ECONOMIC COMPARISON OF DIVERGENT STRAINS OF HOLSTEIN-FRIESIAN COWS IN VARIOUS PASTURE-BASED PRODUCTION SYSTEMS

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Abstract

The objective of this paper was to compare the economic efficiency of three divergent strains of Holstein-Friesian cows. Each strain was randomly allocated to one of three feeding systems: high milk output per cow from pasture (MP), high concentrate feeding system at pasture (HC), and high milk output per unit area from pasture (HS). Physical performance data was obtained from a 5-yr study conducted previously. A stochastic budgetary simulation model was used to simulate a model farm. The economic performance of each strain and feed system was derived for three production scenarios. Within all scenarios, profit was maximised where production was achieved at minimum cost as demonstrated by the comparably greater profitability of the low concentrate (MP and HS) systems. These results show that exclusive genetic selection for increased milk production results in reduced farm profitability as the productivity gains achieved are outweighed by associated increase in reproductive wastage costs in a pasture-based system.

Keywords: strain of Holstein-Friesian, economic scenario, pasture-based system

Introduction

The Irish dairy industry will experience considerable change in the years ahead (Hennessey and Thorne, 2006). Among the main agents of change, reform of EU agricultural policy, increased environmental regulation and economic prosperity will dramatically change the production landscape. The challenge for Irish dairy farmers is to increase the competitiveness of their business through innovation, productivity gain and increased operational scaas the industry evolves (Shalloo et al., 2004a). Genetic improvement of the dairy herd is one avenue to increased profitability on Irish dairy farms (Veerkamp et al., 2002) in a more competitive international dairy production environment.

To evaluate the economic effects of animal performance variation arising from various alternate genetic selection strategies, a comprehensive multidisciplinary systems approach is required incorporating the effects on all major farm components including production revenues as well as variable and fixed costs. Agricultural policy has major implications for the evolution of production systems with reforms likely to result in a single world market focused dairy industry free from milk quota restrictions. Such reforms may result in reduced and more unstable farm gate prices (Dillon et al., 2005). The consequences of various genetic selection strategies must therefore be appraised with due consideration to future agricultural policy outcomes.

Until recently, milk yield has been the main objective criterion for selection in most temperate countries and the use of Holstein-Friesian genetics of North American ancestry has been ubiquitous. The popularity of the North American Holstein-Friesian was most likely because of its increased productivity over other dairy breeds. Overwhelming evidence now shows antagonistic associations between production and health traits (Horan et al., 2004; Evans et al., 2004; Rauw et al., 1998), continued selection for greater milk yield is anticipated to have deleterious consequences for health and fitness of the dairy herd (Pryce and Veerkamp, 2001). Reproductive performance affects the amount of milk produced per cow per day of herd life, breeding costs, rate of voluntary and involuntary culling and rate of genetic progress for traits of importance (Plaizier et al., 1997; Lopez-Villalobos et al., 2000), as well as having a significant effect on the overall profitability of a dairy herd (Britt 1985). The Economic Breeding Index (**EBI**) was introduced in Ireland in 2001 to identify genetically superior animals to increase profitability within Irish dairy herds (Veerkamp et al., 2002). The EBI is currently composed of five sub-indexes (relative emphasis in parenthesis): milk production (49%), fertility/survival (32%), calving performance (8%), beef performance (6%) and health (5%). The objective of the present paper was to investigate the profitability of three strains of Holstein-Friesian dairy cows differing in genetic potential for milk production and reproductive performance across three pasture-based production systems based on various alternate production scenarios arising from changes in EU Agricultural policy.

