21st century. Unfortunately, job opportunities in either the private or public sector will not increase at the same rate as the number of students registering to study Animal Science. It is, therefore, imperative that student training should include entrepreneurial thinking and development, as well as software programming courses to ensure that candidates could be employed beyond the scope of classical animal science in the future. While the role of the “traditional” animal scientist will become less dominant in the future, it will remain critical to ensure that the scientific backbone is indisputable. As animal scientists, we need to be aware of “academic drift” within and between various disciplines and should ensure that stakeholder participation and demands never dominate and overrule pure scientific principles. It is also envisioned that animal scientists will play an even more important role in assisting scientists from other disciplines in addressing global warming challenges in a more holistic and sustainable approach.

The dawn of the fourth industrial revolution and the development of artificial intelligence also influenced the animal science industry. The world of work has fundamentally changed with young career professionals now being faced with a deluge of data to be structured, modeled, and analyzed before making decisions. Modern animal scientists are required to have much broader technical skills than ever before, including a deep knowledge of database usage and being able to program in multiple languages. Traditional disciplines such as breeding, nutrition, genomics, and precision farming, among others, are generating vast amounts of data, and professional animal scientists are now required to be competent in tasks such as the collection of data, storing data, data synchronization, data transformation, data cleansing, data governance, and the development of data models. The development of software agriculture applications (“apps”) will enable scientists to “identify,” “analyze,” “diagnose,” and “prescribe” by having a mobile office in hand due to cell phone technology that continually improves and large data sets that will enhance the intelligence that is used in decision-making processes. Future programs in animal science...
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animal scientists for the future. The teaching environment will undoubtedly change and evolve on a continual basis due to technological developments. Universities in South Africa need to respond to change and face the challenge of providing quality education to provide excellent animal scientists to meet the industry’s future demand for a highly skilled workforce.

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The future of departments of animal sciences in Argentina

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Key words: animal science, Argentina, beef, dairy, education

Introduction

Argentina is recognized for its high-quality beef, as well as its important dairy production sector. Many people probably think of beef production in Argentina as endless plains of grasslands and pastures where large herds of cattle graze peacefully at their own pace all year long (Figure 1). However, in the real world, beef and dairy production systems and, more generally, the current animal production systems are the result of complex interactions among the availability of natural resources and the environmental impact of cattle, cultural traditions, technical expertise, technological availability, social demands, and constraints, as well as economic pressures.

Universities in Argentina are the outcome of their European background and their later evolution due to global changes, local needs, and restraints. The aim of this article is to bring about a brief description of Animal Science Departments in Argentina’s Universities, as well as the authors’ thoughts on future teaching and researching challenges in these universities, facing changing social demands, and needs in relation to animal production.

Implications

• Cattle production systems are facing dramatic changes due to increased social demands for cheap, safe, and high-quality products with less environmental impacts.
• Social demands are boosted by a not well-educated perception of agricultural productive systems and legitimate concerns about environmental and animal welfare issues.
• Future professionals in animal sciences will need traditional and new skills, such as environmental impact assessment, systems analysis theory, modeling, animal welfare, and bioethics.
• The university system in Argentina will have to respond with new and innovative research capabilities.

Relevant Features of Argentina

Argentina is placed in the extreme south of South America with an effective sovereign territory of 2,780,400 km² (Instituto Geográfico Nacional, 2019), with ca. 45,000,000 inhabitants (2019). It is organized under a republican, democratic, representative, and federal government.

Education in Argentina involves four levels, the first three compulsory: initial (kindergarten from 4 or 5 years of age) and 12 years of primary and secondary school. Education is free for all levels, as well as for tertiary instruction under the public system, and private education institutions under governmental supervision are also available. The illiteracy rate is ca. 2% and, according to UNESCO, education in Argentina guarantees equality and favors multiethnic population education and special education for people with impaired abilities. Despite this, ca. 55% of students leave the secondary education system, which results in 50% of persons older than 25 years without having finished this level (Ministerio de Educación y Deportes, 2017).

In Argentina, there is a high demand for higher education studies (ca. 6,000 university students for every 106 inhabitants in part because public universities are free of charge (even the very good ones) and because there are no admission examinations. Only about 24% of the adult populations have a complete superior education (Fanelli and Adrogué, 2018). The system would be expected to have positive effects in terms of equity facilitating the access for students from low income families, but, on average, only 20% and 50% of youngsters from low and medium socioeconomical levels, respectively have access to university studies. The rate climbs to 80% for the high-class levels. Besides, only ca. 11% of students complete their university studies within an average duration of 7–8 years (Nino, 2012). The graduation rate is higher for women and is positively associated with family income. Among the main reasons that account for the high abandonment rate are family income and the fact of being the first generation attending to university studies (Fanelli and Adrogué, 2018).

Employment statistics show that graduates from higher education have lower unemployment rates and lower risk to fall in
the informal economy. Besides, urban employees with higher education receive higher payment than men or women with secondary instruction (García De Fanelli, 2016). Unfortunately, there are no available studies comparing different professions or types of degrees.

The Argentinean University System

Argentina has a mature and consolidated higher education system that offers a high-quality university with several reputable public and private institutions under the Academic Ranking of World Universities (ARWU rank 2019; e.g., Universidad de Buenos Aires, 201–300, Figure 2; Universidad de la Plata, 701–800; Universidad de Córdoba, 801–900) or under the global QS ranking or by different scores that consider the opinions of graduates and employers, as well as the academic reputation and employability of graduates.

In Argentina, the university system must fulfill functions in education, science, and technology and in social extension (Higher Education Law 24.521/95; Ley de Educación Superior, 1995). The public system covers the totality of the territory with at least one public university in each province. The public university governance includes a collegiate body, with representatives of professors, graduates, and students (Superior Council), that is in charge of appointing a Rector. Likewise, every school is under a similar organizational structure (dean and board of directors). On the other hand, private universities used to have a vertical structure with administrative bodies in charge of their direction and academic staff dealing with educational issues (García De Fanelli, 2016). The most widespread organizational structure is based on a chair system grouped around a disciplinary topic such as animal nutrition. Each chair position is covered by a professor who is accompanied by a team of professionals with appointments in research, extension, and lecturing in one or several courses.

By 2017, the whole system involved 2,005,152 undergraduate and graduate students (public: 1,584,392 and private: 420,760 students; 18.2% in careers of the applied science area) and 159,345 postgraduate students (public: 122,829 and private: 36,516 students; Ministerio de Educación, Cultura, Ciencia y Tecnología, 2018). These students were allocated among 131 institutions (public national: 61; public provincial: 5; private 63; international: 2) that employed 189,218 professors and readers (full time = 11%; between 10 and 20 h per week = 23%; up to 10 h per week = 66%) and 53,674 administrative and technical support staff.

Student distribution is highly concentrated in the central part of Argentina with 24% of the total number of students attending an institution within the city of Buenos Aires; 24% in the province of Buenos Aires, and 13% in the province of Cordoba. In addition, the University of Buenos Aires accounts for 15% of the total number of students (https://informacionestadistica.rec.uba.ar/graficos_facultades.html), representing 58% of the total within the city of Buenos Aires (Figure 3).

Women participation in agriculture careers has been increasing steeply during the past century, reaching 30% of graduates in 2017 for the whole country (http://estadisticasuniversitarias.me.gov.ar/#/seccion/1). At the School of Agriculture (University of Buenos Aires), women graduation rate exceeded 20% since 1980 and has stabilized ca. 30% since year 2000 (Figure 4). Nowadays, 57% of the teaching and researchers positions are held by women, and noticeable discrepancies between genders in relation to project directions or areas of research do not exist (Kantolic and Gally, 2018).

At the present time, there are 66 universities offering degrees related with agriculture or animal science: 5/6 year degree in agricultural sciences, “Ingieniero Agrónomo” (28,348 students); animal production specialist (850 students); veterinarians (25,568 students; http://estadisticasuniversitarias.me.gov.ar/#/seccion/1).

The animal science curricula in agriculture-related careers usually includes core basic courses in animal anatomy and physiology, forage production, utilization and conservation, animal nutrition and feeding, animal breeding, and reproduction. After these basic courses, students follow courses in dairy and beef science, poultry and swine production, and other courses of regional or particular interest (Figure 5).

Aside from the university system, the technological and scientific system linked with agricultural issues is completed by the action of the National Institute of Agricultural Technology (INTA, “Instituto Nacional de Tecnología Agropecuaria”), and CONICET (National Scientific and Technical Research
Council). In addition to the above-mentioned institutions, provincial institutes of scientific and technology development exist.

The INTA is a decentralized public body under the orbit of the Argentine Ministry of Agriculture, Livestock and Fisheries of the Nation with operational and financial autarchy, whose institutional goals are: “...to promote and invigorate agricultural research and extension to accelerate the technification and improvement of the agrarian enterprise and rural life.” It has a presence countrywide through 15 regional centers, 52 experimental stations, more than 350 extension units, and research centers (6) and institutes (22). It employs nearly 7,000 staff, of which 2,000 are R&D professionals, 2,000 are extension specialists, 2,400 are technical and support personnel, and 600 are scholarship researchers. Approximately, 700 are staff doing research in animal science disciplines (C. Roig, personal communication). CONICET is the main science and technology

Figure 2. School of Agriculture—University of Buenos Aires.

Figure 3. Photo of students at the School of Agriculture (University of Buenos Aires).
fostering agency with operations across the whole country with more than 10,000 researchers, 11,000 doctoral and postdoctoral fellows, 2,600 technicians and professional support staff, and 1,500 administrative employees.

