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Correlation between Economic Breeding Index and Somatic Cell Count on Irish Dairy Farms

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1. Abstract

The objective of this study was to investigate the correlation between the Economic Breeding Index (EBI) and Somatic Cell Count (SCC) on Irish Dairy farms. The EBI plays a pivotal role in improving the genetic merit and profitability of Irish dairy herds. Somatic Cell count is a key contributor to herd health and can affect the longevity of cows in the dairy herd. Data was collected from fifteen Irish dairy farms participating in milk recording programs and then statistical analysis was carried out looking at herd EBI, health sub index within the EBI, somatic cell count, parity and milk yield. This type of research is important to determine whether or not EBI is continuing to develop favourable phenotypes for the Irish dairy industry.

In this paper I am going to be investigating the Irish pasture based grazing system and milk production in Ireland as a whole along with factors including reducing somatic cell count on dairy farms, environmental management and dry cow therapy. The impact of mastitis on dairy farms, mastitis pathogens and genetic selection for mastitis resistance will also be investigated.

2. Introduction

In Ireland 95% of grass growth occurs between the months of March and October with 75% of milk processed between the months of April and September due to a seasonal system of milk production [1]. Ireland's pasture-based seasonal calving system's evolution is a testament to its temperate climate and capacity to yield substantial amounts of grass, facilitated by ample rainfall and the absence of extreme temperature fluctuations. In countries such as Ireland and New Zealand pasture based systems of milk production predominate, this system is seen as a low cost system of milk production due to minimal inputs in comparison to high input systems of milk production commonly seen in North America [2]. To take advantage of grass growth patterns, the calving season begins in late winter or early spring to align the herds peak lactation performance with peak grass growth [3, 4]. The Irish dairy industry contributes €5 billion to the Irish economy on an annual basis along with supporting 60,000 jobs [5].

Prior to 2001 the relative breeding index (RBI) which focused solely on milk production namely milk fat and protein yield was being utilised by the Irish dairy industry. Genetic merit for milk yield increased by 46 kg per annum under the RBI, however conception rate to first service declined from 55% to 44% [6]. The Economic Breeding Index (EBI) was introduced in 2001 by the Irish Cattle Breeding Federation (ICBF) as a more holistic approach to genetic selection marked by the incorporation of non-production traits to enhance the fertility performance of the national herd and identify genetically superior animals capable of increasing farm profitability [7]. High genetic merit cows or cows with a high EBI value have consistently been shown to have greater milk production, survival and reproductive efficiency across different levels of concentrate supplementation and grassland management scenarios [8].

3. Literature Review

3.1 Pasture Based Grazing Systems

In most European countries indoor systems of dairy production predominate, however in Ireland the majority of dairy farms operate a spring calving pasture based system of production with grass making up over 95% of the dairy cow diet. Between 1990 and 2014 grassland accounted for approximately 61% of Ireland’s land use [9]. Seasonal pasture based systems of production are achieved due to Ireland’s temperate climate coupled with high levels of rainfall contribute to favourable grass growing conditions. The aim of a pasture based system of production is to keep concentrate supplementation to a minimum and supplement when grass growth rates are not meeting herd demand. Ireland's dairy sector exports thrive on a grass-based system, with processed products accounting for the majority of exports, requiring high fat and protein [10]. The Irish dairy industry revolves around maximising the utilization of grass as the primary feed source for livestock.

Ireland's pasture-based dairy systems are well-suited to the country's climate, but climate change is threatening their quality and effectiveness. For example, increased spring frosts delay the turnout of cows in the spring and reduce the grazing period length, while extreme weather events such as heavy rainfall and drought are becoming more common [11]. According to the National Farm Survey (NFS), over 95% of Irish dairy farms used a spring-calving grazing system from 2013 to 2015. Cows were typically turned out to graze immediately after calving and remained on a grazing rotation until winter or as long as the weather permitted, with average intake per cow of 23.7 tonnes of fresh matter between 2013 and 2015 [12]. Figure 1 illustrates the timing of key events in a pasture based system of production along with herd demand and grass growth rates over the grass growing year.

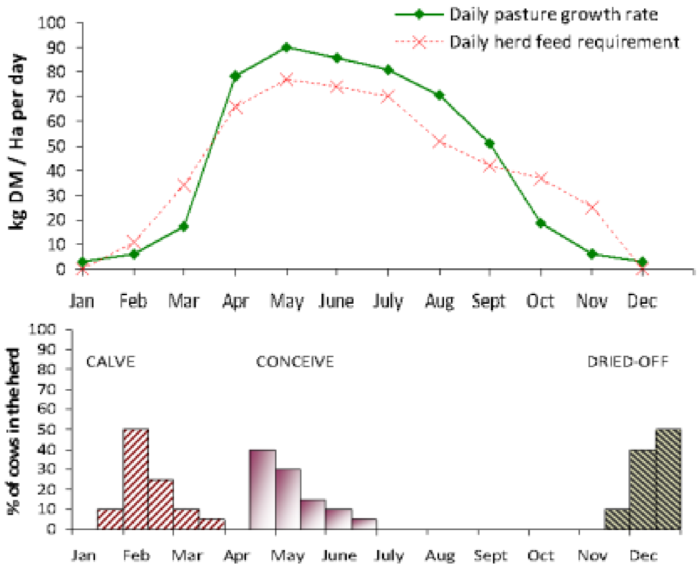

Figure 1. Comparison between grass growth and timing of key events involving lactation of a spring calving herd [85].

The length of the grazing season varies depending on the region in Ireland. The Border Midlands West (BMW) region has an average grazing season length of 205 days compared to 222 days in the south-west and 233 in the south-east region [13]. Grazing duration can be impacted by soil type and climate type, research has shown that lengthening the grazing season by one day decreases farm costs by 16 cents per litre on average.

Pasture based system of grazing are considered to be the cheapest method of feeding dairy cows which gives Ireland and New Zealand a competitive advantage over other dairy producing countries due to our unique ability to grow grass [14]. Research by the Irish Agricultural and Food Research Authority has shown that increasing utilised grass by 1.0 tonne DM/Ha/year is worth €181/ha. It has previously been shown that increased supplementation does not necessarily increase farm profitability, therefore in countries such as Ireland maximising the proportion of grazed grass in the diet reduces farm costs and increases profitability [10].

This is very important in the Irish context as with approximately 18,000 farms involved in primary production, and the value of the dairy goods exported priced at €5 billion in 2022, it is a huge part of the Irish economy. Of course access to land, or the availability of land suitable for this type of grazing can be limiting factors for some farmers.

3.2 Milk Production in Ireland

Agriculture is a major contributor to the Irish economy, with dairy production leading the way, with over 18,000 dairy farmers milking 1.55 million cows. Milk production in Ireland is primarily based on seasonal calving pasture-based systems, characterised by lower production costs [15]. Milk production is a critical trait for dairy cows in Ireland, as it is essential for meeting national demand and ensuring farm profitability. In 2021, Irish dairy farms produced over 8.75 billion litres of milk [16]. The abolition of milk quotas in 2015 led to a rapid increase in milk production, with Ireland increasing output by 18.5% in the following year [13]. This increase was achieved through a combination of factors, including increased cow numbers, higher yields, and more land available for dairying. Ireland has some of the lowest milk production costs in the world [15], which gives it a competitive advantage in the global dairy market.

Increased milk production has had a positive impact on the Irish economy, with output in the agriculture, fisheries, and forestry sector estimated to have multiplied by 1.44 since the abolition of quotas [11]. This growth is likely due to a combination of factors, including Ireland's temperate climate with abundant rainfall, which is ideal for pasture-based grazing systems.

3.2.1 Irish Milk Payment

Milk production is a key determinant of farm profitability, with high milk solids content and low somatic cell count (SCC) commanding higher prices from processors. Ireland has a number of milk processing cooperatives but the main ones include Tirlán, Kerry, Dairygold and Lakelands. Milk solids are a major priority for Irish dairy farmers, as most co-ops use an A + B – C payment system, where A represents kilograms of protein, B represents kilograms of fat, and C is a volume-related processing cost deduction in cents per litre of milk volume [17]. Therefore, farmers aim to maximize milk solids production while minimizing milk volume and SCC. Milk volume is converted from litres collected on each farm to kilograms of milk produced using a density factor. The milk price is often volatile due to the EU's focus on supplying suitable markets and the linkage between EU and international food prices [18]. Caseins represent 80% of the total protein content in cow’s milk while the remaining 20% is made up of whey proteins. Being one of the biggest casein producers in the world, alongside New Zealand and France, it is worthwhile for Irish farmers to maximise their dairy protein content. In Ireland, lactose concentration below 4.35% can lead to penalties for some processors because it is used to represent milk processing ability into different milk products [19]. A lactose concentration above 4.35% is desired, with levels between 4-4.2% being rejected and a significant penalty being applied [20].

Under EU legislation, Total Bacteria Count (TBC) should not amount to more than 100,000/ml with less than 15,000/ml being the desired concentration. Penalties can occur when thermoduric bacteria, such as *Streptococcus* or *Corynebacterium* which can survive heat treatment including pasteurisation, amount to greater than 1,000/ml and should ideally be less than 200/ml [21]. As the Somatic Cell Count (SCC) is considered one of the main indicators of milk quality, dairy farmers are financially rewarded for low herd SCCs and can be penalised for those of more than 400,000 cells/ml as they are deemed unfit for human consumption by the European Union [22].