Materials and Methods

Production Study Details

The design of the 5-yr study and a subset of the production and reproduction data used in the analysis of the various strains and systems of production in the present evaluation have been reported by Horan et al. (2004, 2005). Briefly, three strains of Holstein-Friesian cows were compared: high production North American (**HP**), high durability North American (**HD**) and New Zealand (**NZ**). The HP strain was chosen on the basis of superior pedigree index for milk production, while the HD strain was selected on the basis of superior pedigree index for milk production, fertility and muscularity traits. The NZ strain was selected using the highest possible genetic merit expressed in the New Zealand genetic evaluation system (Breeding Worth). Primiparous animals entering the herd from spring 2003 onwards were bred from within each strain using sires concurrent to the different breeding objectives as outlined above relative to that strain. Each strain represented on average, thirteen sires over the five years of the study. The mean pedigree index (from the February 2004 international evaluations of the INTERBULL Animal Center, Uppsala, Sweden) for each strain is displayed in Table 1.

Table 1: The mean pedigree index for the three strains of Holstein-Friesian cows studied based on their predicted transmitting abilities (and SD) for milk production, survival and calving interval.

Strain	High Production	High Durability	New Zealand
Milk (kg)	+194(90.8)	+76(61.4)	+52(56.0)
Fat (kg)	+9.0(2.96)	+6.3(2.84)	+8.6(2.66)
Protein (kg)	+8.8(2.39)	+5.7(1.58)	+4.2(1.33)
Fat (g/kg)	+0.3(0.53)	+0.7(0.56)	+1.3(0.58)
Protein (g/kg)	+0.4(0.23)	+0.6(0.30)	+0.5(0.21)
Survival (%)	-0.5(1.11)	+0.4(0.51)	+1.2(0.62)
Calving interval (days)	+0.44(1.57)	-1.2(0.71)	-1.6(0.86)
Overall EBI[1] (€)	51	58	75
Sub indices[2]:			
Milk (€)	46	32	41
Fertility (€)	2	25	38
Calving (€)	2	0	5
Health (€)	-2	0	-5
Beef (€)	1	1	-9

All predicted differences were obtained from the February 2004 international evaluations of the INTERBULL Animal Centre (Uppsala, Sweden) using the MACE (multi-trait across-country evaluation). [1]EBI = Economic Breeding Index. [2]Subindices are derived from the economic values of individual traits: Milk (-€0.084/kg) fat (€1.55/kg), protein (€5.27/kg), survival (€10.80/%), calving interval (-€7.17/day), Health (- €55.48/unit logSCC & €1.13/standardised locomotion score), Beef (€2.94).

Each strain was allocated to one of three feed systems (**FS**); high milk output per cow from pasture (**MP**), high concentrate feeding system at pasture (**HC**), and high milk output per unit area from pasture (**HS**). The MP system had an overall stocking rate of 2.47 cows/ha, N fertilizer input of 290 kg N/ha and received 325 kg concentrate /cow in early lactation with the remainder of the lactation diet comprised of grazed grass. The HC feed system had a similar overall stocking rate and N input as the MP feed system but 1,445 kg concentrate/cow was fed. The HS group had similar concentrate (327 kg per cow) and N inputs as the MP system but had an overall stocking rate of 2.74 cows/ha.

Milk production, live weight and reproductive performance data over the five years used in the economic modeling are shown in Table 2 (Horan et al., 2004, 2005). The milk production data shown has been modified based on differences in reproductive performance observed over the study (Horan et al., 2004) to reflect the expected levels achievable in a stable herd where the strains will differ in maturity. Hence, reduced reproductive performance results in an increased proportion of younger cows in the herd of lower milk yields. As reproductive performance did not differ significantly between feed systems (Horan et al., 2004), in agreement with previously published research (Kennedy et al., 2003), all feed systems were assumed to have the same reproductive performance in this economic analysis.

Table 2: The effect of strain of Holstein Friesian on milk production, bodyweight and reproductive performance in three pasture-based feeding systems

