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The use of herd data to teach dairy cattle breeding in further and higher education colleges

Williams, Anwen

Award date:
2005

Awarding institution:
Bangor University

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THE USE OF HERD DATA TO TEACH DAIRY CATTLE BREEDING IN FURTHER AND HIGHER EDUCATION CONTEXTS

A thesis submitted to the University of Wales

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IN CANDIDATURE FOR THE DEGREE OF PHILOSOPHIAE DOCTOR

SCHOOL OF AGRICULTURE AND FOREST SCIENCES
UNIVERSITY OF WALES BANGOR
SEPTEMBER 2005

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ACKNOWLEGEMENTS

I would like to express my appreciation and deepest thanks to Dr Ioan Ap Dewi for his time, effort and support throughout this study. Also, for initially showing an interest in the lactation records, cunning suggestions and assistance that made it possible for the lactation records to become a data set for use within education at FE and HE levels. Sincere thanks for the dedicated supervision and his invaluable guidance that made my study an enjoyable challenge.

Thanks to Mr Gwilym Trefor Jones for his professional advice and guidance on the educational aspect of the study. Thanks also to Dr Hussain Omed for his support and encouragement in supervising the last stages of the study.

I would like to express my appreciation to Mr Alun Jones for offering me the Glynllifon lactation records. Mr Alun Jones was a former student of Madryn Farm School during the late 1940s. He was then employed as a general farm worker, then a cowman and finally as the Farm Manager until his retirement in 1997. Mr Alun Jones could not face seeing the records being discarded and destroyed following his retirement. Over the years great pride and dedication were given to recording and maintaining these lactation records.

Very big thanks to Tomos (age 7) and Mari (age 6) for helping me with 'cwfmly' in their own very special ways. Thank you for all the paper gifts and drawings, which I so much enjoyed admiring and all your inspirations. Also, for allowing me to work through all the little promises that I made.

Finally, my grateful thanks to my husband Martin, for giving me all the encouragement I needed. Thank you for your affectionate and loving support, being there to listen and giving me the incentives and confidence to keep writing.

ABSTRACT

Lactation records of the Glynllifon herd from 1950 to 2000 were used to create a data set for use within teaching contexts. The data set was analysed in terms of physical, production and functional traits and genetic parameters. The data set results compared well with that of the UK dairy industry. Lectures on Selection and Breeding using the data set were then prepared and evaluated within Higher and Further Education institutes.

The data set analysis revealed an all year round season of calving. Breed structure over time was typical to that within the UK during the twentieth century. Herd size increased over time through initially purchasing animals and then breeding replacements to become a closed herd. Average age at first calving was 30.6 months. Milk yield (MY) per cow increased from 3,097kg in 1950 to 6,941kg in 2000. Milk fat (MF) increased from an average of 3.68% in the 1950s to an average of 4.16% in the 1990s; and protein composition (%) increased slightly from 3.23% in the 1970s to 3.27% in the 1990s. Production traits and parity were analysed, and peak production was achieved between the 5^{th} and 6^{th} lactation; fat and protein composition decreased with increasing parity. The number of lactations per cow remained at three lactations throughout the data set. Days of productive life (DPL) and lifespan decreased by 8 days/year and 12 days/year respectively. Somatic cell count (SCC) increased over time and with parity. In 1995 the average SCC for the data set was 68,000cells/ml and 203,000cells/ml in 2000 and increased by 89,250cells/ml for each increase in parity. Calving interval (CI) showed no significant change over time with an average of 374days. Lactation length (LL) showed an increase of one day per year and an overall average of 289days. Day dry (DD) reduced in length over time (0.6 days per year) from 84 days in 1950s to 56 in the 1990s.

Univariate analysis was undertaken for production traits using mixed model methodology. The heritability for milk yield was 0.23, milk fat yield 0.28 and milk protein yield 0.28. Repeatability values were within the range of 0.47 to 0.49. Estimated breeding values (EBVs) for production traits showed no significant change over the years examined. However, three time phases were identified for the data set with respect to milk yield and fat yield, but not protein yield. From the start of the data set in 1950 to 1972 there was a significant increase in milk EBVs of 12.4 per year, then from 1973 to 1985 there was a significant decrease of 28.2 per year, and from 1986 to the end of the data set in 2000 an increase of 21.2 per year. Similar trends were found for breeding values on the NMR lactation records. The ICC between 1975 and 1983 decreased at a rate of 9.64 per year and PTA for milk showed an increase of 40.43 per year between 1986 and the end of the data set.

The analysed data set was then incorporated into lectures on Selection and Breeding for 128 students within FE and HE institutes over two academic years. The questionnaire and lectures were initially piloted. The programme levels included NVQ, NCA and ND as level 1, 2 and 3 qualifications respectively for the FE institute and the HE groups included HND/C, BSc and MSc.

Effective teaching, learning and student satisfaction was achieved. The overall response for all questions by all groups for the Strongly Agree/Agree (SA/A) was between 86% and 95%. The Disagree (D) responses ranged from 0% to 3% and the Undecided/Blank/ Not Applicable (UD/B/NA) ranged between 5% and 14%. Students found the lectures of interest (Q5) with 92% response to the SA/A question. Explaining (Q4) and understanding (Q1) achieved 91% and 90% response for SA/A. Positive response was achieved for aspects of teaching, including was it 'organised' (Q3) with a 95% response for SA/A. Most students enjoyed (Q9) the lectures (SA/A @ 86%). Handouts attained (Q10) 86% response to the SA/A, Bilingual (Q11) had 87% SA/A with the remaining response being UD/B/NA.

A variety of teaching methods and resources were used including gapped handouts, power point presentations, group discussions, farm exercises, IT and college dairy herd. These were found to be effective and enriched the educational experience for all the programme groups. Ensuring understanding and providing a bilingual provision where required all contribute to a positive learning experience. The analysis has heightened the considerable importance of relating education to its respective industry by adopting a valid, active innovative approach for all programmes levels within FE and HE.

CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Abbreviations for educational programmes, dairy traits and organisation in the thesis

MY	Milk Yield
PY	Protein Yield
FY	Fat Yield
CI	Calving Interval
DD	Days Dry
LL	Lactation Length
SCC	Somatic Cell Count
NMR	National Milk Recording
MDC	Milk Development Council
PTA	Predictable Transmitting Ability
EBV	Estimated Breeding Value
ICC	Improved Contemporary Comparison
NVQ	National Vocational Qualification
NCA	National Certificate in Agriculture
ND	National Diploma
HND/C	Higher National Diploma/Certificate
BSc	Bachelor of Science
MSc	Master of Science
HE	Higher Education
FE	Further Education
SA/A	Strongly Agree/Agree
UD/B/NA	Undecided/Blank/Not Applicable
SD/D	Strongly Disagree/Disagree
Herd data set	Glynllifon herd lactation records
'Cwfmly'	Glynllifon herd lactation records

Teacher and lecturer are used synonymously

CHAPTER 1
INTRODUCTION

Agricultural education has a history dating back to the nineteenth century. The demand for agricultural education increased throughout most of the twentieth century through the advent of science and technology and the demand for increasing agriculture productivity (Section 2.2.1). Animal selection and breeding was an important aspect in increasing farm output (Table 2.1). Agricultural education is of key importance in sustaining successful agriculture and promoting innovation and economic success within the dairy industry.

The success of the dairy industry during the mid-twentieth century was based on progeny testing and artificial insemination (AI) (Simm, 2000a). Breeding objectives were directed towards increased milk production (Section 2.3.1). However, by the end of the twentieth century breeding objectives were extended to include functional traits (Section 2.4). Selection and breeding within the dairy industry attained public interest regarding aspects of health and welfare of the dairy cow and ecological genetic diversity involving 'public-good breeding objectives' (Dale, 2004). At the beginning of the twenty-first century biotechnology within the dairy industry has developed significantly and includes embryo transplantation, embryo and semen sexing and mapping of Quantitative Trait Loci (QTL) (Section 2.7). Knowledge is important for the success and prosperity of the dairy industry. The dairy industry will continue to be faced with issues concerning technological innovation; global food security; optimum production; environmental issues and biodiversity (Ormerod *et al.*, 2003).

Agricultural land accounts for 80% of Great Britain's land area and makes an important contribution to the national economy (Teagasc, 2004). The UK is the seventh largest milk producer in the World and the third largest in Europe behind Germany and France (Brigstocke, 2005). Europe accounts for 40% of the global milk production (Simm, 2000b). In Wales a healthy agricultural industry ensures and maintains the socio-economic environmental and the cultural needs within Wales. Milk production contributes a third to Wales' agricultural GDP, with one in five jobs depending on the agricultural sector (Jones, 2003). Producer numbers in the UK have been steadily declining at about 3-4% per year for many years. Dairy Hygiene

Inspectorate (DHI) numbers of registered producers fell by 7% between March 2004 and March 2005 in England and Wales and by 6% in Wales (NAW, 2005b).

The average herd size in the EU-15 is 37 compared to 251 cows per herd in New Zealand. In the UK (2002) about 40% of herds had fewer than 50 cows. It was reported by the Milk Development Council (MDC) (MDC, 2005a) that 58% of all UK cows are in herds of 100-plus. MDC believed that 50% of farmers with the smallest herds account for only 25% of milk production (Brigstocke, 2005).

Declining numbers of dairy farms and increasing farm size leads to a competitive environment for the remaining dairy producers (Nielsen *et al.,* 2003). According to Boelling *et al.* (2003) agricultural education needs to produce a quantified workforce to enhance the competitiveness of agricultural enterprises. There are more people participating in education and the number of students within Wales enrolling in Further Education courses (full and part time) is rising. In 1998/99 there were 320,250 and by 2001/2 there were 475,980. Similarly, within Higher Education there were 99,440 in 1998/99 and by 2001/2 it had risen to 109,690 (NAW, 2005a).

However, there has been a fall in the number of students following traditional agriculture subjects. The employment market for a traditional agriculture graduate is small in the UK, while other professions have increased demand (Kuleuven, 2005). For the 2002-2003 academic year, agriculture was within the bottom five subjects in terms of applicants and admissions (UCAS, 2005).

This study was conducted at a very interesting period for agriculture and agricultural education. Agricultural education has faced a fall in the number of participants entering colleges. Agriculture as an industry is being opened to free trade. Agricultural productivity is no longer an issue and CAP reform allows the landscape and the environment to be key priorities (Section 2.2.8). Agricultural education is no longer isolated and cannot be considered as a 'special case' worthy of protection. Agricultural education and retention of resources, particularly college farms, have to be strongly justified (Nielsen *et al*, 2003; LBCNC, 2004). Provision should also be in place to extend agricultural education into other curriculum areas (Section 2.2.6 and 7.8). Opportunities such as 14-16 school partnerships and 14-19 educational provision are excellent government initiatives (Section 7.9) to capture and educate the non-agricultural population, the consumers and those within the industry with respect to adult education and lifelong learning.

An innovative approach to future provision is required, making learning effective and enriched to suit a wide age group as well as a diverse group of students (Song *et al.,* 2004). Understanding teaching and learning styles can help to enhance the teaching and learning. It is important to establish an active innovative approach and a positive learning environment with interactive dialogues and challenging activities resulting in concrete learning experiences. Relating courses to the real world of farming allows interpersonal, analytical techniques and problem-solving skills to be developed (Kember and Wong, 2000).

Learning and teaching strategies should be planned with students in mind. As discussed by Petty (1998) "tailors don't blame their customers if their suits don't fit ", therefore teachers cannot blame the learner for an ineffective lesson. This study provided an opportunity to reflect on practice and to engage with existing theories yielding a valuable insight into teaching and learning within the subject of Selection and Breeding, at all levels within FE and HE (Section 2.9.2 and 2.9.3).

The key principle of this study was to develop a typical, manageable sized industrial related data set, as an active innovative approach to teaching and learning. The initial stage of this study involved the retrieving, editing and processing of the Glynllifon dairy herd's lactation records (Section 3.3). A complete data set of pedigree, production and some functional data were created for the college farm dairy herd. It was analysed (Chapters 4 and 5) followed by a comparative analysis using national standards data in order to evaluate its appropriateness as a representation of a typical UK dairy data set (Section 4.4 and 5.5). Genetic parameters and variance components were estimated as well as the environmental factors affecting production traits (Section 5.3). The data were then incorporated into lectures and evaluated as to their effectiveness within teaching and learning (Chapter 6). They were evaluated across a range of programme levels from NVQ to MSc within Further Education (FE) and Higher Education (HE) Institutions (Section 6.4).

CHAPTER 2
LITERATURE REVIEW

2.1. INTRODUCTION

Agriculture and agricultural education have an interesting history that evolved hand in hand from the last half of the nineteenth century to the beginning of the twenty-first century. Science and technology have been an important part of agriculture throughout history necessitating an effective educational system. This chapter describes the historical aspects of UK agriculture (Section 2.2) and agricultural education (Section 2.8). It also reviews literature on production traits, selection and breeding as well as education theory and practice (Section 2.3, 2.5 and 2.9 respectively).

2.2 THE DAIRY INDUSTRY IN THE UK DURING THE NINETEENTH AND TWENTIETH CENTURY

2.2.1. The importance of the dairy industry during the nineteenth century

The dairy industry as a sector has made a significant contribution to UK agriculture. The importance of the dairy industry lies in the fact that milk was the nation's most essential foodstuff throughout most of the nineteenth and twentieth centuries (Goddard, 1988).

During the Industrial Revolution the industrialised processes stimulated productivity within dairy production and agriculture in general. New technological improvements and scientific processes all contributed towards an increase in agricultural productivity. These included the use of off-farm inputs, agricultural chemicals, fertiliser, land drainage and mechanisation. Also the application of new technology and mechanisation freed farm workers from the land into factories within Britain's towns and cities. By 1850 most of the population of England worked in the industrial areas. Milk contributed an important part of the urban population's diet and via the railroads, canals and locomotion the dairy industry provided milk and milk products to the industrialised society (Howarth, 1990; Goddard, 1988).

The importance of the dairy industry in supplying milk and milk product for the urban consumer allowed dairy farming to be the most profitable area of farm enterprises.
The close link between agriculture, commerce and industry consequently led to a period of 'high farming' known as the Golden Age of Agriculture, from the 1850s to the mid 1880s (Howarth, 1990; Goddard, 1988).

2.2.2. Early years of the Twentieth century

The key events in the history of the UK milk industry in the 20th century are presented in Table 2.1. During the First World War the uncoordinated efforts of farmers to obtain fair prices (Section 2.2.3) resulted in low farm incomes (DFF, 2001). Later, during the 1930s the Milk Marketing board (MMB) was set up in order to improve the marketing of milk and safeguard farm incomes nationally (Baker, 1973).

Milk was the basic constituent of the nation's diet during the First and Second World Wars. Milk replaced essential imports and provided the 'iron ration' for the evacuated population and the army (Wright, 2000). However, under war conditions the supply of home produced milk was reduced. During the wars dairy cattle were slaughtered to supply the beef market. Grassland areas were reduced as a consequence of the 'ploughing up campaign' and the guaranteed prices for cereals. There was also a lack of stable labour on dairy farms during these periods (Wright, 2000). The supply of milk to schools and factories was introduced in 1927 by the National Milk Publicity Council and led to the Milk Act 1934. 'Welfare' milk was issued in work and factory canteens as well as in schools (Baker, 1974; Barker, 1989).

2.2.3. The Milk Marketing Board

During the First World War there were restrictions on imports and the production and manufacturing of milk was encouraged by the government. However, in 1920 imports restrictions were abolished as well as price controls. Prices were depressed due to the increase in home productivity and the importing of cheap manufactured milk products from other countries (Howarth, 1990). The Government did not intervene and was indifferent in comparison to other European countries and British farmers failed to combine cooperatively in the marketing of products (Goddard, 1988; Baker, 1974). During the early 1920s there were major disputes over payment to such an extent that farmers began to withhold milk throughout the county and London particularly became short of milk. The Ministry of Agriculture was asked to intervene and as a consequence in 1922 The Permanent Joint Milk Committee was set up for London and an Area Joint Committees were set up for other populated towns and cities (Barker, 1989; Goddard, 1988; Baker, 1973).

In 1932 the need for a compulsory Milk Marketing Board (MMB) was proposed before Parliament. The MMB was set up following the Agricultural Marketing Acts of 1931 and 1933 (Barker, 1989; Goddard, 1988; Baker 1974). A pricing system was established and continued throughout the MMB's history (Baker, 1974; Howarth, 1990). The Milk Marketing Board became the sole buyer of milk and all producers had to be registered with the Board. There was a guaranteed market for milk and the same price was paid to all producers regardless of their location or whether the milk was used for manufacturing or the liquid market (Barker, 1989).

2.2.4. Post war years of protecting UK agriculture

The experiences of the war years resulted in the Agricultural Act 1947. The Act's objective was to 'produce as much part of the nation's food' and 'ensuring adequate return on capital'. Ten years later came the Agricultural Act of 1957 to give long term assurance for agriculture. The experiences of the wars and proportion of ministers within the UK government that were directly involved within agriculture, gave agriculture both support and security for many years (Howarth, 1990).

2.2.5. Prosperity for the dairy industry during the post war years

The importance of milk and milk products during the first half of the 20th century in addition to government support (Section 2.2.4) made the UK dairy industry very efficient and effective in terms of production. Genetic factors as well as feeding management, veterinary skills, grassland management and conservation, and mechanisation all contributed to its success (Baker, 1973). As written by Baker (1973) "dairy farming has a record to be proud of". Between 1955 and 1970 total sales increased by 33% while cow numbers increased by only 12%. Within the same period the number of dairy farms declined by 44%, while the production per cow went up 22% and herd sizes almost doubled. From the early 1970s British dairy farmers had a guaranteed market, few constraints and high unit price for their milk (DFF, 2001).

Table 2.1. The UK dairy industry during the twentieth century

Decade	Political events	Selection and Breeding
1920s	First World War	Breed Societies strive for breed improvement, milk recording and pedigree registration of pure-breed animals
1930s	Agricultural Marketing Act 1931 Milk Marketing Board (MMB) 1933	A.I. (Artificial Insemination) Progeny Testing (Simm, 2000)
1940s	Second Wold War Agricultural Act 1947- POST-WAR REVIVAL (Goddard, 1988)	BREED SUBSTITUTION – Friesian breed gained popularity replacing other local breeds in the UK
1950s	Agricultural Act 1957 – long term assurance for agriculture (Goddard, 1988)	Progeny Testing becoming much more commercialised (Russell, 1984) Improved Contemporary Comparison (ICC) (Dalton, 1980). Successful conception from frozen semen in 1952
1960s	Guaranteed prices of agricultural products	Breed Societies – animal conformation of important to breeders (Goddard, 1988).
1970s	Guaranteed market; high unit price (DFF, 2001) MMB Brucellosis screening service 1970 (Baker, 1973) 1972 European Community (DFF,2001) 1977 Co-responsibility levies (DFF,1989)	Throughout the 1970s and 80s progress in production slower than it might have been due to too much emphasis on conformation (DFF, 2001) Late 1970 to early 1980, group breeding scheme (MOET)
1980s	1984 Milk Quotas (DFF, 2001)	Holstein Breed introduced to UK herds Mid 1980, end of ban on the import of semen form USA (Swanson, 2004; DFF, 2001)
1990s **2000s**	1994, deregulated market of milk (DFF, 2001); Milk price reduction (strength of the sterling); BSE Crises; 1999, demise of Milk Marque; and Foot and Mouth Disease (DFF, 2001) Fluctuations in the pound/ Euro Abolition of EU intervention prices	1991 introduced £PIN (DFF, 2001) 1999 ITEM replaced £PLI (DFF, 2001) www.mdcdatum.org (2004) 2000+ Biotechnology nuclear transfer technology, cloning and QLT's.

DFF = Dairy Facts and Figures

2.2.6. External and internal constraints on the dairy industry at the end of the twentieth century

Towards the end of the twentieth century the prosperous years following the Second World War came to an end (Table 2.1). There was no guaranteed market at a relatively high price. Quotas were introduced in 1984 to control the surpluses of dairy products and budgetary cost of the Intervention Schemes, again an indication of the efficiency of the dairy industry over the previous decades (MAFF, 2001). Issues of concern included the European Union Agricultural Policy Reform. The fluctuation of the pound/euro lowered farm gate prices. The BSE crises in 1996 had negative impact on the dairy industry followed by Foot and Mouth Disease in 2001. These factors have all taken their toll on the dairy industry (Franks, 2001; DFF, 2001; Gommer and Hunter 2004; NFUW, 2004; Brigstocke, 2005). In addition the perception of milk as an ideal food has changed over the years. Consumer demand for quality and animal welfare are also key issues. (Murphy, 2001). Sales of milk within the UK showed no increase during the 1990s. In 1989 milk sales were 14,485 million litres and by 1999 it was only 14,238 million litres (AAS, 2001).

In order to allow a competitive market within the dairy industry the Milk Marketing Board was deregulated in 1994. The abolition of the MMB, resulted in the setting up of the farmer-owed voluntary cooperative Milk Marque. However, in 1999 Milk Marque was terminated under the Monopolies and Merges Commission (MMC). Consequently Milk Marque was split into three farmer-owned cooperatives Zenith milk, Axis Milk and Milk Link. The independent quota-holding bodies began purchasing milk in April 2000 (DFF, 1996; Franks, 2001; Brigstocke, 2005).

Reforms of the EU's Common Agricultural Policy have resulted in a fragmented milk price and direct compensation payments were paid to dairy producers. These payments, known as the Dairy Premium Scheme (DPS) and Additional Payment (AP), were introduced in 2004. The DPS and AP were decoupled in 2005, in favour of the Single Farm Payment (SFP) scheme (MDC, 2005b; FMH, 2004).

2.2.7. Demographic trends within the dairy industry

Dairy production holdings within England and Wales fell in number from 28,093 in 1995 to 22,841 holdings in 2004. Also dairy cow numbers declined from 2.1 million to 1.7 within the same period. The sale of milk from farms in England and Wales also reduced, from 14,065 million litres in 1995 to 12,456 million litres in 2004. Average herd size within England and Wales was 20 cows in 1960 and in 1979 had increased to 52 cows / herd. The average size of the dairy herd in Wales has increased from 59 cows in 1995 to 67 cows in 2004. In Wales (2003) 29 % of cows were in herds having 100 to 200 cows (DFF, 2001; DEFRA, 2004).

2.2.8. Dairy cattle breeds in the UK during the twentieth century

The Welsh Black Breed

The Welsh Black Breed has been an important breed in Wales since pre-Roman times. They are believed to have originated as the Celtic cattle of the Longhorn Breeds of Western Europe. By the late nineteenth century there were two distinct strains, the large South Wales and the compact North Wales Welsh black. By the first half of the twentieth century they were important dual-purpose breed. Today it is a single-purpose, hardy, upland beef breed (WBBS, 2003; Felius, 1985; British Cattle, 1980.

The Ayrshire breed

The exact evolution of the Ayrshire breed is unknown, but has Scottish ancestors. During the 18th century they were improved by mating with Shorthorn cattle of Dutch origin, and with West Highland and Shorthorn blood. It is known for its thriftiness, hardiness, longevity and forage conversion efficiency (Felius, 1985; British Cattle, 1980).

Shorthorn breed

The Shorthorn Society is the oldest breed society in the World with its first published herd book in 1822. The dairy Shorthorn has been used to improve other breeds and is believed to be the oldest dual-purpose breed. The popularity of the Shorthorn has declined considerably within the last half of the twentieth century (Felius, 1985; British Cattle, 1980).

The British Friesian

Throughout the world local Friesian populations have been founded on Dutch blood. The origin of the Friesian breed is believed to be around the 18th century when herds of black-and-white cattle were driven out of Jutland into Northern Holland and Friesland to replace local cattle lost to disease and flooding. They were crossed with the original Dutch cattle to form the basis of the Friesian breed. Before the establishment of the Netherlands herd book in 1873 and the Friesland herd book in 1879, both black and red-pied cattle originated form the same base stock and were maintained separately. The British Friesian was an important dual purpose breed meeting the milk and beef demand of the Britain markets. The British Friesian was the first in Britain to use the Type Classification System (Section 2.4.6) (British Cattle, 1980; Felius, 1985).

The Holstein

During the mid nineteenth century, a breeder in Massachusetts imported Friesian cattle from Holland. The American breeders concentrated on developing a large Friesian dairy animal. Today, it is believed that the American cattle are more like the original Dutch type. The British Holstein herd book was first kept in 1946, with reference to cattle imported from Canada (British Cattle, 1980).

Towards the end of the 20th Century there was a transition from the Friesian to the Holstein breed in the UK (HFBS, 1999). The Holstein is associated with higher milk yields and better milk quality (Simm, 2000a) and better udder and conformation (Philipsson and Lindhe, 2003). The use of the Holstein breed has been claimed to be responsible for a decline in functional traits (Harris and Winkelman, 2000; Buckley *et al,* 2000; and Philipsson and Lindhe, 2003). However, Olori *et al.* (2002) argued that decreases in fertility may not be solely attributed to breed type (Section 2.4.4).

2.2.9. The UK's production and pedigree records for the twentieth century

Dairy farmers use milk recording as part of the management procedure for the herd (DFF, 2001). The information obtained has indirectly provided the basis for the UK's genetic evaluation (Cassell, 2000). In 1943 the National Milk Recording Scheme (NMR) under the MMB, was set up to replace milk recording undertaken by Breed Societies (Baker, 1973). From 1943 the NMR continued its service, although now as an independent organisation, as a result of the deregulation of the MMB in 1996 (DFF, 2001). On March 2001 the total percentage of dairy cows recorded by the UK NMR's was 55% (41% of producers) (DFF, 2001).

Breed Societies such as the Holstein Friesian Breed Society (HFBS) and the Holstein Breed Society (HBS) maintain records of an animal's pedigree. Pedigree details are important for modern methods of genetic improvement. Progeny testing in the UK depends on the availability of correct pedigree information from farms (Simm, 2000a; Visscher *et al.,* 2002). Pedigree details are also essential in the use of computerised mate selection programmes to reduce inbreeding in future generations, as inbreeding depression reduces farm profitability (Cassell, 2000; Weigel and Lin, 2000).

Although pedigree information is kept and maintained by breed societies, the dairy breeder provides the information. Missing pedigree data is a significant problem in many herds as well as lack of phenotypic data from maternal relatives. Work carried out by Visscher *et al.* (2002) using DNA markers found a pedigree error of 10%. Zwald *et al.* (2005) expressed a need for improvement in animal identification and data collection within progeny tested herds.

2.3 PRODUCTION TRAITS

2.3.1. Milk Production

Milk is a valuable source of nutrients for the human population (Simm, 2000a). The consumption of milk in the World is more than 500 million tonnes annually, of which 88% is produced from cattle. The dairy cow can produce milk from feed that cannot directly be used in the human diet (Pond and Pond, 2000). Milk production accounts for approximately 18% of the total value of all UK agricultural output (Soffe, 2003). Income from milk accounts for an average of 95% of the dairy enterprise output (Franks, 2001).

The main selection objective in the dairy industry over the past 25 years has been to increase production (Pryce *et al.,* 2002). According to Simm (2000b), increased emphasis on fertility and health in breeding objectives would not compensate for the loss in milk yield although costs associated with fertility and health would be reduced. Simm (2000a) noted that the average yield is six times higher than a calf's requirements. As shown in Table 2.2, in the 1950s UK milk production was approximately 3000kg/cow/annum (Sandoe *et al.*, 1999) but at the end of the 1990s was over 7000kg/cow/annum (DFF, 1999). A combination of selection (between and within breeds), improved feeding, health and management have all contributed to the increase in yield (Simm, 2000a). The importance of milk revenue makes dairy enterprises very sensitive to changes in milk price. Any increase in the price of milk creates an incentive to expand production (Franks, 2001).

Table 2.2. Annual milk yield per cow in the UK (1954 – 2000)

Year of production	Milk yield (kg)	Source
1954-55	3065	(UK) DFF, 1984
1969-70	3750	(UK) DFF, 1984
1974-75	4050	(UK) DFF, 1984
1975	4800	Royal *et al.*, 2000
1979-80	4670	(UK) DFF, 1984
1988	4950	(E+W) DFF, 2001
1996	6600	Royal *et al.*, 2000
2000	6105	(E+W) DFF, 2001
1999-2000	7118	(E+W) DFF, 2001

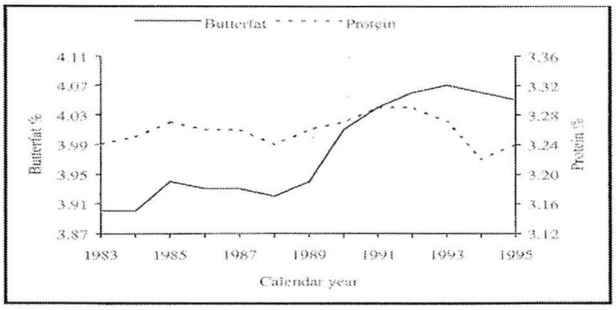
DFF, Dairy Facts and Figures; E+W, England and Wales; NMR, National Milk Recording

2.3.2. Milk fat and protein

Compositional quality payment for milk is based on both milk fat and protein. Wholesale purchasers of milk have their own payment scheme, with a higher monetary value for milk protein content relative to milk fat (FMH, 2004). Since the 1980s, there has been less interest in milk fat as an increase in cheese consumption has resulted in an increased monetary value for protein (Hargrave *et al.*, 1981; Kertz, 2002). Increasing protein levels has proven difficult, despite selective breeding and controlled feeding. Milk protein percentage shows less sensitivity to seasonality compared to milk fat percentage (Kertz, 2002). Sub-clinical mastitis can reduce milk protein (Soffe, 2003) and there is a negative genetic relationship between clinical mastitis and protein yield (Heringstad *et al.*, 2005). The higher the milk yield, the lower the percentage composition of milk fat and protein. Milk quality decreases in older cows due to the increase in milk yield and the associated dilution effect and also because udder problems increase with age (Soffe, 2003).

Milk fat composition in the UK increased from 1989 onwards, whilst in 1994 protein was at its lowest level (Figure 2.1). From 1995 to 2000 protein composition increased slightly and fat composition showed a slight decrease (Table 2.3.).

Figure 2.1. Butterfat and protein content (%) of UK milk



Source: Dairy Facts and Figures 1996

Table 2.3. Annual compositional quality of milk in the UK (1986-2000)

Year	Fat (%)	Protein (%)
1986	3.93	3.99
1995	4.05	3.24
2000	3.91	3.27

Sources: DFF, 1996; DFF, 2000

2.4. FUNCTIONAL TRAITS

2.4.1. Introduction

Functional traits include traits other than production traits that are of economic importance and contribute to the health and welfare of the dairy cow. Functional traits currently evaluated by the MDC (2004b) include udder health for predicting resistance against mastitis, female fertility, calving performance (dystocia and stillbirth), conformational traits, metabolic stress, beef traits and workable traits (milk speed and temperament). The heritability of fertility and health traits is low in comparison to the heritability of production traits (Bourdon, 1997) but they have large additive genetic variance (Fatehi, 2003). The evaluation of functional traits will allow the dairy industry to adopt a more balanced breeding approach, as the efficiency of production includes health, welfare and longevity (Holstein-UK, 2004).

Involuntary culling in dairy cattle is the result of reproductive problems (27%), udder and mastitis problems (27%) and lameness or injury (15%) (Fatehi *et al.*, 2003). Mastitis (and fertility problems) leads to involuntary and premature culling of dairy cows (Philipsson and Lindhe, 2003; Nash, 2003). There is an unfavourable correlation between milk yield and mastitis (Heringstad *et al.*, 2003) and fertility (Kearney *et al.*, 2004).

2.4.2. Longevity

Longevity can be defined as the "length of productive life or herd life" (Lubbers *et al.*, 2000) and is an important trait affecting dairy farm profitability (Yazdi, 2002). The dairy breeder's goal is to increase lifetime profit per animal (Perez-Cabal and Alenda, 2002, 2003). Average lactation age has remained static since 1981, at just over three lactations (Swanson *et al.*, 2003). Actual measurements of longevity are available when cows are culled. To obtain this information sooner in the animal's life several statistical approaches have been examined, for example, the Proportional Hazard Models and Modelling Conditional Survival Probability (Yazdi, 2002).

There are many different environments and management factors influencing longevity which make it difficult to quantify. Herd life is important economically as replacement costs are high. Longevity was incorporated into the selection index Improved Total Economic Merit (ITEM) in the earlier years of the 1990s (Table 2.1) and currently as Profit Life Index (£PLI) (MDC, 2004c) as discussed in Section 2.6.3. In the UK Lifespan PTAs are available for bulls. The genetic evaluation procedure uses indirect information for linear and composite classification scores of feet and legs, udder, fore udder attachment and somatic cell counts. Direct survival information is then used from the completed lactation (MDC, 2004c).

2.4.3. Mastitis and Somatic Cell Count (SCC)

Mastitis is an infection of the mammary glands. It has been a major concern in the dairy industry as discussed by Cronshaw (1947) and later by Goddard (1988). The most common micro organisms are S*taphylococcus aureus, Streptococcus* *agalactiae, Escherichia coli* (E coli) and *Corynobacterium pyogenes.* In the incidence of infections, milk is contaminated and toxins are produced. The body's defence mechanism involves the formation of neutrophils, these together with epithelial and somatic cells of the udder contaminate the milk. Somatic cell count (SCC) is used as an indicator of mastitis and is used in selecting for resistance to mastitis (Webster, 1998; Pyorala, 2003; Nielsen *et al.,* 2004; Haas *et at.,* 2004; Koivula, 2005).

In UK dairy herds, annual clinical mastitis rate rose from 36% to 47% from 1998 to 2003, as did bulk milk somatic cell count (Macrae *et al.,* 2003).

Selection for resistance to mastitis has been considered (Nash *et al.,* 2003). Despite the low heritability, the importance of SCC within the dairy industry resulted in its inclusion in the Lifespan Index and the economic selection indices in the November 2003, PTA update (ADC, 2004; Kirk, 2004).

2.4.4. Fertility

Fertility or reproductive failure in the dairy cow may be defined "as her ability to conceive and produce a viable calf following an appropriately timed insemination" (Royal *et al.*, 2000). Poor fertility is a major reason for involuntary culling of the UK dairy cow (Wall *et al.*, 2003, 2005). A high replacement rate is required to compensate for these losses and Wolf (2003) found that the most efficient dairy producers adopted a high replacement rate to overcome these losses. Fertility and reproductive disorders include retained placenta, induction of oestrus, uterine infection, ovarian cysts, and induction of birth or dystocia (Lawson *et al.*, 2004).

Fertility as a trait

There has been no index for fertility in the UK compared with other European Countries, despite a decline in fertility (Flint *et al.*, 2002). Some countries' argument for excluding fertility from the breeding programme is the low accuracy of predicted breeding value for fertility (Pryce *et al.*, 2002). However, Pryce *et al.* (2002) confirmed that the genetic variation for many of the fertility traits indicates that sire selection for daughter fertility is possible in the UK.

Snijder *et al.* (2001) reported that poor reproductive performance may not be a direct consequence of high milk production. Also Malmo and Beggs (2000) reported a decrease in reproductive performance despite having adopted veterinary management since the late 1970s early 1980s. The decline was claimed to be brought about by increased stocking rate, more cows per labour unit, increased production per cow, and an increase in the number of dairy herds of Holstein Friesian breeds. Roxstorm *et al.,* (2001) found high yielding, well-managed herds to have good reproductive performances. However, the higher genetic merit cows were found to have poorer reproductive performances than their low genetic merit contemporaries (McGuirk 2004).

The current belief is that selection for milk production alone has resulted in a decline in cow fertility. Within the UK it has been confirmed that it would be desirable to incorporate fertility within selection index in order to minimise further deterioration in fertility (Kadarmideen *et al.,* 2001; Pryce *et al.,* 1998, 2002; Veerkamp *et al.,* 2002; Haile-Mariam *et al.*, 2003 and 2004).

Poor fertility and extended calving interval are of economic importance for most systems, but especially in seasonal calving, pasture based systems, in which a tight calving pattern is required for the production of milk from grass (Veerkamp *et al.,* 2002; Olori *et al.,* 2002). Selecting for milk yield may not be the optimal criteria for block calving seasonal herds because of this antagonistic relationship between milk yield and fertility (Buckley *et al.,* 2000; Kearney *et al.,* 2004).

Direct recording of fertility in milk recording schemes is generally poor (Flint *et al.,* 2002). Farms have their own on-farm service information and fertility monitoring system for their own use. The information is not transcribed to the official milk recording system (Pryce *et al.,* 2001). It is possible to identify cows at risk of poor reproduction by monitoring milk protein and lactose content; BCS (Section 2.4.6); body weight change; genetic selection and DNA markers; therapeutic treatment involving endocrine data and milk progesterone (Flint *et al.,* 2002; Buckley *et al.,* 2000).

Genetic improvement of fertility would contribute to the long-term sustainability, profitability and welfare of the cow. Future developments could well include the recording of all inseminations; physiological measures; and genetic markers, all of which could be available to aid the selection for fertility (Arbel *et al.*, 2001; Flint *et al.,* 2002).

Calving Interval (CI)

Calving Interval (CI) is defined as "the number of elapsed days between two consecutive calvings" (Pryce *et al.,* 2000). It is a legal requirement within the UK to record calving date and therefore calving interval is the only reliable recorded data associated with fertility (Pryce *et al.,* 1998, 2000). A calving interval of 365 days is considered optimal, where standard lactation length is considered to be 305 days with a dry period length of 60 days. However the cow's natural lactation length could be extended, increasing the calving interval. Calving intervals of less than 300 days could be the result of abortion or other abnormal occurrences. Calving intervals of over 600 days are considered to be unrepresentative of the national dairy herd. Allowing cows to have an extended lactation can be a way of managing high yielding dairy cows (Pryce *et al.,* 2000 and 2002). Information on CI is only available for cows that conceive and calve again, as only the most fertile cows will have consecutive calving dates. Its limitations also lie in the fact that it is influenced by management decisions and oestrous detection rates (Flint *et al.*, 2002; Olori *et al.,* 2002; Pryce *et al.,* 2002).

Calving interval within the Holstein Friesian breed in the UK is at it's highest during the second lactation with a mean value of 384 days and median value of 370 days (Table 2.4.). Calving interval for first calving heifers was reported by Pryce *et al.* (2000) during 1988 to 1998 to be 398 days with a standard deviation of 75.9%.

Table 2.4. Calving Interval for Holstein Friesian cows (UK)

Lactation Number	Mean Values	Median Values
2	384	374
3	377	371
4	376	370
5	375	370
6	379	372

Source: (MDC, 2004a)

Days Dry

The dry period occurs between the end of the previous lactation and before the parturition of the subsequent lactation. The dry period is essential to the subsequent lactation's milk synthesis and secretion (Bachman and Schairer, 2003). A dry period length of between 51 and 60 days is most commonly adopted and accepted as an appropriate standard within the dairy industry (Bachman and Schairer, 2003). A longer dry period was found by Dingwell *et al.* (2002) to increase the risk of developing intramammary infections (IMI). Gulay *et al.* (2003) suggested that a shorter dry period (30 days versus 60 days) could be adopted without adverse effect on subsequent milk production and would improve Dry Matter Intake (DMI) immediately postpartum. However, it has also been noted that the absence of a dry period would significantly impair production (Bachman and Schairer, 2003).

Age at first calving and subsequent age at calving

The age at first calving determines when the cow enters the milking herd (Castle *et al.,* 1984). Earlier age at first calving increases lifetime production of milk and reduces the costs associated with the heifer rearing enterprise (Slater and Throup, 1994).An optimum age at first calving for milk yield was found to be 24 months (Nilfrooshan and Edriss, 2004).

The age at calving by parity is as shown in Table 2.5. Age at calving, as documented by the MDC, increases by approximately 12 to 13 months between each parity. The range in the age at calving increased from first parity to the fifth parity as recorded by Lubbers *et al.,* (2000).

Table 2.5. Age at calving and subsequent lactations

Parity	**Current age at calving UK Friesian Holstein (months)**	**Range of values (months)**
1	29	20-40
2	42	30-60
3	54	40-75
4	67	50-85
5	79	60-100
Source	MDC, Evaluation (2004a)	Lubbers *et al.*, (2000)

2.4.5. Linear Classification of Traits or Linear Assessment

Linear traits were introduced in the early 1980s to assess differences between animals in terms of their physical characteristics. Type traits are associated with survival and animals with 'good' legs, feet and mammary systems are less likely to be culled (Sewalem *et al.,* 2005). Linear assessments of type or conformation traits are associated with functional fitness, health and longevity and are performed by breed society or progeny testing agencies to enable the prediction of breeding values (Simm, 2000a). Type traits are included in the Production Life Index (£PLI), Section 2.6.3 (MDC, 2004b).

There are correlations between type traits with economically important traits (Simm, 2000a). Feet and leg have indirect and direct effects on production with lameness being considered as the third major health disorder of dairy cows after mastitis and infertility. Feet and leg problems also contribute indirectly to involuntary culling for reproductive failure (Royal *et al.,* 2000; Fatehi *et al.,* 2003).

2.4.6. Body Condition Score (BCS)

Kadarmideen and Wegmann (2003) stated that selection for good body condition is possible. Body Condition Score (BCS) is considered to be important at calving and useful when monitoring and controlling the nutritional status of the cow (Pond and Pond, 2000; Stockdale, 2004). Cows of higher genetic merit tend to be thinner and have a lower BCS than average genetic merit cows. Reproductive performance is also sensitive to changes in BCS (Pryce *et al.,* 2002). BCS as a trait is expensive to measure and is a subjective trait (Cassell, 2000).

2.5. SELECTION, VARIANCE AND GENETIC PARAMETERS

2.5.1. Introduction

Concepts associated with transmitting ability were discussed in the 1920s and the Mount Hope Index was developed for milk yield. The importance of keeping production records, the use of Progeny Testing and Pedigree Index was appreciated during the first half of the twentieth century (Rice, 1942). In order to estimate an animal's genetic merit, Hazel in 1943 developed a method of combining information from several sources as a Selection Index (Cameron, 1997).

2.5.2. Selection

In animal breeding the aim is to breed from the best animals. Artificial selection produces a change in gene frequency as a result of the action of the breeder by separating the individuals of the parent generation into two groups; those that are selected and the group that are culled or not used to breed replacements (Bourdon, 1997; Nicholas, 2000). Selection will result in a change in the population mean. The response to selection is the difference in mean phenotypic value between the offspring of selected parents and the whole of the parental generation before selecting. The selection differential is the average superiority of the selected parents. It is the mean phenotypic value of the selected parents expressed as a deviation from the population mean before selection was made (Willis, 1998). Traditionally selection was based on the animal's phenotypic value. The use of quantitative genetics allows phenotypic values to be "translated" into Estimated Breeding Values (EBV), based on an animal's performance and using information from relatives. The breeding value of males can only be judged from the phenotypic values of its female relatives (Willis, 1998; Bourdon, 1997).

2.5.3. Quantitative genetics in animal breeding

Many traits of economic importance in livestock production are quantitative traits with a normal distribution and are affected by both genetic and environmental influences. The actual genetic merit or the performance of the animal is known as the phenotype (P) and it is influenced by the genotype (G) that it inherits and the environment (E) in which it is exposed. The relationship can be written as P=G+E.
The genotype (G) can be split into additive effect (A) and non additive effect (NA). The additive effect is the combined effect of genes which act additively on the trait. The non additive effects, also known as the gene combination effect are the dominance and epistasis (NA). These can be written as: G=A+NA, and therefore P=A+NA+E.

It is difficult to determine the effect of dominance and epistasis in quantitative traits. However the additive effect (A) of the genotype (G) can be estimated and therefore used in selection and is more commonly referred to as the estimated breeding value (EBV); described further in Section 2.6.3.

The amount of variation in a trait is expressed as the Variance. Variance can be broken down into components attributable to different causes. The observed variation is known as the phenotypic variance (V_P) and following the same argument presented in relation to phenotype: $V_P = V_G + V_E$; $V_G = V_A + V_{NA}$; and $V_P = V_A + V_{NA} + V_E$.

The phenotypic or observed values are influenced by the environment under which they operate. There are two type of environment (E), the permanent environmental effect (Ep) and temporary environmental effect (Et). This gives: $V_P = V_A + V_{NA} + V_{Ep} + V_{Et}$.

The permanent environmental effect is the environmental effect that permanently influences the individual's performance for a repeated trait. The temporary environmental effect influences a single performance record of an individual, but does not permanently affect the individual's performance potential for a repeated trait.

2.5.4. Repeatability

For dairy cows milk yield can be measured in successive lactations. The correlation between successive performances is generally known as repeatability of the trait. Repeatability can be defined as: $(V_G + V_{Ep}) / V_P$.

The repeatability can be greater than heritability but it cannot be less. Estimated repeatability for a trait may differ according to the genetic characteristics of the population and the environmental conditions under which the individuals are kept. Repeatabilities of 0.41 and 0.58 have been estimated for Milk yield and Fat (%) respectively (Table 2.6.) (Bourdon, 1997; Cameron, 1997; Falconer, 1998; Pond and Pond, 2000; Simm, 2000a; Nicholas, 2000 and Goddard, 2003).

2.5.5. Heritability

Heritability can be defined as the degree to which offspring resemble their parents. Heritability can also be considered as a measure of the reliability of the phenotypic values as a guide to the breeding value.

Heritability (h^2) is the ratio of additive genetic variance (V_A) to phenotypic variance (V_P):

$h^2 = V_A / V_P$

The ratio V_A / V_P expresses the extent to which phenotypes are determined by the gene transmitted from the parents. Heritability also defines the relationship between phenotype and estimated breeding value (EBV) as: EBV = h^2 x V_P.

Environmental factors can be taken into account in the evaluation of data (Falconer 1989; Willis 1991; Bourdon, 1997; Cameron, 1997; Nicholson 2000). Table 2.6, shows some of the heritability and repeatability values of dairy production traits

Table 2.6. Heritability and repeatability estimates for dairy traits

Traits	Heritability
Milk Yield	0.25 – 0.60
Fat Yield	0.25 – 42
Protein Yield	0.16- 0.47
Traits	**Repeatability**
Milk Yield	0.43 – 0.58
Fat Yield	0.41 – 0.53
Protein Yield	0.41 – 0.51

Sources: Dematawewa and Berger, 1998; Pryce *et al.*, 1998; Abdallah and McDaniel, 2000; Nicholas, 2000; Pryce *et al.*, 2000; Pond, 2000; Weigel *et al.*, 2001; Olori *et al.*, 2002; Pryce *et al.*, 2002; Flint *et al.*, 2002; Haile-Mariam *et al.*, 2003; Lidauer *et al.*, 2003;.

2.5.6. Correlation Between traits

Genetic and phenotypic correlation among milk, fat and protein yield is generally high and positive (Table 2.7). Selecting for any one of these traits will cause genetic improvement in the yield of the other traits (Bourdon, 1997). Negative correlation exists between functional traits and milk yield as reviewed in Section 2.4.1.

Table 2.7. Genetic and phenotypic correlation between traits

Production traits	Genetic correlation	Phenotypic correlation
Milk yield and fat yield	0.67	0.80
Milk yield and protein yield	0.99	0.93
Fat yield and protein yield	0.73	0.85

Source: Kadarmideen *et al.,* (2000)

2.6. ASSESSMENT OF GENETIC MERIT

2.6.1. Models

There are four basic types of models used in the genetic analysis of animal data. These include the 'Sire Model', which calculates the EBVs of sires based on the performance records of their progeny. The second model is the 'Sire and Dam Model', which calculate the EBVs of sires and the dams. The third model, the 'Sire and Maternal Grand Sire Model' (MGS) calculates the EBVs of all sires who have either offspring or grand-offspring, via their daughter's records. The 'Animal Model', as the fourth model, is used in the UK dairy breeding industry. It involves the prediction of all the animals' EBVs using all the ancestors' records and is predicted for all animals in the pedigree. The advantage of the animal model is the ability to evaluate all animals (as opposed to just sires) in the population (Bourdon, 1997; Cameron, 1997).

The statistical performance of test-day models compared to average lactation yield provide better opportunities to investigate within and between cow variations (Hayes *et al.,* 2003; Jamrozik *et al.,* 2004). The Milk Development Council (MDC) have developed test day records for genetic evaluation, as they provide more accurate and earlier information on bull and cows (MDC, 2004b). As more robotic milking systems or automatic milking systems (AMS) are installed then test day records will become more common (Peeters and Galesloot, 2002). Test day results can also aid in the calculation of the cow's nutritional requirements through the use of energy balance predictions (Heuer *et al.,* 2004).

Models can be classified by the number of traits analysed and the number of records per traits. The 'single trait' model with one measurement can be used for traits such as birth weight. 'Single trait model with repeated measurement' is used for traits such as milk yield which is measured over the life of the animal. 'Multi trait' models involve more than one trait, which are analysed simultaneously and take into account the relationships between traits (Simm, 2000a).

2.6.2. Progeny Testing

Progeny testing was developed 40-50 years ago and is still as important in genetic improvement of dairy cattle (Simm, 2000a). On-farm testing of unproven bulls or young test bulls allows the bull's female progeny to be evaluated with their contemporaries. Proven bulls are then marketed by commercial Artificial Insemination (AI) and Embryo Transplant (ET) companies (Genus, 2002).

2.6.3. Estimated breeding values and indexes

Estimated Breeding Value

The Milk Development Council (MDC) Evaluation Ltd (formerly the Animal Data Centre (ADC)) currently carries out genetic evaluation of dairy traits in the UK. The MDC obtains production records from the Milk Recording Organisations (MRO) and the pedigree records from the Breed Societies. The information on bull and cow proofs is then issued to Breed Societies, MRO and AI companies (ADC, 2001; MDC, 2004b). The MDC genetic procedure involves the Animal Model genetic evaluation; incorporating information from the animal itself and all other identified relatives. Production records are standardised for the effect of lactation number, age within lactation, calving interval and month of calving. Hetrosis and recombination is taken into account for Holstein and Friesian records. Also adjustment for unequal herd variance is carried out so that the genetic potential of each cow can be expressed in all herds. The statistical model also takes into account herd management effects, imported animals, sire by herd interaction, and permanent environmental effect of animals of unknown parental groups (MDC, 2004b).

Within the dairy industry the estimated breeding value is known as the Predicted Transmitting Ability (PTA). Breeding Value is twice the PTA (ADC, 2004). PTA's are used to select superior animals for breeding. PTA's are based on all available information including a cow's own performance and that of its relatives (MDC, 2004b). Reliability (%) indicates the accuracy of the PTA as an estimate of the true breeding value of the animal. The lower the reliability the greater the chance that it will change as more information is included.

Selection indexes

A Selection Index is the overall genetic merit of an individual based on their own performance and their relatives for a combination of traits. Selection Index is the best linear prediction of an individual's overall breeding value across selected traits. The range of traits included in selection indexes has extended over the years to include production traits and functional traits. Miglior *et al.,* (2005) found that the main difference between selection indices in various countries was the relative emphasis on production.

In the UK, a Production Profit Index was launched in 1991 and was a selection index based on yields, on milk, milk fat and protein. Profitable life index was introduced in 1999 and was based on production and longevity. In 2003 it was updated with health and welfare information. Economic weighting for the selection indexes of £PIN and £PLI are monitored and updated as costs change (MDC, 2004b). In 2002 the Holstein and Guernsey breed Societies launched a new index based (Total Overall Performance) on production traits, type traits and health and longevity (Holstein-UK, 2004).

Globalisation of the dairy breeding industry has resulted in producers to convert result from national evaluation schemes (Philipsson and Lindhe, 2003; Norman, 2005). Twenty-five countries participate in an international evaluation for dairy production traits. The INTERBULL Centre in Sweden aims to produce an international ranking of bulls, which have been progeny-tested in different countries. A conversion formulae enable foreign information to be converted to the same scale as that of the UK and is known as the 'Goddard Method', used by INTERBULL (Weigel *et al.,* 2001; Interbull, 2004; MDC, 2004b).

2.7. APPLICATION OF BIOTECHNOLOGY IN DAIRY CATTLE BREEDING

In 1952 the first calf was produced using frozen semen (Abpischools, 2004). Artificial Insemination (AI) allowed genetic progress on the male side and now with Embryo Transfer (ET) techniques allow rapid genetic gain is on the female side, complementing AI programmes (Agtechnic, 2004). Techniques in ET have improved and costs have been reduced and the development of non-surgical recovery, transfer and cryoperservation of embryos has had important commercial benefits (FAO, 2004). A range of biotechnology can be applied to dairy cattle breeding.

Techniques to 'sex' embryos and spermatozoa have also been developed and 'sexed' semen is commercially available in several countries. The use of 'sexed' semen allows replacement to be produced from animals of high genetic merit; low genetic merit animals can be used to produce animals for meat production (Biotechnology, 2004; Wilson *et al.,* 2005).

Cloning and transgenic animals also provide opportunities to breed superior dairy animals (Biotechnology, 2004; Wilson *et al.,* 2005; Etaiwannews, 2004).

Of considerable interest is the use of genetic markers as selection criteria. Quantitative Trait Loci (QTLs) have been associated with several dairy traits (Goddard, 2003; Freyer *et al.,* 2003; Freyer *et al.,* 2004; Kuhn *et al.,* 2003; Schulman *et al.,* 2004; Szyda *et al.,* 2005).

A detailed description and consideration of the potential of these techniques is beyond the scope of this study.

2.8. AGRICULTURAL EDUCATION IN THE UK

2.8.1. The history of agricultural education in the UK

Formal agricultural education is believed to have started as early as 1786 in Europe when the first public experimental farm was established near Braunschweig. In the UK it was not until 1843 that agricultural education was formally recognised by the establishment of Rothamsted through a partnership between Lawes and Gilbert. Education in the UK during the 1840s was known as 'rough education' and attempts were undertaken to raise the intellectual level of the farming population. The first agricultural college was established at Cirencester in 1844 (Park *et at.,* 2002; Goddard, 1988; Cornshaw, 1947). It was not until 1880 that one of the first residential colleges was founded by Professor John Wrightson: this was the Wiltshire and Hampshire Agricultural College near Salisbury (Goddard, 1988; Cornshaw, 1947; Jones, 2004).

Residential agriculture Colleges in England and Wales during the late nineteenth century were expensive and considered for the upper class. This view is well documented by Jones (2004) who wrote on the work of Professor John Wrightson: "the class of men who come must be housed and fed as gentlemen hence the cost and the fees ....I look upon this College as a school of landowners, land agents and colonists ".

The increasing importance of dairy industry towards the end of the nineteenth century demanded knowledge and skills. During the mid 1870s there had been attempts, although unsuccessful, to try and form an examination to encourage the study of agriculture at middle-class schools (Goddard, 1988). However, by the end of the nineteenth century agricultural departments were established at Cambridge, Reading, Bangor and Leeds (Jones, 2004). The National Diploma in Dairying (NDD) was established in 1897, followed by the National Diploma in Agriculture (NDA) in 1900 (Cornshaw, 1947).

During the early twentieth century many landlord farmers saw the need for their tenants to have practical instruction in dairying and cheese making. The Scottish Agricultural College (SAC) was established in 1895. Later in 1899, The Scottish Dairy Institute of Kilmarnock in the West of Scotland was established, followed by The Edinburgh East of Scotland College of Agriculture in 1901, and in 1904 the North of Scottish Agricultural College (SAC, 2004). During the same period Harper Adams was established in 1901. There was a national movement for middle-class education; Farm Institutes were established throughout the UK, and were financed by their County Councils (Cornshaw, 1947; Jones, 2004). In North Wales the Caernarvonshire County Council purchased the Madryn Estate in 1910. The Estate on the Llyn Peninsula, in 1913 became the first County Agricultural College in North

Wales. After the First World War the Madryn Farm School became one of the three Farm Institutes that were set up in Wales, together with another six in England. These courses had a strong element of dairy production. Their objectives were to instruct students drawn from the local farming community in the scientific principles and agricultural practices (Jones, 1992; Morris, 1996).

Following the Second World War, the increased emphasis on agriculture to ensure self-sufficiency in dairy products and other food supplies in Britain gave agricultural education a much stronger position. In 1943 the Government committee investigating agriculture education recommended that every county should have their own Farm Institute 'where men and women could be trained for careers on the land' (Morris, 1996). Since the First World War the Ministry of Agriculture controlled Farm Institutes, but during the 1950s it ceased to have any direct control and they became the responsibility of the Local Education Authorities (LEAs). Colleges founded during this period include Merrist Wood College, (1945); Askham Bryan College (1948); and Bishop Burton (1945); Glynllifon College of Agriculture (1953); and Elmwood College (1956) (British Council, 2004; CEA, 1954).

It was not until the early 1990s that many colleges became independent of the Local Education Authorities (LEAs). For example, in 1994 Glynllifon Agricultural College became in 1994 one of the three sites of Coleg Meirion-Dwyfor, Tertiary College, specialising in land-based programmes (GARM, 2003). Most colleges are now run independently or have merged with other colleges and universities (Park *et al.,* 2002).

2.8.2. Agricultural Education at the beginning of the 21st Century

Traditionally agricultural courses in the UK have been developed through County Colleges, National Colleges or Universities. Practical education and training were emphasised within the Further Education (FE) sector. The Higher Education (HE) sectors were involved with the scientific understanding of agriculture and management (Park *et al.,* 2002). In recent years many of the previously known county Agricultural Colleges are now offering HE courses in association with Universities. Consequently, this has resulted in a great number of institutes offering agricultural related Higher Education courses as well as an increase in the diversity of courses being offered (Table 2.8). Institutes have become modularised, with cross-discipline curricula in response to the decline in agricultural students. This has resulted in extensive provision of courses. The provision of courses in the UK is highlighted by comparing the provision in other countries. In Australia there is one university offering a degree in agriculture per million of population. In Canada (USA) there is one institute for every 4 million. While in the UK there is a ratio of one agriculture related degree course per 800,000 of the population (Park *et al.,* 2002).

The number of courses under category 'D' of the UCAS category in 2004 for a single agricultural course stands at 44, while agriculture and environmental related courses came to a total of 1342 courses (Table 2.8), which reflected the emphasis on environmental issues as opposed to production efficiency (NFUW, 2004). The British Council (Table 2.9) have 69 National Vocational Qualification (NVQ) courses at 25 establishments and the National Diploma / Certificate (ND/C) had 141 courses at 29 establishments. Undergraduate and postgraduate courses came to a total of 269 at 28 and 31 establishments respectively, whereas the number of establishment on the UCAS list was much less. There is a progressive level of qualifications from level 1 to level 5 for agriculture and agricultural-related courses, giving the industry a structured qualification system. The qualification structure within the FE institutes is shown in Table 2.10 and is based on the National Vocational Qualification (NVQ). The framework for higher education has five levels as shown in Table 2.11.

Agricultural student numbers have remained constant since 1996, despite a large increase in the overall number of students entering Higher Education in the UK (Park *et al.,* 2002). However, students with practical background within the dairy industry have decreased due to the decline in the number of dairy farms (Nielsen *et al.,* 2003).

Table 2.8. The number of agriculture and agricultural related courses in the UK 2004

Subject	Number of courses
Agriculture – single subject	44
All agricultural courses	592
Agriculture of which included Conservation	230
Agriculture of which included Environment	1342
Agricultureofwhich included Animal Science	132
TOTALNUMBER OF ESTABLISHMENTS	16

Source: UCAS, 2004

Table 2.9. The number of programme levels within agricultural courses in the UK 2004

Programmes	Courses	Establishments
National Vocational Qualification level 1,2 & 3	69	25
National Diploma / National Certificate	141	29
Undergraduate	158	28
Postgraduate	111	31

Source: British Council, 2004

Table 2.10. Agricultural qualification structure

Level of qualification	Grades required	NVQ qualification	Qualification	Description
5 Higher Level	A Level	NVQ level 5	Degree	Professional Middle Manager
4 Higher Level	A Level	NVQ level 4	Higher National Diploma (2-3yrs)	Higher Technical/Junior Management
3 Advanced Level	A Level	NVQ level 3	GNVQ Advanced National Diploma (2yrs) National Certificate(1yr)	Technical Supervisor/Advanced craft
2 Intermediate Level	GCSE Grade A-C	NVQ level 2	GNVQ Intermediate First Diploma (2yrs)	Basic Craft
1 Foundation Level	GCSE Grade D-G	NVQ level 1	Foundation Studies	Foundation

Source: LBCNC, 2004

Table 2.11. The framework for higher education qualifications in England and Wales and Northern Ireland.

Higher Education	Level	Description
1 Certificate	C level	Certificates of Higher Education
2 Intermediate	I level	Foundation degrees, ordinary(Bachelors) degrees, Diplomas of Higher Education or other higher diplomas
3 Honours	H level	Bachelors degree with Honours, Graduate Certificates and Graduate Diplomas
4 Masters	M level	Masters degrees, Postgraduate Certificates and Postgraduate Diplomas
5 Doctoral	D level	Doctorates

Source: QAA (2001)

2.9. EDUCATIONAL THEORIES AND TEACHING / LEARNING STYLES

2.9.1. Education as a product or process?

Education is complex and dynamic, transferring various inputs, including student time, teaching time, consumable materials, equipments and buildings, into knowledge production and qualified intellectual individuals (Ashworth and Harvey, 1994; Williams and Baker, 1999).

Student learning was considered by Rolls and Slavik (2001) to be either a 'process' or a 'product'. Two societies were distinguished, those willing to continue to learn (the lifelong learners) and those who were taught and would meet the need of the economy. The 'process' of learning involves continued learning stages. The 'product' of learning involves transferring knowledge and competence for an end product, which will enter employment. Learning during the 1960s and 1970s was approached as an outcome, the end product of a process (Smith, 2003). Now it is more of a process where learning theories, and the questions of how and why behavioural change occurs during the educational experience (Rolls and Slavik, 2001).