3.2.2 Milk Recording

Milk recording on Irish dairy farms is an essential practice that plays a crucial role in modern dairy management with 50% of dairy farms taking part in this practice at present. This systematic approach involves collecting and analysing data on individual cow milk production, which provides invaluable insights for farmers in optimising herd performance. This information is then communicated with the farmer providing them with real time performance information of cows within their herd [23]. By regularly measuring parameters such as milk yield, milk quality, and cow health, Irish dairy farmers can make data-driven decisions to enhance overall herd efficiency. Milk recording not only aids in identifying high-performing cows and those in need of additional attention but also helps in managing breeding and nutrition programs. With advances in technology and data analytics, milk recording has become increasingly accurate and accessible, empowering Irish dairy farmers to strive for sustainable and profitable milk production while ensuring the well-being of their herds.

3.3 Irish Cattle Breeding Federation

The Irish Cattle Breeding Federation (ICBF) was set up in 1998 to manage the Irish National Cattle Database which is comprised of details of all dairy and beef cattle in the Irish national herd. The organisation applies science and technology to improve dairy and beef cattle genetics, benefiting Irish farmers, the agri-food industry, and wider communities. The ICBF cattle breeding database provides services that help farmers and industry make the most profitable and sustainable decisions [24]. The ICBF database is essential for the Irish agricultural industry, providing key stakeholders with easy access to national herd data (Figure 2). This benefits farmers by helping them make informed decisions about their breeding programs to produce genetically superior animals that increase farm profitability. For example, marts can use the ICBF database to display animals' weights, number of movements, EBI (for dairy sales) and dairy beef values (beef sales).

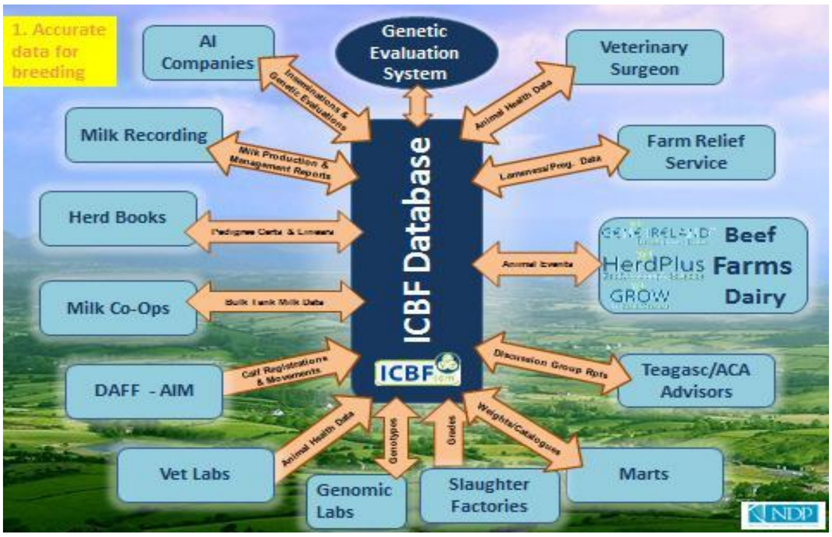

Figure 2. Stakeholders in ICBF [24].

3.3.1 Economic Breeding Index

Prior to the launch of the EBI, Ireland utilised the Relative Breeding Index (RBI) which focused solely on genetic improvement for milk production traits including milk, fat, and protein yields and protein content [25]. Although there were concerns that prioritising milk production alone might diminish survival of the herd, the industry concentrated on maximising genetic improvements in this area due to its high profitability [26]. Nevertheless, the industry underestimated the conflicting genetic connection between milk production and fertility, a crucial trait for profitability in pasture-based systems. This miscalculation led to a less fertile national herd, with other important functional traits being overlooked over time [27–29].

The economic breeding index (EBI) is a single-figure profit based index that was launched in November 2000 through collaboration between ICBF and Teagasc as part of the Irish dairy breeding objective, as a more holistic approach to selection to breed replacements for the national herd. The aim of EBI is to identify genetically superior animals in order to increase farm profitability [30], with a €1 difference in herd EBI expected to equate to a €2 difference in average herd profit per lactation [31]. The EBI is calculated from the breeding values of traits such as milk production (milk yield, fat yield, and protein yield) and functional traits (calving interval and survival), each weighted by its respective economic value [32]. There are eight sub-indexes related to profitable milk production. Production makes up 32%, fertility 25%, carbon 10%, beef 10%, health 8%, calving 7%, management 4% and maintenance 4% as seen in figure 3.

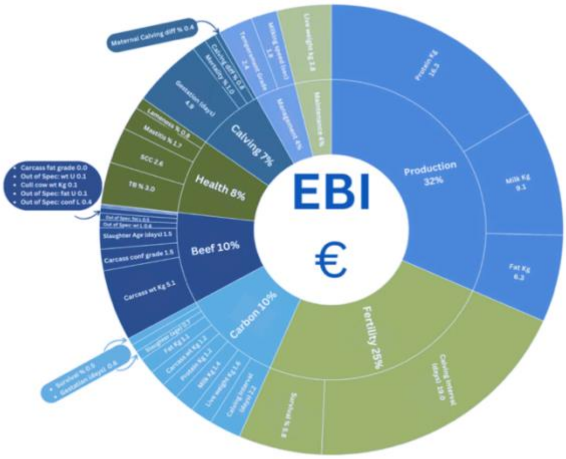

Figure 3. Percentage emphasis of the various traits in the EBI formula. Data based on Jan 2023.

Following the inception of the EBI, additional traits impacting dairy farm profitability have been identified and incorporated, with adjustments made for revised parameters and changes in EU policies [30][33]. Figure 4 illustrates the EBI's progression up to 2021, as well as the amalgamation of milk production with functional traits (fertility, calving, beef, health, maintenance, and management) that influence the economic viability of dairy farms.

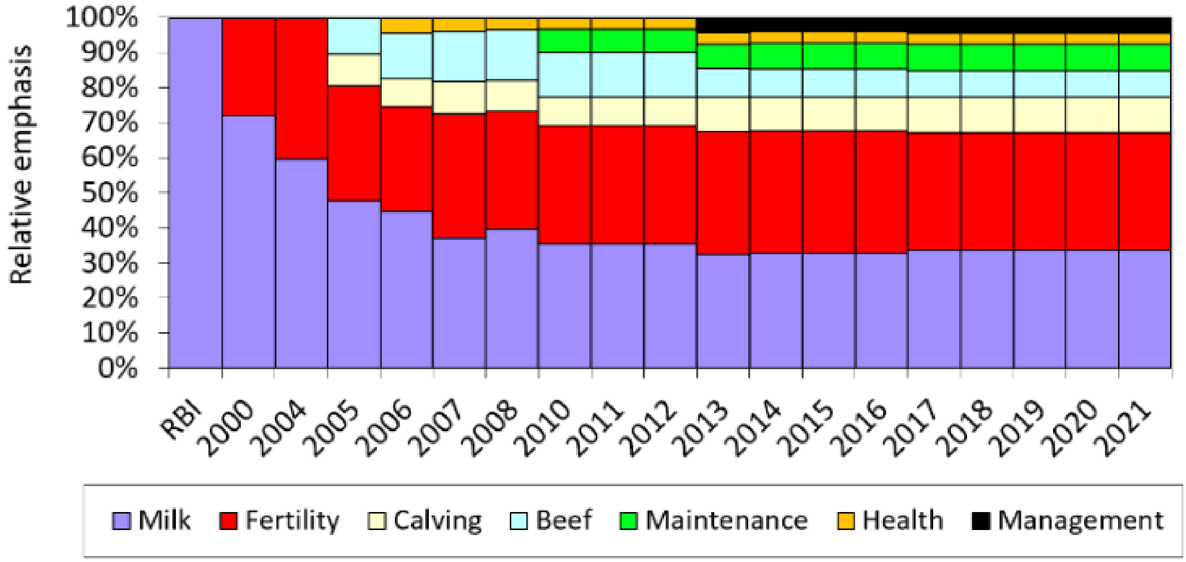

Figure 4. Evolution of the EBI from 2001 to 2017 [33].

Findings from research trials conducted on both controlled [8, 34, 35], and commercial farms [31] have demonstrated a positive correlation between EBI and increased milk solids (MS) production as well as enhanced reproductive performance. As a result of this heightened productivity, an incremental rise in EBI was directly linked to a greater net margin per cow and per litre [31]. Additionally, a recent study that compared the performance of animals with varying genetic merit confirmed the superior reproductive abilities (a 15% higher pregnancy rate at first service) of elite animals (the top 5% nationally based on EBI, averaging an EBI of €154) and their increased survivability (43% less likely to be culled before reaching lactation 5) compared to the national average cows (NA; with an average EBI of €47). While NA cows displayed greater milk yield, elite cows exhibited higher milk fat and protein concentrations, resulting in no significant difference in the total MS produced between the two genetic groups [8, 35].