The Argentine research and development system employs 109,460 people (189 researchers for every 10^5 habitants), of which 76% (83,190 including research scholarship holders) are researchers (43% with a postgraduate degree). CONICET employs 21,640 persons (17,284 develop their research in public universities and public universities employ 44,153 scientists, of which 56–60% are women; Quattrone et al., 2017).

Argentine expenditures in the entire education system is ca. 6.1% of gross domestic product (GDP; in 2015; Ministerio de Educación y Deportes, 2017, p. 71) and in higher education was 0.8% of GDP in 2017 (Cetrángolo and Curcio, 2017). In addition, investment in research and development for 2017 was ca. 0.55% of GDP; financial source: 73% public sector, 18% private, and 9% external, of which 48% was executed by public organizations, 25% by public universities, and 25% by companies (Quattrone et al., 2017, p. 4).

Regarding scientific productivity, between years 2000 and 2019, a total of 108 articles appeared in the Scopus database (survey in discipline Agricultural and Biological Sciences), and 282 peer-reviewed, full articles appeared in the Argentine Journal of Animal Science ("Rev. Argentina de Prod. Animal, RAPA", online ISSN 2314-324X; "Asoc. Argentina de Prod. Animal; AAPA"). Furthermore, a total of 6,195 extended summaries (ca. 1,000 words) were sent to be published in the proceedings of the AAPA annual meeting (Table 1). The RAPA is a peer-reviewed journal (not indexed) that gathers good quality articles of relevance for Argentina and Latin America. The large discrepancy between the number of published articles (108 + 282) and extended summaries presented in the annual meetings of AAPA is remarkable, indicating a gap in producing high-quality, full-text publications among the participants. Behind this difference, it may be speculated that a lack of adequate stimulus for many researchers to fully complete the scientific process exists because, in many institutions, researchers are not compelled to publish as an indicator of work productivity or multiple simultaneous demands competes for its time (e.g., teaching, administrative, and extension).

**Present and Future Challenges**

In Argentina, demands on animal production systems and agriculture, in general, resemble what has been happening...
Animal Frontiers

Environmental impact

Breeding and reproduction in animal production systems

Nutrition and feeding

Forages and pastures

Relative contributions (%)

Total number of publications

Scopus

AAPA journal

Full articles

Proceedings

2019 within Agricultural and Biological Sciences database classified by discipline

108

282

6,195

Animal Frontiers

Technologies to identify genetically superior sires at an earlier age, all new biotechnologies (e.g., advanced genetics or genomics technologies to identify genetically superior sires at an earlier age), reproduction technologies (e.g., artificial insemination, embryo transfer, cloning) or nutrition advances (e.g., growth promotants, alternative feedstuffs) provide alternatives to conventional animal production systems. These alternatives will demand special attention not only due to the technical training requirements, but also due to their bioethical consequences. The novel technologies for animal production have captured considerable public attention and resulted in significant amounts of human and economic resource investments.

Because many of these issues are beyond the scope of traditional animal science experts and present departments, the training program for future animal scientists will need to include experts from other disciplines and departments to provide future animal scientists and practitioners with a broader and more appropriate educational basis.

The current availability and access to the internet, as well as the increased familiarity of students with web information, will facilitate the delivery of a wider range of contents through e-learning devices and virtual reality. In this respect, the COVID-19 pandemic has accelerated and forced the national university system to cope with the delivery of online courses and teaching activities. Within this context, the present challenge is not how to get information but how to differentiate accurate and science-based information from fiction or inaccurate information. The problem of free information on the internet is a particularly sensitive issue in social media environments where the news media, social influencers, and even educators or some societal leaders do not use objective or science-based information.

Up until now, the scientific and technical research in Argentina has been supported mainly by public funds, but joint public–private initiatives are fruitful associations not only for the genuine source of funds for research but also because it fosters mutually beneficial feedback (e.g., specific studies and customer-tailored courses).

There has been a historical lack of sufficient investment in facilities and equipment to meet the specific demands of animal science research and training of graduate and postgraduate students. The lack of up-to-date infrastructure and laboratory equipment, along with the lack of highly capable technical personnel not only constrains the development of basic or applied research but also limits a more fruitful interaction of the university system with the private sector. This problem is not exclusively due to the relative lack of funding but also due to increased bureaucracy and burdensome policies.

Animal production is changing worldwide, as well as its relationship with consumers and especially with the public perception of food, animals, and the environment. Argentina is a salient player in agriculture and specifically in animal production with an important share of Argentina’s economy depending on agriculture and the production of animal-sourced foods. Future animal scientists and practitioners will be required to fulfill traditional technical capacities alongside novel competences to deal with complex productive systems within highly demanding social environments. Hence, higher education institutions will have to face the challenge of adapting their institutional structures, educational curricula, outreach activities, and research topics to facilitate the acquisition and maintenance of these competences.

Throughout the world—there is increased pressure on animal production systems to use fewer natural resources and generate higher-quality products with fewer environmental impacts to meet changing consumer demands. These production, environmental, and societal issues are gaining publicity and persistence in the news media on political agendas and across the education system in Argentina.

Consequently, we think that the analysis of animal production topics should be moving away from a multifactor-single-objective conventional view to a more comprehensive multifactor-multiprojective viewpoint with simultaneous consideration of factors such as soils or climate and multiprojectives as quality and quantity of milk production or environmental impacts. This course of action will demand a more interdisciplinary, transdisciplinary, and multidisciplinary approach in research and teaching. Hereafter, the present complexity of cattle production system studies and interactions with other social and biophysical agents will demand formal system analysis theory and modeling instruction and research. These elements should orient specific disciplinary activities and provide future graduates with effective knowledge, skills, and abilities to enhance their decision-making processes and application of their new knowledge from a broader range of disciplines. This interdisciplinary approach is almost absent in the current curricula and research agenda within animal science training programs in Argentina (Jaurena et al., 2013; Ginies and Jaurena, 2015).

While the standard animal science curricula will remain essentially the same, the future animal science professionals must acquire competences in animal welfare, environmental impact assessment, social perception, and food safety. Above all, new biotechnologies (e.g., advanced genetics or genomics technologies to identify genetically superior sires at an earlier age), reproduction technologies (e.g., artificial insemination,
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Perspectives for the future in Italy: animal science higher education, employment, and research

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Introduction

In 2018, the Italian agrifood system reached 140 billion of euros in gross sales (9% of national gross sales) and represents 43% and 3.2 million employed people (13% of overall employment). Animal products represent 27% of gross sales and, in 2018, lost 2.8% in value compared to a 0.9% increase of the entire sector (Istat, 2019). In 2019, Italian agrifood exports increased 7% over 2018, reaching a value of almost 50 billion euros, with excellent performance in the U.S., UK, and Russian markets (Scordamaglia, 2019). Among animal products, milk and dairy sales increased more than 5%, whereas meat and derivatives lost more than 2% (Antonioni, 2019).

Despite this favorable framework, including the global positive trend in Italian food exports, the Italian primary sector remains fragile: the 2010–2013 standard output dropped by 11.5%, while the European Union (EU) gained 7.5%. The ratio of young (<35 yr of age) to old (>65 yr of age) farmers is one of the lowest in the EU (0.11–0.18). The average age of Italian farmers is 57 yr, placing them at the second oldest among the EU countries in rural areas (European Commission, 2017).

The information and communication technology sector revolution enacted in Italian agrifood chains will require more and more skilled people. Given all other drivers mentioned above, the employment scenario for highly educated people in the feed, farm, food, and fish Italian animal production systems is rosy! We forecast, even with decreasing turnover, that all current students in animal science and veterinary science (the latter with particular interest to the feed-food chains), will have an excellent chance to find a good job and have a rewarding career considering the increasing production and availability of products bearing the Protected Designation of Origin/Protected Geographical Indication and Indicazione Geografica Tipica designation of animal origin from Italian agricultural production (Figure 1).

Employment perspectives

Among EU countries, Italy is known for high and persistent youth unemployment. In the age group of 15–29 yr of age, Italians not in education, employment, or training account for 23.4% compared to the EU figure of 12.9%. In addition, the Italian unemployment index in the age group of 25–29 yr of age is 32% compared to 17.2% of the EU28 (Eurostat, 2019). Ten years after graduation, Italian graduates, defined as people who have been in the educational system for ≥16 yr, have lower unemployment rates (12.3%) compared to those people with 13 yr of education (23.2% unemployment rate). Primary school graduates or those people with 8 yr of education have an unemployment rate of 41.6% (Istat, 2019).

Implications

• In Italy, the courses in animal science include large educational spaces dedicated to practical aspects and internships—both in university experimental farms and in private companies.
• The investment in research and innovation in Italy is lower than in Europe, with an increase driven by a larger number of progressive private/business investments.
• The Italian job market for animal science graduates has excellent opportunities for rewarding careers.
• Italian animal scientists are active in the area of agricultural and veterinary science; however, in the near future, the potential for jobs and research in animal science must consider the outcomes of the SARS-CoV-2 pandemic crisis.

