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The Role of The University of New  
South Wales in the Advances in Wool  
Technology and Sheep Breeding since  
1951

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# The Role of The University of New South Wales in the Advances in Wool Technology and Sheep Breeding since 1951

John Kennedy

## **Abstract**

The University of New South Wales established a School of Wool Technology in 1951 and more than 600 degrees and diplomas were awarded before the activity was closed down in 1997 because of financial pressures on the University. Despite several changes of name the primary objective continued to be the provision of education and research for the benefit of the pastoral industries that produced wool and red meat. Staff, students and graduates made very significant contributions to the revolution in wool marketing which began with the introduction of objective measurements of wool quality and to advances in animal breeding and genetics. Some of these contributions are reviewed.

## INTRODUCTION

When the Wool Technology course began in 1951 in the recently founded (1949) NSW University of Technology it was the first new discipline because the foundation courses in architecture, engineering and science were extensions of courses which had led to Diplomas of the Sydney Technical College (ASTC). It also was the first with technology in the title. The name of the University changed in 1959 to The University of New South Wales (UNSW) and Wool Technology changed in 1967 to Wool & Pastoral Science (WAPS) before becoming Wool & Animal Science in 1988 but the primary objective was to provide education and research for the benefit of the pastoral industries. This included publication of *Wool Technology and Sheep Breeding* that commenced in 1954 to present the text of lectures that were given to wool brokers and buyers in the Wool Exchange in the Sydney CBD. This paper gives an account of some of the contributions that were made by UNSW, particularly in wool marketing and animal breeding. Although Wool and Animal Science was closed down in 1997 because of financial restrictions on The University many graduates continue to make important contributions.

## ESTABLISHMENT

In November 1950 the Council of the New South Wales University of Technology approved the proposal for a course for a Bachelor of Science degree in Wool Technology and authorized commencement from the first term of the 1951 academic year, and added the bold claim that *The course would bring students in contact with developments in a wide variety of fields related to wool production, wool commerce and wool utilisation. It would supply graduates qualified not only in these fields but also who are versed in the scientific principles operating in each part of the wool industry; in so doing it will fill a long -standing need* (NSW University of Technology, 1951). In the three years up to 1950/51 the sheep industry had earned 58% of Australia's export income (Shaw 1984) but during World War II there had been substantial progress in producing synthetic fibres which were recognised to be a threat to wool and hence to the national economy.

There were well-established courses in agricultural science in several universities, including the University of Sydney, however the emphasis in these was on soils, crops and production of grain, particularly wheat. Tertiary education in animal husbandry was limited to the diploma courses of Hawkesbury and Wagga Agricultural Colleges because neither the Department of Animal Husbandry in the University of Sydney nor the Faculty of Rural Science in the University of New England had been established and veterinary science courses concentrated on health of farm animals.

The Wool Technology course had similarities to agricultural science courses in Australian universities but had several special features including:

- emphasis on pastures and production of fibre and meat from grazing animals,
- the inclusion of wool technology and practical work on wool classing which was the province of the technical colleges,
- compulsory study of mathematics and mathematical statistics,
- inclusion of science subjects that were provided for students across the University rather

- than being tailored to wool technology students,
- the study of the humanities which was a feature of the new university.

Another difference was that the degree would be a Bachelor of Science rather than a Bachelor of Agricultural Science or Bachelor of Science in Agriculture but graduates would be eligible for membership of the Australian Institute of Agricultural Science and be recognised as professional agriculturalists.

The distinctive feature of the curriculum was the treatment of the wool and red meat industries as integrated systems operating from the farm through to the consumer so it included study of pasture production, wool biology, fibre science, animal science and husbandry, shearing and clip preparation, assembly of bales in brokers' stores, auction, exporting, scouring, carbonizing and top making. Later, when objective measurement was introduced sampling and testing became important components. For meat the phrase from paddock to plate summed up the approach in the teaching.

The course began in 1951 with an enrolment of six full-time students who were taught biology, biochemistry, chemistry, mathematics and physics in the lecture rooms and laboratories of the Sydney Technical College in Ultimo which was then the main campus of the University. However the School was based in the East Sydney Technical College at Taylor Square, Darlinghurst that was the home of the Sheep & Wool School of the NSW Department of Technical Education and it was here that the wool and agriculturally-related teaching was given until 1958 when the School moved to the Kensington campus.

In January 1951 Dr P R McMahon who was head of the Sheep & Wool School became an Associate Professor and by the end of the year he was appointed to be Foundation Professor of Wool Technology and Head of the School of Wool Technology. A graduate of New Zealand's Massey Agricultural College and Leeds University in the UK he had been recruited to the Department of Technical Education in 1947 and had played a pivotal role in planning of the Wool Technology course (Kennedy, 2000). By 1952 Mr Charles Goldstone, another Massey College graduate, had been appointed as lecturer in livestock production and classes began at East Sydney Technical College. In the early years much of the teaching came from part-time lecturers from the NSW Department of Agriculture, the CSIRO and industry and the students were fortunate to be taught by many leaders in their field. Until 1958 students still commuted (usually by tram) between Darlinghurst, Ultimo and Kensington for classes in science and humanities subjects.

#### UNDERGRADUATE CURRICULUM.

Originally there was no choice allowed in the curriculum but this gradually changed and options were introduced in the third and fourth years. Professor McMahon had a firm view that the course should be broad enough to provide graduates with a number of beachheads that could allow them to develop in different professional directions and he has been vindicated by the variety of careers they followed. In common with agricultural science courses that were based in metropolitan universities there was considerable debate about the extent to which students could, and should, be taught practical skills in animal husbandry. In the early days there were no

University facilities for this but students were required to work on farms during vacations (Initially this was 12 months but was gradually reduced to 6 months) however the skills of wool classing were taught and a wool testing laboratory was part of the infrastructure. There were field trips, usually taking students to research establishments and commercial farms, and from 1971 second year students spent a week on a field station becoming familiar with some husbandry and research techniques.

Unlike conventional science degrees which extended over three years with an additional year for those students who wished to work for honours, the Wool Technology course was over four years and honours could be awarded on a weighted average of performance over the whole course. In final year each student designed and conducted a project which carried the heaviest weight and occupied about 25% of the time commitment. They were required to present seminars to describe their proposed work and, at the end, the results and conclusions reached. Among other things this helped to develop communication skills and it may have been because of this that when the Australian Institute of Agricultural Science began a national competition for presentations by final -year students the UNSW students became very successful competitors and frequent winners.