The economic breeding index is used by farmers to increase performance and profitability of future generations. The performance of an individual cow in the herd depends on their genetic merit and the environment in which she is performing. Therefore we can use the EBI to breed for higher milk solids yield but if the cow is not managed correctly it may not perform to its full genetic potential. The EBI continues to deliver increased profitability, which should be the fundamental objective of any breeding program [8].

3.3.2 Health Sub Index

In 2005, traits relating to calving and beef performance were included in the EBI, increasing the number of traits included from 5 to 13. The health sub index of the EBI is worth 8% total. Within the health sub index, Tuberculosis is worth 3%, somatic cell count (SCC) makes up 2.6%, mastitis is worth 1.7% and lameness 0.8%.

Somatic cell count has an economic weight in its own right under the EBI due to its influence on milk price received. Irish milk processors such as Tirlan operate on a tiered pricing scheme based on the monthly arithmetic mean of the bulk tank SCC. The processor will apply a financial penalty to the farmer if the mean SCC of that month is greater than 400,000 with a greater penalty if the mean SCC is greater than 600,000 and bonuses for farmers under 200,000 cells/ml.

3.4 Somatic Cell Count

3.4.1 Introduction to Somatic Cell Count

Somatic cell count (SCC) is the number of somatic cells per millilitre of milk – it is therefore a useful proxy for the concentration of leukocytes in milk [36]. Milk somatic cell count is a key component of national and international milk quality regulations. It serves as a significant indicator of udder health and the prevalence of mastitis, whether clinical or subclinical. For uninfected udders SCC should be below 200,000 cells/ml with a range of 200,000-300,000 cells/ml indicating the presence of infection [37, 38].

High SCC results in substantial economic losses to both the farmer and processor as well as consumer concerns with regards to animal welfare [39]. Under EU legislation the SCC threshold for milk intended for processing is 400,000 cells/ml where one test per month must be performed at minimum. Milk quality and SCC has a significant impact on the efficiency of milk processing and quality of the end product [40], with an increase in SCC decreasing processability due to larger losses of fat and casein [41].

3.4.2 What are Somatic Cells?

Milk somatic cells consist primarily of leukocytes or white blood cells, which include macrophages, lymphocytes, and polymorphonuclear neutrophils [42]. Through the process of diapedesis somatic cells enter the mammary gland from the bloodstream [43]. Cows classified as having healthy udders typically have a higher concentration of macrophages while mastitis infected udders have a higher concentration of neutrophils within milk [44]. Epithelial cells and leukocytes enter the mammary gland in response to infection or injury. Epithelial cells can be found at concentrations of 0-7% of total cell population in udder secretions [45]. During an infection epithelial cells are either shed or increase in number. In response to infection the immune system increases leukocyte production to eliminate infection and repair damaged tissue [46]. In cows diagnosed with clinical mastitis it was shown that an initial increase in neutrophils followed by lymphocytes, monocytes and macrophages [47].

Somatic cells in milk are used as indicators of mammary health on the basis that they reflect an immune response and thus the presence of infection. A SCC of >100,000 cells/ml is often considered to be ‘normal’, reflecting a healthy mammary gland, whereas an SCC of >200,000 cells/ml is suggestive of bacterial infection. Although a raised SCC is an accepted indicator of an existing bacterial infection, a very low SCC has been associated with an increased subsequent susceptibility to clinical mastitis [48]. We typically see an increase in SCC as a response to an insult to the mammary gland and is modulated by inflammatory mediators as mentioned above. The major factor influencing SCC is infection status. The effects of stage of lactation, age, season, and various stresses on SCC are minor if the gland is uninfected [42].

Somatic cell counts are generally lowest during the winter and highest during the summer which coincides with an increased incidence of clinical mastitis during the summer months [49]. During infection SCC can increase potentially up to 1×10^6 cells/mL to combat the infection leading to reduced ability of the milk to coagulate, decreased cheese yield and recovery of milk nutrients from the curd [50]. Trends in somatic cell count over the course of lactation in Irish dairy herds can be seen in figure 5 below.

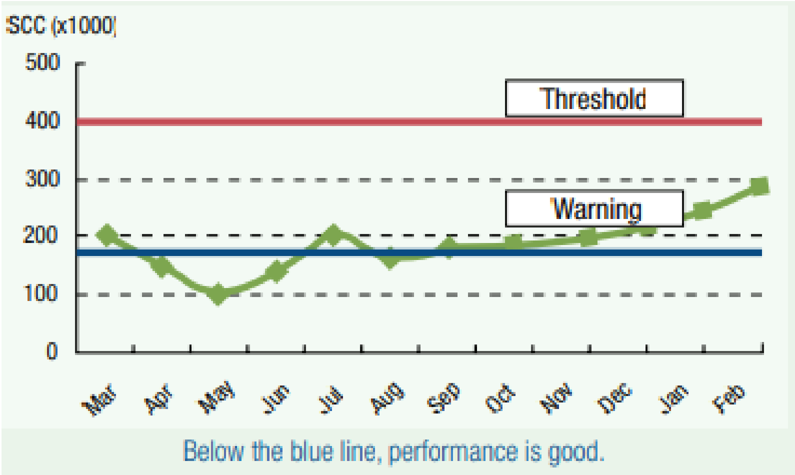

Figure 5. Trends in somatic cell counts over the course of lactation [51].

3.4.3 Risk Factors of SCC and Mastitis

In order to identify risk factors of Somatic Cell Count and mastitis we must look at a typical year for Irish dairy farms, starting in the drying off period . The dry period is a critical time for the mammary gland during which intramammary infections present at the end of lactation can be cured, but also new infections are acquired [52]. Somatic cell count measured at the last milk recording before drying off and at the first milk recording after calving can be used on farm to describe the dynamics of intramammary infections during the dry period. Transmission of contagious mastitis pathogens mainly occurs during milking [53]. Therefore, it is important to maintain good hygiene principles during milking and to identify cows with mastitis early on. Cows that are found to have mastitis should be isolated from the rest of the herd in order to minimise the risk of spreading the infection to other healthy cows.

The economic impact due to loss of milk yield is a risk factor of mastitis infections on dairy farms. Cows with E. coli mastitis have been shown to produce 6.7 kg less milk/d in the first week after diagnosis and approximately 5 kg less milk/d in the following 3 weeks. While cows with Staph. aureus infections produced 8.4 kg less milk/d in the first 2 weeks following diagnosis with milk production in these cows dropping sharply and never quite recovering [54].

3.4.4 Reducing SCC

Reducing somatic cell count requires a holistic approach that focuses on cow health, hygiene, and management practices. Regular monitoring, proper hygiene, and preventative measures are crucial for maintaining low SCC levels and ensuring the long-term health and productivity of dairy cows. Consulting with a veterinarian or dairy extension specialist can provide further guidance tailored to specific farm conditions and challenges. According to research carried out by [55] clean farms, houses and milking parlours were strongly associated with a lower SCC.

Reducing SCC on a dairy farm is essential for maintaining the health and productivity of the herd and the quality of milk. Implementing and maintaining simple steps such as proper hygiene on the farm such as ensuring clean and dry bedding for cows, keeping milking equipment clean and adequately sanitising udders before and after milking, can all aid in ensuring SCC's remain low. Identifying and removing chronically high SCC cows from the herd is also essential as they could be potential carriers of infection, therefore hindering the health of the other herd members.

3.4.4 Environmental Management

The influence of environmental factors on SCC is important to consider when trying to reduce SCC levels on the farm. According to research carried out in Teagasc, Moorepark, Dairy Production Research Centre, farm hygiene has a large impact on bulk tank SCC; with a clean parlour, clusters, sheds, cubicles, yards and roadways all associated with low bulk tank SCC. It is very important for farmers to keep the housing as clean as possible while the animals are being housed over the winter. A high frequency of cleaning the housing area and the use of paper or sawdust as bedding for cows during the housing period were also associated with low bulk tank SCC. The study also found that management practices such as participating in a milk-recording scheme, using a dry cow therapy and practising teat disinfection after every milking were also associated with low bulk tank SCC. Teats should be properly managed before the start of milking, a study by [38] demonstrated the importance of pre-dipping to reduce environmental mastitis by up to 50% and teats should be clean and dry before attaching the milking machine as wet milking of cows will likely increase environmental mastitis.

The use of clean dry bedding, organic in nature should also be used as they are shown to have lower streptococcal populations, Strep. Uberis being the most common cause of environmental mastitis in dairy cows. This species is known to cause both clinical and subclinical infections of the bovine udder and represents the leading pathogen in a growing amount of dairy herds [56].

3.4.5 Dry Cow Therapy

Farmers can implement a dry cow therapy (DCT) program to treat and prevent mastitis infections during the dry period whereby all quarters are treated with an intra-mammary antibiotic. Blanket dry cow therapy with intramammary antimicrobials has long been recommended as part of udder health management on dairy farms. Dry cow therapy is used to cure existing intramammary infections before the dry period and to prevent new high SCC during the dry period [57]. Research has shown that mastitis was seven times more likely during the dry period than during lactation with half of these infections persisting in the subsequent lactation [58]. At present 87% of herds in the Netherdlands, 94.2% of herds in America and 76.9% of herds in Germany utilise blanket DCT [59, 60]. The consequences of not carrying out dry cow therapy can negatively impact herd health, as seen in a study carried out by [61] a missed antibiotic dry cow therapy treatment for a high-SCC cow has an undesirable effect on subsequent lactation milk yield and SCC.