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agriculture and veterinary sciences (bachelor’s level) have an employment index of 84%, which is lower than the average of their contemporary graduates 88.6% (Figure 1). About 15% of first-level graduates are engaged in independent business activities, such as consulting, entrepreneurial activities or farming, and nearly 50% are employed in a public or private company. They earn less than the average of all Italian first-level graduates (1,297 vs. 1,418 euros/mo of net salary). Table 1 describes the employment, career, and salaries of Italian agricultural graduates and all Italian graduates at both levels. Wage disparity still exists among the sexes with males, first-level or second-level graduates, earning 100 euros/mo more than their female counterparts in agriculture and veterinary sciences (Almalaurea, 2019).

Regarding the job market, the Italian perspective is not affected by the other EU countries as a result of the free movement of professions guaranteed by the community agreements. Internally, job perspectives for the next 10 yr are predicted to be impacted by turnover in public administration, which provides opportunities for 20% of graduates, private employment for 40%, independent business and entrepreneurial opportunities 30%, and research and development in public or private sector for 10%.

**Italian higher education system in animal science**

Animal Science degree programs in the Italian universities are organized into two cycles, the first cycle consists of 3 yr and the second cycle consists of 2 yr. The 3-yr, first cycle degree course in animal production is currently offered at 14 universities, which are distributed in most regions of Italy (Figure 2). The degree programs are managed either by agricultural sciences departments, by veterinary medicine departments, or jointly by both departments. At a large university campus, a programmed number of students is expected. This means that each state university decides on the number of open seats for students. These seats are determined by the available resources, such as laboratory space, numbers of faculty, and the job market for a degree. In open-access smaller academies, an initial verification is conducted to ascertain the student’s level of preparation for university classes and any formative deficiencies that will impact their performance. This course of study is usually named “sciences and technologies of animal production” and offers a very broad introduction to agro-technical systems to create the knowledge base for the management of livestock farms. However, other courses are also available, such as: “management of sports and companion animals”; “protection of animal welfare”; “wildlife sciences”; “quality of animal production”; “sustainability of animal production systems”; “management of extensive farms” and “hygiene and health in animal farms.” In some universities, there is an international program with the ability to obtain a double degree. The courses in animal production include large educational spaces dedicated to practical aspects and internships—both in university experimental farms and in private agricultural, livestock, processing, marketing, and consulting companies (Figure 3).

The degree thesis usually includes discussion of a project combined with a training internship. A research or experimental thesis is also encouraged. Student experiences at foreign universities through the Erasmus programs (EU student exchange program) are very limited. Animal production students come, in most cases, from scientific or technical-professional secondary education institutions.
The average time required for a student to obtain the first cycle degree is 4.6 yr. After obtaining the 3-yr qualification, a percentage of students (almost 50%) abandon their studies and look for a job. About 12 mo after graduation, 60% of graduates usually find employment that relates to their educational qualifications. The natural and prevalent continuation of studies is the master’s degree in animal and production sciences.

The second cycle of animal science studies is represented by 16, 2-yr master programs that are currently offered by 15 universities. Courses are managed by departments of agricultural sciences or veterinary medicine or jointly by both departments. There is a wide range of programs at each university. Seven out of sixteen master’s programs have a title of “Animal Science” (or similar) and they are aimed at producing students with a broad range of training that covers several fields of the animal sciences. Other master’s programs are focused on specific topics, such as “food quality and safety” (n = 3), “wildlife management” (n = 2), “sustainable production” (n = 2), “animal welfare” (n = 4), and “precision livestock farming” (n = 1). Some courses offer a double-degree program. During the master’s program, the student must develop an experimental project that is usually carried out in an internal traineeship at the same university or in a foreign country with the support of the Erasmus program or other international grants. On average, each year, 24 (±13) new students start a Master’s program. About 76% of students earn their master’s title within the 2-yr duration of the program. Five years after graduation, about 75% of the students are employed in a field connected to their qualifications.

All departments are composed of different research units, covering most disciplinary competencies. In animal production, most departments have four disciplines and provide laboratories both for research and teaching. These disciplines are animal genetics, animal nutrition, applied animal science, aquaculture, poultry, and zooiculture.

The highest degree of education is the PhD. In 2016, in Italy, there were 12 PhD programs that can be clearly classified as animal science. In the same year, a total of 45 positions in animal science were available to graduates with a PhD. On average, every year, a total of 35 students finish their PhD. In recent years, however, there has been a tendency for a reduced number of positions in animal science that require a PhD. The reduced number of available positions that require a PhD is due mainly to the high costs (about 60,000 euros) for opening a PhD position and the decrease of scholarships available from public funding.

Research and innovation investment

In Italy, the investment in research and innovation is 1.35% of the GDP (1.97% in Europe) with a slow increase that is essentially driven by a progressive increase of private/business investments and a decrease in public investments. The financial resources allocated by the Italian government for research and development, rather than actual expenditures reported by research and development indicators (OECD, 2019), has decreased by 20% over the past 10 yr. During the same timeframe, research and development expenditures reported by the private sector increased by more than 25%. Despite limited public engagement in supporting research,
Italian scientists are quite active in European scenarios in a variety of different fields, including agriculture and animal science. Italian scientists produce a significant number of high-quality publications (as determined by IF and citation indexes) in the area of agricultural and veterinary science that covers about 7.6% of the total number of Italian researchers.

Research and innovation policy are formed both at the national and regional level through the preparation of planning documents and the management of dedicated funds. At the national level, the Ministry of Agricultural, Food and Forestry Policies, the Ministry of Education, University and Research, and the Ministry of Health are the main institutions that deal with agro-food research and they also interface with the EU. In December 2019, the Italian government included in the 2020 budget funding for a new national agency for research as an independent body for the coordination of research funding.

Strategic plans for innovation and research in the food and forestry agricultural sector (RDP 2014–2020) supported the following topics:

- Sustainable increase in productivity, profitability, and efficiency of resources in agro-ecosystems;
- Climate change, biodiversity, soil functionality, and other ecological and social services of agriculture, quality and typicality of agricultural products, food safety, and healthy lifestyles;
- Sustainable use of biological resources for energy and industrial purposes; and
- Development and reorganization of the knowledge system for the agricultural, food, and forestry sector.

At the regional level, agricultural research is regulated by specific rules, regarding innovation development and transfer services. Regional administrations have full autonomy of action. At the regional level, the investments in zootechnical research are about 25% of the total investment in agricultural research (Macri, 2017; research financed by the regions 2017). If the main issues supported at a territorial level in recent years are examined, the most frequently pursued objective has been that of developing new products and processes for improving product quality. A further goal has been the achievement of innovations aimed at decreasing production costs, management of natural resources, and enhancing biodiversity and the health and well-being of farm animals (with particular focus on alternatives to antimicrobials).

In order to strengthen the area of research and innovation, the Ministry of Research and University, since 2012, has supported the creation of a national cluster of agrifood, a recognized association of companies, universities, research centers, and territorial representations, for the development and enhancement of national technology in the agrifood area and the promotion of life-long learning initiatives.

In a perspective that aligns with the 2030 Agenda on sustainability goals, new challenges in the field of research and innovation in animal science must support sustainable competitiveness and encourage the development of healthy and safe breeding systems to secure food safety (goal 2). Interventions aimed at encouraging the supply of environmental services by livestock production systems, reduction of greenhouse gas emissions, definition of integrated strategies for disease prevention, and control activities (goal 15) are priorities. Animal scientists will be asked to repurpose food waste not intended for human consumption for feed use (goal 13). Innovation must consider not only technical-production elements but must also favor improvement of the organizational and management components of livestock production (Figure 4).
farming and feeding technologies, as well as new techniques in animal breeding and reproduction, are increasingly essential to compete effectively in the global market of agrifood products.

**Future Considerations**

The direction and types of training needed for graduates in animal science are difficult to forecast. The changing needs associated with the information and communication technology and biotechnology sectors makes forecasting specific careers a difficult task. To adapt to a dynamic environment, the human capital in livestock applied science and basic disciplines, as well as soft skills, will be reinforced in animal science graduate courses. Training in disciplines such as biology/biodiversity, process engineering, economics, computer science, and communication will be required. In a world in which tomorrow’s jobs have not been invented yet, students must be trained as life-long learners who have been trained in competency-based, challenge-oriented international programs. The future animal science educational programs should change not only in terms of innovative content but also in terms of teaching methods. In this direction, the new generation of animal science courses must use new technological innovations and change their approaches in defining the curriculum content. Short continuous massive open online courses will be continuously generated for the maintenance and improvement of the graduates’ skills necessary for continuous transformation of animal production chains. Additional critical skills students will require include soft skills such as communication, networking, leadership, advising, planning, and organizing. Development of these skills must be prioritized in programs to create a well-trained group of professionals. Only this integrated approach will allow students to develop a modern range of knowledge related to the livestock value chain and to build confidence in the subject and in themselves.

This scenario has undergone an incredible acceleration due to the COVID-19 pandemic. This paper was written before the SARS-CoV-2 coronavirus reached Italy and Europe in full force in early 2020. During recent months, universities adapted quickly and developed distance learning solutions for education and training programs to meet social distancing requirements in an attempt to slow the spread of the virus and minimize the impact on the health care system. This experience makes it clear that nothing will return as before once the crisis has been overcome. The impact of the COVID-19 pandemic on the Italian zootechnical system and the food supply chain will be a major topic of debate among scientists, professionals, and stakeholders for many months to come. Analysis of the short- and medium-term effects of the pandemic on the food production system must be given high priority among the many challenges animal scientists must face in the near future. Additionally, the increased demand for sustainable animal products with the increasing availability of nonconventional foods and the need for sustainable feed production systems creates a challenge for the animal scientist. Food accessibility and economical production must be balanced with the emerging interest by consumers of animal products to ensure ethical animal production systems.