When the course was planned it was intended that students would specialise in either wool production or wool commerce in the final year but this did not eventuate. However when the Faculty of Commerce was established in 1959 a Wool Commerce option was included in the Bachelor of Commerce but did not attract many enrolments and was discontinued. Then in the 1990s planning began for a BComBSc in agribusiness but lapsed when new enrolments in the Wool and Pastoral Science course ceased in 1996. In the 1970s another innovation was the introduction of an Education Option to train high school teachers but this also soon lapsed largely because of the difficulty of scheduling, including the need for students to travel to Sydney Teachers College to study agriculture teaching method. Nonetheless a number of graduates became successful teachers in high schools and technical colleges.

#### TRAINEESHIPS AND SCHOLARSHIPS.

Undergraduate scholarships were very important in attracting students and Professor McMahon put much effort into encouraging endowments for this. In the beginning NSW government departments of Agriculture and Technical Education offered traineeships which paid a stipend and guaranteed employment provided students signed a bond to work for the department for at least five years after graduation. These remained an important source of support up into the 1970s and not surprisingly both departments employed many graduates. In 1953 Wool Research Trust Fund scholarships were the first unbonded scholarships and were very important until they were discontinued in the 1980s. Woolgrower support resumed in 1990 when the Wool R&D Corporation became the lead partner with AWTA Ltd, Dalgety Farmers Ltd and the Australian Council of Wool Exporters in the Co-op Scholarship scheme that provided structured industrial experience during vacations as well as stipends. Earlier several banks and agribusiness firms provided scholarships and the NSW Farmers' Association funded the E L O'Brien scholarship which honored one of its prominent members, and a strong supporter of Wool & Pastoral Science, while in 1988 Dalgety Plc in the UK marked the bicentenary of Australia by endowing a fund for scholarships. Support for local postgraduate students came from the Australian

Government (Commonwealth Scholarships or Australian Postgraduate Awards), the rural R&D corporations particularly Wool, Meat and Dairy, the Rural Development Fund of the Reserve Bank, General Motors Holden Ltd, Boots Drug Co., Roche Ltd and The Australian Wheat Board.

## GRADUATIONS

Four of the initial enrolment (G H Ford, D B Hughes, A J Marrant and K J Whiteley) graduated at the beginning of 1955 and from then until 2000, 359 BSc degrees were conferred. Forty four graduated with First Class Honours and five of these, viz. K J Whiteley (1955), C W Ward (1965), R R Howe (1971), D J Cottle (1976) and Evonne Luton (1999) also received the University Medal. In the early years the student population of the University was almost entirely male and it was 1963 before Barbara Cox and Valerie Robinson were the first female graduates in Wool Technology but eventually 82 women received the degree.

Enrolment of postgraduate research students began very early and the very first graduate of the School of Wool Technology was G C Taneja who was awarded an MSc in 1954 for research that had been done on the Trangie Research Station of the NSW Department of Agriculture with guidance from Dr F H W Morley. He was the first of many research students who benefited from assistance provided by that Department. After earning a PhD from the University of Queensland he progressed to a very senior position in the Department of Agriculture of India.

From 1954 to 2002 there were 26 Graduate Diploma, 106 Master of Science, 107 PhD and 4 Doctorates of Science conferred and 11 who received a Graduate Diploma or Master of Applied Science in Arid Lands Management spent much of their time in the Department of Wool & Animal Science.

Table 1. GRADUATIONS BETWEEN 1954 and 2002

	BSc	Grad Dip	MSc	PhD	DSc
1954-9	19		4	1	
1960-4	24	2	14	6	
1965-9	39	4	15	15	1
1970-4	43	3	18	15	1
1975-9	33	5	14	20	
1980-4	63	3	12	3	2
1985-9	42	5	14	13	
1990-4	48	1	13	14	
1995-9	44	3	2	12	
2000-2	4			8	
Total	359	26	106	107	4

## DISESTABLISHMENT

In the 1980s a University taskforce had recommended closure of the School of Wool & Pastoral Science and dispersal of the activities but there was vigorous opposition, particularly from the wool industry and graduates, and the poorly thought out proposal was not accepted. However the outcome was the establishment of a new School of Fibre Science & Technology consisting of

Departments of Textile Technology and Wool & Animal Science but Wool & Pastoral Science continued to be the name of the course and the degree. It is ironic that when the School decided in the 1960s to abandon Wool Technology as a name the preferred replacement, that was accepted by the Professorial Board but rejected by the University Council, was Wool and Animal Science. The rejection was based on objection from the zoologists who argued that animal science was their preserve.

Disestablishment was the bureaucratic term used by the University to describe the closure of the Department of Wool & Animal Science, the School of Fibre Science & Technology and the Faculty of Applied Science in 1997. The end had been determined earlier when it was announced that 1996 would be the last year in which enrolments of new WAPS students would be permitted. The last BSc degrees were awarded in 2000 to Warwick Badgery, Sally Barton, Justin Conway, Sam Gill and James Mitchell, however the final graduation was in 2002 when PhDs were awarded to Joy O'Keefe and Jennifer MacDiarmid.

Textile Technology and Wool & Pastoral Science were high cost operations as measured by cost per EFTSU (Effective Full Time Student), owing to the relatively small enrolments of undergraduates. In contrast to many other units there was a large enrolment of postgraduate research students in Wool & Pastoral Science, but this did not compensate sufficiently in the costing formula. Costs of staff make up a very large share of the costs of academic units in universities but the number of staff in Wool & Animal Science was progressively reduced by about 50% from 1980 onwards with the consequent significant increase in the load on remaining staff. Over the same period the number of graduates increased with approximately half of the total graduating (Table 1), but this was insufficient to persuade the University to retain an agricultural activity.

#### RETIREMENT OF PROFESSOR MCMAHON.

Professor McMahon retired in 1977 and was appointed an Emeritus Professor in recognition of his very considerable contribution to the University and his colleagues on the Professorial Board contributed to a fund to establish the P R McMahon Prize which was awarded annually to the graduating student who had achieved excellence in wool technology subjects. Earlier his contributions to agricultural science and to the sheep and wool industries had been recognised by election to Fellowships of both the Australian Institute of Agricultural Science and the Australian Society of Animal Production, of which he was a founder member.

Associate Professor John Kennedy BSc<sup>1</sup> MSc (BSc Oxf), who had been on the staff since 1963 following return from Oxford University where he had been the 1959 NSW Rhodes Scholar, was appointed to be Head of the School. When the School of Fibre Science & Technology was established he became the Head for the first three years as well as Head of the Department of Wool & Animal Science and was Chairman of the Faculty of Applied Science for 10 years. He was elected to a Fellowship of the Australian Institute of Agricultural Science in 1985 for his contribution to agricultural science, was awarded a Medal of the Order of Australia (OAM) in 1998 for service to agricultural education, the sheep and wool industry and the community and in

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<sup>1</sup> Graduates of Wool Technology and Wool & Pastoral Science are identified by their degree without reference to UNSW

1999 received a UNSW 50<sup>th</sup> Anniversary Jubilee Medallion for outstanding contribution to the work and life of the University.