To help to reduce mastitis farmers can implement dry cow therapy. The dry period is a critical time for the mammary gland during which intramammary infections present at the end of lactation can be cured, but new infections can be acquired [52] In a study carried out by [62] the beneficial association between the use of dry cow therapy and lower SCC is probably due to minimising the carry over effect of subclinical mastitis across lactations. [63] also showed that dry cow therapy reduced the incidence rate of streptococcal infections during the early dry period but had no effect during the prepartum period. [64] showed a trend between the use of dry cow therapy and low bulk tank SCC.

3.5 Mastitis

Mastitis is a devastating disease affecting the dairy industry worldwide, with a decrease in milk yield and quality as well as an increase in culling rate and a decrease in farm profitability [65]. It is caused by pathogenic microorganisms such as, *Staphylococcus aureus*, entering the udder through the teat canal triggering an inflammatory response (Figure 6). This results in the development of either sub clinical or clinical mastitis [66]. Upon their multiplication, harmful toxins are produced which damage the mammary tissue and result in increased vascular permeability. Subsequently, milk composition is altered: with leakage of blood constituents, serum proteins, enzymes, and salts into the milk; decreased synthesis of caseins and lactose; and decreased fat quality [42, 67].

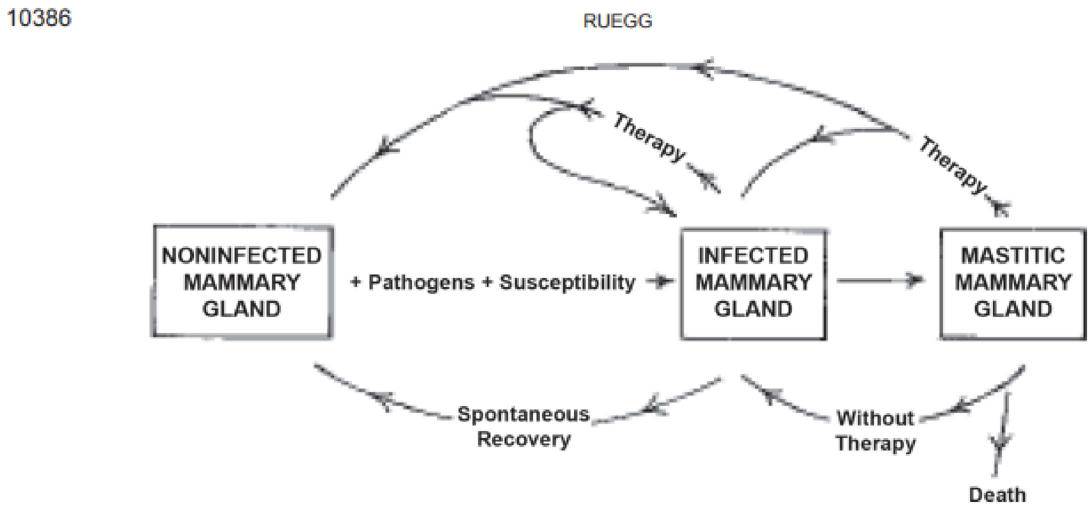

Figure 6: Pathway of development of mastitis infection in the mammary gland [68].

At present 23% of the milking herd are culled due to udder health issues [69]. Mastitis can occur as clinical or subclinical forms with clinical mastitis having mild or severe forms. According to [42] clinical mastitis is characterised by swelling or pain in the udder, milk with an abnormal appearance and, in some cases, increased rectal temperature, lethargy, anorexia and even death. In addition, bacteria are present in the milk, the milk yield is much reduced, and the milk content is altered considerably. Subclinical mastitis (SCM) appears without the presence of any clinical signs, and is the most prevalent form of mastitis. It can be identified through the detection of pathogens in milk cultures, or measuring SCC in milk. Other potential indicators include inflammatory markers such as acute phase proteins [84].

3.5.1 Mastitis Pathogens

There are many different pathogens that can cause mastitis but the majority of infections are caused by *Staphylococci*, *Streptococci*, and gram-negative bacteria such as *Escherichia coli* (E. coli) [48]. However other agents such as yeasts, algae and mycoplasmas have been shown to cause mastitis. Mastitis pathogens are typically categorized as contagious or environmental [70]. According to [71] *Staphylococcus aureus* is the predominant pathogen causing mastitis in dairy cows with prevalence increasing with parity and stage of lactation. Mastitis caused by the major pathogens results in the greatest compositional changes of milk, including increases in SCC, and has the most economic impact of all causative organisms [42].

Environmental bacteria are not reliant on a specific host and instead take advantage of opportunities to invade from the cows' surrounding environment, which may include elements like housing or bedding [72]. Among environmental pathogens, *Streptococcus uberis* has the highest prevalence and appears more often at the end of lactation in older cows than in primiparous cows [71]. The source of environmental pathogens can be the surroundings of the cow (e.g., bedding, manure, and soil) and therefore, it is crucial for farmers to prioritise good hygiene practices in order to minimise the risk of mastitis infections. Typically, these bacteria are acquired in the inter-milking period and undergo multiplication, triggering an immune response that is subsequently managed by the animal's immune system. Presently, environmental pathogens represent the primary cause of clinical mastitis incidents in the UK and Ireland, particularly in herds characterised by low SCC levels [48].

Typically, pathogens responsible for contagious mastitis are found within the mammary gland and can spread from an infected cow or quarter to an uninfected one during the milking process [73]. These contagious agents adhere to the teat's skin, establishing a presence and subsequently infiltrating the teat canal, where the infection takes hold [74]. Contagious pathogens like *Staphylococcus aureus* and *Streptococcus agalactiae* are generally associated with the most significant increases in SCC [75].

3.5.2 Treatment and Control of Mastitis

Due to the devastation caused from mastitis, it is essential to implement control plans to prevent the introduction of responsible pathogens wherever possible. Farmers can implement a number of management practices that can help to control mastitis numbers on the farm such as, washing udders before and after milking, teat dipping, fore stripping, milking clinical cases last, culling chronic cases and the use of dry cow therapy. To date progress on preventing and controlling mastitis within dairy herds has proved difficult due to several issues, including lack of knowledge transfer and proper risk-based assessment of control systems [76]. In the same ways as controlling somatic cell count on farms, farmers can implement good hygiene practices with an aim to reduce and control the level of mastitis.

Intramammary antibiotics should be the first line of treatment for cows with single quarter mastitis. The choice of antibiotic should be guided by a culture taken from the milk and the susceptibility of the pathogen. Treatment of mastitis should be carefully considered as shown by [77] the efficacy of mastitis therapy for chronic S. aureus infection during lactation is extremely low, leading to very low cure rates following treatment. According to a study carried out by [78], treating cows after a high somatic cell count may not be desirable except in special cases such as a young cow in early lactation with a high cell count and no previous treatment.

3.5.3 Genetic Selection

Generally Irish farmers will tend to breed for traits such as milk yield, fertility, and ease of calving since the health subindex of the EBI is worth 8% while production makes up 32% and fertility 25%. Breeding to maximise health and subsequently SCC and mastitis resistance may not be to the forefront of Irish farmers minds. However, if farmers are to consider taking SCC and mastitis resistance into account they should breed for cows with specific udder conformations as generally, SCC and clinical mastitis show similar relationships with a given udder trait. Udder depth and udder attachment generally show consistent results indicating that higher and more tightly attached udders are associated with lower SCC and less clinical mastitis [79]. Somatic cell score is recommended as an indicator trait to achieve genetic improvement for mastitis resistance [80].

3.5.4 Economic Impact of Mastitis

The effect of mastitis on herd level is often overlooked however it has been identified as one of the most economically relevant diseases in Ireland by Animal Health Ireland. Mastitis incidence in Ireland is on average 25% annually with average treatment costs of €71.84 per cow due to the costs of treatment, reduced milk production, contamination of milk, decreased milk quality and increased culling rate [81.] According to the Central Statistics Office (CSO) this costs the Irish dairy Industry €24.5 million annually based on 1.369 million dairy cows [82]. Mastitis results in a considerable reduction in farm profit on Irish dairy farms. Total farm costs increased as bulk milk SCC increased, reflecting treatment, veterinary, diagnostic testing, and replacement heifer costs and net farm profit decreased as BMSCC increased, from €31,252/yr at the baseline to €11,748/yr at a BMSCC >400,000 [83]. Therefore it is in Irish farmers best interest to try keep mastitis infections on the farm as low as possible.