Pedagogy is an organised structured style of teaching and learning (Cohen *et al.*, 1996). It is based on the style of learning which are seen to be appropriate for children, normally the transmission of knowledge by adult to children in the classroom (Nasta, 1994). The andragogical model of learning for adults is based on self-motivation and is self-directed. The content and style of the curriculum is related to the individual learner's work and life experience (Fell, 1999). When students enter a new subject, with minimum experience and little knowledge, the pedagogical style may be the most effective way of initiating understanding. As understanding develops, andragogical methods become more appropriate, as students' independent learning skills develop (Parkinson and St George, 2003).

2.9.2. Teaching and Learning Theories

It is important to be familiar with the range of theories on teaching and learning. Aspects of these theories should be selected if they are of particular relevance (Moore, 2000). There are four major published theories of learning and teaching practice that have emerged over the last seventy years. These are the works of Skinner, Piaget, Vygotsky and Bruner and are the basis of many prominent models of teaching and learning that are used. A detailed description of these four theories is beyond the scope of this review and only the main characteristics are noted here. Skinner's law of 'positive reinforcement' is based on the fact that people learn best by being rewarded. Piaget's work was 'children-centred' and found that from early childhood they were active, independent, meaning-makers who construct knowledge rather than receiving it; without a need of an adult or a teacher to 'kick-start' the process. Developed from this idea is a 'student-centred learning' approach which takes into account the learner's existing understanding and experiences, and then builds and develops upon these initial understandings. Vygotsky, distinguished between 'real' learning and concept development for 'rote' learning. Cognitive development is achieved most effectively by elaborating ideas and understanding through discussions with their teacher and peers using a dialogue rather than monologue. Vygotsky introduced the 'Zone of Proximal Development' in which he demonstrated that the mental ages in learning moves through age-related stages. Bruner introduced the theory of 'spiralling'. It is the process by which the learner constantly returns to 'previous' learning and understanding in the light of new learning experiences. He stressed the role of the home and parent in the individual's cognition and linguistic development. Attention was drawn to how culture affects the way in which individuals went about their learning and to the effect of poverty, racism and alienation (Moore, 2000; TSS, 2004).

2.9.3. Learning styles

Learning style can be defined as 'the preference or predisposition of an individual to perceive and process information in a particular way or combination of ways' (Sarasin, 1998). Learning style as discussed by Draper (2004) is based on basic intuition that 'people and therefore learners are different from each other'. The learning style will be influenced by genotype, previous learning experience, culture, and the society they live in (Verster, 2004). According to Liu and Ginther (2004) learning style relates to practical application, whilst cognitive style relates to theoretical or academic research. They refer to an individual's way of perceiving, remembering, thinking and problem solving as "the construction of cognitive styles". Cognitive means the perception and processing of information within the brain and is a collection of mental processing that includes awareness, perception, reasoning and judgment (Froelich, 2003; Sturt, 2003). People exhibit significant individual differences in the cognitive processing styles that they adopt (Liu and Ginther, 2004). Clark (2000) and Sturt (2003) highlighted the emotional side of learning including feeling, application, enthusiasm, motivation and attitude. Brief details of a variety of learning models are presented below.

Curry's Onion Model

In order to understand the relationship between all the learning theories, Curry developed the Onion Model. The Onion Model has four categories of learning styles. Firstly, personality dimension theories emphasises the influence of personality traits on preferred approach to acquire and integrate information. Secondly, information processing theories highlight a cognitive approach to understand and assimilate information. Thirdly, social learning theories consider how students engage with their peers in the classroom. Fourthly, multidimensional and instructional learning theories look at students' preferred environmental and approaches to learning (Giles *et al.,* 2003; TSS, 2004).

Myers-Briggs Type Indicator (MBTI)

Myers-Briggs Type Indicator (MBTI) is based on Carl Jung's theory of psychological type, at the beginning of the twentieth century. Carl Jung observed that people behave in a predictable fashion and came up with three 'types' of personality. A fourth dimension was added by Myers-Briggs in 1962 which was the Extroverts versus Introverts (Liu and Ginther, 2004). Extrovert students learn by explaining the subject to others. The other types of personalities include Sensing versus Intuition, Thinking versus Feeling and the Judging versus Perceptive (Literacynet, 2004; Personality, 2004).

Gregory Style Delineator (GSD)

The Gregory Style Delineator is designed to identify differences in learning, and categorise people into four distinctive clusters. It represents the manner in which people comprehend and organise information and identifies how they perceive themselves and the world around them (Liu and Ginther, 2004; Literacynet, 2004).

Pask's Learning Strategy

Pask looked at two learning strategies in the early 1970s, the 'serialists' and the 'holistic'. The 'serialists' will tackle the subject step by step and build from the known to the unknown. 'Serialists' tend to be very analytical and logical in their understanding of the specific goals of the problem. The 'holistic' learners will seek an overall framework and then explore areas within it in a more or less haphazard way, until they have filled the whole. Some learners switch between the two styles and are called versatile learners (Pask, 1976; Atherson, 2002; Froelich, 2003; Liu and Ginther, 2004).

Deep level / Surface level processing

The processing level approach is similar to Pask's theories. Deep-level processers, like 'holistic', tend to quickly grasp the overall concepts and are intrinsically motivated. Likewise, Surface-Level processors, like 'serialists', concentrate on the details, require extrinsic motivation and sometimes will miss the global view of a problem (Froelich, 2003).

Field Independence versus Field dependence

First proposed by Witkin (1962; 1979), field independents will easily separate important from complex details while field dependants are good at interpersonal relationships. Also field dependent students prefer to work in groups, require extrinsic motivation and more structured reinforcement from the teacher, with teacher and peer support. Field independents are intrinsically motivated (Froelich, 2003; Liu and Ginther, 2004; Verster, 2004).

Kagan Conceptual Tempo

According to this theory there are two distinct groups, the 'reflective' versus 'impulsive'. They address the fact that some individuals require more time than others to make a decision. The 'cognitive impulsive' will only require a brief look and will come up with a decision there and then, whereas the 'cognitive reflective' will make a careful deliberate choice before deciding (Froelich, 2003).

Keirsey's Four Temperament

The theory of temperament is associated with personality types. The temperament categories are the 'guardians', who are security seeking and are the supervisors, the inspectors, the providers, and the protectors. The 'artisans' are the promoter, the craftsman, the performers, the composers and are sensation seekers. The 'rationales' are the fieldmarshals, the masterminders, and the 'inventors', are knowledge seekers. The fourth temperament is the 'idealist' and the teacher, the councillors, the champions, the healers and identity seekers (Personalitypage, 2004).

Kolb's Learning style

Kolb's Learning Style Inventory is based on Kurt Lewin's Experimental Learning cycle and Carl Jung's dialectic tension. The model focuses on how individuals perceive and process information. Kolb's Learning Cycle referrers to the process of learning where an effort is undertaken to understand the experience and whereby modifications can be made to improve the process. There are four stages and are known as 'experiencing', 'reflection', 'conceptualisation' and 'planning'. Kolb's theory provides a rationale for a variety of learning methods, including independent learning, learning by doing, worked based learning and problem based learning (Ross, 1994; CSS, 2004)

Grasha-Reichmann Student Learning Style Scales (GRSLS)

Grasha and Reichmann learning styles scale were developed in 1974 to determine college students' style of classroom participation, and include six styles. This model focuses on student attitude towards learning, classroom activities, teacher and peer as opposed to studying the relationship between methods, student style and achievement. In order to determine college students' style of classroom participation it is important to focus on the student's attitude towards learning. These include 'Avoidant' which includes students with high absenteeism, having poor organisation of work, and taking little responsibility for the learning; the second is the 'Participative' who take responsibility for self learning and relate well to peers. The 'Competitive' are suspicious of their peers and compete for reward and recognition. The 'Collaborative' enjoy working harmoniously with their peers. The fifth category are the 'Dependent' who become frustrated when faced with new challenges not addressed in class. The 'Independent' prefer to work alone and require little direction from the teacher (Sturt, 2003; Facultyweb, 2004). Yazici (2005) found GRSLS to be valuable for business undergraduates, while Court and Molesworth (2003) found it not so effective with marketing undergraduates.

Howard Gardner's Theory of Multiple Intelligence

Howard Gardner's theory of Multiple Intelligence explains the human intellect. Nine Intelligences were identified; these were Verbal, Linguistic; Logical, Mathematical; Visual, Spatial; Bodily, Kinesthetic; Naturalistic; Musical intelligence; Interpersonal; and Intrapersonal (NCSU, 2004).

Dunn and Dunn Model

The Dunn and Dunn Model is based on '…a biologically and development-imposed set of personal characteristics that make the same teaching method effective for some students and ineffective for others'. The model states that everyone has strengths, but different people have different strengths. It claims that most individuals can learn given the instructional environment that responds to their strengths. Also individual instructional preferences exist and by giving a responsive environment students attain higher achievement. It stresses also that most teachers can learn to use learning styles as a cornerstone of their construction and that many students can learn to capitalize on their learning style strength (Goocites, 2004).

Sensory Preference and the four modalities of learning

The most important sensory modalities are visual, auditory and kinaesthetic. According to Dunn and Dunn (1979) about 40% of learning is brought about by looking, stressing the importance of adopting visual learning style. Auditory learning styles involving listening, and accounts for 20% to 30% of learning. The remaining 30% to 40% are either kinaesthetic or a combination of the major senses. Kinaesthetic learning style involves doing; and Tactic learning style is writing and drawing (NCSU, 2004; Verster, 2004).

Hemispheric Preference or Brain Lateralization theory

Hemispheric preference leads to major individual differences and multiple methods of teaching should be adopted to improve student learning (Liu and Ginther, 2004). This is based on left-brain dominated versus right brain dominated individuals. Left-brain dominated intellectuals, rely on language in thinking and remembering while Right-brain dominated, tend to be subjective, and prefer uncertain information (Versted, 2004).

Dreyfus

The Dreyfus approach to learning identifies five stages of skill development and include first the 'novice' who must be 'told and shown', and given instruction. Then there is the 'advanced beginner' followed by the 'competent' and finally the 'proficient and expert'. In learning we move from 'unconscious incompetence' via 'conscious incompetence' and 'conscious competence' to 'unconscious competence'. There is a need for self confidence, courage, and self-esteem, responsibility for our learning, self questioning, persistency and evaluation. These make the seven stages as discussed by McPherson (2003). The last two of the seven stages were referred by Dreyfus as 'cultural style' and are now known as 'mastery' and 'practical wisdom' (McPherson, 2003).

Noel Entwistle Phenomenography

Entwistle's (1991) theory describes learning as experiencing situations based on intelligence, effort and motivation. The theory outlines six different conceptions of learning. They are increasing one's knowledge; memorizing and reproducing;

utilizing facts and procedures; developing an initial understanding; transforming one's understanding; and changing as a person (Facultyweb, 2004)

McCathy's four learning styles (1980)

McCathys four learning styles included 'innovative learners' where personal meaning was important; the 'analytic learners' require fact when learning; 'common sense learners' value things if they are useful; and the 'dynamic learners' synthesise information from different sources (Verster, 2004).

Grasha – five teaching styles

Grasha identified five different clusters of teaching. The first cluster was the teacher centred, where students are presented with information. The second cluster was the teacher-centred approach emphasising modelling and demonstrating. Then the student centred model is where the teacher designs activities and problem-solving situations. The fourth cluster is when the learning burden is on the student, and demands students' initiative (Learningstyle, 2004).

Learning domains of Bloom's Taxonomy

Bloom's Taxonomy of learning domains is easily understood and widely applied and is basically a hierarchy of educational objectives. It divides the way people learn into three domains. The taxonomy provides a useful structure in which learning materials and tests should be categorized to take into account 'recall', 'creative thinking' and 'critical thinking'. Bloom found that over 95% of the test questions students encountered required them to think only to the lowest possible level, which is to 'recall' information without deeper levels of 'creative' and 'critical thinking' (Clark, 2000; Teacher, 2004; Kent, 2004).

2.9.4. Variation and diverse learning style

Variation and diverse learning styles recognises that different students have different preferred learning methods which must be considered when planning and teaching (Moore, 2000). Variety enriches the experience of students (Powell, 1991), maintaining concentration, and offsets the tendency of diminishing attention (Petty *et al.,* 1998; Curzon, 1999).

Students come to a course with different backgrounds and ability as well as perceived expectations. Students learn in different ways. It is important to create student interest and motivation as well as aiming to reach students in a variety of ways. There are options for addressing diverse learning styles. Using internet sources, many types and level of materials are available to students in different forms, allowing them to engage with course material at their own pace and in the medium that suits them best (Section 2.10.6) (Powell, 1991; Petty *et al.,* 1998).

Kember and Wong (2000) claimed that passive students prefer a didactic method of teaching, while active students will prefer an active innovative approach. However there had been little evidence elsewhere to support this view that compatible learning and teaching styles enhanced learning. This weak link between learning style and learning preference results in the recommendation that a variety of learning methods should be adopted, and students should be encouraged to use different learning methods (Loo, 2004; Hendry *et al.*, 2005). Due to the large individual difference in learning preference it makes it necessary to use diverse learning strategies (Curzon, 1999; Kulinna and Cothran, 2003; Court and Molesworth, 2003; Hendry *et al.,* 2005).

Lecturers should appreciate the range of styles, theories and models available. As argued by Entwistle (1991) lecturers should take account of the range of students' learning and appreciate the danger of allowing their own learning style to be reflected in their own teaching. There is a danger also of allowing one particular approach that may be personally satisfying to the teacher to dominate (Sturt, 2003).

The analogous argument for education is that we should produce material of equal success for all styles of learning. Also learners have different learning methods and must learn to learn (Draper, 2004).

2.9.5. Motivation

Motivation is a prerequisite for effective learning (Petty, 1998) and is of prime relevance in relation to teaching and learning. Skinner's theory states that motivation to learn and behave appropriately can be encouraged through rewards. Piaget believed that students are intrinsically motivated to learn intuitively (Moore, 2000). Future goals enhance motivation and learning, which in turn lead to better performance (Maclellan, 2004; Phalet *et al.,* 2004).

Students' belongingness, esteem and self-actualization must be nourished through the learning activity to encourage and foster motivation (Petty, 1998). During the teaching process students must know what they are expected to do, they must have achievable tasks and praise will all add to motivation (Rolls and Slavik, 2001). Students will be motivated to learn if it is important to them as well as if they know that they will succeed (Biggs, 1999). This was discussed by Svinicki (2005) and was referred to as the 'achievement goal orientation' in which the type of goal the students have has an impact on how they achieve those goals. Students may even undertake a deliberate choice as not to participate in part of leaning, not due to their ability but by being intrinsically unmotivated (Moore, 2000). By application of knowledge and understanding, identifying and using their existing knowledge and skills, students are more likely to increase their motivation (Chalmers and Fuller, 1996).

According to Keller (2004) there are four major categories of motivational strategies which is known as the 'ARCS Motivation Theory' and involves; Attention, Relevance, Confidence, and Satisfaction.

Svinicki (2005) claimed that motivation is a consequence of a situation. Student's motivational approach to learning should be encouraged to develop 'mastery orientation' (Section 2.9.6), in which they master a skill or concept rather than 'performance orientation' where they just undertake a task (Svinicki, 2005). Performance approach orientation students will want to appear the most competent. Performance avoidance orientation students will play safe and avoid making mistakes and are reluctant to show their work.

Students must be motivated before they learn and the achievement goal orientation as a general motivational theory is displayed among students either in the form of 'mastery goal orientation' or 'performance goal orientation'. The 'self-determination theory' as discussed by Svinicki (2005) states that motivation increases when there is an element of choice and control. Individuals are then more likely to adopt a 'mastery orientated approach'.

2.9.6. Types of learning

The following sections will outline briefly the different types of learning that are practiced within education.

Accidental learning /Incidental learning / Unplanned learning

Major scientific discoveries are the consequence of accidental learning. Accidental learning is not intentional, it is information that is acquired initially without purpose which later we devise a purpose for it (Matheson, 2003). Accidental learning as discussed by Matheson (2003) makes excellent foundation for learning, building confidence and adult life.

Collaborative Learning or peer learning

Collaborative learning can be defined as 'learning through the exchange and sharing of information and opinions among a peer group' (e-learning, 2004).

Work based learning

Work based learning allows adequate opportunity and is the basis of vocational qualifications and life long learning. Intended learning outcomes must be established to ensure the success of work based learning. It can be a challenge for both businesses and higher education (Murdoch, 2004).

Self directed learning or student centered learning

Student centred learning is a broad term that is used to "describe ways of thinking about teaching and learning that emphasise student responsibility and activity in leaning" rather than 'content' or what the teachers are doing (Cohen *et al.,* 2000). Students learn from experience and take responsibilities for their learning (Scholes *et al.,* 2004). Mature students may be more self-directed than school leavers. Self-directed learning, as a learning style must be assessed when judging its appropriateness. Self-directed learning had the advantages of increasing the student's confidence, autonomy, motivation, and preparation for life-long learning (O'Shea, 2003).

Mastery learning

Mastery Learning is based on the belief that 80% of students could achieve high grades as achieved by the best 20% under traditional methods. Mastery learning ensures that all students learn and reach a predetermined level before moving on to the next stage of the learning programme. It is an important aspect of adult learning (Curzon, 1999).

Problem Based Learning (PBL)

PBL has its origins in the work of Dewey and Piaget in the 1930s and Lewin in the 1940s. Also the acting and reflecting aspect of PBL is an important part of the experimental learning of the Kolb cycle (Cox, 2001). It has it origins in medicine (Cannon and Newble, 2000) and is about solving problems that belong to a profession (Biggs, 1999). Bovee and Gran (2004) found no significant difference between PBL and students with traditional didactic methods. However students experiencing PBL gained slightly less knowledge, remembered more of the acquired knowledge, and improved on skill (Dochy *et al.,* 2003).

Experimental learning

The logic of experimental learning is that students learn when they are actively involved. Experimental learning encourages the development of interpersonal and transferable skills, which is an important part of employment (Cohen *et al.,* 2000). The Kolb cycle involves experimental learning (Section 2.9.3).

Lifelong Learning

Lifelong learning is a principle that states that the workplace should provide the context in which the graduate must learn and develop (Holden and Harte, 2004). As reported by Mills (2004) there will be 100% new information every five years. Therefore, helping students understand how they naturally take in and process information will help students become life long learners. It was recommended that educators assist students in understanding and mastering different learning strategies to help then become better learners (Ching-Chun Shih and Gammon, 2002). Education should be a lifelong enhancing process contributing to the quality of life. (Phoenix, 2002). Learning styles that enables students to leave education with the ability and willingness to continue to learn are encouraged (HMI, 2003). These include student centered and individualistic interpretation of learning styles that will foster lifelong learning (Moore, 2000).

Accelerated learning

Accelerated learning is based on the physical working of the brain, behaviour, and prioritising the importance of the physical and social learning environment. Accelerated learning is associated with 'progressive' student-centered teaching. It is viewed that teaching and learning are not simply about covering 'curriculum content' but about teaching students 'how to learn'(Moore, 2000).

Active Learning

Active engagement in the learning process is considered of importance (Maclellan, 2004). It is claimed to create a more involved deeper learning, providing an interesting and memorable experience as well as a durable learning and concrete experience. However, it is not a new phenomenon in education. Traditional apprenticeships have practiced this for centuries, where the apprentice learns under the master's supervision through observation, direct instruction and performance (Kember and Wong, 2000).

It is believed that capable students are caught in a system that places too much emphasis on 'linguistic, word smart intelligence or mathematical, number smart intelligence'. These learning strategies have encouraged rote memory teaching strategies resulting in low motivation and poor performance, rather than learning for understanding and creative assessment (Diaz-lefebvre, 2004). Also transmissive teacher-centered approaches led to poor student understanding, low cognitive engagement and rote learning. However, in the subject of physics where a high quality didactic teaching method was adopted there was full understanding on part of the students. The study suggests that perception for quality teaching must be "sensitive to issue of content and context". Also medical students' perception of active verses passive learning revealed to be that they perceived greater education value when a didactic method of teaching is employed (Haidet *et al.,* 2004).

The traditional lecture-based didactic method of teaching and learning alone are insufficient and can be combined with real active learning (Frank and Jewitt, 2001). Active innovative approach to learning will foster deep learning as opposed to surface learning that takes place within a didactic method of teaching (Kember and Wong, 2000).

2.9.7. Assessment

Assessment can inform students about their learning progress and measures the amount of understanding and learning (Petty, 1998). Assignments should motivate students to study as well as providing useful student feedback (Cannon and Newble, 2000). The method of assessment influences what and how students learn and has considerable influence on students approach to leaning (Biggs, 1999).

It is important to avoid over assessing. An overload of assessments leads to a surface learning approach (Bennet *et al.,* 1996). Assessment should facilitate student learning through helping the student to develop problem-solving skills and critical thinking abilities. Assessment can result in too much emphasis on grading and not on its role in helping students to learn (Chambers and Fuller, 1996).

2.9.8. Learning stress

The student's self-esteem is a key factor affecting student's learning. How students perceive themselves within the learning environment will determine their success. Negative self-talk, lack of self-belief, poor self-management and study skills and even disputes with parents, friends or teachers will distract from the learning environment (Moore, 2000). As discussed by Chamber and Fuller (1996) it is easy to want to teach, and have students learning, without realising that they have lives outside the college. It is not always lack of interest, commitment or ability that affects learning but rather their situation. Students 'live real lives outside the classes, and 'artificial deadlines of academia' are of less importance, so that a 'work avoidance' approach is adopted (Svinicki, 2005).

Not all students see learning as a positive experience. Learning can be a painful and daunting experience for some. There can also be too much emphasis on a student's personal experience, trying to 'bring out' the student in the classroom situation, which can become destructive and debilitating (Moore, 2000). Expectation of success is based on past experience and the probability of success, the 'expectation value theory'. As was discussed by Svinicki (2005) encouraging students to acquire the 'mastery orientation approach' which is based on tasks that focuses on learning and making progress rather than being perfect. Providing an environment that encourages mastery orientation and interpreting failure as an opportunity to learn is important. Errors should be considered as "teaching moments and opportunities for learning to occur" (Svinicki, 2005).

2.10. THE TEACHING PROCESS

2.10.1. Setting aims and objectives

Aims and objectives establish educational intent and purpose. Aims express what the teacher will do in general terms, while objectives or outcomes will describe what students learn with more precision, defining the syllabus content and level. (Biggs, 1999; Cohen *et al.,* 1996; Petty 1998). Also, from the student's point of view they state what students will have to achieve, which can be used by the students as targets (Race, 2001).

2.10.2. Lesson planning

The lesson should be planned in order to achieve the established aims and objectives. The Planning Cycle described by Petty (1998) involves setting out the aims, planning and undertaking the action, followed by a process of evaluation.

Planning is an important process in order to allocate resources. Many factors need to be considered including student academic standards, subject resources and constraints such as time, room and materials (Curzon 1999; Petty 1998). It is important to devise a range of learning styles that will satisfy all students. It is important to address questions such as what kind of material to teach and what kind of learning environment to provide, style and activities (Liu and Ginther, 2004).

According to Curzon (1999) lesson planning should use the '20:80 principle', where 80% of the time is spent on the central section of the lesson and the remaining 20% on introduction and conclusion. The lesson structure should have four main components, with an introduction to outline the objectives and create interest and motivation. The central section should be used to present, teach and test the learning, including both declarative knowledge and functional knowledge. Then consolidation should follow to review and link all elements of the lesson. The lesson should end with a conclusion to ensure assimilation and retention (Biggs, 1999).

2.10.3. Delivery of lesson

In the delivery of an effective lesson, both the teacher and student have joint responsibility. The quality of the teaching and learning depend on the input of the lecturer and the student's response (Ashworth and Harvey, 1994; Cannon and Newble, 2000).

A consistent relationship has been found between the teacher's behaviour and student learning. Both verbal and nonverbal immediacy are positively related to student's learning and motivation. High immediacy behaviour motivates students to work harder than low immediacy behaviour. Immediacy coincides with the idea of liking and disliking and therefore incorporating immediacy behaviour is an effective teaching strategy. The Non Verbal Immediacy (NVI) behaviour that has been proposed to affect the immediacy includes tonality, vocal pace, eye contacts, smiling, and use of gestures, body tenseness and trunk and limb movements (Albers, 2004; Love, 2004).

It has been noted that teacher talk occupies 60% of most lessons. Most people talk at about 100 to 200 words per minutes. An hour's lecture therefore contains 12,000 words. The concentration span of students is less than five minutes while they listen to teacher talk. This is because the short term memory (STM) soon gets filled up (Curzon, 1999). Psychologists believe that the process of remembering is the passing of information from the short-term memory (STM) to the long-term memory (LTM), with a high proportion or almost all of the information being forgotten at each stage. When applying this concept to teaching one must ensure that new material is not covered too quickly, as it needs time to 'sink in' to allow information to be taken into the STM. For information to be stored in the LTM it must be used, as in the case of active learning and recalled often within the academic year (Petty, 1998).

In the delivery of a lesson there are learning style resources and there are "as many ways to 'teach' as there are to learn". It is important to respect that people see the world differently, they may have very different preferences as to how, when, where and how often to learn (Blackmore, 2004).

2.10.4. Writing course material

Students' learning materials should be simple in terms of language and design, having short words and sentences and bullet points. The style should always be consistent (Cannon and Newble, 2000; Race, 2001). As Biggs (1999) pointed out "the greatest enemy of understanding is coverage" and too much coverage should be avoided. Effective learning occurs when students become actively engaged in thinking about the material and have time to assimilate it for themselves. Constructionist theorists in educational psychology as discussed by Cannon and Newble (2000) look at how individuals construct their own understanding from information and ideas they encountered. Effective visual design conveys messages in a more effective manner and helps focus the learner's attention on key points (Beriswill, 2004). Visual learning is an effective means of learning for the majority of learners, making Visual Aids an important resource within teaching and learning.

2.10.5. Methods of delivery

Lecture

The word lecture mean to read aloud (Reece and Walker, 1998). Lectures are as effective as any other methods of transmitting information to a group of people (Cannon and Newble, 2000). Lecturing is one of the most economic methods of teaching (Ashworth and Harvey, 1994). Passive students prefer lectures as it is less demanding (Reece and Walker, 1998). The lecture is less effective in stimulating thinking, inspiring interest, changing attitudes, fostering lifelong learning skills and attitude. A lecture is best used to give an introduction and an overview, outlining key areas to be covered, summary and conclusion (Cannon and Newble, 2000). Given that students can access information from a variety of sources, lectures are not the only means of obtaining information (Race, 2001). Within a lecture, discussions can take place, where students will talk to each other about a topic and report back on their findings. A brainstorming teaching strategy generates a large number of ideas in a short time. Discussion groups and brainstorming sessions allow students to take an active part within the lecture (Reece and Walker, 1997). A transmissive, didactic lecture fosters surface learning as opposed to an active innovative lecture, which encourages deep meaningful learning (Kembler and Wong, 2000).

Group work

Good group work hands the responsibility of learning over to the students using open-ended tasks (Petty, 1998). Small group work is based on the Neo-Vygotsky approach. It is concerned with the potential of students to act as 'expert guides' to each other, and move through stages of Zone of Proximal Dimension (ZPD) (Section 2.9.3). It is argued that if students value the success of the group, then students will help and encourage one another to achieve (Petty, 1998). Recent researchers (Bennett *et al.,* 2002) has directed attention away from individual functioning in a group towards the collective aspects of cognition in-group, suggesting that cognition is a product of social interchange and is constructed, shared and distributed among students during social interactions. Student interactions can contribute to individual learning and the contribution should be capable of adding something that tutors cannot achieve.

Tutorial and Seminar

Tutorial and seminar work promote thought and develop attitudes (Ashworth and Harvey 1994). A tutorial involves one to one learning, where there is an individual and in-depth assistance. A seminar on the other hand is a teaching opportunity where a student researches a topic and presents it to the rest of the class followed by a discussion (Reece and Walker 1997).

Demonstration and Practical

Demonstration and practical work have the advantage of linking theory and practice (Reece and Walker, 1998). It is not a complete lesson in itself where the main points are heightened and made clear through reasoning (Curzon, 1999). It is also associated with showing students a practical skill which they will then practice (Reece and Walker 1997). Practical classes allow students to develop observation and group skills (Ashworth and Harvey, 1994). Demonstrations and practical sessions can take the form of a simulation in which the event or situation has to be set up as close to the real thing as possible (Reece and Walker, 1997). Practical activities and tasks should vary in length, demand and style. Student should be able to demonstrate understanding. Variation in group size should be practiced, from individual to all class participation (Powell, 1999).

Visits and visiting speakers

Visits make the curriculum real so that academic work becomes purposeful. It also supports and extends the learning as well as encouraging interpersonal relationships. Visiting speakers bring the "real world" into the teaching and learning experience (Petty, 1998).

2.10.6. Teaching resources

Learning resources should support teaching and facilitate learning (Ashworth and Harvey, 1994). As claimed by Reece and Walker (1998) "a good learning aid is one which does a particular job to assist in the learning of a particular topic for a particular group of learners". Curzon (1999) noted that resources for teaching and learning must address lesson objectives.

Audio Visual Aids (AVA)

Audio visual aids (AVA) relate to all the senses and widen the boundary of insight. Many concepts or ideas are understood visually rather than verbally as 87% of the information enters the brain through the eye. Visual aids gain students' attention, add variety and interest as well aiding memory and conceptualisation. AVA's include Whiteboard, Over Head Projector (OHP), Flip Chart, Videos, Slide Projectors, Power Point Presentation, Interactive White Board (IBW), and DVD's (Petty, 1998).

The use of a whiteboard can complement other methods by drawing attention to key issues and may be used as a "scrap pad" during the lecture (Cannon and Newble, 2000; Petty, 1994). Information is visual and allows opportunity for discussion. Information shown in stages using the 'revealing technique' can be effective as well as the 'overlay technique' when introducing complex diagrams. (Cannon and Newble, 2000; Reece and Walker, 1998; Petty, 1998). Powerpoint is a multi media presentation package. Presentations must be simple, avoiding the use of complex typefaces with distracting backgrounds, design and colour (Cannon and Newble, 2000). Students have been found to express preference to Powerpoint presentations than overhead transparencies provided that the materials were relevant. Additional irrelevant pictures were found to be harmful to students learning (Bartsch and Cobern, 2002).

Handouts

Handouts must be visually attractive, user friendly and contain simple language. The danger with issuing handouts is that the student may never read them again. (Reece and Walker, 1998). Handouts can be used actively when student use them in class to make notes or as 'gapped-handouts' (Race, 2001). Handouts must have a purpose during the teaching session so those students don't just file them away (Cannon and Newble, 2000). Handouts must not be crowded, the use of indent, bullet points and highlighting of important parts will all add to the effectiveness of the handout. It is unadvisable to give more than one or two 'A4' double sided handouts per hour, if more information is required then students should be required to referred to books or journals (Petty, 1998).

Information Technology

Technology integration must 'add value' to the educational experience and be used in a way that supports knowledge and understanding. It is just as important to adopt effective pedagogical practices for technology integration as to any other teaching resource (Dexter and Doering, 2003). Corliss *et al.* (2004) found fewer lecturers than expected actually using information technology, and if used, received positive feedback from their students. Bennet *et al.* (2002) found that 55% of the employment of new methods of information and communication technology (ICT) arose from individual initiatives rather than from any from of institutional strategy.

Cannon and Newble (2000) noted that students who used information technology become more active and independent in their learning, they worked collaboratively with each other rather than competitively. A teacher's role is to act as manager and designer of learning resources, to guide rather than disperse information. There is evidence that on-line courses are more interesting than traditional studying in class (Naruse *et al.*, 2004). Dowling *et al.* (2003) found that the students' performance was higher using flexible delivery models as opposed to face-to-face lectures.

Computer based learning is a generic term used for a computer programme used by a learner to acquire knowledge and skills (e-learning, 2004). Computer based learning resources are widely used but must be selected carefully (Race, 2001). Information and communication technology (ICT) have increased the availability of learning resources to include on-line catalogues, CD-ROMs, Internet, and the World Wide Web (Chambers and Fuller, 1996). Systems available and their acronyms include: Programme Instruction (PI) and Computer Aided Instruction (CAI), both involving a step by step response. Interactive methods include Computer Based Education (CBE), Intelligent Tutorial System (ITS), Computer Managed Learning (CML), Computer Aided Learning (CAL), all having an important role in distance education (Curzon, 1999). The Computer Assisted Learning (CAL) process allows active and creative participation in the process of knowledge accumulation (Kozielska, 2004). Dialogue is an important component of learning and must not be lost through the electronic delivery of learning. Information Technology in collaborative learning are increasing and becoming more popular within education establishments. Amongst the most popular collaborative learning resources are Computer Media Communication (CMC); Interactive chat; Muti-User Dungeons (MUD's); Multi-User Objective Orientated spaces (MOO's); Group Conferencing System; and asynchronous (time-delayed) communication that can be used in e-mail discussion news groups and video conferencing (Webb *et al.,* 2004).

Students are expected to use learning technologies to access, organise and retrieve information and on line course materials (Bonzo *et al.,* 2004). However it has been found that learners experiment with learning resources and may use them improperly in the learning process (St-Pierre, 2004). Student support in the use of IT has been found to be productive and has increased learning performance (Hofmeister, 2004). Likewise, on-line structured training opportunities for lecturers have proved to be beneficial (Preston and Edmonds, 2004; Krueger *et al.,* 2004; Janice and Lou, 2004). Teaching on line required extensive planning, a commitment which is often overlooked (Janice and Lou, 2004).

Visual Learning Environments (VLE) and Virtual classes have proven to be of advantage in small rural areas in Canada and New Zealand (Stevens and Cavanaugh, 2003). Within the UK, centres who have established VLE have proven to be successful. Some land-based examples include Coleg Sir Gar, The Virtual Agricultural College, Wales; the virtual learning environment at University of Plymouth, Nottingham Trent University, University of Paisley, Myerscough College; Otley College of Agriculture and Horticulture in using agricultural images for NVQ programs; and the Environmental Challenges in Farm Management (ECIFM) web based learning package from the University of Reading has also achieved popularity. Multimedia Education Resources for learning and on line teaching (MERLOT) is also a classic example of on-line education portal with educational materials. Information sources can be obtained through many routes, and users can make their own choices when searching for information (Froelich, 2003).

The five stages of Salmon's Model for teaching and learning online (Teachopolis, 2004) includes the access and motivation stage, followed by online specialisation and information giving and receiving. Then the last two stages involving knowledge construction and development stages. Cannon *et al.* (1996) also noted that an educational establishment will not be the sole disperser of knowledge, but rather raise a student's awareness of 'learning how to learn'. The efficiency and economy of electronic delivery of part of the curricula will benefit institutions that are facing increasing student numbers without a proportional rise in teaching resources (Short, 2002).

2.11. ACTION RESEARCH

Action research has its origins in the 1940s, involving Kurt Lewin's Spiral of Step, and parallels Dewey's concept of experimental learning (Smith, 2002). Action research or researched-based practice was referred by Sciön as 'playful trial and error activity', with a sense of purpose and attention to develop theories and understanding (Tickle, 2000). Action research is defined as "personal curiosity and interest that you decide to investigate in a systematic way" (Barnett et at., 1996). In terms of teaching and learning it is about finding out as much as possible about the teaching style and learning and how it can be improved (Reece and Walker, 1998). Reflecting on one's own practice is required in order to improve future practice (Moore, 2000). Action research is a self-reflective spiral of planning, acting, observing and re-planning (McNiff, 1997). Action research requires consideration of the viewpoints of others and may even have to abandon 'cherished practices' (Bennet *et al.,* 1996).

In order to promote and facilitate development in education, professional judgment is a good starting point (Williams and Baker, 1999). As reviewed in HMI FE Handbook, the process of teaching and learning was considered to be "a matter of professional judgment and not a compliance with any checklist." Developing professional knowledge and judgment promote good practice (HMI, 2001). Also, educational evidence requires personal contribution and opinions and this makes it very subjective, less scientific and impossible to find a right answer every time and to please all individuals (Williams and Baker, 1999).

Action research requires validity, truthfulness and appropriateness of information. It must also be reliable, where information is dependable and consistent. Also the information obtained must be used, otherwise there is no value in understanding the evaluation process (Cannon and Newble, 2000). Self evaluation of lessons encourages continuous improvement and feeds into action planning by identifying good features and shortcomings (ELWa, 2002). Peer evaluation can also contribute to an action planning process. The atmosphere must be supportive for peer evaluation to take place (McNiff, 1997). Formative peer evaluation in the form of direct classroom observation and course materials strengthens the teaching and learning process (Keig and Waggoner, 2004).

Students are the key stakeholders in education and therefore using their perspective is an important source of evidence for improving curriculum, pedagogy and learning achievement (Wood, 2003). Kember and Wong (2000) questioned the ability of students to make appropriate judgment about teaching. Students could be influenced by their learning beliefs and the teacher's belief about teaching. Therefore, it should be seen as feedback rather than judgment (McNiff, 1997).

Group interview evaluation has the advantage of being time-saving with a minimum of disturbances. The optimum group size is 6 to 7. A small group places too much pressure on an individual. A large group can lose focus and become fragmented (Cohen *et al.,* 2000). Bennett *et al.* (1996) noted that in group interviews some may find it hard to express themselves. A focus group is a form of interview, without the interaction between group and interviewer, but rather an interaction within the group

(Cohen *et al.,* 2000; Gibbs, 2004). A focus group gives the opportunity to listen and learn from people about their attitude, feelings and beliefs (Gibbs, 2004; Cornwall, 2004). Questionnaires allow data to be analysed qualitatively and systematically (Studentbmj, 2004). Questionnaires have the advantage of being anonymous and can also be analysed statistically. Questionnaires provide information about feelings thoughts and attitude in a time efficient way (Race, 2001). In order to ensure that questionnaires are filled in by all participants they can be completed in the presence of the coordinator (Bennett *et al.*, 1996). Questionnaires can be ambiguous and confusing (Kember and Wong, 2000).

The key principle of this study was to evaluate the use of a single herd data set within teaching and learning. The following chapter discusses the methods and materials used in the analysis of the data set (Sections 3.2 to 3.5), followed by the education evaluation of lectures within Further and Higher Education context (Sections 3.6 to 3.9).

CHAPTER 3

METHODS AND MATERIALS

3.1. INTRODUCTION

An explanation of the materials and methods are given in this chapter. Sections 3.2 to 3.5 involve an explanation of the herd analysis and Sections 3.6 to 3.9 provide an explanation of the materials and methods for the educational evaluation. There will also be specific descriptions given in the following chapters that describe individual analysis.

3.2. THE DAIRY HERD DATA

3.2.1. Historical introduction to the herd's breed, location and its commercial and educational importance

The Glynllifon dairy herd's history dates back to the beginning of the twentieth century when the herd was established as a Welsh Black breed at Madryn Farm School on the Lleyn Peninsula. The Caernarvonshire County Council purchased the Madryn Estate in 1910 and it became the first County Agricultural College in 1913 (Jones, 1992). During the early years of the 1920s low milk prices and poor marketing of milk resulted in low farm incomes throughout England and Wales (Section 2.2.3). In order to improve farm incomes in the North West Wales area, maintaining strong agricultural education was seen as one approach. The other approach was the marketing of milk. Madryn Farm School with other local farmers formed a farmer's cooperative. The cooperative, Hufenfa De Arfon, became responsible for the buying and processing of milk into cheese. The dairy herd was important as a supplier of milk to the creamery as well as being a resource for agricultural education (Jones, 1992; Jones A, personal communications, 2002).

After the First World War the Madryn Farm School became one of the three Farm Institutes that were set up in Wales, controlled by the Ministry of Agriculture (Section 2.8.1). From the 1940s to the 1960s the number of Welsh Black cattle decreased: they were replaced by British Friesian cows. The last Welsh Black animal to be milked at Glynllifon was Llifon Trejan 6th who left the herd in 1969.

In 1953 all of Madryn's students, staff and dairy herd moved to Glynllifon. The Glynllifon College of Agriculture was officially established in 1954 (CEA, 1954).

The Glynllifon Agricultural College continued through the 1960s to the 1980s to provide agricultural education for the rural areas of North West Wales. From the early 1980s, milk production from the College's dairy herd increased by crossbreeding with Holstein bulls.

During the early 1990s the Glynllifon Agricultural College, like many Further Education colleges, became independent of the Local Education Authority (LEA). Glynllifon became in 1994 one of the three sites of Coleg Meirion-Dwyfor, a Tertiary College, specialising in land-based programmes (GAEA, 1994).

3.2.2. Recovery of the original herd records

In 1997 dairy herd records were retrieved from old farm buildings at Glynllifon. During the initial stages of sorting the records, gaps were found in the data (between 1963-1966 and 1972-1977). During 1998 more records were retrieved. Eventually by 1999 a complete set of the Glynllifon dairy herd records had been compiled. Poor storage conditions over the years resulted in some of these records being mouldy and illegible. Fortunately, most of the missing details were confirmed using the British Friesian Herd Books. This resulted in a complete collection of original lactation records for the Glynllifon herd between 1943 and 2000. The majority of the lactation records for the earlier years were from the Welsh Black breed and were omitted from this study.

3.2.3. Description of the lactation records

From the 1940s onwards the authenticity and reliability of lactation records within the dairy industry was maintained through the monitored process adopted by the National Milk Recording (NMR) of the Milk Marketing Board (MMB) and the British Friesian Breed Society (BFBS), who concentrated on the Pedigree Information. The Milk Marketing Board's North Wales Region of National Milk Records carried out monthly recordings of milk yield and butterfat. Individual cow records were calculated, checked and amended at the end of each lactation on the farm and at the NMR office of the MMB where they would be given a red MMB dated stamp confirming the amendment. A lactation certificate would then be sent to the farm with an official red seal from the MMB. In later years they had an embossed endorsement. The lactation recording system as described above remained in operation from 1943 to 1972. Post 1972, the lactation certificate became metricated, typed and was formally known as the 'Cow Record Card'. Then in 1987 another version appeared known as the 'Lactation Records' using blue typed paper.

From 1990 until 1996 an A4 computerised, 'Lactation Record Certificate' was issued for each animal. During this period the lactation records gave more information on the breeding potential of the animals. By the late 1990s on-farm computers were becoming much more widely used in dairy herd management, and the computer package known as the 'Herdfil Plus' and later the 'Imple Pro' were available as an additional service by the NMR. The latest version of the dairy herd records used within this data set was the 'NMR Lactation Certificate'.

The information on the lactation records includes the animal's pedigree and production details. Pedigree details were obtained from the breed society. Production details were collected on the farm by the National Milk Recording (NMR) official, on a monthly basis, for the evening and morning milking. Milk samples were taken for compositional analysis and information on production events such as 'calving', 'service' and 'drying off' were obtained. This information was then transferred to each individual cow's lactation record within the herd. Fertility variables were only available for the last year of the data set and were not studied.

3.3. DATA PROCESSING

3.3.1. Introduction

The original hard copies of the lactation records found on the farm from the 1940s onwards were used to create the data set. The stages involved in the construction of the data set, as outlined below, were initially manual sorting of the records (Section3.3.2.), then visual editing (Section 3.3.3) and finally computer editing (Section 3.3.5).

3.3.2. Manual sorting

Records were sorted manually into decades. Those of the 1940s and early 1960s had to be sorted into breeds, either the Friesian or the Welsh Black. The Welsh Black breed was not used in this study. Lactation records for the Friesian breed were then sorted into 'Cow Family' names and then into order within the families. The total number of lactation records retrieved for the Friesian breed was 4,035 for a total of 976 cows, an average of approximately four lactation records per cow.

3.3.3. 'Visual' editing

Every record (total of 4,035) within all the cow families was inspected. Damaged and illegible lactation records were assessed, and where possible confirmed using the British Friesian Herd Books. A total of 126 lactation records had all pedigree details missing (3.1%) and 42 had missing production details (1%). Ninety four records were damaged and completely illegible (2.3%). A total of 70 records (1.7%) had missing and incorrect date of birth and calving date (Table 3.1). Incomplete lactations were identified and came to a total of 222 lactations (5.5%). These lactations were identified as either 'suckling', 'ill', 'sick', 'sold', 'left' or 'dead'. Lactation records for the Friesian breed during 1948 and 1949 were deleted because of the comparatively low number of observations relative (0.4%) to the other five decades. The visual preliminary edit resulted in 571 (14%) of the lactation records being excluded from the data entry for the Friesian and Friesian Holstein breeds. Lactation numbers ranged from 1 to 13. The total number of records in the lactation 8 and over were small (0.2%) and were combined to create a (>8) lactation group. All the data were based on natural lactation length as opposed to the standard lactation length of 305 days (DFF, 2003).

3.3.4. The lactation records data

The data available on the lactation records included all the pedigree details (Figure 3.1). Production information included lactation number, age, offspring details, event dates and production details. Information on breeding and genetics increased over time. The amount of genetic information at the end of the data set is as shown in Figure 3.1.

3.3.5. Computer Processing

Three thousand four hundred and sixty four lactation records (85% of records found) for the Friesian and later the Friesian Holstein breeds between 1950 and 2000 were entered into a computer database. Each cow family was taken in turn for data processing using Microsoft EXCEL. The information obtained from the lactation records and supplied into the data set for analysis are grouped into Pedigree information, Production, Breeding information and SCC.

Table 3.1. Data editing process prior to data analysis

'VISUAL' EDITS	NUMBER DELETED	% (4035)	NUMBER RETAINED
Total number of records retrieved			4,035
Damaged – illegible records	94	2.3	3,941
Incomplete lactation – dual purpose	74		3,867
Incomplete lactation – sold	79	5.5	3,788
Incomplete lactation – health	69		3,719
Edited records for 1948 and 1949	17	0.4	3,702
Missing all pedigree details	126	3.1	3,576
Missing production details	42	1.0	3,534
Missing and incorrect date of birth	29		3,505
Missing and incorrect calving date	41	1.7	3,464
Total	571	14.0	3,464
COMPUTER EDITS			
Incorrect date of birth and calving date	207		3,257
Missing sire and dam details	9	6.7	3,248
Incorrect production dates (CI and DD)	56		3,192
Milk yield – less than 150days	276		2,916
Milk yield – over 450days	16	7.0	2,900
Calving interval – less than 300days	17		2,883
Calving interval – over 600days	2	0.5	2,881
Total	583	15.0	2,881
Total data set	1,154	29.0	2,881

3.3.6. The data editing process

The final editing of the lactation records identified minor gaps that were not identified in the visual editing, as well as errors and abnormal production ranges. Lactation records from 1950 to 2000 appeared as five different versions (Section 3.2.3). During the transition from one version to other, missing information as well as the duplication of information was at its highest. Until 1972 milk yield was recorded in pounds (lb). These records were converted to kilograms during the computer editing stages.

Missing information on the cow's pedigree details, incorrect date of birth, calving dates and production dates came to a total of 272 (6.7%). A summary of the data editing process is shown in Table 3.1. Milk yield records from lactations of less than 150 days and over 450 days were excluded as described by Pirzada, (2000) which came to 276 (6.8%) and 16 (0.25%) respectively. Records with calving intervals less than 300 days and over 600 days as defined by Pryce *et al.* (2000) were also omitted and came to a total of 19 (0.5%) records.

Figure 3.1. Information obtained from the lactation records

Pedigree information

1. Cow name – pedigree registered name with herd prefix
2. Dam name – pedigree registered name with herd prefix
3. Sire name - pedigree registered name with herd prefix (abbreviated as 1st letter and last letter followed by 1st initial of remaining pedigree names)
4. DOB – dd/mm/yy

Production information

5. Lactation number – from 1st lactation to 13th lactation
6. Calf sex /single or twin (1=female, 2=male, 11=female twins, 22=male twin and 12= female and male twins)
7. Age at calving – calculated in months
8. Calving interval – quoted in days, with no data created for 1st lactation
9. Days dry -for previous lactation, with no data available for 1st lactation
10. Date of calving – dd/mm/yy
11. Milk yield – natural lactation length milk yield in kg (lb for pre 1972)
12. Days in milk – number of days of the natural lactation length
13. Protein Yield - protein % and milk yield (from 11)
14. Fat Yield - fat % and milk yield (from 11)
15. Lactation end date or dry off day – dd/mm/yy

Breeding / Genetic information

16. Index - Cow Production Index (CPI)
17. Base – base year as stated
18. Predictable Transmitting Ability (PTA, base year 90,95 and 2000)
19. Improved Contemporary Comparison (ICC)
20. Index of Total Economic Merit (ITEM)
21. PROFIT INDEX (£PI)
22. Life production index 2000 (£PLI 2000)

Other

23. Somatic Cell Count (SCC, 100,000ml/l)

3.4. CONFIRMATION OF LACTATION RECORD DETAILS

The production cycle of the dairy cow was used to confirm data on the lactation certificate. The relationships between dates, including date of birth, date of calving and age of calving, days dry and calving interval were checked using the relationships outlined in Table 3.2.

Table 3.2. Production relationships used to confirm the data on the lactation records

Date of birth = dams calving date on one of her lactation records
Age at calving (months) = interval between the date of birth to the date of calving
Days dry (days) = lactation end date to the next calving date Days dry (days) = calving interval less lactation length
Lactation length (days) = the date of calving to date dry or the last lactation date Lactation length (days) = calving interval less days dry
Calving interval (days) = date of first calving to date of next calving (2^{nd} lac only)
Calving interval (days) = days in milk + days dry

Calving dates and dates of birth should be identical for dam and daughters for those animals retained in the herd. Also the interval between the date of birth and the date of calving should equal age at calving. The recorded number of days dry on the lactation record should be in agreement with the number of days between the lactation end date and the next calving date on the lactation record. Also, it should equal that of calving interval less the lactation length. Lactation length should equal the number of days between the date of calving and the last lactation date. Calving interval less days dry should also equal the lactation length. Calving interval should equal days in milk plus days dry. Also the length of calving interval should be equal to the number of days between each calving.

All the records were confirmed correct and resulted in no further edits. Following all the visual and computer editing, 1,154 records (29%) were deleted. It can be seen from Table 3.3, that the lowest number of records was found in the 1950s. From 1960 to 1980 the number of records increased, and then decreased thereafter.

Table 3.3. Distribution of records and edits per decade

Decades	No. records retrieved (%)	Records Retained (%)	Computer edits (%)	Edited per decade (%)
1990s	890 (22)	670 (23)	220 (19)	25
1980s	1,117 (28)	996 (33)	121 (10)	11
1970s	957 (24)	736 (26)	221 (19)	23
1960s	707 (18)	417 (14)	290 (25)	41
1950s	364 (9)	62 (2)	302 (26)	83
Total	4,035	2,881	1,154	29

The total number of records retained for use in the data analysis was 2,881 for 763 cows. For the analysis of milk yield, milk fat yield and composition, as well as most of the functional traits, all 2,881 records were used. However, milk protein, Somatic Cell Count (SCC) and most of the estimated breeding values and indexes had a smaller data set as these did not appear nationally on the NMR's lactation records until the 1970s.

3.5. STATISTICAL ANALYSIS

3.5.1. Descriptive Statistics

Descriptive statistics of the phenotypic values of production and functional traits including, mean, minimum and maximum values were calculated per decade. Standard deviation (SD) was calculated in order to compare the variation within the same trait in different groups of animals. Coefficient of variation (CV %) and regression were also calculated and trends over time were investigated for the whole data set. For trends over time or lactation number, the time/lactation number at which a maximum production level was attained was determined, where appropriate, by differentiation of the quadratic equation describing the relationship. These analyses were carried out using both Microsoft EXCEL and MINITAB.

3.5.2. Genetic Components

There are several computer programmes available to estimate variance components and genetic parameters in animal breeding. For this analysis the restricted maximum likelihood (REML) method was adopted using the ASREML programme (Gilmour *et al.,* 1998). ASREML is a programmes that is well recognized and highly regarded within the dairy industry (Swanson, G; personal correspondence, 2000).

Variance components and genetic parameters for milk, fat and protein yield were estimated using the univariate animal model. The model is described in detail in Chapter 5.

Attempts were undertaken to establish the relationships between traits in bivariate animal models. The bivariate analyses did not yield reliable estimates of genetic parameters (presumably because of the low number of records) and the results are not presented in the thesis.

3.5.3. Calculation of genetic parameters

The genetic parameters were calculated using ASREML based on the relationships described below.

$$V_P = V_A + V_C + V_E$$

Heritability (h^2):

$$h^2 = V_A/V_P$$

Permanent environmental variance due to the animal as the proportion of the phenotypic variance (C^2):

$$C^2 = V_C / V_P$$

Repeatability:

$$R = \frac{V_A + V_C}{V_A + V_C + V_E}$$

Where components of VARIANCE are: V_P = phenotypic variance; V_A= additive genetic variance; V_E= environmental variance; V_C= permanent environmental variance.

3.5.4. F-values

For the determination of the significance of fixed effects, F-values were obtained from the analysis of variance after the analysis was completed in the ASREML programme. Significant fixed effects were determined using tables of F-values.

3.6. STUDENT GROUPS, SYLLABUS AND AIMS / OBJECTIVES OF LECTURES

3.6.1. Introduction

Information from the Glynllifon dairy herd lactation records between 1950 and 2000 was used in lectures relating to 'dairy cattle selection and breeding'. The lectures were one and a half hour sessions. The aim of each of the lectures was to introduce an active innovative approach to teaching using the dairy herd and its data, so as to relate lectures to practice. The effectiveness of teaching and learning were then evaluated in the Further and Higher Education context by using both qualitative assessment and quantitative analysis.

3.6.2. The student groups

A range of programme levels within both Further Education (FE) and Higher Education (HE) institutions (Table 3.4) were used to evaluate the suitability of the dairy herd and data as teaching and learning resources within lectures. The subject of 'Dairy Cattle Selection and Breeding' was a syllabus requirement for all the FE and HE programmes.

A total of 186 participants were involved in the study (Table 3.5). Of the 186 students, 58 were pilots and 128 participated in the evaluation (40% were in the HE group, 42% in the FE group and 18% in the farmers' group). The lower level groups' provision was at the FE site of Coleg Meirion-Dwyfor, Glynllifon. The FE programmes included the National Vocational Qualification (NVQ), National Certificate in Agriculture (NCA) and the National Diploma (ND) programmes. The Higher Education programmes included Higher National Diploma/ Certificate (HND/C), Bachelor of Science (BSc) and Master of Science (MSc) of the University College of Wales, Bangor. The third group consisted of unregistered students of all ages who visited the FE college site. They were closely linked with practical agriculture and were combined and titled the farmers' group.

The Awarding Bodies for the above programmes were City and Guilds, Edexel and University of Wales (Table 3.4). The entry requirements for the programmes ranged from no formal qualifications through GSCEs to 'A' levels and degrees. The age range was post 16 years, with the exception of school year 11 in the Farmer's group.

The method of assessment varied from internal assessment and tests to externally set assessment and exams. In all the programmes the dairy herd, data and results, were used for all the lectures as discussed in Section 3.9.

Table 3.4. Nature of Syllabuses and Student Groups

Programmes	Further or Higher education	Awarding Body	Normal Entry Requirement	Course length e Full/part-time course	Assessment Methods used for Awards
NVQ	Further education	City &Guilds	Work experience	2 years part-time	Internal Continuous Assessment
NCA	Further education	City &Guilds	No formal qualifications	1 year full-time	Internal with an External End exam
ND	Further education	Edexcel	4 GCSE's grade C	2 years full time	Internal and external assessments
HND/C	Higher education	Edexcel	'A' level, ND, work experience	2 years part-time	Continuous internal assessments and tests
BSc Year 1	Higher education	UWB	'A' levels, ND, Work experience	3 years full-time	Internal continuous assessment and semester exams
MSc and Third year Undergraduate	Higher education	UWB	BSc, industrial experience	1 year full-time	Internal continuous assessment and year exam
Farmers' group	Combination	None	None	Day visit	None

NVQ=National Vocational Qualifications; NCA= National Certificate in Agriculture; ND= National Diploma; HND/C = Higher National Diploma/ Certificate; BSc = Bachelor of Science; and MSc = Master of Science.

The lectures were evaluated over two academic years because group sizes were generally small, except for the BSc group which was conducted in one year only. The average group size over the two year period was 16, with the smallest group being the MSc with 13 students and the largest, the ND with 22 students (Table 3.5).

Table 3.5 Student group and sizes

	NVQ	**NCA**	**ND**	**HND**	**BSc**	**MSc**	**Farmers' group**	**Total**
Year 1	8	6	11	7	19	5	17	73
Year 2	9	9	11	12	0	8	6	55
Total	17	15	22	19	19	13	23	128

NVQ=National Vocational Qualifications; NCA= National Certificate in Agriculture; ND= National Diploma; HNC = Higher National Diploma; BSc = Bachelor of Science; and MSc = Master of Science.

3.6.3. Lectures on dairy cattle selection and breeding

Lectures were written with respect to the UK dairy industry, using the College herd, records and results of data analysis to address each programme's level and syllabus requirement (Table 3.6.).

Table 3.6. Syllabus Requirement for all Programmes

Programme Level	**Syllabus requirement**	**Source**
NVQ Livestock Production Level	*'selecting animals for breeding'*	City and Guilds, 2001
National Certificate in Agriculture (NCA)	*'the use of dairy traits in the selection of dairy cows for breed replacement using farm records'*	City and Guild, 2001
National Diploma in Agriculture (ND)	*'selecting of breeding males and female stock based upon physical traits and previous performance'*	Edexcel, 2001
Higher National Diploma / Certificate (HND/C)	*'Cow conformation and classification bull proofs and selection criteria, use of Predicted Transmitting Abilities (PTA's) and genetic indices Profitable Lifetime Index'(PLI')*	Edexcel 2001
BSc UCW Bangor	*'Traits of economic importance'. 'Introduction to quantitative methods, estimation of variance components and responses to selection'*	UWB, 2001
MSc UCW Bangor	*'Breeding value estimation; selection index – principles and applications'*	UWB, 2001

Lectures' aims and objectives were outlined to ensure that lecture content and materials addressed specific topics in the syllabuses and involved current information as used in the dairy industry. The outcomes were designed to incorporate an active innovative approach to teaching and learning. Straightforward quick and achievable tasks were included in addition to a supplementary exercise for the more able students. The aims and objectives for each programme level are as shown in Figure 3.2.

Figure 3.2. Aims and objectives for HE and FE programme level groups

NVQ Livestock Production Level 2

AIM: to develop an understanding of the principles of animal selection within dairy farms
OBJECTIVES:
- Discuss breeding and selection within dairy cows; including breeding programme and dairy traits
- Identify good and bad traits in cows
- Carry out linear assessment

National Certificate in Agriculture (NCA)

AIM: to develop a basic understanding of the selection process in dairy production.
OBJECTIVES:
- Breeding programme and dairy traits identification
- Select animals for breeding from milk yield and cow records
- Carry out linear assessment

National Diploma in Agriculture

AIM: to develop an understanding and appreciation of dairy selection based on physical and previous performance
OBJECTIVES:
- Discuss selection methods and terms used within the industry
- Undertake linear assessment
- Select dairy cows and sires based on physical and production characteristics

Higher National Diploma / Certificate (HND/C)

AIM: to develop a knowledge and understanding of breeding values and physical traits.
OBJECTIVES:
- To explain the importance of economic traits and the population genetics
- Interpreting genetic information within the dairy industry
- Use Impel-pro for selecting cows

BSc UW Bangor

AIM: to enable students to develop a knowledge and understanding of breeding traits, variance and response to breeding as applied to the dairy industry.
OBJECTIVES:
- To outline some of the important economic traits
- Understand how quantitative genetics is applied to the dairy industry
- Introduce linear assessment

MSc UW Bangor

AIM: to enable students to develop an appreciation of breeding value and the principles of selection index in dairy breeding.
OBJECTIVES:
- Demonstrate and run ASREML on Glynllifon data
- Calculate genetic variance and parameters
- Interpret the data
- Introduce the concept of selection index

3.7. EVALUATION OF LECTURES AND MATERIALS

3.7.1. Introduction

The lectures were evaluated through a combination of quantitative and qualitative methods. Questionnaires, focus group discussions and semi-structured interviews were conducted during the evaluation process. The data resulted in non-parametric testing allowing the use of ranking and chi-square statistics. Non-parametric testing enables very specific situations to be studied, in this case one style of teaching and one specific topic within their curriculum areas. Chi-square compares the observed or actual result with the statistically expected values in order to decide whether an original hypothesis is valid (Cohen *et al.,* 2000).

3.7.2. Questionnaire

The questionnaire was designed by initially determining and planning the questions to be asked, selecting the questions, their sequence, and then attention was given to the overall layout and design (Section 3.8.4) (Leeds, 2004). Every effort was undertaken to avoid a long questionnaire. Short simple questions were used in order to increase the questionnaire response rate. Questions were designed to be relevant, appropriate and unbiased (Leeds, 2004; Studentbmj, 2004). The overall appearance of the questionnaire was considered in order to look easy, interesting and attractive (Cohen *et al.,* 2000).

Piloting the questionnaire was carried out on a small number of students, 'typical to those involved in the evaluation'. Responses were obtained using the Likert scale (Cohen *et al.* 2000; Srudentbmj, 2004). For the analysis three categories were used which included strongly disagree and disagree (SD/D); blank, undecided and not applicable (B/UD/NA); and strongly agree and agree (SA/A). A brief introductory statement was given at the top of the questionnaire (Leeds, 2004) (Appendix 1, Figure 3.16).

