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Reproductive performance of beef herds in an Irish Special Protection Area

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LIST OF ABBREVIATIONS

CSO	Central statistics office
CAP	Common agricultural policy
GDP	Gross domestic product
DAFM	Department Of Food and Marine
UN	United Nations
OECD	The Organisation For Economic Co-Operation and Development
BCS	Body condition score
AI	Artificial insemination
ICBF	Irish Cattle Breeding Federation
BREXIT	United Kingdom’s exit from the EU
LU	Livestock unit
FAO	Food And Agriculture Organisation Of The United Nations
LH	Lutenising hormone
SPA	Special Protection Area

1 INTRODUCTION

Reproductive efficiency is the driving force in profitability in suckler herds. The calf is the solitary product until the cow is sold therefore, without a calf, there is no profit. Pregnancy has four times the impact of any other production trait yet there is little emphasis on improving these parameters (Fontes *et al.*, 2020). If a cow does not become pregnant, due to missed heat or physiological reason, more often than not, she remains in the herd to wait until the following breeding season. If this cow remains in the herd, additional expenses are incurred through feeding, vaccination and housing costs which leads to loss of profit. Only 85% of cows produce a calf in Irish suckler herds each year (Fontes *et al.,* 2020). Attention to calving intervals and age at first calving are very important. Longer calving interval results in a reduction in calves per cow per year.

Genetic improvement is vital for beef herds to reach EU standards, the most effective way is through artificial insemination using genetically superior sires. Infrastructure designed to help farmers to facilitate genetic improvement has been essential in collected data relating to these reproductive parameters. The best way the Irish beef herd can benefit to the greatest extent is through improving genomic technologies through hybrid vigour and tailoring suitable sires to each herd.

This study gives an insight into the reproductive performances of herds in the special protection area of North Kerry. It compared beef herd profiles from other herds in the local area against each other and also national averages.

2 LITERATURE REVIEW

2.1 General overview of the global beef sector

Beef production continues to be one of the main methods of feeding the world in a sustainable way. Global production of beef reached 320 million tonnes in 2018, more than doubling since 1961 (Ritchie and Roser, 2019). In developing countries, beef production continues to grow. According to the OECD and Food and Agriculture Organization of the United Nations (2019), of beef production in developing countries is expected to increase by 17% until 2028.

Middle-class world population is projected to grow from 3.2 billion in 2017 to 5.2 billion in 2030 and spending on meat and poultry consumption is expected to rise from $35 trillion in 2017 to $51 trillion by 2030 (Hennessy, 2018). By 2050, there will be a 70% increase in global food production, including 200 million tonnes of meat, to keep up with this demand (FAO, 2011). There is strong emphasis on sustainability, how countries can achieve these increases in demand, yet keeping high production standards, both in terms of animal welfare and the impact on the environment. In the European Union, it is expected that the beef production will follow a downward trend in the future. A large proportion of beef cattle in the EU are a dairy-beef cross and projected profitability of dairy farming will switch from beef production into dairy production (OECD and FAO, 2019).

Although there is a forecasted increase in the beef production in developing countries, there are changes occurring in consumer trends, including veganism/vegetarianism and emphasis is placed on methods of beef production, e.g. free-range versus factory rearing, use of antibiotics and growth promoters that all can have a negative impact on beef production (Hennessy, 2018). With these new trends, farmers might need to change their methods of production. This can lead to increasing cost of production and have an effect on overall profitability, especially to small scale beef farmers, and these production costs will have to be passed onto consumers.

2.2 Brief overview of the Irish beef sector on the world market

Ireland is the largest beef exporter in the entire European Union, and is the fifth largest net exporter of beef globally (Taylor *et al.*, 2018). The beef sector is a significant contributor to agricultural output, managing to reach over one-third of total agricultural output of Ireland. According to the Central Statistics Office (CSO), almost €2.5 billion equating to 540,000 tonnes of beef was exported to approximately 70 countries in 2018. In 2018, 1,802,473 head of cattle were slaughtered in Department-approved facilities, which represented a 3.6% increase on 2017 (DAFM, 2019).

The vast majority of exported meat ends up in The United Kingdom: in 2018, €1,014 million worth of bovine products were exported to the UK, out of €1,968m of total exports (**Table 1**).

Table 1. Value of Irish exports to the United Kingdom and worldwide.

Product	**UK**		**Rest of World**		**Total**	
	€ million	**'000 tonnes**	**€ million**	**'000 tonnes**	**€million**	**'000 tonnes**
Bovine meat	1,014	211	955	162	1,968	374
Pig meat	192	65	249	127	441	192
Sheep meat	54	12	249	41	304	53
Poultry	71	47	46	42	117	89

Since almost 50% of Irish beef exports go to the United Kingdom, the exit of the UK market from the European Union and the potential fall of the value of the pound sterling poses a danger to Irish beef producers and exporters. Due to being such close, interconnecting economies, the Irish agriculture sector is forecasted to be impacted more than the rest of the economy (Bord Bia, 2019).

There are three main factors that influence the outcome of Brexit for Irish farmers (Conefrey, 2019):

1. The reliance of specific sectors on the UK market;
2. Barriers created using tariffs which reduce Irish exporters' access to UK market;
3. The level of reliance of different sectors based on their profitability and dependence on direct payments.

There have been reports assessing the potential damage that an unfavourable Brexit deal will have on Irish beef producers. Ireland relies on the UK land-bridge connecting the UK with the rest of the EU: up to 53% of Ireland's exports use this land-bridge, therefore, if there is a hard Brexit, the consequences for Irish exports are unknown (Lawless and Morgenroth, 2017). The future for Irish suckler farmers is uncertain, regardless of the agreement between governments, low income suckler farmers will be the worst effected (Irish Farmers Association, 2017). Even with the best deal, Ireland would expect a reduction in Irish GDP and exports by 2.8% and 3.3% respectively (Hennessy, 2018).

With Brexit, there is an assumed reduction in Common Agricultural Policy (CAP) support, estimated to be around 10%. Coupled with the 10% reduction in beef prices, farmers could face one-third of a drop in family farm income (Thorne *et al.,* 2016).

As well as being a substantial contributor to Irish GDP, the ag-food sector employs over 300,000 people, whether through direct employment through farms and processing plants or indirectly from exports. The Irish suckler industry solely provides 52,000 full time jobs, directly and indirectly (Fontes *et al.*, 2020).