4. Aim/Goals of the investigation

The aim of this study is to investigate the correlation between Economic Breeding Index (EBI) and somatic cell count (SCC) on Irish Dairy Farms. From the data collected, the aim is to analyse the relationship between SCC and EBI. The influence of sub-indexes (SI) within the EBI including the health SI will also be investigated with regard to the effect they have on SCC. Somatic cell count is a multifactorial issue, as a result factors such as milk yield and parity will also be analysed. With the ever-changing economic climate of milk production, it is vital for farms to operate at their highest potential in order to maximise farm income and profitability. By analysing the SCC and the characteristics of EBI on farms, I hope to highlight how the application of the EBI can play a role in achieving a low herd SCC.

5. Materials and Methods

5.1 Sample Size

Milk recording and EBI data was collected from fifteen farms from across Ireland during the year ending 2022. A total of 1,682 animals made up the sample size with herd size ranging from 64 to 185 as shown in Table 2.

Herd Number	No Animals
1	148
2	113
3	116
4	179
5	95
6	108
7	64
8	86
9	86
10	111
11	97
12	67
13	77
14	185
15	150

Table 2. List of herds with corresponding number of animals in each.

5.2 Collection of Data

The milk recording took place on each individual farm using one of three methods. Farm 12 used a robotic milking machine and the robot was able to measure milk volume and take milk samples to test for SCC. Farms 2, 3, 4, 5, 9, 10, 11, 13, 15 used a manual milk recording system where morning and evening milk volume for each cow is taken along with an individual milk sample. This was carried out by a technician from the milk recording company. Farms 1, 6, 7, 8, 14 used the Electronic DIY (EDIY) Milk Recording which involved electronic meters being sent out to the farm and the farmer could use without the technician present. The electronic meter would record the milk weight and automatically take a sample for each cow.

5.3 Grouping of Data

Animals were split into two categories, according to their EBI value and their parity number. With regards to the animals EBI, the animals were further split into two groups as seen in Table 3.. The figure of €161 was decided based on the average cow EBI figure in January of 2023 as reported by the Irish Cattle Breeding Federation (ICBF).

Category	Range	No Animals
EBI	≤€161	387
	≥€162	1295
Parity	1	394
	2	371
	3	308
	4+	609

Table 3. Grouping of Data by EBI and Parity

Animals were split by parity, with 1st 2nd and 3rd parity being investigated individually, while the 4th parity plus were grouped together. This was done to keep the number of animals in each group as uniform as possible. As is seen on most dairy farms, the number of cows exceeding their 4th parity declines, which was the case in all of the fifteen farms included in this study. Herds were then categorised into tertiles based on EBI, SCC and milk yield into bottom, middle and top tertiles. and then sorted by.

6. Results

All Data				
Variable	**Mean**	**Std Dev**	**CV**	**CV %**
EBI (€)	190.14	42.06	0.22	22.12
Milk SI (€)	52.76	28.26	0.54	53.57
Milk SI Reliability (%)	67.18	15.57	0.23	23.18
Fertility SI (€)	81.39	27.94	0.34	34.33
Fertility Reliability (%)	36.37	7.57	0.21	20.80
PTA Milk Kg	45.88	181.83	3.96	396.30
PTA Fat Kg	8.53	6.06	0.71	71.05
PTA Protein Kg	6.66	4.98	0.75	74.80
PTA Fat %	0.11	0.13	1.13	112.68
PTA Protein %	0.09	0.06	0.72	72.05
Lactation	3.23	2.07	0.64	64.07
Milk Yield (kg)	6423.96	1637.51	0.25	25.49
Fat Yield (kg)	266.17	66.74	0.25	25.07
Protein Yield (Kg)	229.88	57.36	0.25	24.95
Fat (%)	4.16	0.47	0.11	11.38
Protein (%)	3.59	0.21	0.06	5.76
SCC (000 cells/ml)	89.33	138.72	1.55	155.28

Table 4. Data from all Herds

As seen in Table 4 above, the mean EBI from all the animals in the data set was €190.14. This is €29 higher than the national average of €161. The range of EBI varied with a minimum EBI value of €10.79 and a maximum value if €345. The mean lactation number for all the cows in the data set was 3.23.

	EBI			
	≤€161		≥€162	
Variable	**Mean**	**Std Dev**	**Mean**	**Std Dev**
Milk SI (€)	35.1	27.1	58	26.4
Milk SI Reliability (%)	68.70	14.10	66.70	16.00
Fertility SI (€)	55.46	22.31	89.14	24.57
Fertility Reliability (%)	35.04	7.98	36.77	7.40
PTA Milk Kg	71.49	194.21	38.23	177.32
PTA Fat Kg	5.42	5.87	9.47	5.81
PTA Protein Kg	5.14	5.10	7.11	4.85
PTA Fat %	0.05	0.13	0.13	0.12
PTA Protein %	0.05	0.06	0.10	0.06
Milk Yield (kg)	6639.37	1875.79	6359.58	1554.27
Milk Solids (kg)	494.82	137.69	496.41	116.82
Fat Yield (kg)	264.63	75.29	266.63	63.99
Protein Yield (Kg)	230.20	64.50	229.79	55.08
Fat (%)	4.00	0.46	4.21	0.47
Protein (%)	3.48	0.20	3.62	0.20
SCC (000 cells/ml)	107.43	176.97	83.93	124.62

Table 5. Results of Animals Split by EBI

The ≥€162 group had a slightly higher milk solids (kg), protein and fat % when compared to the average EBI group (EBI ≤€161). A higher milk fat and protein percentage was seen in the ≥€162 group.

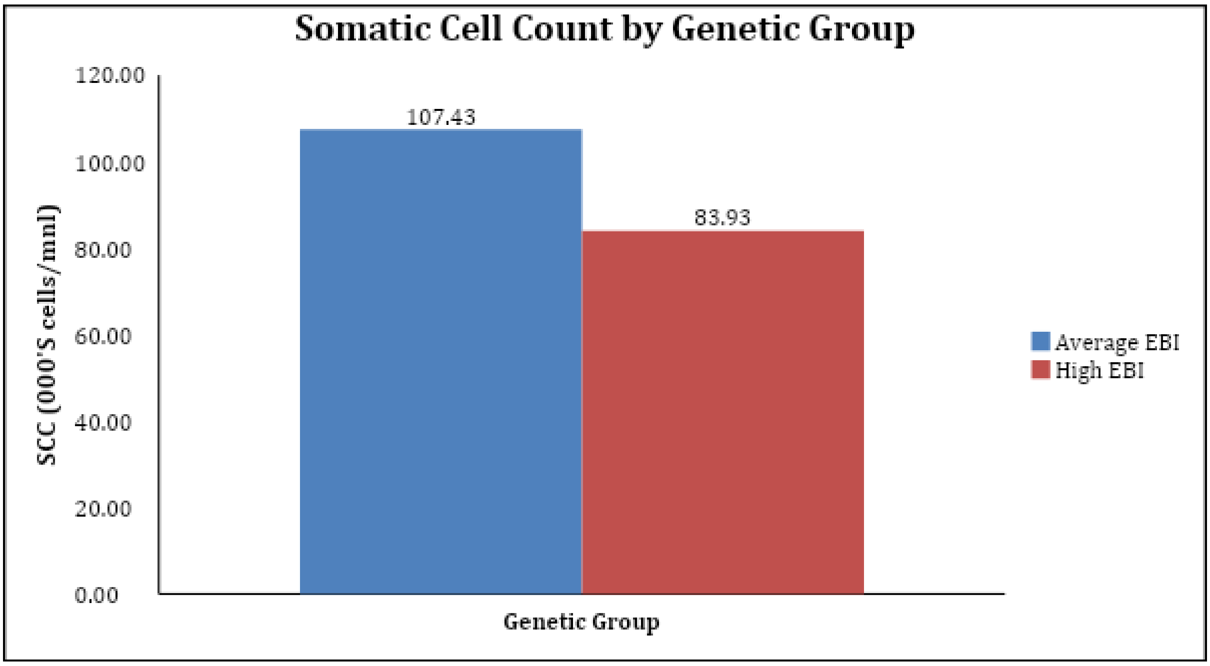

Figure 7. Somatic Cell Count by Genetic Group

As we can see from the Figure 7 above, when we split the total number of cows in the sample by EBI, the "High EBI" group had a lower average SCC than the "Average EBI" group. A result of 107.43 (000's cell/ml) and 83.93 (000's cell/ml) was calculated respectively. There was a difference of 23.5 (000's cell/ml) between both groups.