The questionnaires were completed and collected at the end of the lecture. They were then edited prior to analysis. The editing process involved the identification of questions with: provocative response; 'liar test' response; those with a deliberate attempt to mislead; questions that were uniform in their response; and questionnaires that were partially completed or filled in hurriedly (Cohen *et al.,* 2000).

The Self Evaluation Questionnaire (Appendix 1, Figure 3.18) involved the same mix of questions as those on the student's questionnaire, but re-phrased and asked from the lecturer's point of view. This ensured that both the questionnaires evaluated the same objectives, which were learning experience, teaching style and subsidiary issues (Figure 3.5).

3.7.3. Focus Group discussion and semi-structured interviews

It was not possible to conduct a focus group with all the groups involved in the evaluation because of practical issues such as site location and timetables. The BSc and the MSc programme level groups were on the University site and the 'Farmer's' group who had come for the day from many different areas. Focus group discussions and / or semi structured interviews were conducted with the FE groups (Section 2.11).

Confidentiality and traceability of questionnaires was maintained throughout the study, however most of the students were more than happy to see their questionnaire and explain some of the responses during the focus group. This was done under supervision as to ensure no tampering with the completed questionnaires. Semi-structured interviews were used in conjunction with focus groups to follow-up issues that needed further clarification (Cohen *et al.,* 2000). Semi-structured interviews involved the questionnaire being re-introduced on a one-to-one basis. The focus discussion group / semi structured interviews were conducted one week after the lecture due to timetabling and also allowed students the opportunity to assimilate and reflect on their experiences (Cohen *et al.,* 2000). Students' responses were transcribed verbatim for both focus group and semi-structured interviews.

3.7.4. Peer and Self-evaluation

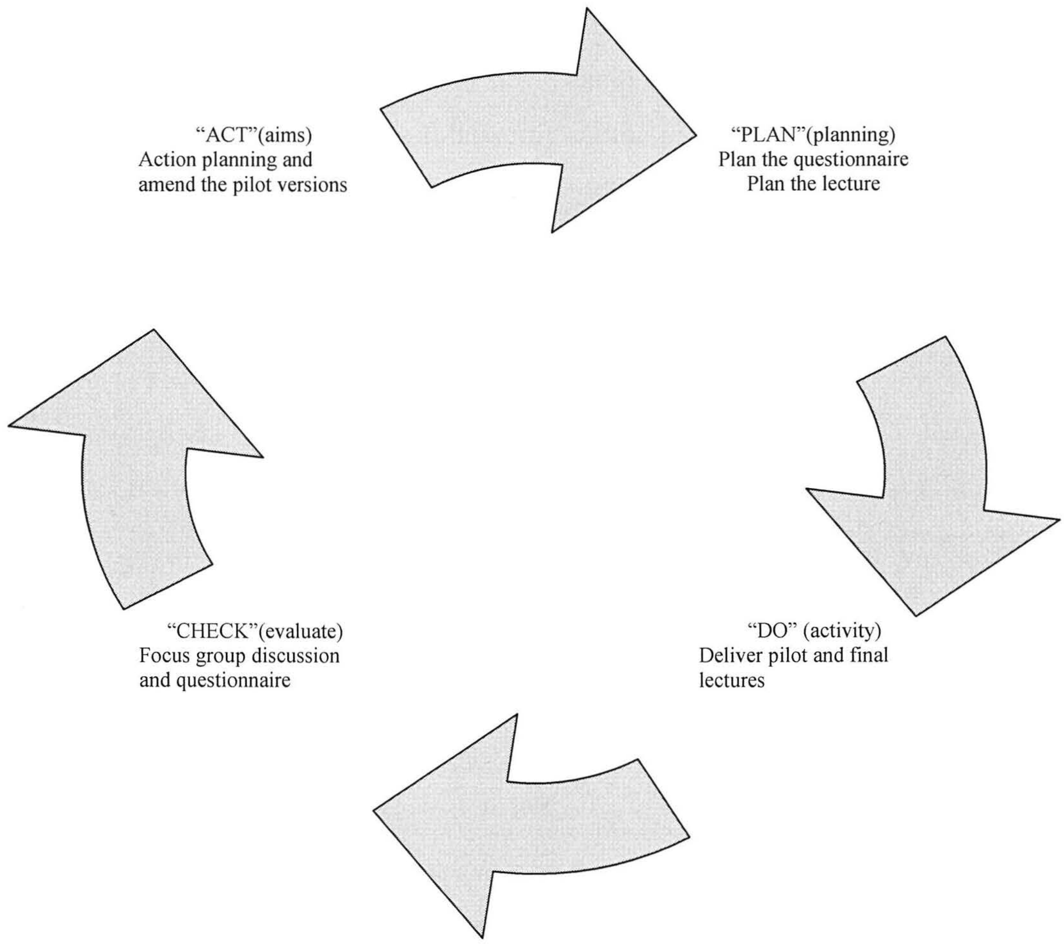
Peer evaluation involved an experienced lecturer attending a lecture. Peer and self-evaluation were carried out during the piloting of lectures (B1), where by strengths and weaknesses were identified for Action Planning (Table 6.7). Self-evaluation only was undertaken for the final version of the lectures (B2) in which a short paragraph was written at the end of each lecture together with the completion of the Self Evaluation Questionnaire as discussed in Section 3.7.2.

3.8. PILOT EVALUATION OF QUESTIONNAIRE AND LECTURES

3.8.1. Introduction

Prior to the evaluation of the lectures a questionnaire was written and piloted (Section 3.8.5). The final version of the questionnaire was then used to pilot the lectures. Then the final versions of the lectures were delivered (Section 3.9) and evaluated as to their effectiveness for teaching and learning (Section 6.4). The education evaluation procedure followed the Planning Cycle of 'plan', 'do', 'check' and 'act', the PDCA cycle, which is also sometimes referred to as the Deming Cycle or the Shewhart Cycle (Arveson, 1998; Petty, 1998) as summarised in Figure 3.3. The student numbers and groups used in the piloting of the questionnaire and lecture, as well as those involved in the final lecture evaluation are given in Table 3.7 and Table 3.8.

Figure 3.3. Summary of the main stages involved in the evaluation



Source: Petty, (1998); Arveson, (1998)

Table 3.7. Groups and timing in the evaluation process.

	Student groups												
Academic year terms	NVQ	NVQ	NVQ	NVQ	NCA	NCA	NCA	NCA	ND	HNC	HND	BSc	MSc
2001-2002 Term 3	R1	R2				R1	R2						
2002-2003 Term 1			B1		B1					B1			
2002-2003 Term 2				B2				B2	B2		B2	B2	B2
2003-2004 Term 2				B2				B2	B2		B2	B2	B2

R1 = piloting first draft of questionnaire for lectures on recording. R2 = piloting second draft of questionnaire for lectures on recording. B1= piloting breeding lectures. B2= final version of the breeding lectures.

Table 3.8. Number of students involved in piloting the questionnaire and the lectures

	NVQ			NCA			
QUESTIONNAIRE	**R1**	**R2**	**Total**	**R1**	**R2**	**Total**	**Total**
	11	8	19	7	7	14	33
	NVQ			**NCA**		**HND/C**	
LECTURES	**B1**		**Total**	**B1**	**Total**	**B1**	**Total**
	10		10	6	6	9	25

R1 = piloting first draft of questionnaire for lectures on recording. R2 = piloting second draft of questionnaire for lectures on recording. B1= piloting breeding lectures.

3.8.2. The questionnaire

The primary objective of the questionnaire was to evaluate the quality of teaching and the learning experience when using the dairy herd and data in course materials. The questionnaire was designed, piloted and amended prior the final version (Figure 3.4).

Figure 3.4. Stages and methods involved with the questionnaire (R1, R2)

Planning the questionnaire

↓

Designing the questionnaire

↓

Piloting the questionnaire

↓

Edit, analyse and amend

↓

Final draft version

3.8.3. Planning the questionnaire

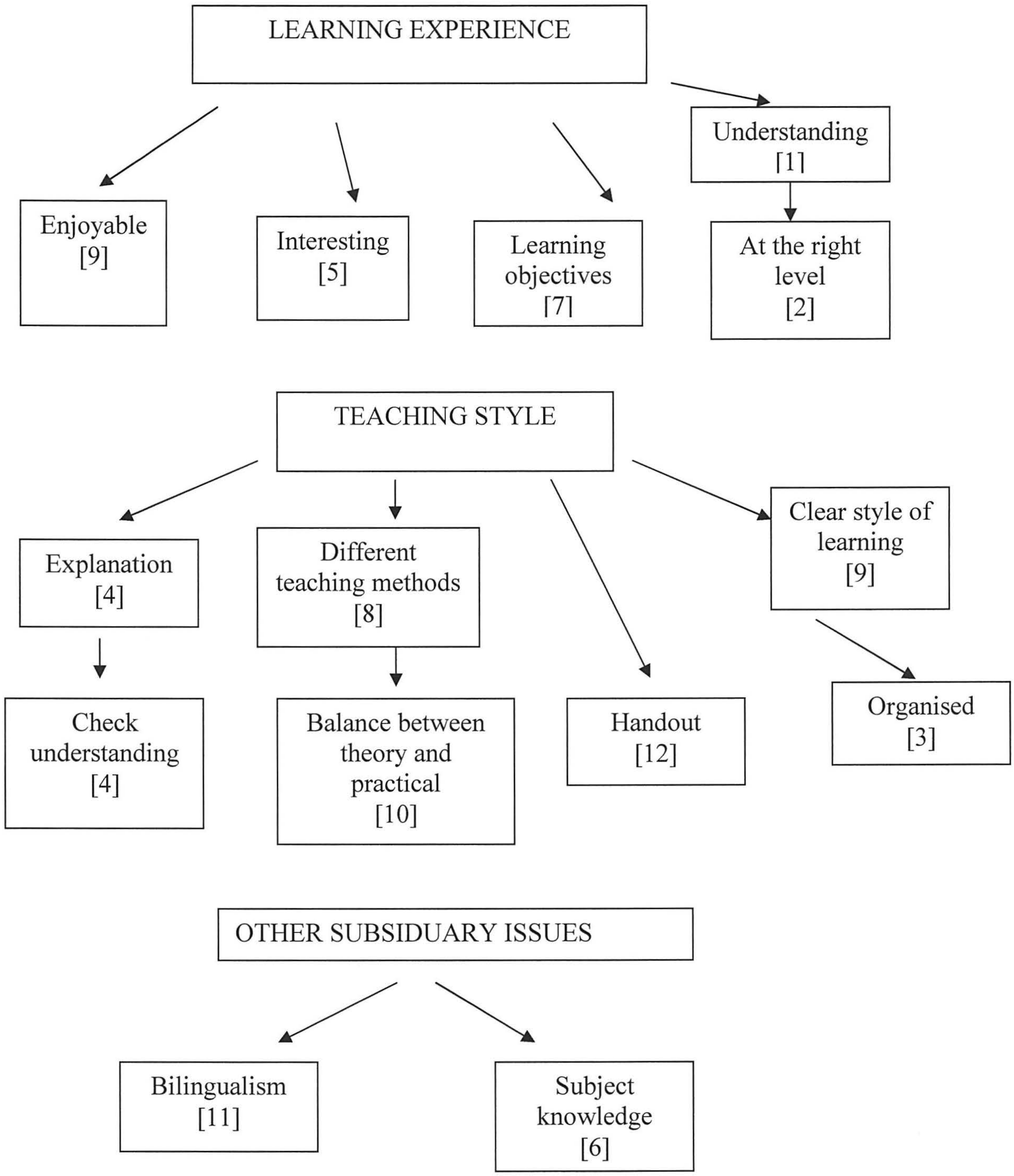
A flow chart technique was used for planning the questionnaire (Figure 3.5) (Cohen *et al.,* 2000). The three areas covered by the questionnaire were learning experience, teaching style and subsidiary issues.

3.8.4. Questionnaire design

Questions relating to the evaluation of teaching and learning were selected from existing questionnaires currently in use at Coleg Meirion Dwyfor (CMD), School of Agricultural and Forest Sciences (SAFS) and from the HMI's Common Inspection Framework 'The Criteria for Judging Standards and Quality' (HMI, 2000).

The amalgamation of questions from the three organisations' questionnaires ensured validity of the individual questions selected. However, as one questionnaire was to be used for all the programme levels, from NVQ to MSc, simplicity of design as well as clarity of wording was an important issue. Every effort was taken to see the questionnaire through the eyes of the students, by imagining how they would react to it (Cohen *et al.,* 2000).

Figure 3.5. Flow chart for planning the questionnaire



[Numbers] Refer to the question number on the questionnaire.

Table.3.9. Origin and purpose of questions used for the questionnaire.

QUESTIONS	BASE ORIGIN AND SOURCE OF THE QUESTIONS	LEARNING EXPERIENCE	TEACHING
QUESTION 1- Developing an understanding of the subject	HMI- 1.1, 2.1.1 &2.2: CMD – 12: SAFS – 6.	Did the 'Cwfmly data' help to develop a better understanding of the subject	
QUESTION 2- The lecture was at the right level	HMI – 1.2: CMD – 11.	Did using the 'Cwfmly data' enable the differentiation of the programme levels?	
QUESTION 3 - Organised lecture	CDM – 42 (course)		In using the 'Cwfmly data' had it lend itself into the lecture in a clear and organised manner?
QUESTION 4- Check understanding and explaining of ideas	HMI – 2.5.6; CMD – 26		Did the 'Cwfmly data' allow ideas to be explained better and opportunities for the lecturer to check candidate's understanding with ease?
QUESTION – 5 Kept the interest	HMI – 2.1.3; CMD – 22	Did the 'Cwfmly data' have an effect on interest and motivation?	
QUESTION – 6 Lecturer's subject knowledge	HMI – 2.3; CMD – 13		From the practical farming level to the academic field of applied science. Did it serve all of the candidates needs sufficiently?
QUESTION – 7 Learning objectives	HMI – 2.4 CMD – 21	Did the students get the message of what was to be done during the lesson using the 'Cwfmly data'?	
QUESTION – 8 Variation in teaching and learning	HMI – 2.5; CMD – 14 ;		When using 'Cwfmly data' were there more opportunities to undertake different methods of teaching?
QUESTION – 9 Clear style of learning, learning enjoyable	SAFS – 3, HMI – 2.5.4	Did using the 'Cwfmly data' make learning more enjoyable?	Clearer style of learning?
QUESTION 10 Theory and practical	HMI – 2.5.5		Did using 'Cwfmly data' allow opportunity for developing theory and practical work, passive and active?
QUESTION 11 Bilingual	HMI – 2.8		FE – to question the need of bilingual in the pilot, as learning material has not been translated and then to question the adequacy of the provision in the final lectures.
QUESTION 12 Learning resources	HMI- 7.2; SAFA – 5	Did 'Cwfmly data' provide additional learning resource?	
QUESTION 13 Identify what you liked	SAFS – 7		
QUESTION 14 Disliked	SAFS – 8		
QUESTION 15 Any other comment	SAFS – 9		

Questions 1-12 were closed response questions and Questions 13 -15 were open questions. Cwfmly = the Glynllifon Cow Family Data Set

The questions selected comprised an acquiescent set of positive statements concerning teaching and learning. Liar test response questions were also included. Closed questions were obtained from all of the three above named establishments' questionnaires. Open-ended questions were obtained from SAFS and were placed at the end of the questionnaire. Subsidiary issues, including 'bilingualism' and 'subject knowledge', were drawn from the HMI's questionnaire (Table 3.9).

The order of questions was deliberately mixed so that the questions "jumped out unexpectedly" to encourage the respondents to think about each question in isolation. Piloting of the questionnaire took place using the lower level programmes in the FE establishment during Term 3 of the academic year 2001-2002 (Table 3.8).

3.8.5. Piloting the questionnaire

Piloting the questionnaire was undertaken to ensure the practicability as well as the reliability and viability of the new mix of already validated questions. Piloting the questionnaire allowed identification of non-compliance or non-response questions, as well as providing opportunity to try the response boxes (SAFS questionnaire) for non-parametric data analysis (Cohen *et al.,* 2004).

3.8.6. Piloting and student groups

Piloting of the questionnaire took place with the lower level programmes, the NVQ (19 students) and NCA groups (14 students) within the FE establishment (Table 3.8), as it was anticipated that they would be mostly at risk when considering literacy difficulties.

The lecture 'Recording of Breeding Information for use in Selection' was used to pilot the questionnaire during Term 3, 2001-2002. This allowed time for analysing and amending the questionnaire for later use in the piloting the lectures on 'Selection and Breeding' during Term 1 of the academic year 2002-2003 (Table 3.7).

The questionnaires were completed at the end of the lecture on 'Recording' for the NVQ and NCA group, known as the R1 group. They were then edited and the results (Table 6.1) were discussed during focus group discussions. The bilingual version of the second draft was piloted for the same lecture 'Recording of Breeding Information for use in Selection' for the other NVQ and NCA group (known as the R2 group) (Table 3.8). Again the questionnaires were completed at the end of the lecture and were edited for the following week's lecture for discussion during the focus group discussion in their 'tutorial' class on the timetable.

This second draft became the final version that was used for all the programme levels within the FE and the HE Institutions.

3.8.7. Piloting the lectures

The lectures on 'Selection and Breeding' (B1) were piloted using three out of the six programme level groups during Term 1 of the academic year 2002-2003 (Table 3.8). These groups were not included in the main evaluation study. Questionnaires (those piloted in Section 3.8.5) were completed at the end of the lectures. Immediately after the lectures, self-evaluation and peer evaluations were written up and discussed.

The B1 lecture contained the objectives as found in Figure 3.2 in addition to those edited in Appendix 1. The lectures were in English and had not been translated. They were delivered at the FE institute.

Figure 3.6. Stages and methods involved in the piloting of lectures (B1)

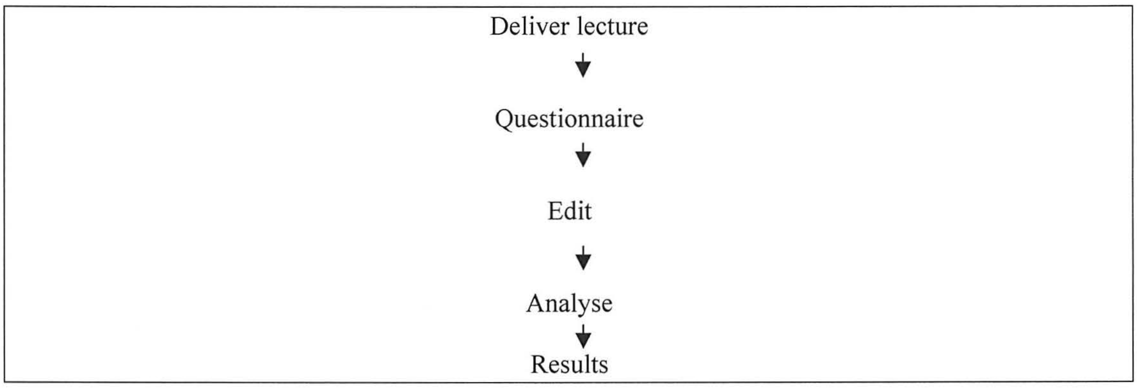
Syllabus/Awarding body requirements
↓
Lesson planning
↓
Pilot the lectures
↓
Edit, analyse and amend
↓
Final draft version (B2)

The questionnaire (piloted in Section 3.7.2) was used as well as focus group discussion (Section 3.7.3) and self and peer evaluation. Self-evaluation notes were completed at the end of each piloted lecture. Peer evaluation was undertaken for piloting the lectures for the NVQ, NCA and HND (Section 3.7.4). The lessons strengths and weaknesses were recorded (Section 6.3.4).

3.8.8. Action planning

An action plan was written (Section 6.3.4) and all the action points were implemented into all the lectures of FE and HE programmes. They were to be the final version for the evaluation (noted as B2 in Table 3.7). They were delivered and evaluated during the academic years of 2002 to 2004.

Figure 3.7. Stages and methods involved in the evaluation of the lectures (B2)



3.8.9. Lesson Plan

All lectures were broken down into three main sections, the introduction, body and conclusion. The introduction and conclusion occupied 20% of the time while the central part took 80% of the remaining time, involving three outcomes (Curzon, 1999) (Section 2.10.2). The introduction allowed an opportunity to discuss the lesson's objectives and their importance in the context of practice within the dairy industry. The introduction contributed to the motivational aspect and purposefulness of the lecture. During the introduction opportunities were taken to assess students' understanding and experience within animal production and dairying. Following the main body of the lesson, the lesson's conclusion allowed an opportunity to assess the extent to which understanding and learning had taken place. Information for further reading was also provided (Figure 3.8).

Figure 3.8. All groups' lesson plan for Introduction and Conclusion

TITLE	Subtitle	Resources	Time (min)	Interaction	Teaching Method
INTRODUCTION	Discuss objectives and state why they are important to the farmer and of relevant to the industry	Overhead projector (OHP) or Interactive White Board (IWB)	10	Class discussion to measure student's experience and understanding	Passive and / or Active
CONCLUSION	End of task summary, discussion and questions. Further reading -where to get more information	Handout with questions to be answered OHP or IWB	10	Complete end of class questions	Active Passive

For full version of exercises, handouts and worksheet see Appendix 1

Gapped handouts, worksheets and visual aids were used during the main body of the lesson. Discussions at the end of activities / exercises were encouraged. Questions were also asked at strategic points during the entire lesson to foster and evaluate learning (Curzon, 1999).

3.9. THE LECTURES' PLANS AND CONTENTS

3.9.1. Introduction

Based on each lesson's aims and objectives (Figure 3.2), lessons contained real live herd data (Section 3.2) and were written using pedagogical and andregogical principles (Section 2.9.1). The MSc programme was delivered at SAFS, UCW Bangor in which full use was made of all the herd records, including the 50 years of past and current lactation records (Figure 3.14). The NVQ, NCA, ND, and BSc made use of the last lactation data set records combined with 'farm activity' using cows currently in the herd (Figure 3.9, 3.10, 3.11 and 3.13). The HND (Figure 3.12)) used 10 years of the National Milk Recording (NMR) computerised version of the herd's records.

3.9.2. The NVQ Course Material

Gapped handouts were prepared to explain breeding programmes and dairy traits. Two farm practical activities worksheets were used to introduce dairy trait and linear assessment. Questions were used at the end of class to revise and summarise the lecture (Figure 3.9). For the more able students a supplementary exercise was prepared (Appendix 1).

Figure 3.9. NVQ Livestock Production Level 2

TITLE	Subtitle	Resources	Time (min)	Interaction	Teaching Method
DAIRY BREEDING AND SELECTION	Breeding and Selection; Breeding programme; and dairy traits	Gapped handout 1 (also on OHP or IWB)	20	Explain, discuss and fill in the blanks on the handout in class	Active
	Good and bad dairy traits	Farm Worksheet 1	20	Farm class exercise with discussion at the end	Active
	Linear Assessment	Farm Worksheet 2 Linear Assessment and handout	30	Small group discussion followed by whole class discussion	Active

For full version of exercises, handouts and worksheet see Appendix1

3.9.3. The NCA Course Material

Gapped handouts on breeding programmes and dairy traits were used followed by a worksheet for completion on the farm. The two farm activities were linear assessment followed by the use of lactation information and farm record cards to select breeding cows. The end of class exercise involved the construction of a breeding programme (Figure 3.10.) and a supplementary exercise was included (Appendix 1).

Figure 3.10. National Certificate in Agriculture (NCA)

TITLE	Subtitle	Resources	Time (min)	Interaction	Teaching Method
DAIRY BREEDING AND SELECTION	Dairy traits and breeding programme	Gapped handout 1	20	Explain discuss and complete exercise	Active
	Selection from farm records	Worksheet 1 Farm record cards	30		
	Linear assessment	Worksheet 2 Handout	30		

For full version of exercises, handouts and worksheet see Appendix 1

3.9.4. The ND Course Material

Methods of selection and terminology used in dairy genetics were introduced using gapped handouts. Two worksheets were prepared for use on the farm, linear assessment and animal selection (Figure 3.11). Sire selection was discussed and used as a supplementary exercise (Appendix 1).

Figure 3.11. National Diploma in Agriculture (ND)

TITLE	Subtitle	Resources	Time (min)	Interaction	Teaching Method
DAIRY BREEDING AND SELECTION	Selection method and terminology	Gapped handout 1 (on OHP or IWB)	20	Explain discuss and exercise	Active
	Linear Assessment	Worksheet 1 Linear Assessment and handout	30	Small group discussion followed by whole class discussion	Active
	Dairy cow and sire selection	FARM Worksheet 2 Bull catalogue	20	Farm class exercise with explanation at the end	Active

For full version of exercises, handouts and worksheet see Appendix 1

3.9.5. The HND/C Course Material

Gapped handouts and Powerpoint presentations were used to introduce terminology used in dairy cow selection. The activity included using the NMR Impel-pro software to write a 'Farm Report'. Dairy breeding values and selection index databases had to be created in order to complete the report involving four short exercises (Figure 3.12). A supplementary exercise was included for the more able students (Appendix 1).

Figure 3.12. Higher National Diploma / Certificate (HND/C)

TITLE	Subtitle	Resources	Time (min)	Interaction	Teaching Method
DAIRY BREEDING AND SELECTION	Selection and Dairy cow breeding	Gapped handout 1 (also on OHP or IWB)	10	Explain and discuss	Active
	Computer Imple-pro Introduction	Gapped handout 2 and Worksheet 1	20	Explain and discuss	Active
	Terminology in dairy selection	Exercise 1, Exercise 2, and Exercise 3 and Exercise 4	40	Small group discussion followed by whole class discussion	Active

For full version of exercises, handouts and worksheet see Appendix 1

3.9.6. The BSc Course Material

The BSc group consisted of a diverse group of students with a range of understanding and experience. Supplementary gapped handouts were available as well as additional notes and a Powerpoint presentation (Appendix 1). The lesson plan was flexible, making it possible to describe basic principles of dairying for ensuring understanding and learning. The course material included farm practical activities and supplementary exercise (Figure 3.13) and (Appendix1).

Figure 3.13. BSc UW Bangor

TITLE	Subtitle	Resources	Time (min)	Interaction	Teaching Method
DAIRY BREEDING AND SELECTION	Dairy traits and breeding policy / programme	Handout 1 (also on OHP or IWB)	30	Explanation and discussion	Active
	Quantitative genetics	Handout 2 and 3 (also on OHP or IWB)			
	Terminology in dairy selection	Handout 3 (also on OHP and IWB)			
	Linear Assessment	Worksheet 1 Farm Activity	40	On farm	Active
	Selection of dairy animals	Worksheet 2		In class	

For full version of exercises, handouts and worksheet see Appendix 1

3.9.7. The MSc Course Material

The MSc group also included additional material in preparation for a diverse group of students. The main educational activity for this lecture involved completing two exercises using the ASREML programme (Section 3.8) (Figure 3.14). Powerpoint presentations were used to cover the basic principles of quantitative genetics (Appendix 1).

Figure 3.14. MSc UW Bangor

TITLE	Subtitle	Resources	Time (min)	Interaction	Teaching Method
DAIRY BREEDING AND SELECTION	Quantitative genetics and selection Index	Power Point Presentation (1-6)	20	Explain and discuss	Active
	ASREML	Presentation Gapped handout Worksheet Exercise 1 Exercise 2	40	Possibly split into two groups followed by whole class discussion	Active
	Selection index	Power point presentation	10		Passive

For full version of exercises, handouts and worksheet see Appendix 1

3.9.8. The farmers group

The farmers group included the NCA, ND and HND lectures (Figure 3.15). These lectures were therefore used and evaluated as for the NCA, ND and HND groups outlined above. It was decided to evaluate these as a group representing "farmers" (accepting that they received different types of lecture materials) rather than combining the farmer groups with the corresponding student groups based on lecture material.

Figure 3.15. The farmers' groups

Group description	Lecture materials used
Prospective agricultural school groups	NCA lectures
Young Farmers Clubs	ND lectures
Visiting groups (farmers)	HND lectures

CHAPTER 4

ANALYSIS OF PHYSICAL, PRODUCTION AND FUNCTIONAL TRAITS

4.1. INTRODUCTION

Herd size and production have increased over time within the UK dairy industry (Chapter 1 and Section 2.3.1, Table 2.2). Production traits including milk, fat and protein are important breeding objectives and contribute to the profitability of the dairy enterprise. Production traits are influenced by environmental factors, such as feeding, health, lactation number and season. Milk yield, fat and protein are moderately heritable, highly repeatable and respond well to selection (Willis, 1998).

It is now considered that the overall economic efficiency of the dairy enterprise involves incorporating traits other than those of production (Abdallab and Mc Daniel, 2000). These traits are known as functional traits, and include longevity, udder health and fertility (Kuhn *et al.,* 2003) (Section 2.4.). Functional traits relate to sustainable production, health and animal welfare of the dairy cow (Holstein-UK, 2004). It is possible to select for milk production traits without adverse effect on functional traits (Berry *et al.,* 2003). In the UK there has been a lack of data for these traits as they have not been routinely recorded compared to other countries such as the Scandinavian countries (Pryce *et al.,* 2002; Kadarmideen and Wegmann (2003). Breeding objectives and selection indexes within the UK dairy industry are now broadening to include traits other than production traits (MDC, 2004b).

This chapter will study the physical trends of the Glynllifon herd data, as well as the production and functional traits of the herd. The physical trends include looking at the herd size and its establishment, family lines and sires, progeny details, age and seasonality of calving (Section 4.3.1). Production traits included milk yield, fat yield and protein yield and their composition. These were studied over time and parity (Section 4.3.3). Functional traits used in this study include longevity (lactation number, days of productive life and lifespan), SCC, calving interval, lactation length and days dry (Section 4.3.5).

The aim of this chapter is to establish the validity of single herd data, as a representation of a typical UK dairy herd. Physical trends, production and functional traits were all compared to those of national standard data within the UK dairy industry. This provided the opportunity to assess the suitability of the data set for its inclusion within lectures at FE and HE institutions (Chapter 6).

4.2. MATERALS AND METHODS

4.2.1. Source of data

The data set used in the analysis of production traits was obtained from the Glynllifon dairy herd from 1950 to 2000 (Section 3.3.). The National Milk Recording Scheme (NMR) was involved with the lactation records details, maintaining continuity throughout the data set as well as ensuring authenticity and reliability (Section 3.2.3).

4.2.2. The data set

Prior to analysis, data sets were created for the traits to be studied, based on the data set as discussed in Section 3.3. These data sets are discussed below.

4.2.3. Size and structure of the dairy herd

The size and structure of the dairy herd were studied using all the retrieved records, which included 4,035 lactation records for 976 cows (Table 3.1), with the exception of seasonality of calving as discussed in Section 4.2.3.5.

4.2.3.1. Milk yield and fat yield, Lactation length, Days Dry and Calving Interval

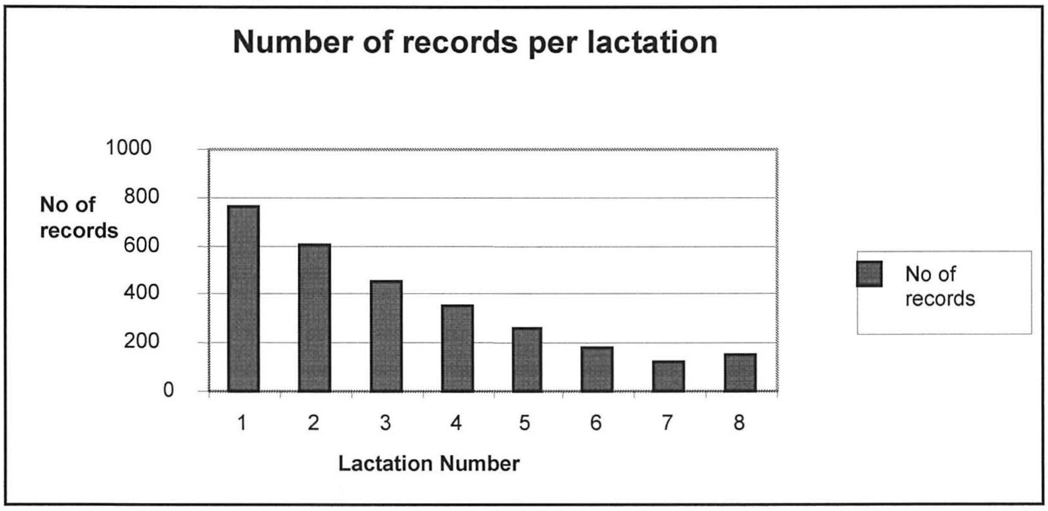
The data size used in the analysis of milk and milk fat as well as the functional traits lactation length, days dry and calving interval involved the full data set as discussed in Section 3.5. Data included 2,881 lactation records for 763 cows (Table 4.1). The lowest number of records was found in the 1950s and the largest number was found in the 1980s. The proportion of first lactation records to all other records was 26% as summarised in Table 4.1. The number of records for these traits declined with increasing parity as seen in Figure 4.1.

Table 4.1. Milk yield and milk fat data set analysis for lactation class

YEARS	LACTATION LA	L1		L>1	
	TOTAL No. (%)	No.	%	No.	%
1990s	670 (23)	191	28	479	72
1980s	996 (35)	232	23	764	77
1970s	736 (26)	194	26	542	74
1960s	417 (14)	129	31	288	69
1950s	62 (2)	17	27	45	73
Total	2881	763	26	2118	74

L1= First Lactation; LA=All Lactations; and L>1= All Lactations over 1.

Figure 4.1. The number of records per lactation (milk yield and milk fat, lactation length, days dry and calving interval data set)



4.2.3.2. Milk Protein

The lactation records prior to 1972 which had no protein data came to a total of 593 records (20%) as seen in Table 4.2. The distribution of observations is found in Table 4.3.

Table 4.2. Data editing for milk protein analysis

Description	Number	Percentage (%)	Number of records
Initial amount of data			2,881*
No protein records	593	20	
Total protein records			2,288

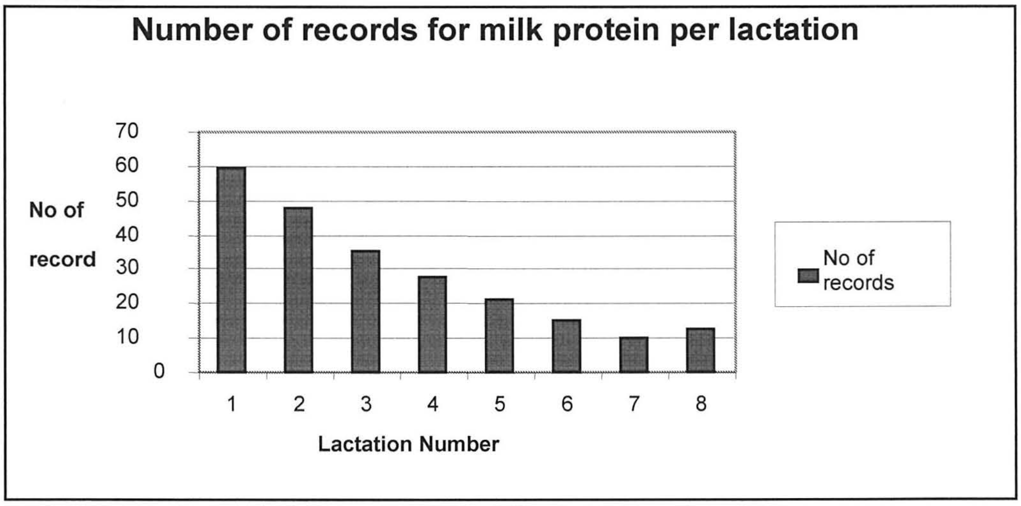
*see Table 3.1. Section 3.3 for edits prior to the 'initial amount of data' (2,881)

Table 4.3. The number and percentage of records for the protein data set per decade

	1990s	1980s	1970s
No of records	670	996	622
% of records	29	44	27

The data set for the protein analysis included three decades of data from the 1970s to the beginning of the 2000s. The numbers of records were found to be higher for 1980s, having 44% of the records with the other two decades of 1970s and 1990s having 27% and 29% respectively (Table 4.3). With each increase in parity the number of records decrease as seen in Figure 4.2.

Figure 4.2. The number and percentage of records for the protein data set per lactation



4.2.3.3. Somatic Cell Count

The analysis of Somatic Cell Count (SCC) was not undertaken nationally in the UK at the start of the data set. From 1995 to 2000, the total amount of lactation records with SCC data was 507 for 91 cows. Similar numbers of lactation records were found for all the six years, as seen in Table 4.4.

Table 4.4. Size of the data set for year of production for SCC analysis

Year of Production	1995	1996	1997	1998	1999	2000	Total
No records	89	92	82	84	74	86	507
L1 (%)	24	26	25	26	25	24	

L1 = Percentage of records in First Lactation

4.2.3.4. Longevity

The potential data set for longevity analysis could have been 2881 lactation records (Table 4.5). However, not all the cows in the data set had completed their productive life in the herd. Cows that were currently milking in the herd and were unlikely to be sold or culled during 2000 could not be included in the data set. On the 1st of March 2000, 108 cows were to be retained in the herd and were not going to be selectively culled (Jones A, personal communication 2000).

Table 4.5. Number of animals in the longevity data set

Description of edit	No records	Number of cows
Total number of records	2,881*	
Total number of cows		763
Less cows currently in the herd	292	108
Total number	2,589	655

*see Table 3.1. Section 3.3 for edits prior to the 'initial amount of data' (2,881)

4.2.3.5. Seasonality of calving

Of the total lactation records (4,035) retrieved for the 976 cows, it was found that 444 lactation records had incorrect or missing calving dates that could not be confirmed with the Breed Herd Books. Also 94 records were illegible and damaged and 17 lactation records were from the 1940s. In total 3,591 (89%) lactation records were used to study the seasonality of calving (Table 4.6.).

Table 4.6. Number of animals in the seasonality of calving data set

Description of edit	No records used	Edited records
Total number of records retrieved	4,035	
Missing date of birth and calving date		70
Incorrect date of birth and calving date		263
Less illegible and damaged records		94
Less records in the 1940s		17
Total number of records edited from the analysis		444
Total number of records in the data set for analysis	3,591	

4.2.4. Definitions used in the analysis

4.2.4.1. Longevity variables

Lifetime variables used in the analysis of longevity included lactation numbers. Lactation number was defined by Brotherstone *et al.* (1997) as 'the number of lactations an animal completes prior to culling'. Last uncompleted lactations did not qualify for inclusion in the analysis. It was the last completed natural (>305days) or standard lactation (305days) that were used for the analysis. Lifespan was calculated from the animal's date of birth to the last day in the herd. Days of productive life (DPL) was measured as the 'interval between first calving and last day of the final lactation' as defined by Perez-Cabal and Alenda (2002).

4.2.4.2. Seasonality of Production

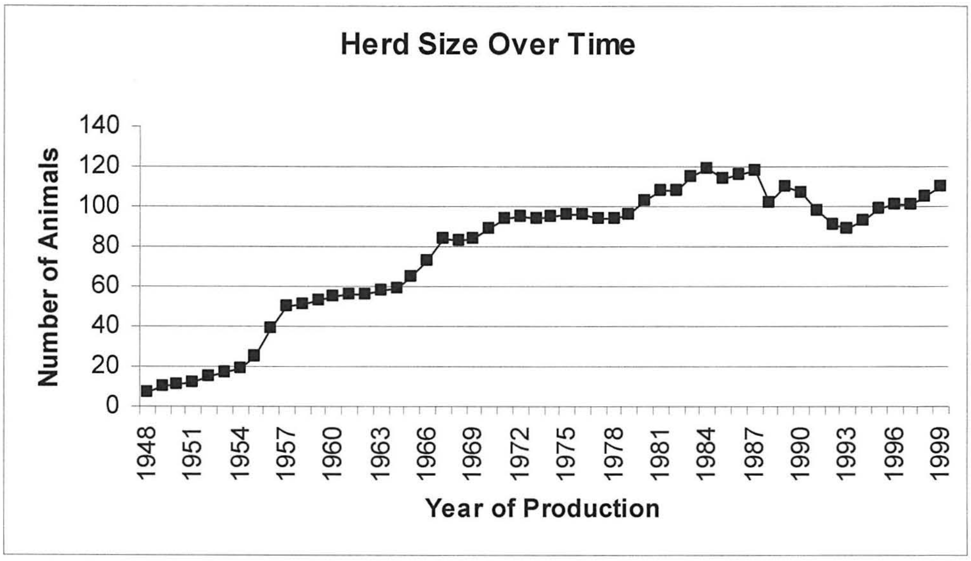
The calendar year was split into three main seasons: 'Season 1' included the winter months of November, December, January and February; 'Season 2' included the spring and early summer months of March, April, May and June; and 'Season 3' included the late summer and autumn months of July, August, September and October.

4.3. RESULTS

4.3.1. Herd size and breeding structure

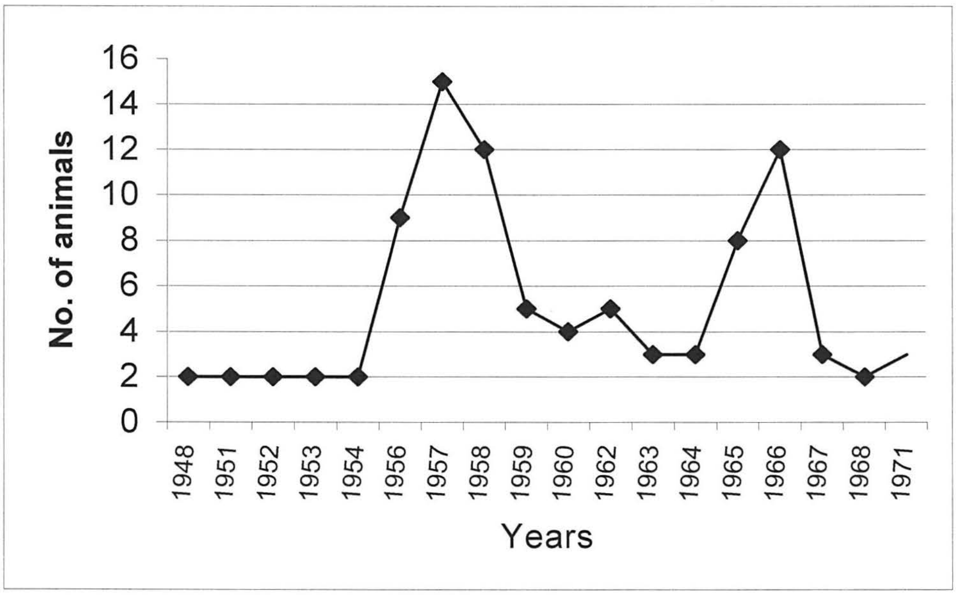
An increase in the herd cow numbers occurred from the late 1940s to the mid 1980s (Figure 4.3(a)). Thereafter the herd size levelled off and decreased slightly following the peak of 119 milking cows in 1984. The increase in herd size was attained by purchase of cows into the herd during the late 1940s until the late 1960s (Figure 4.3(b)). The last dairy cow to be purchased into the dairy herd was in 1968. From the 1970s to the present day, increasing as well as maintaining herd size has relied on heifer replacements within a closed herd.

Figure 4.3. (a). Number of cows in the herd over time



*Number of cows completing lactation per annum

Figure 4.3. (b). The number of animals purchased into the herd annually



The number of animals purchased into the herd during the 20 year period from the late 1940s to the late 1960s was a total of 94 milking cows. The purchasing of breeding stock peaked in the late 1950s and the late 1960s (Figure 4.3(b)). Animals purchased into the herd had full pedigree registration details, and came from well-known pedigree herds throughout England and Wales (Table 4.7).

Table 4.7. Pedigree registered herds from which cows were purchased (1943 – 1969)

PREFIXES FROM ENGLAND	PERCENTAGE OF COWS (%)	PREFIXES FROM WALES	PERCENTAGE OF COWS (%)
ALVIN	2	BANGOR	6
BOOTHURST	4	CEINT	2
BRYNTON	2	CYMYRAN	4
CALCOURT	8	GWYLFA	11
DALESEND	6	PANTYDERI	2
GLANY	4	TERWYFA	4
HERENBROOK	2	TREUDDYN	2
HUNDAY	4	THIRLMERE	6
LAVENHAM	6	WARMINGHAM	2
REDMOSS	4	WESTSTONE	4
STANBURY	2	YSBYTY	11

Of the animals that were purchased into the herd (94 cows), the arithmetic average was 2.13 lactations, ranging between first lactation heifers (65%) to a mature cow in her 10th lactation. Purchased cows had a mean productive life in the herd of 3.78 years. The number of female offspring produced and retained per cow ranged from 0 to a maximum of 7 (Table 4.8).

Table 4.8. Descriptive statistics for cows purchased into the herd

Descriptive statistics	Years In herd	Purchased at lactation No.	No. of Offspring	No. in family
Mean	3.78	2.13	1.48	12.12
Standard Deviation	3.18	2.11	1.59	21.40
Minimum	1.00	1.00	0.00	1.00
Maximum	12.44	10.00	7.00	130.00

The ninety four cows purchased into the herd between the years of 1948 and 1968 came from 79 different cow family lines. All the cows that are currently in the herd at the time of writing can be traced back to 17 of these 79 cow family lines. The most common cow families in the herd in 2000 (Table 4.9) were 'Lydia' and 'Rowena', each with 20 and 30 cows in the herd respectively. Both cows entered the herd during the 1950s.

Table 4.9. Cow Families in 2000

Cow familiy	No of cows	Herd prefix	Enter date
Zillia	9	**Calcourts**	1963
Cutie	6	**Calcourts**	1968
Lydia	20	**Unknown**	1957
Herebelle	7	**Brynton**	1957
Nancy	5	**Alvin**	1956
Tourch	6	**Calcourts**	1968
Rowena	30	**Redmoss**	1958
Pride	4	**Unknown**	1957
Grandeyes	3	**Pantyderi**	1962
Columbine	4	**Unknown**	1966
Amity	3	**Treuddyn**	1958
Maud	3	**Unknown**	1956
Blodwen	2	**Pantyderi**	1960
Viola	4	**Unknown**	1966
Dunly	6	**Weststone**	1957
Petula	4	**Unknown**	1965
Ffiona	2	**Bangor**	1959

Unknown = Unregistered herds

The most common herd prefix within the data set were 'Bangor', 'Boothurst', 'Cymerau', 'Hunday','Pantyderi' and Terwynfa'. It can be concluded that the Glynllifon herd has been founded on 22 pedigree registered herds from England and Wales, 8 of which were in the herd in 2000.

Of the cows that were purchased into the herd, 78% produced males or female offspring that were not retained as replacements and consequently the female pedigree lines disappeared. All the cows in the herd at 2000 could be traced to their ancestors who were purchased during the period 1948 - 1968.

From 1950 to 2000 a total of 226 sires were used within the data set. As seen in Table 4.10 this resulted in 4.8 cows per sire and a mean of 18 lactations per sire. Full pedigree details were known for 178 of the sires who came from 132 different Pedigree Registered Herds. The herd prefix for some of the sires were the same as those found for the dairy cows (Table 4.7).

Table 4.10. Daughters and lactations per sire

Descriptive Statistics	Daughters /sire	Lactations /sire
Mean	4.8	17.85
Standard Deviation	7.59	26.70
Minimum	1	1
Maximum	46	166

Glynllifon bred their own bull, which sired 39 cows in the herd between 1962 and 1966; contributing to 122 lactations or 4% of the data set. A selection of different bulls was used during the 1970s and the 1980s. Some sires appeared once in the data set while others appeared over a period of time. Within the data set the most 'common' bull was 'Bierspool At Last', who sired cows between 1966 and 1969 (Table 4.11).

Table 4.11. List of the most common sire used within each decade of the data set

Pedigree name as used on the lactation records	Abbreviations used in the data set	Time range	No of daughters	% of cows	No of lactations	% of lactations
Boothurst brigand	Btb	1958-1968	44	5	140	4
Glynllifon prince constantijn	Gnpc	1962-1966	39	4	122	4
Bierspool at last	Blal	1966-1969	46	5	166	5
Holmland adema	Hdaa	1971-1975	25	3	94	3
Rhosithel nordema	Rhln	1973-1982	33	4	117	3
Grove speculator	Ges	1980-1984	29	3	112	3
Springbird dewmack/sprdewm	Sdd	1981-1988	27	3	76	2
Hol-steins omar	Omar	1992-1995	17	2	38	1
Etazon labelle	Labelle	1995-1996	18	2	21	1

4.3.2. Herd breeding structure

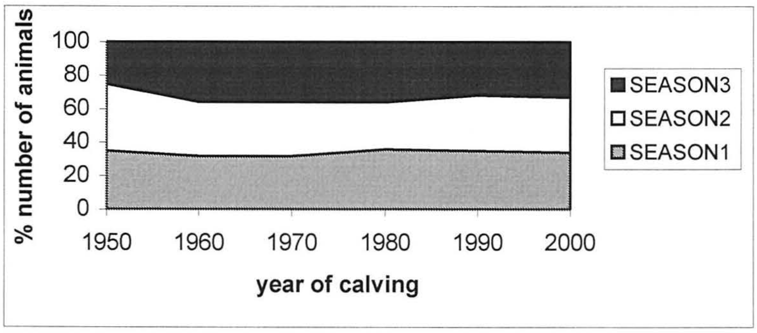
The Glynllifon herd produced animals as replacements for the heifer enterprise and the beef enterprise. Equal numbers of male and female calves were born, the mortality rate was 10%, and 3% of calves were born as twins (Table 4.12.).

Table 4.12. The number, gender and details of progeny for the data set

Animal description	Percentage of animals
Dead	10%
Female Calf	41 %
Male Calf	41%
Twins	3%
No records/blank	6%

The year was divided into three seasons as discussed in Section 4.3.2. Late summer autumn calving was at it lowest in the 1950s then from the 1970s onwards calving occurred in all three seasons representing a typical all year round calving herd as seen in Figure 4.4.

Figure 4.4. Dairy herd season of calving (all lactations)



Season 1 (N,D,J,F); Season 2 (M,A,M,J); Season 3 (J,A,S,O) see Section 4.3.2.

Age at first calving throughout the 1950s to the 1980s had a mean value of 30 months and increased to 33months during the 1990s as seen in Table 4.13. Minimum values at 18 and 19 months were found in 1950s and 1970s respectively and maximum values were found at 47 months in 1990s and 48 months in 1980s.

Table 4.13. Age at first calving (months)

Year	Lactation	Mean	Minimum	Maximum	SD	CV
1990s	L1	33	23	47	3.13	9.57
1980s	L1	30	24	48	3.21	10.73
1970s	L1	30	19	40	3.17	10.64
1960s	L1	30	24	43	2.97	9.86
1950s	L1	30	18	40	4.87	16.03

Animals in their first lactation made up 26% of the herd and had an overall average age of 30 months. The percentage number of lactations decreased and age at calving increased for each lactation number as seen in Table 4.14.

Table 4.14. Lactation number and age

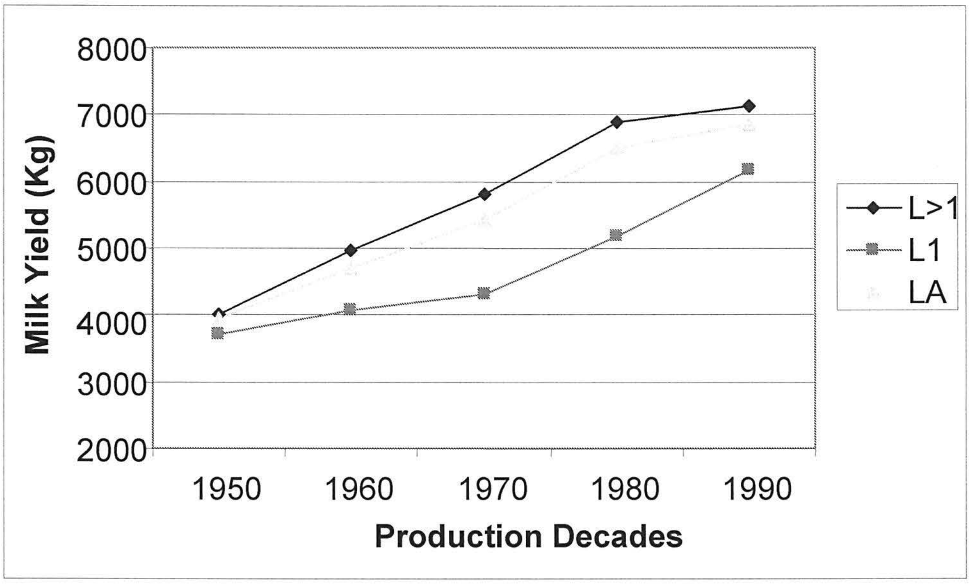
Lactation number	% of lactations	Min	Max	Average (months)
1	26	18	48	30
2	21	31	60	42
3	16	43	73	54
4	12	55	86	66
5	8	66	101	79
6	6	78	120	91
7	4	91	133	103
8>	6	104	186	147

4.3.3. Production traits over time

Milk yield

Milk yield increased from the 1950s to the 1990s for all lactation classes (Figure 4.5.)

Figure 4.5. Mean milk yield over time



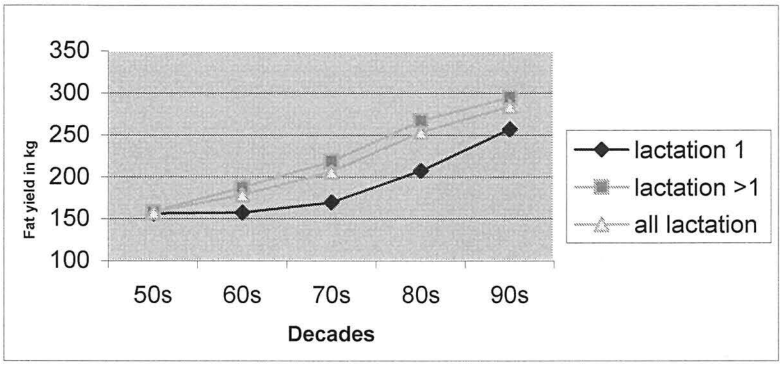
Lactation classes: L1=Lactation 1; L>1=Lactation over one; and AL=All lactation (parity 1 to 8)

The minimum yield was found in the 1950s for all lactation classes and the maximum yield in the 1980s and 1990s at 11,762kg and 11,747kg respectively. Standard deviation ranged between 819 and 1669 and coefficient of variation (%) ranged from 15 to 28. Higher values were found in the earlier years of the data set as seen in Appendix 2, Table 4.18. The regression of mean milk yield by year was significant ($P< 0.05$) and milk yield increased by 79 kg/year for 'all lactations' within the whole data set from 1950 to 2000.

Fat yield and content

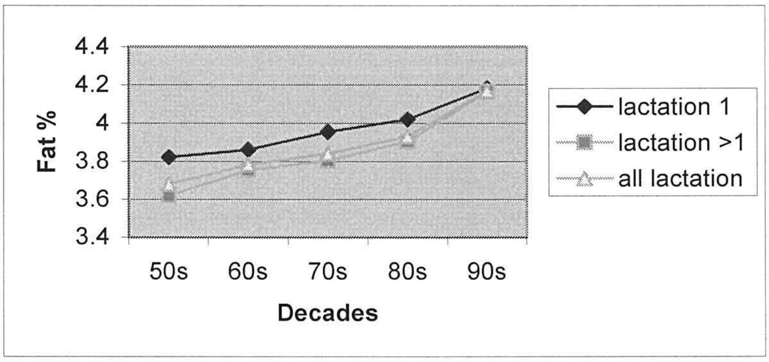
From the 1950s to the 1990s both fat yield (kg) and percentage (%) increased as seen in Figure 4.6 and 4.7 respectively in all lactation classes. 'Lactation >1' displayed higher levels for milk fat yield in all years followed by 'all lactations' and 'lactation 1'. In contrast milk fat composition showed higher mean values for 'lactation 1' throughout the 1950s to the 1980s whereas in the 1990s all lactation classes were almost at the same level.

Figure 4.6. Mean yield of milk fat over time



Lactation classes: L1=Lactation 1; L>1=Lactation over one; and AL=All lactation (parity 1 to 8)

Figure 4.7. Mean percentage of milk fat over time



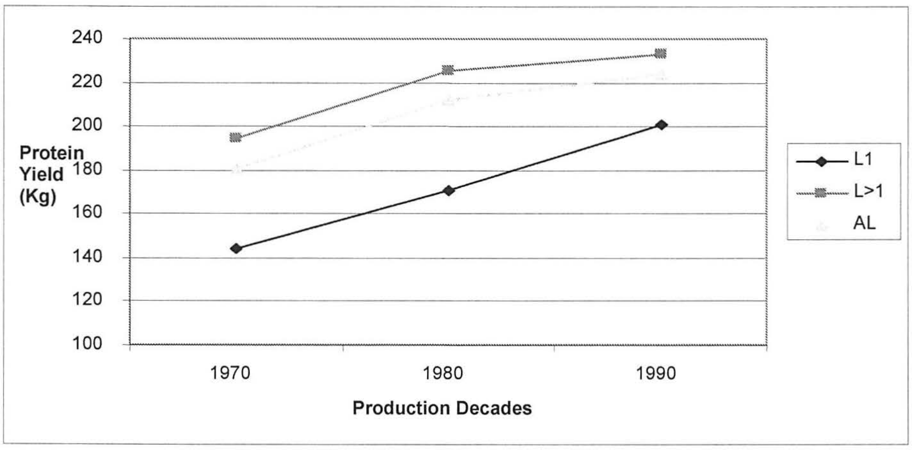
Lactation classes: L1=Lactation 1; L>1=Lactation over one; and AL=All lactation (parity 1 to 8)

The minimum value of milk fat concentration was found in the 1950s at 2.27% for 'all lactation' and the maximum value of 5.5% in the 1960s. Standard deviation ranged between 0.39 and 0.52 and generally decreased with time for 'all lactations', and coefficient of variation (CV%) ranged between 10 and 14 and decreased with time (Appendix 2, Table 4.19). Similar trends were also found for fat yield (Table 4.20 Appendix 2). The regression of mean fat yield and composition by year were significant (both $P < 0.05$). Fat yield increased by 3.87 kg / year and fat composition increased by 0.013 % / year.

Protein yield and content

As seen from Figure 4.8 mean yield of protein increased over time. The first lactating (L1) animals had lower values to those of higher lactation numbers (L>1).

Figure 4.8. Mean yield of milk protein over time

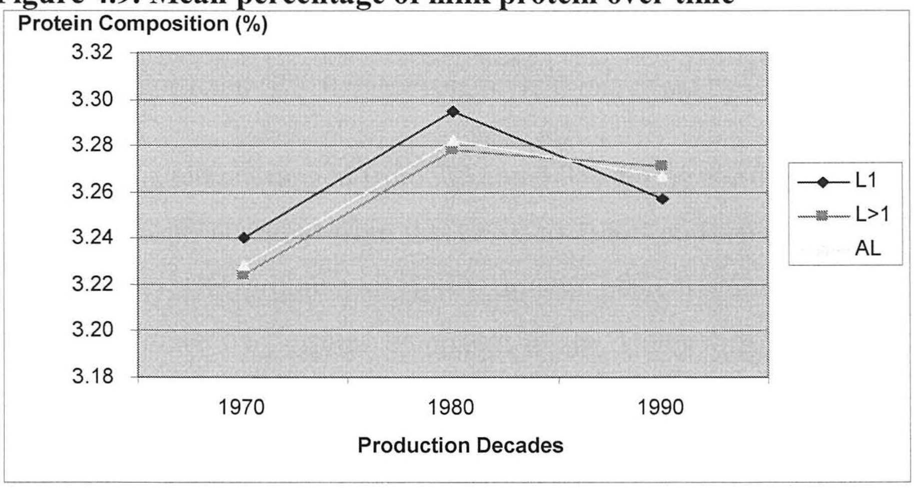


Lactation classes: L1=Lactation 1; L>1=Lactation over one; and AL=All lactation (parity 1 to 8)

Descriptive statistics on protein yield shows an increase over time in all lactation groups (Appendix 2, Table 4.21) Standard deviations and coefficient of variation (CV%) were slightly higher for the 1970s. The regression of mean protein yield by year was significant ($P < 0.05$). Protein yield increased by 2.28 kg / year.

Milk protein percent ranged from 3.2 and 3.3% during the three decades (Figure 4.9). Protein percent increased from the 1970s to 1980s and then decreased by the 1990s. Interestingly 'L1' group had higher protein percent during the 1970s and 1980s relative to other two groups compared to the 1990s where they had lowest mean group value. Both the standard deviation and the coefficient of variation (CV%) showed an increase from 1970s to the 1990s. No significant change in protein percent was found over time ($P>0.05$).

Figure 4.9. Mean percentage of milk protein over time



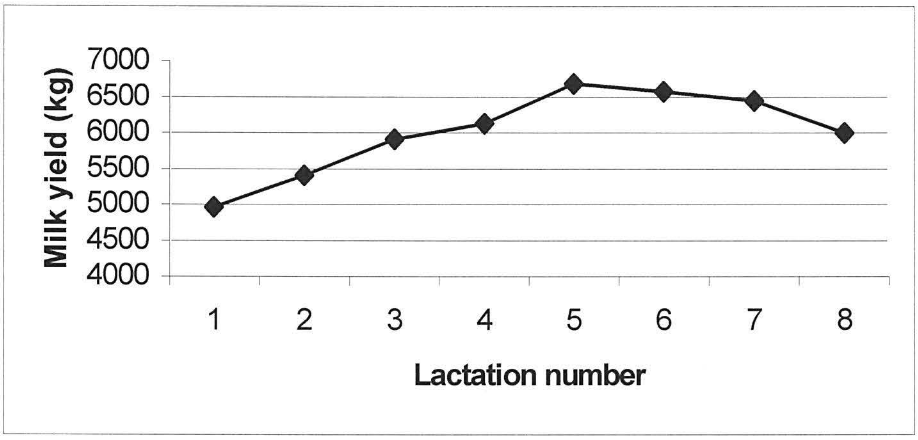
Lactation classes: L1=Lactation 1; L>1=Lactation over one; and AL=All lactation (parity 1 to 8)

4.3.4. Production traits by parity

Milk yield

Milk yield increased with lactation number to reach a peak of 6,524kg at lactation 5.7 and declined thereafter as seen in Figure 4.10.