**Conclusions**

The future of research and training programs in animal science departments in Italy is as much of a challenge as animal scientists have ever experienced. The limitations in free movement of people and products caused by the SARS-CoV-2 pandemic will have a long-lasting impact on animal production.
and animal science. Given the growing demand for ethical food production systems by the millennial generation, animal science graduates must be nimble and flexible enough to rapidly design and implement new strategies for the production of animal-sourced foods. We must prepare future animal scientists with as much of a broad and diverse background of knowledge and skills as possible that will enable them to establish cross-disciplinary approaches among animal, human, and environmental health in a “one-health” approach. In addition, future animal scientists will need to be equipped with new models of animal production systems, coupled with smart working skills and information and technology tools, efficient and safe use of resources, and robust communication capabilities to meet societal demands for animal-sourced foods.

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Bruno Ronchi is professor of animal nutrition and feeding at Tuscia University, Viterbo, Italy. His research mainly concerns studying effects of heat stress on domestic ruminants; effects of exposure to chemical environmental contaminants on animal health and on safety of animal products; and evaluation of chemical composition and nutritional value of forages and concentrates for animal feeding. From 2007 to 2009, he was Director of the Tuscia University Experimental Farm. He is Chair of the Bachelor and Master programs in animal science at the University of Sassari. He is currently President of the Italian Animal Science and Production Association. His fields of expertise are animal breeding, genomics, statistics and modeling, and livestock biodiversity.

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Animal science program accreditation? This is the future

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Introduction

Should voluntary accreditation of 4-year animal science degree programs be the future?

The American Society of Animal Science (ASAS) Committee on Accreditation suggests it is needed and yes, it is the future. Higher education continues to evolve with new challenges, opportunities, and expectations. Graduates with 4-year degrees in Animal Science have been rewarded with plentiful and diverse career options and opportunities. However, now is not the time to rest on our laurels. As times change, so should animal science programs to continually meet current and future implications in our educational processes. Those who invest time and resources in undergraduate animal science programs (students, parents, and employers) increasingly expect more accountability and documentation of what they can expect from their investment. Accreditation is a quality assurance program already used by many undergraduate disciplines including those in agriculture. Now is the time for animal science programs to proactively offer this value-added asset to their animal science degree programs. It is essential to be proactive and take responsibility for our future, for if we do not, others with less commitment may make the decisions for us.

ASAS is committed to a strong future for the next generation of animal scientists. With a large and diverse membership of professional animal scientists, it is well positioned to lead an accreditation effort. ASAS has accepted the responsibility of implementing a voluntary Accreditation Program that will be available initially to institutions within the United States awarding 4-year Bachelor of Science degrees in Animal Science. The work of ASAS is guided by five core principles (https://www.asas.org/about/history-and-mission) and two of those core principles directly align with accreditation; specifically principle #4 Career development for animal scientists, educators and producers is essential to the viability of the allied and animal industries; and #5 Animal science and the production of animal-sourced foods must continually evolve to meet the needs and values of society. The accreditation process requires departments to conduct a self-assessment of their animal science undergraduate program based on academic standards established by an accrediting body/agency. Data generated by this self-assessment is reviewed by trained third-party academic professionals who have received graduate degrees in animal science or animal science related disciplines. Areas that are reviewed range from reviewing curriculum and learning outcomes to the resources available to support students’ academic experience (i.e., advising support, animals, and facilities). Compliance with established accreditation standards results in the animal science program becoming accredited.

Perspective

Implications

• The American Society of Animal Science is in a strong position to support and implement a peer-driven, comprehensive voluntary accreditation program based on its large and diverse animal science professional membership and its involvement with academic programs training future animal science graduates.
• Students, employers, academic institutions, and potential employers benefit from accreditation by ensuring that animal science educational programs meet or exceed academic standards defined by animal science professionals.

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Development of an accreditation option for animal science programs began several years ago and in 2014 the ASAS Board of Directors voted to establish standards for accreditation of Animal Science programs. Since then, there have been multiple actions and votes by the ASAS Board of Directors to investigate and implement the process. To date, the ASAS Board of Directors has voted to charge the Animal Science Accreditation Committee with researching, developing, and proposing an implementation plan, and they have voted to enact and provide infrastructure for an accreditation program for undergraduate programs. The proposed Animal Science Standards for Accreditation were posted for member comment and an implementation strategy was forwarded to the ASAS Board of Directors.

The Animal Science Accreditation Committee, composed of academic and industry professionals, developed an accreditation process, and established proposed standards for accrediting Animal Science undergraduate programs. This committee investigated other accreditation programs currently offered in a variety of disciplines. Examples of professional societies leading accreditation programs include but are not limited to disciplines of range management, forestry, and landscape architecture. The Society of American Foresters (SAF) is responsible for accreditation in that discipline [https://www.eforester.org/Main/Certification_Education/Accreditation/Main/Accreditation/Accreditation_Home.aspx?hkey=acede682-0ce7-4202-85e6-e3371eb38cdc]. Volunteers from SAF academic and industry membership make their accreditation process possible by overseeing the approved standards and reviewing academic programs. Forestry programs volunteer to undergo a comprehensive review by SAF periodically to determine if the criteria set by their society leaders are met. Accredited range management programs are approved by the Society of Range Management and as a part of its mission has accredited range management programs since 1977 [http://rangelands.org/srm-academic-resources/universities-colleges/]. The Landscape Architecture Accreditation Board (LAAB) develops and enacts accreditation standards and processes authorized by the American Society of Landscape Architecture board of trustees [https://www.asla.org/aboutlaab.aspx]. The accreditation of these programs assures a quality and professional education for enrolled students, and provides confidence to all invested.

Veterinary education is accredited by the American Veterinary Medical Association (AVMA) and is responsible for accrediting both Veterinary Schools and Veterinary Technology Programs [https://www.avma.org/education/center-for-veterinary-accreditation]. The veterinary discipline impacts many animal science undergraduates and the AVMA relies heavily on accreditation as a tool to identify programs with a commitment to quality and continuous improvement provided by peer review.

Using this information, the ASAS Accreditation Committee developed the following objectives of Animal Science Program Accreditation:

• To foster excellence in animal science educational programs through the periodic revision of standards for accreditation and to apply those standards in evaluation of the educational environment and effectiveness of animal science programs.
• To recognize the diversity of animal science programs that in addition to production animal agriculture, may include care of companion animals, conservation of species (e.g., captive exotics), and management of laboratory animals.
• To assure students, employers, the public, and other organizations that accredited animal science programs have educational objectives and outcomes consistent with current professional standards for the field of animal science, and have adequate resources to accomplish these objectives.

Accreditation standards for seven components of an animal science undergraduate program were developed and recently published for ASAS membership review and comment. The components of the standards are identified in Figure 1.

To implement the accreditation process, the Accreditation Committee proposed the formation of the Animal Science Council on Accreditation. This council will be composed of professional ASAS members who have the authority to enact the accreditation process for programs who seek accreditation, identify accreditation review teams, deliberate on the institutional application, and review team findings and render a decision on whether an animal science program has met established accreditation standards to receive program accreditation.

Accreditation of animal science programs signifies that professionals in the animal science disciplines are proactively committed to high-quality education and training of the next generation of animal scientists; and that required standards have been identified for their programs. When the Animal Science Standards for Accreditation are met, it ensures that the curriculum covers essential animal science concepts; students acquire knowledge and experiences within the animal science disciplines; that the accredited program has the appropriate institutional support enabling a sustained high-quality program to be delivered to students; and that the program provides the

1. Program mission and objectives
2. Program governance, administration and institutional support
3. Students
4. Program learning outcomes and curriculum
5. Faculty
6. Facilities, equipment and technology
7. Outreach and engagement with industry, public, institution

Figure 1. The components of proposed Animal Science Accreditation Standards.
education needed by graduates of the program to step into diverse professions of animal science, fully prepared to meet industry needs. Students learn of career opportunities and how to prepare for these careers in a variety of ways including career fairs where students interact directly with employers (Figure 2).

### Benefits of Accreditation

Accreditation of professional programs, through program self-evaluation and a third-party peer review processes, is a long proven and accepted method of ensuring quality and consistency of academic programs and is widely used throughout academic disciplines. Peer review of individual agriculture departments including animal science is nothing new and was a routine periodic process provided by the United States Department of Agriculture National Institute of Food and Agriculture. This review option no longer exists. Recognizing that academic reviews are critical to demonstrate that animal programs are meeting the needs of our students, stakeholders, and society as a whole, accreditation is an option that fills that need.

Accreditation of animal science programs will be of value to the academic departments, colleges, and institutions awarding the degrees, to the students graduating from these programs and to the employers of graduates from these programs. The accreditation process engages animal science professionals from academia, industry, and government to provide objective external review and attest to program quality and commitment to continuous improvement. With increasing expectations of accountability in higher education, accreditation provides a valued opportunity to verify program quality and capacity for training students who are well prepared to enter diverse professional positions upon graduation or continue their education in professional degree programs. Figure 3 summarizes what accreditation of animal science programs can offer.

### Why Many Believe This Is an Important Initiative for ASAS to Provide

Not everyone agrees that animal science programs need an accreditation option, nor that ASAS should get involved in accrediting animal science programs. However, after several years of input from membership and all sectors of the diverse profession, most agree that this voluntary program is, in fact, needed and perhaps now more than ever in a challenging environment where funding is limited. ASAS is uniquely positioned to provide the leadership for and support of this effort.