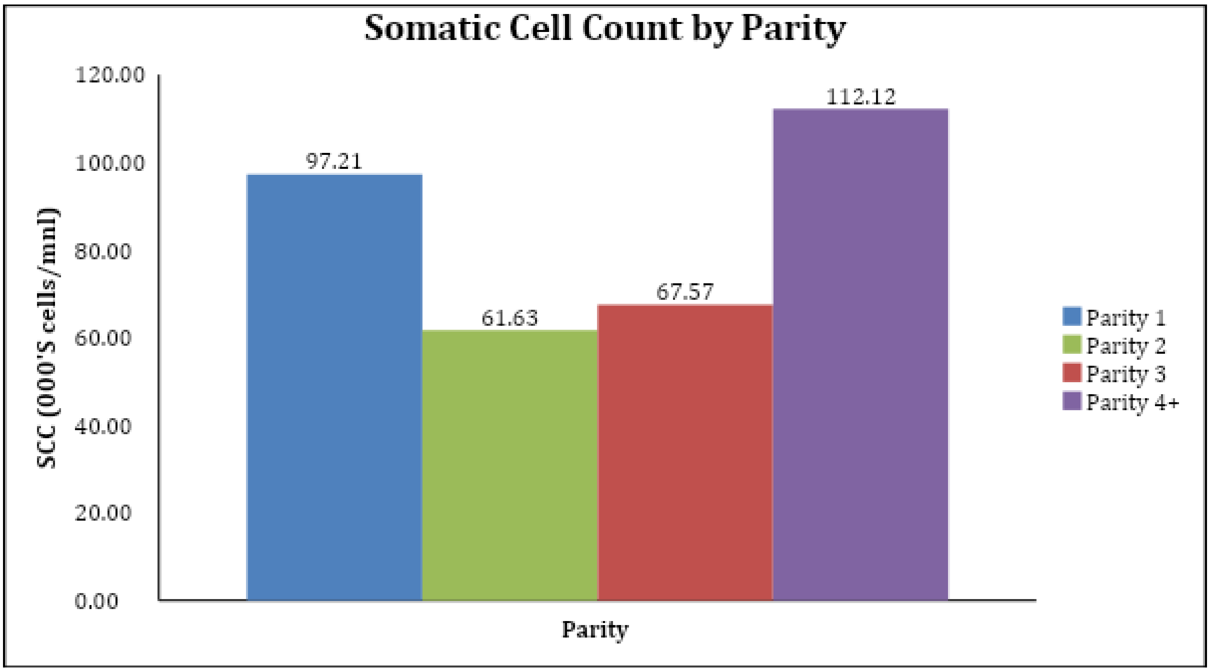

Figure 8. Somatic Cell Count by Parity

When the herds were split up by parity, the first parity group had an average SCC of 97.21 (000's cell/ml), the second and third parity group has an average SCC of 61.63 and 67.57 (000's cell/ml) respectively, while the 4+ parity had an average SCC of 112.12.

	EBI (€)		Milk Yield (kg)		SCC (000 cells/ml)	
Herd	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
1	212.19	35.43	7298.30	1133.25	103.36	129.49
2	192.07	40.13	2997.49	505.21	82.05	181.21
3	165.77	56.47	6789.33	1009.08	63.07	58.80
4	184.91	38.56	6498.26	1130.96	103.99	150.83
5	208.05	32.55	6649.36	1130.64	116.37	144.91
6	177.13	30.70	6820.19	1344.44	77.53	82.98
7	197.01	28.08	7317.81	1042.94	71.22	91.09
8	209.08	46.54	5946.36	1276.90	49.36	46.79
9	180.44	36.14	5228.29	1283.52	117.28	286.49
10	196.60	31.71	5921.09	1005.68	94.28	104.30
11	203.34	55.02	7636.39	1063.33	91.31	116.62
12	174.61	39.41	6543.43	1665.53	90.43	60.51
13	149.59	49.09	7322.64	1906.49	121.42	134.67
14	200.73	31.43	6187.71	1098.36	100.64	179.06
15	183.14	30.09	7286.01	1546.05	53.97	62.65

Table 6. EBI, Milk Yield and SCC of each Herd

Six out of the fifteen herds had a mean SCC of over 100 (000's cell/ml). With the lowest mean SCC being recorded on Farm 8, of 49.36 (000's cell/ml).

Sorted by EBI									
Herd	Tertiles	EBI (€)	Milk Solids (kg)	Milk Yield (kg)	Fat Yield (kg)	Fat (%)	Protein Yield (kg)	Protein (%)	SCC (000 cells/ml)
13	Bottom	149.59	574.88	7322.64	258.46	3.54	316.42	4.33	121.42
3	Bottom	165.77	501.81	6789.33	231.06	3.41	270.75	4.01	63.07
12	Bottom	174.61	503.78	6543.43	229.40	3.52	274.38	4.24	90.43
6	Bottom	177.13	509.53	6820.19	243.98	3.59	265.55	3.94	77.53
9	Bottom	180.44	442.97	5228.29	195.31	3.75	247.66	4.79	117.28
15	Middle	183.14	533.67	7286.01	258.96	3.55	274.71	3.79	53.97
4	Middle	184.91	508.16	6498.26	235.60	3.63	272.57	4.22	103.99
2	Middle	192.07	215.54	2997.49	105.36	3.52	110.17	3.70	82.05
10	Middle	196.60	469.90	5921.09	216.91	3.68	252.99	4.30	94.28
7	Middle	197.01	571.37	7317.81	252.00	3.45	319.37	4.38	71.22
14	Top	200.73	487.89	6187.71	224.32	3.64	263.57	4.29	100.64
11	TOP	203.34	582.91	7636.39	272.96	3.58	309.96	4.08	91.31
5	Top	208.05	516.44	6649.36	241.71	3.65	274.73	4.16	116.37
8	Top	209.08	462.82	5946.36	207.89	3.51	254.93	4.32	49.36
1	Top	212.19	575.94	7298.30	266.84	3.67	309.09	4.26	103.36

Table 7. Herds sorted by EBI

Herds were compared and sorted in order from worst to best by their EBI score. As seen in Table 7. above.

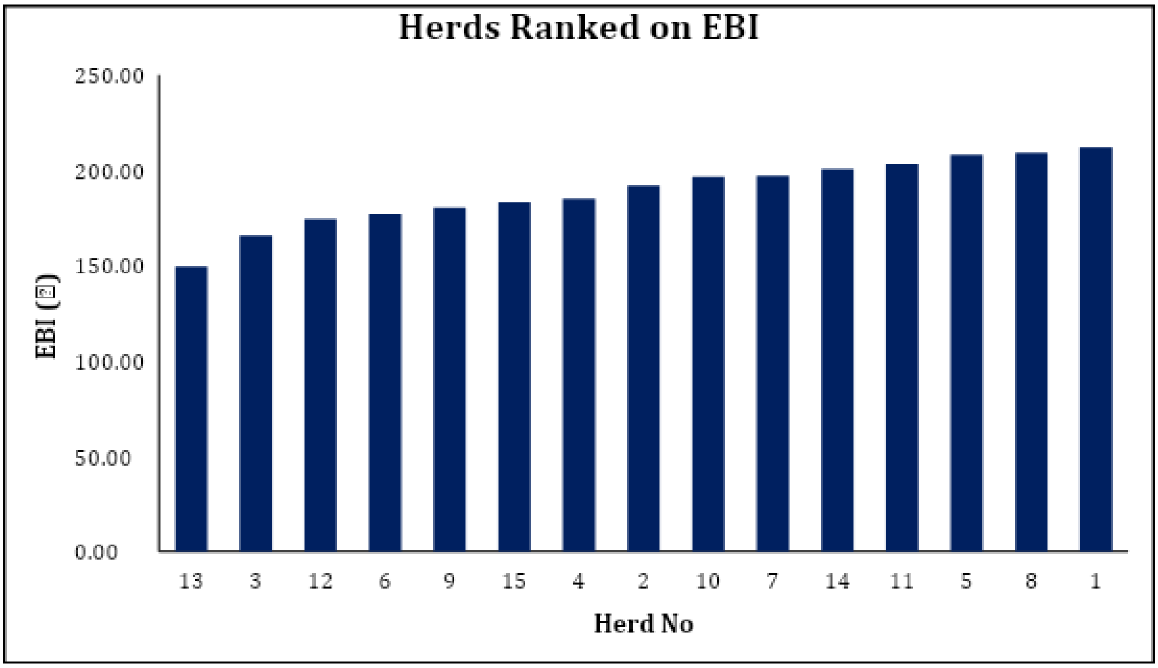

Figure 9. Herds Ranked by EBI

From the data seen in Figure 9. when ranked the herds according to their EBI, herd 13 had the lowest EBI while also having the highest mean herd SCC. Herd 13 was the only herd to be under the national average EBI of €161. Herd 1 had the highest EBI of 212.19.

