

Review

The History of the School of Animal Science at the University of Padova (Padua) and the Evolution of Animal Science in Italy

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Abstract: In its 800-year history, the University of Padova (Padua, Italy) has come to play an important role in the development of animal science in Italy and Europe. Having founded the oldest university botanical garden (1545; UNESCO World Heritage Site) and anatomical theatre (1595), and awarded the first university degree to a woman (Elena-Lucrezia Cornaro-Piscopia, 1678), the University instituted the Public School of Agriculture (*Orto Agrario*) in 1765 and the *Collegium Zooiaticum* in 1773. Between 1986 and 1995, under the leadership of Professor Mario Bonsembiante, animal scientist and rector, the scientific-technological center of Agripolis was established, including the Faculties of Agriculture and Veterinary Medicine (with the experimental farm and veterinary hospital), the *Istituto Zooprofilattico delle Venezie*, and *Veneto Agricoltura*. Agripolis rapidly became the most innovative center in Italy for teaching, research, and extension services in the fields of agricultural, animal, veterinary, food and environmental sciences. In the last 35 years, the number of Italian animal scientists has remained almost constant, but they have moved on to more innovative research topics closer to society's demand and concerns, and significantly enhanced their international standing, reaching the first position in Europe and the fourth in the world in terms of citations.

Keywords: zootechnics; animal research; bibliometric analysis; animal scientists; research topics; farm animals; animal foods; environment

Citation: Bittante, G.; Bailoni, L.; Cecchinato, A.; Gallo, L.; Mantovani, R.; Ramanzin, M.; Zampieri, F.; Schiavon, S.; Sturaro, E. The History of the School of Animal Science at the University of Padova (Padua) and the Evolution of Animal Science in Italy. *Agriculture* **2022**, *12*, 902. <https://doi.org/10.3390/agriculture12070902>

Academic Editor: Vincenzo Tufarelli

Received: 14 May 2022

Accepted: 18 June 2022

Published: 21 June 2022

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1. Introduction

The history of the University of Padova (Padua, Italy) is not well known internationally because most of the information is in Italian, thus limiting its accessibility. Yet it has played a key role in the cultural development of Europe in several disciplines for centuries.

The role the University of Padova played in the field of animal science was in the past even less well known. In recent decades, however, the Paduan school of animal science has now attained national and international renown thanks to international databases.

Founded in 1222, the University of Padova celebrates its 800 years of history in 2022. As part of the celebrations, the animal scientists in the various departments of the University organized the 24th Congress of the Italian Animal Science and Production Association (ASPA) in Padova (21–24 September 2021). As president of the Scientific Committee (with the major collaboration of Maurizio Ramanzin, Alessio Cecchinato, and

Stefano Schiavon), Giovanni Bittante was asked to give an invited lecture on “Italian Research in Animal Science: from ASPA-Padova-1987 to ASPA-Padova-2021 and beyond”. As president of the organizing committee, Lucia Bailoni (with the major collaboration of Roberto Mantovani, Luigi Gallo, and Alessio Cecchinato) gave a brief presentation of the history of animal science at the University of Padova, and Fabio Zampieri gave a general history of the University. These presentations formed the basis of the present article.

2. The History of Animal Science and the Agricultural and Veterinary Institutions in Padova

According to a legend recounted by Titus Livius (Livy, born in Padova in 59 BC), the city of Padova was founded in 1183 BC by the Trojan hero, Antenore [1]. The earliest archeological remains of the Veneti population excavated in Padova date back to around the 11th to 10th centuries BC.

The city became an ally of Rome and was gradually integrated into the Republic with the Latin name *Patavium*, becoming one of the wealthiest cities in the Roman Republic and Empire.

2.1. Middle Ages: Free Commune of Padova and the Carraresi Signoria

Padova became a leading Italian *commune* in the Middle Ages. Such was its cultural and religious importance in the 12th–14th centuries that the poets Dante Alighieri and Francesco Petrarca, and Saint Anthony of Padova spent long periods in or around the city. After his death in 1231, Saint Anthony was buried in the Basilica known locally as *Il Santo*. Aside from the Basilica, the artistic importance of medieval Padova can be observed in the city’s many frescoes, particularly those by Giotto, which merited Padova its UNESCO [2] World Heritage Status as the “*Urbs picta*” (painted city).

The University of Padova was founded in 1222 (Table 1) when a group of students and teachers from the University of Bologna (the world’s oldest university) decided to move to Padova in search of greater academic freedom (*libertas scholastica*). They established a free body of scholars, who were grouped into *nationes* according to their place of origin. Within these *nationes*, the students approved statutes, elected the *rettore* (rector, or chancellor), and chose their teachers, who were paid with money collected by the students. The defense of freedom of thought in study and teaching became a distinctive feature, which lives on today in the University’s motto: *Universa Universis Patavina Libertas*, i.e. Paduan freedom is universal for everyone.

Table 1. Chronology of the history of animal science, and of the Faculties of Agriculture and Veterinary Medicine in Padova, Italy.

Year	Historical Period		Ref
	Institution	Action	
<i>Free Commune of Padova:</i>			
1222	“ <i>Universitas Studii Paduani</i> ” — The University of Padova	Established; second in Italy after Bologna.	
<i>The “Serenissima” Republic of Venice:</i>			
1405	“ <i>Horto medicinale</i> ” — Botanical Garden	Established by University of Padova; first in the world.	[3]
1595	Permanent Anatomical Theatre	Established by University of Padova; first in the world.	
1762	“ <i>Cathedra ad Agriculturam Experimentalem</i> ” —Professorship in Experimental Agriculture	Awarded to Pietro Arduino by the University of Padova; the first in the world.	[4]

1765	Public School of Agriculture— “Orto Agrario”	Established by Professor Pietro Arduino; the first in Italy.	[4]
1769	Academy of Agriculture, Padova	Established; now the Galilean Academy of Science, Literature and the Arts.	[5]
1773	“Collegium Zooliatricum”, Padova	Established by Professor Giuseppe Orus; the second in Italy.	[6], [7]
1805	Kingdom of Italy (Napoleonic):		
1805	Public School of Agriculture “Orto Agrario”	Luigi Arduino, agriculturalist, appointed Tenured Professor of rural economy.	[4]
1805	Professorship in Veterinary Medicine	Abolished.	[6]
1813	Austrian Empire—Kingdom of Lombardy-Venetia:		
1817	Professorship in Theoretical and Practical Veterinary Medicine “Cathedra ad Agriculturam Experimentalem”	Established.	[6]
1819	Professorship in Experimental Agriculture	Abolished.	[4]
1866	Kingdom of Italy (Savoy dynasty):		
1867	“Regio Orto Agrario”	Merged with the School of Engineering.	[4]
1870	“Cattedra di Agricoltura” — Professorship in Agriculture	Abolished.	[8]
1873	Collegium Zooliatricum and Professorship	Abolished.	[6]
1925	“Regio Orto Agrario”	Transferred to a new location in Portello, Padova.	[4]
1928	“Regia Stazione Sperimentale di Pollicoltura”	Established in Rovigo.	[9]
1929	IZSve—“Istituto Zooprofilattico Sperimentale delle Venezie” (Italian authority and research organization for animal health and food safety)	Established in Padova.	[10]
1946	Republic of Italy:		
1946	Faculty of Agriculture, Padova	Established in the Porta Portello district by the University of Padova.	[8]
1951	IZ—Institute of Zootechnics, Padova	Established by the University of Padova under the direction of Professor Elvio Borgioli with Assistant Professor Mario Bonsembiante.	[8]
1987	7th ASPA Congress	Organized by IZ in Padova.	
1987	Mario Bonsembiante, Director of IZ	Elected Rector of the University of Padova.	
1989	AGRIPOLIS Campus, Legnaro-Padova	Approved by the Academic Senate.	
1991	Department of Animal Science, Padova	Formed out of the Institute of Zootechnics.	
1992	Faculty of Veterinary Medicine	Established;	[11]

		transferred to Agripolis in 1994.	
1994	Department of Animal Science	Transferred to Agripolis Campus.	
1995	Faculty of Agriculture	Transferred to Agripolis Campus.	
1995	IZSve—“Istituto Zooprofilattico delle Venezie”	Transferred to new headquarters at Agripolis.	[10]
1999	Regional Agency “Veneto Agricoltura”	Transferred to new headquarters at Agripolis.	
1997	University of Padova Botanical Garden	Declared World Heritage Site by UNESCO.	[3]
2012	School of Agriculture and Veterinary Medicine	Created from the two Faculties.	
2012	Department of Animal Science	Suppressed and divided into three departments: DAFNAE, MAPS and BCA.	
2012	DAFNAE – Department of Agronomy, Food, Natural resources, Animals and Environment	Established; most of the animal scientists move there.	
2012	MAPS—Department of Animal Medicine, Production and Health	Established; some of the animal scientists move there.	
2012	BCA—Department of Comparative Biomedicine and Food Science	Established; some of the animal scientists move there.	
2012-	DAFNAE	Ranked 1st department in Italy for quality of research by Italian Ministry of Universities and Research.	
2018	DAFNAE and BCA	Declared “Departments of Excellence” by the Italian Ministry of Universities and Research.	
2021	24th ASPA Congress	Organized by DAFNAE, MAPS, and BCA in Padova.	
2022	University of Padova	800-year celebrations	

Initially, law and theology were the subjects taught, but the range of disciplines soon expanded. In 1399, the institution was divided into two parts: a *Universitas Iuristarum* for civil law and canon law, and a *Universitas Artistarum* where astronomy, dialectics, philosophy, grammar, medicine, and rhetoric were taught. There was also a *Universitas Theologorum*, which had been established in 1373 by Pope Urban V.