Dr Geoff Robards BSc (PhD Melb), who had held senior positions in research and management in the NSW Department of Agriculture before becoming a senior lecturer in nutrition was Head of the Department from 1994 until its closure. He was elected to a Fellowship of the Australian Society of Animal Production in 2000.

#### PROFESSOR OF WOOL TECHNOLOGY.

When a second chair was established Dr Haydn Lloyd Davies FAIST FASAP, previously officer-in-charge of the M C Franklin Laboratory in the University of Sydney, became Professor of Pastoral Science in 1975 but the chair in Wool Technology was not filled after Professor McMahon retired and it remained unoccupied for many years despite vigorous appeals by graduates and industry to the Vice-Chancellor. However in 1990 the Wool Research & Development Corporation (WRDC) agreed to provide funds for a Professor of Wool Technology and the position was established in the School of Fibre Science & Technology but when an appointment was made the WRDC declined to proceed with the funding and there was no impact on activities in the Department of Wool & Animal Science.

#### INFRASTRUCTURE FOR RESEARCH AND TEACHING.

For the first seven years at East Sydney Technical College there was very little provision for university activities but in 1958 the School moved to the main campus at Kensington to share a new prefabricated concrete building with several other groups. Gradually it was able to expand to occupy the whole building and to spread into part of the adjacent project building as well as some of the original huts. Thirty years later the Department moved again into a refurbished portion of the Robert Webster Building which housed the Department of Textile Technology.

The wool testing laboratory that was established in 1953 at East Sydney to provide a service to the wool and textile industries was transferred to Kensington and continued to be an essential facility for teaching and research. At the outset the main user was the Flock Testing service and clean scoured yield, staple length and crimps per inch (from which quality number was deduced) were measured on greasy samples. Measurement of fibre diameter using the projection microscope was available but was replaced by measurement with airflow instruments when this became standard then when the FDA was developed by CSIRO the University obtained a prototype and later was able to upgrade to the Fibre Fineness Distribution Analyser and obtain an Optical Fibre Diameter Analyser on loan from the developers. The laboratory was accredited by Interwoolabs and also became a participant in the second tier of the Interlaboratory Round Trials which were monitored by the IWTO.

The first field station operated by the School was 1170 ha near Carrathool leased from Mulberygong Ltd in 1962 and managed by Professor Euan Roberts as a site for sheep breeding investigations. These activities transferred to near to Hay when a portion of the Common was vested in the University in 1966. Expansion occurred through purchase of adjoining land and irrigation water. The Hay Field Station was used by many postgraduate students and the



University also leased a portion of the Falkiner Memorial Field Station near Deniliquin from the CSIRO and used this to initiate sire evaluation and sire referencing studies. Portions of other Commons at Wellington, Stuart Town and Manildra were vested in the University and became the Central West Field Station which was managed by the Institute of Rural Technology but the main user was Wool & Pastoral Science. The Manildra block was relatively small and was intended to be used for cropping research but the resources of the School were too stretched to achieve much so the block was relinquished. Professor Ian Johnstone established a parasitology research unit on Wellington and with access to water from the river Mr Doug McFarlane developed an area for irrigated pastures and associated grazing experiments and on Stuart Town he established a large scale fertiliser/stocking rate experiment which ran for several years. In 1966, to the surprise of many, the University became involved in the arid zone when the Vice-Chancellor, Professor J P Baxter, negotiated a lease for 10 years over Fowlers Gap Station of nearly 40,000 ha, north of Broken Hill. This had been a field station of the NSW Soil Conservation Service until the Service relinquished all but a small regeneration area and a pastoralist was given a short term lease. Eventually the University was granted a 99 year lease and developed Fowlers Gap into an international centre for research and teaching in a wide variety of activities. It was used by WAPS for research on pastoral management, sheep production and the biology of feral goats and for teaching and research on range management. Professor Ian Johnstone played big role in the development of Fowlers Gap and he began research on wool production and sheep management which John Kennedy continued and extended with grants from wool industry funds. The rams used in the station flock of approximately 3000 breeding ewes were bred in a nucleus in which replacements were selected on birth status and measured criteria of wool weight and quality. The flock achieved net reproduction rates well above the average for the district.

Facilities for research with cattle became available when Professor Roberts negotiated to lease land near Tea Gardens from the AMP company and persuaded Poll Hereford breeders to donate stock. A more permanent arrangement came when the University purchased part of Burraduc station on the northern shore of Myall Lake. This became the site for collaboration with the NSW Department of Agriculture in research on crossbreeding. A Sheep Research Unit was established in the grounds of Prince Henry Hospital, a University teaching hospital at Little Bay and was utilised by many research groups that used sheep as experimental animals.

#### INDUSTRY INVOLVEMENT.

Shortly after the School of Wool Technology opened Professor McMahon and Mr Goldstone organised lectures to be presented in the Wool Exchange in the Sydney CBD to give the wool trade some of the latest information on wool production. These grew into short courses of lectures and demonstrations which for a time were held twice a year to cater for the wool trade and producers but eventually became an annual event in the May school holidays and provided opportunities for presentations and vigorous debate on industry issues particularly the introduction and adoption of objective measurement in wool selling and sheep breeding.

Professor Euan Roberts became the main organiser and the journal *Wool Technology and Sheep Breeding* was started as a means of publishing these presentations and continued to do so but also expanded to be a journal for publication of research papers.

#### RESEARCH AND CONTRIBUTIONS OF GRADUATES TO THE PASTORAL INDUSTRY.

Full-time MSc and PhD students contributed greatly to the research output of the School and Department. Approximately 75% of these students had taken their first degree from a university other than UNSW, including many from overseas and nearly half of the PhDs were awarded to international students.

The main areas of research, postgraduate training and employment of graduates became pasture agronomy and range management, wool metrology and marketing, genetics and animal breeding, animal nutrition, animal health, and animal reproduction.

#### WOOL METROLOGY AND MARKETING.

When Professor McMahon was at Leeds University it was the preeminent centre for research on fibre and textile science and nearby in the mills of Bradford most of the wool from Australia and New Zealand was processed. He was awarded a PhD for a prize winning thesis but he also took the opportunity to learn about the practicalities of conversion of raw wool into top and fabrics and made time to develop knowledge of mathematical statistics. Back in New Zealand he was appointed Wool Metrologist for DSIR so it was inevitable that wool metrology and its role in marketing would become a major teaching and research activity in the School of Wool Technology. One indication the value of this to Australia is that approximately 25% of all the BSc graduates have been involved for at least some part of their career in the revolution in wool marketing that began in the 1970s.