Three important characteristics that make Accreditation an asset for those who want it:

1. **Verified value**

   The value of a college education is of interest to all investors in that education. This includes the students, their parents, prospective employers of the graduates, and the academies delivering the education. Value is measured and perceived differently by everyone. Programmatic accreditation provides a common process used throughout academia to ensure defined standards of quality that are met by the program and degree granting institution. Most degree granting programs are housed at institutions already engaged in regional or national accreditation which accredits the entire institution. Programmatic accreditation is a status earned by an animal science program.

   Currently students and parents of students have access to little subjective information on what can be expected from an animal science program and how it measures up to industry and employer expectations. Prospective employers have asked for an understanding of the content and training they can expect animal science graduates to have experienced during their undergraduate career. Accreditation provides public acknowledgment and
Partnerships

Institutions are committed to offering outstanding undergraduate experiences and training. Those voluntarily seeking accreditation welcome the opportunity to have their programs reviewed by animal science professionals, benefit from the input and critique received, and have yet another means of demonstrating the value of their program to students, academia, industry, and society. Accreditation also supports and enhances institutional assessment programs already in place.

2. Partnerships are valued and necessary

The diverse disciplinary expertise of animal science is known to engage academic, industry, and government partners in teaching, research, and extension activities. These partnerships are an essential element in past, present, and future advances and accomplishments in the field. Therefore, Animal Science accreditation relies on an active engagement and participation by academic, industry, and government partners in the accreditation process. This is necessary to ensure that the next generation of animal scientists are well prepared and trained. Input by industry professionals provides essential and timely insight into the ever-changing arena in which animal scientists work. Incorporation and application of new technologies, discoveries, and regulations must be considered as the field continues to evolve. Many of the careers of future animal scientists begin with their employment in these very career paths. Accreditation values and uses the contributions of all animal science professional partners in preparing for the future.

3. Program uniqueness is encouraged

Animal Science programs offering 4-year Bachelor of Science degrees in animal science vary significantly in size, scope, geographic location, and focus. Individuality of programs is encouraged with the proposed accreditation program. Accreditation standards are not written to be prescriptive in their requirements but rather encourage programs to employ novel, innovative, and evolving methods and processes to accomplish the required standards. The proposed standards identify key required elements of an accredited program but do NOT identify how those elements might be accomplished. It is by intent that the WHAT of the requirements are defined but the HOW is determined by the institution/department applying for accreditation. Accreditation is not designed to make all programs look alike, teach alike, serve the same student demographics, or serve the same student professional aspirations. Large enrollment programs will manage courses and course offerings differently than those with smaller enrollments. Programs training mainly preprofessional students (e.g., Graduate School and Veterinary School) will differ from those with students intending to seek industry or production careers immediately upon graduation. Programs will vary in how they provide students with experiential learning with animals and other experiential learning options.

Uniqueness of individual programs is expected and encouraged. While the standards identify key elements that all programs must possess, it is up to the program administration to show how those requirements are met. The success of a program meeting those standards is evaluated by the visiting review team and self-study documentation.

Conclusion

The accreditation process engages animal science professionals from academia, industry, and government agencies to provide objective external review and provides data to assess program adherence to academic standards and commitment to continuous improvement. With increasing expectations of accountability in higher education, accreditation provides a valued opportunity to verify program quality and capacity for training students who are well prepared to enter diverse professional positions upon graduation, or continue their education in professional degree programs. ASAS is in a strong position to support and implement a peer-driven, robust, and comprehensive accreditation program. The membership and board of ASAS represents the diversity of professionals working in the animal sciences and working within the programs producing today’s graduates. As the pressure for accreditation grows from a range of related organizations, ASAS is the logical entity to administer and provide leadership to develop and implement an accreditation process based on standards widely accepted and supported by its membership. Recognition of these standards, and support of ASAS in this role, will provide a peer-created, peer-driven, widely accepted accreditation program that will establish the standards and a third-party validation of all of our efforts to educate and train the next generation of animal scientists and industry professionals.
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Introduction

Future concepts of university education have long incorporated movement to full virtual delivery but have met with skepticism citing the importance of a traditional college experience. In fact, the University of Phoenix and Purdue Global administer full undergraduate degree programs online, but the question always remains, is online education as good as a traditional education (Ubell, 2019)? Is this truly what the future holds for university education? Animal science departments in particular have balked at making a complete shift to virtual learning, because of the importance in “hands on” experience in our field. Before the COVID-19 pandemic, campuses and animal science departments were evolving toward a digitized environment: transferring grade books to Learning Management Systems (LMS), moving from paper to online textbooks, providing recordings of lectures, offering online review sessions, using plagiarism detection software, providing the ability to register virtually and much more. The COVID-19 pandemic vastly accelerated the move to virtual classrooms and provided the first glimpse of what a fully virtual online animal science education might look like. Will the stop-gap procedures put in place during the recent COVID-19 pandemic truly influence the future of higher education?

There are over 4,000 public and private colleges and universities in the United States (https://www2.ed.gov/rschstat/catalog/colleges-universities.html). The U.S. postsecondary education system instructs more than 20 million students per year and generates more than $700 billion in revenue (https://nces.ed.gov/programs/coe/indicator_cud.asp). Current predictions are that COVID-19 pandemic will result in a 15% decrease in the number of U.S. students enrolled in a university and a 25% decrease in the number of international students enrolled at U.S. institutions (Smalley, 2020). Additionally, some universities are questioning whether students will be able to return to campus in the Fall of 2020. If virtual learning is the only delivery mechanism in the Fall of 2020, enrollments will decrease further (Korn et al., 2020). Should in-person classes resume in the Fall, concerns include adequate supplies of personal protective equipment, appropriate procedures for cleaning and disinfecting shared surfaces, requirements for health monitoring or testing for infection, infrastructure requirements needed to ensure social distancing and a changing student population. Fewer students may be on campus because of delayed admission decisions, canceled admissions tests (ACT, SAT), canceled campus visits, safety concerns of parents, or

Implications

• Online teaching has been part of animal science departments for more than a decade, but COVID-19 hastened the conversion of many classes to fully virtual experiences.
• A virtual classroom will never fully replace the hands-on experiences associated with animal science courses, but the technology enabling online education is advancing.
• In the future, an estimated 90% of classes will have an online or virtual component.

Key words: animal science, online learning, virtual learning
because students decide to stay closer to home during an uncertain period. Other students may find they prefer an online education where they can control their schedule and perhaps mitigate costs associated with a physical, on-campus presence. Regardless of the myriad of questions, courses, and classrooms are likely to be vastly different moving forward.

One of the pillars of animal science information transfer is face-to-face instruction and hands-on experiential learning activities. Thus, the COVID-19 pandemic challenged the most dedicated animal science educator. Most animal science departments have incorporated online education in their outreach programs and many animal scientists have been teaching online in a variety of formats for more than a decade. According to the National Center for Education Statistics (2018), before COVID-19, one third of all undergraduates were enrolled in online classes with 13% learning exclusively online (National Center for Education, 2018). Furthermore, online course enrollment increased for 14 consecutive years (Seaman et al., 2018). Because animal science departments at land-grant universities have closely aligned teaching and extension missions, many have long-term online distance learning capabilities.

With the need to move all education online within a short period of time, the dedicated faculty in the animal sciences made it work and learned in the process. Those lessons will allow teaching and outreach faculty to create tools to improve education and potentially reach people who do not have the resources to attend a university campus. This paper is the result of discussion of many educators in the animal sciences who came together to discuss the challenges and lessons learned during the COVID-19 pandemic. Readers may also view the webinar that provided the foundation for this paper (Radcliffe et al., 2020; https://vimeo.com/403860309). These experiences are likely to help reshape the global landscape of higher education and may serve as a roadmap for how educators engage in both online and in-person education in the future. The aims of this article are to discuss methodologies to facilitate the shift to online instruction and examine some philosophies associated with online education.

Moving Online: The Virtual Push Today and in the Future!

Some educators had 2 weeks to move to online instruction, which for some began with a hybrid version of a course (in-class and online instruction). Others had 72 hours to move teaching from face-to-face to 100% online. As a result, educators across the world have become experienced in rapidly moving courses to an online platform—not necessarily experts in best practices, but certainly experienced in “getting it done.” Figure 1 is a roadmap that describes the collective experiences of the authors as guidance for moving classes online.

As depicted in Figure 1, the path taken largely depends on the type of online classroom an educator chooses. There are many types of virtual delivery including: Synchronous Delivery, Asynchronous Delivery, Hybrid Delivery, and Online Laboratory. There is an abundance of research on the pros and cons of teaching synchronously and asynchronously (Bernard et al., 2009; Jordan et al., 2013; Pei and Wu, 2019) and a number of tools currently available to facilitate building of an online classroom (Figure 2).

- **Synchronous Delivery:** Traditional classroom delivery occurs when instructors interact with students during designated times on specific days. Video conferencing technologies such as Zoom, WebEx, or Microsoft Teams, for example, allow educators to maintain this model online. This format requires that each student have a computer or cell phone and a connection to the internet at the designated time. Synchronous delivery allows instant student engagement and allows instructors to pace course content and depth based on student reaction in real-time. The chat and “raise hand” functions of many of these technologies enable students to ask questions in a low-risk manner, and instructors can respond live and alter remaining class content as needed. Synchronous delivery in a virtual learning environment is not without distractions. There is, just as when attending a face-to-face lecture, an expectation of the students to listen and engage with the material. As with in-person classes, there are always students who are involved on their computers or cell phones in ways that are not part of the class. Moreover, the engaged student may have added challenges that come with a home office (or other makeshift learning environment). Another possible requirement of synchronous delivery of virtual content is availability of high-speed internet at designated times.