2.2. The Renaissance: The “Serenissima” Republic of Venice

From the 15th to the 18th century, the University of Padova was renowned for its research, particularly in the areas of medicine, astronomy, philosophy, and law.

The Botanical Garden, established by the University of Padova in 1545 [12], is the oldest university botanical garden in the world together with the contemporary Botanical Garden of Pisa. It was dedicated, in particular, to the study of herbs (*hortus simplicius*), from which were extracted substances with pharmaceutical properties [3], but which were also used for human nutrition. In 1987, the University of Padova Botanical Garden was declared a “World Heritage Site” by UNESCO with the following statement: “The Botanical Garden of Padova is exceptional by virtue of its high scientific value in terms of experimentation, education and collection, and of its layout and architecture. Its herbarium and library continue to be among the most important in the world” [13] (Table 1).

Another outstanding Renaissance treasure at the University of Padova is the Anatomical Theatre, completed in 1595 [14]. The oldest permanent university anatomical theatre in the world, it figured significantly in the scientific discoveries of the Paduan school of human anatomists (Andreas Vesalius, Realdo Colombo, Gabriel Fallopius, Hieronymus Fabricius ab Aquapendente, Iulius Casserius, Johann Wesling, and Johann Georg Wirsung) [15,16]. However, the Paduan anatomists not only studied human anatomy but also developed comparative anatomy, the science of comparing the body structures of humans with other animal species (leading, e.g., to the discovery of blood circulation by William Harvey) [16]. In particular, Hieronymus Fabricius is considered one of the fathers of modern comparative anatomy [17].

The Paduan school of mathematics, physics, and astronomy was also highly renowned during the Renaissance, counting among its scholars famous scientists, such as Nicolaus Copernicus and Galileo Galilei.

The University of Padova is proud to have awarded the very first degree of Doctor of Philosophy to a woman (on 25 June 1678), the recipient being the Venetian noblewoman and mathematician Elena Lucrezia Cornaro Piscopia [18].

2.3. The Age of Enlightenment: The “Serenissima” Republic of Venice

The Age of Enlightenment coincides with the last century of the 1000-year history of the “Serenissima” Republic of Venice. It was an era that brought new scientific and cultural success to the University of Padova, and saw the foundation of institutions of agricultural science and veterinary medicine, and the development of animal science.

A further important advance was the development of anatomy in the 18th century, which investigated the correlations between alterations in body structures and clinical symptoms. The most important anatomist of this century was Giovanni Battista Morgagni (1682–1771), whose masterpiece *De Sedibus et Causis Morborum per Anatomen Indagatis* (1761) is a landmark in the field and marks the beginning of modern pathologic anatomy.

In the second half of the 18th century, the University of Padova invested in research in agriculture, livestock farming, and veterinary medicine. During this period, the Academy of Agriculture (1769) was also founded in Padova, which in 1997 became the Galilean Academy of Science, Literature, and the Arts (Table 1).

2.3.1. The Public School of Agriculture of Padova and Pietro Arduino

In 1762, the University of Padova established a new professorship in agricultural science, the “*Cathedra ad Agricolturam Experimentalem*”, the first in the world, and awarded the position to Pietro Arduino (Caprino Veronese, 1728—Padova, 1805) (Figure 1).

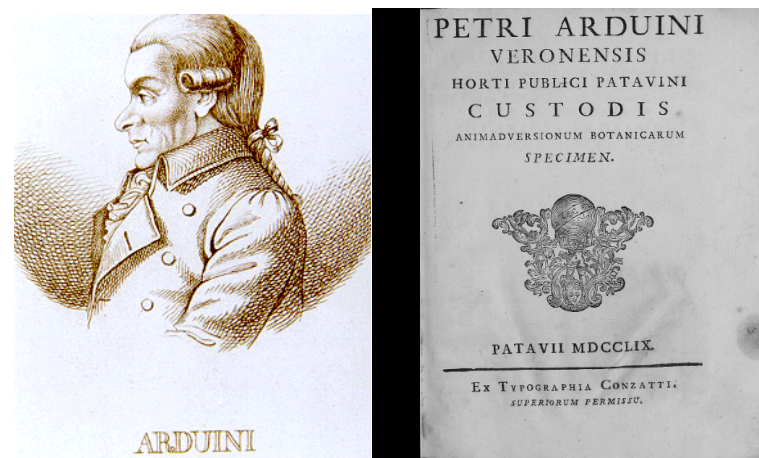


Figure 1. Pietro Arduino—*Petri Harduini* (1728–1805), “*Cathedra ad Agricolturam Experimentalem*” (Professor of Agricultural Science) at the University of Padova from 1762, founder of the Public

School of Agriculture “Orto Agrario” (1765) and his treatise “*Animadversionum botanicarum specimen*” (1759).

He was principally a botanist and wrote the two volumes that comprise the “*Animadversionum botanicarum specimen*” [19].

The University did not see its investment in agricultural sciences as confined to theory, but also extended it to experimentation and practice [20]. It therefore charged Pietro Arduino with setting up the new “Orto Agrario” (agricultural farm) in 1765 as the Public School of Agriculture’s main facility [4], and nominated him “*Horti Publici Patavini Custodis*”. In the following year, he published his book “*Memorie Di Osservazioni e Di Esperienze Sopra La Coltura e Gli Usi Di Varie Piante Che Servono o Che Servir Possono Utilmente Alla Tintura All’Economia, All’Agricoltura, Ec.* (Memoir of Observations and Experiments on the Cultivation and Uses of Various Plants that are Employed or That Could be Usefully Employed in Dying, the Economy and Agriculture, etc.) [21]. The Central Library of the Agripolis Campus (Legnaro, Padova) is now dedicated to the founder of the School of Agricultural Sciences of Padova (*Biblioteca Universitaria Pietro Arduino*).

2.3.2. The “Collegium Zooiaticum” of Padova and Giuseppe Orus

The “*Serenissima*” Republic of Venice decided to create a school of veterinary medicine and in 1770 awarded a grant to a young candidate, Giuseppe Orus (Parma, 1751–Padova, 1792), to train as a veterinarian in the recently created National Veterinary School of Alfort in France.

After graduating, he moved to Padova and created the “*Collegium Zooiaticum Patavinum*” (1773), which became part of the University of Padova in 1779 [7]. Giuseppe Orus was a distinguished researcher and a very active person, carrying out many studies and research activities in several countries and within the Republic of Venice. He died in 1792 at a young age, and the following year saw the posthumous publication of his treatise “*Trattato Medico-Pratico Di Alcune Malattie Interne Degli Animali Domestici* (Medical-Practical Treatise on Some Internal Diseases of Domestic Animals; Figure 2) [22].

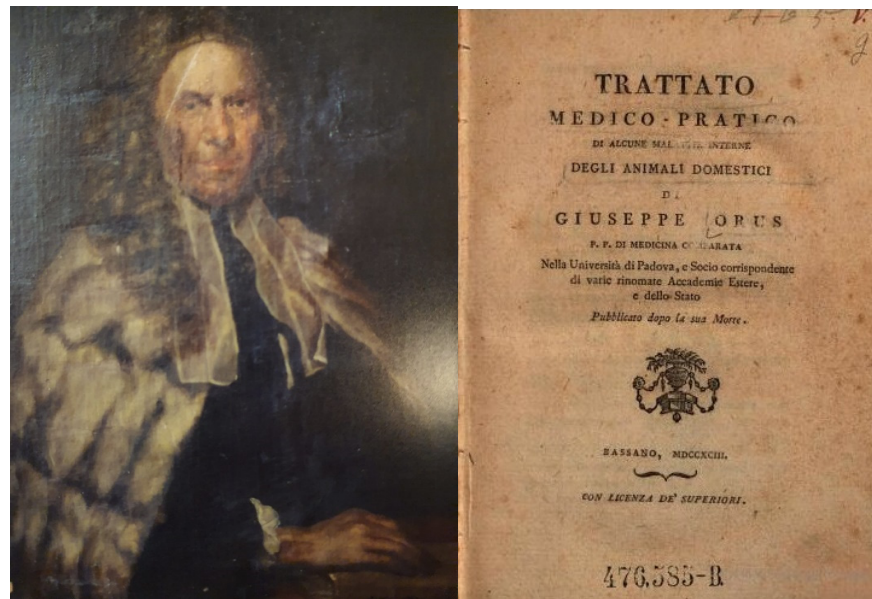


Figure 2. A portrait assumed to be of Giuseppe Orus (1751–1792), founder of the “*Collegium Zooiaticum*” of Padova, and his “*Medical-Practical Treatise of Some Internal Diseases of Domestic Animals*” published posthumously in 1793.