The Specialist beef production was the most common type of farming in Ireland, in 2016: out of 137,500 farms, over 72,400 farms were engaged in beef exclusively comparing to 16,700 specialist dairy farms Ireland has around 4.1 million hectares of grassland, making it ideal for the outdoor rearing of animals and production of grass fed beef, giving light as to why Irish beef is seen to be one of the highest quality beef products (Central Statistics Office, 2016). Ireland is the leader in terms of water efficiency producer of food globally according to the UN, boasting a 0.2 percent stress rating. Ireland's animal welfare standards are of an extremely high standard by global standards, hormonal growth promotors are strictly forbidden. Ireland's green image is marketed globally, famous for grass fed beef. The health benefits of grass fed beef are tried and tested, low fat content with two to six times more Omega-3 fatty acids. These properties are becoming very popular especially in affluent markets. (Hennessy, 2018).

2.3 Assessing the efficiency of beef farms

Income, costs and profitability are seen as the main parameters evaluating efficiency on Irish beef farms. According to the National Farm Survey (Hennessy and Moran, 2016), the average output per hectare for cattle farms in 2015 was €1,257, and the average gross margin €499. Only 25% of cattle farms were defined as economically viable.

2.3.1 Costs on Irish farms

There is a continuous increase in cost of production year-to-year. These costs hikes are mainly due to a rise in direct costs, feed, fertilizer and contracting. Expenses such as fertilizer, energy and feedstuffs can be a large percentage of the farming expenditure, and expected to increase (Bord Bia, 2019). Timing can have an effect on these costs, farmers that choose to have autumn calves are also faced with an increased concentrates bill, due to higher milk production needing high quality silage and/or concentrates (Crosson, 2016). In a recent survey by the CSO outlining the income in agriculture in Ireland, it shows the price of nitrogen fertilizer has increased, leading to an overall decrease in demand. The volume of fertilisers consumed by Irish farmers fell by 7.6% in 2019 but price increases resulted in the cost of these fertilisers decreasing by just €3.8m (-0.7%), from €582.1m to €578.3m (Central Statistics Office, 2019). Gross output reduced by 5% on the average beef producing enterprise in 2018 compared to 2017 (**Table 2**).

Table 2. Average Gross and Net Margin 2017 and 2018

	2017 €/hectare	**2018 €/hectare**	**% change 2018/2017**
GROSS OUTPUT	**976**	**924**	**-5**
CONCENTRATE COSTS	141	169	20
PASTURE AND FORAGE COSTS	247	255	3
OTHER DIRECT COSTS	114	118	4
TOTAL DIRECT COSTS	**502**	**541**	**8**
GROSS MARGIN	**474**	**382**	**-19**
ENERGY AND FUEL	114	120	5
OTHER FIXED COSTS	375	362	-3
TOTAL FIXED COSTS	489	482	-1
NET MARGIN	**-15**	**-100**	**N/A**

In 2018, this decrease in gross output was accompanied by an 8% increase in direct costs, leading to an overall 19% reduction in the average gross margin per hectare (Teagasc, 2018). Increased calving interval can have an effect an calves per cow per year. While reduced milk yield and slippage in calving pattern account for most of the economic cost of extended calving intervals, fewer calves born per cow per year is a further source of lost revenue. Assuming a 7% mortality rate for a 100 cow herd, a slip in herd calving interval from 375 days to 443 days, results in revenue losses of approximately €33 per cow. Slippage in calving pattern due to extended calving interval increases annual feed cost by €71 per cow (Patton, 2012).

Overhead costs increased by 1 percent on Cattle Rearing farms in 2018, with increases in energy and fuel (5% and 6% respectively) and increased depreciation costs for machinery and land (11 and 8% respectively) (Hennessy and Moran, 2015). Without the direct payments and subsidies, the vast majority of Irish beef producers would be making a loss and wouldn't be able to compete. The Teagasc National Farm Survey 2015 found that cattle rearing farms had the highest reliance on direct payments, on dry stock farms, the market income before direct payments is less than zero. This indicates that there is little or no profit coming from production, hence the heavy reliance on direct payments. (Hennessy and Moran, 2015).

2.3.2 Production systems

In a comprehensive study by Taylor *et al.* (2018), different production systems (Finishing, calf-to-slaughter; Live, calf-to-live sale; Mixed, a combination of Finishing and Live) were compared to differentiate the level of profitability of suckler beef farms in Ireland and furthermore, to identify the key drivers of profitability. Finishing and Mixed farms are dependent on stocking rate primarily compared to beef live weight was the main source of profitability on Live farms. There are certain criteria that should be reached in order to be able to make a profit. In a report by (Crosson, 2016) for Teagasc, outlining the goals for driving profit in beef farming, having a defined system planned is essential. The farm needs to be analysed and pick production systems suited to the farm itself and its facilities, with simple and effective objectives. Managing animal health is an obvious method to drive profits, a healthy animal free of ailments will maximise weight gain and reproductive capacity. Special attention needs to be paid to infectious diseases, parasitic diseases and metabolic diseases that may hinder the animals ability to thrive.

2.4 The role of reproduction and reproductive management in beef farming

Reproductive efficiency is a key driver of the productive, economic and environmental sustainability of beef cow herds (Fontes *et al.*, 2020). In the beef industry, the calf is the main output, followed by the value of the cow herself when being culled.

Therefore the management of reproduction is critical in order to maximise the output. In the study of Diskin and Kenny (2016), the main targets that beef producers should be aiming for when looking at the production cycle were outlined:

1. 365 days calving interval;
2. less than 5% dry cows culled annually;
3. over 95% of cows weaning a calf;
4. heifers calving close to 24 months of age;
5. compact calving with 80% of cows calved in 6 week period;
6. replacement rate 16%-18%;
7. emphasis on hybrid vigour for economically important traits relating to reproduction, calving ability, and calf weaning weight;
8. timing of calving date with onset of pasture availability in the spring.

In the same study, the following benchmarks were set up in order to achieve the mentioned goals (Diskin and Kenny, 2016):

1. occurrence and timing of puberty in heifers,
2. resumption of oestrus cycles after calving,
3. expression and detection of oestrus, and
4. breeding and the establishment of pregnancy.