In the 1950s wool quality was assessed by feel and visual appearance and classers and valuers became very skillful in applying these methods, however some scientists notably W R Lang of the Gordon Institute in Geelong and N F Roberts of the CSIRO were showing that these subjective assessments, although they were the basis on which greasy wool was valued for sale, did not always align closely with the traits which were important to the processor. Many scientists became strong proponents of changing the selling system to include measurement and this began to be achieved in 1972 when sale by sample and certificate was offered as a marketing option. Now virtually all wool is sold with measurements of at least yield and mean fibre diameter.

The School of Wool Technology had been at the forefront of pressure for change and John Skinner BSc PhD, Bob Whan BSc MSc, Sas Douglas BSc MSc, David Charlton MSc and Hugh Hopkins BComMSc, produced theses that reported research which helped to pave the way (Appendix 1). Added to this were the special schools which provided a forum for very lively debate on the pros and cons of using measurement and the publication of the proceedings in *Wool Technology & Sheep Breeding* helped to broaden the debate. Prominent promoters of change were Ken Whiteley BSc, who became a lecturer in Wool Technology in 1959 after returning with a PhD from Leeds University, Bob Whan and David Ward BSc, the Director of

the Australian Wool Testing Authority. Bob Whan was a wool classer before he enrolled in Wool Technology, and also studied in Leeds before he became leader of a research group in the Bureau of Agricultural Economics. In 1972 he was elected as the (Labor) Member for Eden Monaro to the Federal Parliament where he continued his support for reform of wool marketing. His numerous contributions to primary industry and the community were recognised in 1990 when he became a Member of the Order of Australia (AM). David Ward had joined the CSIRO in the Division of Textile Physics where research on measurement began but it was not long before he joined the Wool Testing Authority and he also became a member of the Order of Australia in 1999 when he was awarded a Medal of the Order (OAM) for service to the wool industry particularly through development of wool testing in Australia and internationally.

The pressure for change had a favourable outcome in 1970 when the Australian Government allocated \$1,500,000 to the Australian Wool Board to fund the Australian Objective Measurement Project (AOMP) to investigate the technical and economic feasibility of potential new systems for sampling, testing and sale by sample. With some of these funds Ken Whiteley was able to gather a small team of researchers to contribute to the Technical Report (AWB 1973) which provided the scientific and economic justification for the introduction of sale by sample and certificate. It is notable that 14 of the 31 authors in the Report are Wool Technology graduates.

The significance of the role played by these graduates was recognised with several awards, beginning in 1983 with the presentation to Ken Whiteley of the Urrbrae Medal for an outstanding contribution to Australian agriculture in the areas of economics and marketing, followed in 1988 by the award to him of the Warner Memorial Medal of the Textile Institute for outstanding contribution to textile science and engineering. Then in 1989 a group received the CSIRO Medal for the research achievement which led to the introduction of objective measurement and sale by sample and certificate. The members of this group were the UNSW graduates Ken Whiteley, Bob Whan, Sas Douglas, David Charlton and Rob Rottenbury MSc and Rob's CSIRO colleagues Murray Andrews, Dave David, Bruce Mackay and Jim James. In 1980 Ken had moved from the University into the CSIRO Division of Textile Physics and soon was Chief of the Division and then Chief of the new and larger Division of Wool Technology.

When sale by sample and certificate was offered to growers as a marketing option the measurements began to be accepted but R&D was still needed to improve the test methods and design equipment and procedures to enhance their commercial use. Approximately 40 WAPS graduates spent part or all of their career in groups established for this in UNSW, the CSIRO and AWTA Ltd, including 15 in the Ryde laboratory of CSIRO and 13 in the research section of AWTA Ltd.

At the time most of the processors of Australasian wool were in the northern hemisphere and they had to be convinced that objective measurements were acceptable as a basis for trading and be assured of the accuracy and precision of the test methods. The processors belonged to the International Wool Textile Organisation (IWTO) so it had to be persuaded to adopt new standards and to base them on Australasian standards. Several graduates played key roles in this lobbying as well as in the Testing of Wool (TX/12) Committee of the Standards Association where the Australian standards were developed. UNSW was represented on TX/12 by WAPS

staff who with many graduates were active contributors to the committee and its working groups and John Kennedy was the independent chairman for 12 years.

Undoubtedly one of the most significant contributions by UNSW was educating the graduates who put measurement into commercial practice. The majority were employed in AWTA Ltd which became the dominant test house. E P Gohl BSc was the first when he was appointed as Senior Testing Officer in 1957 and he was followed into the organisation by another 29 which made it the biggest non-government employer of WAPS graduates. These included David Ward who started as Wool Supervisor in 1965 and was the CEO from 1966 until 2001, Michael Jackson BSc who succeeded him as the Managing Director and Sas Douglas who joined in 1970 as Assistant Director and was Deputy Managing Director until 2001. In other test houses Hugh Oates BSc went from managing the Victorian laboratory of AWTA to be Technical Manager in the NZ Wool Testing Authority where Mark Player BSc and Lindsay Spencer BSc were Operations Manager and Technical and Development Manager, respectively, after both began as research officers. David Ward and Michael Jackson were also Managing Director of NZWTA when it was controlled by AWTA Ltd.

Another recommendation of the AOMP was that research be undertaken to develop measurement techniques for wool fibre characteristics important in processing which are not yet measurable (AWB 1972). UNSW's particular contribution to this was the introduction of an IWTO test method for average yellowness which was based on research of Ken Whiteley, Dennis Teasdale who succeeded him as the senior lecturer in wool technology and Barbara Thompson who was employed on funds from the Wool Research Trust Fund. Professor Whiteley also designed an instrument to measure the length, strength and position of break of staples that, with a reference from classical mythology, was cheekily named Perseus because the rival CSIRO instrument had the prosaic name of ATLAS (Automatic Tester for Length and Strength). Despite this, after extensive evaluation by AWTA Ltd ATLAS was chosen to measure Australian wool. Fibre curvature and bulk of carpet wools are other standardised measurements that are based on the studies of resistance to compression by Professor Whiteley and postgraduate students.

Quality assurance was another element in fostering confidence in the use of measurement in trading wool and the Final Report of the AOMP recommended the establishment of an independent national body to oversee that proper standards of sampling and testing were maintained and to inspect test house operations (AWB 1972). The Wool Measurement Standards Authority (AWMSA) was created to do this but when the Australian Government decided to quit this role the Wool Surveillance Authority was formed within the National Association of Testing Authorities (NATA) and Chris Winston BSc MSc who had been a scientist in CSIRO was recruited to be the Manager.