2.4. French Revolution and Restoration: The Napoleonic Kingdom of Italy and the Austrian Empire

The fall of the “*Serenissima*” Republic of Venice in 1797 marked the beginning of a dark age. Padova initially fell under the rule of the French (the Napoleonic *Regno d’Italia*, Kingdom of Italy), and then the Austrians (the Habsburg *Regno Lombardo-Veneto*, Kingdom of Lombardy and Venetia).

This was also a troubled period for the University of Padova and for its freedom of teaching. The *Orto Agrario* was maintained, and in 1805 (Table 1) it was placed under the direction of Luigi Arduino, son of the agriculturalist Pietro Arduino. The younger Arduino published a catalog of the crops cultivated in the *Orto Agrario* [23] and carried out several studies on various topics, which included the extraction of sugar from sugar cane and the cultivation of *Solanum* species.

Unfortunately, the professorship in Veterinary Medicine was abolished.

Later, during the Austrian domination, the professorship in Agriculture was abolished, although a new professorship in “Theoretical and Practical Veterinary Medicine” was instituted (Table 1).

2.5. The Modern Age: The Savoy Kingdom of Italy

A few years after the referendum, which resulted in the Veneto region joining the new Kingdom of Italy under the Savoy dynasty, the *Orto Agrario* was merged with the Faculty of Engineering (1867), while the professorships of Agriculture and Veterinary Medicine, and the *Collegium Zoiatricum* were abolished (Table 1). Over the late 19th and early 20th centuries, the University of Padova enlarged to include the Faculties of Engineering, Pharmacy, and Political Sciences along with its traditional Faculties of Law, Medicine, Arts and Philosophy, and Science.

The First World War saw heavy fighting in the Veneto region to the north of Padova, with severe economic, social, and environmental consequences. With the advent of fascism, the *Orto Agrario* was moved to a new site in the Portello district of Padova, while a new experimental station for aviculture was created in nearby Rovigo, and the *Istituto Zooprofilattico delle Venezie* was established in Padova (Table 1). However, under fascism the University’s values of free thought and cultural independence were seriously compromised. Its professors had to swear allegiance to the regime, and the passing of Italy’s racial laws and the expulsion of Jewish professors opened one of the darkest periods in the University’s history. Rector Concetto Marchesi shook the University from its slumber, and at the height of the Nazi occupation made a courageous appeal to the students to fight for the freedom of Italy. The University of Padova was awarded the Gold Medal for Military Valor for its resistance to the occupation, the only university in Italy to receive such an honor.

2.6. Contemporary Age: The Republic of Italy

During the post-war period, the University opened new faculties (Education, Agricultural Sciences, Psychology, Veterinary Medicine, and Economics and Business Administration) and produced great literary figures, such as Diego Valeri and Concetto Marchesi; engineers of the stature of Giuseppe Colombo, the “master of celestial mechanics”; the mathematician Tullio Levi Civita; jurists Alfredo Rocco and Livio Paladin; philosophers Luigi Stefanini and Enrico Opocher; and Doctor Vincenzo Gallucci, who carried out the first heart transplant in Italy.

The second half of the last century was also a period of student protests and political terrorism, and the University was left to deal with these serious problems without adequate help or support from central government. However, its increasing autonomy helped the University of Padova build a new cultural and scientific community comprising professors, staff, and students as well as the city and its province, which gradually allowed it to overcome these problems.

2.6.1. The Re-Founding of the Faculty of Agriculture

Soon after the end of the Second World War and the referendum that established the Republic of Italy, the University of Padova instituted the 4-year degree course in Agricultural Science (1946; Table 1), which was given full recognition by the Italian Government in 1951, 186 years after the founding of the Public School of Agriculture, the *Orto Agrario*. The new faculty was housed in buildings located close to the *Orto Agrario* in the Portello district of Padova. A new Experimental Farm was created in Legnaro (11 km southeast of Padova), where new facilities for agronomic and livestock research were built.

Mario Bonsembiante was in one of the first cohorts of young students embarking on their degrees in 1946. He became a student representative and accompanied the official Paduan delegation to Rome to obtain official recognition of the faculty from the Ministry of Universities and Research.

2.6.2. Mario Bonsembiante and the Founding of the Paduan School of Animal Science

Following its foundation, the new Faculty of Agriculture created a full professorship in General Zootechnics, and invited the famous animal nutritionist and geneticist, Professor Elvio Borgioli, from the University of Florence to take up the post. Professor Borgioli selected as his first assistant the young Mario Bonsembiante (1928–2009), who took over as Full Professor of General Zootechnics after Professor Borgioli return to the University of Florence in 1963.

Mario Bonsembiante [24,25] “was the founder of the University of Padova’s Institute of Zootechnics, which attained a solid scientific reputation, the Dean who modernized the Faculty of Agriculture, and the Professor who created a large academic school whose many students and collaborators are now working in research and education as full professors in four scientific sectors of four faculties of three universities”.

He was one of the founder members of the *Associazione Scientifica di Produzione Animale* (ASPA, 1973), and a member of the editorial board of the scientific journal *Zootecnica e Nutrizione Animale* (1975–2001), now the Italian Journal of Animal Science.

He was nominated by the Italian Ministry of Agriculture to the Central Technical Commissions of several Herd Books and of the Working Group for the National Plan for the Development of Biotechnology, and was a member of the European Union’s Beef Advisory Committee.

Mario Bonsembiante (Figure 3) wrote more than 250 scientific papers and 5 books, and coordinated large research projects. His main research activities [24] “during his long career were focused on the rumen and energy metabolism, the use of pasture, grass conservation, the effect of beta-carotene on the fertility of cows, the feeding and nutrition of monogastrics and ruminants, the development of intensive systems for poultry and beef production, the use of beef breeds in crossbreeding dairy cows, the control and synchronization of estrus in beef heifers and cows, the use of agro-industrial byproducts for suckler heifers and cows, agricultural systems in mountain areas and their interactions with the environment, food security and traceability, the retention and transfer of radioactive molecules in ruminants, the effects of sodium bicarbonate on the welfare and production of different animal species, and food supply to meet the demands of a hungry world. In later years Mario Bonsembiante was closely involved in the use and development of biotechnologies in the agri-food sector”.

For his distinction in various fields, Mario Bonsembiante received the Award for Science from the President of the Italian Republic, the Gold Medal from the Ministry of Public Education, as well as other important prizes and awards.

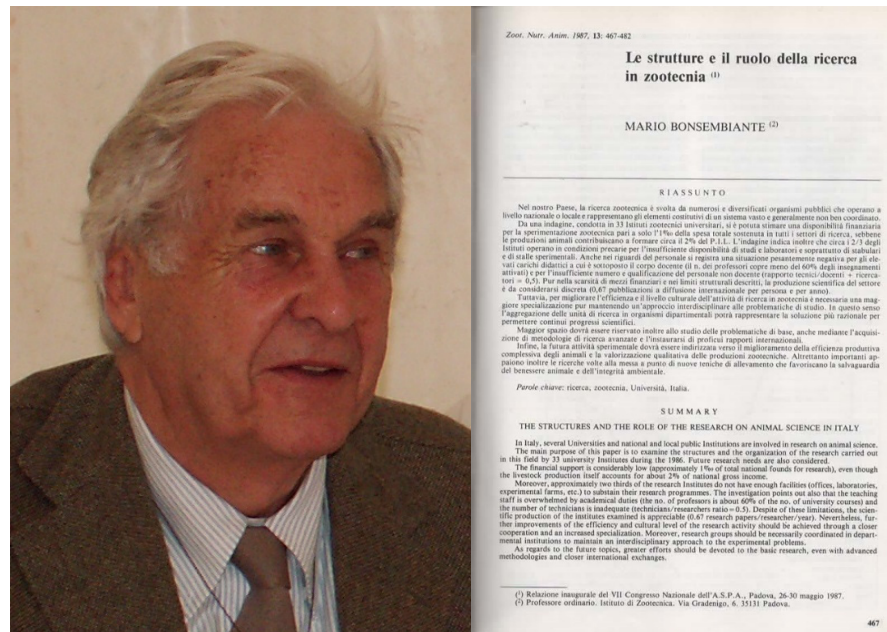


Figure 3. Mario Bonsembiante (Padova 1928–Padova 2009), Emeritus Professor of General Zootechnics, director of the Institute of Zootechnics (for 20 years), Dean of the Faculty of Agriculture (for 8 years), Rector of the University of Udine (2 years), Rector of the University of Padova (for 6 years), founder of the Agripolis Campus and the Faculty of Veterinary Medicine, and his inaugural lecture of ASPA-Padova-1987 congress [26].