Feed system	MP			HC			HS		
Strain	**HP**	**HD**	**NZ**	**HP**	**HD**	**NZ**	**HP**	**HD**	**NZ**
Number of lactations	65	65	65	65	65	65	65	65	65
Milk Production									
Milk (kg/cow)	6,748	6,656	6,335	7,724	7,588	6,597	6,531	6,527	6,255
Fat (g/kg)	40.6	40.9	43.9	40.0	40.1	44.5	41.0	41.1	45.6
Protein (g/kg)	34.5	35.6	36.5	35.4	35.8	37.2	34.8	35.5	36.1
Lactose (g/kg)	46.3	46.6	46.7	47.7	47.1	47.5	46.6	46.7	46.6
Average live-weight (kg)	558	590	552	564	594	541	551	580	542
Reproduction*									
Gestation length (days)	284	284	278	284	284	278	284	284	278
42-day in-calf rate (%)	54	65	74	54	65	74	54	65	74
Overall Pregnancy rate (%)	74	86	93	74	86	93	74	86	93
Total services per cow	2.07	1.79	1.61	2.07	1.79	1.61	2.07	1.79	1.61

*Breeding was initiated at on average 60 days in milk.

Economic Analysis

The Moorepark Dairy Systems Model (**MDSM**) (Shalloo et al., 2004), a stochastic budgetary simulation model was used to simulate a model farm integrating biological data for each strain in each feed system. The model integrates animal inventory and valuation, milk production, feed requirement, land and labour utilisation and economic analysis. The assumptions used in the model are outlined in Table 3 below.

Land area was treated as an opportunity cost with additional land rented in when required and leased out when not required for on-farm feeding of animals. Variable costs (fertiliser, contractor charges, medical and veterinarian, artificial insemination, silage and reseeding), fixed costs (machinery maintenance and running costs, farm maintenance, car, telephone, electricity and insurance) and prices (calf, milk and cow) were based on current prices (Teagasc, 2004). A differential was placed between the strains in terms of male calf and cull cow value based on the variation in strain bodyweight. Three economic scenarios were investigated. In Scenario 1 (S1), it was assumed that farmers were constrained by the EU milk quota, i.e. quota applied at farm level. Farmers with cows producing greater yields would reduce cow numbers to exactly meet quota (evaluation based on a fixed output). Surplus land was leased out. In Scenario 2 (S2), it was assumed that EU milk quota applied at an industry level thereby allowing farms with high producing cows to maintain cow numbers and lease the additional quota required. Where quota leasing was an option the lease cost was taken at 4.79 c/kg of milk. In Scenario 3 (S3) it was assumed that farmers were constrained by land area but leasing milk quota was possible, therefore output could be increased through increased feed input.

Table 3: Assumptions used in the model farm for the years 2005 and 2013

Strain of Holstein Friesian	HP	HD	NZ
Farm size (ha)	40.0	40.0	40.0
Quota (kg)	468,000	468,000	468,000
Reference fat (g/kg)	36.0	36.0	36.0
Price protein to fat	2	2	2
Quota lease price (c/kg)	4.8	4.8	4.8
Replacement Heifer price (€)	1,397	1,397	1,397
Labour costs (€/month)	1,905	1,905	1,905
Prices and Costs: 2013			
Gross milk price (c/kg)	22.3	22.3	22.3
Reference cull cow price (€)	270	270	257
Reference male calf price (€)	102	102	64
Concentrate costs (€/tonne)	189	189	189
Opportunity cost of land (€/ha)	267	267	267

Results

The benefits of the economic appraisal within a farmlet study such as this, is to quantify the effect of genetic change within a controlled management environment where observed differences can be attributed to genetics, feeding system or a combination of these factors.

Current Milk Production Environment (S1 scenario)