Objective measurement had ramifications throughout the wool industry including wool commerce where in 1950 the usual qualification for employment in the broking and buying sectors was experience in wool classing. Valuing was based on the skills of subjective appraisal although buyers often measured lots post-sale to help them in assembling consignments. Employment of WAPS graduates in mainstream broking firms did not begin until 1978 when Farmers & Graziers Cooperative (F&G) began taking some as trainees in the agency and merchandising divisions although just before this Margaret Lamb BSc and Kery Collien BSc had

been field officers with Economic Wool Producers Ltd., a small innovative company which used measurement in selling. In 1991 the recently appointed chief executive of Dalgety Farmers Ltd approached the Department to discuss employment of graduates and three were taken into the wool division. Chris McDonnell BSc became NSW Manager of Wool and Wool Stores for Landmark and Bill Mitchell BSc progressed to be National Manager of Trading & Risk Mnaagement in Wesfarmers Landmark. Formal study of price risk management had been included in the undergraduate curriculum when Wool Marketing was offered as a subject and several graduates went down that path including Bill Mitchell who set up Platinum Agribusiness Ltd after he left Wesfarmers, Michael Conn BSc who set up a futures trading desk in Macquarie Bank and John Watson BSc who did a similar thing in the Commonwealth Bank.

One of the F&G trainees was Michael Avery BSc who moved into wool buying and exporting and in 2009 became President of the Australian Council of Wool Exporters and Processors and a Director of both AWTA Ltd and AWEX Ltd. At least ten other graduates worked in buying and exporting firms including four women which was unheard of when the School was established.

For many years UNSW and Lincoln University in New Zealand were the only universities that offered a degree course with substantial teaching of wool technology. In Lincoln, David Cottle BSc (PhD UNE) followed by Peter Maher BSc PhD were the responsible academics and in UNSW Ken Whiteley was followed by Dennis Teasdale, a Textile Technology graduate, then David Cottle. They were assisted in the teaching of practical wool skills by J R Paynter, R E Sallaway and Geoff Lenehan GradDip. Dennis Teasdale published some of his teaching material as *The Wool Handbook: A to Z of Fibre to Top* (Teasdale 1995) that continues to be a valuable educational resource and the *magnum opus* of David Cottle who is Professor of Sheep & Wool Science in the University of New England is *The International Sheep & Wool Handbook* (Cottle 2010) which he compiled and edited. In July 1993 the Cooperative Research Centre (CRC) for Premium Quality Wool started with the core partners of Australian woolgrowers (through the Wool Research & Development Corporation), the CSIRO, Agriculture Western Australia and the universities of New South Wales, New England and Western Australia. The University of Adelaide joined in 1995. A feature of the CRC was the Education Program in which the universities collaborated to offer teaching in wool production, wool metrology and wool marketing to students in the partner universities through the medium of videoconferencing. UNSW was a key player and Dr Peter Auer, another Textile Technology graduate, was appointed as a lecturer in the Department of Wool & Animal Science to establish the videoconferencing facility and teach in and coordinate the contribution. Brad Crook BSc PhD had a similar role in UNE. After the Department was disestablished and the original CRC was wound up Peter Auer helped to organise the educational material for repository on Woolwise the website of the Australian Wool Education Trust (AWET), which is chaired by David Ward OAM. This material was updated and extended on the initiative of Professor Cottle after he joined UNE and it now is part of modules which are available through the AWET. Curtin University was not a partner in the CRCs but it appointed John Stanton BSc PhD followed by Kathryn Ford BSc PhD to teach wool science and marketing to students on the Muresk campus. Don Hughes BSc MSc became Head of the Scool of Rural Studies in NSW TAFE which continued to train wool classers with several graduates on the staff and John Reynolds BSc PhD and Richard McEvoy BCom were Executive Officer of the NSW Sheep Industry Training Committee which trained shearers and shed staff.

A very large proportion of the substantial funding that was provided for research and postgraduate training came from levies paid by farmers, supplemented by contributions from the Australian government. The administration of these funds changed dramatically in the 1980s when on the initiative of Mr. John Kerin, Minister for Primary Industry, the Australian government established numerous commodity councils and corporations with boards that were appointed by the Minister on the recommendation of a selection committee. Except for the Meat R&D Corporation, each of these selection committee comprised a core group of four plus nominees of the particular industry. The first chairman of the selection committees was Dr Kevin Foley who had started at UNSW as a Wool Commerce student but after a couple of years converted to major and gain a PhD in economics and later worked in the Australian Wool Corporation (AWC). The member of the core group with scientific qualifications was John Kennedy. The next chairman was Peter McIness BSc MSc (PhD WA) who had been the chairman of the board of the Australian Meat & Livestock R&D Corporation. Ken Whiteley was selected to be a member of the board of the Wool Research Council but before the creation of this council several graduates had been involved in administration of the funds in the AWC, including Peter Booth PhD who became Group Manager of the R&D Department. Several years later Alan Trounson BSc MSc (PhD Syd) was appointed to the board of Australian Wool Innovation Ltd. and Grant Burbidge BSc was elected to the board of Meat & Livestock Australia Ltd.

The AWC came into existence in 1973 soon after the conclusion of the AOMP to facilitate the research, promotion and marketing operations of the industry and shortly after this Ken Whiteley spent some of his study leave from UNSW establishing the Fibre Specification Department. Sandra Welsman BSc was appointed Manager and many other graduates subsequently worked in an expanded Raw Wool Services Department occupying such roles as Controller of Technical Developments, Fibre Specification Officer, Controller of Special Projects, Registrar of Classer Registration and Controller of Pesticide Testing. Russell Pattinson MSc joined after he completed postgraduate study in WAPS and he progressed to be Group Manager-On Farm Technology in the AWC and then Group Manager-Australian Operations in the Woolmark Company. The AWC established the Committee on Objective Measurement, later renamed the Committee on Quality Assurance and Specification, to advise the board on policy and Ken Whiteley and then John Kennedy represented UNSW.

#### GENETICS, ANIMAL BREEDING, PLANT BREEDING.

On his way home from Leeds Dr McMahon had some contact with some of the animal scientists in the USA who were pioneering the development of quantitative genetics and in 1943 he published estimates of genetic parameters of the New Zealand Romney. In the 1950s in Australia he became an active participant in the debate about the use of measurement and quantitative genetics in stud Merino breeding and in 1954 to encourage performance recording he obtained financial support from the Wool Research Trust Fund to start a Flock Testing service in the School of Wool Technology. Mr Euan Roberts, another graduate of Massey College, was given a temporary appointment to organise it. This service became a feature of the School and continued until the closure but external funding declined and it became largely user-pay with substantial in-

kind subsidy by the University. Initially staff from the School visited studs at ram shearing to weigh fleeces and collect samples which were brought back to be scoured and measured but the scheme evolved so that studs did the weighing and collection using equipment supplied by the School. When the measurements and statistical analyses were completed breeders received a report which included advice on selection options. In the early years Euan Roberts actively promoted flock testing with displays at the Sydney Sheep Show, held in the Showground at Moore Park, and country shows as well as through articles in *Wool Technology & Sheep Breeding*. He was the first to be awarded a PhD in Wool Technology for a thesis which reported his research on practical applications of performance recording. After appointment to the permanent staff as a lecturer he made many valuable contributions including development of the Hay Field Station where he initiated the work which led to the White Suffolk sheep breed and sire referencing and sire evaluation schemes. The White Suffolk is now a recognised breed and sire evaluation has taken on so well that there is an Australian Merino Sire Evaluation Association, with Ben Swain BSc as the Executive Officer. In 1993 Associate Professor Roberts became a Member of the Order of Australia (AM) for service to the wool industry and to education.