2.6.3. Mario Bonsembiante and His Dream of the Agripolis Scientific and Technological Center

Two months after the ASPA-Padova-1987 Congress, Mario Bonsembiante was elected Rector of the University of Padova for a three-year term, then re-elected for a second term three years later. He is known as the Rector who modernized the University towards autonomy [27]. He also dreamed of a new scientific-technological center for agriculture, food, the environment, and veterinary medicine. This was to be not just a university campus, but an organism involving the regional and national governments, producers' associations and private companies. The project was named *Agripolis* ('city of agriculture') and was approved by the Academic Senate. Some of the fields belonging to the University's Experimental Farm in Legnaro were chosen as the site for the new complex. During his 6-year rectorate, Mario Bonsembiante raised most of the funds needed and was the key driver in establishing the *Agripolis* university campus. He also persuaded the Veneto Regional Government to move the Regional Agricultural Agency (*Veneto Agricoltura*) to a large new building in *Agripolis*, and to restore a nearby old Benedictine Closter to hold meetings and training courses for farmers and technicians. *The Istituto Zooprofilattico delle Venezie*, the Italian north-east authority and research organization for animal health and food safety, also decided to transfer their headquarters from Padova to *Agripolis*. Figure 4 shows an aerial view of the *Agripolis* campus.



Figure 4. Aerial view of the scientific and technological center *Agripolis*, which includes the University Campus of the School of Agriculture and Veterinary Medicine. The photograph shows the *Stecche* (the two buildings on the left, housing mainly DAFNAE and TESAF), the *Pentagono* (lower center left; teaching rooms and the *Pietro Arduino* central library), the Veterinary Hospital, MAPS and BCA (the group of buildings upper center-left), the *Ca' Gialla* and students' services (canteen, offices, teaching rooms, apartments; the two buildings in the lower right-hand corner), the fields of the Experimental Farm (upper area; the buildings housing the animal facilities are not visible), the regional government agency *Veneto Agricoltura* (the curved building lower center), and the *Istituto Zooprofilattico delle Venezie* (the 5 buildings upper right). The old Benedictine Closter (teaching rooms, research labs and student accommodation) is not visible.

2.6.4. Mario Bonsembiante and the Re-Founding of the Faculty of Veterinary Medicine

Following approval by the Academic Senate of the University of Padova, under the rectorate of Mario Bonsembiante, and by the Italian Ministry of Universities and Research, the new Faculty of Veterinary Medicine was established in 1992, i.e., 219 years after the founding of the "*Collegium Zoiatricum*" (Table 1). After two years based in Padova, in 1994, its first Dean (Professor Giovanni Bittante) transferred the faculty to Agripolis, sharing facilities with the Faculty of Agriculture. In the following years, new buildings were erected to house the Educational Museum of Veterinary Medicine and the Veterinary Hospital. A new building accommodating both teaching and research facilities is expected to be completed by 2024.

In 2012, the Faculty of Veterinary Medicine, together with the Faculty of Agriculture, was absorbed into the School of Agricultural Sciences and Veterinary Medicine, which comprised two departments: the Department of Animal Medicine, Production and Health, and the Department of Comparative Biomedicine and Food Sciences. In 2000, 2010, and 2020, a team of experts from the European Association of Establishments for Veterinary Education (EAEVE) comprehensively assessed the general organization, content and objectives of the single-cycle (Master's) Degree Course in Veterinary Medicine and granted its approval.

The Educational Museum of Veterinary Medicine houses specimens and collections of skeletons and bones, and anatomical exhibits of wild and domestic animals that include both normal and pathological examples. The Veterinary Hospital delivers services to animal owners and provides diagnoses and treatments of various diseases affecting farm animals. It also offers a 24-h emergency service.

2.6.5. The Beginning of the Third Millennium

To cope with the problem of overcrowding, the University of Padova has in recent years expanded into other areas of the Veneto region. New university sites have been established in Vicenza, Rovigo, Treviso, Feltre, Castelfranco Veneto, Conegliano, Chioggia, and Asiago, while summer courses have also been resumed in Bressanone (South Tyrol, Italy).

Two courses organized by the School of Agricultural Sciences and Veterinary Medicine are now available at external university sites. These are the course in Safety and Hygiene of Food Products, which is concerned in particular with foods of animal origin and is held in Vicenza, and the course in Viticulture and Enology Science and Technology, held in Conegliano (Treviso, Italy).

As part of the celebrations for the 800 years of the University of Padova, in 2021 (21–24 September) the University's animal scientists (DAFNAE, BCA, and MAPS departments) organized the 24th Congress of the Italian Animal Science and Production Association (ASPA), 34 years after the congress was last held in Padova (1987).

Agripolis is currently one of Italy's largest and most dynamic centers for research and teaching in agricultural and animal sciences, food, the environment, and veterinary medicine.

3. Evolution of Animal Sciences in Padova and Italy from 1987 to 2021

The 7th Congress of the Italian Animal Science and Production Association (ASPA) was held in Padova 26–30 May 1987. The opening talk was given by Professor Mario Bonsembiante, who was then Dean of the Faculty of Agriculture, and would be elected Rector of the University of Padova two months later. The title of the talk was "The structure and role of research in animal science in Italy" [26]. It presented an accurate analysis of the state of research in animal sciences in Italian universities, and it serves here as the basis for identifying and tracking the major changes in the animal sciences in Italy during the 34 years between the two congresses in Padova.

3.1. Human and Financial Resources, Staff Structures, and Facilities in Italian Universities

In 1987, about 300 animal scientists held permanent positions in Italian universities (Table 2), around one third as full professors, one third as associate professors, and one third as university researchers; in addition, there were around three dozen assistant professors remaining from the old system (and soon to retire), these positions having been replaced with the posts of university researchers under the University Reform Law (N 382/1980). The various university institutes of animal science also employed about 150 technicians (one for every two scientists), and 60 administrative staff and librarians (about one for every 5 scientists).

These human resources were distributed across 31 different research institutions within the universities, so their average size was very small (about 10 scientists, 5 technicians and two other staff members). Financial resources were correspondingly very modest, and almost all funding derived from public money, with private companies, breeder associations, and other institutions, making a negligible contribution to animal science [26,28].

A survey carried out on the adequacy of resources in university departments found there to be vastly insufficient numbers of technicians and other staff, research laboratories, animal facilities, and experimental farms [26].

Table 2. Animal scientists and other personnel in Italian universities in 1987 and in 2021.

	1987		2021			Total
	All	Genetics (AGR/17)	Nutrition (AGR/18)	Hus- bandry (AGR/19)	Small Animals (AGR/20)	
Permanent faculty	304	66	82	117	44	309
• Full professors	95	22	24	35	11	92
• Associate professors	86	33	38	56	17	144
• Researchers	86	11	20	26	16	73
• Assistants	37	0	0	0	0	0
Temporary researchers	0	16	15	24	12	67
Professors and research- ers	304	82	97	141	56	376
Technicians	157	n.a.	n.a.	n.a.	n.a.	n.a.
Admin. and librarians	60	n.a.	n.a.	n.a.	n.a.	n.a.

n.a. = data not available.

In 1987, Italian universities were undergoing a profound transformation as a result of the University Reform Law (No. 382/1980), which saw small institutes (often “*monocattedra*”, i.e., pyramidal structures with only one full professor at the top) replaced by fewer, larger, and more intra- and inter-collaborative Departments, often interdisciplinary.

Another important re-organization, the so-called 3 + 2 reform (No. 30/2000, Bologna Declaration) introduced into Italy the educational structure consisting of a 3-year bachelor’s degree and a 2-year master’s degree (except for Veterinary Medicine, which remained a 5-year degree) and gave individual universities wide autonomy in delivering them.

The last important reform to the Italian university system was implemented with a series of laws and ministerial decrees (laws 133/2008, 169/2008, 1/2009, and 240/2010). The minimum size of a university department was increased to 40 professors and researchers, and as a consequence the number of departments was reduced, with smaller, single area/discipline departments merging to form larger, interdisciplinary departments. Faculties were replaced by a smaller number of university schools. The other important part of this last reform regarded the criteria for selecting candidates for vacant positions, with greater weight given to the bibliometric indices of the candidates and the selection committee members.

Thirty-four years after ASPA-Padova-1987 congress, the number of animal scientists with permanent positions in Italian Universities is about the same as before. As can be observed from Table 2, there are about the same number of full professors, considerably more associate professors, the position of assistant professor has disappeared, and the number of university researchers with permanent positions is decreasing and will disappear soon, to be replaced by temporary posts (6 years).

As almost all the departments are now interdisciplinary (unlike the old institutes in the 1980s), it is not possible to count the number of technicians, administrative staff and librarians supporting the animal sciences, nor the number of laboratories, animal experimental facilities, farm animal buildings and pilot dairy plants serving them. The impression is that there are far fewer technicians, more administrative staff (along with more onerous bureaucracy) and fewer librarians (with the increase in online publications). Over these years, many small, single-discipline laboratories have been replaced by fewer, larger, multidisciplinary laboratories and platforms.

3.2. Human and Financial Resources, Staff Structures, and Facilities in the University of Padova

Padova is a paradigm example of the sweeping transformations that have taken place in Italian universities over the last 34 years.