Heifers are the next generation of cattle that will be supplying the farm with the calves for beef production (Diskin and Kenny, 2016). Ideally, successive generations of heifers should be genetically superior for important reproductive and production traits to their dam. It is essential the herd is performing at the highest level attainable. As regards age at first calving, a heifer calving down at two years of age helps to ensure they reach 8 or more lactations. In comparison to dairy , beef cows have a seasonal calving pattern. If the first heat is missed, it is not uncommon for a heifers to calve at three year old, reinforcing the pressure to properly time the breeding and subsequently calving of herd at the most opportune time regarding grass growth and temperature (Diskin and Kenny, 2016). However, in most Irish farms, the majority of heifers do not reach the two years of calving target age, with only 10% of maiden heifers calving by 24 months of age. The calving interval is up to 400 days, compared to the ideal 365 day timeframe. (Diskin, 2016a). Calving interval has been a constant problem as demonstrated in **Table 3**. The ICBF statistics confirm that Irish suckler herds do not reach their maximum potential, making it obvious that farmers are not putting enough emphasis into the reproduction of the herd. Farmers are hesitant to calve heifers at two years of age. Reasons why farmers are reluctant to calve beef heifers at 22-26 months are:

1. Heifers are not fully mature at 15 months of age;
2. Under the impression the heifer will have stunted growth by bulling her too early;
3. More likely to have difficult calving;
4. They won't go calve as a 3 year old;
5. Poor sale value if there is a difficult calving. (Teagasc, 2020)

Compared to dairy farms, the importance of producing good quality female replacements is not at the forefront of the list of goals. Hybrid vigour is essential for weaning heavier calves, crossbred calves can average 13% heavier than purebred dam offspring. In 2007, the ICBF euro star system was introduced to Ireland (McHugh et al., 2015). The aim of this system was to develop a Replacement Index, concentrating on the maternal traits, such as calving interval, calving difficulty and milk yields. The scale is a one-to-five star rating, five star rating being the best. McHugh et al (2015) evaluated the performance of high and low replacement index cows, and found that across all maternal traits, the five-star replacement index cows outperformed the one-star rating cows. For example, five-star cows calved for the first time on average 66 days earlier than one star cows. Cows with higher rating weaned heavier calves, produced more calves in their lifetime, and had lower levels of calving difficulty and calf mortality. Five star cows also had shorter calving interval (371 days compared to 378 days for one star cows) (O'Kiely and Ferguson, 2015).

Table 3. ICBF beef calving statistics 2010-2019

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Calving interval	401	401	390	389	406	400	392	394	396	401
% Calves dead at birth	1.1	1.2	1.3	1.0	0.9	1.1	1.3	1.1	1.2	1.0
% Calves dead at 28 days	2.4	2.3	2.7	2.8	2.2	2.6	3.1	2.6	3.1	2.3
Calves per cow per year	0.80	0.81	0.86	0.85	0.80	0.84	0.85	0.87	0.85	0.85
% Of heifers calved at 22-26 months	27	15	19	21	17	18	21	25	23	22
Spring 6 week calving rate (%)							55	52	53	52
Autumn 6 week calving rate (%)								55	56	60
Cows not calved in period (%)	12.7	11.8	7.3	9.2	11.1	8.2	8.2	8.5	9.1	9
% Cows culled in period					17.9	16.1	15.8	16.5	19.2	18
% Recycled cows					24	20	17	18	19	20
Average no. Of calvings per cows	4.4	4.5	4.5	4.4	4.4	4.5	4.5	4.5	4.4	4.5
Births with known sire (%)	84	84	81	75	77	77	82	82	86	86
Births with calving survey data (%)	88	87	85	77	81	81	86	86	86	86
Births with difficult calving (%)	3.4	3.6	3.7	3.1	2.7	3.1	2.8	2.5	2.6	2.4
Ai sired calves (%)					24	14	15	16	16	16

In order for the cow to become pregnant, she needs to be either naturally mated or serviced with artificial insemination (AI). If using AI, the farmer needs to have adequate heat detection methods in order to breed the animal. There are a number of limitations for beef farmers relating to the breeding of stock. The lack of ovulation of dominant follicles during the postpartum period is associated with infrequent LH pulses, with both maternal-offspring bonding and low BCS at calving being implicated as the predominant causes of delayed resumption of cyclicity in nursed beef cows (Crowe *et al*., 2018).

Producers need to assess whether they will choose natural mating methods, or will they choose AI. Since the goal of the breeding season is to achieve around 80% of cows calving within approximately six weeks, the farmer has to prepare according to how he will approach the reproduction. If using a bull, he needs to be fertility tested or if bought into the herd, needs to be purchased at least two months before breeding season. The cows have to be checked according to the am.- pm. rule to maximise heat detection rates. Chances of detecting oestrus is increased by the use of technological aids such as tail paint, oestrus synchronisation programmes, mount detectors, and pedometers (Diskin and Sreenan, 2000). In 2016, Diskin analysed the activity of cows in heat when housed on slats or out-wintering pads (OWP) compared to pasture (**Table 4**). If the cows are housed on slats, the number of standing heats and the duration of heats are greatly reduced. If there is only one female in the group showing signs of heat, there is a substantial difference between the number of mounts received: as low as 7 when on slats compared to 27 when showing heat out on pasture (Diskin, 2016).

Table 4. AI and Heat detection in beef herds

Underfoot surface	**Number of heats**	**Average duration of standing heat (hours)**	**Number of mounts**	
			Mean	Range
Slats	18	5.6	7.62	3-29
OWP	48	7.8	18.2	3-139

Failure to detect heat in cows is primarily a management problem. Only about 10% of missed detections is due to physiological problems related to the cows such as delayed uterine involution due to metritis and endometritis (Parr *et al.,* 2015).

Animal and Bioscience Research Department, Teagasc, Animal & Grassland Research and. There is a delay in return to cyclicity in cows with a delayed uterine involution due to hyperketonaemia and lipomobilization (Paiano *et al.*, 2019). Collection of breeding data by the farmer is not commonplace. Ideally, they need to be checked more than the recommended twice a day, every 4-5 hours after the morning check. This is why farmers should look at additional heat detection methods. Vasectomised bulls with a chin ball harness are becoming more popular in Ireland, steers and scratch cards are also used (Diskin, 2016b). Beef cows also have an added problem of their calf still at foot: a strong maternal bond develops to the calf, which delays the resumption of cyclicity. It is very important to manage the weaning period carefully, as the proper management can shorten the return to regular cycling and therefore can reduce calving intervals. Methods such as isolation and cow-calf separation are commonly used and are proven to a surge of LH pulse frequency when carried out at 30 days postpartum (Stagg *et al.*, 1998). Ideally the calves should be separated with no tactile contact. Studies comparing the different methods of calf isolation to induce first postpartum ovulation, the restriction and isolation method had the quickest effect, where calves were completely isolated from their mothers, and we allowed only once a day contact for suckling and then separated into different buildings, at least 60 meters away from their own calves and other mothers and their calves (Stagg *et al.*, 1998). Stagg *et al.* (1998) also showed that in beef cows restricted to once-daily suckling for 20–30 minutes, complete calf isolation shortens the interval to first postpartum ovulation. This confirms previous data (Silveira *et al.*, 1993) indicating that breaking the maternal-calf bond shortens this interval compared with the interval associated with ad libitum calf access/suckling.