Table 4 shows the key herd output parameters from the model for the three strains in the MP, HC and HS feed systems in scenario 1. In this scenario all groups are restricted to a butterfat-corrected fixed quota of 468,000 kg thereby not requiring the entire 40ha of land for production. Within each FS the highest farm profit was realised with the NZ strain with the farm profit of the HP strain lowest and the HD strain intermediate. Within the HP strain, the highest profit was realized in the HC FS (€17,295), with the lowest profit within the HS FS (€14,232). Regarding the HD and NZ strains, maximum farm profit was realized in the MP FS (€24,925 and €27,869, respectively), the lowest farm profit realized in the HC FS (€21,385 and €21,712, respectively) while the HS FS was intermediate (€23,916 and €27,620, respectively). The increase in farm profit for the HP strain in going from the MP to the HC FS was associated with a large milk production response to increased supplementation in the HC FS thereby requiring 5.6 fewer cows calving to fill the quota, 5.9 fewer hectares of land, and also resulting in a reduction in both labour and replacement costs. In contrast the reduction in farm profit for the NZ and HD strains in going from the MP to the HC FS (€6,157 and €3,540, respectively) was a consequence of a smaller reduction in cow numbers and land requirements because of lesser milk production responses to concentrate and a reduction in milk returns associated with a disproportionate increase of fat to protein in the HC FS for the NZ strain resulting in a marginal reduction in profitability in the HC FS. Unlike the NZ strain which undergoes little change in farm profit going from the MP to the HS FS, the reduction in farm profit for the HD and HP strains was associated with an increase in the number of cows calving, replacement costs, and labour costs.

Table 4: Key herd parameters in a fixed quota scenario (S1) using anticipated future costs and prices for three strains of Holstein Friesian cows; High Production (HP), High Durability (HD) and New Zealand (NZ), within the Moorepark (MP), High Concentrate (HC) and High Stocking Rate (HS) feed systems.

Feed System	MP			HC			HS		
Strain of Holstein Friesian	NZ	HD	HP	NZ	HD	HP	NZ	HD	HP
Milk price (c/kg)	26.2	24.7	24.5	26.7	24.4	24.5	26.3	24.7	24.5
Farm size									
Total hectares used (ha)	32.0	32.5	32.2	25.5	27.0	26.3	28.4	30.7	30.9
Quota lease (kg)	-	-	-	-	-	-	-	-	-
# Cows calving (no.)	65.8	65.1	64.5	61.1	60.8	58.9	64.9	68.3	68.8
Livestock units (LU)	74.1	73.1	71.8	68.9	68.3	65.6	73.2	76.7	76.6
Stocking rate (LU/ha)	2.32	2.25	2.23	2.70	2.53	2.49	2.58	2.50	2.48
Labour units (h)	2,311	2,304	2,296	2,254	2,250	2,227	2,301	2,343	2,350
Milk produced (kg)	419,940	440,707	438,363	402,545	450,813	450,426	406,692	444,420	445,400
Milk sales (kg)	407,844	428,725	426,500	391,304	439,629	439,595	394,747	431,851	432,745
Fat sales (kg)	17,595	17,433	17,455	17,650	17,307	17,308	17,644	17,400	17,390
Protein sales (kg)	14,766	14,974	14,676	14,166	15,367	15,478	14,054	15,128	14,994
Milk returns (€)	106,710	106,101	104,629	104,538	107,269	107,895	103,672	106,674	105,837
Livestock sales (€)	26,897	29,011	30,599	24,997	27,077	27,940	26,562	30,430	32,642
Total costs (€)	105,715	110,163	118,789	107,801	112,936	118,516	102,592	113,165	124,224
Margin per cow (€)	424	383	255	355	352	294	425	350	207
Margin per kg milk (cents)	6.64	5.66	3.74	5.39	4.74	3.84	6.79	5.38	3.20
Feed costs per kg milk (cents)	4.60	4.50	4.50	7.00	6.40	6.20	4.50	4.40	4.50
Replacement costs (€)	15,555	19,747	28,912	14,456	18,431	26,400	15,361	20,713	30,843
Labour costs (€)	31,844	31,473	31,005	29,594	29,375	28,310	31,446	33,014	33,075
Total profit per farm (€)	27,869	24,925	16,416	21,712	21,385	17,295	27,620	23,916	14,232

Quota Leasing Environment (S2 scenario)

The key herd output parameters from the model for the three strains in the three feed systems, within a quota leasing environment (S2) are shown in Table 5. In this scenario an equal number of cows (89.8) were calved for each strain within each feed system. The NZ strain again achieved the highest farm profit in all systems of production, with the HP strain lowest and the HD strain intermediate.
The highest profit for the HP strain (€18,846) was achieved in the HC FS as in S1, with the lowest again realised in the HS FS (€14,291). Within this scenario the HD strain again achieved their greatest farm profit in the MP FS and suffered largest reductions in profit when moving to the HC FS. The HP strain increased margin per cow going from the MP to the HC FS unlike both other strains. Similar to the S1 scenario, the greatest farm profit for the NZ strain was realised in both the MP and HS FS. The HP and HD strains encountered reductions of €3,177 and €2,085 in farm profit in going from the MP to the HS FS. Relative to S1, the profitability in all cases in this scenario has increased.