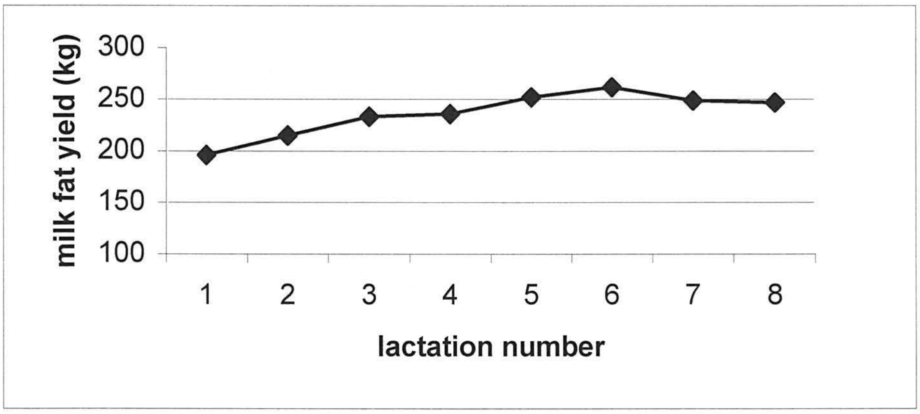
Figure 4.10. Milk yield and lactation number



Milk fat

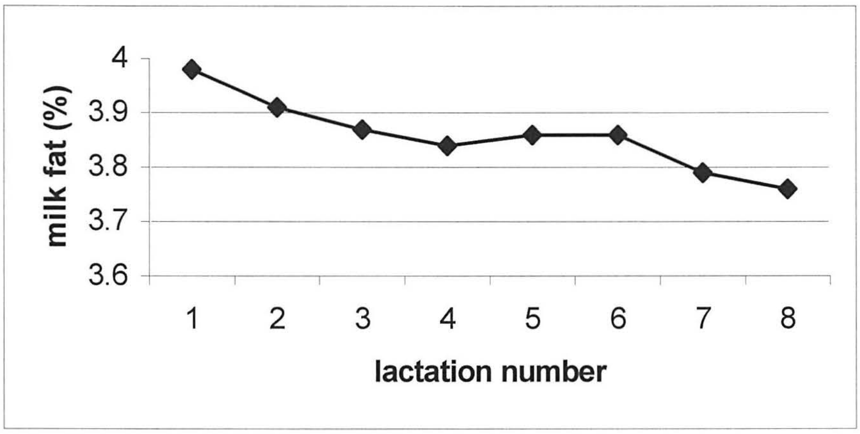
Milk fat yield increased from the first lactation to lactation 6.45 with a maximum of 274kg of milk fat and then decreased thereafter as seen in Figure 4.11.

Figure 4.11. Mean milk fat yield for parity in all years



Milk fat percentage decreased from lactation 1 to lactation 4 and then levelled out in lactation 5 and 6 and thereafter decreased as seen in Figure 4.12. The decrease in fat composition was found to be significant ($P<0.05$) and decreased by 0.0273% per lactation.

Figure 4.12. Mean milk fat percentage for parity in all years



Milk protein

Milk protein yield increased with lactation number and peaked at lactation 5.61 with 234kg of milk protein and then decreased as seen in Figure 4.13.

Milk protein concentration increased between the first and second parity and then decreased ($P<0.05$) by 0.0120 per lactation (Figure 4.14).

Figure 4.13. Mean milk protein yield for parity in all years

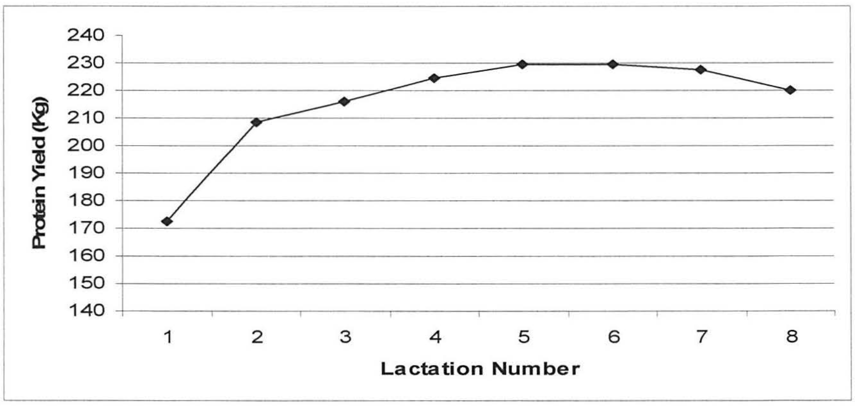
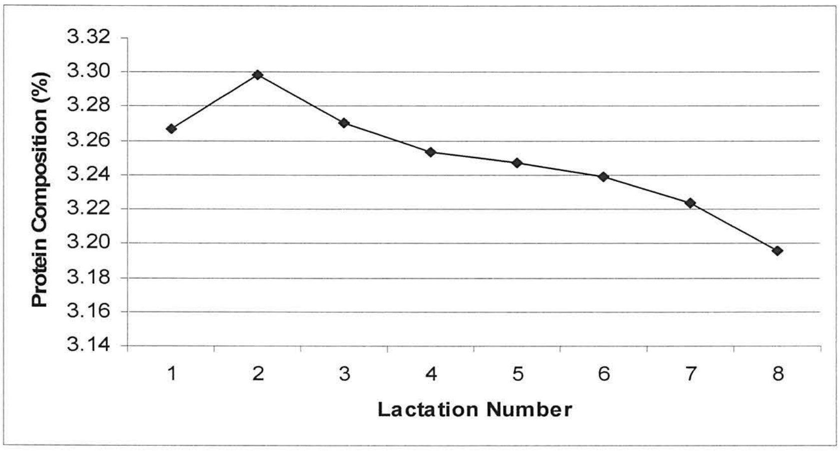


Figure 4.14. Mean milk protein concentration for parity in all years



4.3.5. Functional traits

Lactation number

Overall mean lactation number from the 1950s to the end of the data set was found to be 3.42 lactations. There was no significant change over time in the lactation number ($P>0.05$). Maximum lactation number within the data set was 13, during the 1970s. Coefficient of variation was high ranging from 63% to 71% as shown in Table 4.15.

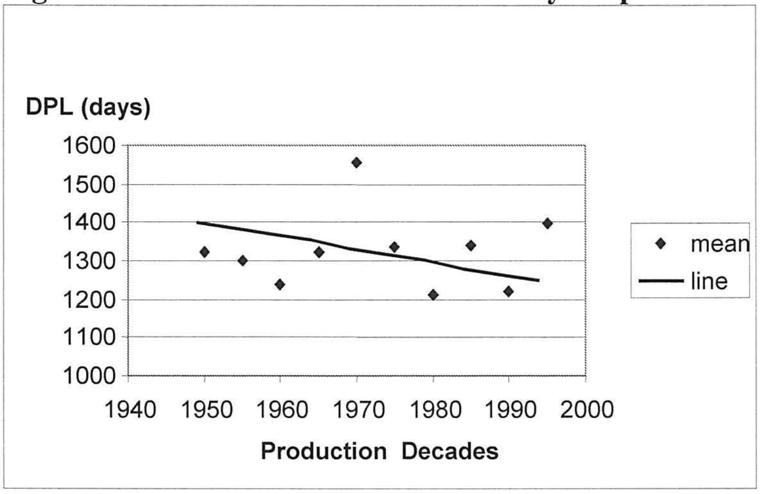
Table 4.15. Number of lactations completed prior to culling

Year	Mean	Minimum	Maximum	S.D	C.V (%)
1990s	3.17	1	11	2.26	71
1980s	3.06	1	12	2.04	66
1970s	3.64	1	13	2.30	63
1960s	3.27	1	11	2.28	69
1950s	3.94	1	12	2.48	63

Days of productive life

It can be seen that mean days of productive life (DPL) decreased over time as well as the standard deviation and the coefficient of variation (Appendix 2, Table 4.23). DPL decreased by 8 days per year ($P<0.05$; Figure 4.15.).

Figure 4.15. The association between days of productive life and year.



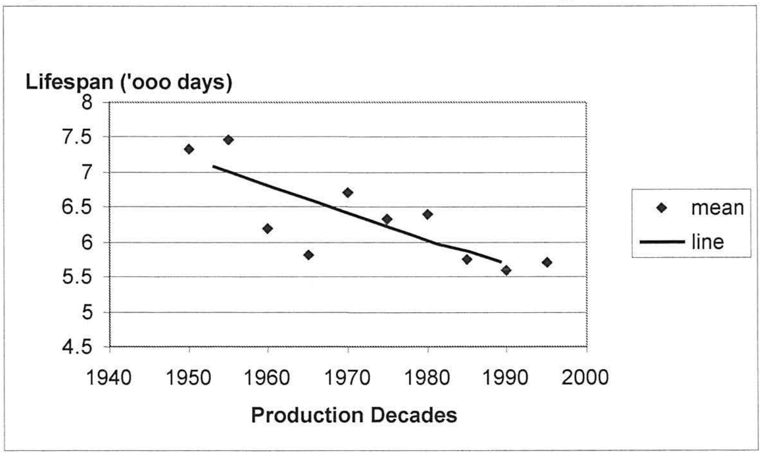
DPL = 17009 – 7.94 Year of Production R^2=0.0075 (individuals)

DPL = 15039 – 8.12 Year of Production R^2=0.59 (subsets decades)

Lifespan

The mean value for lifespan (Appendix 2, Table 4.24) was greater during the start of the data set. The regression of mean lifespan by year was significant ($P<0.05$). Lifespan decreased by 12 days per year (Figure 4.16.). Standard deviation and coefficient of variation values were lowest for the last two decades.

Figure 4.16. The association between lifespan and year



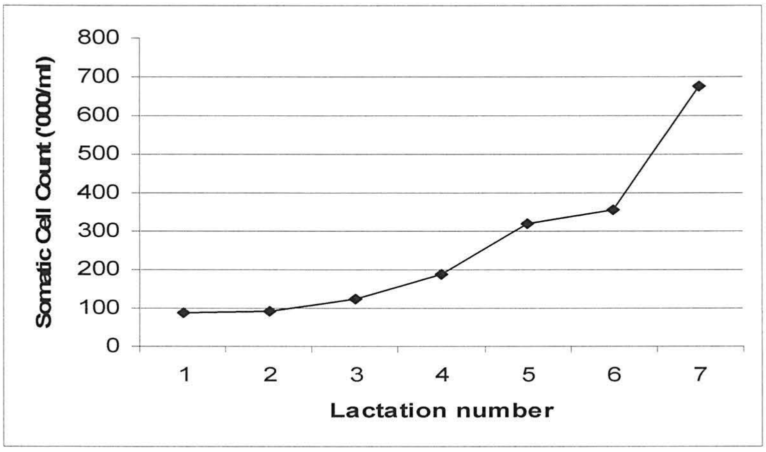
Lifespan (days) = 25474.39 -11.73 Year of Production R^2= 0.015 (individual)

Lifespan (days) = 26534.11 -12.47 Year of Production R^2= 0.69 (subset decades)

Somatic cell count (SCC)

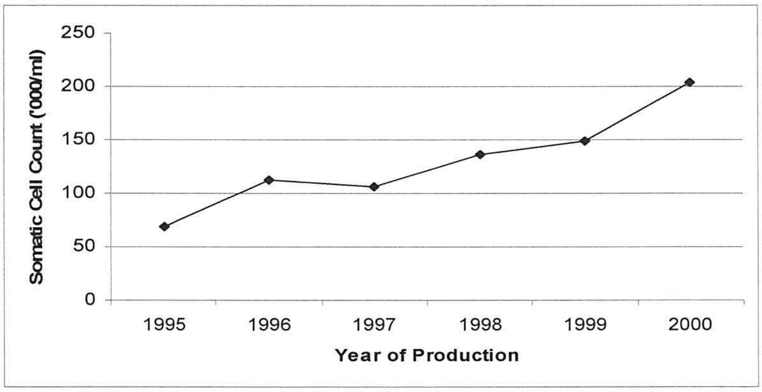
Mean SCC was at its lowest during the first lactation, then increased thereafter for each parity as seen in Figure 4.17. The regression of mean SCC by lactation was found to be significant (P>0.05). The SCC increased 89.25 ('000cells/ml/lactation). Maximum SCC was found to be 689 ('000cells/ml) at lactation 7.4.

Figure 4.17. Mean SCC for parity



Mean SCC for all lactations for year of production over time shows a significant (P>0.05) increase, as seen in Figure 4.18. The SCC increased 25.476 ('000cells/ml/year) (Appendix 2, Table 4.25).

Figure 4.18. Mean SCC for Year of production over time for all lactations



Calving interval

Calving interval had an overall mean of 374 days for the whole data set. Calving Interval did not show a significant change over time (P>0.05). Coefficient of variation was 11-12% as seen in Table 4.16. Calving interval showed an increase in the second parity (Table 4.17).

Table 4.16. Calving Interval (days) over time

Year	Median	Mean	Minimum	Maximum	SD (days)	CV%
1990s	361	374	300	568	46	12
1980s	366	376	300	589	40	11
1970s	357	369	312	536	39	11
1960s	371	380	304	586	41	11
1950s	355	363	312	599	43	12

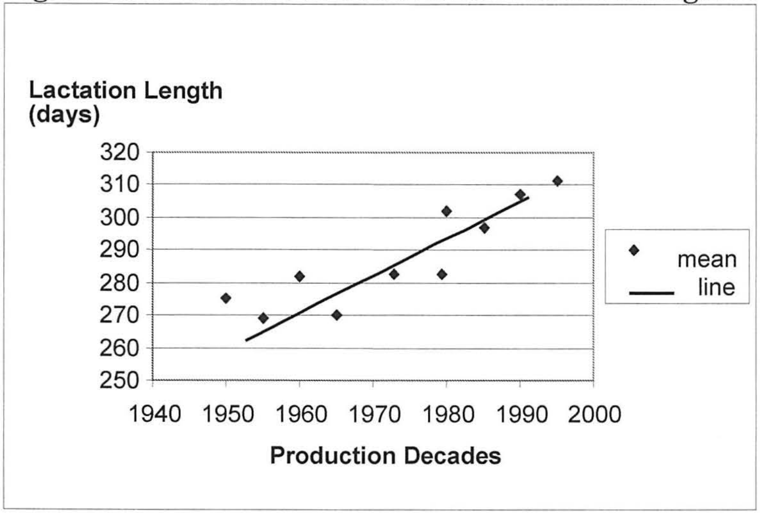
Table 4.17. Calving Interval (days) with parity

Lactation Number	Calving Interval (days)
2	389
3	369
4	372
5	375
6	378

Lactation length

Lactation length increased over time ($P<0.05$) at approximately a day per year. As seen in Appendix 2, Table 4.26, the increase was evident for 'all lactations', all lactations over the 'first lactation' (L>1) and the 'first lactations' (L1). The overall mean lactation length for the data set was 289 days for 'all lactations' (LA), 296days for heifers (L1) and 288 days for (L>1). Standard deviation was within the range 30 to 40 days and coefficient of variation within the range 10 - 15%.

Figure 4.19. The association between lactation length and year

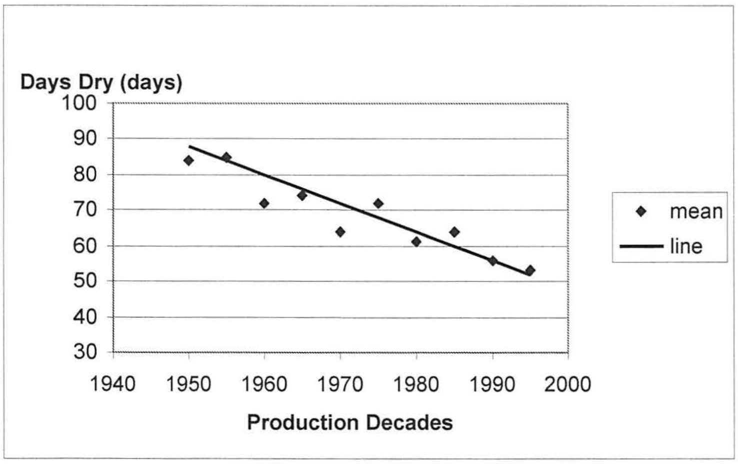


LL = -1727.2 + 1.02 Year of Production R^2= 0.087 (individual)
LL = -1371.9 + 1.22 Year of Production R^2= 0.71 (subset decades)

Days dry

The length of the dry period showed a significant reduction in length (P=<0.05) over time of 0.6 days per year from 1950 to 2000 (Figure 4.20.). The mean number of days dry decreased over time from a mean value of 84 days in the 1950s to 56 days in the 1990s (Appendix 2, Table 4.27). The overall mean was 67 days. The number of days dry ranged from 21 days to 168 days. Standard deviation and coefficient of variation were higher in the earlier decades of the 1950s and 1960s. Standard deviations were within the range of 20-30 days, while the coefficient of variation was in the range 30 - 40%.

Figure 4.20. The association between days dry and year.



Days Dry = 1302.324 + -0.62X Year of Production R^2=0.061 (individual)

Days Dry = 1267.148 + -0.73X Year of Production R^2=0.81 (subset decades)

4.4. DISCUSSION

4.4.1. Introduction

The main focus of the analysis undertaken in Section 4.3 with respect to physical trends, production and functional traits was to determine whether the single herd data provided a representation of the national structure. The discussion will compare and contrast the results with other published findings to determine the suitability of the data as a basis for developing lectures on dairy cattle breeding and selection.

4.4.2. Herd size and breed structure

The Glynllifon herd size has increased over time (Figure 4.3(a), Section 4.3.1). Until the 1970s, secure market for milk, restricted imports and a fair price encouraged an increase in production (Section 2.2.5) and hence herd size. In 1957 the Glynllifon herd had 50 British Friesian cows and 7 Welsh Black cows; by 1975 the herd had increased to 96 British Friesian cows, an increase of 2.5 cows per annum. Likewise it was reported by Morris (1976) that national average herd size had increased by 2.5 cows per herd per annum.

However, from the mid 1980s the herd size levelled off and then decreased in the early 1990s. Then it started to increase to its original peak of the early 1980s by the end of the data set. Various factors may be responsible. Quotas were introduced in 1984 and continued to be an issue in the 1990s. BSE was a sensitive subject and many cows were culled. There was also growing uncertainty regarding the price of milk, due to the strength of sterling. Also as a college farm educational issues could have had an impact as student numbers were falling and the college was taken over as part of the Coleg Meirion-Dwyfor Tertiary College.

The differential between the Glynllifon average herd size and national herd size grew wider with time. During the earlier years the Glynllifon dairy herd size was between 57 cows (1956-1957) and 96 cows (1974-1975). These figures were well above herd size average for England and Wales at 22 and 66 respectively (MMB, E&W). However, during the 1990s herd cow size became closer to the national herd average. In 2000 the NMR (E&W) herd average was 126 cows; the Glynllifon herd average was 108 cows. However the herd size is considerably larger than the average for Wales at 67 (MDC, 2005). Although there has been an increase in herd size, there had been a loss of family blood lines. The data set identified a total of 79 different family lines that entered the herd between 1940 and 1960. By 2000 there were only 17 family lines (Table 4.9) as a result of both voluntary and involuntary culling.

Dairy breeds were also lost through breed substitution. Welsh Black disappeared and were replaced with British Friesian. They were later crossed with the Holstein breed. This is very much in accordance to national trends within the UK and world wide (Section 2.2.8). As reported by Sandoe *et al.,* (1999), increased production and intensive selection leads to fewer breeds dominating the population and results in the loss of 'biological diversity'. The maintenance of genetic diversity and the preservation of locally adapted breeds are issues for animal breeders in the future (Boelling *et al.,* 2003).

4.4.3. Cow families and sires

Purchasing of animals from reputable herds (Table 4.7) resulted in an increase in herd size until 1968. Then in the late 1960s the herd became a 'closed herd' and increased in size by breeding replacement heifers. Breed improvements were achieved with the use of proven sires and a pure breed home bred bull to maintain a pedigree-registered herd. Maintaining a 'closed herd' and breeding bulls was practiced by many reputable herds at this time (BFHB, 1967).

4.4.4. Progeny

The calf mortality rate for the data set is similar to national averages at 10% (DFF, 2002; FMH, 2004). The female to male ratio was approximately one to one. Three percent of calvings yielded twins. This was found to be comparable to Komisarek and Dorynek (2002), who reported 4% of calves to be born as twins within dairy herds.

4.4.5. Age at first calving

The age at first calving was 30 months with a range of 18 months to 48 months. The national average is 29 months (MDC, 2005). In the data set there was an increase in age at first calving to 33 months in the 1990s (Table 4.13). This is comparable to the national trend reported by MDC (2004a). It was reported by Nilforooshan and Edriss

(2004) that the age at first calving affected production. Also the older the age at calving, the chance of being culled increased (Sewalem *et al.,* 2005).

4.4.6. Seasonality of calving

The Glynllifon dairy herd has always been known as an 'all-year round calving herd'. As one of the main founder members of the 'Hufenfa De Arfon', the herd's objective was to ensure an all year supply of milk to the creamery (HAD,1988). An all year round calving herd has an educational advantage, as students can experience cows at different production cycles at most times within the academic year.

4.4.7. Production traits

Production traits compare well with UK national data. Annual milk yield at the beginning of the data set in 1954-1955 was 3,065kg (DFF, 1971), and the mean value for 1955 at Glynllifon was 3,861kg. In 2000 the dataset's milk yield average was 6,941kg, compared to a milk yield of NMR Herds at 7,118kg (DFF, 2002) for the same year. Milk fat and protein yield also increased as reported by the MDC (2004a).

Lactation number is known to affect many traits (Pryce *et al.,* 1998 and Dematawewa and Berger, 1998) and lactation number and milk yield were found to increase up to lactation 5-6, in agreement with Pirzada, (2000), DEFRA, (2001) and Whittmore (1980). Milk composition of both fat and protein decrease with parity as a result of the dilution effect (Soffe, 2003) as discussed in Section 2.3.2.

The coefficients of variation (CV%) for production traits were found to be 16% to 29% for the data set. The coefficients of variation reported by Pryce *et al.,* (1998) and Kadarmideen *et al.,* (2000) were within the range of 16 - 17% and 23 – 24% respectively for production traits.

4.4.8. Longevity

National concern over longevity has resulted in its inclusion within the selection index since the early 1990s, because a high percentage of cows are culled before they reach maturity (ADC, 2001; Holstein-UK, 2004; RABDF, 2002).

The Glynllifon dairy herd data, with respect to average lactation age remained static from 1981 at just over three lactations (3.12), which is comparable to the national value (3.13) reported by Swanson *et al*., (2003). Days of productive life and lifespan for the herd were found to have decreased by 8 days per year and 12 days per year respectively. It can be concluded that longevity has fallen over time for the Glynllifon data set reflecting the concerns of the UK dairy industry (MDC, 2004b).

4.4.9. Somatic Cell Count (SCC)

The Glynllifon SCC analysis showed a significant increase with parity and over time. Mean SCC for parity showed an increase from 87,000 cells/ml during the first lactation to 677,000 cells/ml in the 7th lactation (Appendix 2, Table 4.25). These results are in agreement with Smith and Richardson (2003) who conducted their analysis using a much larger NMR database. Also it was found that for the Glynllifon herd SCC had increased over time in accordance with national trends (Macrae *et al.,* 2003, Smith and Richardson, 2003 and Swanson *et al.,* 2003).

4.4.10. Lactation length, Calving Interval and Days dry

The length of lactation within the last two decades of the data set was within the standard lactation length of 305 days (DFF, 2004). Lactation length was found to be 302 days in the 1980s and 307 days in the 1990s. Mean lactation length for the data set increased over time. Increasing lactation length has a positive effect on production and extended lactation can be practiced. However lactation length could also increase as a consequence of a decline in fertility as reported by Flint *et al.* (2002) and Pryce *et al.* (2002).

Similarly, the length of the dry period decreased over the study period to that of national standard length. Mean days dry for the 1980s was calculated to be 61 days and during the 1990s it was found to be 56. As was reported by Bachman and Schairer (2003), the most commonly adopted and accepted number of days dry is between 51 and 60.

Calving interval (CI) did not show a significant increase, contrary to national trends (Price *et al.* 2000; Royal *et al.* 2000; and Wall *et al.* (2003). The optimum CI is taken as 365 days (Pryce *et al.,* 2002). The data set mean calving interval was found to be

374 days which compares well with that of the MDC (2004a) at 378 days.

The reduction in days dry and the increase in lactation length could have compensated for the constant length of the calving interval. Calving interval (CI) can be analysed as a measure of fertility without the bias of culling (survival) and the effect of milk yield (Olori *et al.,* 2002). Unfortunately dates of conceptions and the length of days open (DO) were unavailable for the herd. Reproductive efficiency has decreased over time as reported by Abdallah and Mc Daniel (2000) who found that cows born in 1993 conceived 28 days later than cows born in 1950, resulting in an extended calving interval or lactation length. Often the high genetic potential of dairy cows has made it difficult to dry off cows and also time of peak yield is a difficult time to achieve conception (Pryce *et al.,* 1998). It is not possible to explain the increase in lactation length, reduction in days dry of the Glynllifon data set.

4.4.11. Conclusion

Although the data set is small, the results for the physical, functional and production traits compare well to those of national datasets. This suggests that the herd's data set is a representative of UK dairy herds. The single herd data set from the Glynllifon herd is a manageable size data set that can be used for educational purposes. As the herd is still productive within an educational setting it and can be visited and used practically to relate real life situations in the context of teaching and learning.

CHAPTER 5
ESTIMATION OF GENETIC PARAMETERS AND BREEDING VALUES FOR PRODUCTION TRAITS

5.1. INTRODUCTION

Genetic improvement though breeding has made an important contribution to farm profitability over the years (Simm, 2000a; Swanson *et al.*, 2003.). The Chairman of the MMB in the Milk Production Annual Report (1972) claimed that the increase in yield per cow was due to breeding and selection, but the major single factor was improved AI bulls (MMB, 1972). However, during the 1970s and early 1980s the rate of genetic progress in the UK had slowed down. This was due to a ban on importation of semen from the USA and Europe (DFF, 2001; MDC, 2004b). During this period, the improvement in production traits was the result of management. It was not until after the mid 1980s that rate of genetic progress began to increase (Sandoe, 1999; DFF, 2001; Swanson *et al,* 2003). Today, the current rate of progress for production traits in the UK Holstein Friesian population is very similar to that of other major dairying countries. This increase in genetic improvement in the UK was viewed by Brigstock (2005) to be the influence of the North American Holstein. Brigstock (2005) claimed that during the last 10 years the UK has experienced real genetic improvement faster than anywhere else in the World.

The objectives of this study, based on 50 years of the Glynllifon dairy herd data, were to investigate the effect of environmental factors on production traits and to estimate genetic parameters for these traits. A comparative analysis of breeding values from NMR lactation certificates allows a further opportunity to assess the appropriateness of the data set as a teaching and learning resource.

5.2. MATERIALS AND METHODS

5.2.1. Source of data

The data used in this study was of the Glynllifon dairy herd, as discussed in Section 3.2.

5.2.2. The editing process

The editing process is as discussed in Section 3.3. The edits resulted in a data set that comprised 2,881 lactation records for 763 cows and 36 cow families. The data set for the three production traits, milk and fat (Section 4.2.3.1) and protein (Section 4.2.3.2.) were used for the ASREML analysis. Information including pedigree details (cow, sire and dam), date of birth and production as well as lactation length, calving interval, days dry, calving age and calving date were as shown in Figure 3.1, Section 3.3.4.

5.2.3. Statistical analysis

ASREML (Gilmour, 2003) was used to estimate variance components and genetic parameters for milk, fat and protein using the univariate animal model. Phenotypic variance (Vp), habitability (h^2), permanent environmental effect of animal as a proportion of the phenotypic variance (c^2) and repeatability were calculated as defined in Section 3.5.3.

The animal model predicts the breeding value for all the animals in the data set. The animal model included the random effects of animal and the permanent effect associated with animal. The fixed effect in the model were year and season (as a combined effect), and lactation number. Lactation length (days) was included as a linear covariate.

In order to investigate genetic trends over time, annual average EBVs, were regressed by year of birth.

The breeding values for the Glynllifon herd were investigated using genetic information from the NMR lactation records (Figure 3.1). Breeding values were available from 1975 to 1987 and were expressed as Improved Contemporary Comparison (ICC). From 1988 to the end of the data set breeding values were expressed as Predicted Transmitting Ability (PTA) as discussed in Section 2.6.3. The data set had breeding values for 357 cows. There were 159 cows (45%) with ICC values and 198 cows (55%) with PTA values. These records were investigated for production traits milk, fat and protein. Milk yield breeding value from the lactation records were then compared with EBVs calculated by ASREML in the present study.

5.3. RESULTS

5.3.1. Estimation of variance components and genetic parameters from univariate analysis

Variance components, estimate of additive genetic variance (V_A), error variance (V_E), and phenotypic variance (V_P) are shown in Table 5.1. The heritability (h^2) and repeatability (R) estimates and their standard errors (se) for milk, fat and protein yields are also shown in Table 5.1. The heritability of these traits was moderate ranging from 0.23 to 0.28, with a higher heritability for fat yield and protein yield than for milk yield. Repeatability results show that milk, fat and protein were moderately repeatable with estimates ranging form 0.47 to 0.49. Standard errors for heritability and repeatability estimates for milk, fat and protein yield were generally small.

Table 5.1. Estimates of variance components and genetic parameters of production traits in univariate analysis.

Traits	No of records	h^2 (se)	R (se)	V_A	V_C	V_E	V_P
MY	2881	0.23 (0.050)	0.47 (0.022)	178762	195490	420651	794903
FY	2881	0.28 (0.047)	0.47 (0.023)	372.660	249.986	709.945	1332.591
PY	2281	0.28 (0.056)	0.49 (0.025)	218.799	168.998	397.499	785.296

MY= Milk yield, FY = Fat yield, PY = Protein yield, h^2 = Heritability, s.e. = Standard Error, R = Repeatability, V_C = Permanent environmental variance, V_A = Direct additive genetic variance, V_P = Phenotypic variance, V_E = Error variance.

5.3.2. Relationships between production traits

The effect of lactation number, year and season of calving and lactation length was determined for milk, fat and protein yields and the results are presented in Table 5.2. These results indicate that lactation number, year and season of calving and lactation length had a significant effect ($P<0.05$) on milk, fat and protein yields.

Table 5.2. The effects of lactation number, year and season of calving and lactation length on production traits (F-values from ASREML analysis).

Trait	Lactation number	Year and season of calving	Lactation length (days)
Milk yield	2753.72*	12.26*	1814.67*
Fat yield	2278.39*	12.92*	1785.48*
Protein yield	2393.39*	11.91*	1554.34*

* Significant (<0.05)

5.3.3. The effect of lactation length on milk production

It can be seen from Table 5.3 that lactation length had an effect on milk, fat and protein yield. As expected, milk yield, fat and protein all increased with increasing lactation length.

Table 5.3. The effect of lactation length on milk production traits (kg/day) (F values from ASREML analysis)

Milk yield	Fat yield	Protein yield
18.53*	0.7525*	0.6158*

* Significant (<0.05)

5.3.4. Effect of lactation number of milk, fat and protein yield

Milk, fat and protein yield increased with parity up to lactation 5 and then decreased thereafter as seen in Figure 5.1, 5.2 and 5.3 below.

Figure 5.1. Effect of lactation number on milk

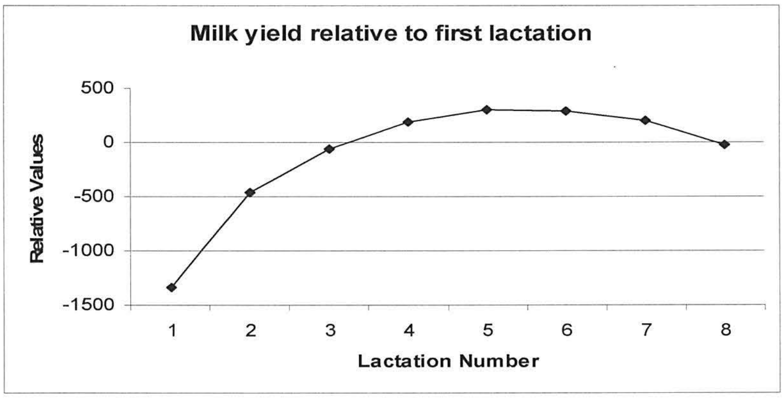


Figure 5.2. Effect of lactation number on fat

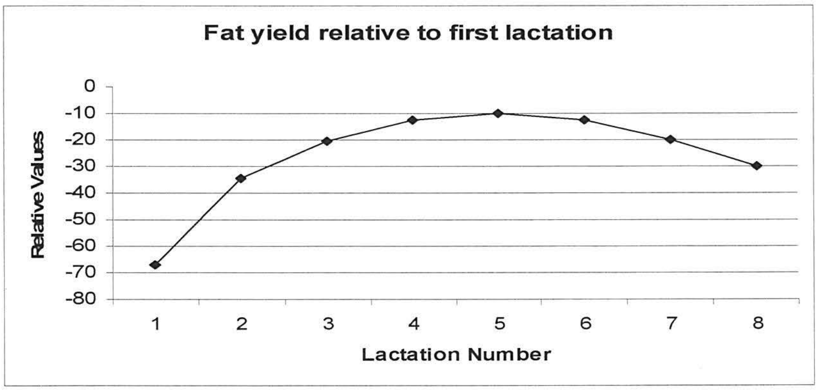
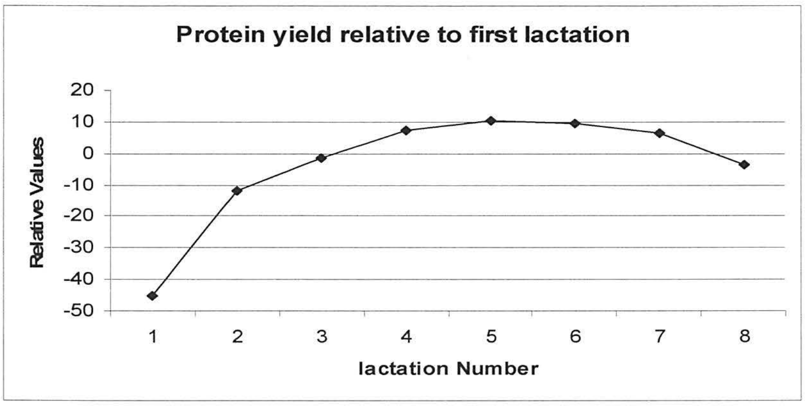


Figure 5.3. Effect of lactation number on protein



5.3.5. Estimated Breeding Values (EBVs)

Overall the regressions of mean EBVs for milk yield by year (Figure 5.4) and fat yield by year (Figure 5.5) were not significant ($P > 0.05$).

Figure 5.4. EBVs for milk yield over time

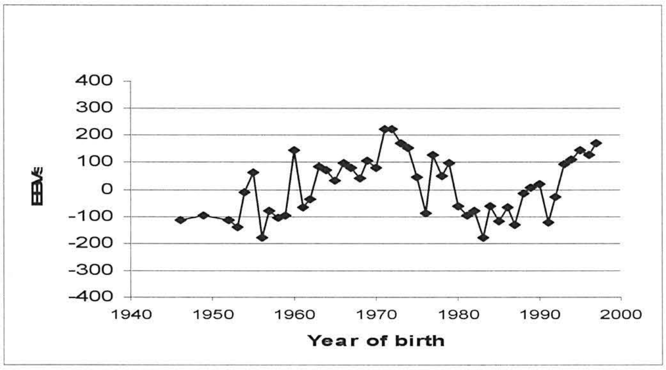
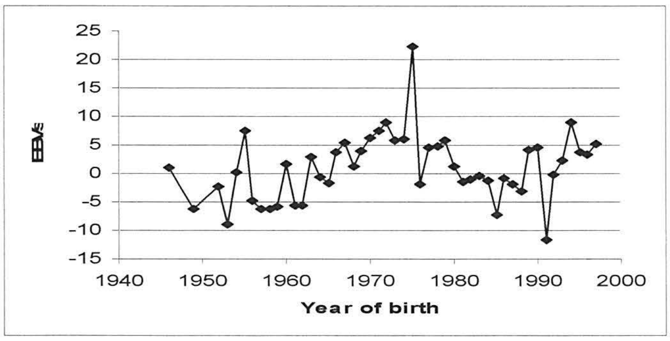
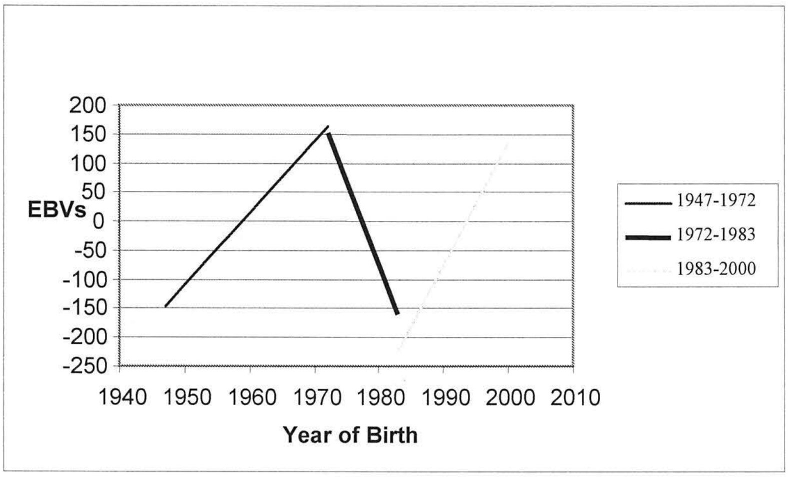


Figure 5.5. EBVs for fat yield over time



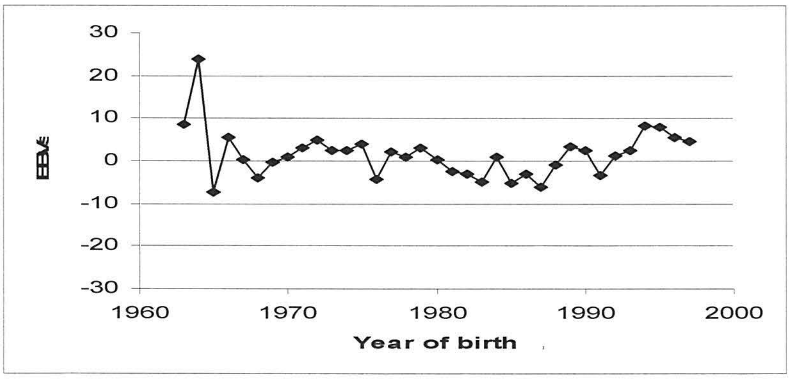
The milk yield EBVs were considered within three time phases (Figure 5.6). From the start of the data set, up until 1972, there was a significant increase in milk EBVs, (Milk EBVs increased by 12.4 per year ($Y = -24290 + 12.4X$, $R^2 = 61\%$)). From 1972 to 1983, and milk EBVs decreased ($P < 0.05$) by 28.2 per year ($Y = 55762 - 28.2X$, $R^2 = 62\%$). From 1983 to the end of the data EBVs, increased ($P < 0.05$) by 21.2 per year ($Y = -42264 + 21.2X$, $R^2 = 72\%$).

Figure 5.6. Regression lines for milk yield EBVs over three time periods



Milk fat EBVs followed a trend similar to that of milk yield EBVs. Trends in protein yield EBVs (Figure 5.7) were not significant ($P > 0.05$) when considered as a whole data set or within time periods.

Figure 5.7. EBVs for protein yield over time

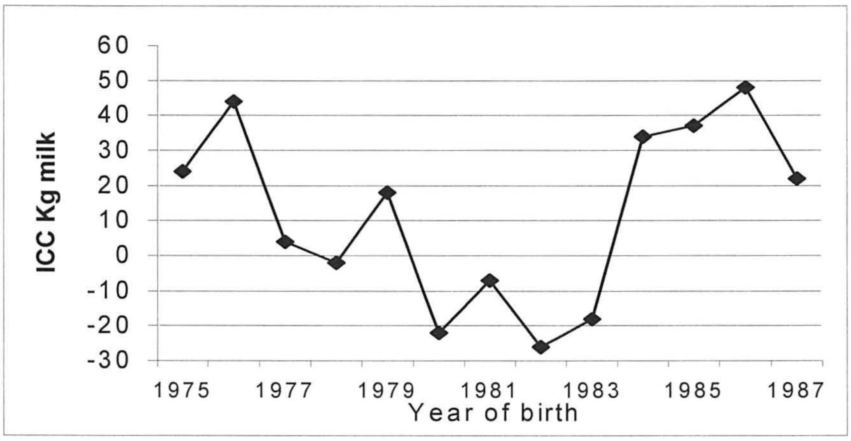


5.4. COMPARISON OF ESTIMATED BREEDING VALUES

5.4.1. Improved Contemporary Comparison for milk, fat and protein yield

ICC values for milk yield (Figure 5.8.), fat yield and protein yield (Appendix 3, Figure 5.20. and 5.21) display similar trends. From the mid 1970s to the mid 1980s a significant decrease was found ($P <0.05$) for all three traits, followed by an increase from the mid 1980s. Milk yield ICC increased ($P < 0.05$) by 9.64 kg per year from 1983 to 1990.

Figure 5.8. ICC milk yield over time



5.4.2. Predicted Transmitting Ability (PTA)

Milk PTAs for cow and sire

Figure 5.9 and 5.10 show an increase over time for mean milk PTAs for cow and sire. Sire PTAs were generally higher than cow PTA values. PTAs increased by 40.43 per year and 78.64 per year for cows and sires respectively.

Figure 5.9. PTA of milk yield over time for cows

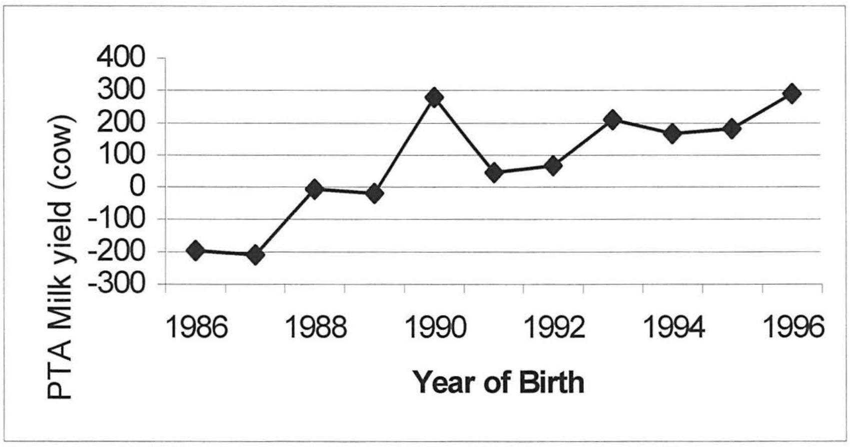
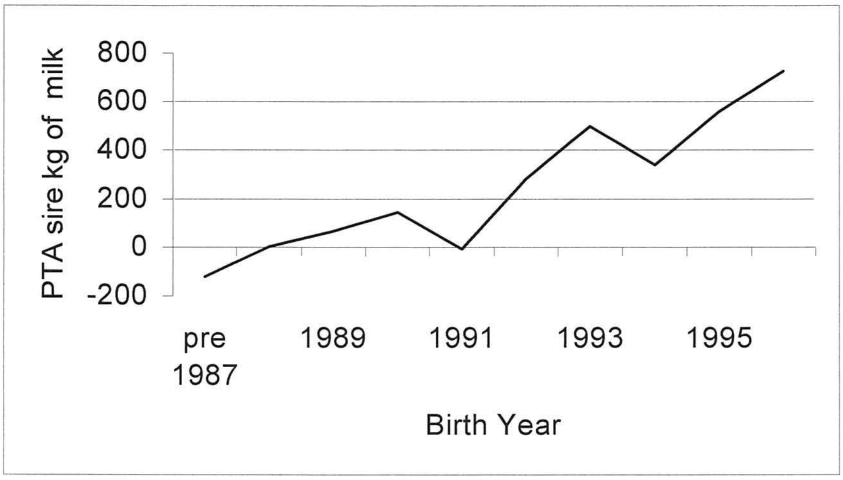


Figure 5.10. PTA of sire milk yield values over time



Fat and Protein Yield PTAs for cows

Fat yield PTAs (Figure 5.11) and Protein yield PTAs (Figure 5.12) increased ($P < 0.05$) from the late 1980s to the end of the data set.

Figure 5.11. PTA fat yield over time

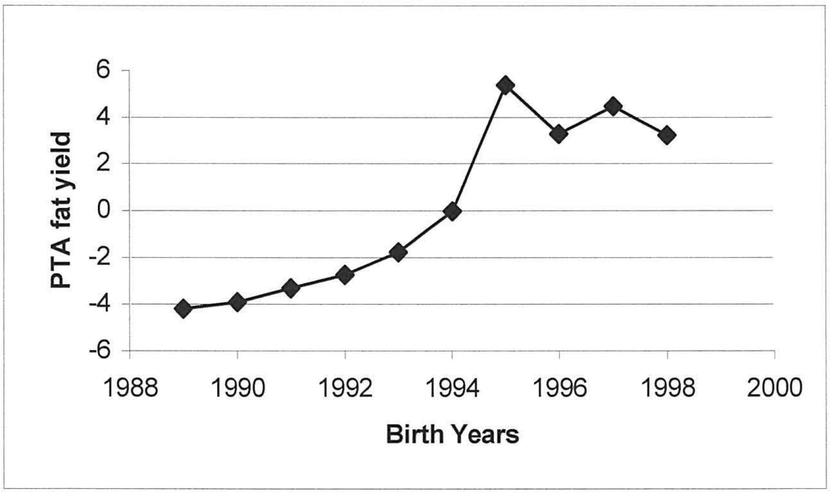
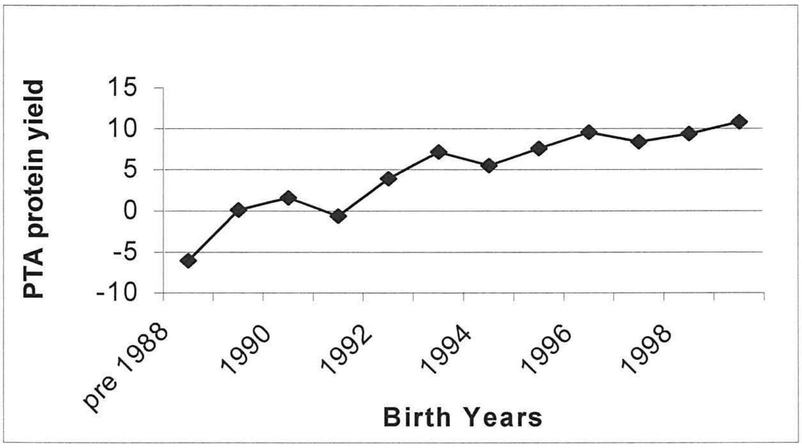


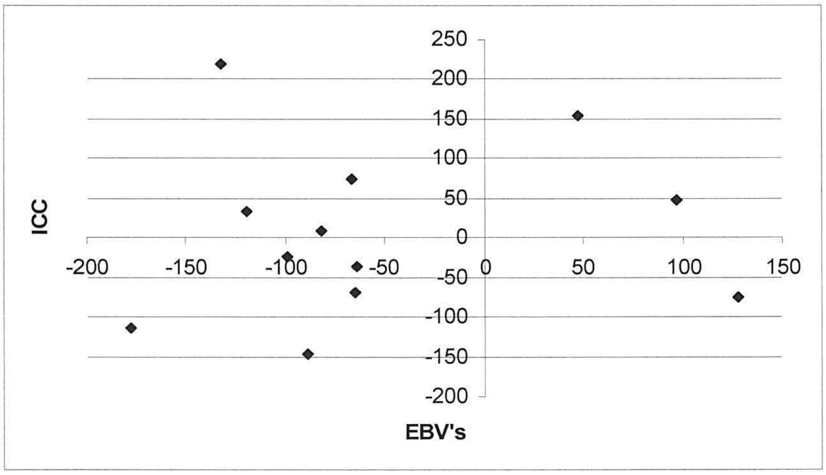
Figure 5.12. PTA protein yield over time



5.4.3. The relationship between EBV, ICC and PTA

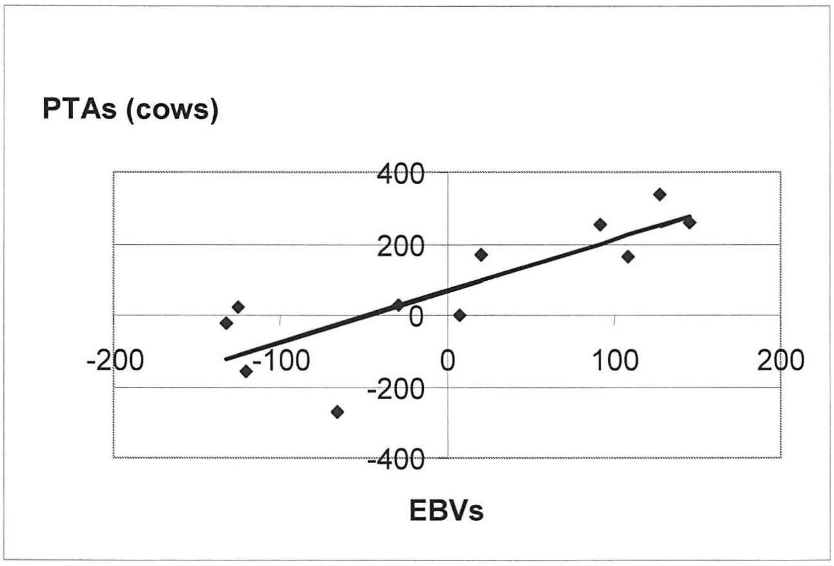
The relationship between the EBV's as calculated by ASREML compared with ICCs and PTAs were examined by regression analysis. There was no significant relationship (P>0.05) between EBVs and ICCs (Figure 5.13).

Figure 5.13. Relationship between EBV's and ICC for cows



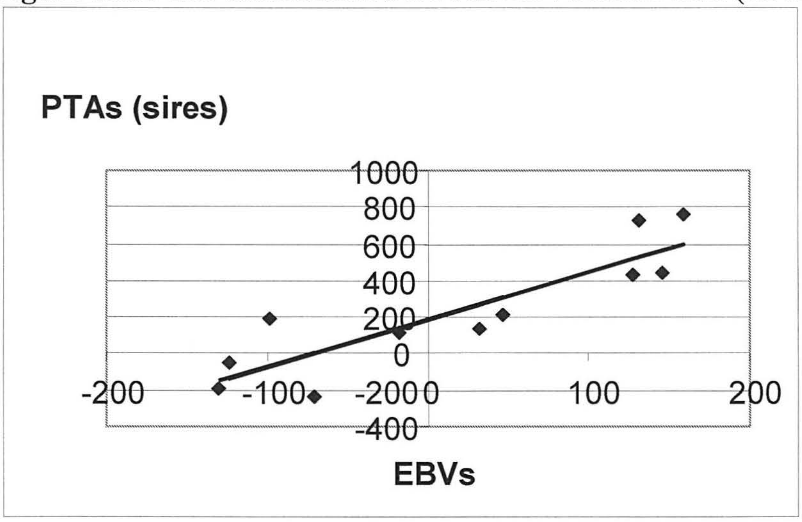
A significant positive relationship (P<0.05) was found between EBVs and PTAs for both cows and sires (Figures 5.14 and 5.15 respectively).

Figure 5.14. The association between EBVs and PTAs (cows)



PTA = 66.94 + 1.44EBV R^2=0.66 $P<0.05$

Figure 5.15. The association between EBVs and PTAs (sires)



PTA= 184.67 + 2.59EBV R^2=0.77 $P<0.05$

5.5. DISCUSSION

5.5.1. The data set size and structure

The data set size used within the genetic evaluation of production traits is comparatively small as it involves data from a single herd. Records were also lost during the editing process (as discussed in Section 3.3). It was found to be a manageable size data set for use with the software ASREML. The information on the

NMR lactation records breeding values was not available at the start of the data set nationally from 1975 onwards. Initially they were known as Improved Contemporary Comparison (ICC) and then as Predicted Transmitting Ability (PTA).

During the productive life of the cow the ICC and PTA values are recalculated and change with additional lactations. In all cases the last calculated ICC and PTA values were used for the data analysis. However, the 108 cows currently milking were included within the data set. In reality their PTA values may not be their final values as they could change as more lactation information were obtained, following the data set end date. Possibly they should be excluded, but that would have reduced the data size even further and therefore were included in the analysis. The effect of their inclusion could possibly be reflected in the fact there was a widening of the gap between cow and sire breeding values as found in Figure 5.14.

5.5.2. Effect of fixed effects and covariates

Lactation number, lactation length, and year and season of calving had a significant effect on production traits. As found in Section 4.3.4 (Figure 4.10 to 4.14) production traits increased with parity up to the fifth and sixth lactation and then declined thereafter for all the production traits (Maltz *et al.,* 1990; Norman, 2005). Interestingly it is the effect of the lactation number that has led to the interest in longevity and its inclusion in the Selection Index during the early 1990s (MDC, 2004b). Reduced longevity results in cows being culled before they reached maturity and the peak of their lifetime production (DEFRA, 2001).

Year and season of calving affects production (Pryce *et al.,* 1998; Kadarmideen *et al.*, 2000; Norman *et al.*, 2005). The effects of season on production is well known to the dairy manufacturing industry as the MMB implemented an economic incentive known as the 'seasonality of payment' in order to attract producers to supply milk throughout the year (DFF, 1998). Contrary to this, the herd at Glynllifon produced an all year round supply of milk in order to supply the local creamery, and to provide an all year round educational experience for its students.

Increasing lactation length was also found to have a positive effect on production. It is considered by some to be an economic advantage to managing 'extended lactation' cows (Crossman and Koops, 2003; Haile-Mariam *et al.,* (2003). Lactation length for the data set was also found to have increased over time (Section 5.5.3. and 4.3.5).

5.5.3. Variance components and genetic parameters

Genetic and environmental components of variance are important within animal selection and breeding. Heritability of milk yield was found to be 0.23 and both fat yield and protein yield to be 0.28. Heritability values within the range of 0.15 to 0.40 were reported by Raffrenato *et al.*, (2003), Calus *et al.*, (2003) and Druet *et al.*, (2003). Lower values within the range of 0.20 to 0.25 were found by Kearney *et al.*, (2004). These values are in agreement with published heritability estimates for milk yield, fat and protein yield. Further comparable examples are provided in Table 2.6, Section 2.5.5.

Heritability values for production traits estimated in this study are towards the lower boundaries of published estimates, possibly because of the size of the data set (Pond and Pond, 2000). There were unknown management factors, including dairy cow nutrition in terms of concentrate input, grazing and conservation. Also, as discussed by various authors, variation in heritability could be due to analysis performed on test-day data (Lidauer *et al.*, 2003); first lactation animals (Pryce *et al.*, 2002) and standard lactation length, as opposed to natural lactation length (Olori *et al.,* 2002).

Repeatability values are within the range of 47% and 49% for production traits as cited by other authors and reported in Section 2.5.5 (Table 2.6).

5.5.4. Estimated Breeding Values and genetic trends

Estimated breeding values for milk and fat yield (Figure 5.4 and 5.5) increased from the beginning of the data set to the early 1970s. The increase can be attributed to the improvement in AI bulls (MMB, 1972). Then there followed a decline until the mid 1980s and an increase thereafter. The reason for this decline in genetic improvement from the early 1970s within the UK until the mid 1980 was the ban on the importation of semen from the USA (MDC, 2004c; DFF, 2001). It is only now that the genetic gain within the UK is considered to be comparable with other major dairying countries (Section 5.1).

The ICC from the late 1970s decreased until the early 1980s (Figure 5.8). Then from the mid 1980s PTAs for dam and sire increased (Figure 5.9 and 5.10.). Milk PTAs increased by 40.43 per year and 78.64 per year for cows and sires respectively. The average PTAs by year of birth for Holstein Friesian cows in 1990 was -277kg milk and in 2000 it had reached PTA of 287kg of milk. Similar findings are obtained for bulls, showing an increase from 1990 of -160 to 422 kg milk PTA in 2000, based on 305day yield for first to fifth parity lactation records (MDC, 2004c). Bull PTAs for the Glynllifon herd had a higher increase; this could possibly be explained by the selection of bulls within the top 10% of AI sires.

5.5.5. The relationship between EBVs, ICC and PTA

No association was found between ICCs and EBVs. ICCs were used earlier on in the data set from 1975 to 1987. Possibly the methods of analyses differed and the amount of data available was small. However, there was a strong association between PTA's and EBVs as might have been expected given that both are based on an animal model analysis.

5.5.6. Conclusion

It can be concluded that the results from the single dairy herd data are representative of those obtained for the UK dairy population with respect to genetic parameters and genetic trends.

It can be concluded that a small manageable data set based on the Glynllifon herd can be used within a teaching and learning context yields estimated of genetic parameters comparable to published values.

CHAPTER 6
EDUCATIONAL EVALUATION

6.1. INTRODUCTION

Results for the educational evaluation of the lectures on Selection and Breeding using the herd data (Chapter 4 and 5) are described in the following sections. The lectures were evaluated for programmes within Further Education (FE) and Higher Education (HE) Institution (Section 3.6.2). The questionnaire used in the evaluation was initially piloted, as well as the lectures for NVQ, NCA and HNC groups (Section 3.8.5 and 3.8.7 respectively). The educational evaluation was undertaken as discussed in Section 3.6. In order to ensure the validity of the data, completed questionnaires were then edited as described in Section 6.3.5. Qualitative techniques combined with quantitative techniques were used to analyse and evaluate the effectiveness of teaching and learning (Section 6.3 to 6.6).

6.2 METHODS AND MATERIALS

Details of the student groups, programme level groups and method of evaluation are given in Chapter 3.

6.3. RESULT OF PILOT QUESTIONNAIRE AND LECTURES

6.3.1. Piloting the questionnaire

The first draft version of the questionnaire had 18 questions on three 'A4' pages in English (Appendix 1, Figure 16). It was piloted with the NVQ/ NCA 'R1' group (Table 3.7). Comments received during the focus group discussion were recorded in Table 6.1 and the action plan in Table 6.2.

Table 6.1. Focus group discussion summarised

Topics	Dislikes	Preferences
Questionnaire Length	The three-page questionnaire, as used at Coleg Meirion Dwyfor (CMD).	Fewer questions on a two-sided A4 questionnaire.
Wording	Words such as 'facilitate' and 'challenging' provided difficulties	Change wording (Appendix 1)
Bilingual	Having English version only	Welsh version of the questionnaire
Open questions	The open questions had lines for writing responses. Lines were considered 'off-putting'	Blank box was preferred as used by the School of Agricultural and Forest Sciences (SAFS)
Direct questions	Response scale	The Likert scale as used by SAFS

The comments were action planned and the questionnaire was reduced from three A4 sides to two sides of A4. The number of questions initially was 18 and was reduced to 15 (Appendix 1, Figure 17). A translated version of the questionnaire was also prepared.

Table 6.2. Questionnaire Action Plan

QUESTIONS	AMENDMENTS	REASONS
Question 2	Deleted	Vocational question and inappropriate for use in HE groups
Question 7	Deleted	Considered irrelevant for analysis of a single lecture.
Question 14 and 15	Combined	Similar in nature
All questions	Simple Language	To ensure full understanding
All questions	Translated into Welsh	Opportunity to choose the language they preferred to communicate.
Questionnaire	Format as discussed in Focus group discussion (Table 6.1)	Students' preference

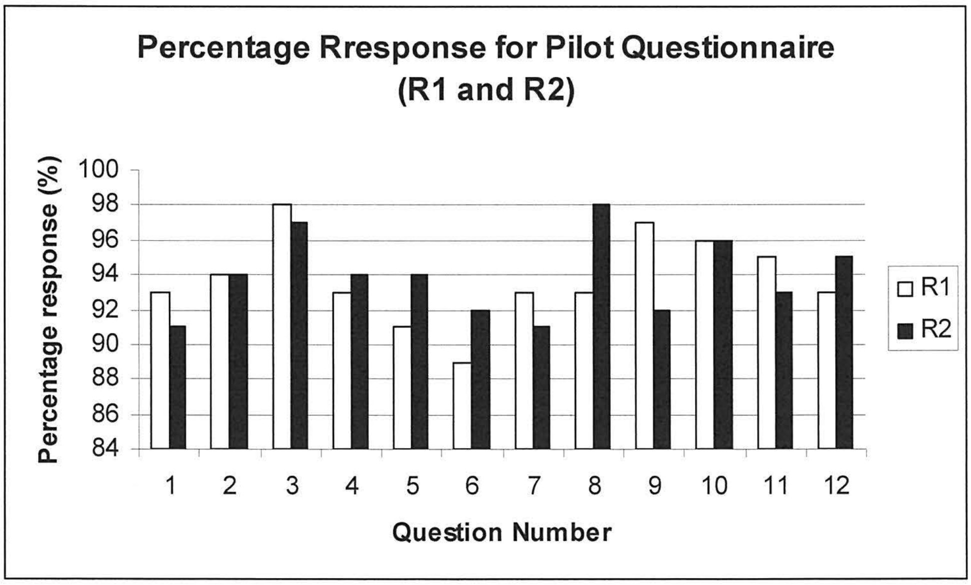
6.3.2. The amended draft version

The questionnaire responses by 'R2', NVQ and NCA groups for the amended draft version were positive. The students were satisfied and expressed no recommendations or concerns during the focus group discussion. The amended draft version was also reintroduced to the initial 'R1', NVQ and NCA groups during a second focus group discussion. All members of the groups openly admitted that they would be happy to fill the amended second draft version at the end of a lecture.