2.4.1 The role of the ICBF

The role of the ICBF is to improve return for farmers through improvement in genetics. This improvement can impact the breeder, producer, processor, distributor, retailer and all individuals and organisations. Each party that receives a greater increase in income compared to increase in costs , as a result of utilizing hybrid vigour and data collection is seen as net beneficiary (Wickham, 2012). Cromie and Wickham (2020) performed an outlook in 2010 calculating expected increases in Suckler Beef Value (SBV) for the following 10 years.

Already between 2009 and 2010, an increase of €55 to €64 in SBV was found for commercial females. In **Table 5**, the predicted versus the actual performance show the value of upgrading one-star cows to four- and five-star cows. The difference in profit factoring in the improvements from both the sire and the dam, could be as much as €168/progeny.

Table 5. Comparison of progeny performance for AI Sires

Traits	1 Star	2 Star	3 Star	4 Star	5 Star	Difference
€uro-Star Indexes SBV (€)	30.9	65.1	77.4	87.4	115.1	84.2
PREDICTED PERFORMANCE-GENETICS						
Calving difficulty %	6.5	6.7	6.2	6.3	6.2	-0.3
Gestation Length Days	1.6	1.6	1.8	1.8	1.6	0.0
Mortality %	0.6	0.6	0.6	0.6	0.6	-0.1
Age at 1st Calving Days	2.7	-2.5	-1.3	-2.0	-5.7	-8.4
Calving Difficulty %-Maternal	7.6	7.4	7.4	7.2	7.2	-0.4
ACTUAL PERFORMANCE-PHENOTYPES						
Calving Interval Days	-1.5	-1.6	-1.7	-1.8	-2.0	-0.5
Calving Difficulty %	8.9	7.5	6.2	6.1	5.9	-3.1
Gestation Length Days	286.5	287.4	287.1	287.7	287.5	1.0
Mortality %	2.0	1.8	2.7	1.7	2.1	0.1
Age at 1st Calving Days	907.1	909.0	919.2	918.0	920.4	13.3
Calving Difficulty %-Maternal	8.8	6.9	7.8	6.5	8.0	-0.8
Calving Interval Days	394.5	398.3	403.2	395.1	397.5	3.0

3 OBJECTIVES

There is little data on beef enterprises in SPA relating to reproductive parameters. The topic of this thesis is to study the reproductive performance of beef herds in an Irish Special Protection Area. One of the farms analysed belongs to the thesis author, it will be used as a comparison to the ICBF herds in the locality. We would hope to see how well the farm performed in terms of certain reproductive parameters and what could be improved.

The beef sector in Ireland has one of the lowest incomes in agriculture, therefore by studying these parameters, we may be able to determine what could be adjusted and improved to increase profit.

We want to see the comparison between herd E and the rest of the farms in terms of reproductive efficiency. The most important reproductive parameters will be assessed; calving interval, age at first calving, average age calving, calves per cow per year and calving season length. By studying how herd E competes against the others, we could then make suggestions and advise on how to improve the herd profile.

This study can highlight the link between these parameters, and how certain parameters can influence others. The aim was to see how calving interval, calving season statistics and calves per cow per year were connected.

There was only 22 farm profiles in this study, therefore it will not be an accurate representation of the entire Irish beef herd, however it should help underline the strengths and weaknesses that suckler farms in SPA encounter.

4 MATERIALS AND METHODS

Herd level reproductive parameters were collected from the ICBF database for 21 herds in the south-west County Kerry SPA (Special Protection Area), Ireland.