- **Asynchronous Delivery:** Courses with asynchronous delivery rely on LMS (virtual platforms that help faculty interact with students on and off campus), e-mails, and discussion boards that let students complete course requirements on their own time. The primary advantage of asynchronous delivery for both educators and students is the flexibility that comes with this type of delivery. Access to the course is available when it is convenient for both parties. Depending on the course, asynchronous delivery may also allow students to alter the pace of their learning. Students can move quickly through material that they have mastered in other courses or slow down to listen to segments of lectures that were confusing or more difficult to comprehend. These advantages are also the greatest disadvantages of asynchronous delivery. Not all students excel in a self-guided learning environment; many need the structure of a classroom environment and schedule to succeed. It may also be more difficult for instructors to identify if students are struggling with a concept. Asynchronous delivery also challenges educators to find novel ways to promote thoughtful discussion, a necessary component of critical thinking and learning.

- **Hybrid Delivery:** To capture the student engagement advantage offered by synchronous learning with the flexibility of asynchronous delivery, many animal science instructors have adopted a hybrid model. This model uses asynchronous delivery of some portions of course content, such as lectures and assignments. Other portions, such as “meet-up” sessions are available at designated times to provide...
touchpoints for instructors and students. Recorded sessions are available for students who did not attend at the designated time. It also allows students to access and review content that was delivered live.

- Online Laboratory Classrooms: Laboratory classes are far more difficult to move online compared with the lectures. Most animal science departments take pride in their experiential learning activities, which are not easily replaceable with online learning exercises. However, requirements to decrease transmission of COVID-19 necessitated the move of laboratory classes online. Ease of transition to an online format is highly dependent on laboratory subject matter. An applied nutrition lab focused on diet formulation or a math-based genetics lab may be much easier to deliver online compared with introductory animal science or animal production laboratories, which traditionally have significant components of hands-on learning. Virtual tours of farms or detailed videos showing dissection of a rumen, for example, have been used as replacement exercises. To keep students engaged, educators should make the online laboratory as interactive as possible (Radcliffe, 2020). For instance, limiting video clips to short segments creates a natural break where students can engage through questions and discussion prior to moving on (https://www.purdue.edu/innovativelearning/teaching-remotely/).

The success of online instruction for tasks or concepts more easily mastered using hands-on techniques is relatively unknown. In a recent study, first- and second-year veterinary students learned online to administer a corneal nerve block...
(CNB) in dairy calves prior to dehorning. Although those students who learned online were just as effective in administering the CNB compared with the group that received hands-on training, they were less confident and had poorer technical skills (Winder et al., 2017). The authors go on to state that “while online training is not recommended as a sole method of instruction, in the absence of available hands-on training it may be a suitable alternative method.” Technology will no doubt become increasingly important in online laboratory experiences as state-of-the-art 3-D interactive modules and/or simulators become available.

Most animal science faculty moved quickly to asynchronous delivery of classes because it was the easiest and fastest method to adopt, and arguably the most convenient for students. However, as COVID-19 quickly drives the development of new technology for online education and pushes educators to learn how to use the available online technologies (Figure 2) increased adoption of synchronous active online classrooms is likely (Reimers and Schleicher, 2020).

Teaching, like any skill, takes time and practice to develop. Effectively teaching in a virtual environment will also take time to develop. For the most part, universities have allowed professors to decide if or when they would like to develop this skill set but studies show that before COVID-19 only 9% of instructors preferred online to in-person teaching (Pomerantz and Brooks, 2017). COVID-19 will require almost all teachers to develop this skill set. How does the virtual classroom affect faculty that cannot adapt to the changes? Will retirements and resignations of talented teaching faculty be more commonplace? Will there be long-term changes in who is attracted to teach at a university?

Additionally, while there has been a great deal of emphasis on learning to teach online, the flip side is will students be able to learn virtually? Some students will adapt quickly, and some will not. Research demonstrates that marginal students will have the most difficult time adapting to online learning (Xu and Jaggars, 2014). These results, coupled with changes in learning system availability, will inadvertently shift student populations.

To gauge how students were coping with the sudden switch to online instruction, an online assignment was given to students in Dr Jodi Sterle’s ANS 211: Issues Facing Animal Science course at Iowa State University and in Dr Scott Radcliffe’s ANS 324: Applied Nutrition course at Purdue University. Students were asked to submit responses to only the questions they felt comfortable answering. Only a “complete/incomplete” grade was given, and as long as a student answered something, it was considered “complete.” Students in Dr Sterle’s class are mostly sophomores, and most, but not all, were Animal Science and Dairy Science majors. The students in Dr Radcliffe’s class were mostly juniors and seniors and most were Animal Science majors. This exercise was meant to be only a check-in to see how students were doing and an opportunity to reflect on their current experiences. Students were very honest and forthcoming, as well as compassionate and appreciative of their instructors’ efforts to move to online quickly. Seven main themes emerged (Appreciation, Hands-on Learning, Retention, College Experience, Motivation, Workload, and Understanding) and these themes are depicted in Figure 3. Not necessarily denoted in Figure 3 was the overwhelming sentiment from Dr Sterle’s students that they retained less material and the sentiment from Dr Radcliffe’s class that the course was heavily dependent on online technologies before the shift helped.

### Testing and Assessment

Assessment of a student’s understanding of the subject matter has been one of the biggest challenges as educators moved to online courses because students are unsupervised and have unlimited access to the internet. Additionally, educational scientists have spent time studying best practices for online assessment (Diamadis and Polyzos, 2005), but in the rapid movement associated with COVID-19 few educators spent significant time evaluating their options. Online testing will continue to be a challenging area moving into the future. However, there are several options that are continuously evolving:

- **Integrity pledges:** Many universities already have or are adopting some form of academic integrity pledge that the students must sign prior to taking an exam.
- **Test alternatives:** Assessments of what a student “knows” may also look different in the future compared with the
standard written exam. Educators will adopt alternative approaches to assess a student’s knowledge where appropriate. Some examples might be a written “essay” assignment, preparation of a video summarizing a concept, or an online oral presentation.

- Open-book exams: In this case, instructors will accept that students have access to the material they would previously have had to memorize and open-book exams that concentrate on application of information will be used. When objectives are clear, open-book exams can be more challenging for students than traditional closed-book exams (Green et al., 2016).
- Online testing and proctoring tools: Proctoring systems have the capability to fully display an exam on a computer monitor and prevent the opening of additional windows. Students are locked out of an exam if they try to open another window on their computer. Some systems even prevent the use of other devices registered to the same student.
More advanced systems offer online video proctoring if so desired. Online proctoring systems tend to be successful at reducing cheating and assuring student compliance but have been met with skepticism by students who view them as intrusive, potentially discriminatory and an additional cost (Dimeo, 2017).

Adequate testing and assessment techniques have been difficult to implement in the switch to an online classroom. However, future online and virtual testing capabilities that are both flexible and secure are likely to be incorporated into virtual and traditionally taught classes.

**Advising and Mentoring**

Many universities were already offering online meetings as an option for meeting with advisees, while others quickly migrated to online meetings. Advising challenges include scheduling meetings, reminding students about meetings, and keeping students. The online meeting platform must be Family Educational Rights and Privacy Act (FERPA) compliant and the advisor must be aware of data that can and cannot be shared.

The impact that animal science educators make on their students go beyond teaching various disciplines and extend to roles as advisors, mentors, and on some levels, as confidantes. In the procession towards digital teaching platforms, it will be imperative to identify methods that maintain the critical interpersonal interactions that allow animal science educators to serve a multitude of roles.

**Equity and Inclusion in a Digital Age**

Within the last decade, higher education has made a real and lasting effort to enhance equity and inclusion (Proctor, 2005; Anderson, 2019). A complete discussion on the potential switch to a virtual classroom today must address the issue of equity and inclusion in the virtual space. However, as none of the authors of this paper are experts in this area, they recognize that the equity and inclusion issues observed in the transition to virtual classrooms are important issues that must be discussed at the highest levels of the university system. One arbitrary grouping of students observed in animal science departments by these authors included 1) rural students, 2) students who left university and added additional jobs, 3) urban students, and 4) first-generation students. Interestingly, although these four groups represent different demographics, students struggled with the same issues: lack of access to a computer, lack of adequate internet access and/or a safe supportive learning environment, and additional responsibilities that reduced time available for studying.