6.3.3. Pilot questionnaire response rate

The response rate refers to the number of questions that were responded to and not left unanswered on the questionnaire. The chi-test result showed no significant difference ($P<0.05$) between the response rate for the 'R1', NVQ and NCA group (average response of 93.8%) for the first draft version, and the 'R2', NVQ and NCA groups (average response of 93.9%) for the amended version (Figure 6.1).

Figure 6.1. Percentage response for the pilot questionnaire



The open questions, 13, 14, and 15 had no responses comments

The amended version became the final version of the questionnaire that was later used in the evaluation of the lectures in the pilot stage (Section 6.3.4) and the final version of the lectures for all the programme levels within the FE and the HE institutions (Section 6.4).

6.3.4. Piloting the lectures

Introduction

The lectures on breeding (B1) were piloted by three student groups (NVQ, NCA and HND/C (Section 3.8.7) by completing the questionnaire, followed by focus group discussion. During the pilot lectures, peer evaluation and self-evaluation were also conducted.

Self-Evaluation of pilot lectures

Strengths and weaknesses were identified for the programme level groups NVQ, NCA and HND/C and are as found in Table 6.3. The strength of the lectures was the adoption of an 'active' approach, while the weaknesses were identified as timing issues, amount of information to be covered and lack of bilingual handouts.

Table 6.3. Self-evaluation results for the pilot lectures

Strengths*	Weaknesses*
▪ Students concentrated better on handouts where blanks had to be filled in ▪ Students enjoyed being involved in completing industrially related exercises	▪ Too much information was provided in one session. The lectures were rather rushed ▪ Groups were accustomed to bilingual handouts within the FE institute and it was questioned and requested from several members within the groups ▪ Time was wasted travelling from class to farm ▪ Class time in relation to work on the farm clashed

*Summarised version for all three groups

Peer Evaluation of pilot lectures

Strengths and weaknesses were identified by peers and are documented in Tables 6.4, 6.5 and 6.6 for each of the programme level groups. Clear uncomplicated handouts were found to be the strength of the NVQ pilot lecture (Table 6.4), while no bilingual provision and too much information during the lecture were found to be the weaknesses. These were also weaknesses within the other two pilot groups, the NCA and HND/C. Adopting an active approach to teaching through the use of gapped handouts, exercises and discussions were found to be positive aspects of the NCA and HND/C lectures (Table 6.5. and 6.6. respectively).

Table 6.4. The NVQ Piloted Lecture

Strengths	Weaknesses
▪ Information delivered in a clear and concise manner ▪ Opportunity for questioning ▪ Well prepared handouts	▪ Possibly too much information for one session ▪ Bilingual provision not in place

Table 6.5. The NCA Piloted Lecture

Strengths	Weaknesses
▪ Well structured lectures with good interaction ▪ Excellent exercises which students enjoyed ▪ Good discussion	▪ Some students were rushed ▪ Farm was rather unaccommodating ▪ Bilingual provision not in place

Table 6.6. The HND/C Piloted Lecture

Strengths	Weaknesses
▪ Excellent use of teaching resources ▪ Interactive handouts allowed opportunity for explaining, expanding and discussing	▪ Too much information to be digested in one session ▪ Bilingual provision not in place

Student evaluation of pilot lecture

The response rate to the questions from all three student groups was positive (Figure 6.2). However, open questions at the end of the questionnaire had not been answered. Focus group discussions provided the following comments:-

- Too much information to go through for the HND/C group
- Bilingual provision was appreciated by the NVQ and NCA groups
- Farm related activities were considered worthwhile by all three groups
- Gapped handouts were favoured by all three groups

Action planning

An action plan was constructed based on comments from students, self-evaluation and peer-evaluation. The main points are outlined below in Table 6.7.

Table 6.7. Action planning for lectures

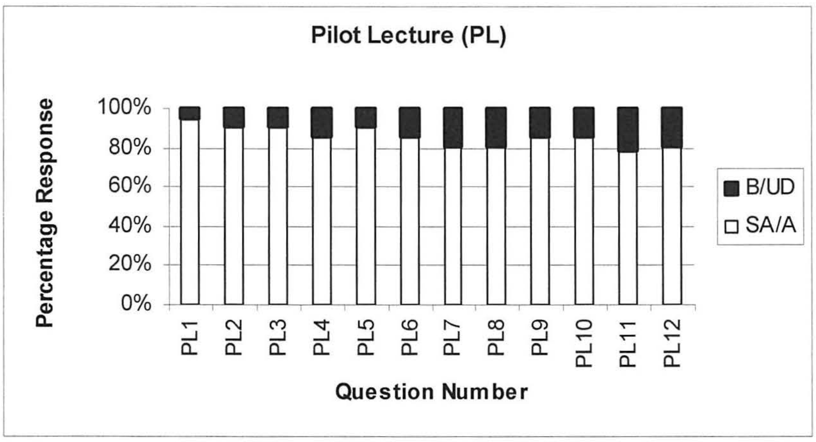
Summary of peer and self-evaluation	Actions
Class location in relation to farm	Address time table issue and room allocation
Farm classes to be negotiated with farm staff	Address time table issue and farm activities
Must limit the amount of information provided	Limit to no more than three main objectives
Bilingual handouts to be available	Translation

The 'actions' were implemented in all the lectures within FE and HE programmes and the final versions of the lectures can be seen in Appendix 1.

The pilot lectures and final lectures comparison

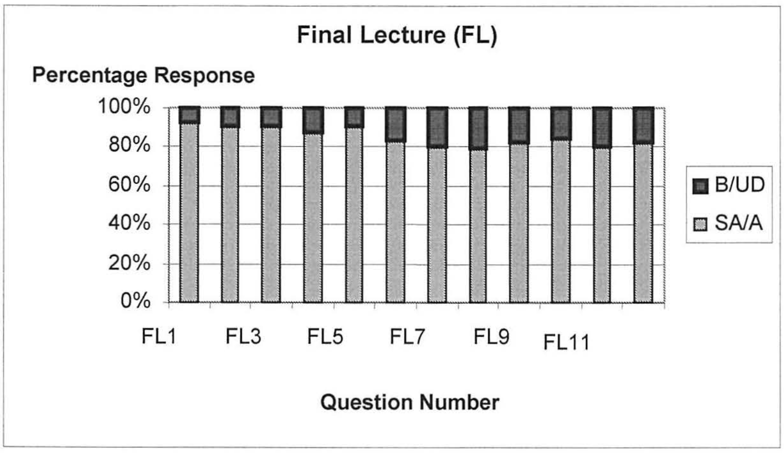
The pilot groups NVQ, NCA and HND (known as B1, in Table 3.7) and their corresponding groups for the final lectures (B2) had a response range of between 79% and 98% for 'SA/A'. There were no 'SD/D' responses and the 'UD/B' response appears on all the questionnaires within the range of 2% to 21% for both pilot lecture (B1) and final lectures (B2) as shown in Figure 6.2 and 6.3 respectively.

Figure 6.2. Pilot lecture response rate



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree
Strongly Disagree / Disagree (SD/D) received no responses during the evaluation

Figure 6.3. Final Lecture response rate



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree
Disagree / Strongly Disagree (D/SD) received no responses during the evaluation

6.3.5. The editing process of questionnaire for the lesson evaluation

The editing process resulted in 119 (or 93%) of the questionnaires being used for analysis. The remaining 9 (or 7%) questionnaires were omitted for reasons outlined in Table 6.8. Edited questionnaires came from the lower programme levels, NVQ, NCA, ND and HNC. Out of the 9 questionnaires, 5 had uniform responses, 2 'liar test' responses, 1 questionnaire had not been attempted and one partially completed questionnaire. These candidates openly admitted to their lack of effort even as they handed in their questionnaire. They were offered an opportunity to undertake a semi-structured interview. Only six of the nine respondents came to the semi-structured interview. On interviewing it was apparent that four candidates found it difficult to express an opinion on any of the educational matters and the semi-structured interview was inconclusive. The other two candidates, one on the ND and the other on the HND, expressed a very strong dislike for questionnaires (and generally found them 'a waste of time' and 'laborious') and failed to cooperate in a semi-structured interview (Table 6.8).

Table 6.8. Details of edited questionnaires

Programme level	No of questionnaires edited	Questionnaire Response	Interview response
NVQ	1	All questions filled as 'NA'.	Absent for interviewing
NCA	3	Liar Test	Unsure about most of the questions
		All questions filled as 'SA'.	Unsure about most of the questions.
		All questions filled as 'D'.	Unsure about most of the questions
ND	3	All questions filled as 'UD'.	Unsure about most of the questions
		Name on top with no questions answered	Absent for interviewing
		All questions filled as 'NA'.	Dislike for questionnaires
HNC	2	Liar Test	Dislike for questionnaires
		Three 'AS' response, while the others were all left blank.	Absent for interviewing.

NVQ=National Vocational Qualifications; NCA= National Certificate in Agriculture; ND= National Diploma; HND/C = Higher National Diploma/ Certificate; BSc = Bachelor of Science; and MSc = Master of Science.

6.3.6. Response rate to the questionnaire's open questions

As can be seen in Table 6.9, the BSc, MSc and Farmer's groups had 89% response (written comments) to the open questions (Questions 13,14 and 15), compared with only 25% for the groups located on the FE site.

Table 6.9. Number of open questions responded to the analysis

	NVQ	NCA	ND	HNC/D	BSc	MSc	Farmer Group
No of Questionnaires	17	15	22	19	19	13	23
No of comments	4	3	6	5	19	12	18
% comment	23	20	27	26	100	92	78
% based at FE and HE sites	25%				89%		

NVQ=National Vocational Qualifications; NCA= National Certificate in Agriculture; ND= National Diploma; HND/C = Higher National Diploma/ Certificate; BSc = Bachelor of Science; and MSc = Master of Science.

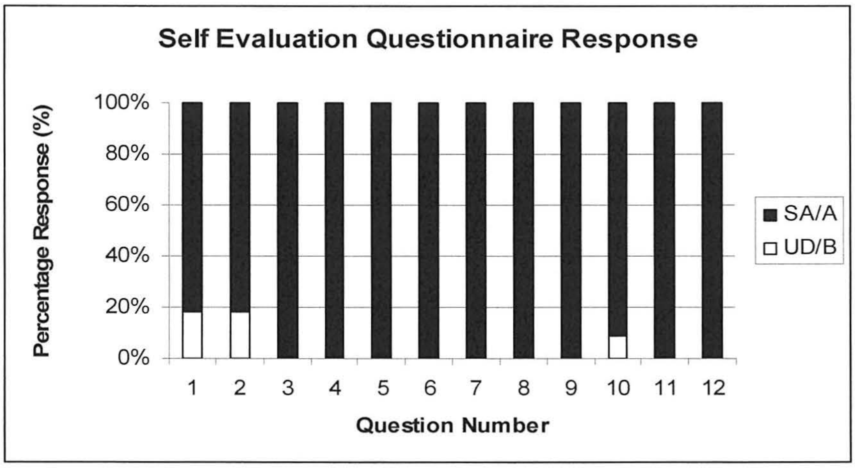
6.3.7. Academic year 2002-2003 and 2003-2004 results

Chi-squared analysis revealed no significant difference between the responses obtained for academic year 2002-2003 and those of academic year 2003-2004 (Appendix 1, Table 6.16). The two academic year's results were therefore combined for analysis.

6.3.8. Self evaluation questionnaire results

All questions had 'SA/A' response for the FE and Farmer's group. The HE groups, BSc and MSc gave the response category undecided (UD) for questions 1, 2 and 10 (Figure 6.4). Self evaluation comments were written and included general descriptions and feelings about the lectures as well as the students' response during the lectures.

Figure 6.4. Self-evaluation questionnaire responses



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree
Disagree / Strongly Disagree (D/SD) received no responses during the evaluation

Self-evaluation questionnaire responses were not significantly different ($P < 0.05$) across groups (Section 6.5).

6.4. STUDENTS' EVALUATION OF LECTURES

6.4.1. Individual questionnaire responses by all groups

The overall results from all the programme levels provided a positive response to the lectures. All 12 questions had an SA/A' response, ranging between 86% and 95%. The number of 'D' responses ranged between 0% and 3% for just under half (47%) of questions (questions 1, 2, 5, 7, 9, 10 and 12) and 'UD/B/NA' ranged between 5%

and 14%, for all twelve questions. Focus group discussions and open questions also provided positive feedback. Of the seven programme levels involved in this study, only three (ND, BSc and MSc) responded with negative comments.

Table 6.10. Percentage response to each question by all groups

Questions	SA/A (%)	UD/B (%)	SD/D (%)
QUESTION 1 (Understanding)	91	8	1
QUESTION 2 (At the right level)	88	10	3
QUESTION 3 (Organised)	95	5	0
QUESTION 4 (Explaining and understanding)	90	10	0
QUESTION 5 (Interesting)	92	5	3
QUESTION 6 (Subject knowledge)	90	10	0
QUESTION 7 (Learning objectives)	84	14	2
QUESTION 8 (Different teaching methods)	88	12	0
QUESTION 9 (Enjoyable)	86	13	2
QUESTION 10 (Theory and practice)	86	12	3
QUESTION 11 (Bilingualism)	87	13	0
QUESTION 12 (Handout)	86	12	2

B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree, SD/D = Strongly Disagree or Disagree

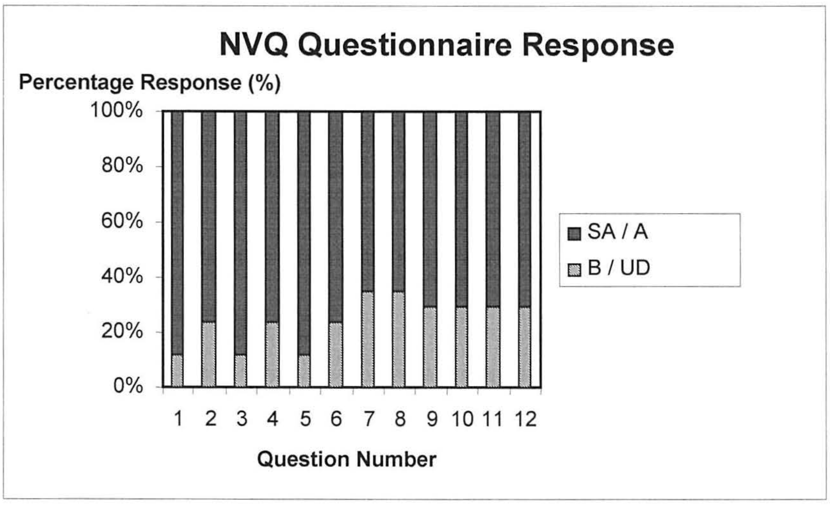
6.5. COURSE MATERIAL AND LESSON EVALUATION RESULTS BY GROUP

The following sections are results for each of the programme groups within the Further and Higher Education Institutes.

6.5.1. The NVQ programme level group

During the editing process one questionnaire was removed (Section 6.3.5, Table 6.8). Some questions were left blank and undecided (from 12% to 35%). However, the overall NVQ programme level group responded positively to all the questions with no 'SD' or 'D' response. The response for 'SA/A' ranged between 65% and 88% (Figure 6.6). During the focus discussion group all the candidates were able to support their 'SA' and 'A' responses with positive statements (Figure 6.7). Positive responses were received for the open questions by 4 students (Figure 6.8). It was clear from statements during the focus group discussion ('did something that will help me in my work') that industry-related activities were appreciated. Taking time to explain each stage was also valued as indicated by the comment 'each stage was explained' (Figure 6.7). Working together as groups was also appreciated with comments such as 'everybody involved and working together' (Figure 6.8).

Figure 6.6. NVQ Questionnaire Response



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree
Disagree / Strongly Disagree (D/SD) received no responded during the evaluation

Figure 6.7. Focus group discussion comments

'we did not have to sit in the class and listen and write'
'did a lot of different things, less boring'
'did something that will help me in my work'
'filling in the handouts was better than writing'
'did not have to take notes'
'spent time on the farm doing things'
'each stage was explained'
'useful farming facts'

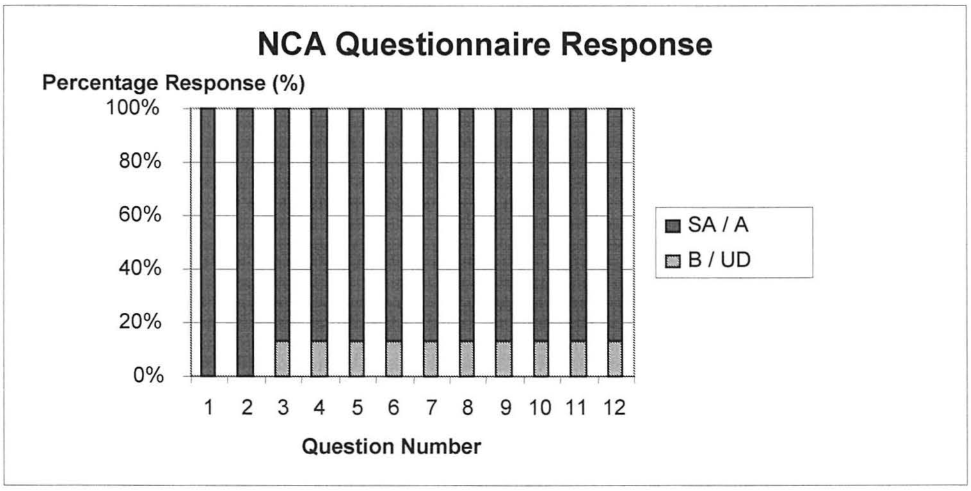
Figure 6.8. Open Question response (Question 13 and 15)

'interesting lesson not boring'
'explained well'
'good activities no writing'
'everybody involved and working together'

6.5.2. The NCA programme level group

Three questionnaires were edited from the NCA programme level group as discussed in Section 6.3.5, Table 6.8. The NCA group responded positively to all the questions with no 'SD' or 'D' responses. The 'AS'/A' response ranged from 87% to 100%, while the response for the 'UD/B/NA' ranged between 0 and 13% (Figure 6.9).

Figure 6.9. NCA Questionnaire Response



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree
Disagree / Strongly Disagree (D/SD) received no responded during the evaluation

During the focus group no negative response was expressed. The comments obtained during the focus group discussion (Figure 6.10) and the open questions (Figure 6.11) supported the 'SA/A' response provided by the NCA group. It was apparent that industrial related activities, and gapped handouts, combined with exercises, were strongly approved of with comments such as 'it was practical and useful', 'had work sheets' and 'exercises and handouts were good'. Also explaining issues in Welsh during the lecture was appreciated, receiving statements such as 'it was explained to us in Welsh'.

Figure 6.10. Focus group discussion comments

'it was related to farming'
'it was explained to us in Welsh'
'it was practical and useful'
'no sitting and listening but discussing cows'
'not too much useless information'
'variation in things'
'had work sheets'

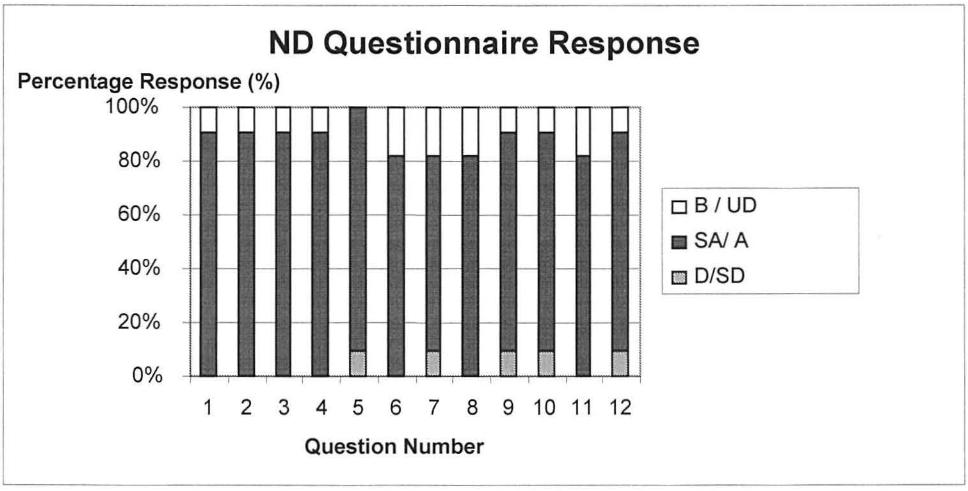
Figure 6.11. Open question response (Question 13 and 15)

'information that can be used at home on the farm'
'interesting information'
'exercises and handouts were good'

6.5.3. The ND programme level group

Three questionnaires were edited out of the ND programme level group (Section 6.3.5, Table 6.8). All the three response categories (B/UD/NA, SD/D and SA/A) were provided by the ND group on the questionnaires (Figure 6.12).

Figure 6.12. ND Questionnaire Response



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree

The 'UD/B/NA' responses ranged from 9% to 18%. The 'D' responses came from three (9%) candidates for five of the questions on the questionnaire and were supported by comments during the semi-structured interview (Table 6.9). The five questions to receive 'D' responses were 5, 7, 9, 10, and 12. Questions 5 and 9, concerning the students 'interest' and 'enjoyment', received 'D' responses by two students who disliked dairy cows. Questions 10 and 12 received 'D' responses by students who preferred farm tasks and considered nothing else to be 'practical'. Question 7 received a 'disagree' response by a 'late arrival' who had missed the lessons objectives at the start of the session.

Table 6.11. Focus group comments (to support the 'D' responses)*

Questions on questionnaires	**Description**	**Comment by students**
Question 5	Interesting	Disliked cows and dairy production.
Question 7	Lesson objectives	Turned up for class 10 minutes late (obviously a true answer).
Question 9	Enjoyable	Did not enjoyed the subject, they were also uninterested in dairy production.
Question 10	Theory and practice	'Carrying out Linear Assessment on the farm was not considered 'practical', as it was not 'hands on practical farm work'.
Question 12	Learning support	'Needed more practical'

*Semi structured interview

The questionnaire response to 'SA/A' ranged between 73% and 91%. Comments were obtained to support the 'SA/A' response. The focus group discussion (Figure 6.13) and open questions (Figure 6.14) led to comments on industrial related activities 'learn things that are essential for farming career'; gapped handouts with exercises, 'enjoyed the worksheet and the exercises'; and being able to converse in Welsh, 'able to do work in Welsh'.

Figure 6.13. Focus group discussion (response to 'SA'/A' response)

'valuable and useful information'
'easy to understand, what I thought was a difficult subject'
'range of useful work'
'enjoyed the worksheets and the exercises
'mature discussions and useful exercises'
'able to do the work in Welsh'

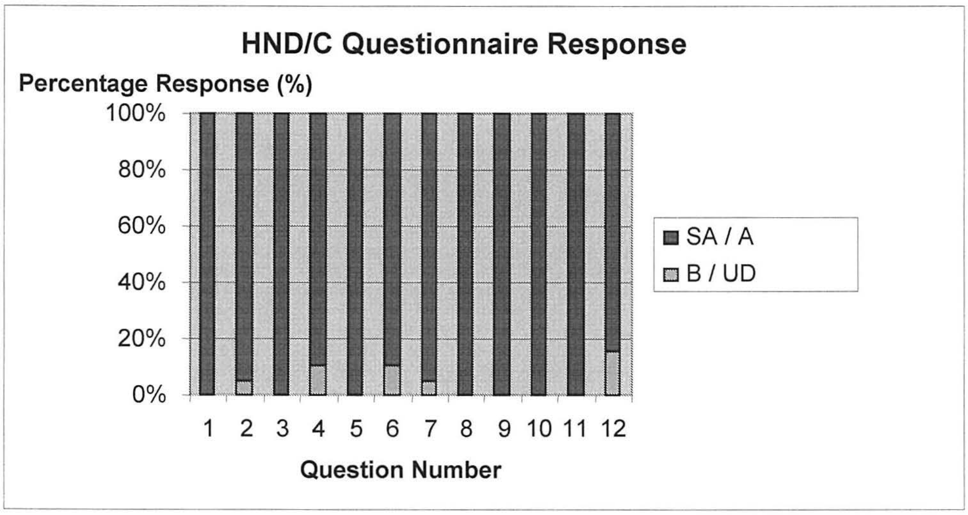
Figure 6.14. Open question response (Question 13 and 15)

'learn things that are essential for farming career'
'learn things that are useful in the future'
'learn things that are useful in everyday farming life'
'learn things that will help us in the future'
'learn things that I did not know before'

6.5.4. The HNC/D programme level group

Over half (58%) of the questions on the questionnaire within the HND/C had 100% response for the 'SA/A' category. The 'UD/B/NA' response ranged from 5% to 11% (Figure 6.15).

Figure 6.15. HND Questionnaire Responses



Disagree / Strongly Disagree (D/SD) received no responded during the evaluation

The open questions (Figure 6.16) and the focus group feedback (Figure 6.17) support the group's positive responses. The use of computers within the lectures was approved of, with comments such as 'using computers to learn about selection and breeding was very good'. Comments were made on the industrial related activities presented through the medium of Welsh; 'good to have lecture notes in Welsh' and 'learn something we can go home and do for the farm' (Figure 6.16. and Figure 6.17).

Figure 6.16. Open question comments (question 13 and 15)

'structured and methodical lectures'
'using computers to learn about selection and breeding was very good'
'breeding jargon explained and shown how to apply in farming'
'all terms explained in simple language'
'good to have lecture notes in Welsh'

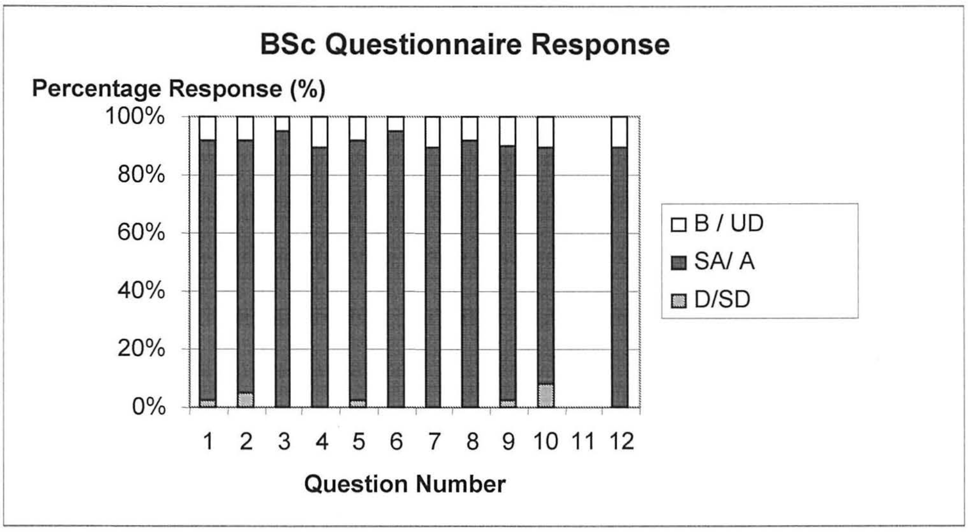
Figure 6.17. Focus group discussion comments

'combine theory and practical is really what we need'
'able to discuss in either language'
'enjoy using computers in the lecture'
'learnt something we can go home and do for the farm'
'will be able to read and understand bull / cow selection
'I appreciate the application of breeding with other livestock'

6.5.5. The BSc programme level group

Questionnaires provided feedback for all three response categories (B/UD/NA, SD/D and SA/A) (Figure 6.18). An overwhelming positive response was obtained and comment were specifically given for the 'SA' category on the closed questions of the questionnaire as well as for the open questions (Question 13 to 15), Figure 6.18 and Table 6.12. Explaining issues, having an organised varied approach, and relating lectures to industry were all appreciated.

Figure 6.18. BSc Questionnaire Responses



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree
Bilingual questions not included in the questionnaire

Positive responses were given to the closed and open questions (Figure 6.19 and Table 6.12). Comments for 'SA' as found in Table 6.10 included statements such as 'had no subject knowledge, I now feel I gained good understanding'; 'good use of theory and practice'; and 'very interesting and enjoyable'.

Table 6.12. Questionnaire response for closed questions

Questions	Description	Comment made for an 'SA' response
Q1	Understanding	' had no subject knowledge, I now feel I gained good understanding'
Q2	Right level	'everything was explained very clearly'
Q3	Organised	'very well organised'
Q5	Interesting	'variety of method used'
Q6	Subject knowledge	'good answer to all questions asked'
Q9	Clear style	'very interesting and enjoyable'
Q10	Theory and practice	'good use of theory and practice'
Q12	Handout	'informative and well laid out'

Example of Strongly Agree responses only

Responses to the open questions (Figure 6.19) also included references to the application of information to industry, and ensuring understanding through explaining issues in a clear and structured way. Comments such as 'the practical aspect, being able to see the principles discussed at first hand, ideal for non-agricultural background students'; 'enjoyed actually relating information to real animals outside'; handout backs up information give in the lecture – can see for yourself what it means'; and 'thoroughly enjoyable, informative and well presented', all suggest student satisfaction with respect to teaching and learning.

Figure 6.19. Open question responses (Questions 13 and 14)

'very informative, well organised + structured'
'thoroughly enjoyable, informative and well presented'
'very interesting and enjoyable'
'very well explained. Good effort'
'handouts backs up information given in the lecture – can see for yourself what it means'
'the lecturer was easy to understand and willing to explain and answer questions'
'seeing animals made it easier to understand'
'enjoyed actually relating information to real animals outside'
'seeing theory in practice'
' it was good that the liner assessment was explained while looking at the cows, easier to see what it means than looking at pictures'
'being able to look at the herd, rather than just theory /photos'
'going out to the cows, applying the linear assessment to the animals'
'the practical aspect, being able to see the principles discussed at first hand, ideal for non-agri students'

Comments regarding aspects of dislike were given by three out of the 19 respondent. Comments were provided on specific questions of the questionnaires (Table 6.13) and for the open questions (Figure 6.20). It was apparent that a minority of students felt there was too much information and handouts. Also the term 'practical' was misleading for some students. Some students wished for the dairy selection index to be explained further (Figure 6.20).

Table 6.13. Questionnaire response on specific questions (to support the 'D' responses)

Questions	No of comments	Comments given in the box
Q1(understanding)	1	'Too many handouts'
Q2 (right level)	1	'More pause needed to recollect and absorb information'
Q5 (interesting)	0	
Q9 (clear style)	1	'Too many handouts to swap between'
Q10 (theory and practical)	3	1. 'Very little practical compared due to compaction and no of animals together' 2. 'Would have appreciated being able to properly undertake practical activities (assessment) lack of time' 3. 'More time given to assessment in the field'; more examples of how particular aspect relate practical to the farm would have been helpful' and 'more explaining of ideas'.

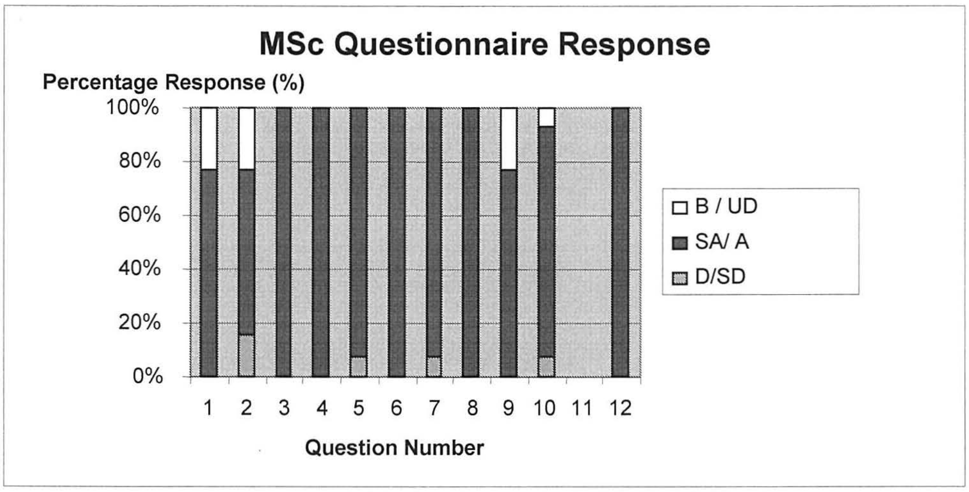
Figure 6.20. Open Questions comments for aspect that you disliked (Question 14 and 15)

' lot of handout and information to go through' and 'too much paperwork'
'some of the ideas were a bit confusing such as PIN, PTA'
'hard to follow – got confused at times'
'more explanation needed'
' not being able to see the overhead or flip chart from the back, too low down'
'overhead were obstructed'

6.5.6. The MSc programme level group

The MSc group's feedback to the lecture included all three categories (B/UD/NA, SD/D and SA/A). A third of the questions had 100% response to the SA/A category as shown in Figure 6.21.

Figure 6.21. MSc Questionnaire Responses



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree
Bilingual questions were not included in the questionnaire

Positive responses outweighed the negative comments. Positive feedback by students included complements on 'the exercise about PTA'; the mathematical elements of breeding like PTA, PIN, PLI'; 'enjoyed the topic and explanation of EBVs and how its calculated'; and that 'it was a clear way of teaching' as found in Figure 6.22 in addition to those in Figure 6.24 and Table 6.15. Negative comments were received for the amount of information in the given time as well as the number of handouts (Figure 6.23). The interpretation of what 'practical' should be was also raised (Table 6.14).

Figure 6.22. Open questions (aspects that you liked) Question 13

'the mathematical element of Breeding like PTA, PIN, PLI'
'the exercise about PTA'
'selection'
'to have time to work out calculations for heritability, repeatability in the lecture which allows better understanding'
The provision of plenty of handouts was very helpful
Practicability and efficiency
Practical involvement with the subject
It was a clear way of teaching
Learning resources (presentation, slides, overhead sheet, handout)
Enjoyed the topic and explanation of EBVs and how its calculated
It was good

Figure 6.23. Open questions (aspects that you disliked) Question 14

Some areas seemed a little rushed eg going through examples
Would have liked to have more time to go through it in more detail
To have different type of material given at the same time. Handout and acetate that were different and didn't have time to listen to what was being said.
Reading material – very helpful, but quite a lot sharing similarities of phrases

* provided by student in the academic year 2003-2004 only

Figure 6.24. Open question (further comment on any aspect) Question 15

'a handout of overhead material would have been useful.'
'I don't have much to say only that I have done the course some good years back so it is a good refreshment of memories. It has been nice'

Table 6.14. Response to specific questions (to support the 'Disagree' responses)

Question form questionnaires	Description	Comment provided on questionnaire
Question 2	at the right level	'could have been more detailed on biology of breeding…description of biology'.
Question 2	at the right level	'It is a repetition'
Question 5	Interesting	'No comment provided.'
Question 10	practical and theory	'It is a lesson, it was not designed to be a practical'
Question 7	lesson objectives	No comments

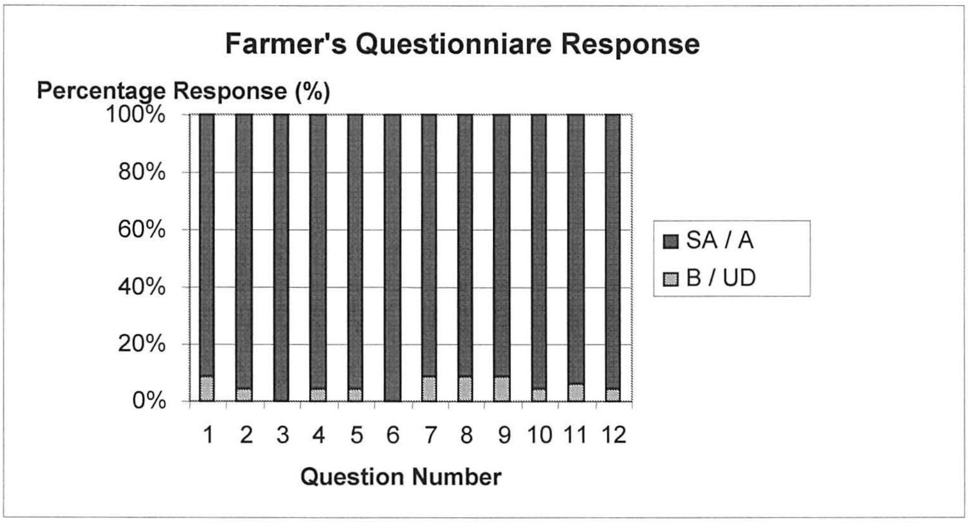
Table 6.15. Response to specific questions (to support the 'Strongly agree / Agree' response)

Question form questionnaires	Description	Comment provided on questionnaire
Question 1	Understanding	It had helped me to revise areas which I already knew about
Question 2	at the right level	I did not learn anything new apart from ASREML
Question 8	Different teaching methods	But there is a limited scope for varying in a University course compared to school classroom
Question 10	practical and theory	Examples and exercises so it is good.
Question 12	Handouts	'good for you to do real life examples… clear structure and clear thought'

6.5.7. Farmers' group

The Farmers' group provided a positive feedback with a range of 91% to 100% response for 'SA/A' questions (Figure 6.25). No negative feedback was given and positive responses were found for the open questions (Figure 6.26).

Figure 6.25. Farmer's questionnaire response



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree
Disagree / Strongly Disagree (D/SD) received no responded during the evaluation

It was apparent from the comments that industrial related information was appreciated and considered useful and worthwhile by the all the farmers' group. The positive responses included statements such as 'practical solution in selecting animals for breeding' and that lectures were 'enjoyable and informative'.

Figure 6.26. Open question response farmers' group

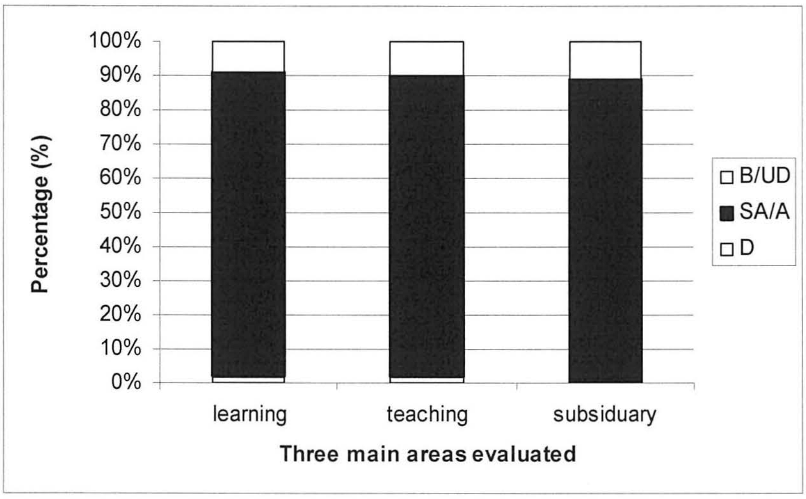
*' practical solution in selecting animals for breeding'
*' good use of scientific knowledge given in a practical way'
*' enjoyable and informative'
*' interesting and well thought out'
*' good use of farm data in education'

* one quote taken as a representative of other similar comments

6.6. THE EVALUATION OF TEACHING AND LEARNING

The questionnaire was directed primarily at evaluating teaching and learning. When all the results for the FE and the HE were evaluated with respect to the learning experience, teaching style and subsidiary issues (Figure 3.5, Section 3.8.3), it was found that the 'SA/A' category ranged between 88% and 89% for all three areas with only 2% for the 'D' category (Figure 6.27).

Figure 6.27. Teaching, learning and subsidiary issues



B/UD = Blank or Undecided, SA/A = Strongly Agree or Agree, D=Disagree

6.7. DISCUSSION

6.7.1. Pilot lectures and questionnaires

The initial stage of the educational evaluation involved the piloting of the lectures on Selection and Breeding (Section 3.8.7). The questionnaire (Section 3.8.5) to be used in the evaluation was also piloted. No major weaknesses were identified for action planning in the lecture or the questionnaires (Table 6.1 to 6.6). The actions undertaken were student preferences and were all justifiable within the context of teaching and learning.

During the piloting of the lectures self, peer and students' evaluation noted the fact that too much information was provided within one session. Learning objectives were then limited to no more than three per lesson. Too much coverage as discussed by Biggs (1999) should be avoided, as it can overload the short-term memory (STM) (Petty, 1998) (Section 2.10.3). Bilingualism was not highlighted as an issue when piloting the lectures and the questionnaire. However, during the focus group discussion bilingualism was found to be a sensitive issue by most of the students within the FE groups. Bilingual provision can be justified given Coleg Meirion-Dwyfor's Welsh Language Policy.

Quantitative analysis found no significant differences between the draft and the final versions of the questionnaire or the lectures (Section 6.3.3 and 6.3.4 respectively). These results therefore support the fact that 'professional judgment is a good starting point' within education (Williams and Baker, 1999); HMI, 2000). Piloting the questionnaires and lectures confirmed the fact that students were capable of completing a questionnaire and were able to make judgments on most aspects of teaching and learning.

6.7.2. Self evaluation questionnaire

Self-evaluation questionnaire responses (Figure 6.4) were not significantly different ($P < 0.05$) across groups. Overall, a positive teaching and learning environment was achieved.

However, during the self-evaluation of the HE groups (BSc and MSc) it was suspected that one or two of the students had not understood the lecture. Clearly, with a diverse group of students, some student will be familiar with the subject and others completely new to the subject. The White Paper on the Future of Education (January, 2003) highlighted the fact that more diverse groups of students will enter higher education and provisions should be in place to deliver more flexibility in courses. These lectures on selection and breeding were flexible and were adapted to suit various abilities. Additional handouts were prepared for students that were new to the subject and supplementary exercises were written to stretch the more able students. However, the diversity of the students should have been identified at the start of the lecture, stressing the importance of knowing the student group (Moore, 2000). In most cases the lecturer would know their students, but with a one-off evaluation study this was not the case, as the characteristics and background of the students were unknown.

The data set was flexible and could be adapted with the minimum of time and effort for a diverse group of students. Supplementary exercises were primarily written to stretch the more able students. They were used for the NVQ 2003-2004, a mixed ability group. They were also used for the NCA 2003-2004, ND 2003-2004 and the HND/C 2002-2003 lectures.

As mentioned above additional handouts were prepared for students that were new to the subject. However, as the students were unknown these additional notes were taken by all the students, rather than helping the ones who were new to the subject. Therefore, this led to comments claiming that there were too many handouts (Section 6.5.5.and 6.5.6). If these students were a known group (as in the case of the NVQ 2003-2004) then it would have been possible to target these students to ensure appropriate level and understanding.

6.7.3. The importance of focus group

Quantitative analysis allows results to be made and qualitative analysis gives an explanation (Cohen *et al.,* 2000). Student preferences were identified by qualitative analysis. Qualitative analysis and the use of focus group discussions were valuable methods for the FE groups who failed to provide written comments. Fortunately, timetabling made it possible to conduct a focus group discussion for the FE groups. The FE groups preferred to express their views verbally rather than in writing on the questionnaire. Certain issues, for example bilingualism, would not have become apparent unless focus group discussions had taken place (Figure 6.7 and 6.10).

6.7.4. Questionnaire response for the open questions

Open questions were mostly left blank especially within the FE groups (Table 6.8 and 6.11). More effort is required to think of an answer for an open question (Cohen *et al.,* 2000) and very often students' views on education are limited (McNiff, 1999). Good teaching and bad teaching was unthought-of by many students in the FE group and innocently believed that 'every teacher was good or otherwise would not be in the job'. Also schooling had not given them the experience to answer or have an opinion on educational matters, compared to the HE groups who were older and who possibly had experienced different teaching styles. Focus group discussions had the advantage of allowing issues to be discussed and opinions to be expressed by the FE groups, so that preferences could be identified and expressed on educational matters.

6.7.5. The response category on the questionnaire

During the completion of a questionnaire every effort was made to encourage students to look over their questionnaire to ensure that they had responded to all questions. Good, honest efforts were made to complete the questionnaires. However, 'B/UD/NA' responses were given by all groups for all questions, equally within the pilot and final versions.

Interestingly this was also the case in the self-evaluation questionnaire. It was found that in the evaluation of lectures certain situations made it difficult to fully 'agree' or fully 'disagree' and the 'undecided' response was an option that was taken (as in the case of Question 1 and 2 for the HE groups). Possibly the 'agree' and 'disagree' were too far apart and consequently led to an undecided response. Possibly a combination of dichotomous and rating scales should have been adopted. However, this would have complicated the questionnaire. It is definitely an issue that should be addressed within future evaluations within education.

However, in some cases the 'undecided' response was a non-committal answer and/or lack of understanding and experience. In the case of some of the students in the NVQ and NCA groups (Section 6.5.1 and 6.5.2), it was impossible to get rid of the 'undecided' response even when the questionnaire was read and explained during the focus group discussion.

During the focus group discussions it was found that it was difficult to distinguish between the 'agree' and the 'strongly agree' response. Cohen *et al.* (2000) also referred to the fact that 'SA' to one person can be an 'A' to another. The ND group discussions suggested that if the first question had been answered with a 'strongly agree' then the rest would follow with 'strongly agree' response and similarly for an 'agree' response.

6.7.6. Individual question responses by all groups

QUESTION 1 (Understanding)

Understanding must be achieved for learning to take place and can be attained through various methods (DFES, 2005). Understanding can be sufficiently measured by the learner (Webb, 2004). Therefore, with 91% confirming to having understood the lectures it can be concluded that an active approach using real herd data had successfully achieved 'understanding'. However, a small minority of students (three students) responded negatively; the BSc group provided a 'D' response, while the MSc group gave a 'UD/B/NA' response. This possibly reflects the diverse abilities and background of the students within the HE groups as discussed in Section 6.5.6.

During the focus group discussions, the bilingual students within the FE groups stated that their understanding improved when they were able to converse in Welsh. Welsh-speaking students were sensitive to the language used and felt that when English conversations were used they became afraid to ask, for fear of being considered ignorant, stupid or inattentive.

QUESTION 2 (At the right level)

Knowing the student group is important in order to deliver the lecture at the right level (Moore, 2000). The FE groups were known groups and were less diverse than the HE groups. As for question 1 the Higher Education group gave responses to the 'D' and the UD/B/NA categories. However, with an 88% response to the 'A/SA' by all groups it can be stated that the lectures were at the right level for the majority of the students.

QUESTION 3 (Organised)

It was found that 95% of the students agreed that the lectures were well organised. Planning the lesson, setting aims and objectives is an important aspect of teaching. A lecture that is delivered in an organised manner will influence understanding and learning (Race, 2001).

QUESTION 4 (Explaining and understanding)

Most students found explaining and understanding to be an important aspect of the lecture (Moore, 2000). Comments provided by the NVQ included 'explained well'

(Figure 6.8); NCA 'it was explained to us in Welsh' (Figure 6.10), ND 'easy to understand, what I thought was a difficult subject' (Figure 6.13); HND/C 'all terms explained in simple language' (Figure 6.16); and BSc 'everything was explained very clearly' (Table 6.10). The inclusion of exercises and discussions allowed opportunities for explaining to be carried out, as expressed by the MSc comment 'to have time to work out calculations for heritability and repeatability in the lecture which allows better understanding' (Figure 6.22). Also, the peer and group discussions at the end of the exercises ensured and reinforced understanding.

QUESTION 5 (Interesting)

The majority of the group (92%) found the lecturers to be interesting. The 'D' and the 'UD/B/NA' responses were given by the ND, BSc and MSc groups. Dairy production did not appeal to all students, especially those that have been brought up on hill and upland farms, as commented by some of the ND student during the focus group discussion (Table 6.9). Similarly some students of the diverse group of HE students could well have found the subject of no personal interest.

QUESTION 6 (Subject knowledge)

During the focus group some of the FE students questioned the need for this question as it was expected that the lecturer knew the subject, resulting in a 10% response for the 'UD/B/NA'. Overall the results were positive, with 90% responses in the 'SA/A' category.

QUESTION 7 (Learning objectives)

It is important that students know what they are expected to do (Petty, 1998). Some students were unclear as to what 'objectives' meant and direct translation failed to clarify the meaning of the word. The 'UD/B/NA' was mostly provided by the FE groups. The 'D' response was given by a student who had arrived late and missed hearing the introduction. It could be claimed that this answer reflects an honest response to the questionnaire (Table 6.9).

QUESTION 8 (Different teaching methods)

In order to satisfy all students, different teaching methods, styles and environments (class and farm) were provided which was found to increase students' attention

(Curzon, 1999; Cannon and Newble, 2000; Liu and Ginther, 2004). Some of the FE students were unaware of the fact that different methods of teaching were used consciously, and found it to be a 'difficult question'. An interesting comment was provided by one student (Table 6.13) that 'there is a limited scope for varying in a University course compared to school classroom'. Having the herd data set allows different teaching methods to be adopted with ease for a range of learning styles.

QUESTION 9 (Enjoyable)

Curzon (1999) explained how past experience and the removal of perception and threat from the learning environment is sometimes required for effective learning to take place and for it to become enjoyable. The introduction of the herd data and the involvement of the farm and the herd provided an enjoyable learning experience for the majority of the FE students. Response to the 'D' was obtained from ND (the sheep farmers) that agrees with responses for questions 5 (Section 6.5.3).

QUESTION 10 (Theory and practice)

Practical work, in the sense that an active approach is taken, has the advantage of linking theory to practice (Reece and Walker, 1998) (Section 2.10.5). 'Practical' is defined differently by different students. With respect to this evaluation practical means an 'active' involvement as opposed to a 'didactic' method of teaching. The meaning of practical for other students is 'hands on activities on the farm' (Table 6.9). This question should be rephrased for future use within educational questionnaires.

QUESTION 11 (Bilingualism, FE groups and HND/C)

All lecture notes and the questionnaire was translated following the pilot sessions. All students were reluctant to admit in writing (open question) that they preferred bilingual questionnaires and lectures. However, during the focus group discussions many admitted to have understood the Welsh version better. They were ashamed that they did not fully converse confidently in both languages. Most students felt ashamed to admit their language preference, and therefore, bilingualism issues were only raised during focus group discussions. An appreciation of bilingual provision was expressed during the focus group discussion, but not on the questionnaire.

As discussed by Baker (2001), not all bilinguals are 'balanced bilinguals' and one language dominates the other under different situations. Bilinguals will use two languages with different people, and for different purposes or even one language for conversation and the other for writing and reading. This is often the case with many of the bilingual students within the FE site. Also a situation may arise where a person may not have sufficient competence in either language and is known as semilingual (Baker, 2001), which again can be found in the lower level groups as in the case of the questionnaire with the word 'objectives'. Therefore the type of language used within translation is important. Bilingual education must provide the help needed to allow students to meet their 'educational goal' (Kemppainen *et al.,* 2004).

Understanding how bilinguals may use their language in learning was discussed by Haritos (2004), and was suggested to be determined by personal and contextual variables. 'Personal variables' include the social and cognitive relationship of languages within the classroom, home, and community. 'Contextual variables' include the type of task and social interaction surrounding the task. The FE students wanted to use the English terms, but preferred to discuss them in Welsh, as they felt that they attained a better understanding through Welsh. Reservations were expressed as to the translation of English terms into Welsh. It was felt to handicap them when they are out in industry. These attitudes confirm the fact that the choice of language will be determined by social mobility, labour market and higher education opportunities as was discussed by Kemppainen *et al.* (2004). The students felt that they wanted to improve both languages as both were essential for the field of work, and engaging with friends, family and professional people. It can be said that FE students prefer to be translanguaging, which is the 'random switching to and from languages' with a concurrent use of both Welsh and English languages (Baker, 2001).

Students were asked about their pattern of language usage, including language(s) spoken by parents and siblings at home and on the farm, language preferences, and self-assessment of language abilities. It was found that the dominant language was Welsh for the NVQ, NCA and ND group in terms of communicating with friends, at home, on farm and at the place of work. Welsh was also the preferred language of communicating. When asked about their language ability, they gave a much higher scoring for Welsh of which was their first language. Self-assessment of their ability in English was on average lower. Some were more fluent and as expressed by Baker (2001) individuals differ in their learning of languages in terms of ability and aptitude. It can therefore be concluded that there is a need for the provision of agricultural education through the medium of Welsh within the FE sector. This will then give 'opportunity to extend and develop students' linguistic skills in a way that will promote independent learning and personal development' (Moore, 2000).

Without the use of focus group discussions and qualitative analysis, the importance of bilingualism within the FE groups would have been missed. Estyn has addressed bilingualism for all FE institutions in the new 'Common Inspection Framework' (HMI, 2000) with references to Welsh and / or bilingual aspects in several sections, either directly or indirectly. References have also been made in the Higher Education Council Strategic Aims 'to encourage each institution to play its part according to its mission in meeting the social, economic and cultural needs of Wales, including those associated with the Welsh language, and of the United Kingdom and beyond' (QAA, 2001). Therefore, the course materials were justifiably translated for all the FE programmes and the HND/C programme.

Where there are different cultures within a group it is important to respect and be sensitive to the need of each individual. As Bruner claimed 'culture affects the way in which children went about their school learning'. This is true at the FE site where students prefer to converse in their first language resulting in such comments as 'it was explained to us in Welsh' (Figure 6.10) (Moore, 2000).

QUESTION 12 (Handout)

It was anticipated that the BSc and the MSc were a diverse learning group and additional handouts from the lower programme groups were brought into the lecture. These were to be issued for the students that needed them, and for those who would find them useful. However, 'take it if you need it' did not quite go to planned as all the students took the 'additional' handouts. Hence, the students had an excessive amount of handouts to that planned. It was recommended by Petty (1998) that no more than two 'A4' double-sided handouts per hour should be given. However, the majority of the students (86%) found the handouts to be helpful. Two students from the HE groups even requested the Powerpoint presentation handouts, which were a summary of the handouts that were issued. There is a risk with handouts that students may never read them again (Reece and Walker, 1998), so it was anticipated that this would be minimised by giving students gapped handouts as part of an active approach to teaching.

Using real life, dairy herd data set, brings challenge and interest when designing handouts. They are easy to adapt and update as more information is obtained for the herd. Gapped handouts gave handouts a purpose. Handouts became a working document and as discussed by Cannon and Newble (2000) the handouts then had a purpose (Section 2.10.6).

6.7.7. Programme groups

NATIONAL VOCATIONAL QUALIFICATION (NVQ)

The NVQ group had the lowest academic entry requirement of all the programmes involved in this study. Although they possessed good practical experience and understanding of farming, the NVQ group gave the highest response to the B/UD/NA category. Focused group discussions highlighted the fact that some of the students had no opinion on educational matters. As these were straight from school, they had less experience on education issues and were indifferent to many aspects of teaching. They also did not consider themselves 'important enough to be given the choice'. It was questioned by Kember and Wong (2000) whether students could make appropriate judgments about teaching. However, focus group discussions provided evidence to support their questionnaire responses.

The importance of collaborative learning as described by Vygotsky (1978) was well displayed by the NVQ group. Being able to elaborate and discuss their learning with peers via farm activities was appreciated and commented upon (Figure 6.7 and Figure 6.8). They considered the farm practical activities 'Dairy Traits' (Worksheet 1) and Linear Assessment (Worksheet 2) to be worthwhile and of relevance to their own farms. The tasks were achievable, in accordance with the Behaviourist School (Section 2.9.2) that believe in praise and encouragement by giving achievable tasks. Using the herd and its data was an essential part of learning for the NVQ group where teaching and learning could be attained within a positive learning environment.

NATIONAL CERTIFICATE IN AGRICULTURE (NCA)

Using the herd and its data was considered to be the best possible solution to aid learning and provide a positive learning environment. It was expressed during the focus group discussion that carrying out exercises, explaining and understanding were important. The application of knowledge to everyday farming activities was also appreciated as well as the ability to converse in Welsh. 'Selection for Breeding' and 'Linear Assessment' farm practical activities were considered to be useful farming information 'making coming to college worth it'. The NCA group were motivated and mature groups, that preferred to find out rather than being told within a classroom environment. They displayed very much the Cognitive School (Section 2.9.2) beliefs of ask the learner, rather than tell and allowing problems to be solved through exercises. This involves creative thinking, where decisions and opinions have to be made. Activities involving the completion of farm exercise on breeding and selection bring problem solving and discussions into the learning process in a very positive way.

NATIONAL DIPLOMA IN AGRICULTURE (ND)

In this group there were two contrasting years in terms of student attitude, experience and ability. The 2003-2004 year was quiet, polite and complimentary, whereas negative responses were obtained from the academic year 2002-2003. The 2002-2003 group had not written any comments on the questionnaires initially and were specifically asked to write a comment for question 13, 14 and 15 before handing them in at the end of the lesson. Disappointingly, they completed question 14 on 'aspect they disliked', but during the focus group they apologetically admitted that it was an opportunity to express their opinion on an unrelated current issue. The responses to the open question were therefore edited. A semi-structured interview on a one to one basis was then carried out to validate the reliability of the remaining questions in the questionnaire. As with all the other groups a focus group discussion was then undertaken.

As for the other FE groups, bilingual education was considered important. Also the application of knowledge to farming situations, understanding and undertaking exercises were considered as being positive aspects of the lecture. Although the definition of 'practical' was misleading for some and the dairy cow was not a favourite animal amongst the students, many of whom were from beef/sheep farms. It can be concluded that the lectures in both academic years were an effective teaching and learning experience leading to overall student satisfaction.

HIGHER NATIONAL DIPLOMA IN AGRICULTURE (HNC/D)

Student numbers were low for the HNC/D programme level and had to be drawn from disciplines other than agriculture for both academic years. However, they had good knowledge of animal production in all the areas from agriculture, equine to small animals. The Imple-pro software package was understood and adopted to surprisingly well. During the lecture students soon began to appreciate the application of breeding using dairy cows. The overall response was very encouraging as a response of 100% was obtained for questions 1, 3, 5, 8, 9, 10 and 11. Also, they expressed no dislikes on the questionnaire or during the focus group discussions.

Piaget's notion of development from concrete to formal thinking was applicable for the HND/C group (Moore, 2000). Existing knowledge concepts and understanding of animal production within their field, was used to promote further and more complex understanding of dairy breeding and selection. The application of selection and breeding to practical dairy farming was valued. Introducing dairy breeding values (PTA) for dairy trait and selection index (£PIN and £PLI) through the use of computers allowed an active approach and relating the data to a real herd maintained interest and motivation that was highly commended by all members of the groups.

Bachelor of Science (BSc)

The questionnaires were completed fully by the entire group. Comments were written by all of the students (Table 6.9) and none had to be edited (Section 6.3.5). Their comments, both positive and negative show that what pleases some may not please others (Figure 6.19, 6.20 and Table 6.12 and 6.13). The diverse student group made it very difficult to please all the students and consequently one would expect some negative responses. A small number of the students would have appreciated more time to explain £PIN and PTAs. The lesson coincided with farm activities (afternoon milking), which made carrying out Linear Assessment exercises difficult on the farm. This was expressed by some of the students (Table 6.13).

Qualitative analysis revealed that explaining, understanding and delivering the lecture in a clear, structured and organised manner was important. Variation in the method of teaching was commented upon positively. The use of handouts and application of knowledge to farm situations using farm animals was appreciated. This supports Reece and Walker (1998) who noted that much more information is taken in when seeing rather than listening.

Master of Science (MSc)

The MSc students group had opinions on educational issues and were able to express their feelings in writing. As the academic year 2002-2003 group was a smaller group which had been previously met, it was therefore easier to ascertain their level of knowledge and understanding and to cater for individual needs within the group. However, this was not the case with the academic year 2003-2004.

The latest version of ASREML had not been released when the lectures were written. It is possible that the latest version would have clarified some of the issues raised in the class when conducting the selection exercise using EBVs during the academic year 2003-2004. However understanding had been achieved and the practical application, involving real herd data was appreciated. The use of real data within the exercises resulted in the work being taken very seriously when discussing breeding values and calculating heritability. Aspects of teaching and learning proved to be successful in terms of teaching and learning. However a minority of two students considered the pace of the lecture too rushed and one claimed that there were too many handouts. It can be concluded that using a manageable data set size such as that for the Glynllifon herd to demonstrate ASREML was successful in terms of teaching, student learning and satisfaction. The use of the computers and the ASREML software 'added value' to educational experience as described by Dexter and Doering (2003) (Section 2.10.6).

FARMERS' GROUP

The Farmers' group consisted of participants from industry of all ages, who visited the college as well as prospective students. Their views were very complimentary with no dislikes. The course materials used were those of Higher National Certificate /Diploma, National Certificate and National Diploma. Their approval confirms the effectiveness of the course material in terms of teaching and learning outside the programme level groups.

6.7.8. Three main areas of the evaluation

The individual questions on the questionnaire were grouped into three areas and were designed to evaluate the learning experience, teaching and subsidiary issues (Figure 3.5) for all the programmes.