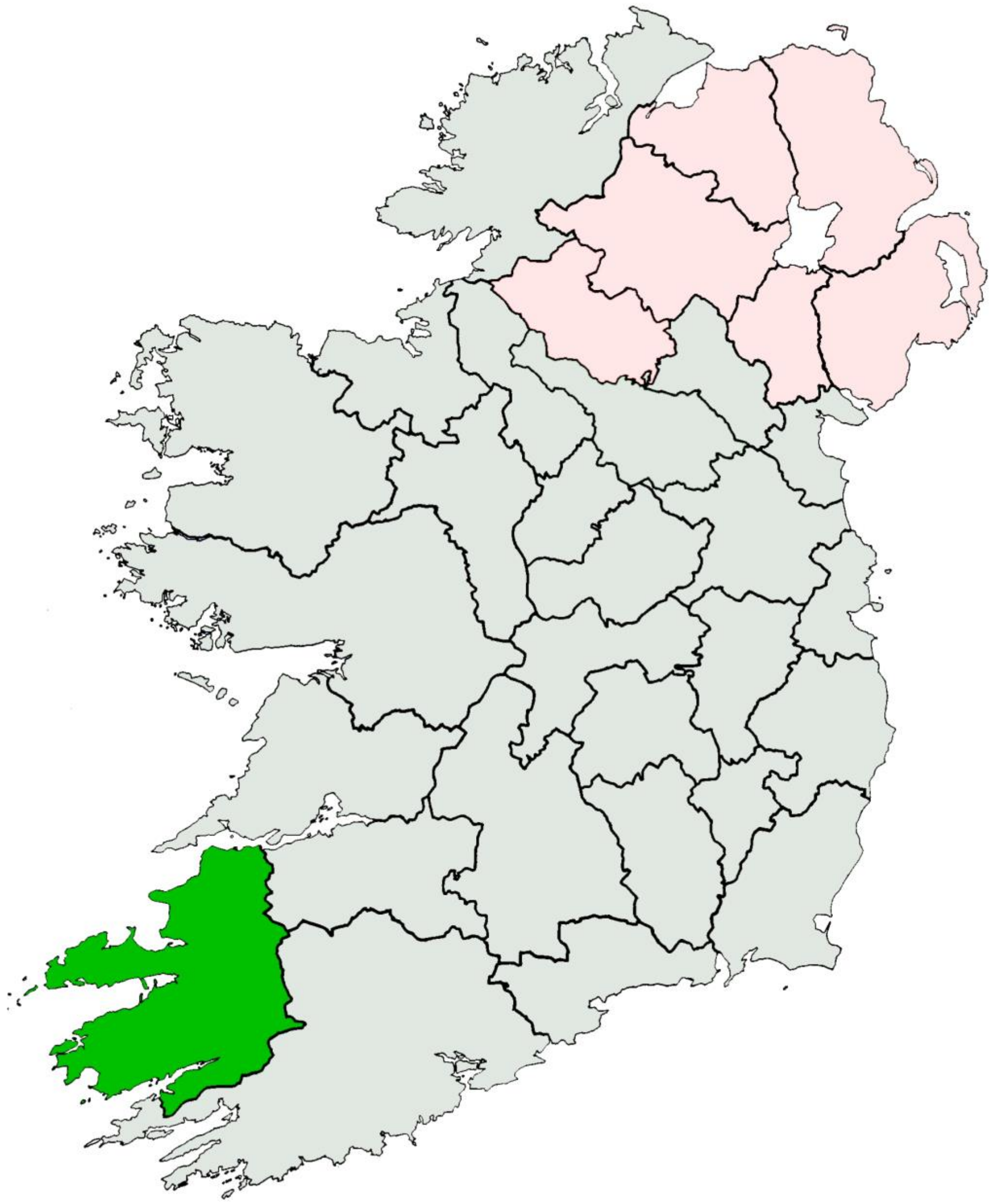


Figure 1. Map of Ireland with County Kerry highlighted in green

Special Protection Areas (SPA) are designated areas of conservation designed to protect natural habitats, flora and fauna. SPAs focus on the protection of areas which bird species traditionally use as nesting, breeding or over-wintering sites.

The herds in question are in the Special Protection Area for the Hen Harrier. The farmland is dominated by peatland and wet grassland. There are six SPA in Ireland for the Hen Harrier.

There is no intensive farming on these grasslands, they are low intensity, high nature value farms, which is ideal for the protection and conservation of the Hen Harrier nesting sites and territory. Funds are provided from the European innovation partnership initiative to compensate farmers for not farming intensively and removing nest sites.

The mean number of eligible females (All females (cows and heifers) that calved, in the herd in the period from 01 July 2019 until 30 June 2020 and all females that calved, at any time, before 01 July 2019, did not calve in the report period and are still in the herd on 01 July 2020) is 19.3 with standard deviation of 12.2. The smallest and largest herd had 3 and 56 eligible females, respectively. The collected data covered the period 01 July 2019 to 30 June 2020. The following parameters were investigated;

1. Beginning of the calving season;
2. End of calving season;
3. Length of calving season;
4. Number of eligible females;
5. Average age of calving (months);
6. Average age of heifer at time of calving;
7. Number of female calves;
8. Total heifer births- Number of heifers that calved in the herd as a proportion of the entire herd;
9. Calving interval (days)-average number of days between successive calvings for cows;
10. % calved/eligible females- Number of calvings compared to total number of eligible females;
11. Rate of mortality at birth- Number of calves born dead as a proportion of all births during the period;
12. Rate of mortality at 28 days- Number of calves born dead or dead within 28 days, as a proportion of all births recorded during the period;
13. Number of calves per cow per year- Number of calves per cow per year, expressed as a proportion of all eligible females in the herd. (365/Calving interval in days)x(No. of calves alive at 28 days/No. of eligible females);
14. Percentage of heifers calved at 22-26 months of age- The number of heifers calves in the period that were between 22 and 26 months of age;

15. Autumn 6-week calving rate- Number of cows calved within the first 6 weeks as a proportion of all cows calved during the Autumn;

16. Spring 6-week calving rate- Number of cows calved within the first 6 weeks, as a proportion of all cows calved during the Spring;

17. Cows not calved in period (%)- Number of cows not calved during the analysed period expressed as a proportion of all eligible females;

18. Cows culled in the period- Number of cows culled (sold or died) during the period as a proportion of eligible cows;

19. Recycled cows in the period- Percentage of cows that slipped from one calving season to the next (e.g. autumn to spring period) as a proportion of eligible cows;

20. Rate of births with known sire- Number of births with a known sire (valid in database), expressed as a proportion of all calf births recorded during the period;

21. Births with difficult calving- Number of calving's scored 3 "serious difficulty" of 4 "veterinary assistance" as a proportion of all calf births;

22. Rate of AI sired calves- Number of calves sired by beef AI bulls as a proportion of all calves born in the period.

The data from these farms were compared to a non-ICBF member herd, belonging to the thesis author. This herd will be referred to as Herd "E". Data such as birth dates, sex, and progeny were collected using information from the Department of Agriculture and the Marine database. Information regarding sires was collected from Munster AI database. Data on calving surveys and difficulty were gathered from the farm records. The herd level reproductive parameters were also calculated for this farm as a comparison. The performance of this herd was compared to those of others by graphical methods: in each plot the herds were ordered from the highest to the poorest performance regarding each parameter, and herd E is highlighted with different colour.

Based on the available data, associations between several pairs of variables were tested. Only a subset of all possible statistical comparisons between parameters was performed, in order to provide meaningful conclusions. In these comparisons, emphasis was put on herd size, age at first calving, calving interval, and the number of calves per year. Pairwise correlation between the analysed parameters was tested using Spearman's rank correlation. Statistical analysis was performed in R version 4.0.2. (R Core Team, 2020). Spearman's rank correlation coefficient ranges from -1 to +1, indicating perfect negative and positive relationship, respectively. If the coefficient is 0, then the two parameters are uncorrelated.

The following thresholds for the absolute value of the coefficient were used to evaluate the strength of the relationship:

0 - 0.299: weak;

0.3 - 0.499: moderate;

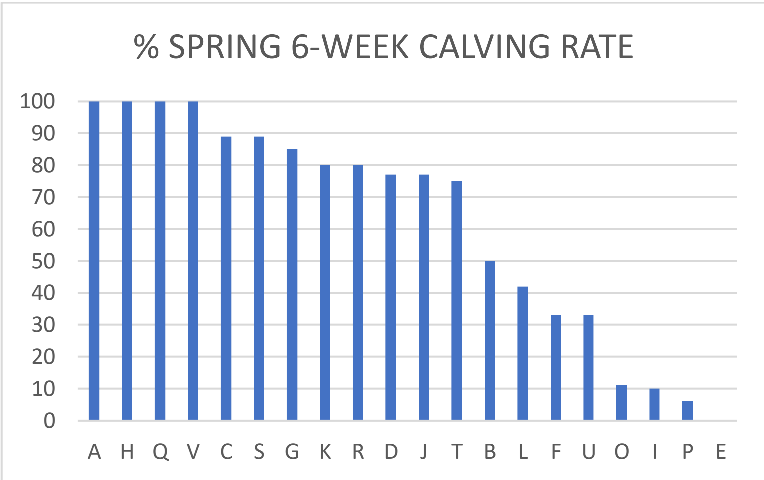
0.5 - 1: strong.