Euan Roberts and John James collaborated in teaching and research in genetics and animal breeding after John was appointed as lecturer in genetics and biostatistics in 1962. He had a BA, with a major in mathematics, from the University of Queensland and had become experienced in the study of genetics and animal behaviour while assisting the research of Dr Glen McBride of UQ. When WAPS closed he was an Associate Professor with a DSc from UNSW for his published work on quantitative genetics, biostatistics and animal behaviour and the honour of being the first to receive the Helen Newton Turner Medal that was established in 1993 to recognise an outstanding contribution to the genetic improvement of Australian livestock. His many achievements are summed up in the citation for the award which stated *inter alia* Professor James is regarded as Australia's leading scientist in quantitative genetics and the theory of genetic improvement. *Professor James' contributions have been made in several areas-through his research, his teaching and professional activities, and involvement with industry in Australia and overseas. The contributions by Professor James are substantially larger than most appreciate. The range of new theory he has produced, its high relevance to the design of modern genetic improvement programs and the impact of this work on moulding our approaches to how genetic improvement can be achieved in practice has been very substantial.* He also was elected as a Fellow of the Association for the Advancement of Animal Breeding and Genetics of which he is a past president.

Approximately 10% of graduates, many of whom gained a PhD, had careers in research and application of genetics in animal and plant breeding and over 50 UNSW theses (Appendix 1) were written by students who were supervised by Professors James, Roberts and McMahon (who had assistance in the early years from Drs F H W Morley of the NSW Department of Agriculture and A A Dunlop and Helen Newton Turner of the CSIRO).

The Trangie research station of the Department of Agriculture was a pioneering centre for genetic research and in the 1950s and 1960s many new graduates were placed there to carry on the Merino breeding studies which were initiated by Drs Morley and R B Dun. Bill Pattie BSc PhD, Brian McGuirk BSc MSc (PhD Edin), Sue Mortimer BSc PhD and Pat Taylor GradDip

MSc made substantial contributions to research on Merino genetics while based at Trangie and the extensive data accumulated there became a rich source for analysis by postgraduate students. Bill Pattie progressed to be the director of production research in the Department before becoming a senior lecturer in Hawkesbury Agricultural College, Reader in Animal Breeding in the University of Queensland and Professor of Agriculture and Pro Vice-Chancellor in the University of the South Pacific. Brian McGuirk was in CSIRO when he was commissioned by the Production Research Advisory Committee of the AWC to review the progress of the national research effort in Merino breeding. After providing a comprehensive report to the Advisory Committee in 1987, he convened a national conference and edited the proceedings (McGuirk 1987). Not long after this he moved to the UK and joined Genus plc a leader in dairy cattle improvement. The Department's Cowra station became a centre for research on breeding for sheepmeat production that was led by Neal Fogarty BSc MSc (PhD Nebraska), who later was Leader of Sheep Genetics and Improvement. On the north coast at the Wollongbar centre Barrie Restall BSc PhD and Bill Pattie (by then in the University of Queensland) became the experts on genetics and breeding of Australian Cashmere goats. Both were elected to Fellowships of the Australian Society of Animal Production for this and many other contributions. On the Glen Innes station the contribution of Doug Fowler BSc MSc PhD to animal breeding was adaptation of obstetric ultrasonography to identify ewes carrying multiple pregnancies and development of strategies to manage ewes bearing and rearing twins.

In other states Bob Howe BSc was Director of The Animal Breeding Research Institute of the WA Department of Agriculture, another important centre for research on Merino breeding, and Raul Ponzoni PhD was the leader of genetic research in the South Australian Department of Agriculture and in SARDI. In 2009 both Raul Ponzoni and Neal Fogarty were elected as Fellows of the Association for the Advancement of Animal Breeding and Genetics for their eminent service to animal breeding, particularly to the development and implementation of performance recording in wool and meat sheep. Dr Ponzoni was acknowledged as a key technical member of the 1980s Working Party which provided the foundation on which Woolplan and LAMBPLAN were developed and Dr Fogarty's 1995 definitive review of genetic parameters for liveweight, fat and muscle measurements, wool production and reproduction provided parameters that were fundamental to the development of LAMBPLAN. Another graduate who played a key role in the development of Woolplan was Peter Morgan BSc (PhD UWA) of AWTA Ltd who stimulated the inclusion of quality assurance features and arranged for provision of test samples for round trials of testing laboratories and regular processing of standard data sets by service providers. These performance recording schemes are now known as MERINOSELECT and LAMBPLAN and are offered by Sheep Genetics Australia where the Manager is Sam Gill BSc, one of the last to graduate in Wool & Pastoral Science. Andrew Moseley BSc, a producer of Boer goats and White Dorpers who for a time was a BREEDPLAN consultant in ABRI is a member of the Sheep Genetics Advisory Committee and Bronwyn Clarke BSc (PhD UNE) is a genetic advisor for MERINOSELECT.

Outside Australia Roberto Cardellino MSc and Jack Mueller PhD have been leaders of genetic improvement programs in Uruguay and Argentina, respectively, and Pukah Kohun PhD is a Principal Research Scientist in the National Research Institute of PNG.

The second postgraduate degree to be awarded in Wool Technology was an MSc to SSY Young



who was a colleague of Helen Turner in CSIRO. Later he was awarded a DSc for his published contributions to the theory of selection, which included co-authoring *Quantitative Genetics in Sheep Breeding* (Turner and Young 1969) with Helen Turner. Sid Young moved to the USA and became Professor of Genetics in Columbia University. Rob Woolaston BSc PhD was Program Manager then Deputy Chief of the CSIRO Division of Livestock Industries in which Ian Purvis BSc ( PhD UNE) is both Officer-in -Charge of the F D McMaster Laboratory in Armidale and Theme Leader for the program on Transforming the Animal and its Products and Yutao Li PhD was a member of the group awarded the 2003 CSIRO Medal for discovery and industrial application of molecular genetic tests in cattle and continues work to identify economically important traits of cattle and pigmentation genes in Merino sheep. Since 2006 Mark Morrison BSc (PhD Illinois) has been Science Leader of the metagenomics program in CSIRO. He was a Professor of Microbiology in the Department of Animal Science in Ohio State University when he was the first appointment made under the CSIRO Chief Executive's Science Leader Scheme which aims to attract the best mid-career scientists from around the globe. Metagenomics is a new field combining molecular biology and genetics and Mark's research aims to improve understanding of gut function and health to be able to lower animal greenhouse gas emissions, improve feed use and reduce the use of antibiotics, for example (CSIRO 2007).He is considered to be a world leader in gut microbiology and genomics.