THE LEARNING EXPERIENCE QUESTIONS

The learning experience questions were in relation to 'understanding' (Question 1); 'at the right level' (Question 2); 'interesting' (Question 5); 'learning objectives' (Question 7); and 'enjoyment' (Question 9). A positive response was obtained from all groups for all the questions with an overall response range of 84% to 92% to the 'SA/A' category. It can be confidently stated that an overwhelming majority of students within all the groups found the lectures to be a positive learning experience and had achieved learning satisfaction.

It is important to create a positive learning environment. Some of the FE students are anti formal education. School experience of pain, anxiety and frustration was not uncommon for many of the FE students. It can make students feel vulnerable, uncertain, and frustrated (Cbin, 2004). Therefore previous perceptions must be removed from the learning environment. The educational experience at college must be socially and mentally safe for students to enjoy learning. Learning is most effective when it takes place in a non-threatening situation (Petty, 1998; Cannon and Newble, 2000). Allowing the agricultural students to take responsibility for their learning in farm related tasks and to encourage rather than seeking fault with students was considered very important (Cannon and Newble, 2000).

It is also important to appreciate that students are busy with activities outside the university and college. Many have family, social, recreational and employment commitments (Chambers and Fuller, 1996). Freeman and Thomas (2005), also pointed out that it is important to accept the fact that 'the educational environment may not be the most important place in which the students work'. The FE agricultural students during weekends become active members of working farms and have little time to complete assignments. Therefore class activities, short exercises and the avoidance of over-assessing is an important consideration when planning lessons and assessment schedules.

Creating a learning environment that provides a worthwhile experience for all the students was important. Race (2001), suggested that it is important to think of three different student types. Some students will 'want to learn', some will 'need to learn' and some have been 'told to learn'. It was also possible to identify students' attitudes throughout the study towards learning using the Grasha Richman Student Learning Style scale (GRSLS) (Section 2.9.3). With so many variations among students in terms of learning preferences and personalities, adopting an innovative active approach was the most appropriate method to take (Court and Molesworth, 2003).

THE TEACHING STYLE QUESTIONS

It can be concluded that a positive response (86% to 95%) was attained for an active innovative method of teaching involving the herd and its data. Adopting an active learning approach, and aiming for understanding, had an impact on students' learning (Kember and Leung, 2005) and was appropriate for all the student groups.

As discussed by Kember and Wong (2000), positive results would be expected from the FE students who have an active belief about learning. These students see learning as an active process, but would not give a high rating to a traditional, didactic method of teaching. Likewise, students who had a passive concept of learning would discourage an innovative active method of teaching. This was not found to be the case, as all groups within HE and FE, from level 1 (NVQ) to level 5 (MSc) provided positive a response to an active method of teaching.

OTHER SUBSIDIARY ISSUES

Subsidiary issues as referred to by the HMI for FE institutes include subject knowledge and bilingualism (HMI, 2001). Both subsidiary questions were sensitive questions for the students and lecturer. However it can be claimed that a positive outcome for the two questions were achieved. Subject knowledge needs to be ensured, especially when the programme level ran form NVQ to MSc in the study. Bilingual (Question 11) was apparent during the focus group discussion only, but quantitatively and in terms of written comments it could easily have been underestimated.

6.7.9. An active approach to learning

Taking an active part in learning was a 'concrete experience' for all programme groups. Active approaches through group work and discussion on the farm, allow students to acquire interpersonal and intellectual skills (Bruening *et al.,* 2002). It is important that students learn how to work and solve problems together as it is an essential part of adult working lives.

Interestingly, an active and deductive approach to teaching has as much value today as it had at the beginning of the twentieth century, as was advocated by Sir George Stapledon (1882-1960) at Ponterwyd in 1913. He expressed his views on education in an unpublished, undated manuscript at the beginning of the 20th century that was reviewed by Moore-Coler (2000). Stapledon believed that to attain progress in real learning an active innovative approach is required. He claimed than that the 'petty education' then was "... suffering from the repetition of well proven facts obtained by poaching on all out researchers," what he referred to as the 'Choke-me-facts-and-leave-me-to-die repetition type education' (Moore-Coler, 2000). Vygotsky also advocated the 'active meaning-making process' as opposed to 'rote learning' (Section 2.9.2).

The lactation records data set allows students to explore and find information from the data such as trends, effect of parity or genetic progress as opposed to being told, as advocated by the cognitive school. All groups in the study from the HE, FE and Farmer's group appreciated an active innovative method of teaching. Relating real life, industrial situations are an important element of education. Education must not be isolated from their respective industries and organisations.

The most effective teaching strategies found by Hong and Hong (2005) were reported to be student-centered activities, relating between teaching content and real life, open-ended questions, encouragement of creative thinking and the use of technology. This is very much a similar list of headings used in this study. These innovative active approaches to teaching are a mixture of teaching strategies, also confirming the fact that a variety of teaching methods must be applied. A variety of teaching methods can also be the best method to accommodate different learning styles (Court and Molesworth, 2003).

6.7.10. Conclusion

Questionnaire responses, focus group discussions and semi-structured interviews support the use of data and the dairy herd in the delivery of the lecture on 'Selection and Breeding'. Direct involvement with industry, through the use of the college farm and its data results in a positive contribution to students' learning and satisfaction. All the minor shortcomings were out-weighed by strengths with respect to teaching, learning and subsidiary issues. Both the qualitative and quantitative data yielded positive responses to lectures when analysed in terms of individual programme groups (Section 6.7.7), individual questions (Section 6.7.6) and when classed as learning, teaching and subsidiary issues (Section 6.7.8).

This study supports the fact that herd data lends itself to an active approach to learning. The use of the herd data was successful in all programme groups. It can be concluded that the application of knowledge to real life situations within the related industry via exercises, discussion, handouts and use of technology accounted for a positive experience in terms of student learning and satisfaction. Explaining and providing actual examples drawn from the industry (dairy herd lactation records) increased interest, motivation and understanding. The use of the dairy herd and its data provided a positive and effective environment for teaching and learning for all groups within the range of programme levels for Further and Higher Education.

It has been established that there are uses for past lactation records of the Glynllifon herd within lectures on selection and breeding. Such records are valuable resources to support teaching and learning that have the potential to be used, transferred and shared within the educational workplace across a range of programme levels.

CHAPTER 7
GENERAL DISCUSSION

7.1. INTRODUCTION

As a result of the globalization of businesses, education has become a commodity. Education is nowadays considered to be more competitive and consumer-led, a commercial product within the international arena. It has been suggested that the economic value of education nationally is to be found through an increase in student numbers rather than the human investment and the continued growth for the country (Freeman and Thomas, 2005; Taylor *et al.,* 2005). However, an efficient teaching and learning environment continues to be the objective of most educational institutes within the UK and each student is an individual, a client, and a customer for the provision of an educational service.

The previous chapters (Chapters 4 and 5) have analysed the appropriateness of a single herd data set as an educational resource to enhance the efficiency of teaching and learning. The herd data was evaluated (Chapter 6) for FE and HE programme groups from NVQ to MSc (Chapter 3). The teaching method adopted was a range of active innovative approaches, which resulted in a positive response and achieved students' satisfaction across all groups.

The following sections discuss the herd data set, its editing and the increased emphasis on recording of functional traits within the UK. Section 7.2 discusses the student population, the environment in which they are evaluated and the unique nature of the FE student groups. The importance of qualitative and quantitative analysis within education is discussed together with the use of action research. Then follows a reflection on the history of the agricultural industry and its education. This is a very interesting point in time for agriculture and its education. Speculating on the farming systems and then looking at Glynllifon, how it has survived and its likely future within education is discussed in Section 7.4 to Section 7.8. It is concluded in the following sections that the college farm is a resource that should be used to its full potential to increase the efficiency of teaching and learning across the range of programme areas and curriculum. However, it is not the only option available as a range of other options could be considered.

7.2. THE HERD DATA SET

7.2.1. Size of the data set

The data set was a comparatively small data set, based on a single herd from 1950 to 2000. The potential number of lactation records for analysis was 4,032 for 976 cows, which were edited to 2,881 lactation records (71%) for 763 cows (78%) (Table 3.1, Section 3.3). As a result of editing, the number of lactation records per cow decreased from 4.13 lactations per cow to 3.78 lactations per cow.

The edited data set became a manageable data set that was both sufficient and appropriate for use within teaching and learning (Chapter 6) as a typical representation of the UK dairy industry (Chapter 4 and 5).

7.2.2. Data set time scale

Lactation records were found for the Welsh Black and Friesian breed from 1943 onwards. The Welsh Black lactation records were excluded from the study. Low numbers of lactation records were found for the 1940s and 1950s. During these two decades average herd sizes were much lower, as both the Welsh Black and Friesian breed of cows were in the herd. Also during the 1950s many cows were affected by John's disease (Jones A, personal communications 2005). The lactation records for the 1940s, having the lowest number, were not included in the data set. The start date of the data set became 1950 (Section 3.4, Table 3.3).

As the herd still exists, lactation information is continually being produced by the cows in the herd. In order to have a complete data set, an end date had to be determined, which became the 1st of March 2000.

7.2.3. Editing the lactation records

The consequence of data editing was a reduction in the number of records available for analysis. It required great discipline when it came to the editing stage. As with the earlier years every effort was undertaken to retrieve all the lactation records for the Glynllifon herd (Section 3.2.2). However, ensuring the quality and validity of the data was an important objective of the editing process in addition to maintaining its size.

The NMR was involved in maintaining and validating the Glynllifon lactation records throughout the entire data set in. This provided uniformity, reliability and authenticity to the data set (DFF, 2001).

7.2.4. Editing incomplete lactations

A total of 222 lactations (5.5%) had to be edited during the visual editing because they were incomplete. Another 276 (7%) were edited because they were less than 150 days (Table 3.1). These lactations were mostly the result of dual-purpose management, to supply the home beef market from the 1940s to the early 1960s.

7.2.5. Edit for incorrect details on the lactation records

Incorrect dates identified during the computer edits came to 272 (6.7%) (Table 3.1). Almost all (96%) of the lactation edits during the 1990s were a result of incorrect recording of dates. Some cows appeared to have 'calved' before their 'date of birth' and other cows 'date of birth' came before their dam's date of birth. Correct recording of events and pedigree details is a nationally and internationally concern as reviewed by Visscher *et al.* (2002) and Zwald *et al.* (2005) (Section 2.2.9). One would have expected better recording of events within the 1990s as a result of improved technology. It was also reported by Pirzada (2000) that between 30% and 70% of records had to be edited for official UK dairy information. Royal *et al.* (2000) also found that 50% of records between 1995 and 1998 had no insemination information. Pryce, J.E. (personal communication, 2000) confirmed that editing 30% of records within the UK official recorded data sets were regarded as being 'acceptable' during the 1990s.

7.2.6. Longevity data

Longevity data was based on the assumption that animals came to the end of their productive life on leaving the Glynllifon herd. However, the animal could have been sold as 'newly calved' to other farms, either privately or through livestock auctions in the area. Also, another weakness concerning longevity analysis, as discussed by St-Onge *et al.* (2002), is that cows are not free to produce to their potential, as they are in competition with others in the herd, especially potential replacements. Also, possibly some cows could be favoured because they come from a desirable 'blood-line', and not due to any particular intrinsic survival per se.

The profitability of the dairy enterprise influences the dairy cow's probability of being retained in the herd. Economic factors such as salvage value of cull cows and fluctuations in beef prices could all result in premature culling. Political influences such as quotas or BSE also contribute to a shorter or longer productive life in the herd. However, despite the lack of knowledge concerning 'herd exit date' on the lactation records the longevity data were in agreement with national data (Section 4.4.8).

7.2.7. Production and functional traits

The availability of records for functional traits was poor in relation to the production traits for the Glynllifon herd. This is a national concern, a reflection of the economic importance of production traits in relation to functional traits. As reported by Windig (2005), the most important factor influencing survival was milk yield. The antagonistic relationship between milk yield, health and fertility is well established (Section 2.4). The recording of fertility and health included on-farm records for service date, pregnancy diagnoses (PD), and veterinary visits. The information would be discarded every few years (Jones, A., personal communications 2003), which is typical of most dairy herds in the UK (Pryce *et al.,* 2002). As expressed by Philipsson and Lindhe (2003), improvements in recording systems are needed in many countries. A national integrated system is required so as to remain competitive with countries such as those in Scandinavia. The well integrated recording system in Scandinavian countries enabled the early adoption of total merit index (TMI) which included health and fertility traits.

The analysis of production and functional traits of the Glynllifon herd (Chapter 4) were in agreement with national standards. The genetic parameters and variance components of production traits were analysed using an univariate animal model. The heritability, repeatability and variance components were comparable to published data. The calculated EBVs followed similar trends as the UK dairy industry with respect to ICC and PTA over time (Chapter 5).

7.3. THE EDUCATIONAL DATA SET

7.3.1. The population size for the educational evaluation

The educational analysis was undertaken over two academic years within Further and Higher Education courses. The total number of students in the evaluation of the lectures on Selection and Breeding was 128, with an additional 58 students in the piloting of the lectures and questionnaire. Piloting the questionnaire and lectures involved the FE students due to the practicality of timetabling, location and also the fact that these groups had the highest number of students (Table 3.5 and 3.8). It allowed the possibility to use 'groups of respondents who are drawn from the possible sample but who will not receive the final revised versions' as was recommended by Cohen *et al.* (2000).

7.3.2. Overview of groups

There were opportunities to evaluate the lectures on Selection and Breeding across a range of programme levels and within varying educational environments. The FE students (NVQ, NCA and ND) were within their subject area and were able to relate class work to practical farming problems. They were not so committed to academic studies, but were within their learning environment and all students within the groups were individually known to the lecturer. The Farmers' group, a mix of YFC, school, and adult visiting groups all had practical farming knowledge, but were unfamiliar groups in a new environment. The HND/C groups were known diverse groups, within the land base programmes (agriculture, equine and animal care). The BSc students were in an unfamiliar group within an unfamiliar learning environment, while the MSc were within their learning environment, but some members of the groups were known in the educational context. This variation between groups, across levels, allowed the opportunity to demonstrate the flexibility and adaptability of the data set within education in terms of teaching and learning. There were opportunities to use a range of teaching resources, including the farm, current and past data of the herd and the use of IT, allowing for the evaluation of an active innovative approach to teaching and learning.

7.3.3. Further Education Agricultural students

The data set could be used within the principles of pedagogy and androgogy for Selection and Breeding lectures (Section 2.9). The style of teaching for post 16 year old students within agriculture involves the principles of andragogy rather than pedagogy. Agricultural students are very 'adult' within their field of farming. They have generally been involved on the family farm since a very young age and have considerable wealth of experience, attitude and knowledge. This is not always reflected in their formal qualifications. Like the mature adult, most students "bring with then a wealth of experience that is there to be built on" (HMI, 2003) and used in a practical activity. It is important to 'tap into the experience' to see what they already know and then develop the materials from this base (HMI, 2003). In contrast, the HE students attained higher academic qualifications, but are limited in their application of livestock production and therefore required aspects of pedagogy. Repeated cycles of pedagogy and andragogy are often required as discussed by Parkinson and St George (2003) (Section 2.9.1). Unfortunately with HE students the 'prior knowledge, skill or attitude that is a pre-requisite to a given course' (HMI, 2003) were unknown. The data set was demonstrated to be adaptable within all principles of learning.

The mental age in learning as discussed by Vygosky (Section 2.9.2) is referred to as the Zone of Proximal Development (ZPD) and can be identified within the programme levels. Other stages of learning were also apparent, including the Dreyfus (Section 2.9.3) stage of skill development, and McPherson (2003) 'mastery' and 'practical wisdom'. The FE students were within a higher level of attainment than some of their HE counterparts. This is simply due to previous acquisition of knowledge and prior experience within their home farms.

7.3.4. Quantitative and qualitative analysis

The research methodology used in this study was a combination of qualitative and quantitative analysis. Quantitative analysis involved descriptive statistics, one way analysis of variance, multiple regressions, the animal model ASREML and chi-squared analysis. Qualitative analysis encompassed questionnaire response, semi-structured interviews and focus group discussions within the educational evaluation. Quantitative analysis of the questionnaires supports the hypothesis that active innovative approach to teaching results in student learning and satisfaction. Quantitative analysis also allows an opportunity to explain what accounted for student learning and satisfaction. Qualitative analysis allows statistical analysis to be conducted systematically (Cohen *et al.,* 2000).

7.3.5. Action research and the educational practitioner

Harushek, (2001) and Hirsen (2002) expressed concern that educational research grounded on scientific principles is rare and that it should be experimented systematically across a range of areas. As discussed by Bennett *et al.* (1996), there are so many variables within the educational environment.

Reflective research, or action research, is possibly the best option when there is a desire to improve aspects of educational practice (McNiff, 1997). As Bigg (1999) pointed out, it is important to look at teaching reflectively as there is no single all-purpose method of teaching. As was expressed by Race (2001), learning would be very boring if all teachers used exactly the same approach. Very often teaching strategy reflects that experienced by the lecturer. Investigating new and creative way of developing teaching for improved student learning and satisfaction is challenging in itself, even though an answer may never be found. Understanding of teaching styles and learning styles can help lecturers enhance their teaching (Reece and Walker, 1998; Moore, 2000; Goodwin, 2003).

Reflecting on practice, and engaging with existing theories, has provided a valuable insight into teaching and learning within the subject of Selection and Breeding. Subjects should be approached in a variety of active and didactic method of teaching. The findings of the study indicate that it was important to establish a positive learning environment, using a range of teaching styles including interactive dialogues and industrial related activities, which resulted in a concrete learning experience. Variation is important as there is no one style that is effective for all objectives and learning styles (Hoyt and Lee, 2002).

7.4. REFLECTING ON THE HISTORY OF AGRICULTURE AND EDUCATION DURING THE NINTEENTH AND TWENTIETH CENTURY

As the College farm and its herd's data set spans over half a decade, a reflection on its history could not be excluded. It can be concluded that the agricultural industry and agricultural education have gone through a complete circle.

The educational role of the Glynllifon herd was established at the beginning of the twentieth century at Madryn Farm School on the Lleyn Peninsula. Increasing demands on agricultural output resulted in the native Welsh Black being substituted for the Friesian breed. Increasing demand for agricultural education resulted in the re-establishment of the Madryn Farm School at Glynllifon Estate by the Gwynedd Local Education Authority (Section 3.2.1).

The historical periods as outlined in Section 2.2 for the dairy industry parallels those of the agrochemical industry as discussed by Montague (2000). The period between 1870 and 1904 was referred to by Montague (2000) as 'the depression years and beyond', which were reviewed in Section 2.2.1 as a period when imported food and insecure market resulted in low farm incomes. During this period, agricultural education had begun, but only as an option for the minority (Section 2.8.1). This was followed by the period referred to by Montague as the 'War, Prosperity and Poverty 1905-1945', when there were public concern over food supply as discussed by authors such as Baker (1973), Goddard (1988), Barker (1989) and Howarth (1990). Farm outputs then became protected through the Marketing Acts, followed by the Agricultural Acts of 1947 and 1957. The mission to 'feed the nation' following the war years resulted in a prosperous agriculture. During this period agricultural departments were set up within Universities and Farm Institutes at local levels (Section 2.8.1).

The period 1945-1973 was titled by Montague as 'The Golden Years'. The political drive and determination of the post war years for production efficiency lead to an agricultural industry that was secure, safe and strong. This was very much as the "Golden Age of Agriculture" as discussed by Howarth (1990) that occurred almost a century before between 1850 and 1880 (Section 2.2.1). During 'The Golden Years' education also prospered, County Agricultural Colleges were established which provided agricultural education for the rural community and the agricultural population at large as discussed by Cornshaw (1947), Morris (1996), Park *et al.* (2002) and Jones (2004).

These 'Golden Years' of the nineteenth and the twentieth century were followed by insecure markets and falling prices. During the end of the nineteenth century improvements in transportation and refrigeration systems and the influence of international trade led to cheap imports, which resulted in an insecure markets and falling prices (Section 2.2.2).

During the twentieth century, the European Union introduced the milk quota. The MMB disbanded in 1994 and in 1999 Milk Marque was split as a result of the MMC (Monopoly and Merges Commission) (Section 2.2.3). The MMB was set up in the 1930s to resist the downward pressure on producers' income resulting from the increasing power of dairy companies (Section 2.2.6). The European Competitive Law reduced the ability of dairy farmers to cooperate and collaborate to ensure a sustainable and profitable dairy industry. These issues resulted in fragmented markets leading to falling milk prices as discussed by authors such as Franks (2001), Murphy (2001), Gommer and Hunter (2004) and Brigstock (2005). At the end of the twentieth century Montague (2000) referred to three phases: the 'Adapting to the Common Market' from 1973 to 1984; then 'The drive for production ends' between 1984 and 1990; followed by 'The decade of International realisation' (1990-2000). As expressed by Valencia and Anderson (2000) and Vanden Ban (2002), farmers compete increasingly with one another all over the world as there is no mechanism to support and protect prices through import restrictions. Food can be imported and educating agriculturalists for UK production is not considered such an important issue as the interest in 'environmental goods'.

Post–war agricultural education was viewed by Beaumont *et al.* (1943) as having no coordination, diverse sources of finance and no uniformity of aim or method. It is interesting that Beaumont *et al.* (1943) objected to agriculture being separated from other technical education by the Local Educational Authorities. However, by the end of the 1960s County Agricultural Colleges were under the LEA (Local Education

Authority) given secure catchment areas where students would be given grants to attend their county college.

By the 1990s County Agricultural Colleges become independent of the LEAs and many were amalgamated with other institutions (Section 2.8.1) which resulted in a less secure environment. There is competition for students within FE, and college farms present opportunities for asset stripping. Also college farm's have traditionally been used to support agriculture courses and did not have to justify their existence against the resources demands of other curriculum areas.

7.4.1. Farming systems in the future

Farming systems have evolved as a result of socio-economic and government requirements. Boelling *et al.* (2003) and Simm (2000b) predicted a distinct separation between organic and intensive farming. Simm (2000b) noted that the EU produces high quality products at high costs, whereas other regions of the world have low costs of production. In this 'separate review' organic farming will support sustainable development and high intensive production system will ensure food security, (Boelling *et al.,* 2003; Kolmodin *et al.,* 2003). CAP will inevitably have an effect on the industry. It was anticipated by Brigstocke (2005) that UK dairy farms would become similar to those in the USA. There will be small family farms, which are often not commercial, but rather a way of life as compared to the large agribusiness enterprises with 500 or more cow herds that will produce most of the milk. There has been a trend towards this type of dairy farming within the North West Wales area. Large dairy farms (>500-1000 cows) on the Lleyn Peninsula, include Nanhoran Estate and recently the established Jersey herd at Cefn Amlwch. The agricultural education system needs to be aware of these farming system trends. Whatever the system of farming employed, even if farming might not be the direct source of income, education is essential for ensuring a fair standard of living within the rural areas of Wales (DEFRA, 2004).

Agriculture is not a profession that is viewed as providing high remunerations, despite good employment prospects (Park *et al.,* 2002). Also opportunities to farm are limited without family connections or consolable farming wealth (Hill and Rey, 1987). A study conducted by RABDF (2005) found that the majority (92%) of dairy producers are sole traders or in partnerships. The cost of their own labour was excluded from the 'profit and loss account' and they were therefore subsidising milk production. The true market value of a farmer's own labour was not considered. Also it was reported that sons or daughters of farmers spend 79% of their time doing semi-skilled work (RABDF, 2005). Colman and Harvey (2005) also claimed that UK dairy farmers are not 'profit maximisers'. It was found that for many years dairy farms have been operating with returns to labour below the minimum wage. Also the majority of smaller dairy farms did not cover their own labour costs.

A strong correlation has been found between efficiency, profitability and scale of production. However, not all small herds will leave the dairy industry, while large herds were more likely to do so (Colman and Harvey, 2005). As reported by Lester (1999) the structure of the dairy industry is fragmented and predominantly comprised of small businesses, with the number of owner-managers and family labour outnumbering employed workers (Lester, 1999). These small farms, often family run, have a strong survivability, and therefore making a strong case for maintaining and ensuring local agricultural educational provision at all levels within the linguistic and cultural needs of the rural areas (HMI, 2003).

7.5. THE GLYNLLIFON FARM AND ITS DAIRY HERD

Up until the late 1970s and mid 1980s Glynllifon Agricultural College had developed strong links with industry. It demonstrated technical competency and provided a positive relationship with the industry. Thereafter, the college farm failed to maintain its role in the forefront of developments within the dairy industry of the North West Wales area. Other family farms in the area have taken the lead. Students come to broaden their knowledge and experience from farms that are far more technically developed. However, Glynllifon is better than the lowest 25% of other dairy family farms, but is no different to the other 50% that are currently recording with the NMR (DFF, 2001).

The best 50% of the NMR dairy farms could be used and are used for teaching practice locations by the college and other commercial organisations such as the MDC. Visits to other dairy farms no longer consolidate information. Visits are required to show advancement and development in the dairy industry within the area.

The farm experience is only of benefit for those students that have no experience of dairying.

It could well be said that the college herd has adopted a sustainable method of production from the 1970s onwards. However, these systems were modern and up to date during the 1970s and 1980s and were well respected within the farming community.

The decision-making process over the Glynllifon dairy enterprise had always been driven by the commercial prerogatives, rather than for the benefit of education as summarised in Figure 7.1.

Figure 7.1. The Glynllifon's commercial attitude

- The NMR SCC's provision as an additional service in 1991 was not undertaken until 1994 when it became free to all NMR producers (Section 4.2.3.3.).
- Poor uptake of NMR dairy software (initially Herd file plus followed by Imple-Pro). Only currently used as an educational resource.
- Management decisions of the 1970s are still in existence. The milking parlour, cubicle housing and conservation system of winter housing and ad lib feeding has remained the same. The paddock grazing system has been maintained but remains as it was during the late 1960s.
- Average size of herd has not increased in line with other high performing and specialised dairy farms (see Section 4.3a).
- Not selected as an Experimental farm by the MDC.
- Poor use of EBVs in the selection procedure on the farm (gap between dam EBVs and sire EBVs; Section 5.4.3, Figure 5.14).
- Housekeeping as commented upon on two questionnaires by BSc academic year 2002-3003.
- Communication of 'College Farm News' to staff, students and farms is non existence.
- High proportion of edited records during the 1990s compared with earlier decades (Section 4.2.3.1, Table 4.1).
- Educational timetables interfere with commercial operations of the farm, whereas farm visits are very accommodating (BSc group Linear Assessment Exercise).

College farms have found it very difficult to justify their existence as teaching resources in the last decade. It is the commercial attitude that has made the Glynllifon farm viable and justifies its existence within further education. As colleges and universities grow and merge, they then compete for resources. The farm could easily be seen as a means of releasing assets. It must be seen as a venture that generates income for the rest of the college. If the farm was not operating commercially, and was running at a loss, questions would be asked and options explored. To keep the Glynllifon farm as an educational resource it must be financially viable in order to justify it's existence within the tertiary college of Coleg Meirion-Dwyfor.

However, it is essential that the farm advances in technological developments in order to meet the need of the students. The relationship that has been established between the college and the farm is of value to the industry. It encourages farms to become innovative and allows a natural provision for life-long learning in the innovative world of dairy farming.

7.6. THE USE OF FARMS IN OTHER COLLEGES

At the time this study was conducted there were no comprehensive reports on the use of farm data within education at any level within agriculture. However, personal communications suggest that it is a common practice for staff to use live industrial data in an active approach. It was more on an individual initiative, which relied on the interest and dedication of the individual staff. Departments within colleges should be encouraged to be involved with their industry, and be given the time on a regular basis rather than a one off initiatives as in the case of 'Industrial Experience' for a week (ELW, 2004). This would strengthen the link between educational departments and industry.

It was noted by Hong and Hong (2005) that creative teaching was closely connected to real life experiences. During the Agricultural College era (1950s to the 1980s) when the sole curriculum was agriculture, all lecturers were allocated time within the timetable for industrial related tasks. The dairy lecturer's duties also included completing the NMR lactation records, selecting bulls, completing pedigree records. Teaching staff with a commercial management responsibility on the farm would enrich teaching, without the disadvantage of routine management commitment. However, today this is not the case, lectures have become 'educationalists' with many different subjects to teach and the involvement with the commercial running of the farm and its enterprise has been left in isolation to the farm staff.

7.7. INDUSTRY AND AGRICULUTAL EDUCATION

Links between farm size and educational achievement is well established (Hill and Ray, 1987). Training and small business performance was reviewed by Frase and Storey (2002) and it was shown that those who participated in Barclays Bank Small Firm Training Loan Scheme (SFTLS) are more likely to survive and grow. Kilpatrick (2000) discussed the relationship between education and training outcomes at macro and micro levels. Education and training enhance the ability and willingness of farmers to make successful changes to their management practice and alter their value and attitude towards new practice. However, Jackson-Smith *et al.,* (2004) found only a slight relationship between financial returns of the business and the ability to understand financial concepts.

There is evidence to support the industry's concern over agricultural education with respect to selection and breeding. This again reinforces that fact that education must address the industry's requirements by looking at education both as a product and as a process (Section 2.9.1) and ensure quality education at all levels within FE and HE. There must be an end 'product' in the 'process' of learning. Also, the majority of students on the lower level FE courses see learning as a product (Rolls and Slavik, 2001) as opposed to a 'process'. It is this product of learning that motivates most of the FE students to come to college and to take part in learning. As pointed out by Phalet *et al.* (2004) students' future goals motivate them to learn and encourage them to participate within education. Issues raised with respect to education by the dairy industry include concerns about interpretation of EBVs, fertility index, functional traits and linear assessment.

The true understanding of EBVs has been questioned, and its full use and potential value within the selection decision may not have been exploited. The MDC (2001) wrote with respect to Lifespan PTAs and SCC PTAs that 'PTAs for these traits have been published for several years now; it is clear from the number of queries received that there is some uncertainty and confusion on their interpretation and use'.

Flint *et al.* (2002) suggested that the fertility index is "only of any use if it is used….it must be made available and published for it to have any impact on the fertility of the UK dairy herd". It was also implied that there is a need for better communication and links between the dairy companies, R&D and education.

Selecting dairy cows for a sustainable production system with the inclusion of functional traits was also an issue at the beginning of the data set, as confirmed by Rice (1942) who stated that 'the most important item in the dairy business is the individual cow. If the cow is healthy, a good producer, long-lived, and able to transmit her good qualities to her offspring, then there is a firm foundation for the multitude of activities that must result before milk, butter, cheese, or ice cream appear on the consumer table'. This is similar to what dairy farmers strive for at the beginning of the twenty-first century (Holstein-UK, 2004). These are issues that should be included within the education curriculum for application within the dairy industry.

Linear assessment or type classification was first used by breed societies (Section 2.4.5) as an educational effort to encourage breeders to improve the conformation of their dairy cows (Cassell, 2000). Linear assessment has now attained its objective as well as being an important part in the genetic evaluation of traits within the dairy industry.

Education and the agricultural industry should work effectively together and be mutually supportive. The individual dairy producer's viewpoint is important in the development of the curriculum, as they are the decision-makers in the dairy industry. For example, dairy producers will select sires that will increase the profitability of their business. The dairy producer's objectives can therefore affect the content of lectures on sire selection.

7.8. AGRICULTURAL EDUCATION WITH DIVERSE GROUPS OF STUDENTS

In order to survive, agricultural education can and must serve a broad spectrum of students in the future and build public awareness of the industry. Students can benefit from a more complete educational programme by involving a more diverse group of students, as was the case for the HE programmes. Several agricultural departments within the Universities and Colleges who participated in discussions believed that agricultural education could be a part of every student's learning experience within a range of curriculum areas.

It is therefore important to cater for a diverse group of students, but it is also important to extend the boundaries of education for the knowledgeable and experienced agricultural students. The data set as used in this study certainly had the potential for use with diverse groups, and can be adapted with the minimum of preparation time.

Farm-based real life data provides a positive learning environment for a range of programme areas, allowing students to be more active participants in their learning process. This increases their critical and creative thinking skills, as well as improving their problem solving skills. They learn how to learn and develop several learning skills such as communication, teamwork, collaboration and presentation, in addition to achieving ownership of their learning outcomes. At all programme levels there were opportunities for creativity and an analytical approach including appropriate use of the herd, herd data and IT.

7.9. THE COLLEGE FARM AS A TEACHING RESOURCE

Until the late 1980s the dairy enterprise would have been operating under the financial security of the County Council, as well as being a profitable enterprise with a better return on capital than there is today. The Glynllifon farm is an educational resource that has survived the passage of time. Education is similar to a business, competing for scarce resources in the economic sense.

Agricultural education has developed from being a distinct specialised sector of FE. The role of colleges has today broadened to encompass the whole of the land base industry. Establishing a close relationship with industry and sectors of the economy within our community will create a brighter future for agriculture. The future is more likely to see partnerships and joint ventures between schools, FE colleges and Higher Education and the business sector (DFES, 2005). The establishment of industrial links with Universities and Colleges is encouraged through government initiatives as well as setting up of research and development activities within education establishments (DEFRA, 2004).

The government would like to see more 14-19 years old aspiring to higher education as outlined in The White Paper "The future of Higher Education" (January 2003). The Education Maintenance Allowance (EMA) was introduced to encourage and increase participation of 16-19 years old to stay in education (DFES, 2005). The government aims to create a more appropriate curriculum and qualifications framework for 14-19 years old. Mixing study at school and college was proved to be a successful experience at New College, Nottingham (Parkinson, 2005). The Government also aim to "increase and broaden participation in higher education and develop skills of the workforce" (Prospects, 2005). The introduction of the foundation degree is aimed at "the increase in participation of 18-30 year olds" and also hopes to see more flexibility in courses to meet the need of a more diverse student body and improve support for those studying part time (DFES, 2005).

The challenge for the Glynllifon dairy enterprise is to continue to be economically viable, and to continue to serve and support education. It must adopt modern systems of production and trial the use of new biotechnology, in order to keep up with other enterprises in the twenty first century and beyond. Effective curriculum development must take account of current practices and respond to its changing technology and labour requirements. The college farm should continue to provide sound agricultural education to meet the need of the local economy and the rural community of North West Wales as well as being a realistic commercial entity.

7.10. INDUSTRIAL RELATED DATA SET WITHIN EDUCATION

A lecturer can always see weaknesses and room for improvements in their own lectures. As discussed by Petty (1998), mistakes are inevitable and a necessary part of learning. It was very encouraging to read that Holms (1999) considered an effective lesson not to mean having 100% success. If so, he claimed that no lesson can be thought to be thoroughly effective. If learning has taken place you can consider the lesson to be effective on some level. The perfect effective lesson is something that a good teacher continues to strive for throughout their career. However, there is no guarantee that a satisfying teaching experience will result in effective learning or satisfied learners. As stated by Reece and Walker (1998), what works well with one group might not work well with another group.

The data set has proven itself to be a worthwhile, reliable and representative source of data for the selection and breeding part of the curriculum across a range of programme levels. The data set provided a comprehensive and valuable source of information for teaching and learning whilst allowing for active, innovative and varied teaching approaches to attain positive learning. It also has immense potential across a range of other disciplines, including numeric and IT key skills, statistics, biology and applied biology as in the case of land based, animal care and equine courses.

The learning environment, resources and data should represent the industry that it serves. Also a range of learning styles should be adopted to address the diverse nature and age of the learners. In developing a realistic data set for teaching and learning, it must be of a manageable size. Data must be analysed as to its suitability. It must be appropriate, a true representation, delivered in a positive environment, and with an active innovative approach. It can be stated that this is a timely study that has proven the appropriateness of the use of an industrial related data set, across a range of programme levels. It has the capability of meeting the need of a diverse student population across a range of groups in FE and HE institutions. The data lends itself to an innovative, active and varied approach to teaching.

Effective teaching, learning and student satisfaction was attained in this study through an active innovative approach with the use of the college farm and its dairy herd data. However, an effective active approach to teaching could well have been attained without such capital intensive teaching resource. The commercial attitudes that have to be adopted for management of the college farm does not make it the perfect educational resource as discussed in Section 7.1. Learning outcomes could be achieved just as effectively by various other methods. The use of other local dairy farms in the area could achieve the same learning outcomes. Many farms in the area are above national comparators and are very accommodating and experienced when it comes to educational visits. Farm visits have the advantage of improving and maintaining the relationship between the college and local farms businesses within the area, establishing a link between education and industry.

With respect to using industrial data sets within teaching and learning, a sub-set of a national herd database could be used. This would avoid the need to retrieve data from paper based records. It would also reduce the data editing required (Chapter 3).

Also, it is possible nowadays to achieve the learning outcomes with the advancement in Information and Communication Technology (ICT) (Section 2.10.6). The use of Audio Visual Aids (AVA) and Visual Learning Environments (VLE) should not be considered as second best. Both FE and HE should encourage progress and development in VLE. These resources should be developed co-ordinately to avoid the duplication of resources and should be use nationally. It would ensure quality and maintain national standards within colleges of Further and Higher Education.

It could be argued that there is no real need for a college farm in order to achieve the learning outcomes. However, having access to a college farm allows close integration of teaching activities to meet the learning outcomes. The benefits to teaching of having a college farm have to be evaluated in a wider context that includes the resource demands of the institution at large.

REFERENCES

Abdallah, J. M. and McDaniel, B.T. (2000). Genetic Parameters and trends of milk, fat, days open and body weight after calving in North Carolina Experiment Herds. *Journal of Dairy Science*. 83(6): 1364-1370.

Abpischools. (2004). Reproductive technology. [On-line]: Available: www.abpischools.org.uk Accessed: 19 March 2004.

Agtechnic. (2004). Biotechnology in animal breeding. [On-line]: Available: http://www.agtechinc.com/overview/ Accessed: 9 November 2004.

Albers, D.L. (2004). Nonverbal Immediacy in the Classroom. Department of Psychology Missouri Western State College. [On-line]: Available: cronk@mwsc.edu/manuscripts/236.asp. Accessed: 28 March 2004.

Animal Data Centre. ADC. (2001). Facts Sheet of genetic evaluation procedures. [On-line]: Available: www.animladata.co.uk/publications.Accessed: 28 May 2002.

Animal Data Centre. ADC. (2004). Facts Sheet of genetic evaluation procedures. [On-line]: Available: www.animaldata.co.uk/publications. Accessed: 8 June 2004.

Annual Abstract of Statistics (AAS). (2001). No 137. Stationary Office. London.

Annual Abstract of Statistics (AAS). (2004) No 140. Stationary Office. London.

Arbel, R., Bigun, E., Sturman, H. and Hojman, D. (2001). The effect of Extended Calving Intervals in High-Yielding Lactating cows on Milk Production and Profitability. *Journal of Dairy Science*. 48: 600-608.

Arveson, P. (1998). The Deming Cycle. [On-line]: Available: http://www.balancedscorecard.org/bkgd/pdca.html. Accessed: 6 June 2001.

Ashworth, A and Harvey, R. (1994). Assessing Quality in Further Education. Jessica Kingsley Publishers Ltd. London.

Atherson, J.S. (2002). The Experimental Learning Cycle. Learning and Teaching. Learning form experience UK. [On-line]: Available: http://www.dmu.ac.uk/~jamesa/learning/exerient.htm Accesses 7 June 2004.

Bachman, K.C., and Schairer, M.L. (2003). Bovin Studies on Optimal Lengths of Dry Periods. *Journal of Dairy Science.* 86(10): 3027-3037.

Baker, C. (2001). Foundation of Bilingual Education and Bilingualism. Multilingual Matters Ltd. Clevedon. UK.

Baker, S. (1973). Milk to Market. Forty Years of Milk Marketing. William Heinemann Ltd. London.

Barker, J. (1989). Agricultural Marketing. Oxford Science Publications. Oxford.

Bartsch, R.A. and Cobern, K.M. (2003). Effectiveness of Power Point presentations in Lectures. [On-line]: Available : PUBMED : Accessed: 8 August 2004.

Beaumont, Cumber, Evans, Goodenough, Loveday, McClean, and Youard R.J. (1943). Post-war agricultural education in England and Wales. Paper / Bill number: Cmd.6433. Agriculture (Miscellaneous Provisions) Act, 1944: 7 & 8 Geo. 6. [On-line]: http://www.bopcris.ac.uk/bopall/ref9634.html Accessed: 18 April 2005.

Bennett, C., Howe, C. and Truswell, E. (2002). A review of research in small-group teaching and suggestions for good practice. [On-line]: Available : http:ltsnpsy.york.ac.uk. Accessed : 10 August 2004.

Bennett, C., Foreman-Peck, L. and Higgins, C. (1996). Researching into Teaching Methods In College and Universities. Kogan Pages Limited. London. UK.

Beriswill, J. (2004). ABC's'R': Teaching visual design principles. [On-line]: Available: http://dl.aacc.org/14623 Accessed: 27 November 2004.

Berry, D.P., Buckley, F., Dillon, P., Evans, R.D., Rath, M. and Veerkamp, R.F. (2003). Genetic Relationship among Body Condition Score, Body Weight, Milk Yield, and Fertility in Dairy Cows. Journal of Dairy Science. 86(6): 2193-2004.

Biggs, J. (1999). Teaching for Quality Learning at University. Open University Press. Buckingham.

Biotechnology. (2004). Techniques in Animal Breeding [On-line]: Available: http://www.biotechnology.gov.au/biotechnologyOnline/whatis/whatis.hml Accessed: 11 November 2004.

Blackmore, J. (2004). In Pedagogy: Learning style resources. [On-line]: Available: http://www.ltseries.com/LTS/sitepgs/lrnstyles.htm Accessed: 15 July 2004.

Boelling, D., Groen, A.F., Sorensen, P., Madsen, P. and Jensen, J. (2003). Genetic improvement of livestock for organic farming systems. *Livestock Production Science.* 80(1/2): 79-88.

Bonzo, J., Smyth, J. and Toro-Posada, S. (2004). Computerised Patient and Case Simulation Project. [On-line] Available: http://dl.aacc.org/14562 Accessed: 29 March 2004.

Bourdon, R.M. (1997). Understanding Animal Breeding. Prentice-Hall, Inc. USA.

Bovee, M.L. and Gran, D.F. (2004). Effects of Contrasting Equivalent Teaching Approaches on Student Rating. *Journal of Allied Health.* 33(1): 70-74.

Brigstocke, T. (2005). The Future Strategy for Dairy Farming in the UK. Royal Association of British Dairy Farmers (RABDF). Dairy House. Warwickshire. UK.

British Cattle. (1980). British Cattle. The National Cattle Breeding Association. UK.

British Council. (2004). Education UK – The best you can be. [On-line] Available: http://www.bcsearch_result.page_pls_user_sresults_col Accessed: 2 September 2004.

British Friesian Herd Book. BFHB. (1967). The British Friesian Cattle Society. (Vol 49(1959) to 59(1969)).Scotsbridge House, Rickmansworth. Herts. UK. Pedigree Registered Herds.

Brotherstone, S., Veerkamp, R.F. and Hill, W.G. (1997). Genetic parameters for a simple predictor of the lifespan of Holstein Friesian dairy cattle and its relationship to production. *Animal Science.* 65: 31-37.

Bruening, T.H., Lopez, J., McCormick, D.F. and Dominguez, D.R. (2002). Active Learning: the impact on students participating in an extended field trip to Puerto Rico. *Journal of Agricultural Education.* 34(4): 67-75.

Buckley, F., Dillon, P., Rath, M. and Veerkamp, R.F. (2000). The Relationship between Genetic Merit for Yield and Live Weight, Condition Scoring, and Energy Balance of Spring Calving Holstein Friesian Dairy Cows on Grass Based Systems of Milk Production. *Journal of Dairy Science*. 83: 1878-1886.

Calus, M.P.L. and Veerkamp, R.F. (2003). Estimation of Environmental Sensitivity of Genetic Merit for Milk Production Traits Using a Random Regression Model. *Journal of Dairy Science*. 86(11): 3756-3764.

Cameron, N.D. (1997). Selection Index and Prediction of Genetic Merit in Animal Breeding. CAB INTERNATIONAL, London. UK.

Cannon, R. and Newble, D. (2000). A Handbook for Teachers in University and Colleges. A Guide for Improving Teaching Methods. Kogan Page Limited. London. UK.

Cassell, B. (2000).What traits should we consider to breed tomorrow's cows? *Hoard's Dairyman*. 145(18): 718

Castle, M.E. and Watkins, P. (1984). Modern Milk Production. Faber and Faber Limited. London. UK.

Cbin. (2004). Educational Experience [On-line]: Available: http://www.cbin.ec.gc.ac/documents/national_reports/learning_life_e.html Accessed: 28 April 2004.

CEA. (1954). Caernarvonshire Education Authority. Agricultural Reports and Minutes. Gwynedd County Council. Caernarfon.

Chalmers, D. and Fuller, R. (1996). Teaching for Learning at University. Kogan Page. London.

Ching-Chun Shih, and Gamon, J.A. (2002). Relationships among learning strategies, patterns, styles and achievement in web-based courses. *Journal of Agricultural Education.* 43(4):1-11.

Clark, D. (2000). Learning Domains or Bloom's Taxonomy. The three types of learning. [On-line]: Available: http://www.nwlink.com/~donclark/hrd/bloom.html. Accessed: 9 June 2004.

Cohen, L., Manion, L. and Morrison, K. (1996). A guide to teaching practice. Routledge Falmer. London.

Cohen, L., Manion, L. and Morrison, K. (2000). Research Methods in Education. Routledge Falmer. London.

Colman, D. and Harvey, D. (2005). The Future of UK Dairy Farming. [On-line]: Available: http://www.mdcdatum.org.uk/PDF/FUTUREOFUKDAIRYFARMING.pdf Accessed: 10 April 2005.

Corliss, S., Bush, A., Svinicki, M., Achacoso, M. and McGregor, A. (2004). Developing Faculty to use Technology Effectively in the Classroom. *Society for Information Technology and Teacher Education International Conference.* (1): 2055-2060.

Cornshaw, H.B. (1947). Dairy Information. Dairy Industries. London. UK.

Cornwall. (2004). Gathering evidence- A guide for using Focus groups. [On-line]: Available: www.cornwall.gov.uk/Consultation/focus1.htm Accessed: 15 December 2004.

Court, S. and Molesworth, M. (2003). Developing Teaching Strategies for Research Methods that are Appropriate to the Learning Styles of Marketing Communication Students. *Journal of Marketing Management.* 19: 675-697

Cox, J.E. (2001). Veterinary Education and Problem-based learning. The Veterinary Journal. 162: 84-86.

Crossman, M. and Koops, W.J. (2003). Modelling extended lactation curves of dairy cattle: a biological basis for the multiphase approach. *Journal of Dairy Science.* 86: 988-998.

CSS. (2004). Kolb learning style. [On-line]: Available: http://www.css.edu/users/dswenson/web/PAGEMILL/Kolb.htm Accessed: 12 December 2004.

Curzon, L.B. (1999). Teaching in Further Education. Cassell. London. UK.

Dairy Facts and Figures (DFF). (1971, 1984, 1996, 1998, 1999, 2000, 2001, 2002, 2003, 2004) The Dairy Council. UK.

Dale, P.J. (2004). Public-good plant breeding: What should be done next? *Journal of Commercial Biotechnology.* 10 (3): 201-209.

DEFRA (2001): Livestock Knowledge Transfer DEFRA initiative operated by ADAS/ IGRA/ University of Bristol. Dairy: 243 (fat), 244 (protein). Lifetime production 721.

DEFRA (2004). Provisional Data. [On-line]: Available: http://www.defra.gov.uk Accessed: 13 January 2004.

Department for Education and Skills (DFES). (2005). A strategy for 2006. [On-line]: Available: http://www.prospect.ac.uk Accessed: 13 April 2005

Dematawewa, C.M.B. and Berger, P.J. (1998). Genetic and Phenotypic Parameters for 305 day Yield, Fertility, and Survival in Holsteins. *Journal of Dairy Science*. 81(10): 2700-2709.

Dexter, S. and Doering, A. (2003). A Model and Resources for Educating Teachers. [On-line]: Available: http://dl.aacc.org/12049 Accessed: 29 March 2004.

Diaz-lefebvre, R. (2004). Multiple Intelligences, Learning for Understanding, and Creative Assessment: Some Pieces to the Puzzle of Learning. *The Teachers College Record.* 106(1): 49-57.

Dingwell, R.T., Duffield, T.F., Leslie, K.E., Keefe, G.P., DesCoteaux, L., Kelton, D.F., Lissemore, K.D., Schukken, Y.H., Dick, P. and Bagg, R. (2002). The Efficacy of Intramammary Tilmicosin at Drying-off, and other Risk Factors f or the Prevention of New Intramammary Infections during the Dry Period. *Journal of Dairy Science*. 85(12): 3250-3259.

Dochy, F., Segers, M., Van den Bossche, P. and Gijbels, D. (2003). Effects of problem-based learning: a meta-analysis. [On-line] Available: Pub-Med. 533-568. Accessed: 11 March 2003.

Dowling, C., Godfrey, J. and Gyles, N. (2003). Do hybrid flexible delivery teaching method improve accounting students' outcomes? *Accounting Education.* 12(4): 373-391.

Draper, S.W. (2004). Learning Styles (notes). [On-line]: Available: http://www.psy.gla.ac.uk/~steve/lstyles.html Accessed: 7 June 2004.

Druet, T., Jaffrezic, F., Boichard, D. and Ducrocq, V. (2003). Modelling Lactation Curves and Estimation of Genetic Parameters for First Lactation Test-Day Records of French Holstein Cows. *Journal of Dairy Science.* 86(7): 2480-2490.

e-learning. (2004). education and e-learning. [On-line]: Available: http://www.e-learningguru.com/gloss.htm Accessed: 17 June 2004.

ELW. (2002). Action planning in education. [On-line]: Available: http://www.elwa.org.uk Accessed: 3 September 2002.

ELW. (2004). Assembly Sponsorship Public Body. [On-line]: Available: http://www.elwa.ac.uk. Accessed: 7 January 2004.

Etaiwannews. (2004). Cloning techniques as potential to increase protein levels within the dairy industry. [On-line]: Available: http://www.etaiwannews.com /Tiwan/2004/07/21/1090374659.htm Accessed: 11 November 2004.

Facultyweb. (2004). Learning styles. http://facultyweb.cortland.edu /andersmd/learning/Grasha.htm Accessed: 25 June 2004. http://facultyweb.cortland.edu/andersmd/learning/Phenomenography.htm Accessed: 16 June 2004.

Falconer, D.S. (1998). Introduction to quantitative genetics. New York, Longman Scientific and Technical.

FAO. (2004) [On-line]: Embryo Transplant. Available: http://www.fao.org/ DOCREP/004/T0117E/T0117E11.htm Accessed: 9 November 2004.

Farm Management Handbook (FMH). (2004), (2005). The UK reference for Farm Business Management. The Scottish Agricultural College. Edinburgh.

Fatehi, J., Stella, A., Shannon, J.J. and Boettcher, P.J. (2003). Genetic Parameters for Feet and Leg Traits Evaluate in Different Environments. *Journal of Dairy Science*. 86(2): 661-666.

Felius, M. (1985). Cattle Breeders of the World. MSDAGVENT. Rahway, N.J., USA.

Fell, R.F. (1999). Adult Learning and Action Learning – A Real Workplace Learning Approach. *Journal of Agricultural Education and Extension*. 6(2):73-81.

Flint, A.P.F., Wall, E., Coffey, M., Simm, G., Botherstone, S., Stott, A.W., Santarossa, J., Royal, M.D. and Wolliams, J.A. (2002). Introducing a UK Fertility Index. *Cattle Practice*. 10: 4.

Frank, A. and Jewitt, C. (2001). Action in Learning and Teaching. *British Educational Research Journal.* 27(2): 201-218.

Franks, J.R. (2001). Trends in the Economics of Milk Production in England and Wales: Some predictions of future structure. *Farm Management*. 11(2): 67-84.

Freeman, I. and Thomas, M. (2005). Consumerism in education: A comparison between Canada and the United Kingdom. *The International Journal of Education Management.* 19(2): 153-177.

Freyer, G., Sorensen, P., Kuhn, C., Weikard, R. and Hoeschele, I. (2003). Search for Pleiotopic QLT on Chromosome BTA6 Affecting Yield Traits of Milk Production. *Journal of Dairy Science*. 86(3): 999-1008.

Freyer, G., Sorensen, P., Kuhn, C., and Weikard, R.(2004). Investigations in the character of QLT affecting negatively correlated milk traits. *Journal of Animal Breeding and Genetics.* 121(1): 40-51.

Froehlich, D. (2003). Cognitive Styles: A Review of the Major Theories and Their Application to Information Seeking in Virtual Environments. [On-line]: Available: http://www.personal.kent.edu/~plucasst/cognitivestyles.htm Accessed: 16 June 2004.

GAEA (1994) Reports and Minutes. Gwynedd Agricultural Education Authority.

Genus (2002). Dairy Breeding. AI Bulls for Dairy and Beef. Genus. UK.

Gibbs, A. (2004). Focus Group. [On-line]: Available: http://www.soc.surrey.ac.uk/sur/SRU19.html. Accessed : 15 December 2004.

Giles, E., Pitre, S. and Womack, S. (2003). Multiple Intelligences and learning styles [On-line]: Available: http://www.coe.uga.edu/epltt/mi-ls.htm. Accessed: 16 June 2004.

Gilmour, A.R., Cullis, B.R., Welham, S.J. and Thomson, R. (1998). ASREML. NSW. Agriculture, Orange, Australia.

Gilmour, A.R. (2003). ASREML. NSW. Agriculture, Orange, Australia.

Goddard, M.E. (2003). Animal breeding in the (post-) genomic era. *Animal Science.* 76: 353-365.

Goddard, N. (1988). Harvest of Change. The Royal Agricultural Society of England 1838-1988. Quiller press. London.

Gommer, P.J. and Hunter, P.J. (2004). Exposure of the Human Population to BSE infectivity over the course of the BSE epidemic in Great Britain and the impact of change to the over thirty month rule. *Journal of Risk Research.* 7(5): 523-543.

Goocites. (2004). Dunn and Dunn model [On-line]: Available: www.goocites.com/~educationplace/Model.html Accessed: 26 June 2004.

Goodwin, G. (2003). Research into practice – making the connection. [On-line]: Available: http://www.nfer.ac.uk/whatsnew/pressrel_template.asp Accessed: 30 April 2004.

Gulay, M.S., Hayen, M.J., Bachman, K.C., Belloso, T., Liboni, M. and Head, H.H. (2003). Milk Production and Feed Intake of Holstein Cows Given Short (30-d) or Normal (60-d) Dry Period. *Journal of Dairy Science.* 86(6): 2030-2038.

Gwynedd Agricultural Reports and Minutes (GARM). (2003). Local Education Authority. Gwynedd County Council. Caernarfon.

Haas de, Y., Veerkamp, R.F., Barkeman, H.W., Grohn, Y.T. and Schukken, Y.H. (2004). Association between Pathogen Specific Cases of Clinical Mastitis and Somatic Cell Count Patterns. *Journal of Dairy Science.* 87: 95-105.

Haidet, P., Morgan, R.O., O'Malley, K., Morgan, B.J. and Richards, B.F. (2004). A controlled trial of active versus passive learning strategies in a large group setting. *Nursing Standard.* 18(20): 33-36.

Haile-Mariam, M, Bowman, P.J. and Goddard, M.E. (2003). Genetic and environmental relationship among calving interval, survival, persistency of milk yield and somatic cell count in dairy cattle. *Livestock Production Science.* 80(3): 189-200.

Haile-Mariam, M, Bowman, P.J. and Goddard, M.E. (2004). Genetic parameters of fertility traits and their correlation with production, type, workability, liveweight, survival index and cell count. *Australian Journal of Agricultural Research.* 55(1): 77-87.

Hargrove, G.L., Mbah, D.A. and Rosenberger, J.L. (1981). Genetic and environmental influences on milk component production. *Journal of Dairy Science.* 64: 1593-1597.

Haritos, C. and College, H. (2004). Focusing in on Memory Through a Bilingual Lens of Understanding. *Bilingual Research Journal.* 28(2): 181-205.

Harris, B.L. and Winkelman, A.M. (2000). Influence of North American Holstein genetics on dairy cattle performance in New Zeland. *Proceedings of Large Herds Australian Conference.* 122.

Harushek. (2001). Methodology in educational research [On-line]: Available: http://www.LTSeries.com/LTS/sitpags/lrnstyles.htm Accessed: 5 May 2004.

Hayes, B.J., Carrick, M., Bownam, P. and Goddard, M.E. (2003). Genotype x Environmental Interaction for Milk Production of Daughters of Australian Dairy Sires form Test-Day Records. *Journal of Dairy Science.* 86: 3736-3744.

Hendry, G., Heinrich, P., Lyon, P., Barratt, A., Simpson, J., Hyde, S., Gonsalkorale, S., Hyde, M. and Mgaith, S. (2005). Helping students understand their learning styles: Effect on study self-efficacy, preference for group work, and group climate. *Educational Psychology.* 25: 395-407.

Heringstad, B., Rekaya, R., Gianola, D., Klemetsdal, G. and Weigel, K.A. (2003).Genetic change for clinical mastitis in Norwegian Cattle: a threshold model analysis. *Journal of Dairy Science.* 86: 369-375.

Heringstad, B., Chang, Y.M., Gianola, D. and Klemetsdal, G. (2005). Genetic association between susceptibility to clinical mastitis and protein yield in Norwegian dairy cattle. *Journal of Dairy Science.* 88(4): 1509-1514.

Her Majesty's Inspectorates (HMI). (2000). The Criteria for Judging Standards and Quality. Estyn (FE) Handbook. Estyn, Anchor Court, Keen Road, Cardiff. [On-line]: Available: www.elwa.org.uk. Accessed: 12 October 2000.

Her Majesty's Inspectorates (HMI). (2003). Guidance on the Inspection of Further Education Institutions. Estyn, Anchor Court, Keen Road, Cardiff. [On-line]: Available: www.estyn.gov.uk. Accessed: 16 November 2003.

Heuer, C. (2004). The use of Test Day Information to Predict Energy Intake of Dairy Cows in Early Lactation. *Journal of Dairy Science*. 87(3): 593-601.

Hill, B. and Ray, D. (1987). Economics for Agriculture. Food, Farming and the Rural Economy. Macmillan Education Ltd. London.

Hirsen. (2002). Education and action research [On-line]: Available: http://www.LTSeries.com/LTS/sitpags/lrnstyles.htm Accessed: 5 May 2004.

Holstein Friesian Breed Society. (HFBS). (1999). Scotsbridge House, Rickmansworth. Herts. UK.

Hofmeister, D. (2004). Student Experience and Student Support Increase Performance. Society for Information Technology and Teacher Education *International Conference*. 1: 484-486.

Holden, R. and Harte, V. (2004). New graduate engagement with "professional development": A pilot study. *Journal of European Industrial Training*. 28: 272-282.

Holmes, H. (1999). Newly Qualified Teacher. The Stationary Office. London.

Holstein-UK. (2004). [On-line]: Available: http://www.holstein-uk.org/Weblive/Education Accessed: 6 April 2004.

Hong, J-S. and Hong, J-Ch. (2005). Creative Teachers and Creative Teaching Stratiegies. *International Journal of Consumer Science*. 29: 352-358.

Howarth, R.W. (1990). Farming for Farmers? The Institute of Economic Affairs. London.

Hoyt, D.P. and Lee, E. (2002). Teaching "styles" and Learning Outcomes. [On-line]: Available: http://www.idea.ksu.edu/resources/index.html. Accessed: 6 March 2005.

Hufenfa De Arfon (HAD). (1988). South Caernarfon Creamery 1938-1988. 50th Anniversary. South Caernarfon Creameries Ltd.

Interbull. (2004). Interbull evaluation. [On-line]: Available: http://www-interbull.slu.se/eval/feb04.html Accessed 10 March 2004.

Jackson-Smith, D., Trechter, D. and Splett, N. (2004). The contribution of Financial Management Training and Knowledge to Dairy Farm Financial Performance. *Review of Agricultural Economics.* 26(1): 132-147.

Jamrozik, J., Stranden, I. and Schaeffer, L.R. (2004). Random regression Test Day Models with Residuals Following a Student's-*t* Distribution. *Journal of Dairy Science*. 87: 699-705.

Janice, H. and Lou, Y. (2004). Improving Virtual Teaching and Learning: A Professional Development Model for Online Educators. *Society for Information Technology and Teacher Education International Conference.* 1: 503-506.

Jones, A. (2000). Farm Manager of Glynllifon. Personal communications.

Jones, B.K. (2003). The Future of the Dairy Sector in the EU. Presentation by Mr Bryan K Jones, Farmers' Union of Wales. [On-line]: Available www.cprw.org.uk /magartcl/ unionview.htm Accessed: 6 July 2003.

Jones, G. (1992). Cam Cyntaf yn Llyn. *Fferm A Thyddyn*. Calan Gaeaf. 10: 13 17.

Jones, G. (2004). Professor Wrightson & Downton Agricultural College. Downton [On-line]: http://www.ejgreen.freeserve.co.uk/downton/agricollege.htm Accessed: 3 August 2004.

Kadarmideen, H.N., Thomson, R. and Simm, G. (2000). Linear and threshold model genetic parameters for disease, fertility and milk production in dairy cattle. *Animal Science* 71(3):411-419.

Kadarmideen, H.N., Coffey, M.P., Kossaibati, M.A. and Esslemont, R.J. (2001). Genetic evaluations and parameter estimates for dairy cow fertility in the United Kingdom. *Proceedings of the British Society of Animal Science*. 36.

Kadarmideen, H.N. and Wegmann, S. (2003). Genetic Parameters for Body Condition Score and its Relationship with Type and Production Traits in Swill Holsteins. *Journal of Dairy Science*. 86: 3685-3693.