Limited Land within Quota Leasing Environment (S3 scenario)

Table 6 shows the key herd output parameters from the model for the three strains in the MP, HC and HS feed systems in a fixed land area scenario. In this scenario an equal land base (40.0ha) was available to each farm. The highest farm profit was achieved by the NZ strain in the HS FS (€33,947) with 91.6 cows calving or 9.4 more than in the MP FS. This results in an overall stocking rate of 2.58LU/ha and an increase in margin per hectare of €58 and €169 compared with the MP and HC FS for this strain. As in scenarios 1 and 2 the HP strain achieved the lowest profit, achieving greatest profit in the HC FS (€18,835) or €471/ha. Within this environment (S3) cow numbers and feed costs were greatest for the NZ strain in the HC FS whereas margin per hectare and margin per kg milk were reduced by €111 and 1.72c compared with the MP FS. The HD strain achieved maximum profit in the MP FS (€27,475), achieving a margin of €687/ha with lowest profit for this strain realised in the HC FS as in both other scenarios. This was related to an increase of ten cows calving, a reduction in margin per cow of €68 and an increase in feed costs of 1.9c/kg milk.

Table 5: Key herd parameters in a quota leasing scenario (S2) using anticipated future costs and prices for three strains of Holstein Friesian cows; High Production (HP), High Durability (HD) and New Zealand (NZ), within the Moorepark (MP),High Concentrate (HC) and High Stocking Rate (HS) feed systems

Feed System	MP			HC			HS		
Strain of Holstein Friesian	NZ	HD	HP	NZ	HD	HP	NZ	HD	HP
Milk price (c/kg)	26.2	24.7	24.5	26.7	24.4	24.5	26.3	24.7	24.5
Farm size									
Total hectares used (ha)	43.7	44.8	44.8	37.5	39.8	40.1	39.2	40.3	40.3
Quota lease (kg)	148,972	162,146	167,246	183,546	209,551	230,621	150,997	135,562	131,981
# Cows calving (no.)	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8
Livestock units (LU)	101.2	100.8	100.0	101.2	100.8	100.0	101.2	100.8	100.0
Stocking rate (LU/ha)	2.32	2.25	2.23	2.70	2.53	2.49	2.58	2.50	2.48
Labour units (h)	2,417	2,417	2,418	2,418	2,417	2,418	2,418	2,417	2,418
Milk produced (kg)	573,330	607,385	610,260	591,364	665,694	686,730	562,258	583,927	581,240
Milk sales (kg)	556,816	590,871	593,746	574,850	649,180	670,216	545,743	567,413	564,726
Fat sales (kg)	24,022	24,026	24,300	25,298	25,557	26,388	24,392	22,862	22,694
Protein sales (kg)	20,160	20,637	20,431	20,811	22,692	23,598	19,430	19,876	19,567
Milk returns (€)	145,703	146,245	145,674	153,590	158,416	164,517	143,344	140,175	138,131
Livestock sales (€)	36,722	39,983	42,598	36,722	39,983	42,598	36,722	39,983	42,598
Total costs (€)	149,013	157,059	170,757	164,002	173,602	188,215	146,517	153,096	166,412
Margin per cow (€)	372	324	195	292	276	210	373	301	159
Margin per kg milk (cents)	5.82	4.79	2.86	4.44	3.72	2.74	5.96	4.63	2.46
Feed costs per kg milk (cents)	4.60	4.50	4.50	7.00	6.40	6.20	4.50	4.40	4.50
Replacement costs (€)	21,236	27,215	40,250	21,236	27,215	40,250	21,236	27,215	40,250
Labour costs (€)	43,475	43,377	43,163	43,475	43,377	43,163	43,475	43,377	43,163
Total profit per farm (€)	33,367	29,121	17,468	26,262	24,746	18,846	33,522	27,036	14,291