Before 1987, the Faculty of Agriculture comprised 10 institutes with about a hundred professors and assistant professors (it included the Institute of Zootechnics, with 3 full professors, a dozen senior assistants and assistants, and around 15 other staff members). Over the span of a few years, the 10 institutes were replaced by 4 departments (including the Department of Zootechnical Sciences, since 1991) and almost all the senior assistants and assistant professors became associate professors and university researchers. After the 1987-ASPA-Padova Congress, with the election of Professor Mario Bonsembiante as Rector of the University of Padova and the creation of the Agripolis Campus, the new Faculty of Veterinary Medicine came into being. At the beginning of the new century, the number of departments was increased to 7, with the Department of Zootechnical Sciences becoming the inter-faculty Department of Animal Science, along with an increase in the number of permanent positions.

After the “3 + 2” reform, the University Padova introduced several new courses, including the bachelor’s and master’s degrees in “Animal Science and Technology”, the bachelor’s degrees in “Animal Care” (in English) and “Science and Culture of Gastronomy”, and the master’s degrees in “Biotechnology for Food”, “Italian Food and Wine”, and “Food and Health” (all in English), all of which included important animal science modules. Within a few years, Padova had the largest number of students enrolled in the disciplines of agriculture, and veterinary and food sciences of all Italian universities, which meant that a limit had to be placed on the number of new students.

After the last large reform, the Faculties of Agriculture and Veterinary Medicine were merged into the School of Agriculture and Veterinary Medicine (see Table 1). In the new School, the seven departments of the two former Faculties (three in Agriculture, three in Veterinary Medicine and the inter-faculty Department of Animal Science) became the departments DAFNAE, TESAF (agriculture), BCA, and MAPS (Veterinary Medicine). The Department of Animal Science was abolished, with most of the animal scientists moving to DAFNAE, and some to BCA and MAPS. The experimental animal facilities (for beef cattle, pigs, rabbits, and poultry) and the pilot dairy plant were assigned to DAFNAE, but a new inter-departmental teaching animal barn (for dairy cows, horses, sheep, and poultry) was established.

After 34 years, the University of Padova had gone from having one dozen animal scientists (about a twentieth of the total in Italy) grouped under one thematic institute to having three dozens of animal scientists (about a tenth of the total in Italy) divided between three interdisciplinary departments.

3.3. PhD Courses in Animal Science in Italy and Padova

The institution of the third university level, the PhD degree, is one of the most important innovations of the first university reform in Italy (L.382/1980). The first cycle was launched in 1985, so the 7th ASPA Congress of Padova was the first to see the University’s PhD students presenting some of their thesis results.

There were only a few 3-year PhD courses to begin with, and few student scholarships. The first cycles of the PhD in “Zootechnical Sciences” were launched by the Institute of Zootechnics of Padova in consortium with the corresponding Institutes of the University of Florence and the University of Udine, typically with 2–4 PhD students per cycle, and a cycle initiated every two years.

Some years later (2001–2004), another consortium was formed between the universities of Padova, Milan and Perugia for a new 3-year PhD program in “Conservation, Management and Improvement of Animal Genetic Resources” with 2–3 new scholarships every two years. The reform introduced by the many laws promulgated between 1990 and 2001 gave universities greater autonomy in how they organize their PhD courses, plan

their educational programs, and fund their scholarships. Some years later, these two consortia were closed, and in 2004 the University of Padova founded a PhD School in “Zoo-technical Science”, with two curricula: Animal Management and Animal Genetics. The school had a higher number of scholarships, varying from 7 to 14 per year. In fact, the reform opened up the possibility of universities offering scholarships funded not only by the government, but also by bank foundations, private companies, and other public institutions, such as the *Istituto Zooprofilattico delle Venezie* and *Veneto Agricoltura*. The PhD course itself also financed one or two scholarships per year through a co-funding system whereby funds are collected from each tutor on the PhD School Council. This system is still in operation and is based on penalties and premiums according to the scientific performance of the student tutors, and the general services benefitting the PhD course. In 2011, the need to reduce the number of PhD courses and broaden their scope, while at the same time reducing the number of departments, resulted in the merger of two PhD programs into a new PhD school in “Animal Science and Agri-Food Production”, with two corresponding curricula. This PhD program is led by DAFNAE, in collaboration with the animal scientists of BCA and MAPS, and other scientists in the fields of food, wine, beverages, and agricultural chemistry.

Following another reform (Ministerial decree 45/2013), the PhD school became the PhD course in Animal and Food Science, and the two curricula were abolished. In recent years, the number of scholarships sponsored by a variety of public and private bodies has been stable, in the order of 12–14 per year, and there are somewhere in the region of 30–34 tutors on the council of the PhD course, so that, on average, each tutor is assigned a new PhD student every three years. Many efforts have been made to increase the degree of internationalization: at least 30% of the scholarships are reserved for foreign students, and all educational activities are held in English. Moreover, almost all the students spend at least 6 months abroad in another research center working on the Padova course or on joint research projects.

Evidence of the strength the PhD programs have gained, and their importance for Italian animal science at the current time is provided by the number of scientific presentations given by PhD students and post-doc scholarship holders, which was negligible at the ASPA-Padova-1987 congress, but accounted for more than half the scientific program at ASPA-Padova-2021.

3.4. Objectives and Methods of Research in Animal Science

Comparison of the scientific programs of the two ASPA Congresses held in Padova in 1987 and 2021 is an effective means for appreciating how the scientific interests of Italian animal scientists have evolved in the last 34 years. A summary of the scientific sessions of the two Congresses is reported in Table 3.

First of all, a quantitative remark: even though there were almost the same number of animal scientists with permanent positions in both years, and the maximum number of papers per scientist remained unchanged (one as presenter and one as coauthor), there were more than twice as many sessions and presentations in 2021 as in 1987 (32 vs. 16 and 365 vs. 149, respectively). This increase is mainly due to the key role assumed by PhD courses and post-doc positions in Italy over this period.

The scientific program of the ASPA-Padova-1987 Congress was very traditional: almost half the sessions (7 out of 16) and presentations (68 out of 149) dealt with food-animal production, according to animal species and category (Table 3). Four more sessions with 40 presentations were on themes of animal feeding and nutrition. There was only one session on each of the following topics: animal demography and reproduction (10 presentations), genetics (mainly quantitative genetics and single gene alleles; 11 presentations), and metabolic and hormonal profiling of animals (the methodological novelty of the time; 11 presentations).

Table 3. Scientific sessions of the 7th (1987) and 24th (2021) Congresses of the Italian Animal Science and Production Association (ASPA) held in Padova.

7th ASPA Congress 1987		24th ASPA Congress 2021	
Oral	Sessions	Oral	Sessions
149	<i>n</i> = 16	191 ¹	<i>n</i> = 36
Animal Production		Animal Production	
4	Aquaculture	12	Animal efficiency (2 sessions)
7	Aviculture	11	Feed efficiency and animal growth (2)
12	Rabbit production	Environment	
12	Pig production	10	New feeds and waste recycling (2)
14	Small ruminants	5	Non-conventional systems
9	Beef Production	11	Env. impact monitoring, mitigation (2)
10	Milk production and quality	8	Precision livestock farming (2)
Feeding and Nutrition		Animal welfare	
7	Feed value – lab methods	18	Improving animal health, welfare, resilience (3)
7	Rumen metabolism, degr.	6	Animal behavior and welfare
14	Feed processing storage	Non-food animals	
12	Evaluation of forages and byproducts	10	Companion animals and society (2)
General zootechnics and genetics		Genetics	
10	Demography and reproduction	10	Quantitative genetics, inbreeding, crossbreeding (2)
11	Genetics	6	Genetic diversity
New technologies, society's concerns		6	Role of local breeds
11	Metabolic and hormonal profiles	5	Genomics of local breeds
4	Radionuclide transfer in meat and milk	11	Genomic and phenomic tools (2)
5	Round table: crossbreeding and beef	7	Improving animal health, welfare, resilience
		15	Omics technologies (3)
		Animal foods	
		12	Effects of feed on the food value (2)
		6	Food production and processing
		10	Nutritional profiling of foods (2)
		6	Sensory quality, labeling, and promotion
		6	Free communications

¹ In addition to the 191 oral presentations, there were 174 poster presentations.

Only one session (with four presentations) responded to a strong demand of society (the transfer of radionuclides in meat and milk after the Chernobyl disaster of the previous year), and there was one round table with five presentations, which concluded a research project on crossbreeding and beef production and quality funded by the Italian Ministry of Agriculture.