5 RESULTS AND DISCUSSION

5.1 Parameters relating to the calving season

5.1.1 Spring and autumn 6-week calving rate

The mean (±SD) spring calving rate was 61.9±35.2% with a median rate of 77%. A strong negative correlation was found between herd size and Spring 6-week calving period (rho=-0.530, p-value=0.016). The mean autumn 6-week calving rate was 63.7±31.9 with a median rate of 65.5% (**Figure 2**).



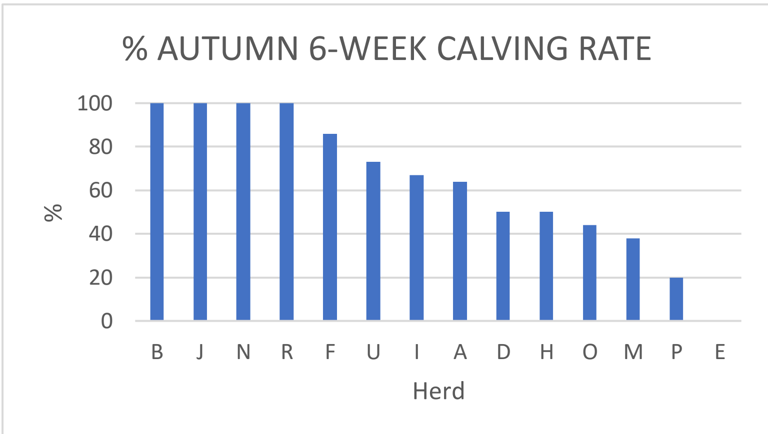


Figure 2. Six-week calving rates in Spring and Autumn

Herd E had the poorest performance in the 6-week spring and autumn calving rates. This may be a result of poor management during heat detection and mistimed artificial insemination. The aim of the 6-week calving period is to have 80% of cows calved. Herd E had a very long calving period of 25 weeks and 6 days. It had the longest calving period in the study **(Figure 3)**.

A cow calving earlier in the calving season are more likely to go back in calf. They have more time to recover from calving, are likely to be in positive energy balance and have started cycling again before the breeding season begins (Ramsbottom, 2016).

In order to detect oestrus, the cows must be observed two to three times a day, this is labour intensive, especially difficult when there is only one stockperson on site. Missed heats can result in the cow slipping from one calving period to the next and therefore, widening the calving rate. The use of a vasectomised bull with a chin-ball for Herd E could improve detection rates and shorten calving interval and period.

This is in agreement with previous findings where the failure of detection is mainly due to management problems, too little time spent observing cows and failing to recognise the signs of heat (Diskin and Kenny, 2016). In Herd E, the calf is not separated until they are housed for winter. This could relate to the absence of heat signs. Ideally, the calf should be separated from the mother at 3-4 weeks of age and let feed morning and evening. The cow should be at 50-60 meters away from the calf, the cow should come into heat within 10 days (Stagg *et al.*, 1998; Diskin, 2016a).

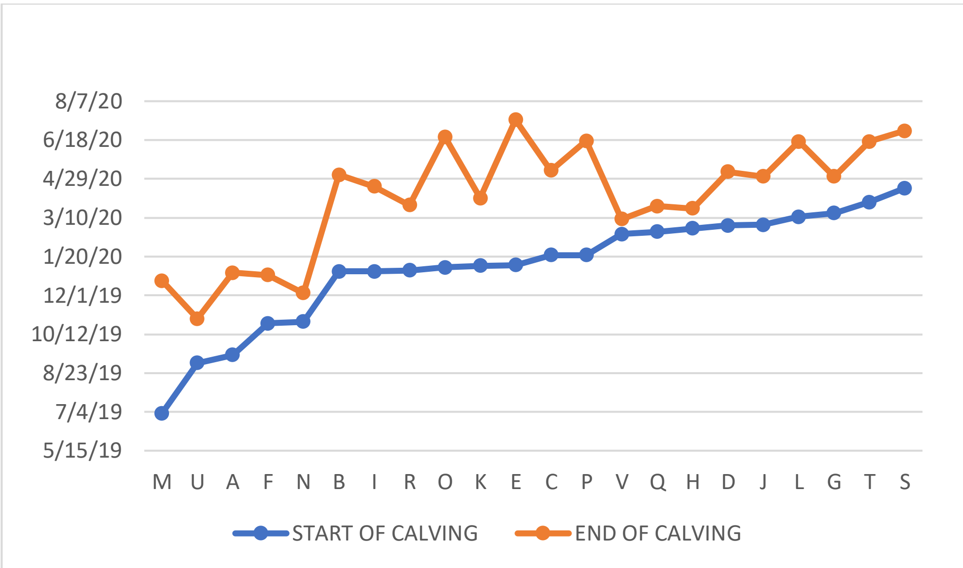


Figure 3. Comparison of calving periods on all herds

5.2 Parameters of heifer reproduction

The mean age at first calving was 31.2±4.8 months (**Figure 4**). We found a weak positive relationship between herd size and age at first calving (rho=0.131, p-value=0.6292). There is a strong positive correlation between age at first calving and calving interval (rho=0.597, p-value=0.015). A moderate negative correlation between age at first calving and calves per cow per year was seen (rho=-0.499, p-value=0.049).

The age at first calving varied from 24 months in Herd C, to 39 months in Herd U. Herd E, highlighted, had the fifth highest rating for heifer age at 28 months.

Herd E should continue to select a number of high-quality heifers to calve at 2 years old. This will mean there will be more output from the heifer over her lifetime. It will also result in quicker genetic improvement (Teagasc, 2020). The significance of this result also highlights the lack of replacement heifers in beef herds nationally. Herd E should consider replacing stock with repeatedly long calving intervals.