Gerard Davis BSc(PhD UNE) worked in CSIRO then took the risk with Dr Jay Hetzell, a colleague, of starting a company to commercialise some of their beef cattle genetic marker work. The company became the licensee of the CSIRO intellectual property and now is part of the international company Pfizer Animal Genetics with Gerard as Global Head of Development and Operations.

In 2009 Claire Wade BSc PhD became Professor of Animal Genetics and Computational Biology in the Faculty of Veterinary Science in the University of Sydney. Claire was a quantitative geneticist in the Victorian Department of Agriculture and the University of Queensland Veterinary School before working in The Broad Institute of MIT and Harvard in the USA on the mouse and dog genome projects and then leading the international team that sequenced the horse genome.

Although only a small number of graduates have been plant breeders they have been very productive particularly Paul Cotterill BSc PhD whose PhD thesis reported studies on crossbred lamb carcasses but gained him a position as a quantitative geneticist in the CSIRO Division of Forest Products where he progressed to be Chief of the Division and then became the initial chief executive of Ensis a joint venture between CSIRO and Scion NZ that was set up to commercialise results of research on forests and forest products. He also co-authored *Successful Tree Breeding with Index Selection* (Cotterill & Dean 1989) and spent several years in Portugal as a senior member of Stora Enso Celebi. Others who have worked with trees are Rob Woolaston who as a genetics consultant has the leading international forest products companies among his clients and Richard Kerr BSc (PhD UNE).Richard is Research Geneticist with PlantPlan Genetics, the commercial arm of the Southern Tree Breeding Association which has branched out into research on crops with a shorter rotation than trees including potatoes. Keith White BSc PhD(in the School of Botany) was the first to go into plant breeding and has been a leading breeder of canola, oilseed sunflowers and grain sorghum in agribusiness where he has held

senior positions including General Manager of AgSeed Research and a founding director of Dovuro Seeds, the leading canola seed company in Australia.

A few also have become involved in genetic improvement of aquatic species including Raul Ponzoni who now is Principal Scientist and Leader of Genetics Projects in the World Fish Centre, Alex Safari PhD who went from working on sheepmeat genetics in the NSW Department of Agriculture to a Research Fellowship in the Seafood CRC in Flinders University and Yutao Li who has applied her quantitative skills in the CSIRO team working on prawn production.

One of the most distinguished geneticists is Susan Serjeantson AO, BSc (PhD Hawaii) who when she was Professor of Human Genetics in the Australian National University received the Ian Clunies Ross National Science & Technology Award for excellence in the application of science and technology and was honoured in 2000 with appointment as an Officer of the Order of Australia for her service to science, particularly through research in the field of human genetics, and to academic administration as an advocate of scientific research in roles such as Deputy Vice-Chancellor of the ANU, President of the Federation of Australian Scientific & Technological Societies and Executive Secretary of the Australian Academy of Science. Professor Alan Trounson BSc MSc (PhD Syd), a contemporary of Professor Serjeantson, began his post-doctoral career on a Dalgety International Research Fellowship studying embryo transfer in cattle in Cambridge from where he was recruited by Professor Carl Wood to the Monash University team commencing work on human IVF. Alan's subsequent achievements have earned him many awards and he now is President of the California Institute for Regenerative Medicine but in Australia he contributed to animal production as a director of the Rural Industries R & D Corporation and Australian Wool Innovation Ltd as well being involved in a commercial goat enterprise.

One of the first postgraduate students was Greg Shanahan MSc PhD whose PhD thesis reported studies on the genetics of insecticide resistance in the sheep blowfly. Dick Hart BSc PhD was encouraged by Greg to pursue similar research and after a career that included director of research in Ciba Geigy he was seconded to the AWC to coordinate R&D on flystrike and later directed animal production research in the NSW Department of Agriculture (a role that at other times was filled by Bill Pattie, Peter McInnes, Geoff Robards and Tony Gleeson MSc). Other parasitologists are Roger Prichard BSc PhD, now Professor of Parasitology in McGill University, who led research in CSIRO into the biochemistry of resistance of gastrointestinal parasites to anthelmintics and Ross Windon BSc PhD who was part of the Sheep Genomics Project identifying genes in sheep that confer resistance to gastrointestinal parasites.

## Appendix 1

Theses in Wool Metrology & Marketing

PhD theses

Skinner, John Norman. The relative economic value of wool traits

Shah, Syed Maqsood Ali Shah. The significance of variations in the mechanical properties of wool keratin with special reference to quality assessment.

Chaudri, Muhammad Aslam. The influence of single fibre characteristics on the felting and bulk compressional properties of wool.

Balasubramaniam, Eliathamby. Some observations on the biophysical and mechanical properties of crimped wool

Campbell Mary Elizabeth, The influence of sheep selection and nutritional level on the relationship between crimp frequency and chemical composition of wool fibres: with particular reference to high sulphur protein fractions

Kaplin Ian Joel, An electron microscope study of the ultrastructure of high and low crimp wool and mammalian hair keratins

Kulkarni Vishwanath Ganpat, The isolation and characterisation of cortical cells and their constituent protein fractions from high and low crimp wool fibres

Kurdo Kasim Omer Aziz, The role of resistance to compression in the processing of superfine wool on the worsted system

Hansford, Kerry Anne. Influence of nutrition and reproduction on length, strength and position of break of merino wool

Russell, Benjamin Conway. Estimation and implications of sampling variance in raw wool sale lots

Swan, Paul Gerard. Objective measurement of fibre crimp curvature and the bulk compressional properties of Australian wools

Ford, Kathryn Lisa. Some options for improving economic returns from wool in the pastoral zone of NSW

#### MSc theses

Villarroel Leon, Juan. A study of alpaca fibre.

Chapman, Ralph Edward. An investigation of abnormal wool growth with particular reference to crimping.

Balasubramaniam, Eliathamby. The estimation of some rheological constants in the yield region of single wool fibres.

Hill, David Deveril. Seasonal and nutritional variations in the sulphur content of Merino wool fibres

Douglas, Stephen Arnold Sholto. The application of objective measurement to wool marketing in Australia.

Whan, Robert Bruce. The relationship of staple crimp to fibre crimp and the inter-relationship between crimp and fibre parameters.

Khan, Mumtaz Ahmad. Chemical modification of the crimp structure of wool fibres.

Ali, Muhammad Ashraf. The comparative felting and compressibility of wool types.

Armstrong, Leslie Deeks. The torsional properties of wool fibres containing artificially induced high sulphur contents.