In his opening speech, Professor Mario Bonsembiante outlined his ideas concerning the future aims of animal science [26]. He declared that increased production, which had

been the main objective until then, should no longer be pursued. The new objectives should be:

- To study genetic differentiation in relation to the production efficiency and feed intake capability of animals, and the reduction of nutrient waste at the digestive and metabolic levels;
- To improve knowledge of the nutritional value of feedstuffs, and the nutrient requirements and digestive and metabolic processes of animals;
- To enhance the reproductive efficiency of farm animals through genetic improvement and appropriate crossbreeding schemes, and by reducing infertility due to poor health and nutrition;
- To focus attention on biotechnologies, given their enormous potential for animal science and production, and their ethical implications;
- To study the use of biotechnologies to attain objectives not achievable with conventional tools, such as the genetic improvement of resistance to stress and disease;
- To develop synthetic vaccines against a theoretically enormous number of antigens;
- To respond to the need to safeguard the environment, and to view animal farming as no longer exploiting and disfiguring the land, but as a useful and integral part of the landscape and the rural ecosystem;
- To improve and develop extensive farming systems in internal areas to limit the depopulation and degradation of ecosystems, especially in areas with high landscape value and tourism potential;
- To reduce the environmental impact of intensive farming systems by improving animal nutrition, constructing new buildings and facilities, and devising a rational management of slurry to enhance the integration of livestock farming into the landscape;
- To respond to the need to change the concept of food quality as being linked to energy content (which consumers sometimes view as a negative attribute);
- To determine the quality of animal foods in terms of appearance, sensory profile, authenticity, their value for human health, and their processing aptitude.

Professor Bonsembiante's presentation concluded that "the response (of animal scientists) to the ethical concerns of citizens should be to safeguard the environment and human health, as well as the welfare of animals. There is a risk of upsetting the equilibrium between animals and the environment, and between animals and humans if scientific progress does not keep pace with technological progress" [26].

The scientific program of the ASPA-Padova-2021 Congress was completely different from the one held thirty-four years previously (Table 3). In 2021, there were only two food-animal production themes (4 sessions with 23 oral presentations), which were concerned not only with production, but also with efficiency (feed efficiency and animal efficiency); four themes (7 sessions, 34 presentations) focused on the environment, ranging from new feeds and waste recycling to non-conventional systems, environmental impact monitoring and mitigation, and precision livestock farming; two themes (4 sessions and 24 presentations) concerned animal welfare, including the improvement of animal health, wellbeing, and resilience, and studies on the relationships between animal behavior and welfare; two sessions (10 presentations) were on non-food animals, dealing mainly with companion animals in relationship to society. Substantial space (7 themes, 11 sessions, and 60 presentations) was given to different areas of genetics, including quantitative genetics, inbreeding and crossbreeding, genetic diversity, the role of local breeds and their genomics, genomic and phenomic tools, omics technologies, and the genetic improvement of animal health, welfare and resilience; and lastly, four themes (4 sessions with 34 presentations) concerned foods of animal origin, including the effects of feed on the food value of animals, animal food production and processing, the nutritional profiling of foods, and the sensory quality, labeling, and promotion of animal foods.

Comparison of the 1987 and 2021 programs clearly shows the huge shift in animal science from a focus on animal phenotyping and husbandry to a greater focus on the physiological and genetic processes of animals, and on broadening its scope to include farms, the environment, the animal food industry, consumer needs and preferences, and society's concerns. Thirty-four years after his address to the Congress, Professor Bonsembiante's vision can be said to have been fulfilled.

3.5. Quantitative and Qualitative Evolution of Scientific Publications in Animal Science

A survey carried out by the Italian National Research Council [29] found that at the end of the 1970s, only 20% of the principal investigators on national projects had published work in peer-reviewed scientific journals, and less than half of them had published only in local journals. The average scientific productivity of principal investigators was 1.2 articles/year, only 0.2/year of them in refereed journals. A survey carried out few years later (1982–1986) on all Italian animal scientists (not just principal investigators) found the situation had improved [30], with average productivity in terms of articles published in international journals at 0.67, which is slightly higher than the average for all scientists (0.62). It is worth noting that the major peer-reviewed journal of that period was “*Zootecnica e Nutrizione Animale*” (Zootechnics and Animal Nutrition), an Italian publication and the official journal of the ASPA, which provided only summaries in English.

Commenting on the figures for animal scientists, Professor Bonsembiante considered them to be good, given that the funds assigned to the scientists in this sector amounted to only a fifth of those assigned to most other scientific sectors [26]. While deeming the average quality of research to be satisfactory, albeit with profound differences between the various Italian institutes, Professor Bonsembiante pointed out that it was not enough to carry out good work if the results could not be circulated at an international level, as “publication in local journals represents a waste of intellectual resources that the country cannot sustain”. He went on to say that while scientific meetings and conferences were very important for discussion, debate, and the evaluation of research, the favored means of dissemination was publication in peer-reviewed journals with an international circulation. He therefore proposed that, starting with ASPA-Padova-1987, conference proceedings should no longer publish the full scientific contributions presented, but only the abstracts. The proposal was approved.

Lastly, Professor Bonsembiante stated that a further qualitative improvement to Italian animal science research would be achieved only through better scientific and cultural training of young researchers, including increasing international exchanges with the foremost research centers.

The negligible numbers of articles published in internationally renowned scientific journals and of citations received in 1987 can be clearly observed in Figure 5, which depicts information extracted from the Citation Report of the Web of Science database (searched only for country = Italy, and subject category = Agriculture Dairy Animal Science).

It is worth noting that the numbers of Italian articles and citations remained very modest, albeit with a very gradual increase, until the end of the last century. In the last two decades, however, the number of published articles has increased rapidly with the latest figures showing them to have reached 1000/year. The increase in citations was almost exponential, reaching 20,000 in 2021 (partial data for 2022 excluded).

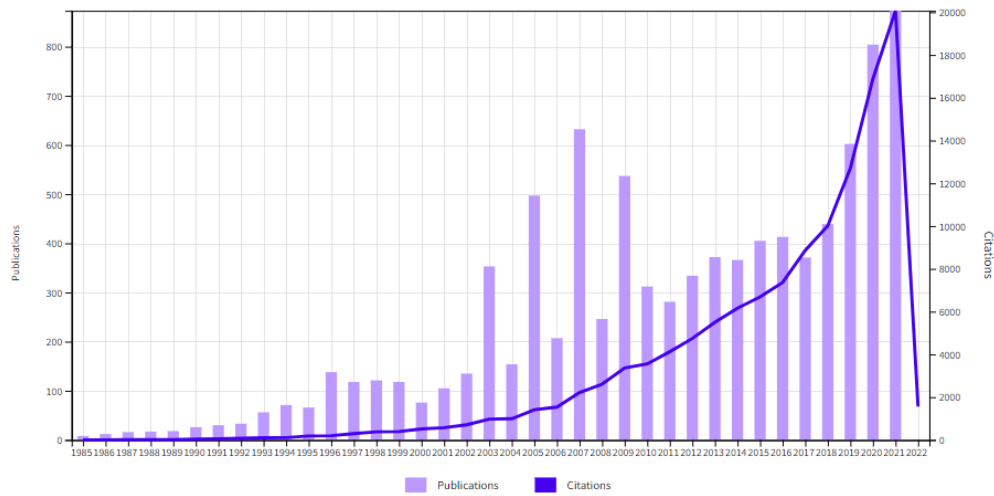


Figure 5. Numbers of Italian articles published in scientific journals in the category “Agriculture Dairy Animal Science” and of citations received by year of publication (Web of Science).

The internationalization of Italian animal science and scientists is reflected in the evolution of the ASPA’s scientific journal. In 2002, the “*Zootecnica e Nutrizione Animale*” (previously published in Italian with abstracts in English) began publication exclusively in English as “The Italian Journal of Animal Science”, and has been indexed by the Web of Science since 2006, and by Scopus since 2011. The number of articles it publishes has continued to grow, while its editors, authors, and readers have become increasingly international, with almost 50% of articles now written by non-Italians. At the same time, the scientific quality and reputation of the Journal has progressively increased, evidenced by the increase in its impact factor, placing it between the Q2 and Q1 quartiles of the categories “Agriculture Dairy Animal Science” and “Veterinary Science” (Figure 6).

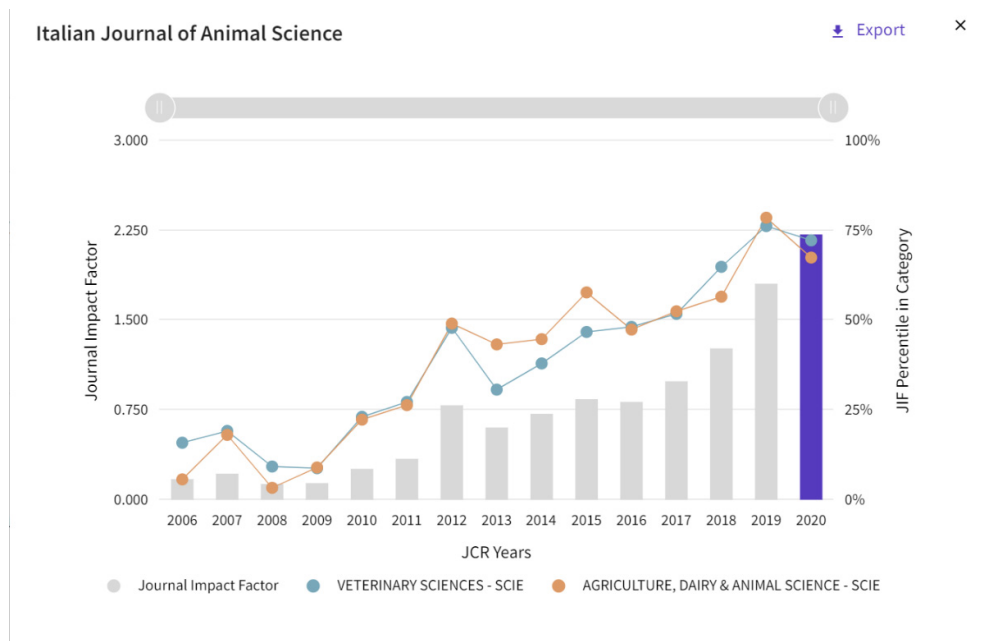


Figure 6. Average impact factor of the Italian Journal of Animal Science by year of publication, and ranking of the journal in the “Agriculture Dairy Animal Science” and “Veterinary Science” subject categories.