This is in agreement with previous research, by removing the worst 5-10% of the herd, it can drastically improve the reproductive statistics of the herd. Herd E should also aim to have replacement heifers calving at 2 years of age and use synchronisation programmes if necessary (Patton, 2012).

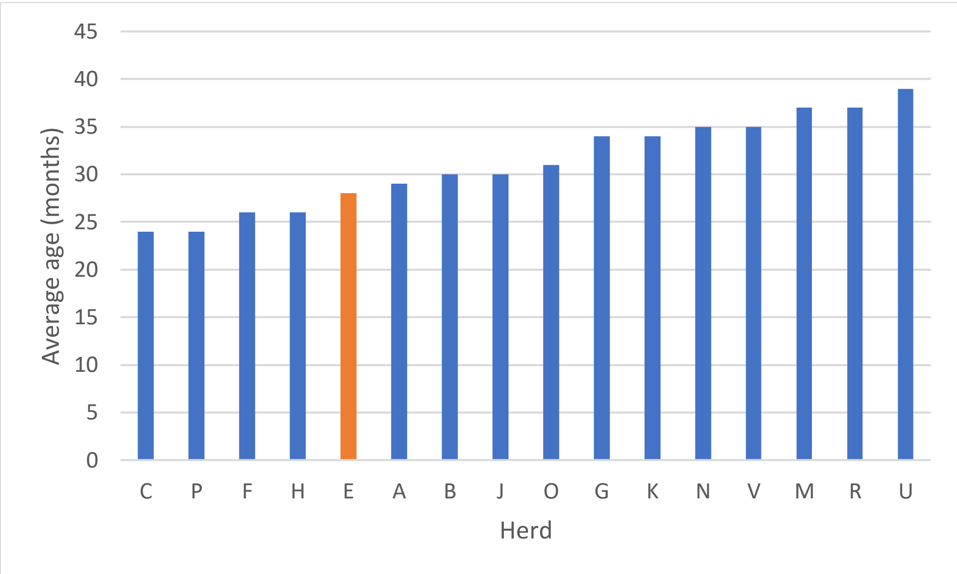


Figure 4. Average age at first calving in the studied herds

Herd E had 63% of heifers calving within 22-26 months old compared to the national average of 23%. Six of the herds analysed did not have heifers in the herd **(Figure 5)**. Herd N had a 100% rate, further analysis of herd N could provide a deeper insight into their breeding approach.

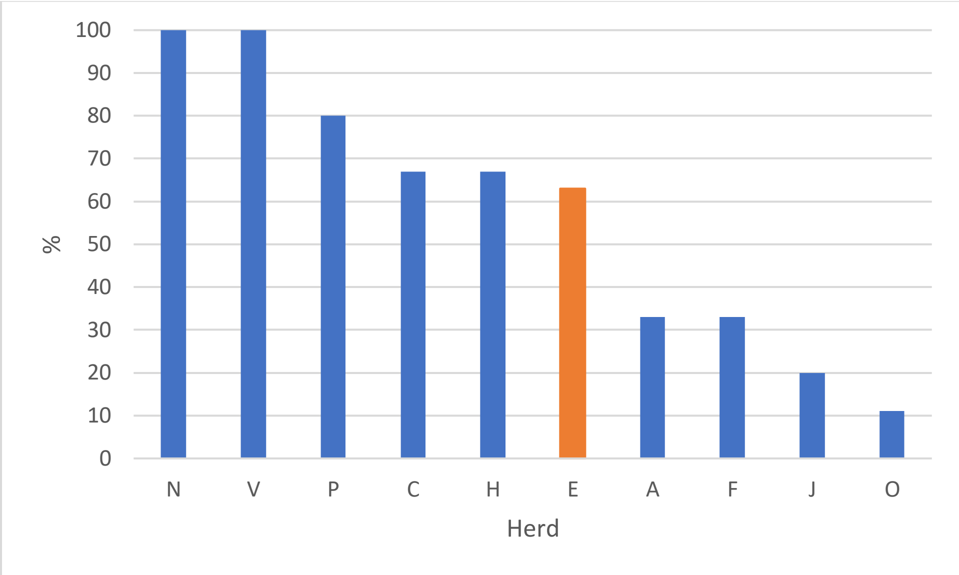


Figure 5. Percentage of heifers calved within 22-26 months of age

5.3 Parameters of cows

5.3.1 Calving interval

The mean calving interval was 412.5±80.8 days with a median of 378.5. There was a weak negative correlation between the herd size and calving interval (rho=-0.110, p-value=0.6253). This suggests that as the herd size increased, the calving interval decreases slightly. Larger herds tend to have a better standard of management, also larger herds need to have a short calving period, or they would not be able to utilise grazing efficiently (Ramsbottom, 2016).

Herd E had an average 360 day calving interval (**Figure 6)**, compared to the national average of 401 days. In herd E cows are moved into maternity paddocks to give birth and do not return into the slatted unit, this may have a favourable effect on standing heat.

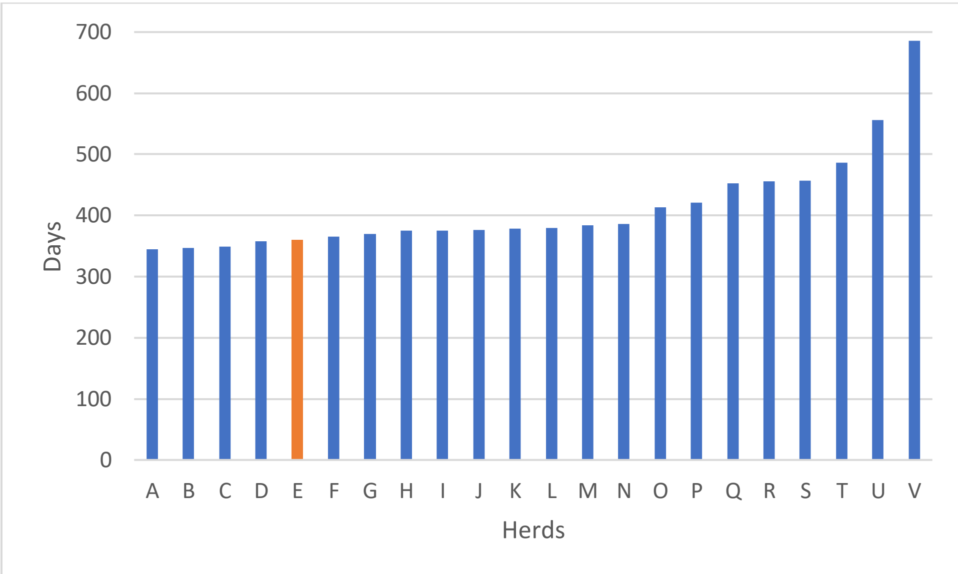


Figure 6. Calving interval in order of increasing days

5.3.2 Age at calving

The mean age at calving is 65.3±16.8 months with a median age of 65.5 months. We found a moderate positive correlation between the herd size and the age at calving (rho=0.355, p-value = 0.1054). Herd E has an average age of 60 months **(Figure 7)**, the oldest cow in the herd at calving was 13 years and 2 months old and the youngest was 1 year and 9 months. The herd needs to be assessed for potential culling and replacement options. There is a weak negative correlation between age at calving and calves per cow per year (rho=-0.179, p-value=0.4267).