Kadarmideen, H.N., Thompson, R., Coffey, P.M. and Kossaibati, M.A. (2003). Genetic parameters and evaluations form single- and multiple-trait analysis of dairy cow fertility and milk production. *Livestock Production Science.* 79: 183-195.

Kearney, J.F., Schutz, M.M. and Boettcher, P.J. (2004). Genotype x Environmental Interaction for Grazing vs. Confinement. II. Health and Reproductive Traits. *Journal of Dairy Science*. 87: 510-516.

Keig, L. and Waggoner, M.D. (2004). Collaborative Peer Review: The role of faculty in improving college teaching. [On-line]: Available: http://www.ntlf.com/html/lib/94-2dig.htm Accessed: 22 August 2004.

Keller, J. (2004). ARCS-Motivation Theory. [On-line]: Available: http://ide.ed.psu.edu/IDDE/ARCS.htm Accessed: 28 July 2004.

Kember, D and Leung, D. (2005). The influence of active learning experiences on the development of graduate capabilities. *Studies in Higher Education*. 30(2): 155-170.

Kember, D. and Wong, A. (2000). Implications for evaluation for a study of students' perception of good and poor teaching. *Higher Education*. 40: 67-97.

Kemppainen, R., Ferrin, S.E., Ward, C.J. and Hite, J.M. (2004). One should not forget one's mother tongue. *Bilingual Research Journal*. 28(2): 207-229.

Kent. (2004). Bloom's Taxonomy. [On-line]: Available: http://www.kent.k12.wa.us/KSD/MA/resources/blooms/blooms.html Accessed: 9 June 2004.

Kertz, A.F. (2002). Can we learn from fat and protein levels and ratios? *Hoard's Dairyman*. 147(3): 110-111.

Kilpatrick, S. (2000). Education and Training: Impacts on Farm Management Practice. *Journal of Agricultural Education and Extension*. 7(2): 105-116.

Kirk, J.H. (2004). Mastitis 101 – The Basics. [On-line]: Available: http:www.vetmed.ucdavis.edu/vetext/ Accessed: 3 July 2004.

Koivula, M., Mantysaari, E.A., Negussi, E. and Serenius, T. (2005). Genetic and Phenotypic Relationship among Milk Yield and Somatic Cell Count Before and After Clinical Mastitis. *Journal of Dairy Science*. 88(1): 827-833.

Kolomodin, R., Strandberg, E., Jorjani, H. and Danell, B. (2003). Selection in the presence of a genotype by environment interaction: response in environmental sensitivity. *Animal Science*. 76(3): 375-385.

Komisarek, J. and Dorynek, Z. (2002). Genetic aspects of twinning in cattle. *Journal of Applied Genetics*. 43(1): 55-68.

Kozielska, M. (2004). Developing creativity of students in a computer-assisted learning process. *European Journal of Physics.* 25(2): 279-285.

Krueger, K., Boboc, M., Smaldino, S., Cornish, Y. and Callahan, W. (2004). InTime Impact Report What was InTime's Effectiveness and Impact on Faculty and Preserves Teachers? *Journal of Technology and Teacher Education.* 12(2), 185-210. [Online]. Available: http://dl.aace.org/15305 Accessed: 29 March 2004.

Kuhn, Ch., Bennewitz, N., Reinsch, N., Xu, N., Thomsen, H., Looft, C., Brockmann, G.A., Schwerin, M., Weimann, C., Hiendleder, S., Erhardt, G., Medjugorac, I., Forster, M., Brenig, B., Reindardt, F., Reents, R., Russ, I., Averdunk, G., Blumel, J. and Kalm, E. (2003). Quantitative Trait Loci Mapping of Functional Traits in the German Holstein Cattle Population. *Journal of Dairy Science*. 86: 360-368.

Kuleuven. (2005). Agricultural employment. [On-line]: Available: http://www.agri.kuleuven.ac.be /intorg/ica/guide/uk/page2.html Accessed: 10 April 2005.

Kulinna, P.M. and Cothran, D.J. (2003). Physical education teacher' self-reported use and perception of various teaching styles. [On-line]: PUBMED: Accessed: 3 September 2004.

Lawson, L.G., Brunn, J., Coelli, J.F., Agger, J.F. and Lund, M. (2004). Relationship of Efficiency to Reproductive Disorders in Danish Milk Production: A Stochastic Frontier Analysis. *Journal of Dairy Science*. 87(1): 212-224.

LBCNC, (2004). Land Based College National Consortium. [On-line]: Available: www.lbcnc.ac.uk Accessed: 19 June 2004. http://www.landbase-education.org.uk/courses.html Accessed: 22 March 2004.

Learningstyle. (2004). Learning Styles [On-line]: Available: www.learningstyle.org.uk Accessed: 6 May 2004

Leeds. (2004). 5 Questionnaire design [On-line]: Available: http://www.leeds.ac.uk/iss/documnetation /top/top2/top2-5.html Accessed 15 December 2004.

Lester, S. (1999). Vocational qualifications in practice and principle: lesson form agriculture. [On-line]: Available: http://www.devmts.demon.co.uk/vqsagric.htm Accessed : 6 April 2005

Lidauer, M., Mantysaari, E.A. and Stranden, I. (2003). Comparison of test day models for genetic evaluation of production traits in dairy cattle. *Livestock Production Science*. 79: 73-86.

Literacynet. (2004). Myers-Briggs Type Indicator [On-line]: Available:www.literacynet.org /lp/learn21earn/teachers/mbtindicator.html Accessed: 16 June 2004

Liu, Y. and Ginther, D. (2004). Cognitive Styles and Distance Education. [On-line]: Available: http://www.westga.edu/~distance/liu23.html. Accessed: 16 June 2004.

Loo, R. (2004). Kolb's learning styles and learning preferences: is there a linkage? *Educational Psychology.* 24(1): 99-108.

Love, G. (2004). Create a More Effective Learning Environment: The Effect of Nonverbal Immediacy in Multi-Cultural Classrooms. James Madison University. Harrisonburgh. VA.

Lubbers, R., Brotherstone, S., Ducrocq, V.P. and Vissscher, P.M. (2000). A comparison of a linear and proportional hazards approach to analyse discrete longevity data in dairy cows. *Animal Science*. 70(2): 197-206.

Maclellan, E. (2004). How convincing is alternative assessment for use in higher education? *Assessment & Evaluation in Higher Education*. 29: 311-321

Macrae, A., Whitaker, D., Burough, L. and Kelly, J. (2003). Mastitis trends in UK dairy herds: 1998-2003. Proceedings of the British Mastitis Conference. [On-line]: Available: www.vet.ed.ac.uk/dhhps/ Accessed: 17 February 2004.

Malmo, J. and Beggs, D. (2000). Reproduction Management Programs for Seasonal Calving Dairy Herds. *Proceedings of Australia and New Zealand combined dairy conference*. 636.2.034 PRO. 229-240.

Maltz, E., Kroll, O., Spahr, L., Devir, S., Genizi, A. and Sagi, R. (1990). Milk yield, Parity, and Cow Potential as Variables for Computarised Concentration Strategy. Journal of Dairy Science. [On-line]: Available: http://jds.fass.org/cgi/content/abstract/74/7/2277 Accessed: 29 March 2004.

Matherson, D. (2003). A conceptual analysis of accidental learning as an educational activity. Presented to the European Conference on Educational Research, University of Hamburg, 17-20 September 2003. Available [On-line]: Education-line database. Accessed: 4 February 2004.

McGuirk, B. (2004). Breeding for improved cow fertility. *In Practice*. 26 (5): 272-275.

McNiff, J. (1997). Action Research Principles and Practice. Macmillan Education Ltd. Kent.

McPherson, I. (2003). Dreyfus renewed: possibilities for professional formation. Scottish Educational Research Association (SERA). Annual Conference, Perth, 27-29 November 2003. Symposium Paper 1.

Miglior, F., Muir, B.L. and Van Doormaal, B.J. (2005). Selection indices in Holstein cattle of various countries. *Journal of Dairy Science*. 88(3): 1255-1263.

Milk Development Council (MDC). (2001). Fact Sheet: MDC Publications Dept. Cirencester. UK.

Milk Development Council (MDC). (2004a). Fact Sheet: MDC publications. UK. [On-line]: Available: http:/www.animaldata.co.uk /publications/Stats UK. Accessed: 23 April 2004.

Milk Development Council (MDC). (2004b). Fact Sheet: MDC publications. UK. [On-line]: Available: http:/www.animaldata.co.uk/publications/paper (1-4) Accessed: 3 April 2004.

Milk Development Council (MDC). (2004c). Fact Sheet: MDC publications. [On-line]: Available : http:/www.animaldata.co.uk/publications/Technical Book. Accessed: 13 April 2004.

Milk Development Council (MDC). (2005). Fact Sheet: MDC publications. UK. [On-line]: Available: www.mdcdatum.org.uk/farmdata/producernumber.htm Accessed: 22 April. 2005 http://www.mdcdatum.org.uk/PDF/ CAPReform/in/ Wales.pdf Accessed 15 April 2005

Milk Marketing Board (MMB). (1972). Milk Production Annual Report (England and Wales). Milk Marketing Board. Themes Ditton. UK.

Mills, D.W. (2004). Applying What We Know - Student Learning Style. [On-line]: Available: http://www.csrnet.org/csrnet/articles/student-learning-styles.html Accessed: 11 May 2004.

Ministry of Agriculture, Fisheries and Forest (MAFF). (2001). Economic evaluation of the UK milk quota system.

Montague, D. (2000). Farming, Food and Politics. The Merchant's story. Irish Agricultural Warehouse Society (IAWS) Group plc. Dublin.

Moore, A. (2000). Teaching and Learning. Pedagogy, Curriculum and Culture. Routledge Falmer. London.

Moore-Colyer, R.J. (2000). Science, Education and the Rural Tripper: Sir George Stapledon (1882-1960) at Ponterwyd, ca. 1913. *Journal of the University of Wales Agricultural Society.* 80.1-22

Morris, D.W. (1976). Practical Milk Production. Farming Press. London. UK.

Morris, G.D. (1996). Coleg Llysfasi 1921 – 1996. W.O. Jones (Printers) Ltd. Llangefni.

Murdoch, I.L. (2004). Developments in the evaluation of work-based learning: A UK prospective. *Industry and Higher Education.* 18(2): 121-124.

Murphy, J.J. (2001). Milk fat Composition and Nutritional Value. *Proceedings of the British Society of Animal Science.* 255-257.

Naruse, Y., Toga, S. and Hayase, Y. (2004). Development of an Online Course to facilitate Interaction with Learners. *Society for Information Technology and Teacher Education International Conference.* 1: 751-760.

Nash, D.L., Rogers, G.W., Cooper, J.B., Hargrove, G.L. and Keown, J.F. (2003). Heritability of Intramammary Infections at First Parturition and Relationship with Sire Transmitting Abilities for Somatic Cell Score, Udder Type Traits, Productive Life, and Protein Yield. *Journal of Dairy Science*. 86(8): 2684-2695.

Nasta, T. (1994). How to design a vocational curriculum. Kogan Page Limited. London. UK.

National Farmers' Union of Wales (NFUW). (2004). [On-line]: Available: www.cprw.org.uk /magartcl/ unionview.htm; www.cprw.org.uk /foot and mouthcl/unionview.htm Accessed: 16 October 2004.

NAW. (2005a). National Assembly of Wales. [On-line]: Available: http://www.wales.gov.uk /subleducationtraining/content/learning country/tlc-chapter3-51-e.htm Accessed: 24 April 2005.

NAW. (2005b). National Assembly of Wales. [On-line]: Available: http://www.wales.gov.uk /keypubstatisticsforwales/contentpublications/ agriculture/2004/farm-fact-2004-e.pdf Accessed: 24 April 2005.

NCSU. (2004). Index of Learning Styles (ILS). Howard Gardner's theory of Multiple Intelligence [On-line]: Available: www.ncsu.edu/felder-public/ILSpage.html Accessed: 16 June 2004.

Nicholas, F.W. (2000). Introduction to Veterinary Genetics. Blackwell Science Ltd, Oxford. UK.

Nielsen, B.H., Jacobsen, S., Anderson, P.H., Niewold, T.A. and Heegaard, P.M.H. (2004). Acute phase protein concentrations in serum and milk from healthy cows, cows which clinical mastitis and cows with extramammary inflammatory conditions. *The Veterinary Record.* 154: 361-365.

Nielsen, M.S.W., Domecq, J.J., Davis, L.E., Beede, D.K., Budin, M. and Martsolf, F. (2003). A partnership of Universities and Agri-Business for an Effective Dairy Herd Management Learning Experience for Undergraduate: The Dairy Challenge. *Journal of Dairy Science.* 86: 1029-1035.

Nilforooshan, M.A. and Edriss, M.A. (2004). Effect of age at first calving on some productive and longevity traits in Iranian Holsteins of the Isfahan province. *Journal of Dairy Science.* 87(7): 2130-2135.

Norman, H.D., Wright, J.R., Powell, R.L. and VanRaden, P.M. (2005). Merit of Genetic Prediction of Milk Yield by Parity for Holstein Bulls. [On-line]: Available: www.aipl.arsusda.gov/publish/jds/submit/jdsabstr _040775.html. Accessed: 6 January 2004.

Olori, V.E., Meuwissen, T.H.E. and Veerkamp, R.F.R. (2002). Calving interval and survival breeding values as measure of cow fertility in a pasture-based production system with seasonal calving. *Journal of Dairy Science*. 85(3): 689-696.

Ormerod, S.J., Marshall, E.J.P., Kerby, G. and Rushton, S.P. (2003). Meeting the ecological challenges of agriculture change: editorials' introduction. *Journal of Applied Ecology*. 40(6): 939-942.

O'Shea, E. (2003). Self-directed learning in nurse education: a review of the literature. *Journal of Advance Nursing*. 1(1): 62-70.

Park, J., Rehman, T. and Keatinge, J.D.H. (2002). Some contemporary challenges of teaching agriculture at institutions of Higher Education. *Farm Management*. 11(5): 327-338.

Parkinson, J. (2005). Mixing study at school and college. Pioneering programme for 14 to 16 year olds at New College, Nottingham. BBC News Online Education Staff. [On-line]: Available:http://newsvole.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/l/hi/educ.../347090.st. Accessed 24 April 2005.

Parkinson, T.J. and St George, A.M. (2003). Are the concept of andragogy and pedagogy relevant to veterinary undergraduate teaching? *Journal of Veterinary Medicine Education*. 30(3):247-253.

Pask, G. (1976). Styles and strategies of Learning. *British Journal of Educational Psychology*. 46: 128-148.

Peeters, R. and Galesloot, J.B. (2002). Estimating Daily Fat Yield form a Single Milking on Test Day for Herds with a Robotic Milking System. *Journal of Dairy Science*. 85: 682-688.

Perez-Cabal, M.A. and Alenda, R. (2002). Genetic relationship between lifetime profit and type traits in Spanish Holstein cows. *Journal of Dairy Science*. 85(12): 3480-3491.

Perez-Cabal, M.A. and Alenda, R. (2003). Lifetime Profit as an Individual Trait and Prediction of its Breeding Values in Spanish Holstein Cows. *Journal of Dairy Science*. 86(12): 4115-4122.

Personalitypage. (2004). Myers-Briggs Type Indicator [On-line]: Available: http://www.personalitypage.com/info.html Accessed: 25 June 2004.

Petty, G. (1998). Teaching Today, Practical guide. Stanley Thornes (Publishers) Ltd. Cheltenham.UK.

Phalet, K., Andriessen, I. and Lens, W. (2004). How Future Goals Enhance Motivation and Learning in Multicultural Classrooms: Effects of Time Perspective in Student Motivation. Educational Psychology Review. 16(1): 59-89.

Pheonix, D.A. (2002). A Culture of Lifelong Learning? *Journal of Biological Education.* 37(1): 4-5.

Philipsson, J. and Lindhe, B. (2003). Experiences of including reproduction and health traits in Scandinavian dairy cattle breeding programmes. *Livestock Production Science*. 82: 99 – 112.

Pirzada, R.H. (2000). Genetic analysis of production, fertility and health traits of dairy cows. PhD thesis. University of Wales, Bangor.

Pond, W.G. and Pond, K.R. (2000). Introduction to Animal Science. John Wileye and Sons.Inc. United State of America.

Powell, R. (1991). Resource for Flexible Learning. Network Education Press. Stafford. UK.

Preston, J. and Edmonds, C. (2004). Making Accessibility Accessible: A Collaborative Project in 508 Compliance for Online Higher Education. *Society for Information Technology and Teacher Education International Conference.* 1: 4949-4951.[On-line]. Available: http://dl.aace.org/15258. Accessed: 10 June, 2004.

Prospect (2005). Prospect-uk. [On-line]. Available: www.prospect.ac.uk. Accessed: 16 April, 2005.

Pryce, J.E., Esslemont, R.J., Thomson, R., Veerkamp, R.F., Kossaibati and Simm, G. (1998). Estimation of genetic parameters using health, fertility and production data from a management recording system for dairy cattle. *Animal Science.* 66: 577-587.

Pryce, J.E., Coffey, M.P. and Brotherstone, S.H. (2000). The GeneticRrelationship between Calving Interval, Body Condition Score and Linear Type and Management traits in Registered Holsteins. *Journal of Dairy Science.* 83(11): 2664-2671.

Pryce, J.E., Coffey, M.P., Brotherstone, S.H. and Woolliams, J.A. (2001). Selection Index using Calving Interval, condition scoring and milk yield in dairy cattle. *Proceedings of the British Society of Animal Science.* 37.

Pryce, J.E., Coffey, M.P., Brotherstone, S.H. and Woolliams, J.A. (2002). Genetic relationship between Calving Interval and Body Condition Score on Milk Yield. *Journal of Dairy Science.* 85(6): 1590-1595.

Pyorala, S. (2003). Indicators of inflammation in the diagnosis of mastitis. PMID: 14556695. *Journal of Dairy Science.* 86: 2470-2479.

QAA. (2001). The Quality Assurance Agency for Higher Education. [On-line]: Available: www.qaa.ac.uk Accessed: 22 July 2001.

QAA. (2005) The Quality Assurance Agency for Higher Education. [On-line]: Available: http://www.qaa.ac.uk/ academicinfrastructure/ FHBQ/EWNI/default.asp: Accessed: 26 April 2005.

RABDF. (2002). Royal Association of British Dairy Farmers. Longevity – the true cost. Dairy House. Warwickshire. UK.

RABDF. (2005). Royal Association of British Dairy Farmers. Identifying the true costs of farmers own labour. Dairy House. Warwickshire. UK.

Race, P. (2001). The Lecturer's Toolkit. A Practical guide to Learning, Teaching and Assessment. Kogan Pages. London. UK.

Raffrenato, E., Blake, R.W., Oltenacu, J., Carvalheira, J. and Licitra, G. (2003). Genotype by Environment Interaction for Yield and Somatic Cell Score with Alternative Environmental Definitions. *Journal of Dairy Science*. 86(7): 2470-2479.

Reece, I. and Walker, S. (1998). Teaching Training and Learning. Business Education Publishers. Tyne and Wear.

Rice, V.A. (1942). Breeding and Improvement of Farm Animals. McGraw-Hill Book Company, Inc. London.

Rolls, M.J. and Slavik, M. (2001). The Agricultural Teacher's Mission: Intentions and Expectations. The Journal of Agricultural Education and Extension. 7(4): 159-168.

Ross. (1994). Learning Styles Inventories [On-line]: Available: http://www.indstate.edu/ctl/styles/tstyle.html Accessed: 16 June 2004. learningstyle.org.uk Accessed: 3 May 2004.

Roxstrom, A., Strandberg, E., Bergland, B., Emanualson, U. and Plilipsson, J. (2001). Genetic and environmental correlation among female fertility traits and milk production in different pastures of Swedish Red and White Cattle. *ActaAgric. Scandinavia.* 51: 7-14.

Royal, M.D., Darwash, O.A., Flint, A.P.F., Webb, R., Woolliams, J.A. and Lamming, G.E. (2000). Decline fertility in dairy cattle: changes in traditional and endocrine parameters of fertility. *Animal Science*. 70(3): 487-501.

Russell, K. (1985). The Principles of Dairy Farming. Farming Press Ltd. Ipswich. UK.

Sandoe. P., Nielsen, B.L.,Christensen, L. G. and Sorensen, P. (1999). Staying good while playing god-the ethics of breeding farm animals. *Animal Welfare* 8:313-328.

Sarasin. A. (1998). Learning Style. [On-line]: Available: http://www.findarticle.com /p/articles /mi_m3765/is_n2_v17/ai_16474988 Accessed: 11 November 2004.

Scholes, J. Webb, C., Gray, M., Endacott, R., Miller, C., Jasper, M. and McMullan, M. (2004). Making portfolio work in practice. *Journal of Advance Nursing.* 46(6): 595-603.

Schulman, N.F., Viitala, S.M., de Koning, D.J., Virta, J., Maki-Tanila, A. and Vilkki, J.H. (2004) Quantitative Trait Loci for Health Traits in Finish Ayrshire Cattle. *Journal of Dairy Science.* 87: 443-449.

Scottish Agricultural College (SAC). (2004). The Scottish Office. [On-line]: Available: (http://www.scotland.gov.uk. history/colleges and http://www.royagcol.ac.uk/ document/intro.htm. Accessed: 10 April 2004.

Sewalem, G.J., Kistemaaker, G.J., Ducrocq, V. and Van Doormaal, B.J. (2005). Genetic Analysis of Herd Life in Canadian Dairy Cattle on a Lactation Basis Using a Weibull Proportional Hazard Model. *Journal of Dairy Science*. 88(1): 368-375.

Short, N. (2002). The use of information and communication technology in vetinary education. *Research in Veterinary Science.* 72(1): 1-6.

Simm, G. (2000a). Genetic improvement of cattle and sheep. Farming press: Ipswich, UK.

Simm, G. (2000b). Future Dairy Cattle Breeding Strategies. *Cattle Practice*. 8: 391-400.

Slater, K. and Throup, G. (1994). Dairy Farm Business Management. Farming Press Ltd. Suffolk. UK.

Smith, C. and Richardson, H. (2003). Cell Count trends in UK recorded herds. *Proceedings of the British Mastitis Conference*. National Milk Recording plc (NMR). 2003. 101-103.

Smith, M.K. (2002). Action Research. [On-line]: Available : (http://www.infed.org/research /biblio/b-learn.htm. Accessed: 5 July 2004.

Smith, M.K. (2003). Learning Theory – models, product and process. [On-line]: Available: (http://www.infed.org/research Accessed: 16 June 2004.

Snijder, S.E.M.., Dillion, P.G., O'Farrell, K.J., Diskin, M., Wylie, A.R.G., O'Callaghan, D., Rath, M. and Bolland, M.P. (2001). Genetic merit for milk production and reproductive successes in dairy cows. *Animal Reproductive Science.* 65: 17-31.

Soffe, R.J. (2003). The Agricultural Notebook. Blackwell Science. Oxford. UK.

Song, H., Wang, S. and Smith, R. (2004). Experiences in Teaching Technology Applications in Education. *Society for Information Technology and Teacher Education International Conference.* 1: 4278-4282.

Stevens, K and Cavanaugh, C. (2003). The development of visual classes in digital intranets in rural Canada and New Zealand. [On-line] Available: http:/dl.aace.org./11728 Accessed: 6 October 2004.

Stockdale, C.R. (2004). Effect of level of feeding of concentrates during early lactation on the yield and composition of milk form grazing dairy cows with varying body condition score at calving. *Australian Journal of Experimental Agriculture*. 44(1): 1-9.

St-Onge, A., Hayes, J.F. and Cue, R.I. (2001). Economic values of traits for dairy cattle improvement estimated using field-recorded data. *Canadian Journal of Animal Science.* 82: 29-39.

St-Pierre, A. (2004). Factors Enhancing Teachers' Performance in a Web-Educational Setting. Society for Information Technology and Teacher Education Conference. [On-line]: Available: http://dl.aacc.org/14850 Accessed: 29 January 2004.

Studentbmj. (2004). How to design a questionnaire. [On-line]: Available: www.studentbmj.com/back_issues/0601/education/187.html Accessed: 15 December 2004.

Sturt, G. (2003). Learning Style. [On-line]: Available: http://www.garysturt.free-online.co.uk/learnsty.htm Accessed: 16 June 2004.

Svinicki, M.D. (2005). Student Goal Orientation, Motivation, and Learning. [On-line]: Available: http://www.idea.ksu.edu/resources/index.html Accessed: 11 April 2005.

Swanson, G.J.T., Mrods, R.A. and Lindberg, C.M. (2003). Paper 2. Genetic Progress for Production plus Health, Welfare and Profit. [On-line]: Available : http://www.animaldata.co.uk/publications/paper2.htp Accessed: 12 January 2004.

Szyda, J, Liu, Z., Reinhardt, F. and Reents, R. (2005). Estimation of Qualitative Trait Loci Parameters for Milk Production Traits in German Holstein Dairy Cattle Population. *Journal of Dairy Science*. 88(1): 356-367.

Taylor, C., Fitza, J. and Gorard, S. (2005). Diverse, specialisation and equity in education. *Oxford Review of Education*. 31(1): 47-69.

Teacher. (2004). Learning styles. [On-line]: Available: http://www.teachers.ash.org.au/researchskills/dalton.htm Accessed: 9 June 2004.

Teachopolis. (2004). on line teaching [On-line]: Available: www.teachopolis.org Accessed: 28 June 2004

Teagasc. (2004). The virtual Agricultural College, Wales. Irish Agriculture and Food Development. [On-line]: Available: http://www.teagasc.ie. publications/2004/conferences/agriculturaleducation/paper05.htm Accessed: 4 January 2004.

Tickle, L. (2000). Teacher Induction: The Way Ahead. Open University Press. Buckingham. UK.

TSS. (2004). Teaching style [On-line]: Available: www.tss.uogaelph.ca /resources/teachers/packages.html Accessed: 16 June 2004.

UCAS. (2004) and (2005) . UCAS. course search. [On-line]: Available: (http://search.ucas.co.uk. cig-bin/hsrun/search) Accessed: 6 November 2004.

Valencia, V. and Anderson, D. (2000). Choosing optimum milk production system in a changing economic environment. *Farm Management*. 10(10): 618-630.

Van der Ban, A.W. (2002). Increasing the ability of farmers to compete in the market. *Journal of Agricultural Education and Extension*. 8: 101-106.

Veerkamp, R.F., Dillon, P., Kelly, E.,Cromie, A.R. and Groen, A.F. (2002). Dairy cattle breeding objectives combining yield, survival and calving interval for pasture based systems in Ireland under different milk quota scenarios. *Livestock Production Science*. 76(1/2): 137 – 151.

Verster, C. (2004). Learning Style and Teaching. [On-line]: Available: http://www.teachingenglish.org.uk/think/methadology/learning_style.shtml Accessed: 22 July 2004.

Visscher, P.M., Woolliams, J.A., Smith, D. and Williams, J.L. (2002). Estimation of Pedigree Errors in the UK Dairy Population using Microsatellite Markers and the Impact on Selcetion. *Journal of Dairy Science.* 85(9): 2368-2375.

Vygotsky, L.S. (1978). Mind in Society. Cambridge, Mass. Harvard University Press.

Wall, E., Brotherstone, S., Woolliams, J.A., Banos, G. and Coffey, M.P. (2003). Genetic Evaluation of Fertility Using Direct and Correlated Traits. *Journal of Dairy Science*. 86(9): 4093-4102.

Wall, E., White, M.S., Coffey, M.P. and Brotherstone, S. (2005). The Relationship Between Fertility, Rump Angle, and Selected Type Information in Holstein-Friesian Cows. *Journal of Dairy Science.* 88(1): 1521-1528.

Webb, E., Jones, A., Barker, P. and van Schaik, P. (2004). Using e-learning dialogues in higher education. *Innovations in Education and Teaching International.* 1: 93-103.

Webster, J. (1998). Understanding the Dairy Cow. Blackwell Scientific Publications. London. UK.

Weigel, K.A. and Lin, S.W. (2000). Use of computerised Mate Selection Programmes to Control Inbreeding of Holstein and Jersey Cattle in the Next Generation. *Journal of Dairy Science*. 83(4): 822-826.

Weigel, K.A. and Rekaya, R., Zwald, N.R. and Fikse, W.F. (2001). International Genetic Evaluation of Dairy Sires Using a Multiple-Trait Model with Individual Animal Performance Records. *Journal of Dairy Science*. 84: 2789-2795

Welsh Black Breed Society. (WBBS). (2003). Christopher Davis (Publishers) Ltd. Swansea.

Whittemore, C.T. (1980). Milk Production. Longman Handbooks in Agriculture. London.

Williams, I.W. and Baker, C. (1999). Ymchwil yn y Dosbarth. Llawlyfr I Athrawon, Darpar Athrawon a Myfyrwyr. Ysgol Addysg Prifysgol Cymru Bangor.

Willis, M.B. (1998). Dlaton's Introduction to Practical Animal Breeding. Blackwell Scientific Publications Ltd: Oxford, UK.

Wilson, R.D., Weigel, P.M., Fricke, P.M., Rutledge, J.J., Leibfried-Rutledge, M.L., Matthews, D.L. and Schutzhus, V.R. (2005). In Vitro Production of Holstein Embryos Using Sex-Sorting Sperm and Oocytes form Selected Cull Cows. *Journal of Dairy Science.* 88: 776-782.

Windig, J.J., Calus, M.P.L. and Veerkamp, R.F. (2005). Influence on herd environment on health and fertility and their relationship with milk production. *Journal of Dairy Science*. 88(1): 335-347.

Wolf, C.A. (2003). Custom dairy grower industry characteristics and contract terms. *Journal of Dairy Science*. 86(9): 3016-3022.

Wood, E. (2003). The power of pupil perspectives in evidence-based practice: the case of gender and underachievement. *Research Papers in Education.* 4(4): 365-383.

Wright, N.C. (2000). The Milk Supply in Time of War. *RASE Journal*. 101: 1940-1941.

Yazdi, M.H., Visscher, P.M., Ducrocq, V. and Thompson, R. (2002). Heritability, Repeatability of Genetic Evaluation and Response to Selection in Proportional Hazard Models. *Journal of Dairy Science*. 85: 1563-1577.

Yazici, H.J. (2005). A study of collaborative learning styles and team learning performance. *Education and Training*. 47: 216-229.

Zwald, N.R., Weigel, K.A. and Lawlor, T.J.Jr. (2005). Genetic parameters for conformation traits in herds that differ in mean final score and completeness of pedigree and performance data. *Journal of Dairy Science*. 88(1): 386-391.

APPENDIX 1

Figure 3.16. Questionnaire (final version)

The questionnaire will provide a summary of your views about this lesson. Your answers will help us to improve the quality of lessons. Please tick the box and add any comments, in the box underneath the question.

1. **This lecture has helped me develop a good understanding of the subject area.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

2. **The lecture was at the right level for me.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

3. **The lecture was well organised.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

4. **The lecturer checks that I understand things and there was enough explaining of ideas.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

5. **I was kept interested throughout the lecture.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

6. **The lecturer had a good subject knowledge.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

7. **The learning objectives were made clear to me.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

8. **The lecturer used a variety of teaching and learning methods.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

9. **I am satisfied that the lecturer made learning enjoyable.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

10. **There was a balance between theory and application (practical work);**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

11. **The teacher met my language needs including providing access to bilingual teaching (FE students only).**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

12. **I am satisfied with the learning resources (handout, books and references) that were available to support my learning.**

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

13. **Please identify any aspect of this lecture that you liked.**

14. **Please identify aspect of this lecture that you disliked.**

15. **Are there any further comments you would like to make about any aspects of the lesson?**

Thank you for your time. Anwen Williams

APPENDIX 1.

Figure 3.17. Questionnaire (draft version [R1])

This questionnaire will provide a summary of your views about this lesson. Your answers will help us to improve the quality of your lessons. Please add any comments or suggestions that you may have in the boxes underneath each of the question.

1. **I think that this lecture has helped me develop a good understanding of the subject area.**

   Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

2. **Links are made between the course and my activities outside college**

   Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

3. **The lecture was at the right level for me.**

   Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

4. **The lecture is well organised.**

   Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

5. **My lecturer checks that I understand things there was enough explaining of ideas.**

   Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

6. **I was kept interested throughout the lecture.**

   Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

7. **The lecturer established a good working relationship that helped me learn.**

   Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

8. **My teacher had a good subject knowledge.**

   Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

9. **The learning objectives were made clear to me.**
Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

10. **The lecturer used a variety of teaching and learning methods that resulted in a clear style of delivery to facilitate learning.**
Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

11. **The lesson was challenging and helped me to enjoy learning.**
Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

12. **Was there a balance between theory and practical work.**
Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

13. **Did the teacher meet your language needs including providing access to bilingual teaching.**
Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

14. **There was an effective use of learning resources and reflect the variety of students' interests.**
Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

15. **I am satisfied with the learning resources (hand-out, books and references) that were available to support my learning.**
Strongly agree___ Disagree ___ Undecided ___ Agree ___ Strongly agree ___ Not Applicable ___

16. Please identify aspects of this lecture which you liked.

17. Please identify aspects of this lecture which you disliked.

18. Are there any further comments you would like to make about any aspect of the lesson?

APPENDIX 1.

Figure 3.18. Self evaluation questionnaire

Opportunities given to students to develop a good understanding of the subject area.

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

1. The lecture was at the right level for the students.

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

3. The lecture was well organised.

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

4. Student understanding was maintained and ideas were explaining.

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

5. Students were kept interested throughout the lecture.

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

6. Did you have enough subject knowledge to lecture efficiently?

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

7. The learning objectives were made clear to the students.

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

8. A variety of teaching and learning methods were adopted.

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

9. The learning was made enjoyable.

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

10. There was a balance between theory and application (practical work);

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

11. Bilingual teaching was provided (FE students only).

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

12. The learning resources (handout, books and references) support the students learning.

Strongly disagree ☐ *Disagree* ☐ *Undecided* ☐ *Agree* ☐ *Strongly agree* ☐ Not applicable ☐

Stages from Piloting to Final Evaluation

Number of participating students - 186 [58 (pilot) and 128 (evaluation)]

<table>
<tr><th>Timescale</th><th>TERM 3
2001 - 2002</th><th>TERM 1
2002 - 2003</th><th>TERM 2
2002 - 2003</th><th>TERM 2
2003 - 2004</th></tr>
<tr><td>Stages</td><td>Piloting of Questionnaires</td><td>Piloting of Lectures (B1)</td><td colspan="2">Final Evaluation of Lectures (B2)</td></tr>
<tr><td>M
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T
S</td><td>Questionnaire PLANNING (SAFS, HMI and CMD Questionnaires)
↓
Questionnaire DESIGN (Cohen et al., 2000)
↓
PILOT
NVQ (R1) 11students
NCA (R1) 7students

FOCUS GROUP DISCUSSION

ACTION PLAN
AMEND

PILOT
NVQ (R2) 8 students
NCA (R2) 7 students
↓
FINAL VERSION OF QUESTIONNAIRE
[used in the pilot and final version of the lectures]</td><td>LESSON PLAN
Write lectures based on syllabus requirement, aims and objectives, data set and resources (herd and computers)
↓
PILOT
NVQ (10 FE)
NCA (6 FE)
HND/C (9 HE)

QUESTIONNAIRE
FOCUS GROUP DISCUSSION
PEER AND SELF ASSESSMENT (strengths and weaknesses)
↓
ACTION PLAN
Amend <u>all</u> lectures as action planned and used as final versions for the

EDUCATIONAL EVALUATION</td><td colspan="2">EDUCATIONAL EVALUATION
Two academic years
↓
Programme areas
NVQ (17 FE)

NCA (15 FE)

ND (22 FE)

HND/C (19 HE)

BSc (19 HE)

MSc (13 HE)

FARMERS GROUP(23)
↓
QUESTIONNAIRE

SELF-ASSESSMENT QUESTIONNAIRE

FOCUS GROUP DISCUSSION

SEMI-STRUCTURED-INTERVIEW

RESULTS</td></tr>
</table>

APPENDIX 1. a.
NVQ LECTURE

Gapped handout 1

BREEDING AND SELECTION IN DAIRY COWS

- Within your herd of cows, you will have a combination of *good and poor / bad cows*
- Only the best cows will be used for breeding *heifers*
- The poor /bad cows will be either *culled or used to breed beef animals*
- Dairy cows must produce *plenty of good quality milk*
- The cow must produce *one calf every year*
- The cow must have *good feet and udder* (linear assessment)
- The cow must be *healthy and remain in the herd for as long as possible* (longevity)

BREEDING PROGRAMME

Simply list all the good things that you are looking for in your herd. You will use your breeding programme to select your best cows for breeding your dairy heifers (replacement).

GLYNLLIFON BREEDING PLAN

- PRODUCTION – *plenty of good quality milk*
- MANAGEMENT – *regular calving and ease of handling*
- BODY CHARACTERISTICS – *good feet, udder and body depth* (Linear assessment)

DAIRY TRAITS- TRAITS FOUND IN DAIRY COWS

- *Milk yield*
- *Milk protein*
- *Milk fat*
- *Mastitis*
- *Regular calving*
- *Ease of handling*
- *Speed of milking*
- *Feet*
- *Udder*
- *Body depth*
- *Longevity*

DAIRY TRAITS - Farm Practical Activity

- Work individually or in pairs (as discussed) and Identify 4 cows with good traits and 4 cows with bad traits and list them on Table 1
- Consider the cow's milk yield, Table 2, and record it on Table 1
- Complete Table 3 for discussion at the end of the activity.

Table 1. Dairy Characteristics

GOOD DAIRY CHARACTIERISTICS			BAD DAIRY CHARACTERISTICS		
Cow No.	Characteristics	Milk (kg)	Cow No.	Characteristics	Milk (kg)

Table 2. Milk Yield

Cow Number	Milk yield (kg)	Cow Number	Milk yield (kg)
4	9,400	91	11,300
7	6,750	99	10,450
9	8,500	107	8,540
11	5,450	109	9,300
14	6,500	111	6,300
16	11,240	114	8,900
18	6,300	116	9,100
19	7,500	119	7,950
27	6,400	125	9,250
34	7,500	126	10,350
37	8,900	129	7,890
41	9,200	133	12,700
45	10,760	134	9,670
48	5,050	136	6,900
51	10,320	138	6,890
55	7,300	144	7,400
68	7,100	146	9,650
69	7,300	149	8,750
77	6,700		
82	5,700	Average yield	8,234
85	6,890		
89	7,320		

Table 3. Discussion

Herd weakness:
Herd strength:

LINEAR ASSESSMENT - Farm Practical Activity

Select a cow and draw a diagram of body depth, rear leg and fore udder attachment. Use the handout to help you decide on a score. The diagram should represent the score.

Body Depth: Cow No...........Score............... Draw a diagram of body depth

Rear Leg: Cow No.........Score................. Draw a diagram of rear leg

Fore Udder Attachment: Cow No ....Score....... Draw a diagram of fore udder attachment

Discussion points

1.

2.

3.

END OF CLASS QUESTIONS

Answer all the following questions

1. State **TWO** options for managing poor/bad cows.

   1..................................

   2......................................

2. Name **FOUR** good traits that you would be looking for in your dairy herd.

   1.....................................

   2......................................

   3.....................................

   4......................................

3. Name **THREE** of the linear assessment traits that you have looked at today

   1..................................

   2..................................

   3..................................

Supplementary Exercise

Write a breeding programme for your farm by selecting the following sentences.

- The cows that will be used for breeding dairy heifers must be able to produce plenty of good quality milk
- The milk produced from cows must be sold for the best price
- It is important that the cows make money so that the farm is profitable
- The cows must have good feet and udder
- The cow must be able to produce a calf each year
- The cows must be friendly and good natured
- Other

Breeding programme for my farm

APPENDIX 1.b.
NCA LECTURE

Gapped handout 1

THE BREEDING PROGRAMME

- It is important that all dairy farms should have a _breeding programme for their dairy herd._
- In formulating a breeding programme it is necessary to _define the breeding goals._

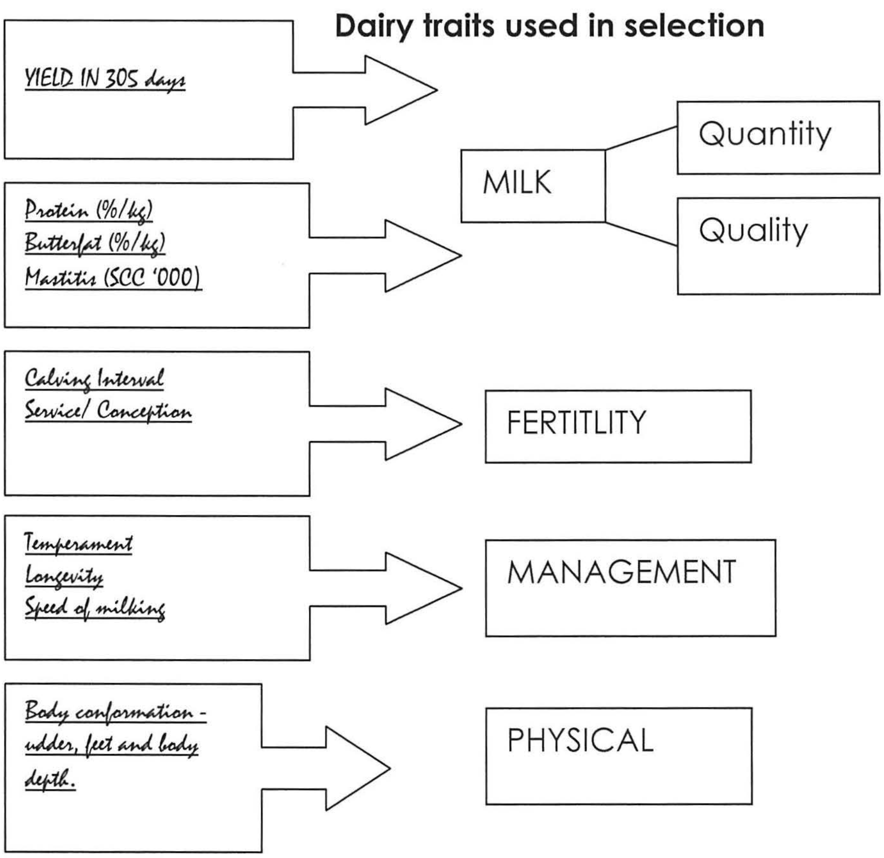
Breeding goals should be confined to economically important traits; these are the traits which affect farmer's income. The farmer's income depends mainly on _the ability of his cows to efficiently produce milk of a high quality and produce a good calf annually._

These traits are

- _Milk_
- _Protein_
- _Heifer calf replacement_
- _Beef calves (for beef enterprise within the farm business)_
- _Fertility_

THE PRINCIPLES OF BREEDNG

BREED YOUR BEST COWS TO THE BEST AVAILABLE BULLS. YOU ARE MORE LIKELY TO MAKE GENETIC PROGRESS.



SELECTION FOR BREEDING – Farm Practical Activity

Select 6 cows for breeding from the information provided in Table 1, and the completed record cards.

Table 1. Milk Yield

Cow Number	Milk yield (kg)	Cow Number	Milk yield (kg)
4	9,400	91	11,300
7	6,750	99	10,450
9	8,500	107	8,540
11	5,450	109	9,300
14	6,500	111	6,300
16	11,240	114	8,900
18	6,300	116	9,100
19	7,500	119	7,950
27	6,400	125	9,250
34	7,500	126	10,350
37	8,900	129	7,890
41	9,200	133	12,700
45	10,760	134	9,670
48	5,050	136	6,900
51	10,320	138	6,890
55	7,300	144	7,400
68	7,100	146	9,650
69	7,300	149	8,750
77	6,700		
82	5,700	Average yield	8,234
85	6,890		
89	7,320		

Six top milking cows to be kept for breeding (milk yield records)	**Six bottom cows to be culled (cow record cards)**
1	1
2	2
3	3
4	4
5	5
6	6

Discussion points:

Cow record cards

COW RECORD CARDS
Cow name………Zillia 45…………………………………..
Comments
Mastitis in rear left quarter – treat with erythromycin for 5 days

COW RECORD CARDS
Cow name…………Petula 98………………………………..
Comments
In calf, bad udder conformation and high cell count

COW RECORD CARDS
Cow name…………Rowena 134………………………………..
Comments
Problem with milk fever again – down for 2 days

COW RECORD CARDS
Cow name………Fiona 24…………………………………..
Comments
Slow milker, nervous in the parlour

COW RECORD CARDS
Cow name……………Blodwen 34……………………………..
Comments
In calf but very high cell count

COW RECORD CARDS
Cow name………………Zillia 78…………………………..
Comments
Stood on her teat and damaged teat canal

COW RECORD CARDS
Cow name……………Amity 85……………………………..
Comments
Not in calf, 6th repeat – vet

COW RECORD CARDS
Cow name…………Amity 89………………………………..
Comments
Calving difficulties but in calf to a dairy test bull

COW RECORD CARDS
Cow name……………Rowena 144……………………………..
Comments
Bad udder conformation

COW RECORD CARDS
Cow name……………Dunlu 56……………………………..
Comments
Vet – foot problem

COW RECORD CARDS
Cow name……………Rowena 139……………………………..
Comments
Suckling other cows

COW RECORD CARDS
Cow name……………Herebella 90……………………………..
Comments
Nervous and excitable always kicks when you put the cluster on

COW RECORD CARDS
Cow name…………Amity 68………………………………..
Comments
In calf – bad feet

COW RECORD CARDS
Cow name………………Blodwen 40…………………………..
Comments
not in calf – aborted / test result –ve for brucellosis

LINEAR ASSESSMENT – Farm Practical Activities

Linear assessment is a method of describing the physical characteristics of dairy cows. It will help to make judgment as to the cow's suitability for breeding replacement stock. Once the cows in your herd are given a score then it can be compared with other animals. Cows can then be 'ranked' in order of preference for selection in the herd.

	COW...	COW...	COW...	COW...	COW...	COW...
Status						
Body depth						
Rear legs						
Foot angle						
Udder support						
Udder depth						
Teat placement						
Teat length						

Discussion points

END OF CLASS QUESTION

1. Formulate a breeding plan for a herd, based on what you have learnt today

Supplementary Exercise

Based on milk yield records, cow record card and linear assessment, complete the following table

	Keep				Cull			
Milk yield								
	Keep				Cull			
Udder								
Feet								
	Keep				Cull			
Fertility problems								
	Keep				Cull			
Temperament								

APPENDIX 1.c.
ND LECTURE

Gapped handout 1

SELECTION METHOD ON DAIRY FARMS

Once you have decided on the breeding programme, you need to select the cows for breeding. There are three methods of selecting cows for breeding. These will be discussed in class together with the completion of class exercise.

- TANDEM SELECTION – selecting for one trait at a time e.g. milk yield. Then when milk yield will have reached an acceptable level you will select for another trait that needs improving.
- INDEPENDENT CULLING LEVEL – cull for unwanted traits e.g. udder shape, temperament, low yield or high cell count.
- INDEX SELECTION – Indexes have been calculated and are available on the NMR dairy cow list. They are £PLI. £PIN, PTA and the Fertility Index.

THE TERMINOLOGY USED IN ANIMAL SELECTION

GENENTIC INDEX is a measure of an animal's ability to pass its genes on to the next generation. It is not the effect of MANAGEMENT and ENVIRONMENTAL factors. It is the animal's own performance. So you can compare animals in different herds and under different systems.

PTA - Predicted Transmitting Ability. Genetic index are expressed as PTA, and have a base year.
PTA2000 - the average merit of cows milking in 2000, which is set as zero for that year.
£PIN - Profit Index. The financial value to their genetic merit. It is the expected increase in income per lactation for each daughter.
RELIABILITY (%) - a measure of the accuracy of the index.
TYPE INDEX - the ability of the cow or bull to transmit their genes for type to the next generation. For bulls it is called TYPE MERIT (TM) for cows it is COW TYPE MERIT.
PEDIGREE INDEX – gives an estimate of a young animal's genetic potential before it has any index of its own. It is usually based on the parents' genetic merit.
THE RELIABILITY is usually low 20% - 40%.

LINEAR ASSESSMENT - Farm Practical Activity

Linear assessment is a method of describing the physical characteristics of dairy cow and will help to make judgment as to the cow's suitability for breeding replacement stock. Once the cows within your herd are given a score then they can be compared with other cows. They can be 'ranked' in order of preference for selection in the herd.

	COW ……	COW …..	COW …..		COW ……	COW …..	COW …..
Status				Status			
Chest width				Chest width			
Body depth				Body depth			
Angularity				Angularity			
Rump angle				Rump angle			
Rump width				Rump width			
Rear legs (1)				Rear legs (1)			
Rear legs (2)				Rear legs (2)			
Foot angle				Foot angle			
Fore udder				Fore udder			
Rear udder				Rear udder			
Udder support				Udder support			
Udder depth				Udder depth			
Teat placement				Teat placement			
Teat placement				Teat placement			
Teat length				Teat length			

Discussion points:

DAIRY COW SELECTION - Farm Practical Activity

In order to make a judgment about individual cows in you herd you need to look at the production records. All these records need to be looked at together when selecting your cows for breeding. Your knowledge of the cow as a dairy farmer is also very importance.

Cow number	Lactation number	Milk yield (kg)
4	4	9,400
7	1	6,750
9	6	8,500
11	1	5,450
14	5	6,500
16	6	11,240
18	4	6,300
19	3	7,500
27	2	6,400
34	2	7,500
37	2	8,900
41	2	9,200
45	5	10,760
48	2	5,050
51	4	10,320
55	3	7,300
68	3	7,100
69	1	7,300
77	1	6,700
82	1	5,700
85	4	6,890
89	3	7,320
91	3	11,300
99	5	10,450
107	1	8,540
109	4	9,300
111	5	6,300
114	4	8,900
116	3	9,100
119	3	7,950
125	2	9,250
126	4	10,350
129	1	7,890
133	4	12,700
134	4	9,670
136	3	6,900
138	2	6,890
144	3	7,400
146	4	9,650
149	3	8,750
Total yield		329,370

Cow record cards

COW RECORD CARDS
Cow name………Zillia 45…………………………………..
Comments
Mastitis in rear left quarter – treat with erythromycin for 5 days

COW RECORD CARDS
Cow name…………Petula 98………………………………..
Comments
In calf bad, udder conformation and high cell count

COW RECORD CARDS
Cow name…………Rowena 134………………………………..
Comments
Problem with milk fever again – down for 2 days

COW RECORD CARDS
Cow name………Fiona 24…………………………………..
Comments
Slow milker, nervous in the parlour

COW RECORD CARDS
Cow name……………Blodwen 34……………………………..
Comments
In calf but very high cell count

COW RECORD CARDS
Cow name………………Zillia 78…………………………..
Comments
Stood on her teat and damaged teat canal

COW RECORD CARDS
Cow name……………Amity 85……………………………..
Comments
Not in calf, 6^{th} repeat – vet

COW RECORD CARDS
Cow name…………Amity 89………………………………..
Comments
Calving difficulties but in calf to a dairy test bull

COW RECORD CARDS
Cow name……………Rowena 144……………………………..
Comments
Bad udder conformation

COW RECORD CARDS
Cow name……………Dunlu 56……………………………..
Comments
Vet – foot problem

COW RECORD CARDS
Cow name……………Rowena 139……………………………..
Comments
Suckling other cows

COW RECORD CARDS
Cow name……………Herebella 90……………………………..
Comments
Nervous and excitable always kicks when you put the cluster on

COW RECORD CARDS
Cow name…………Amity 68………………………………..
Comments
In calf – bad feet

COW RECORD CARDS
Cow name……………..Blodwen 40…………………………..
Comments
not in calf – aborted / test result –ve for brucellosis

COW EVALUATION TABLE 1

Factors	**Keep**		**Cull**
Milk yield	**High**	**Average**	**Low**
Mature cows	10% or more above herd average	Within 10% of herd average	10% or mores below herd average
Second lactation	Above herd average	Within 20% of herd average	20% or more below herd average
First calvers	Above or within 10% of herd average	10% to 30% below herd average	30% or more below herd average

Source: Teagasc Modular Training Programme, (Bell, 2001).

Based on the information given, complete the table.

Factors	Keep		Cull
Milk yield	High	Average	Low
Mature cows			
Second lactation			
First calvers			

COW EVALUATION TABLE 2

Other Factors	Keep		Cull
Milk production level	**High yielders**	**Average yielders**	**Low yielders**
Disposition temperament	Not easily excited	Quiet /docile	Nervous
Not pregnant	Less than 150 days	Less than 120 days	120 days or more
Physical defects Injured teats Misshaped udders that are difficult to milk	Temporary	Temporary	Permanent
Milking qualities	Medium to slow	Fast	Slow to hard
Health Mastitis or kidney problems	Temporary	Good	Chronic or temporary
Udder conformation	Undesired but sound	Highly desirable and sound	Undesirable
Feet and legs	Undesired but sound	Highly desirable and sound	Undesirable
Body conformation	Poor to fair	Fair to good	Anything but the best

Source: Teagasc Modular Training Programme, (Bell, 2001).

Other factors regardless of yield will result in cows being culled. Serious health problems, chronic infection, dangerous cows, suckling other cows or permanent physical defects are all possible examples.

Based on the information given, complete the table.

Other Factors	Keep		Cull
Milk production level	**High yielders**	**Average yielders**	**Low yielders**
Disposition Temperament			
Not pregnant			
Physical defects			
Milking qualities			
Health			
Udder conformation			
Feet and legs			
Body conformation			

END OF CLASS QUESTIONS

1. Explain in you own words **ONE** method of selection

2. Name **FOUR** traits in the section of beef bulls for a dairy herd

3. Name the **TWO** selection index used in the selection of dairy bulls

4. Comment on the selection of bulls on the Glynllifon farm

Supplementary Exercise

SIRE EVALUTAION FOR THE HERD

Select FIVE bulls for the herd from the SEMEX BULL CATALOGUE

Bull Pedigree Name	Reasons for selecting / Comments
1.	
2.	
3.	
4.	
5.	

APPENDIX 1.d.
HND/C LECTURE

Gapped Handout 1

SELECTION

Every dairy farmer should have a breeding policy that is designed to achieve steady improvement in all traits, but giving priority to some.

Every dairy farmer will have a breeding policy driven by ECONOMIC factors. These may include the following:-

- CONFORMATION: dairy traits on Linear Assessment or beefing quality
- PRODUCTION: milk yield and milk quality
- REPRODUCTIVE EFFICIENCY: rapid return to oestrous or ease of calving
- FOOD CONVERSION EFFICIENCY: milk output per MJ of UME
- HEALTH DISEASE RESISTANCE: somatic cell count
- TEMPRAMENT
- LONGEVITY

GENETICS AND THE ENVIRONMENT

- SUPERIOR GENETIC MERIT COWS REQUIRE GOOD MANAGEMENT TO EXPLOIT THEIR GENETIC POTENTIAL. THEY NEED A PROPER ENVIRONMENT AND GOOD STOCKMANSHIP. BREEDING IS ONLY HALF THE STORY, GOOD NUTRITION AND MANAGEMENT ARE ESSENTIAL

POPULATION GENETICS

- The more traits chosen the slower the rate of improvement
- Selection for a single trait produces change in other traits. This is known as correlated response. Selecting for milk yield will increase body size and will increase somatic cell count (SCC)
- Pedigree recording is of little value in selection due to the dilution effect within each generation

COMPUTER BASED EXERCISE - Imple-pro

The Glynllifon dairy herd production and genetic information is available on the NMR Imple-pro software. Use the programme to create a report for the Farm Manager on 'Selection of Cows for Breeding'.

Investigate the herds PTA's and use Selection Index to identify animals for breeding. Your report should select a total of 25 cows for breeding.

PREDICTED TRANSMITTING ABILITY (PTA)

PTA is a **genetic index.** The PTA has a number attached, which refers to the national **base year**. The base year is related to the average merit of cows in that year which is set at zero.

- 'PTAs are a measure of genetic merit and can be used to select superior animals for breeding for improving the genetic merit of the herd'.
- 'PTAs indicate the amount of milk, fat and protein which an animal is predicted to pass on or transmit to its progeny.
- 'PTAs are expressed as deviations form a fixed genetic base PTA2000
- 'PTA is the weighted sum of 3 components and changes as more information is obtained form each additional lactation's production information.

It must be remembered that in practice, actual yields will vary substantially due to management and environmental factors.

RELIABILITY % - indicates how reliable, or how accurate, the PTA information is. The more information obtained, the higher the reliability. Reliability of 50-60% is considered low to moderate, whilst 99% is very high. High values are obtained from widely proven AI bull.

SOMATIC CELL COUNT (SCC) PTAs

SCC levels increase when an animal has mastitis and is a major economic loss for dairy farmers. Genetic evaluation may be able to play the part of breeding to reduce mastitis.

Selection for yields brings a related increase in SCC levels and mastitis. The PTAs are expressed as % PTA, as with production PTAs, the interpretation is the same (see Supplementary Exercise).

EXERCISE 1

Create a database for PTA for milk yield, fat and protein. Identify the highest-ranking cows in the herd using 'new table formation'. Save the file and import into 'word' for use in your report.

PROFIT INDEX (PIN)

- It is a **selection index** based on production.
- It is the **financial value** of the **genetic index, PTA**.
- It is a **single financial value** that expresses an increase in revenue per lactation for each daughter.
- The **formula** is simply the PTAs of milk, fat, protein x economic factor. The economic weighting is based on financial factors such as the price of fat and protein.

EXERCISE 2

Create a database for PIN. Identify the highest-ranking cows in the herd using 'new table formation'. Save the file and import into 'word' for use in your report.

PROFITABLE LIFE INDEX (£PLI)

- £PLI is a profit index using production factors and longevity.
- It is the net margin per cow per lactation
- It is an index that combines survival.
- Lactation and type is used to calculate longevity score.
- Type trait associate with longevity are; fore udder attachment; foot angle; udder depth; teat length. Also data on the actual survival (completed lactations) is used.

The length an animal spends in the herd is an important economic factor that significantly affects profit. Lower replacement rate equals lower replacement cost and it allows for opportunity to cull low producing cows. Also herd milk yield increases by having a higher proportion of mature cows in the herd.

EXERCISE 3

Create a database for £PLI. Identify the highest-ranking cows in the herd using 'new table formation'. Save the file and import into 'word' for use in your report.

EXERCISE 4

Create a database for linear traits. Identify the strengths and weaknesses for the herd.

Discussion points:

SUPPLEMENTARY EXERCISE

CASE STUDY FOR THE GLYNLLIFON HERD - **Somatic Cell Count (SCC)**

Economic losses due to mastitis are high on dairy farms; it is possible to reduce the incidence of mastitis by a control programme of improve management practices and breeding.

NOTES
When using SCC it is very important to appreciate that negative values means a reduction in SCC level therefore a reduction in the incidence of mastitis.
The range of %PTA is +/- 30% and 95% of bulls are within the range of +/-10%. SCC PTA Bull A is –10% therefore a reduction of 10% in SCC LEVELS
BULL B is +10% and will give a 10% increase in SCC level.

Reliability of % SCC PTA
SCC habitability is 11% and milk 35% (the lower the habitability the lower the reliability). This means that reliability will be lower, for a reliability of 70% SCC – 80 daughters are required, and while in comparison for milk only 26 daughters will be required for 70% reliability.

Evaluate the SCC situation within the herd and discuss the choice of bulls available for the Glynllifon herd.

Bull Pedigree Name	**Reasons for selecting / Comments**
1.	
2.	
3.	
4.	
5.	

Selection Method

- • Tandem selection – selecting for a single character until it reaches an acceptable level and then selecting for another
- • Independent culling level- culling for production weaknesses less than herd average or not meeting the minimum standard
- • Index selection Combine different traits into a singe genetic index. Examples are £PIN and £PLI
- • Individual selection of bulls to cow

HND/C

Example of a PROFITABLE BREEDING PROGRAMME

1. PRODUCTION CHARACTERISITCS – milk yield and quality
2. MANAGEMENT CHARACTERISTICS – calving interval, service/conception
3. BODY CHARACTERISTICS – stature, general appearance and locomotion

HND/C

Replacement heifers are needed to

- Maintain herd number
- Replace sold or dead animals
- Improve on genetic merit and efficiency by selecting heifers that will have sound conformation and excellent performance
- REPLACEMENT RATE – 20-25%

HND/C

BREEDING POLICY

- On most farms breeding policy will involves the selection of bulls and cows for profitable healthy milk production.
- By using your best cows and buying superior genetic bulls
- To produce the replacement heifers

HND/C

Selection and Breeding

- Linear Assessment
- Production

- PTA
- Selection index
- PIN, PLI

HND/C

APPENDIX 1.e.
BSc LECTURE

Handout 1

SELECTION AND BREEDING FOR PROFITABLE MILK PRODUCTION

TRAIT can be defined as 'any observable or measurable characteristic of an individual' (Bourdon, 1997).

- OBSERVABLE TRAITS or SUBJECTIVE TRAITS – are assed using a scoring system e.g. linear assessment for conformation score
- MEASURABLE TRAITS or OBJECTIVE TRATIS – measurable traits e.g. milk yield: production records with information on milk yield and quality.

FIVE BASIC CATEGORIES OF TRAITS for DAIRY COWS

- FITNESS TRAITS – reproductive and viability traits are important for the survival of the species e.g. calving interval and conception rate.
- PRODUCTION TRAITS – these are of economic value and include milk yield and growth rate.
- QUALITY TRAITS – milk fat and protein (%)
- TYPE TRAITS – Linear assessment and conformation
- BEHAVIOURAL TRAITS – docility and temperament

BREEDING POLICY

- In formulating a breeding programme it is necessary to define the objectives.
- Breeding objectives are confined to economically important traits. The principles of breeding are to breed your best cows to the best available bulls for genetic progress.
- The genetic factors account for variation in milk yield as well as the environmental factors. Environmental factors such as level of nutrition, calving date, age and breed type all affect milk production.