It is worth noting that the large increases in the number of Italian publications in 2003, 2005, 2007, and 2009 (Figure 5) was due to the publication of the ASPA congress abstracts in the Italian Journal of Animal Science. However, while the number of publications was much greater, the number of citations did not increase, hence the decrease in the journal's impact factor and ranking. Since 2011, the ASPA congress abstracts have no longer been published in the journal.

3.6. Characteristics of Italian and Paduan Publications in Animal Science Research in the 21st Century

Limiting our analysis to the last decade (2012 to 2021) we were able to obtain from the Web of Science database the Citation Report of Italy in the subject category "Agriculture Dairy Animal Science". This obviously underestimates the scientific productivity of Italian animal scientists, who also publish in journals in several other subject categories (especially where their research deals with genetics, the environment, and food sciences), although in these cases, it is not possible to distinguish between articles written by animal scientists and those written by geneticists, food scientists, or researchers from other disciplines.

Taking the most recent 10,000 Italian articles published, the top 10 journals were as follows: Italian Journal of Animal Science, which published 20.1% of all articles; Journal of Dairy Science, 11.3%; Animals, 9.7%; Reproduction in Domestic Animals, 6.2%; Small Ruminant Research, 4.3%; Large Animal Review, 3.8%; Journal of Animal Science, 3.7%; Animal, 3.2%; Animal Genetics, 2.9%; and Livestock Science, 2.7%. Of the Italian articles published in journals in categories other than "Agriculture Dairy and Animal Science", almost half were in the "Veterinary Science" category, 23% in "Agriculture Multidisciplinary", 15% in "Food Science Technology", 12% in "Zoology", 5% in "Reproductive Biology", and 4% in "Genetics Heredity".

As Italian animal scientists participate in international collaborations, many Italian articles are coauthored with animal scientists from other countries. Of these non-Italian coauthors, 7.0% of the articles were American, 4.3% Spanish, 3.9% French, 2.8% German, 1.9% Dutch, 1.8% Brazilian, 1.7% English, 1.4% Scottish, and 1.3% Belgian.

The citation report also identifies authors' affiliations. The 10 leading Italian institutions in terms of the percentages of papers published are as follows:

- A total of 13.6% in the University of Milan (55 scientists; 17,376 citations; H = 53);
- A total of 12.1% in the University of Padova (33 scientists; 15,067 citations; H = 52);
- A total of 10.0% in the University of Bologna (35 scientists; 13,586 citations; H = 54);
- A total of 7.2% in the University of Naples Federico II (24 scientists; 8349 citations; H = 41);
- A total of 6.0% in the University of Bari Aldo Moro (20 scientists; 6509 citations; H = 37);
- A total of 5.8% in the Italian National Research Council (n.a.; 8381 citations; H = 42);
- A total of 5.7% in the University of Turin (30 scientists; 7080 citations; H = 43);
- A total of 5.5% in the University of Sassari (19 scientists; 7,004 citations; H = 40);
- A total of 5.0% in the University of Perugia (16 scientists; 5793 citations; H = 38);
- A total of 4.7% in the University of Pisa (17 scientists; 4314 citations; H = 31).

The list shows that half the affiliations are with universities in the north, and half are with universities in southern and central Italy.

The University of Padova ranks second in Italy over the last decade, but has moved to the first position in the last three years, and can boast the highest average number of publications per full-time animal scientist. The role of Padova is underscored by the number of articles per author given in the citation report: in the ranking of Italian animal scientists, 5 Paduans are in the top 10 positions (4 in the first 5), the other 5 being from the universities of Bologna, Basilicata, Piacenza, and Bari (2).

At the international level, the University of Padova's Agripolis Campus is ranked 40th (1st in Italy) out of all veterinary faculties, and 46th (1st in Italy) out of all agricultural faculties, according to the 2021 Global Ranking of Academic Subjects (Shanghai ranking) [31].

4. Bibliometric Evolution of Italian Animal Science and Benchmarking with Other European Countries

According to the Web of Science's evaluation tool In Cites [32], Italy is the seventh country in the world for the total number of citations received in all research fields, after the USA, China, England, Germany, France, and Canada, and ahead of Australia, Japan, and Spain. Italian publications received 14,599,772 citations, 15.4% of the number received by American publications (94,593,275) in the same period. It is worth pointing out that Italy's population is 18.2% of the USA's population, its GDP is 10.5% of American GDP, and its total area is 3.1% that of the USA.

If we look only at citations received by publications in Agricultural Sciences [32] rather than all scientific fields, the international ranking changes. Italy is now ranked fifth after China, the USA, Spain, and Brazil, and ahead of Australia, Germany, Canada, France and India. The number of citations received by Italian publications in Agricultural Sciences (382,365) amounts to 32.1% of those received by the USA (1190,752).

As the Citation Report covers every country represented in the database, we were able to make comparisons between Italy and other countries. To this end, we selected those major European countries with similar populations, GDPs, and total surface areas, which were, in addition to Italy, France, Germany, Spain, and the UK (for the latter we summed the data for England, Scotland, Wales, and Northern Ireland). The major bibliometric indicators are listed in Table 4.

Table 4. Bibliometric data of articles from five major European countries published in the last decade (2012–2021) in scientific journals in the category "Agriculture Dairy Animal Science" (Web of Science).

	Italy	France	Germany	Spain	UK
Articles published in the decade, <i>n</i>	5337	3791	5255	5340	4007
Articles published in 2021, <i>n</i>	875	379	613	742	593
Citations in the decade, <i>n</i>	50,149	38,464	38,075	36,406	43,330
Citations/article, <i>n</i>	9.40	10.15	7.25	6.82	10.81
H-index of the country	71	64	58	57	73

Data for the various nations of the UK (England, Scotland, Wales, and Northern Ireland) are recorded separately in Scopus database.

As the Table shows, Italian animal scientists published an almost identical number of articles to German and Spanish scientists in the last decade, but received a larger number of citations per article, and, consequently, a greater number of total citations. France and the UK, on the other hand, had a slightly larger average number of citations per article than Italy, but as the number of articles was lower, so, too, was the total number of citations. The researchers of the University of Padova contributed to these results with a total of 797 papers (15% of Italian production) and 9164 citations (18% of the total citations for Italy), with a positive trend along the years (data not showed in Table). It should be pointed out that these figures refer only to articles published in journals in the subject category "Agriculture Dairy Animal Science" and their corresponding citations, and therefore represent an underestimation of the scientific productivity of animal scientists of all countries, especially those whose animal scientists publish their articles mainly in journals of other categories. We also used the Citation Report to obtain each country's

Hirsh-Index (H-index), a bibliometric indicator for assessing the research output of scientists. Italy had a slightly lower index than the UK, but a higher index than the other three countries.

The results of this comparison reveal the different – and largely unexpected – patterns of the scientific production of animal scientists in the countries compared. In the previous section of this article, we showed that the productivity of Italian animal scientists increased almost exponentially in the last decades, which is corroborated by the higher number of articles published in Italy in the last year examined, compared with the other countries (Table 4). The temporal pattern of the number of articles published by animal scientists from the same five countries is depicted in Figure 7.

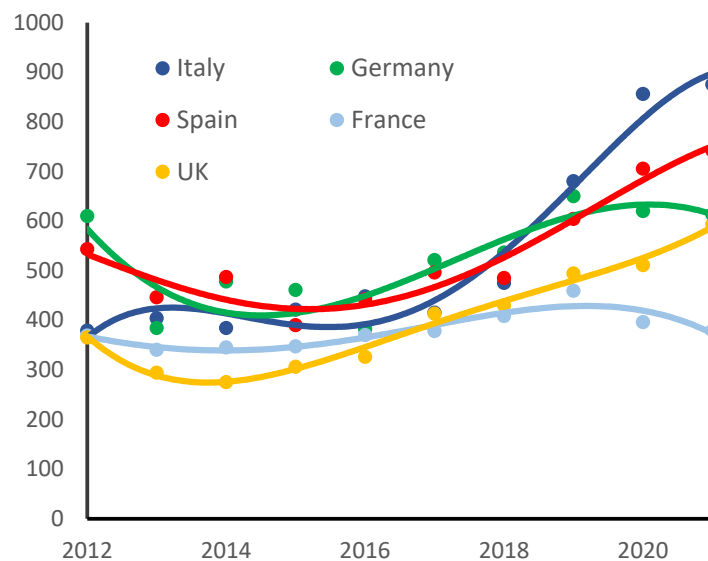


Figure 7. Number of articles published in scientific journals in the category “Agriculture Dairy Animal Science” by five major European countries by year of publication and country (Web of Science).