Influence of Genetic Strain on Farm Profit

Table 6: Key herd parameters in a limited land base scenario (S3) using anticipated future costs and prices for three strains of Holstein Friesian cows; High Production (HP), High Durability (HD) and New Zealand (NZ), within the Moorepark (MP),High Concentrate (HC) and High Stocking Rate (HS) feed systems

Feed System	MP			HC			HS		
Strain of Holstein Friesian	NZ	HD	HP	NZ	HD	HP	NZ	HD	HP
Milk price (c/kg)	26.2	24.7	24.5	26.7	24.4	24.5	26.3	24.7	24.5
Farm size									
Total hectares used (ha)	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Quota lease (kg)	102,090	98,512	103,599	221,575	212,081	229,129	161,937	131,075	133,301
# Cows calving (no.)	82.2	80.1	80.2	95.7	90.1	89.6	91.6	89.1	90.0
Livestock units (LU)	92.7	89.9	89.3	107.9	101.2	99.8	103.2	100.0	100.2
Stocking rate (LU/ha)	2.32	2.25	2.23	2.70	2.53	2.49	2.58	2.50	2.48
Labour units (h)	3,219	3,129	3,115	3,747	3,520	3,482	3,585	3,479	3,497
Milk produced (kg)	525,058	541,972	544,843	630,486	668,289	685,200	573,529	579310	582,599
Milk sales (kg)	509,934	527,237	530,099	612,879	651,710	668,723	556,684	562,926	566,046
Fat sales (kg)	21,999	21,439	21,695	27,644	25,656	26,329	24,881	22,681	22,747
Protein sales (kg)	18,462	18,415	18,241	22,188	22,780	23,545	19,820	19,719	19,612
Milk returns (€)	133,421	130,480	130,044	163,733	159,016	164,133	146,202	139,051	138,439
Livestock sales (€)	33,630	35,677	38,031	39,151	40,139	42,503	37,458	39,667	42,697
Total costs (€)	135,414	138,682	151,006	175,684	174,369	187,800	149,713	151,786	166,844
Margin per cow (€)	385	343	213	284	275	210	371	302	159
Margin per kg milk (cents)	6.03	5.07	3.13	4.31	3.71	2.75	5.92	4.65	2.45
Feed costs per kg milk (cents)	4.60	4.50	4.50	7.00	6.40	6.20	4.50	4.40	4.50
Replacement costs (€)	19,448	24,284	35,935	22,641	27,321	40,160	21,662	27,000	40,344
Labour costs (€)	39,814	38,705	38,536	46,350	43,546	43,067	44,346	43,034	43,264
Total profit per farm (€)	31,637	27,475	17,069	27,201	24,785	18,835	33,947	26,931	14,292

Discussion

The productivity and subsequent profitability of a dairy cow is determined by its environment (especially feeding) as well as its own inherent capabilities (genetic potential for production and health traits) (Holmes et al., 2002). Both animal and feed factors influencing farm profitability are numerous and differ greatly in significance depending on the economic characteristics of the production environment. For this reason, the findings of studies investigating the economic influence of alternate genetic selection strategies are often contradictory and the extrapolation of results to alternative production environments is erroneous. This study highlights the large influence of genetic strain and production system on farm profitability within Irish pasture-based production systems.
Similar to the current study, previous studies (Shalloo et al., 2004a; Evans et al., 2006) have shown significant genetic influences on farm profitability in a variety of pasture-based feeding systems. These results reinforce the significance of reproductive capacity within pasture-based systems (Schmidt, 1989; Plaizier et al., 1997) with high profitability realised with animals combining high genetic potential for both production and fertility traits (HD and NZ strains) rather than with those selected purely for increased milk production potential (HP strain). Reductions in economic performance through reduced fertility arise through; reduced milk yield per cow per day of herd life, increased culling for reproductive reasons, fewer available replacement heifers, increased semen usage, and added costs of veterinarian interventions (Britt, 1985; Plaizier et al., 1997). Esslemont and Peeler (1993) reported desired annual total culling rates of 18% to maximise the benefit of age and genetic improvement while Esslemont et al. (2001) reported optimal financial performance to arise with a 365- to 370-d calving interval and a failure to conceive culling rate of about 7%.