As an example, when the COVID-19 crisis dictated virtual classrooms, many students returned to family homes in the midst of spring calving or planting season. Suddenly, many students were working 8- to 12-hour days on the ranch or farm before beginning their studies for the day. Additionally, many students already struggle to balance part-time jobs with coursework when they are living on campus and have structured schedules. The self-discipline necessary to focus on college content may become even more difficult when living at a family home with potential work hours doubled or tripled. It is

![Figure 4. Availability of high-speed internet by county across the U.S. Federal Communications Commission (2017).](https://example.com)
Example 1: Movement of a Sophomore-Level Nutrition Class from Hybrid to Fully Online

Dr Jones’ lecture-based, sophomore-level nutrition class was already using a hybrid model of instruction. Before the COVID-19 pandemic, Dr Jones delivered content live to students in a lecture hall on designated times and days but allowed students to access the class on Zoom. She started using this instruction protocol in Spring 2019, when several winter storms closed local schools but the University was not closed. Some students felt unsafe traveling to class on icy roads. Feedback revealed that many nontraditional students particularly appreciated the flexibility of having a Zoom link because they were traveling from a nearby military base or had young children. This year, Dr Jones also posted a video recording within 24 hours of a lecture to the class Learning Management System so students could watch lectures, if they missed class due to judging competitions, illness, or family/military obligations. She was surprised to find that having Zoom available live or as a recorded lecture had little impact on class attendance, but she recognizes that may be different for a class offered at 8:30 a.m. instead of 11:30 a.m. In response to the university movement to continuous virtual learning in March 2020, Dr Jones shifted her class to asynchronous delivery, but maintained a Wednesday “meet up” session for students that wanted to ask questions or go over specific material. After the first exam, when several students underestimated the studying needed to answer 30 questions in 60 min in an open-book, online exam, Dr Jones also began a live Kahoot session to help students better assess their mastery of material.

Example 2: Movement of Research Methods in Applied Biology in Canada (Adapted with Permission from von Keyserlingk, 2020)

At the beginning of the COVID-19 pandemic, Dr von Keyserlingk (University of British Columbia) moved a Research Methods in Applied Biology course fully online. Students who are thinking about whether to complete an undergraduate thesis in their final year or are simply interested in research take the course. The course is grounded in experiential learning. Students identify and collaborate with a scientist/researcher working in an area of the student’s interest. During the term, students volunteer a minimum of 20 hours with the scientist and work on a research project. Although most researchers are located on campus, over the past decade the virtual world has helped expand the areas in which students identified researchers as potential mentors. For instance, this past year one student was interested in working on biomechanics of horses and found a scientist working on this subject in the United Kingdom, while another student found someone studying penguins on an island off the coast of Argentina. In these cases, the students engaged in research through data entry tasks, scoring of videos, or other tasks needed by the researcher.

Much of this course required peer-to-peer review of the various required assignments (e.g., preparation of a poster summarizing some of the research done in their mentors’ laboratory). The breakout room tab on Zoom was a lifesaver as we were able to put students into small groups of 3 to 4 to allow for peer-review of their posters. Within each breakout room, students shared their...
screens one at a time and requested critical feedback from their colleagues. This was then followed up by each student presenting the final version of their poster a week later using Zoom—our attempt at providing the virtual equivalent of an undergraduate student poster session at a conference. In the voice of one of the students it was clearly a success: “The online poster presentation was a rare and valuable opportunity to be treated as a scientific equal as an undergraduate.” (Student, APBI 398, April 2020)

unrealistic to expect that a student will be able to focus only on their education in a society where social distancing, increasing unemployment, and agricultural supply chain issues will be the norm for the foreseeable future. Additionally, as the economic ramifications of the COVID-19 pandemic become clearer and students realize that education may be less expensive not living on campus, it is likely that many animal science students will elect to stay and learn while living at a family home versus return to “brick and mortar” university systems. The potential loss of this group of students must be addressed. The challenge of retaining these students is further exacerbated by the fact that even the most dedicated scholars may be limited by access to technology and high-speed internet when living on a farm or ranch in rural areas (Figure 4; https://www.fcc.gov/reports-research/maps/connect2health/#ll=41.22274,-96.269529&z=4 &t=broadband&bbm=fixed_access&dmf=pop_urbanruralS0_50&zlt=county). Anecdotal reports by animal science faculty concerning students who left campus, indicate there are many people who download lectures or take exams in the parking lots of fast-food restaurants because of limited broadband speed in their own homes. Animal science educators must be cognizant of all these challenges so COVID-19 does not become the justification for widening the achievement gap between different student groups (Figure 5, Marré, 2017).

Conclusions

Because of the rapid nature of the change to a virtual teaching landscape in response to the COVID-19 pandemic, this article focuses on the rapid move to virtual classrooms, leading to a more important question: What will animal science classrooms look like in the future?

• The virtual portions of animal science courses will be greatly enhanced. This was likely to occur with or without the COVID-19 pandemic, but the pace of this change will be increased.
• Animal science departments will recover from changes imposed by the COVID-19 pandemic with a greater understanding and appreciation of digital teaching tools. As a result, instructors will be able to spend time incorporating these tools into their classrooms in productive and complementary ways.
• Instructors of animal science courses will view face-to-face instruction as more valuable, utilizing online tools to enhance face-to-face interactions.

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• Quality virtual classrooms may work better for some subjects and provide different opportunities for some students, resulting in creation of more courses that are 100% online and cater to those students.
• Some subjects and students may require movement of the virtual environment to a different space than currently envisioned.
• Collaboration across universities may be used more frequently to teach core online classes. Experts within a subject area may be brought together from different institutions, resulting in a course that is better than anything that could have been developed individually.

This article covers the changes that were made in the move to online instruction and the associated difficulties associated with those changes. While difficult, the challenges met and overcome represent extraordinary opportunities to animal science departments as they move to virtual environments.

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Perspective

Perspectives for the future in China: challenges and opportunities facing animal teaching, research, and industry

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The Current Situation

Following more than 20 years of rapid development, China is the largest producer of meat and eggs and the third-largest producer of milk in the world. Since 2016, the animal industry in China has reached a plateau in which the yields of meat, eggs, and milk increased by no more than 3% per year (Department of International Cooperation and Agricultural Trade Promotion Center, Ministry of Agriculture and Rural Affairs of People’s Republic of China, 2018). Meanwhile, in contrast to pursuing a large annual output of animal products, the Chinese government has increasingly emphasized the establishment of rules and regulations, as well as standards to push the industry toward sustainable, efficient, and environmentally friendly production of safe, high-quality animal products. According to a personal survey of the enterprises, producers are required to spend about 10–14 million RMB (approximately 1.4–2.0 million US dollars), which is equivalent to 20% of the total investment on infrastructure and facilities of a pig farm with a size of 500 breeding sows to comply with environmental protection regulations. This capital requirement also poses a high financial threshold for new investors. Chinese (mainland) imports of livestock and poultry products reached 36.2 billion U.S. dollars in 2019 (National Bureau of Statistics of China, 2019). The Sino-U.S. trade agreement, signed on January 15, 2020, will result in an increased volume of imported livestock and poultry products (more than 10 billion U.S. dollars of meat, milk, and egg products) appearing on the Chinese domestic market with a competitive edge on price (Office of the U.S. Trade Representative, 2020). This added volume will substantially increase the competitive pressure on the Chinese livestock industries.

More importantly, animal disease epidemics heavily depress the development of a sustainable animal industry in China. For example, the spread of African swine fever (ASF) in China since 2018 caused producers to lose tens of billions (U.S. dollar) losses during 2019. In addition, hundreds of pig farms, especially mid- and small-sized farms, went out of business.

The Opportunities for Education

To strengthen the ability of agricultural industries to withstand risk, more companies are beginning to integrate the feed industry, animal husbandry, and processing. Only powerful and integrated companies, along with some unique mid- and small-size enterprises, can survive and attain profit in China. However, many young people prefer to move to urban areas to enjoy a convenient lifestyle rather than work on remote and isolated farms, causing a deficiency in farm labor.
throughout China. Considering the huge demands for qualified employees with well-trained professional knowledge, skills and interdisciplinary background, employers are willing to offer high salaries to qualified employees. Unfortunately, the candidates with a traditional background in animal science regardless of degree are at a relative disadvantage when applying for these high-salary positions due to the absence of cross-disciplinary training.

To strengthen the graduates’ abilities to deal with challenges and cooperate with colleagues from across branches in integrated enterprises, designing the animal science curriculum and supporting courses for the future has become a primary issue. Establishment of new courses reflecting the transformation of the industry to develop students with the following abilities would be welcomed.

1) Application of artificial intelligence in the animal industries;
2) Understanding experimental design, statistical analyses, interpretation of data, and scientific communication skills (oral and written);
3) Training in biotechnology, including cell and molecular biology, genetic engineering, and fermentation engineering;
4) Expertise and skill in nutritional strategies to keep animals healthy, minimize agricultural environmental impact and emissions, and promote production efficiency;
5) Skills in control and prevention of infectious diseases;
6) Animal product quality control and monitoring;
7) Design of animal husbandry buildings and auxiliary infrastructure, including design of facilities, feed processing and conveyor systems, environmental control systems, and other engineering skills;
8) Excellent interdisciplinary background covering animal husbandry, veterinary science, feed processing, environmental monitoring, financial accounting and analysis, and so forth.

The Opportunities for Research

The Chinese government also annually identifies scientific issues on the frontiers, including the common problems impacting the development of animal industries. They also create funding for projects addressing these priority issues through the National Natural Science Fund or other projects of national scientific programs.

Issues concerning the development of animal genetic resources and breeding, control and prevention of epidemics, feed production/processing/efficient utilization, animal immunity, environmental stress and animal health, animal nutrition, application of artificial intelligent in the animal industry, animal waste processing and environmental protection, and animal behavior and animal welfare attract more financial support than has previously been available from the government and from the industries.