The graph clearly shows that compared with the other large European countries, Italy is currently seeing the fastest growth in the number of articles published per year, followed by Spain.

The quality, as opposed to the quantity, of research can be gauged by the number of “top scientists” in a given subject category in a given country. Stanford University’s list of the world’s top-ranking scientists is derived from the top-cited 2% of scientists with publications indexed in Scopus (Elsevier BV) in each subject category. It comprises two databases, one based on the citations received by the scientists during a single year (2020), the other on the citations accumulated from the beginning of their careers to 2020 [33]. We extracted the subset of top scientists in the subject category “Dairy & Animal Science”, and the subtotals per country. The countries with the largest number of top scientists are listed in Figure 8.

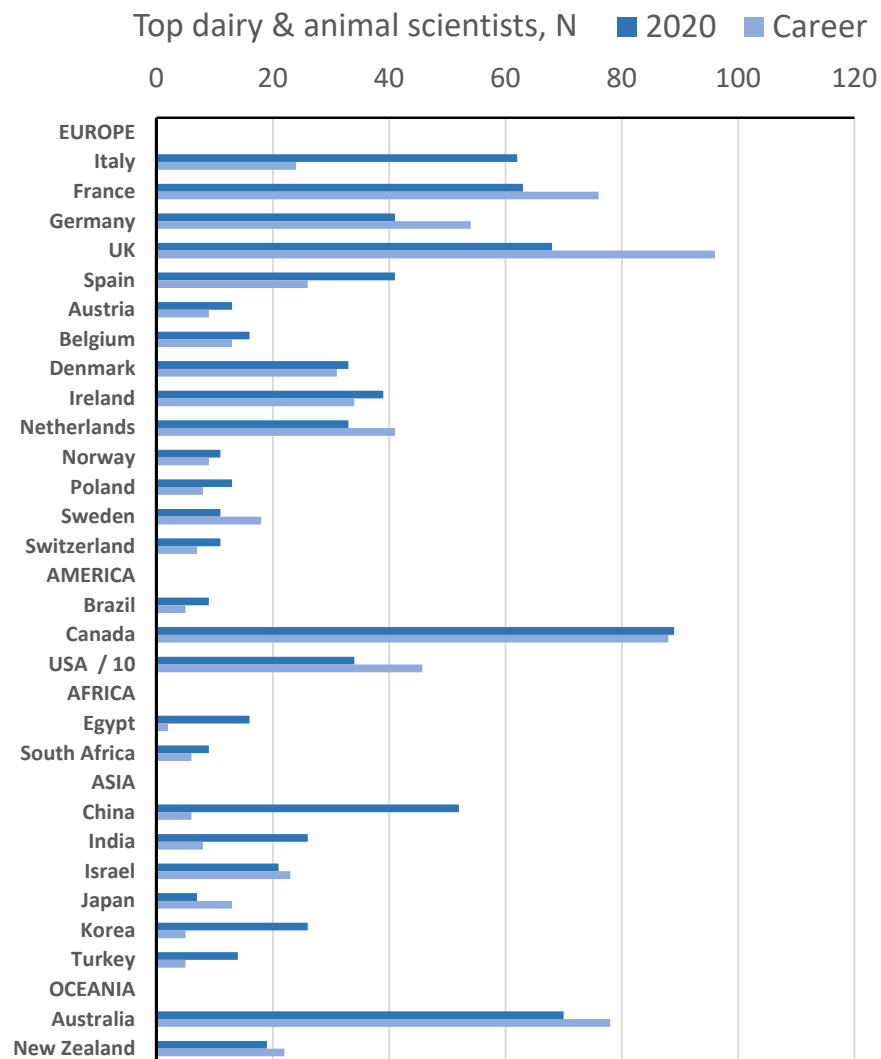


Figure 8. Number of “top scientists” in the subject category “Dairy & Animal Science” according to the Stanford University lists of citations in 2020 and citations accumulated over the scientists’ entire careers (data for the USA have been divided by 10 and should be multiplied by 10 to obtain the true figures).

The differences between the two values for each country reflect the evolution of animal science over time. The countries with a larger number of “2020” than “Career” top scientists are those where animal science has recently developed at an international level and where there are a large number of good, young researchers (for example, China, India, Egypt). In contrast, those countries with a larger number of “Career” than “2020” top-scientists are seeing their impact at an international level diminishing. Due to the very high number of top-scientists from the USA, the data were divided by 10 to avoid flattening all the other countries; to obtain the true figures, the numbers should be multiplied by 10 (340 “2020”, and 457 “Career” top scientists).

We can see from Figure 8 that, after the USA, Canada and Australia, the UK, France and Italy have a similar number of “2020” top animal scientists (62 to 68), followed by Germany, Spain, and Ireland (39 to 41). The pattern over time is very different in these European countries, declining in the UK, France and Germany, and increasing in Ireland, Spain and, in particular, in Italy. This corroborates the yearly trend of articles published from 2012 to 2020 shown in Figure 7. It is also clear that the geographical distribution of

animal science is changing, with large Asian and African countries assuming growing importance. In Italy, the University of Padova is the leading institution, with scientists featuring in both lists of top animal scientists (half of Padova's full professors appear in the lists). After Padova, are the universities of Milan, Bologna, Naples, Piacenza, Sassari, Turin, Viterbo, and Catania.

5. Conclusions and Perspectives

Animal science in Padova and Italy, as well as internationally, is facing difficult challenges. The first challenge is to develop an agricultural system that can guarantee food security and safety by producing plant food and feed for animal food production, and that can at the same time contribute to the production of biomass to generate renewable energy (thermal and electric) with the aim of controlling global warming. The second challenge is to exploit at the maximum level the "circularity" of food chains by recycling and recognizing the value of manure and waste, while at the same time reducing the use and abuse of external inputs (such as energy, chemicals, fertilizers, and packaging), thus making overall improvements to the ecological fingerprint of food production. The third challenge is to ensure the coexistence, interaction and co-development of production technologies, industrial efficiency, process quality, the protection of regional foods, recipes, and gastronomy, and the preservation of history, traditions, and culture: "food is culture, not just nutrients". The fourth challenge is to go beyond the concept of human-animal "One Health" towards the concept of "One Health—Welfare and Ethics", which takes a holistic global approach to the health and welfare of humans, animals, and also crops, covering all food chains, and which encompasses fields ranging from health to ethics, and considers the wellbeing of all living beings in the anthromes. Last, but surely not least, the fifth challenge is to achieve these goals, especially on a global scale, while minimizing further impacts on natural and agroecosystems, biodiversity, and their non-provisioning ecosystem services. It should be borne in mind that these five challenges are not independent of each other, but instead are closely interrelated. The research is therefore of a complex, interrelated nature and must be approached with interdisciplinarity and system methods. Hyper-specialization could also be useful for providing very specific point information, but it will not be the scientific frontier of our future. To approach this frontier, will require deep, accurate analyses to be made in specific fields of research, but also the ability to comprehensively address all related research fields, and integrate the results of individual studies into an overall vision through inter-actions between scientists of different disciplines. It is, therefore, also essential to reduce the importance of bibliometric evaluation of the quantity and quality of research, which is seeing too many scientists (including animal scientists) engaged in sometimes absurd races to "easy", hasty publication of often repetitive articles on popular topics that attract citation. Participation in interdisciplinary groups is no easy task, and the articles that emerge from this complexity are difficult for the editors and reviewers of many scientific journals to understand, which means that scientific productivity is often low, and frontier scientists become frustrated. We have no solutions to put forward, but we are conscious of the urgent need for all scientists – and animal scientists in particular – to change the paradigm. Italian research is sometimes closer to this interdisciplinary ideal for various reasons: the influence of classical culture in our country and on the education and training of young researchers, the traditional search for high process-quality that is a characteristic of "made in Italy", and the focus placed on regional foods and gastronomy in a "farm to fork" perspective and at a high level of complexity. These features, sometimes viewed as weaknesses, need to become the strengths of our activities. Padova's Agripolis Campus is destined to represent a focal point for this type of approach in the future, since complexity, interdisciplinarity, and cultural vision informed its founding and have consistently informed its objectives.

Author Contributions: Conceptualization, G.B.; methodology, G.B. and L.B.; software, G.B. and A.C.; writing—original draft preparation, G.B.; writing—review and editing, L.B., A.C., L.G., R.M.,

M.R., F.Z., S.S., and E.S.; supervision, G.B.; project administration, G.B., L.B., L.G., and R.M.; funding acquisition, G.B. and L.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Data Availability Statement: The data supporting the reported results can be found in publicly available databases, as specified in the manuscript.

Acknowledgments: We thank all the animal scientists of the University of Padova (the departments of DAFNAE, BCA and MAPS) who, as members of the Scientific and Organizing Committees, helped bring to fruition the ASPA PADOVA 2021 Congress (<https://www.aspapedova2021.org/>).

Conflicts of Interest: The authors declare no conflict of interest.

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