Sorted by SCC									
Herd	**Tertiles**	**EBI (€)**	**Milk Solids (kg)**	**Milk Yield (kg)**	**Fat Yield (kg)**	**Fat (%)**	**Protein Yield (kg)**	**Protein (%)**	**SCC (000 cells/ml)**
8	Top	209.08	462.82	5946.36	207.89	3.51	254.93	4.32	49.36
15	Top	183.14	533.67	7286.01	258.96	3.55	274.71	3.79	53.97
3	Top	165.77	501.81	6789.33	231.06	3.41	270.75	4.01	63.07
7	Top	197.01	571.37	7317.81	252.00	3.45	319.37	4.38	71.22
6	Top	177.13	509.53	6820.19	243.98	3.59	265.55	3.94	77.53
2	Middle	192.07	215.54	2997.49	105.36	3.52	110.17	3.70	82.05
12	Middle	174.61	503.78	6543.43	229.40	3.52	274.38	4.24	90.43
11	Middle	203.34	582.91	7636.39	272.96	3.58	309.96	4.08	91.31
10	Middle	196.60	469.90	5921.09	216.91	3.68	252.99	4.30	94.28
14	Middle	200.73	487.89	6187.71	224.32	3.64	263.57	4.29	100.64
1	Bottom	212.19	575.94	7298.30	266.84	3.67	309.09	4.26	103.36
4	Bottom	184.91	508.16	6498.26	235.60	3.63	272.57	4.22	103.99
5	Bottom	208.05	516.44	6649.36	241.71	3.65	274.73	4.16	116.37
9	Bottom	180.44	442.97	5228.29	195.31	3.75	247.66	4.79	117.28
13	Bottom	149.59	574.88	7322.64	258.46	3.54	316.42	4.33	121.42

Table 7. Herds sorted by SCC

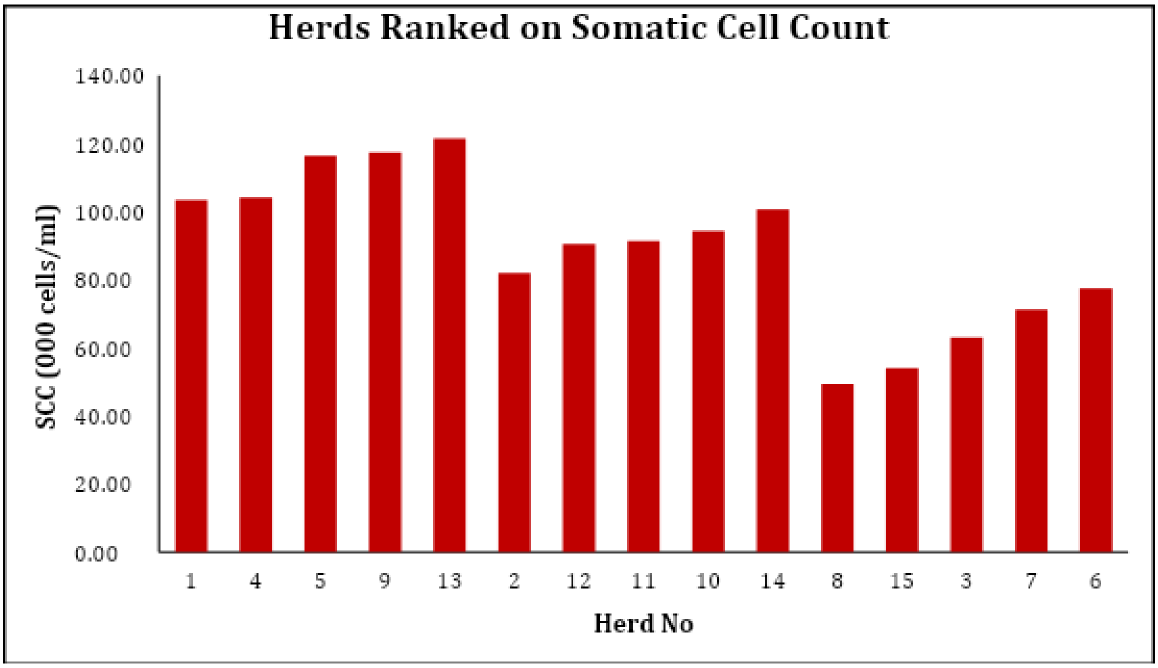

Figure 10. Herds Ranked on Somatic Cell Count

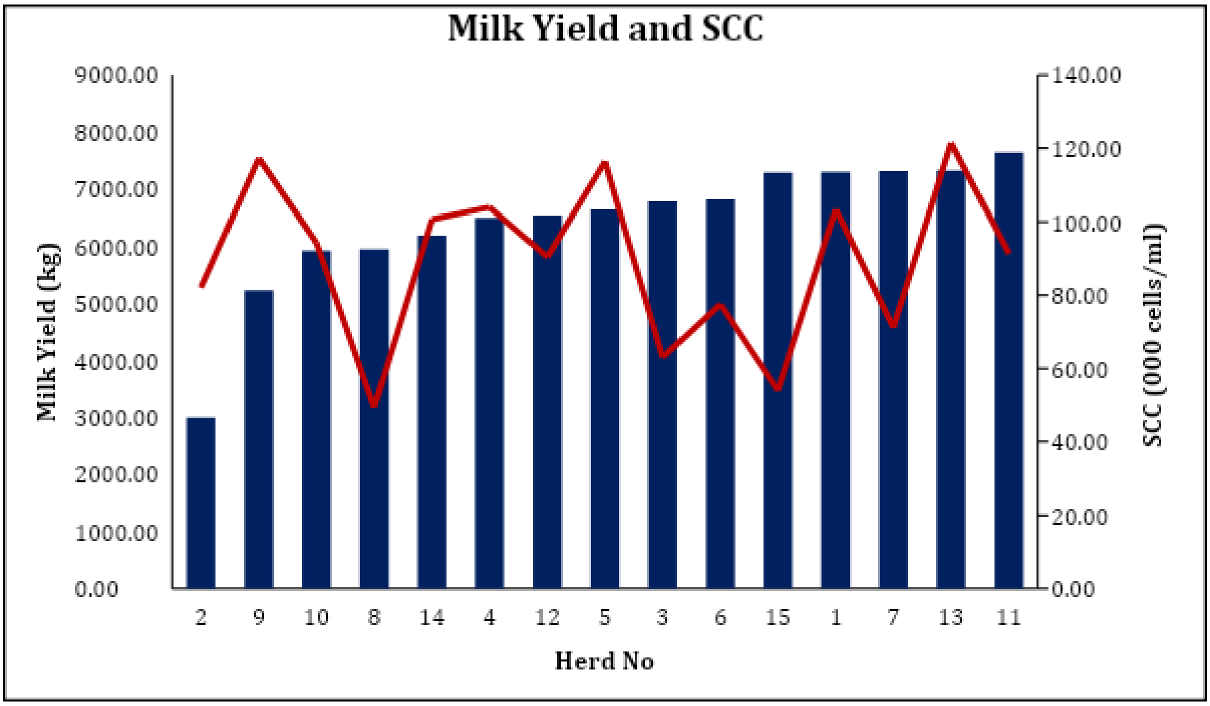

Figure 11. Milk Yield and SCC by Herd

When we look at milk yield herd 2 had the lowest milk yield of 2997.49kg while herd 11 had the highest milk yield of 7636.39kg Herd 13 had the second highest milk yield of 7322.64kg while also having the highest SCC of 121.42 (000's cell/ml).