According to the Statistical Bulletin on National Investment in Science and Technology for 2018 (National Bureau of Statistics of China, 2019), the total expenditure of research and development in China reached 1,967.8 billion RMB (approximately 281 billion U.S. dollars), which is an 11.8% increase. Expenditures on basic research were more than 109 billion RMB (approximately 15.6 billion U.S. dollars). The ratio of research and development expenditure to gross domestic product increased by 2.19%, bringing the average level of Organization for Economic Cooperation and Development (OECD) close to 2.37% but yet far below than that of 2.79% in the United States. However, as one of three main funding recipients, Chinese universities received 7.4% of total
research and development expenditures, ranked after industries (more than 77%) and state-run institutions (13%).

The government understands that investment in high-level scientific research activities of animal science and development of the full-fledged potential and ability/skills of students who will have careers in animal husbandry and related works is money well spent. Additionally, university administrators must do their best to provide facilities that encourage faculty and students to upgrade student skill sets for professional careers of the future because employment opportunities exist for well-trained graduates (Figure 1). To facilitate effective research in the field of animal/veterinary science, adequate project funding, maintenance of infrastructure, including animal research farms and well-equipped laboratories, and well-trained technicians are also needed.

**Conclusions**

In summary, it is of great importance for the university education system in China to cultivate students with professional knowledge and know-how to serve the rapidly transforming animal industry. This must be done by increasing the needed funds to promote multidisciplinary training and high-quality scientific research activities.

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CSAS Society News

Presidents Message

Despite these unprecedented times, animal scientists around the world are still working diligently to maintain high quality animal research. In the spirit of looking forward, the Canadian Society of Animal Science is pleased to present the April issue of Animal Frontiers, showcasing seven review articles giving a glimpse of how phenomics will impact livestock production in the future. The contributions from Africa, Europe, Asia, and the Americas provide a global perspective of how livestock scientists view the automation of phenotype recording. We hope you enjoy this special issue celebrating the 10th anniversary of Animal Frontiers!

Stay safe and healthy,
Christine Baes, on behalf of the Canadian Society of Animal Science Executive

CSAS Student Competitions at the 2020 ASAS-CSAS Joint Annual Meeting

It is with regret that we advise that the Canadian Society of Animal Science Graduate Student oral and poster competitions at the 2020 ASAS-CSAS Joint Annual Meeting in Madison, WI were cancelled due to increased COVID-19 concerns. This decision was based on travel restrictions in place, uncertainty around when restrictions may end, as well as announced changes to the conference from ASAS regarding virtual and in-person options for attendance and presentation.

We hope that students will still consider submission of their abstracts to the 2021 meeting and encourage all 2020 conference attendees to visit the website for alternatives for potential symposia and presentation formats (www.asas.org/meetings/annual-2020).

We look forward to providing a quality student competition at the 2021 ASAS-CSAS Joint Annual Meeting.

Upcoming Events

| Date           | Event                                                                 | Location                        |
|----------------|----------------------------------------------------------------------|---------------------------------|
| 19/07/2020 – 23/07/2020 | American Society of Animal Science / Canadian Society of Animal Science Annual Meeting | Monona Terrace Community and Convention Center, Madison, WI |
|                | CSAS AGM & Lunch: Wednesday, July 22, 12:30 – 2:00 PM                |                                 |
|                | CSAS Awards Banquet: Wednesday, July 22, 6:00 – 9:30 PM               |                                 |
|                | CSAS Member Mixer: Wednesday, July 22, 9:30 PM – 12:00 AM             |                                 |
| 20/07/2020 – 23/07/2020 | 2020 Poultry Science Association Annual Meeting Louisville, Kentucky |                                 |
| 23/07/2020 – 25/07/2020 | MeatEx Canada [Canada International Meat Exhibition], Toronto, Ontario |                                 |
| 11/08/2020 – 13/08/2020 | Canadian Beef Industry Conference Penticton, BC                       |                                 |
| 31/08/2020 – 04/09/2020 | 71st Annual Meeting of the European Association of Animal Science Porto, Portugal |                                 |
| 06/10/2020 – 08/10/2020 | 2020 Poultry Science Association Latin American Scientific Conference Paraná, Brazil |                                 |
| 09/11/2020 - 10/11/2020 | AIC 2020 Conference - Investments in Agri-food Research and Innovation |                                 |

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EAAP is the International Federation of Animal Science for Europe and the Mediterranean area. Join EAAP and become member of the most exciting international animal science network and then have access to many services that are indispensable for every animal scientist worldwide.

THE 71st EAAP ANNUAL MEETING WILL BE HELD IN PORTO (PORTUGAL) FROM 31st AUGUST TO 4th SEPTEMBER 2020

After 32 years, Portugal has the honor to once again host the annual EAAP meeting, this time in the fabulous city of Porto. Topics for the meeting include the societal challenges of animal production in a growing world, sustainability of livestock production systems, feeding the world and ensuring resource efficiency and sustainability, technology in animal production, mountain farming systems, adaptations to climate challenges, and animal product quality and safety. The Plenary Session will focus on: the responsibility of animal production and climate change. This year 1,500 abstracts were submitted to the EAAP annual meeting—a record high!

The EAAP Annual Meeting provides an opportunity for the application of new ideas through parallel sessions, a plenary meeting, and poster presentations about scientific achievements in global livestock production. In a unique discussion forum, the research community meets with the industry, to plan for how to address the multiple challenges that will be faced by the animal science sector in the future.

A vast and excellent social program throughout the week is planned, starting with the welcome ceremony, an unforgettable Portuguese night, a gala dinner, as well as great technical tours and accompanying persons program.

The lead organizer is the Portuguese Association of Animal Science (APEZ), with the patronage of the Ministry of Agriculture, Rural Development and Fisheries from the Portuguese Government.

Conference local organizers: geral@apez.pteapap2020@skyros-congressos.com

Porto 2020 Annual Meeting in Relation to the COVID-19 Situation.

For updated information and decisions about the 2020 EAAP meeting and the current situation regarding the COVID-19 pandemic, please visit www.eaap2020.org and www.eaap.org

INDIVIDUAL MEMBERSHIP OF EAAP

The EAAP membership is open to all scientists. It is a great opportunity to be up-to-date on the latest publications and other relevant information in the animal sector. EAAP has more than 4000 members already! Join us at http://www.eaap.org/Content/Individual_Member_Information.html
### 2020 ASAS NATIONAL AWARD RECIPIENTS

| Award                                                        | Recipient                                      | Institution                                      |
|--------------------------------------------------------------|------------------------------------------------|-------------------------------------------------|
| AFIA Nonruminant Nutrition Research Award                    | CHARLES NYACHOTI                              | University of Manitoba                          |
| AFIA Ruminant Nutrition Research Award                       | TERRY ENGLE                                   | Colorado State University                       |
| Agri-King Outstanding Graduate Student Award                 | AHMED ELOLIMY                                 | University of Arkansas                          |
| Animal Growth and Development Award                          | LUIS TEDESCHI                                 | Texas A&M University                            |
| Animal Industry Innovation Award                              | JASON WOODWORTH                               | Kansas State University                         |
| Animal Management Award                                       | REINALDO Cooke                                | Texas A&M University                            |
| Animal Physiology and Endocrinology Award                     | MILO WILTBANK                                 | University of Wisconsin - Madison               |
| ASAS Fellow-Administration                                   | MARK MIRANDO                                  | USDA-NIFA-AFRI                                  |
| ASAS Fellow-Extension                                        | DANIEL SCHAFFER                               | University of Wisconsin - Madison               |
| ASAS Fellow-Industry                                         | DANIEL BENZ                                   | US Food and Drug Administration, Center for Veterinary Medicine |
| ASAS Fellow-Research                                         | MIKE TOKACH                                   | Kansas State University                         |
| ASAS Fellow-Teaching                                         | ROBERT COLEMAN                                | University of Kentucky                          |
| ASAS Retiree Service Award                                    | JACK BRITT                                    | Jack H Brit Consulting and Earthcast Technologies, Inc. |
| Bouffault International Animal Agriculture Award              | JAMES REECEY                                  | Iowa State University                           |
| Corbin Award in Companion Animal Biology                     | MARIA DE GODOY                                | University of Illinois at Urbana-Champaign      |
| Gary L. Cromwell Award for Mineral Nutrition                  | JAMES MATTHEWS                                | University of Kentucky                          |
| Distinguished Teacher Award                                  | JEANNETTE MOORE                               | North Carolina State University                 |
| Early Career Achievement Award                                | ANGELA CANOVAS                                 | University of Kentucky                          |
| Equine Science Award                                         | ROBERT COLEMAN                                | University of Kentucky                          |
| Extension Award                                              | MATT POORE                                    | North Carolina State University                 |
| Joseph P. Fontenot Travel Scholarship Award                   | AUDREY EARNHARDT                              | Texas A&M University                            |
| L.E. Casida Award                                            | ROBERT WETTEMANN                              | Oklahoma State University                       |
| Meats Research Award                                         | CHRISTOPHER KERTH                             | Texas A&M University                            |
| Morrison Award                                               | TERESA DAVIS                                  | Baylor College of Medicine, Children’s Nutrition Research Center |
| Wilson G. Pond Travel Scholarship Award                       | ELIZABETH MESSERSMITH                         | Iowa State University                           |
| Wettemann Graduate Scholar in Physiology Award               | KACIE MCCARTHY                                | University of Nebraska-Lincoln                  |
| Rockefeller Prentice Award in Animal Breeding and Genetics   | KENNETH STALDER                               | Iowa State University                           |
| Wettemann Graduate Scholar in Physiology Award               | KELSEY SCHUBACH                               | Texas A&M University                            |