Simm, (2000) postulated that the optimum method of selection on a number of traits was to use a selection index which places a weighted emphasis on traits based on their economic importance. In 2001 in Ireland, the Economic Breeding Index (EBI; Veerkamp et al., 2002), a profit based index, selecting dairy cows for the predominantly grass based, seasonal calving systems of milk production was developed to increase the profitability in dairy herds through genetic selection using the precepts of selection index theory (Hazel, 1943).

Kahi et al. (1998) stated that the most profitable genotype was that which gives the highest profit per unit of the most limiting input. Within an Irish context, currently quota is the limiting factor (as reflected by the S1 scenario) whereas expected changes in the agricultural policy environment are likely to result in the S2 or S3 scenarios prevailing in future years. These results and those of Veerkamp et al. (2002) demonstrate that increased farm profitability for Irish dairy farmers, within probable future economic climates, can only be realised where productivity gains are achieved without detrimental impact on health and welfare traits.

Selection index theory, as outlined by Hazel, (1943) is based on the premise that an animal may be poor on one trait and still achieve a high genetic evaluation by compensating based on their superiority on other traits within the index. In this study, the highest EBI (EBI = €80) NZ strain returned the highest profit, the lowest EBI (EBI = €52) HP strain returned the lowest profit whereas the HD strain were intermediate on EBI (€57) and farm profit in all scenarios investigated thereby validating EBI as an accurate genetic selection tool to predict the potential profitability of pasture-based dairy cows in the Irish economic climate. It can also be concluded from this result that the overall level of genetic potential of the HD and NZ strains for milk production and health traits (as measured by EBI) rather than their geographic origin is responsible for the profitability differential based on the similarity between observed and predicted economic performance. In contrast, the large differential in overall profitability between the HP and HD strains in these results is unexpected given the relatively small differential in genetic potential (EBI of €52 and €57, respectively). While the greater replacement costs incurred by the HP strain were expected, it was anticipated that their superior milk production potential (milk sub-index = €46) would compensate and therefore deliver a similar overall profitability to the HD strain. The increased productivity of the HP strain was not realised in this study as impaired reproductive performance reduced milk productivity similar to the observations of Britt, 1985; Garcia and Holmes, 1999 and Stevens et al., 2000.

This result implied that for Irish seasonal pasture-based systems, the economic significance of fertility traits is underestimated and must be considerably increased to reflect the significant influence of fertility on farm profitability. Alternatively, the milk production potential of sires with inferior genetic potential should be revised downward to provide a more accurate estimate of their true production potential within a seasonal production system.

Influence of Feed System on Farm Profit

Previous research has shown that increased concentrate supplementation at pasture does not influence the reproductive performance of animals when adequate amounts of high quality pasture are provided (Horan et al., 2004; Kennedy et al., 2003). Similarly, McCarthy et al. (2006a) reported no significant effect of feed system on udder health while Roche et al. (2006) found no effect of feed system on the rate of body condition score loss in early lactation. Consequently, where adequate nutrients are supplied in the basal diet, supplementary concentrate feeding can only influence overall farm profitability through its influence on animal production performance. The data collected here suggests that the revenue gains associated with genetic improvement considerably overshadow any influence of feeding system on farm profitability.