BREEDING PROGRAMME

Every dairy farmer will have a breeding policy driven by ECONOMIC factors. These may include the following:

- CONFORMATION – linear assessment
- PRODUCTION – milk quality and quantity
- REPRODUCTIVE EFFICIENCY – rapid return to oestrous or ease of calving
- FOOD CONVERSION EFFICIENCY – milk output per MJ of UME
- HEALTH DISEASE RESISTANCE – somatic cell count(SCC)
- TEMPRAMENT
- LONGEVITY

Handout 2 (to supplement OHP if required)

QUANTITATIVE GENETICS

Most quantitative traits that are of interest to the dairy industry are normally or near-normally distributed, because they are affected by many genes.

VARIANCE measure of the amount of variation in phenotypic value, genotypic value or breeding value.

- High variance indicates a very variable character
- Low variance gives a higher peaked curve and a small spread along the X-axis
- Variance measures the deviation of each item from the overall mean
- To make the variance more meaningful (get rid of the square)and Standard deviation is used and it is the square root of the variance
- This allows the actual unit of measurement to be used rather than the unit to the power of 2
- The STANDARD DEVIATION describes the variability
- One standard deviation either side of the mean is 68% of the population, two will have 95% of the population and standard deviation will have 99%
- The standard deviation is expressed as a percentage of the mean and becomes the coefficient of variation (CV). Some characters such as milk yield are quite variable (high coefficient of variation) while other like daily gain are less variable.

Variation or differences among individuals within a population allows the selection of animals. Selection would be difficult if there was little variation in a trait although breeders will want to reduce the variation within the population (herd) so that they have the top 25%.

Supplementary Exercise

CALCULATE VARIANCE FOR DAIRY COWS BORN AT GLYNLLIFON PERFORMANCE RECORD : milk yield form the NMR records.

1. Calculate the mean (average)
2. Calculate the deviation (difference between individual performance and the average. Normal distribution will show half to be lower and half to be higher than the average (-ve or +ve).
3. Square of the deviation (multiply the difference in average by itself, below average or –ve numbers become +ve when squared)
4. Add up the square deviations and then divide by n-1, where 'n' is the total number of records

THIS IS THE VARIANCE OF OUR SAMPLE OF OBSERVATIONS

Handout 3 (to supplement OHP if required)

COVARIATION or **CORRELATION COEFFICIENT**

- is the measure of the relationship between phenotypic values, genotypic values or breeding values. It describes how two traits or values vary together in a population.
- is the degree of resemblance between variables, phenotypic value, genotypic values or breeding values. It is a measure of the strength of the relationship between two variables.
- Genotype value and environmental deviation are not independent of each other.
- Correlations exist in milk yield e.g. feeding to yield results in the better phenotypes being given more food. This introduces a correlation between phenotypic value and environmental deviation.
- Since genotypic and phenotypic values correlate, there is a correlation between genotypic values and environmental deviations.

REGRESSION. (Regression coefficient)
The expected or the average change in one variable (y) per unit change in another (x). Regression coefficient is used to predict values. Regression, like covariance's and correlation, reveal the sign or the direction of the covariant.

HERITABILITY

- Heritability is a 'measure of the strength of the relationship between performance (phenotypic value) and breeding values for a trait in a population' (Bourdon, 1997).
- Heritability can also be defined as the 'proportion of total variance that is attributable to difference in breeding values, and this is what determines the degree of resemblance between relatives' (Bourdon, 1997).
- If a trait is highly heritable, animals with high performance tend to produce high performing offspring's, and likewise with low producing animals.

REPEATABILITY : Multiple measurement
When more than one measurement of a character can be made on an individual, the phenotypic variance can be partitioned into variance within individuals and variance between individuals. Milk yield can be measured in successive lactations allowing for repeatability of milk yield.

The dairy industry

PREDICTED TRANSMITTING ABILITY (PTA)

PTA is a **genetic index.** The PTA has a number attached, which refers to the national **base year**. The base year is related to the average merit of cows in that year which is set at zero.

- 'PTAs are a measure of genetic merit and can be used to select superior animals for breeding to improve the genetic merit of the herd'.
- 'PTAs indicate the amount of milk, fat and protein which an animal is predicted to pass on or transmit to its progeny.
- 'PTAs are expressed as deviations form a fixed genetic base PTA2000
- 'PTA is the weighted sum of 3 components.

RELIABILITY %

Reliability indicates how reliable, or how accurate, the PTA information is. The more information is obtained the higher the reliability e.g. 50-60% low to moderate and 99% very high – widely proven AI bull.

PROFIT INDEX (PIN)

- It is a selection index based on production.
- It is the financial value of the genetic index, PTA.
- It is a single financial value that expresses an increase in revenue per lactation for each daughter.
- The formula is simply the PTAs of milk, fat, protein x economic factor.

The economic weighting is based on financial factors such as the price of fat and protein.

PIN=(Milk kg PTA x –0.03) + (fat kg PTA x 0.05) + (protein kg PTA x 3.00)

Profitable Life Index - £PLI

- £PLI is a profit index using production factors and longevity.
- ADC recommends that it should be used as an initial screening.
- It is the net margin per cow per lactation and an index that combines survival.
- Lactation and type is used to calculate longevity score. Type trait associated with longevity are; fore udder attachment; foot angle; udder depth; teat length. Also data on the actual survival (completed lactations) is used.
- As can be seen in the formulae below lifespan has it's own economic weight

£PIN = (milkPTA x –0.03) + (fatPTA x 0.50) + (proteinPTA x 3.00) + (lifespanPTA x 28)

- This formula is simply the £PIN plus a lifespan value. These weightings will change as prices changes for economic factors in milk production e.g. milk price or quota.

FARM CLASS WORK SHEET - Linear Assessment

Linear assessment is a method of describing the physical characteristics of the cow and will help to make judgment as to the cow's suitability to breed replacement stock. Once the cows in your herd are given a score then it can be compared with other animals and cows can be 'ranked' in order of preference for selection in the herd.

Exercise 1

Table 1.1. Linear Assessment

	HEIFER	HEIFER	HEIFER	COW....	COW....	COW....
Status						
Chest width						
Body depth						
Angularity						
Rump angle						
Rump width						
Rear legs						
Foot angle						
Fore udder						
Rear udder						
Udder support						
Udder depth						
Teat placement						
Teat placement						
Teat length						

EXERCISE 2

Table 2.1 List of PTA and PIN2000 for cows in herd

Cow name	Milk (kg)	Fat (kg)	prt (kg)	Fat (%)	Prt (%)	Rel (%)	PIN 2000
Gcutie1	-18	0	2.4	0.01	0.05	53	10
Dunlu58	255	13.2	10.6	0.05	0.04	57	43
Cbine21	-35	5	-0.8	0.1	0.1	56	1
Rowena133	71	4.2	2.8	0.02	0.01	59	12
Lydia63	-161	-3.3	-4.7	0.05	0.01	57	-11
Nancy69	113	-2.6	3.7	-0.13	0	53	10
Hbel55	166	8	3.3	0.02	-0.04	57	13
29	250	6.1	4.5	-0.07	-0.06	48	14
Gzilla78	197	8.6	4.8	0.01	-0.03	60	19
Gzilla79	47	5.2	1.7	0.06	0	61	9
Gndeyes29	40	7.5	4.8	0.11	0.06	61	23
Gndeyes31	378	15	13.3	-0.01	0.02	51	51
Viola33	229	15.2	8.5	0.1	0.02	47	37
Amity63	277	10.4	7.5	-0.02	-0.03	59	28
Nancy62	144	15	6.3	0.16	0.03	59	30
Hbel53	166	11.3	7.6	0.08	0.04	51	33
Cbine17	-237	-7.1	-4.8	0.05	0.06	62	-17
Rowena77	-155	15	-5.3	-0.16	-0.01	63	-216
Lydia35	-112	4.8	-4.3	0.17	-0.01	63	-11
Gzilla95	79	13.5	6.9	0.18	0.08	52	34
Gndeyes39	218	15	11.4	0.11	0.08	48	49

Table 2.2. List of bulls (list 2001)

Bull name	Milk (kg)	Fat (kg)	prt (kg)	Fat (%)	Prt (%)	Rel (%)	PIN 2000
A	461	10.5	14.5	-0.14	-0.01	80	51
B	195	10.3	10.8	0.04	0.08	70	44
C	150	6.7	7.1	0.01	0.04	79	28
D	0	0	0	0	0	0	0
E	102	1.9	5.5	-0.04	0.04	52	20
F	0	0	0	0	0	0	0
G	216	2.1	8.1	-0.12	0.02	51	28
H	222	7.9	8.1	-0.02	0.02	60	31
I	373	13.1	13	-0.04	0.02	91	49
J	226	15.1	10.9	0.1	0.06	92	46
K	-19	5.8	0.6	0.12	0.02	62	6
L	38	8	-0.5	0.1	-0.03	50	1

GROUP DISCUSSION

Learning resource – dairy breeding magazines and production records

END OF CLASS QUESTIONS

1. Why is it important to have a breeding policy?
2. What are the traits that are used in selection?
3. Which type traits in your opinion are the most important?
4. What is PTA?
5. Which selection index do dairy farmers most commonly use?

Supplementary Exercise

SELECTING BREEDING STOCK WITHIN A PRODUCTION PROGRAMME

EXERCISE 1

From the list of dairy cows in Table 1.1 you need to select the best cows for breeding your replacement heifers. Your breeding objective is to increase milk yield. Assume that the differences in milk yield are due to genetic factors and that the cows are healthy and display normal dairy traits. Based on this information select 50% of the group for breeding replacements.

Table 1.1 Lactation Milk Yield

Cow Number	Milk yield (kg)	Cow Number	Milk yield (kg)	**Cows Selected**	**Result from EXCERSISE 3**
4	9,400	91	11,300		
7	6,750	99	10,450		
9	8,500	107	8,540		
11	5,450	109	9,300		
14	6,500	111	6,300		
16	11,240	114	8,900		
18	6,300	116	9,100		
19	7,500	119	7,950		
27	6,400	125	9,250		
34	7,500	126	10,350		
37	8,900	129	7,890		
41	9,200	133	12,700		
45	10,760	134	9,670		
48	5,050	136	6,900		
51	10,320	138	6,890		
55	7,300	144	7,400		
68	7,100	146	9,650		
69	7,300	149	8,750		
77	6,700				
82	5,700	Average yield	8,234		
85	6,890				
89	7,320				

EXERCISE 2

In Exercise 1 the only information provided related to milk yield. If more information was given cows selected for breeding may differ. Phenotypic values such as milk yield will be influenced by many environmental factors. Therefore the effect of these factors has to be taken into account before selection decision can be made.

ELIMINATION OF ENVIRONMNETAL EFFECT (Additive correction factor)

Correcting for the effect of lactation number

Environmental factors such as lactation length and number can be taken into account using correction factors prior to you making the selection decision. The corrected milk yield allows you to compare as if all the cows were in the same lactation number or lactation length.

Table 2.1 Additive correction factor for lactation number

Type	Mean	Calculation	Differences
Lac 1	6750	6750-6900	150
Lac 2	7200	7200-6900	300
All group	6900		

Table 2.2. Correction factor

Correction factors	
Lac 1	+150
Lac 2	-300

Complete the following tables

Type	Mean	Calculation	Differences
Lac 1			
Lac 2			
Lac 3			
Lac 4			
Lac 5			
All group			

Lac 1	
Lac 2	
Lac 3	
Lac 4	
Lac 5	

EXERCISE 3

Table 3. Additive correction factor calculations

Cow no.	Lact no.	Milk yield (kg)	adjusted	Adjusted yield	Cow no.	Lact No.	Milk yield (kg)	adjusted	Adjusted yield
4	4	9,400			107	1	8,540		
7	1	6,750			109	4	9,300		
9	6	8,500			111	5	6,300		
11	1	5,450			114	4	8,900		
14	5	6,500			116	3	9,100		
16	6	11,240			119	3	7,950		
18	4	6,300			125	2	9,250		
19	3	7,500			126	4	10,350		
27	2	6,400			129	1	7,890		
34	2	7,500			133	4	12,700		
37	2	8,900			134	4	9,670		
41	2	9,200			136	3	6,900		
45	5	10,760			138	2	6,890		
48	2	5,050			144	3	7,400		
51	4	10,320			146	4	9,650		
55	3	7,300			149	3	8,750		
68	3	7,100			Total yield		329,370		
69	1	7,300			Average yield		8,234		

Discussion and Conclusion:

TRAITS

- **TRAIT** - any observable or measurable characteristic of an individual
- **QUALITATIVE TRAITS**
- **QUANTITAITIVE TRAITS**
- OBSERVABLE TRAITS
- MEASURABLE TRAITS

DAIRY COW BREEDING

- BREEDING POLICY
- SIRE SELECTION
- DAIRY COW SELECTION
- REPLACEMETN RATE
- P=G+E

BSc (Bangor)

QUANTITATIVE GENETICS

- NORMAL DISTRIBUTION
- VARIANCE
- STANDARD DEVIATION
- COEFFICIENT OF VATIATION
- CORRELATION
- REGRESSION

BSc (Bangor)

basic genetic model for quantitative traits

P = G + E

Vg = Va + Vd + Vi

Va=Vd + Vi +Ve

BSc (Bangor)

Breeding value

- Linear Assessment
- Production

- PTA
- Selection index
- PIN, PLI

BSc (Bangor)

Where to get more information

- Bourdon, R.M.1997. Understanding Animal Breeding. Prentice Hall
- Simm, G. 1998. Genetic improvement in Cattle and Sheep. Farming Press
- www.animaldata.co.uk

BSc (Bangor)

APPENDIX 1.f.
MSc LECTURE

Handout 1

Estimation of variance components and genetic parameters for the Glynllifon Herd using univariate analyses

The animal model ASREMIL program can be used to estimate the variance components and genetic parameters for milk, fat and protein yield using actual lactation information between 1950 and 2000. The stages involved are as follows:-

Table 1. XLS.file Glynllifon Herd

COW	DAM	SIRE	DOB	LAC	CLF	AGE	CI	DD	MY	LL	FAT	PROT
gzilla12	gzilla	chyb2	04/29/70	6	1	94	355	81	5969	283	3.64	3.26
gzilla12	gzilla	chyb2	04/29/70	7	1	105	341	58	7654	278	3.33	3.21
gzilla12	gzilla	chyb2	04/29/70	8	1	116	329	51	9041	305	3.35	3.12
gzilla12	gzilla	chyb2	04/29/70	9	1	130	441	79	7662	299	3.43	2.98
gzilla12	gzilla	chyb2	04/29/70	10	12	143	384	85	7991	305	3.49	3.09
gzilla14	gzilla5	Oyt	12/20/70	1	2	27	0	0	3792	281	3.89	2.98
gzilla14	gzilla5	Oyt	12/20/70	2	2	38	343	62	5538	305	3.79	3.21
gzilla14	gzilla5	Oyt	12/20/70	3	1	51	376	47	5593	304	3.68	3.27
gzilla14	gzilla5	Oyt	12/20/70	4	1	62	343	39	6695	305	3.72	3.16
gzilla14	gzilla5	Oyt	12/20/70	5	2	75	394	84	7125	305	3.90	3.14

LAC=lactation number; CLF= calf, 1=male, 1=female; AGE=age at calving; CI= calving interval; DD= days dry; MY= milk yield; LL=lactation length; FAT= milk fat(%); and PROT=milk protein(%)

Table 2. CSV.file

COW	DAM	SIRE	LAC	AGE	CI	DD	DOB	FAT	PROT
Gndeyes4	pigndeyes2	btb	1	32	0	0	19643	52	167
Nancy37	nancy32	red	3	50	398	79	19832	221	299
Hbel40	Hbel29	sdd	1	25	0	0	19873	176	303
Gzilla	ctzilla8	blb	5	72	359	86	19692	193	285
Alice4	alice2	btb	1	34	0	0	19633	140	322
Rowena31	rowena7	hdaa	9	121	339	44	19842	215	297
Rowena42	rowena31	gla2	3	56	326	35	19822	287	305
Hbel11	hbel5	blal	11	146	398	102	19812	159	297
Lady3	lady2	btb	1	32	0	0	19613	94	234
Gndeyes6	gndeyes4	gnpc	4	64	359	94	19691	97	264
Amity9	Amity	btb	6	94	352	90	19751	242	305
Rowena7	rowena3	thwm	3	51	394	102	19701	129	297
Rowena7	rowena3	thwm	4	63	374	77	19712	168	301
Branwen8	branwen5	Mrj	6	94	401	71	19793	137	193

LAC=lactation number; CLF= calf, 1=male, 1=female; AGE=age at calving; CI= calving interval; DD= days dry; MY= milk yield; LL=lactation length; FAT= milk fat(kg); and PROT=milk protein(Kg)

The CSV.file was then renamed as a 'DAT file' and appears as in Table 3 below.

Table 3. DAT. file

```
gzilla,ctzilla8,blb,3,49,361,62,19672,6316,288,3.67
gzilla,ctzilla8,blb,4,61,344,56,19682,6264,273,3.04
gzilla,ctzilla8,blb,5,72,359,86,19692,6684,285,2.89
gzilla,ctzilla8,blb,6,84,358,73,19702,6617,305,3.08
gzilla,ctzilla8,blb,7,98,405,86,19712,6638,285,3.40
gzilla,ctzilla8,blb,8,109,338,53,19722,6600,276,3.41
gzilla,ctzilla8,blb,9,120,356,80,19732,3321,97,2.90
gzilla2,ctzilla8,hya2,1,29,0,0,19663,4507,303,4.22
gzilla2,ctzilla8,hya2,2,40,352,49,19673,4860,305,4.60
gzilla2,ctzilla8,hya2,3,54,404,96,19683,4850,254,4.08
```

A command file was written as an 'AS.file' for the ASReml programme to proceed as seen in Table 4. The ASReml will now commence by using LEFT click on the mouse followed by RETURN and RUN command. An 'asr.file' will then appear if the programme has been successful as in Table 5.

Table 4. AS.file

```
Glynllifon data
 animal !P
 sire !P
 dam !P
 lactno 13
 inter
 dry
 ymonth 187 !I
 my !m0
 days
mart1.dat !ALPHA !MAKE !REPEAT
mart1.dat
my ~ lactno ymonth days !r animal ide(animal)
```

Table 5. ASR.file

```
ASReml [ 3 Sep 2001]  protein test on glynllifon data
 24 Jan 2002 13:14:34.770  32.00 Mbyte  MSWIN  C:\awilliamsprotein
************************************************************
 A valid license to run ASReml was not found
 You are not permitted to use ASReml without a valid license
 except for a trial period of up to 30 calendar days
************************************************************
 * ASREML 2001 *********************************************
 * Jan Scale of spline and pol design matrices has changed.*
 *      This will change the components but not the fit. *
 * Feb predict syntax has changed.                  *
****************************************************** ARG *
  sire !P
  dam !P
  ymonth 187 !I
  protein !m0
  Reading pedigree file protein.dat : skipping  0  lines
 PEDIGREE [protein.dat ] has     827 identities,    2707 Non zero elements
  Reading protein.dat  FREE FORMAT skipping  0  lines
 Univariate analysis of protein
 Using    2327 records of    2327 read
  Model term        Size Type   COL  Minimum    Mean     Maximum  #zero #miss
   1 animal        827 Direct   1   3.000     433.9      827.0       0     0
   2 sire          827 Direct   2   2.000     423.7      822.0       0     0
   3 dam           827 Direct   3   1.000     147.3      818.0       0     0
   4 lactno         13 Factor   4   1         3.2669      13         0     0
   5 age            1 Covariat  5  19.00      57.87      186.0       0     0
   6 inter          1 Covariat  6 218.0      277.3       634.0     599     0
   7 dry            1 Covariat  7   1.000     46.20      265.0     614     0
```

The ASREML will provide valuable data that can be used to calculate the following parameters; Phenotypic variance (Vp); heritability (h^2); permanent environmental effect of animal as a proportion of the phenotypic variance (c^2); and repeatability. They are calculated using the following formulas:-

HERITABILITY (h^2)

$$h^2 = \frac{VA}{VA + VC + VE}$$

or

$$h^2 = \frac{\text{additive genetic variance}}{\text{phenotypic variance}}$$

VA = Additive genetic variance ; VC = permanent environmental variance; VE = residual error (error variance); VP = phenotypic variance (VA + VC + VE).

RELIABILITY (R)

$$R = \frac{VA + VC}{VA + VC + VE}$$

PERMANENT ENVIRONMENTAL VARIANCE DUE TO ANIMAL AS A PROPORTION OF PHENOTYPIC VARAINCE (C^2)

$$C^2 = \frac{VC}{VP}$$

VP = phenotypic variance (VA + VC + VE)

Environmental Factors such as the effect of lactation number, calving age and lactation length can be determined. An example of the effect of milk, fat and protein yields can be seen in Table 6 and 7.

Table 6. the effects of lactation number, calving age and lactation length on production traits (Figures are F-values obtained from ASREMIL analysis).

Trait	Lactation number	Calving age	Days dry
Milk yield	1206.63	81.75	5540.55
Fat yield	1043.24	4.10	7002.21
Protein yield	1533.45	3.15	4653.95

Lactation number had an effect ($P<0.05$) on milk, fat and protein yield. Calving age had an affect on milk yield ($P>0.05$), but not on fat and protein yield. Result on days dry also had an affect on milk, fat and protein yield ($P>0.05$).

Table 7. Effect of lactation number, calving age and lactation number on production traits in (kg)

Trait	Lactation number(kg)	Calving age (kg/months)	Days dry (kg/day)
Milk yield	32.59	27.86	45.77
Fat yield	0.78	2.53	1.55
Protein yield	1.93	1.32	2.65

(Figures obtained from ASREMIL analysis sln.file).

ASREML – analysis (Exercise 1)

Using the data for the lactation records, carry out the ASREML analysis. Calculate the additive genetic variance (VA), error variance(VE), phenotypic variance (VP), permanent environmental variance (C^2) of milk, fat and protein yield for the data set in order to complete Table 8.

Table 8. Estimates of variance components and genetic parameters of production traits in univariate analysis.

Traits	No of records	h^2 (se)	C^2 (se)	R (se)	VA	VC	VE	VP
MY	3464	0.25 (0.013)	0.22 (0.015)	0.47 (0.005)	195316	173507	420753	789576
FY	2896	0.31 (0.023)	0.19 (0.021)	0.51 (0.006)	519.37	316.76	821.38	1657.51
F%	2896	0.64 (0.033)	0.16 (0.034)	0.70 (0.014)	569.32	141.31	176.48	887.11
PY	2997	0.26 (0.024)	0.29 (0.031)	0.55 (0.007)	366.27	399.70	621.31	1387.28
P%	2997	0.47 (0.036)	0.23 (0.022	0.80 (0.012)	4311.91	2146.32	2771.64	9229.87

Abbreviations used for dataset are defined in Table 8. MY= Milk yield, FY = Fat yield, PY = Protein yield, h^2 = Heritability, s.e = Standard Error, C^2 = Permanent environmental variance due to the animal as a proportion of phenotypic variance, R = Repeatability, VC = Permanent environmental variance, VA = Direct additive genetic variance, VP = Phenotypic variance, VE = Error variance.

INTERPRET THE DATA:

Univariate analysis for milk, fat and protein yield are shown in Table 8. as Heritability and repeatability estimates and their standard errors. The heritability of these traits were moderate ranging from 0.25 – 0.64. Repeatability results shows that milk, fat and protein were highly repeatable with estimates ranging form 0.47 to 0.80. Standard errors for heritability and repeatability estimates for milk, fat and protein yield were generally small.

DISCUSSION POINTS:

Gapped handout 2

Dairycowdata.asr

****
****

ASReml [Dec 2003] milk test on dairycowdata
MSWIN C:/dairycowdata

Sire !P
Dam !P
Ymonth 187 !I
Milk !m0
Reading pedigree file dairycowdata.dat : skipping 0 lines
PEDIGREE [dairycowdata.dat] has 2431 identities, 3463 Non zero elements
Reading dairycowdat.dat FREE FORMAT skipping 0 lines
Univariate analysis of milk
Using 3464 records of 3464 read

Model term	Size type	COL	Minimum	Mean	Maximum
1 Animal	2431 Direct	1	3.0000	618.7714	2431
2 Sire	2431 Direct	2	2.0000	197.8	2431
3 Dam	2431 Direct	3	1.0000	584.6	2431
4 Lactno	13 Factors	4	1	3.2611	13
5 Age	1 Covariat	5	18.00	54.52	186.0
6 Inter	1 Covariat	6	145.00	275.4	842.85
7 Dry	1 Covariat	7	14.00	49.88	265.0
8 Ymonth	187 Factors	8	1	78.47	185
9 Milk	1 Variate	9	500.00	5753.92	11978.77
10 Days	1 Covariate	10	2.000	286.2	491.00
11 Ide(animal)	2431 Identity	11	3.0000	618.7714	2431

Source	Variance	Components
Animal	V_A = Additive genetic variance	195316
Ide(animal)	V_C = permanent environmental variance	173507
Variance	V_E = residual error (error variance)	420753

Analysis of variance	DF	F-incr	
4 lactatno	13	1206	
5 age		1 81.75	
8 ymonth	183	12.46	
10 days		1	5540

* The variance ratio, p=0.05 (F tables).

Dairycowdata.sln.file (Exercise 2)

From the dairycowdata.sln file answer the following questions

How much less milk would you expect to have for every extra one day dry..................................Kg?

For the year and season of calving (ymonth), how much milk would you expect to get relative to the average for:-

19632....................kg
19751....................kg
19881....................kg
19962....................kg

What effect has increasing the age at calving have on milk yield?

....

4. Plot the lactation number and yield and explain the effect of lactation number on milk yield over they cow's typical life time production.

Milk yield is an important economic trait within the dairy industry and cows will be selected on the basis of their milk yield results. This is known as selective culling. From the list of cows on the ASREML handout identify five cows and bulls that you may selectively cull.

Cow Name	Bull Name

Dairycowdata.sln			
Days	1	18.83	0.2529
Ymonth	19632	-298.3	242.4
Ymonth	19643	-197.9	267.5
Ymonth	19751	77.85	285.7
Ymonth	19783	84.88	297.4
Ymonth	19881	187.3	359.1
Ymonth	19893	155.2	376.8
Ymonth	19951	284.4	421.6
Ymonth	19962	345.9	467.8
Age	1	-1.353	1.489
Lactno	1	-1438	277.4
Lactno	2	-572.4	278.6
Lactno	3	-149.6	284.2
Lactno	4	102.6	288.8
Lactno	5	237.5	294.2
Lactno	6	266.2	302.7
Lactno	7	200.6	309.8
Lactno	8	120.2	321.1
Lactno	9	-60.21	330.9
Lactno	10	-269.8	355.6
Lactno	11	-674.3	419.6
Lactno	12	-484.7	504.2
Lactno	13	-2038	791.5
Animal	Gzillia22	-316.3	267.2
Animal	Growena59	-267.7	289.2
Animal	Gamity91	356.4	312.4
Animal	Gpetula42	239.1	235.3
Animal	Gdunlu19	433.5	318.6
Animal	Gblodwen4	286.2	311.7
Animal	Gherebell29	658.8	411.1
Animal	Growena122	599.4	354.1
Animal	Gamity117	-77.3	266.9
Animal	Gpetula94	631.0	487.9
Animal	Gdunlu57	255.5	352.4
Animal	Gblodwen38	392.4	234.2
Animal	Gzillia56	396.8	422.2
Animal	Gzillia83	643.1	376.1
Animal	Knm	544.5	389.1
Animal	Gsts	233.1	377.1
Animal	Per	-178.3	288.3
Animal	Chyw2	-7.3	164.7
Animal	Oyt	-34.5	189.4
Animal	Mmblck	345	282.6
Animal	Thmnj	433	311.3
Animal	Red	-85.4	308.8
Animal	Rhln	366.2	432.2
Animal	Hdaa	355.3	491.5
Animal	Cto	-288.7	265.4
Animal	Fna	-432.5	256.9

Supplementary Exercise

Discuss the following data with respect to premature culling

SLN.file (MILK YIELD)

lactno	1	-1438.	277.4
lactno	2	-572.4	278.6
lactno	3	-149.6	284.2
lactno	4	101.6	288.8
lactno	5	237.5	294.2
lactno	6	266.2	302.7
lactno	7	200.6	309.8
lactno	8	120.2	321.1
lactno	9	-60.21	330.9
lactno	10	-269.8	355.6
lactno	11	-674.3	419.6
lactno	12	-484.7	504.2
lactno	13	-2038.	791.5

PROTEIN (PROTEIN YIELD)

lactno	1	232.5	18.76
lactno	2	234.4	20.04
lactno	3	236.2	21.41
lactno	4	237.9	23.09
lactno	5	246.0	25.01
lactno	6	253.6	27.11
lactno	7	245.9	29.25
lactno	8	242.6	31.50
lactno	9	241.3	34.24
lactno	10	233.4	37.30
lactno	11	232.4	41.83
lactno	12	220.6	46.33
lactno	13	213.0	57.80

FAT (FAT YIELD)

lactno	1	262.5	18.76
lactno	2	264.4	20.04
lactno	3	266.2	21.41
lactno	4	269.9	23.09
lactno	5	272.0	25.01
lactno	6	278.6	27.11
lactno	7	276.9	29.25
lactno	8	274.6	31.50
lactno	9	271.3	34.24
lactno	10	268.4	37.30
lactno	11	266.4	41.83
lactno	12	250.6	46.33
lactno	13	253.0	57.80

QUANTITATIVE GENETICS

- Phenotypic value (P) is the value observed and measured on an individual.
- Genotype (G) is the assemblage of genes in an animal.
- Environment (E) is all the non-genetic circumstances that influence the phenotypic value.

MSc (Bangor)

- Genotype and the environment influence the phenotypic value.
  - P = G + E
- A value associated with the transmission of genes is the average effect or the additive effect.
- It is not possible to measure the average effect and therefore breeding value is used.

MSc (Bangor)

P = G + E
P = (A +D+I) + E

- Dominance deviations are interaction between alleles, and within-locus interaction (D).
- The genotype value may contain an additional deviation due to non-additive combination when more than one loci is considered, the interactive deviation (I).

MSc (Bangor)

VARIANCE.

- The amount of variation is measured and expressed as the variance
- VP = VG + VE
- = VA + VD + VI + VE
- The ration VA/VP expresses the extent to which phenotypes are determined by the gene transmitted form the parents. HERITABLILITY

MSc (Bangor)

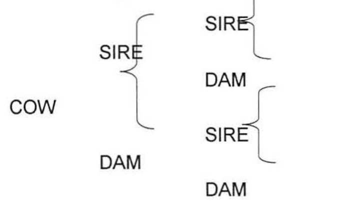
Selection Index

- Breeding Value
- PTA
- Economic Weighting
- £PIN
- £PLI

MSc (Bangor)

PEDIGREE INFORMATION

Pedigree is the records of ancestry.



MSc (Bangor)

PEDIGREE RECORDS

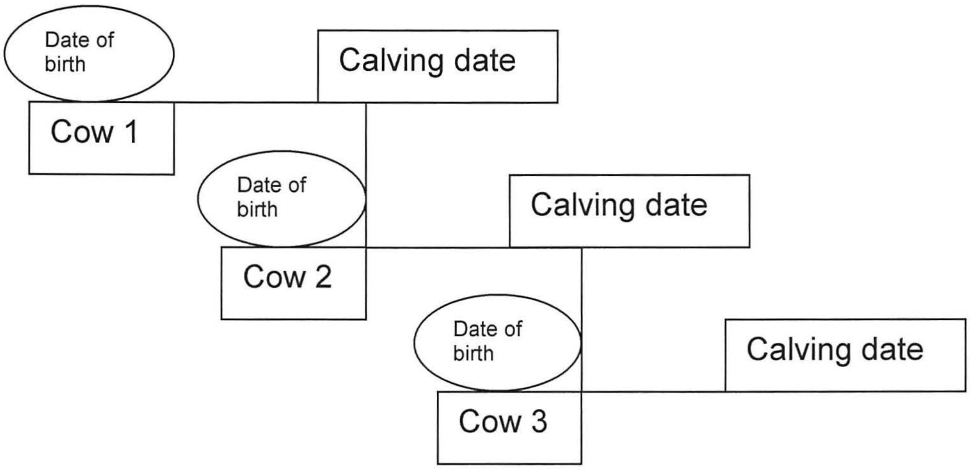
- The further back you go the less influence ancestors will have
- nomenclature systems can be misleading when used in the pedigree system
- pedigrees may be inaccurate through innocent mistakes
- efficiency of pedigree records relate to the correlation between EBV and performance measurement

PERFORMANCE TESTING

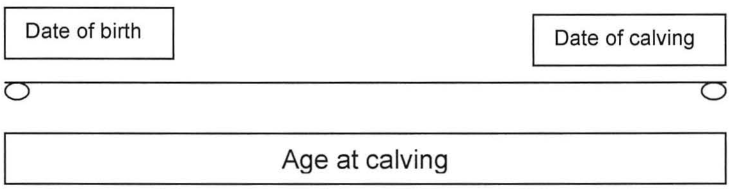
- Involves making decision on the recorded performance of animals
- It is a guide to the EBV
- Needs to use contemporaries and take into account pre-test environment
- Involves a large number of animals difficult on farms
- Performance testing is suitable with traits of moderate to high heritability and with live animals

APPENDIX 1.g. Additional Lecture Notes

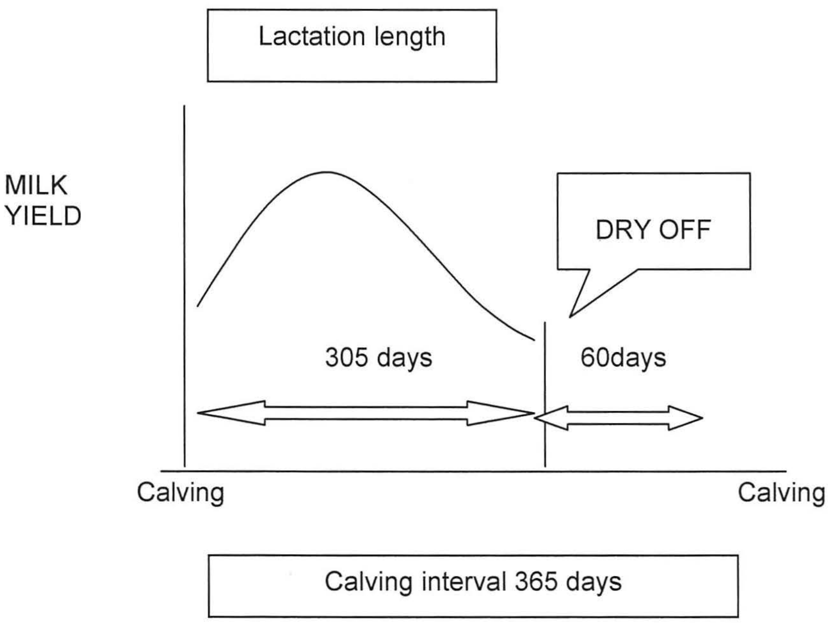
Relationship between calving date and date of birth within generation



Confirmation of calving date and date of birth using age at calving



The production cycle



APPENDIX 1.g. Additional lecture notes

DEFINITION FOR SOME OF THE TERMS THAT MIGHT BE USED DURING THE LECTURE

SELECTION - 'the process that determine which individual becomes parents, how many offspring's they may produce, and how long they may remain in the breeding population.'

CULLING – 'the process that determines which parents will no longer remain parents.'

ARTIFICIAL INSEMINATION (AI) – 'a reproductive technology in which semen is collected from males, then used in fresh or frozen from to breed females.'

DAM - 'a female parent.'

SIRE - 'a male parent.'

HEIFERS – 'a cow in her first lactation.'

PEDIGREE DATA – 'information on the genotype or performance of ancestors and (or) collateral relatives of an individual.'

COLLATERAL RELATIVES – 'relatives that are neither direct ancestors nor direct descendants of an individual, eg siblings, aunts, uncles, and nephews.'

PROEGONY DATA – 'information on the genotype or performance of descendants of an individual.'

GENETIC PREDICTION – 'the area of academic animal breeding concerned with measurement of data, statistical procedures, and computational techniques for predicting breeding values and related values.'

MATING SYSTEMS – 'a set of rules for mating.'

ANIMAL DATA CENTER (ADC) - 'the prime function of the ADC is to calculate genetic evaluation for dairy bulls and cows (all breeds) in the UK.'

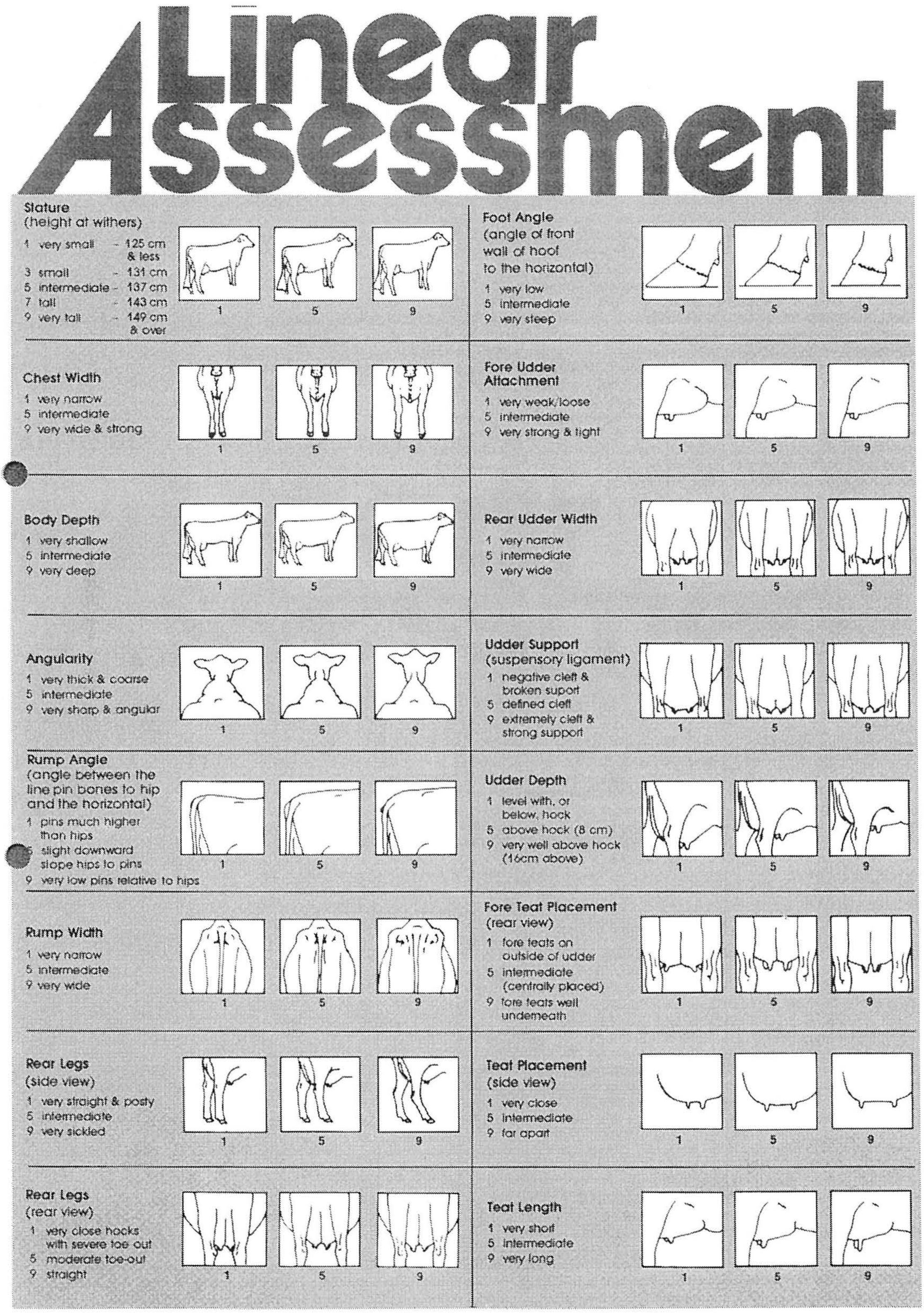
BREED SOCIETIES – 'many breeders register their animals with Breed Societies. Pedigree files are obtained by the ADC from the Societies. Theses are important for identify validation and enabling the evaluation programme to identify relationships between animals. Breed Societies also run linear type classification schemes and promote their breed through shows.'

MILK RECORDING ORGANISATION (MRO) – 'the MRO supply the MDC with milk records and ancestors information. They carry out the on farm official recording scheme operated within the UK.'

INDIVIDUAL ANIMAL MODEL (IAM) – 'this is the procedure used to calculate the PTA's. It estimates PTA's for all cows and their sires for which their pedigree and lactation records have been received from the Breed Societies and Milk Recording Organisation (MRO).'

(Bourdon, 1997)

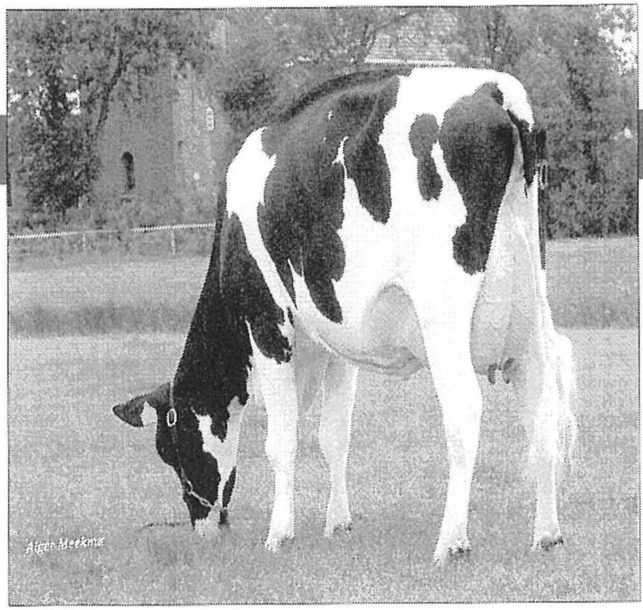
APPENDIX 1.g. Additional Lecture Notes



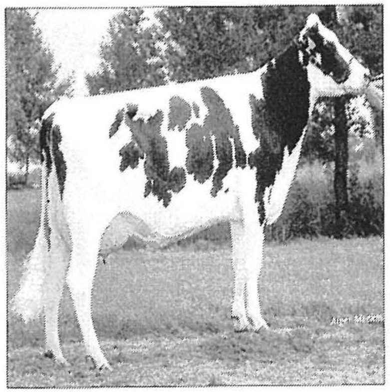
Source: Milk Marketing Board (MMB)

Boudewijn

Holim Boudewijn *TL



Klaske 217


Betje 69


Boukje 149

HBN: 63829877874 Genus Code: FH1582 Source: Holland 100% Holstein

Pedigree

Sire	Wardin Bell Gene	PG Sire	Carlin-M Ivanhoe Bell EX93 *BL
Dam	Holim Kim VG86	PG Dam	Wardin Kingpin
02-02 1 305d 8.842kg 5.02%F 3.78%P		MG Sire	Skalsumer Sunny Boy EX93
		MG Dam	Holim Heidi VG87

Boudewijn is a maternal grandson of Holim Heidi, who dominates the Dutch proofs with four sons in the top ten INET rankings.

Production Traits

PIN95	£127	
PLI	£123	
PTA95	FEBRUARY 1999	
Source:	ADC Conversion	
Milk	+ 745 kg	
Fat	+ 48.8 kg	+0.29%
Protein	+ 29.7 kg	+0.09%
204 Daughters in 191 Herds		
Reliability 86%		

Linear Assessment February 1999 Source: Holstein UKI

110 Daughters 102 Herds Reliability 90% Holland 67% UK converted

Trait		Value		Dutch figures
Stature	Short	0.33	Tall	102
Chest Width	Narrow	-1.62	Wide	95
Body Depth	Shallow	0.77	Deep	102
Angularity	Thick	1.68	Angular	107
Rump Width	Narrow	-0.95	Wide	97
Rump Angle	High Pins	0.59	Sloped	102
Rear Legs	Straight	0.51	Sickle	104
Foot Angle	Low	0.26	Steep	101
Fore Udder	Loose	-0.30	Strong	101
Rear Udder	Low	2.46	High	111
Udder Support	Broken	1.77	Strong	105
Udder Depth	Deep	-0.95	Shallow	99
Teat Placement	Wide	0.63	Close	104
Teat Length	Short	1.07	Long	105
BODY	Poor	0.77	Excellent	102
DAIRY	Poor	1.95	Excellent	107
LEGS / FEET	Poor	0.56	Excellent	105
MAMMARY	Poor	1.68	Excellent	105

Use Boudewijn for heavyweight production of fat and protein

- *Boudewijn will pass on medium stature to cows with high rear udders which are well supported.*
- *The easy calving choice for farmers demanding high PIN and high solids, Boudewijn ranks in the top five in the world for combined fat and protein*

Management Traits

Calving Ease -2

Somatic Cell Count +6%

Milking Speed 100

Semen Fertility N/A

Temperament 99

Lifespan -0.1

HOLSTEIN

Type Merit Proofs produced by Holstein UK

	Bull Name	Supplier		ID	Production PTAs (Predicted Transmitting Abilities) Rel %	Milk	Fat	Prot	Fat %	Prot %	£PIN	Somatic Cell Count Rel %	% PTA	Type Merit** Rel %	TM	£PLI
ITB	RICECREST MARSHALL-ET	ALTAGLOBA	65	2297473	**79**	1112	23.2	32.3	-0.29	-0.06	91	63	-3	81	1.6	100
ITB	COGENT COURIER ET	COGENT	01	586950	**75**	1106	15.8	35.8	-0.38	0.00	93	35	16	75	1.5	99
ITB	LORAK	SUPERSIRE	71	1095001791	**77**	1028	24.4	32.8	-0.23	-0.01	97	79	11	81	1.2	94
ITB	MCCLOE-POND TRENT	AVONCROFT	65	17226843	**76**	798	29.9	27.2	-0.02	0.01	94	58	-6	77	1.0	91
ITB	MANAT	DAIRYDAUG	60	830287	**83**	907	23.3	26.0	-0.18	-0.05	79	81	13	89	2.9	90
ITB	MOET LOOKOUT ET	GENUS	01	587438	**84**	950	23.5	28.9	-0.19	-0.03	86	53	-4	82	1.7	89
ITB	BAGWORTH ZANDER KEET	LIC (UK)	62	98282	**67**	413	33.2	20.4	0.25	0.10	89	N/A	N/A	N/A	N/A	89
ITB	VISION-GEN OZZIE ET	GENUS	65	122185573	**73**	1136	31.8	29.3	-0.18	-0.11	92	53	-9	74	1.3	89
ITB	SILVERPOST SINATRA PI	GENUS	63	169100560	**86**	785	26.6	22.5	-0.06	-0.04	76	78	1	87	1.9	87
ITB	CRICHEL PRINCIPAL	COGENT	01	574334	**96**	810	24.0	27.0	-0.12	0.01	86	87	14	91	2.0	86
ITB	HOLIM BOUDEWIJN	AVONCROFT	63	829877874	**96**	296	35.9	17.1	0.37	0.11	86	95	13	83	1.0	86
ITB	WELCOME GARTER ET	AVONCROFT	65	17131025	**75**	1123	27.4	29.8	-0.24	-0.09	89	56	15	76	1.6	86
ITB	SIKKEMA-STAR AIR MAGNA ET	SEMEN WOR	65	17044645	**73**	783	26.3	22.6	-0.07	-0.04	76	53	-5	75	1.8	84
ITB	TIDY-BROOK J STEVEN TCG-ET	AVONCROFT	65	2282997	**86**	695	23.9	24.2	-0.05	0.02	80	58	-3	84	1.4	83
ITB	GLEN-TOCTIN TERRELL-TW	AVONCROFT	65	18013208	**71**	734	20.0	25.7	-0.13	0.03	79	51	-1	71	1.3	82
ITB	JESTHER	AVONCROFT	71	5994022699	**82**	895	17.4	26.6	-0.26	-0.03	74	78	-2	79	1.3	82
ITB	EMIL	SUPERSIRE	60	800955	**76**	775	22.0	25.9	-0.13	0.01	81	67	1	78	2.3	81
ITB	SILDAHL BW DUTCH BOY	DAIRYDAUG	65	17058140	**78**	915	23.2	25.7	-0.19	-0.05	77	60	-13	80	1.5	80
ITB	T LALUFFE	DANSIRE	61	237454	**80**	796	22.8	26.2	-0.12	0.00	82	62	8	82	1.2	79
ITB	BERNARDIS BW LAIBERT	SEMEN WOR	72	2701003310	**76**	900	25.0	25.3	-0.15	-0.06	79	59	-7	79	1.6	79
ITB	LEXVOLD LUKE HERSHEL ET	ALTAGLOBA	65	2294436	**78**	1078	16.8	28.2	-0.35	-0.10	72	62	0	81	1.6	78
ITB	LOUNGE	SUPERSIRE	71	5112013651	**75**	723	21.4	24.6	-0.11	0.02	78	78	5	78	1.4	78
ITB	MONZA	AVONCROFT	71	5996002810	**76**	1123	22.4	27.2	-0.31	-0.13	75	65	-3	81	1.8	78
ITB	OLYMPIAN LEXIKON ET	SS DIRECT	01	568056	**94**	719	25.7	23.5	-0.04	0.01	80	82	16	73	1.1	77
ITB	KYNARTON FLAUTIST ET	AVONCROFT	01	569562	**84**	554	21.9	21.4	0.00	0.04	74	63	6	N/A	N/A	77
ITB	SANDEL	DAIRYDAUG	60	830405	**77**	849	17.5	27.2	-0.22	-0.01	77	68	3	81	1.8	77
ITB	FLEURY-I COUNTRY	GREENACRE	64	6505858	**83**	676	26.9	19.8	0.00	-0.03	71	79	9	82	2.1	77
ITB	STEEPLEHIGH-I C C RIDLER	SEMEX	64	6817117	**78**	708	30.5	19.5	0.04	-0.04	74	73	-4	77	1.8	77
ITB	SANDY-VALLEY FORBIDDEN ET	WWSS DIRE	65	17011697	**77**	781	19.4	22.9	-0.17	-0.03	69	59	1	78	2.4	77
ITB	ALZI JUROR FORD	SEMEN WOR	72	3604039709	**77**	853	22.2	22.5	-0.17	-0.07	69	59	3	79	2.5	77
ITB	Enrico	SUPERSIRE	60	800989	**73**	637	20.9	20.5	-0.06	0.00	67	62	4	74	2.5	76
ITB	T LAMBADA	DANSIRE	61	237273	**80**	825	24.6	21.9	-0.11	-0.07	70	62	2	80	1.4	76
ITB	RICECREST ERIN	ALTAGLOBA	65	17304779	**79**	886	15.2	25.2	-0.28	-0.05	67	63	-9	81	1.3	76
ITB	COGENT DREADNOUGHT ET	COGENT	01	581642	**86**	904	23.1	24.9	-0.18	-0.06	75	62	-14	76	1.5	75

APPENDIX 2

PRODUCTION AND FUNCTIONAL TRAITS

Table 4.18. Descriptive Statistics for milk yield

LAC	YEAR	MEAN	MIN	MAX	SD	CV
LA	**1990s**	6864	2846	11747	1340	20
LA	**1980s**	6488	1952	11762	1339	21
LA	**1970s**	5413	1012	9904	1549	28
LA	**1960s**	4690	1097	9717	1287	27
LA	**1950s**	3938	2142	6506	1053	27
L1	**1990s**	6171	3479	9335	1109	18
L1	**1980s**	5184	1952	7612	819	16
L1	**1970s**	4311	1012	7345	1143	26
L1	**1960s**	4070	1097	7437	991	24
L1	**1950s**	3725	2252	6443	1075	29
L>1	**1990s**	7140	2846	11747	1326	18
L>1	**1980s**	6884	3228	11762	1209	17
L>1	**1970s**	5807	1023	9904	1485	26
L>1	**1960s**	4968	1299	9717	1311	26
L>1	**1950s**	4018	2142	6506	1045	26

Abbreviations used LA=all lactations, L1=first lactation and L>1= all lactations over 1

APPENDIX 2

PRODUCTION AND FUNCTIONAL TRAITS

Table 4.19. Descriptive statistics for milk fat concentration analysis

LAC	YEAR	MEAN	MIN	MAX	SD	CV%
LA	**1990s**	4.16	3.02	5.43	0.41	9.94
LA	**1980s**	3.93	2.60	5.24	0.41	10.38
LA	**1970s**	3.84	2.51	5.28	0.40	10.36
LA	**1960s**	3.77	2.45	5.81	0.39	11.44
LA	**1950s**	3.68	2.52	4.43	0.36	9.88
L1	**1990s**	4.18	3.25	5.12	0.37	8.93
L1	**1980s**	4.02	2.87	5.24	0.36	8.98
L1	**1970s**	3.95	2.68	5.28	0.42	10.54
L1	**1960s**	3.84	2.85	5.31	0.40	8.57
L1	**1950s**	3.83	3.03	4.43	0.33	9.02
L>1	**1990s**	4.14	3.02	5.43	0.43	10.33
L>1	**1980s**	3.90	2.60	5.24	0.42	10.70
L>1	**1970s**	3.80	2.50	5.10	0.38	10.08
L>1	**1960s**	3.74	2.45	4.92	0.39	10.37
L>1	**1950s**	3.63	2.52	4.32	0.36	10.04

LA = all lactations, L1= first lactations and L>1= all lactations over other than first lactation

Table 4.20. Descriptive statistics for milk fat yield analysis

LAC	YEAR	Mean	MIN	MAX	SD	CV%
LA	**1990s**	284	129	524	58	20
LA	**1980s**	253	84	481	51	20
LA	**1970s**	206	38	371	58	28
LA	**1960s**	177	36	353	52	30
LA	**1950s**	145	62	356	41	28
L1	**1990s**	257	147	395	47	18
L1	**1980s**	208	84	317	35	17
L1	**1970s**	170	41	310	47	28
L1	**1960s**	156	36	332	41	27
L1	**1950s**	143	75	253	44	31
L>1	**1990s**	295	129	524	58	20
L>1	**1980s**	267	123	481	47	18
L>1	**1970s**	219	38	371	56	26
L>1	**1960s**	186	47	353	54	29
L>1	**1950s**	145	62	356	40	28

LA = all lactations, L1= first lactations and L>1= all lactations over o other than first lactation

APPENDIX 2
PRODUCTION AND FUNCTIONAL TRAITS

Table 4.21. Descriptive statistics for milk protein yield analysis

LAC	YEAR	MEAN	MIN	MAX	SD	CV%
LA	**1990s**	224	102	365	43	19
LA	**1980s**	212	64	367	42	20
LA	**1970s**	181	33	322	48	26
L1	**1990s**	201	118	303	36	18
L1	**1980s**	170	64	245	26	15
L1	**1970s**	144	33	238	35	25
L>1	**1990s**	233	102	365	43	18
L>1	**1980s**	225	106	367	38	16
L>1	**1970s**	194	60	322	44	23

LA= all lactations, L1= first lactations and L>1= all lactations over the first lactations

Table 4.22. Descriptive statistics for milk protein concentration analysis

LAC	YEAR	MEAN	MIN	MAX	SD	CV%
LA	**1990s**	3.27	2.73	4.43	0.19	5.70
LA	**1980s**	3.28	2.73	4.37	0.18	5.48
LA	**1970s**	3.23	2.61	3.97	0.20	6.21
L1	**1990s**	3.26	2.81	3.83	0.17	5.30
L1	**1980s**	3.29	2.86	3.81	0.17	5.04
L1	**1970s**	3.24	2.61	3.92	0.20	6.28
L>1	**1990s**	3.27	2.73	4.43	0.19	5.85
L>1	**1980s**	3.28	2.73	4.37	0.18	5.61
L>1	**1970s**	3.22	2.70	3.97	0.20	6.19

LA= all lactations, L1= first lactations and L>1= all lactations over the first lactations

APPENDIX 2
PRODUCTION AND FUNCTIONAL TRAITS

Table 4.23.Days of Productive Life (DPL) in the herd

Year	Mean	Minimum	Maximum	S.D	C.V
1990s	1222	162	4724	953	77
1980s	1210	153	4439	994	82
1970s	1555	193	3963	1013	65
1960s	1240	167	4972	845	68
1950s	1321	179	4265	924	70

Days of Productive Life (DPL) interval between first calving and last day of the final lactation.

Table 4.24. Life in the herd from DOB to last lactation date

Year	Mean	Minimum	Maximum	S.D	C.V
1950s	7.47	2.86	14.77	3.45	46
1960s	5.81	2.24	12.16	2.80	48
1970s	6.32	2.09	16.32	3.04	48
1980s	5.74	2.13	14.63	2.39	41
1990s	5.71	2.78	12.61	1.87	33

Table 4.25. Descriptive statistics for SCC for lactation numbers in all years ('000cells/ml)

Lactation No.	Mean	Minimum	Maximum	S D	C.V
1	87	14	708	115	76
2	93	14	784	136	68
3	126	13	1011	138	67
4	187	13	1216	247	78
5	322	16	2841	520	62
6	358	21	2317	498	72
7	677	21	2683	915	74

APPENDIX 2
PRODUCTION AND FUNCTIONAL TRAITS

Table 4.26. Descriptive statistics for lactation length

LAC	YEAR	MEAN	Minimum	Maximum	SD	CV
LA	**1990s**	307	153	450	40	13
LA	**1980s**	302	153	435	30	10
LA	**1970s**	285	150	305	32	11
LA	**1960s**	282	167	365	42	15
LA	**1950s**	267	169	445	48	18
L1	**1990s**	309	177	421	31	10
L1	**1980s**	303	153	435	32	11
L1	**1970s**	291	159	305	38	13
L1	**1960s**	289	167	365	42	15
L1	**1950s**	286	170	445	50	18
L>1	**1990s**	306	153	450	44	14
L>1	**1980s**	303	163	431	30	10
L>1	**1970s**	287	150	305	29	10
L>1	**1960s**	278	169	365	42	15
L>1	**1950s**	266	169	375	44	17

LA = all lactations, L1 = first lactations, L>1 = all lactation over the first lactation

Table 4.27. Days dry

YEAR	MEAN	Minimum	Maximum	SD	CV
1990s	56	21	159	21	38
1980s	61	22	168	22	36
1970s	64	22	161	22	34
1960s	72	23	167	30	42
1950s	84	21	168	37	44

APPENDIX 3
ESTIMATED BREEDING VALUES

Figure 5.16. ICC fat concentration over time

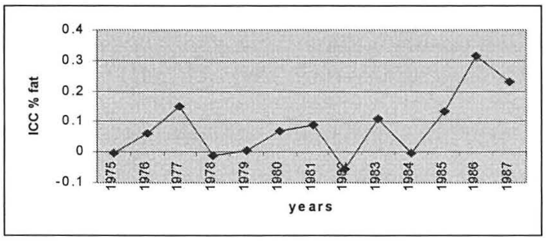


Figure 5.17. PTA fat conc. over time

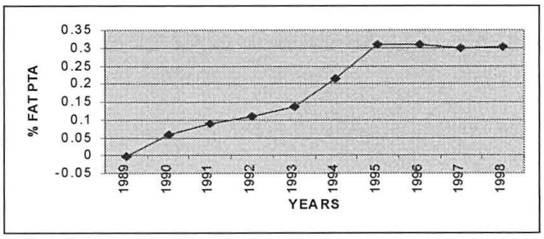


Figure 5.18. ICC protein concentration over time

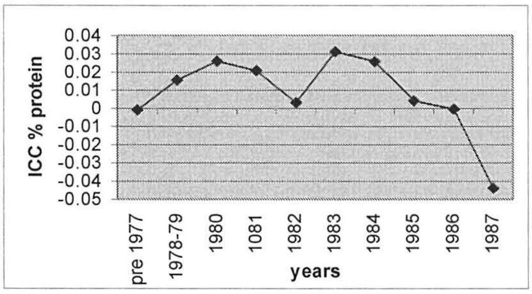


Figure 5.19. PTA protein conc. over time

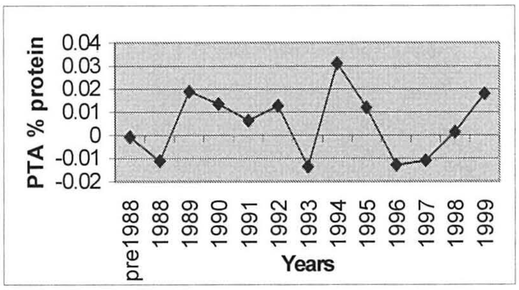


Figure 5.20. ICC of fat yield over time

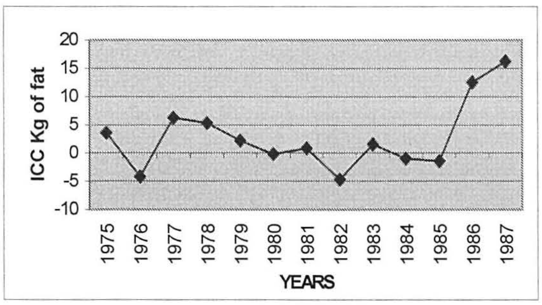


Figure 5.21. ICC of protein yield over time