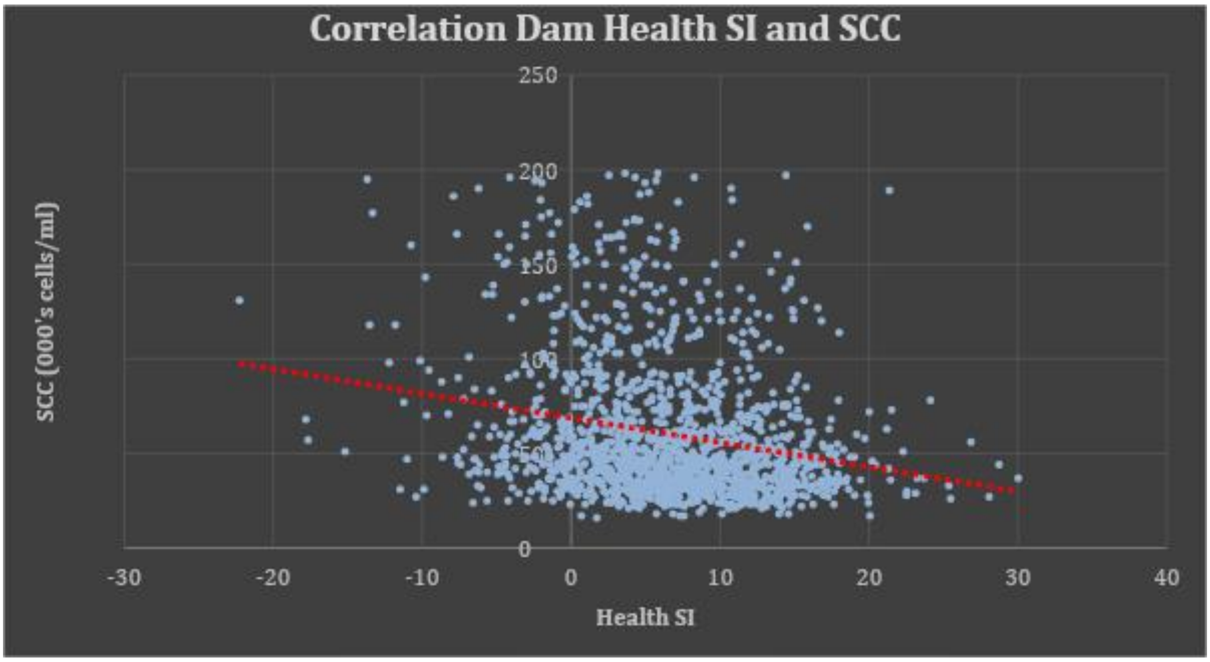

Figure 12. Correlation Dam Health Sub Index and SCC

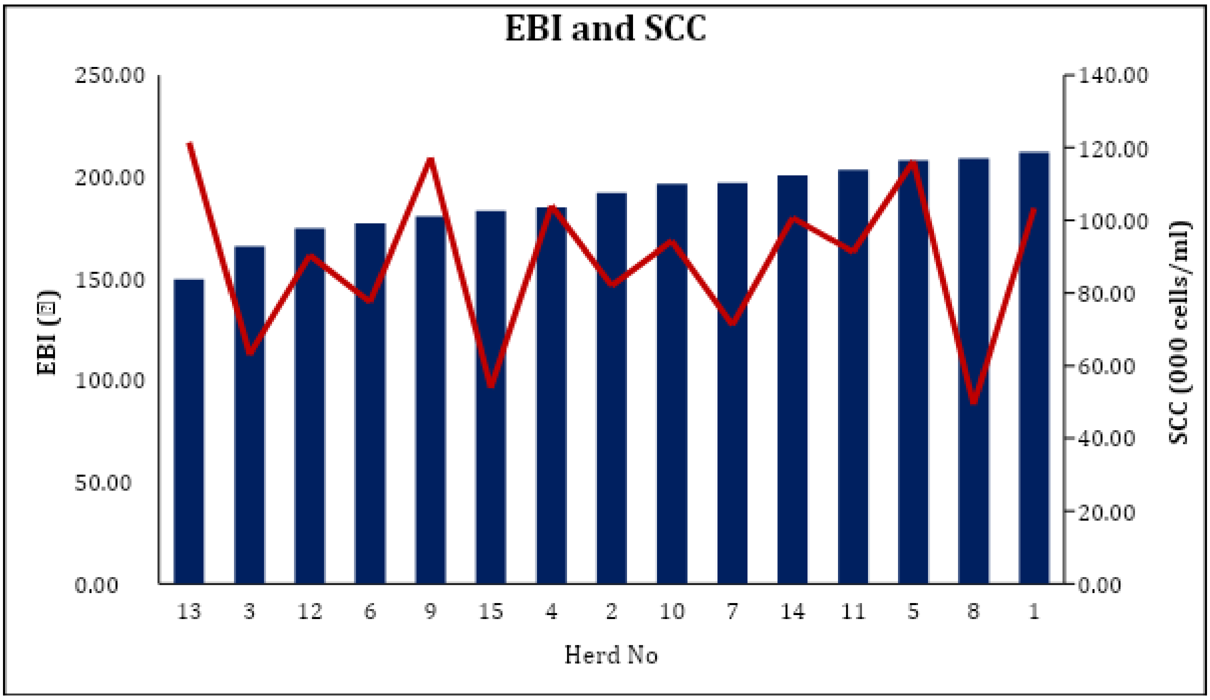

Figure 13. Herd EBI and SCC

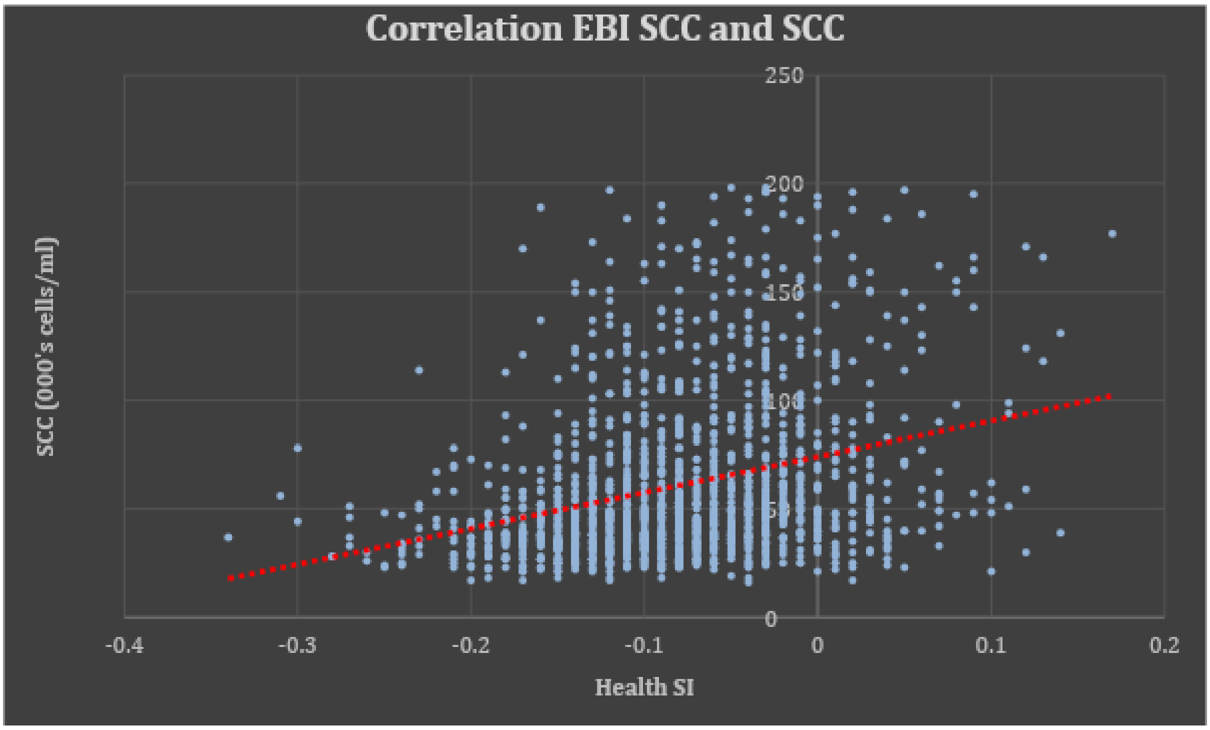

Figure 14. Correlation of EBI SCC and SCC from Milk Recordings

7. Discussion

When grouping the cows according to EBI we did see a positive relationship between EBI and SCC, showing that for at least this data set, cows with a higher EBI tended to have a lower SCC on average. From the results we can see that there was a decrease in SCC in the Higher EBI group. This would be expected and in line with previous research in both controlled and commercial studies. A difference of 23.5 (000's cell/ml) however, is not particularly high in the grand scheme of SCC. When correlating the relationship between EBI and somatic cell count there was a low positive correlation of 0.3.

However, the herds utilised in the present study were all considered high EBI herds that have adopted the technology, therefore the sample of herds used would not be reflective or a fair representation of the average dairy herd in Ireland. The fifteen herds that made up this data set were all of relatively high EBI. When compared to the rest of the country with the national average being €161. When looking at herd level, only one herd out of the fifteen in the sample had a mean EBI of less than the national average of €161. This was therefore a problem when it came to getting an accurate picture of the national herd and getting a range of EBI values varying from low to high, with not enough herds in the data set being on the lower end of the Economic Breeding Index.

Somatic cell count is a multifactorial issue on farm level and simply using EBI as a lone parameter is not a reliable enough predictor of SCC at a herd level. Environmental factors and management practices on farm level play a huge role in SCC levels on both a herd and individual cow level. Six out of the fifteen herds had a mean SCC of over 100 (000's cell/ml) while nine were under 100 (000's cell/ml). 60% of the herds in the data set had a very good herd SCC of less than 100 (000's cell/ml). This is exceptionally good by national standards with the national average SCC being 175 (000's cell/ml) as of 2022. Farms in the data set would have to have very good dairy herd management and environmental management as the genetic potential of the dairy cows can only take you so far before other factors take over. We have seen from the above literature review on environmental management that there is an association between low milk SCS and an increased level of hygiene and frequency of cleaning of the holding yard, passageways and cubicles. Factors such as this cannot be ignored when analysing herd Somatic Cell Count.

First parity cows from the data set were recorded to have a higher somatic cell count when compared to second and third parity cows, with cows from fourth parity onwards also having a higher somatic cell count. Replacement heifers typically make up 20 – 35% of a herd in Ireland. These animals are introduced to the herd without ever being tested for SCC until their first lactation. Since the farms in the data set showed to have a higher average SCC in first lactation animals, this could possibly be a reason for seeing the increase.

8. Conclusion

The Economic Breeding index is a very valuable tool for Irish farmers to use to maximise the genetic potential of their herd. It has played a pivotal role in the selection of animals for desired traits as mentioned above. The utilisation of the Economic Breeding Index by Irish dairy farmers can help to increase milk yield and milk solids such as protein and fat %. Although the Health Sub Index makes up only 8% of the total weighting it should not be overlooked when selecting cows for breeding. As the data above shows a relationship between cows EBI value and their somatic cell count , with cows of a higher EBI having a lower somatic cell count on average.

Environmental and management practices play a significant role in the performance and overall health of dairy cows, regardless of their genetic potential. Early identification of high somatic cell count cows and mastitis cases, through practices like milk recording, can help improve herd SCC and herd health. Along with practising dry cow therapy to help reduce the numbers of new intramammary infections at the onset of the lactation period and therefore minimise the economic impact of high SCC and mastitis in the herd.

To further investigate the relationship between EBI and somatic cell count, a larger and more diverse dataset would be beneficial. This would allow for a more comprehensive analysis of the relationship between these two variables, and could help to identify any potential confounding factors

9. Acknowledgements

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