Charlesworth, David Huntley. A study of dust contamination in merino wool in low rainfall areas.

McKinnon, Jennifer Mary. Area and clip influences on greasy wool characteristics.

Middleton, Christine. The effect of nutritional variation on the composition of wool keratin and the determination of the acetyl content of wool and its extracted proteins by gas chromatography.

Watson, Neil Ronald. The bilateral structure of crimped wool fibres.

Charlton, David. Some objective characteristics of greasy wool sale lots.

Hopkins, Hugh W. Some observations in the appraisal of wool fibre characteristics and their commercial significance

Scott, Robert Ferguson. Objective measurement of wool traits by near infrared reflectance

spectroscopy

Keogh, Michael J. Greasy wool measurement using near infrared spectroscopy

Marler, James William. Spectroscopic measurement of the yield parameters of washed wool.

Rottenbury, Robert. The role of fibre-length measurement in assessing early stage processing performance of greasy wool.

Winston, Christopher Rashleigh. Studies of rapid heating of high density bales of greasy wool to improve the ability to open bales prior to scouring

Pattinson, Russell David. The influence of raw wool characteristics on the prices received for wool

Roberts, Gerald Michael O'Brien. The implications of the additional wool measurements of staple length, staple strength and position of break for wool growers in North-West Queensland

Tucker, Rowena E. An investigation of interlotting standards for wool

Lu, En Long. Australian wool consignments for the Chinese textile industry

Lindsay Andrew Robert Crawford. The measurement of wool colour using a certified tile calibration.

Theses in Genetics, Animal Breeding & Plant Breeding

DSc Theses

James J W. Studies of population genetics and behaviour with special reference to animal production. 1973

Young S S Y. Contributions to the theory of selection with particular reference to Merino sheep. 1966

PhD Theses

Roberts, Euan Maurice. The practical application of the method of selection promising the greatest improvement in Merino productivity.

Shanahan, Gregory James. The inheritance of type 2 resistance in *Lucilia Cuprina* Weid. : the Australian sheep blowfly.

Ford, Geoffrey Hunter. Age changes in production characters in merino rams and ewes and a study of flock structure in breeding flocks of merino sheep

Pattie, William Anthony. Selection for weaning weight in merino sheep.

Fowler, Douglas George. Studies on the association of skin folds and fertility of rams

Jackson, Neville. A comparison of the genetic means of seven merino studs for wool, body and reproductive traits.

Robertson, Donald Evan. Selection in small populations.

Tierney, Michael Leo. Genetic studies of puberty in merino ewes

Woolaston Robert Roy. Studies of the production characteristics of several sheep breed types and crosses

Ponzoni Raul W. Studies on the estimation of genetic parameters

Gregory Ian Philip. A study of the genetic parameters of meat sheep

Cotterill Paul Percival. Estimates of genetic and environmental parameters for some cross bred lamb carcass and growth characters

Fukui, Yutaka. Studies in controlled breeding of sheep

McKinley Adrian Howard. A study of genetic and environmental factors causing variation in the fibre diameter and other traits of the wool of merino sheep

- Mitchell Brenda. A study of the growth and carcass characteristics of large lambs
- Mueller Joaquin P. Population structure and selection criteria in animal breeding programs
- Mortimer Suzanne. Efficiency of multi-trait selection methods with and without restrictions
- Winton Ross Graham. Genetic aspects of resistance against infection with *Trichostrongylus colubriformis* in sheep
- Chowdhary, Sarvit Singh. A study of the productive characteristics of some merino-based dual purpose sheep
- Beard Kevin Thomas. Studies on breeding objectives and selection indices applicable to the Australian dairy cattle industry
- Wade Claire Margaret. Optimum selection policies for merinos
- Gunawan, Benny. Genetic studies of quantitative characters in synthetic populations
- Mian, Beradar. Estimation of breeding values of merino rams using reference sire systems
- Crook, Bradley John. Direct and correlated responses to selection for skin fold score in merino sheep
- Eppleton, Jeffrey. Studies on the fertility of frozen-thawed ram semen
- Pitchford, Wayne. Effects of crossbreeding in sheep and cattle : a study of the effects of genotype and environment on various traits in crossbred sheep and cattle
- Maher, Andrew Peter. A comparison of lamb and wool production in crosses of three ewe-types and three sire-breeds
- Miraei Ashtiani, Seyed Reza. Some aspects of the design of sire evaluation programs : a study of progeny testing across genetically different groups
- Roshanfekar, Hedayatollah. Effect of selection intensity on selection response : a comparison between theory and experimental results
- Li, Yutao. Evaluation of selection for a quantitative trait combined with culling on low fitness
- Safari, Eskandar. Pedigree analysis of Trangie selected lines
- Salehi, Abdolreza. Detection and estimation of cytoplasmic inheritance of production of sheep
- Pomares, Cayetano C. Studies on the viability and fertility of liquid-stored goat buck semen
- MSc theses
- Taneja, Gopi Chand. Selection for mutton qualities in Australian Merino sheep.
- Young, Sydney Sze Yih. The importance of differences between observers in some criteria used in sheep breeding experiments.
- Scott, George Everly. An investigation of sampling and scouring methods applied to the merino fleece
- Shanahan, Gregory James. Dielidrin resistance in the Australian sheep blowfly, *Lucilia cuprina* Wied.
- Kennedy, John Patrick.: A investigation of the inter-relationships and inheritance of wool production, wool quality and lamb production in a flock of medium wool Merino sheep ; The estimation of phenotypic and genetic parameters in a flock of Australian Romney Marsh sheep
- Harrington, Rodney Bernard. Some applications of a digital computer in sheep breeding research.
- Pym, Robert Alexander Every. The genetic correlation between feed conversion and growth rate in broiler chickens.
- McGuirk, Brian John Hybrid vigour in sheep production

- Fogarty, Neal Breed structure and genetic analysis of the Dorset Horn breed in Australia
- Rose, Mary. Wrinkle score selection and its influence on the reproductive performance and mortality of merino sheep in north west Queensland.
- Dekhili, Mohamed. Investigations of reproductive performance of Border Leicester-Merino cross ewes in F1 and subsequent generations
- Cardellino, Roberto Carlos Genetic differences between sheep breeds in Uruguay.
- Alemayehu, Zelealem. Comparative performance of indigenous Ethiopian, exotic, and crossbred sheep, and estimation of genetic and environmental parameters
- Taylor, Patrick John. An investigation of the causes of death and the factors affecting neonatal survival in merino and merino cross lambs
- Pitono, Agoeng Djoko. A comparison of ewe productivity, lamb performance and gross income in sheep crossbreeding
- Salehi, Abdolreza. The effect of flock structure on flock productivity under various conditions in sheep breeding
- McKiernan, W. A. Growth, carcass value and body measurements from high and low muscled cattle

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