The optimum system of milk production depends greatly on the prevailing economic environment (milk price, feed costs etc.) as well as the relative availability of the key factors of production (land, milk quota etc.). Within a milk quota scenario (S1), profit is maximised where production is achieved at minimum cost as demonstrated by the comparably greater profitability of the low concentrate (MP and HS) systems. This is similar to findings by Harris and Freeman (1993) where it was shown using a linear programming model that economic weight for herd life substantially increased in the restrictive quota situation. The limitation on output results in more emphasis being put on efficiency for each litre of milk produced. In a low milk price situation, pasture based systems are also more favourable, through their capability for low-cost milk production with the achievement of high output per hectare (Penno et al., 1996).

Within an environment where milk quota is not a limiting factor (S2 and S3), land availability becomes the next limitation to the pasture-based systems under consideration. Similar to previous studies (Penno et al., 1996), this analysis shows that based on the anticipated reduction in milk price in future years, higher stocking rates (HS) systems will be most profitable. Such systems will be characterised by their capability for low-cost high milk productivity per hectare with lesser milk production per cow. Similar to previous studies (Lopes-Villalobos et al., 2000; Grainger and Goddard, 2004), the data show that under a scenario where land is limited and stocking rates increase (S3), the economic advantage of the smaller NZ strain will be increased due to the comparably lesser reduction in margin per cow in the HS system.

Strain of Holstein Friesian by feed system interactions have been reported within regard to milk production (Horan et al., 2005) and DM intake (Horan et al., 2006). This suggests that the type of cow used may differ depending on the system of production. The results of this study show that the highest farm profit observed on the study was with animals of lesser milk production with good fertility on a MP or HS FS in all scenarios, whereas the highest farm profit for a HP strain animal was the HC system in all scenarios. While the HC system did improve the profitability of the HP animal, the increased profitability was still inferior to that of genetically superior animals across all systems of production.

Influence of Agricultural Policy change on Farm Profit

Comparisons of genetic groups or feeding systems must be made on the basis of that which gives the highest profit per unit of the most limiting input (Kahi et al., 1998). The economic principles applying to a no quota environment are substantially different to those that apply within a quota environment (Shalloo et al., 2004a). Where quota is not limiting, output from the farm is maximised through increasing milk sales until marginal revenue from additional milk sales is equal to the marginal cost of the additional milk. The system of milk production operated is therefore governed by the concentrate to milk price ratio (Clark and Kanneganti, 1999) and the milk production response to the concentrate supplementation. Where the milk price is high, systems adopted will maximise realised profitability through increased concentrate supplementation (Soder and Rotz, 2001).

The Common Agricultural Policy is currently undergoing significant change with the most recent reform, the Luxembourg agreement anticipated to result in a reduction in milk price of 5c/L (from 27 to 22c/L) (Binfield et al., 2003) for EU milk producers with further reductions also likely. It is evident from this analysis that both within the current quota system and based on projected changes to their production environment, the future viability of Irish dairy farmers depends on the realisation of maximum efficiency in pasture based milk production systems, through the further development of low cost pasture-based production systems (similar to the MP system) focused on increased productivity. The aim within such a feed system must be to maximise the proportion of grazed grass in the diet, increase utilisation and maintain high intakes (Horan et al., 2006) throughout the grazing season. Complementary genetic selection must therefore deliver animals capable of high productivity from pasture. Based on the current analysis, it is apparent that these animals will be characterised by both high milk production and reproductive potential.

Conclusions

The purpose of this paper is to demonstrate the magnitude of variation in profitability between strains of Holstein-Friesian dairy cows, differing in genetic potential for milk production and reproductive performance, across different pasture-based production systems and within various production scenarios, and not to recommend any given existing strain of Holstein-Friesian for use in Irish pasture-based systems. Large variation in farm profit arises from various genetic selection strategies and production system choices with the optimum genetics and production system being the combination which results in the greatest farm profit within that production environment. This study demonstrates how genetic selection for increased milk production (HP strain) in conjunction with increased concentrate supplementation within Irish pasture-based systems will result in reduced profitability in future years relative to selection on a combination of production and reproductive traits (HD and NZ strains) within a greater reliance on high quality grazed pasture. These results validate the use of EBI as a valuable genetic selection tool but suggest that the weighting on fertility traits needs to be increased within the index to reflect the true value of fertility to farm profitability.

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