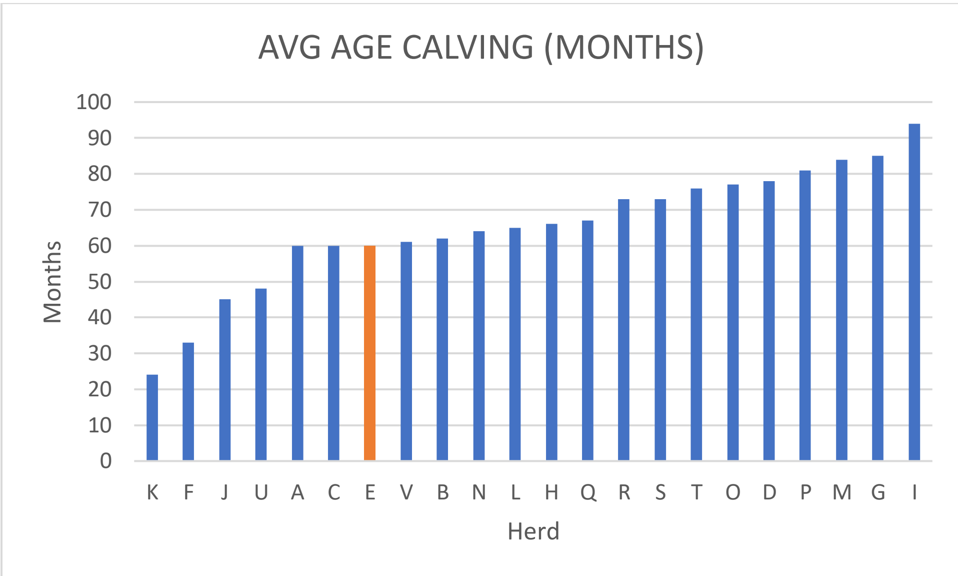


Figure 7. Average age at calving in the surveyed herds

5.3.3 Calves per cow per year

The mean number of calves per cow per year is 0.8±0.2 and a median of 0.84. We found a weak negative correlation between the herd size and number of calves per cow per year (rho=-0.014, p-value=0.9512). Herd E performed poorly in this comparison. In 2019, herd E had 0.67 calves per cow per year **(Figure 8)**, 21 out of 32 eligible females' calves. The national average is 0.85 calves per cow per year but the aim for beef herds is 0.95. The cost of keeping a suckler cow each year can reach €800 depending on the type of land and whether the calving season is in spring or autumn (Woods, 2003). If the cow does not manage to wean a calf each year, she is not earning her keep. Herd E had 11 empty females in 2019. This means that herd E lost out on the value of a possible 11 extra weanlings. This needs to be addressed by culling cows with extended dry periods and repeated AI serves. There is a strong negative relationship between calving interval and calves per cow per year (rho=-0.669, p-value=0.0007). A longer calving interval would result in less calves per year, this is one of the main objectives of breeding beef herds. It is essential that the cow produces a calf every year, or else the cost of keeping the cow will not be balanced by the revenue from her calf.

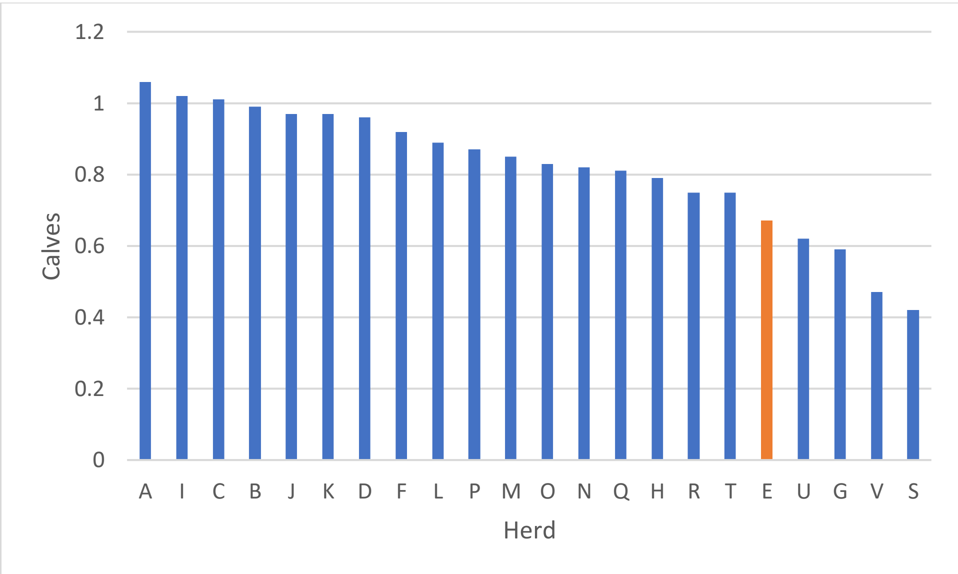


Figure 8. Calves per cow per year

5.3.4 Percentage calved/eligible females

The mean number of eligible females **(Figure 9)** (All females that calved, in the herd in the period from 01 July 2019 until 30 June 2020 and all females that calved, at any time, before 01 July 2019, did not calve in the report period and are still in the herd on 01 July 2020) is 19.3±12.2 females with a median of 16.5.. The mean rate was 90.8±13.2% with a median rate of 94%. There was a weak negative relationship between age at first calving and the rate of eligible cows that calved (rho=-0.268, p-value=0.316). This is in agreement with previous authors that the later that puberty begins in heifers the longer is their post calving anestrous period as beef cows therefore reducing the yearly birth rate (Diskin, 2016a). Herd E performed poorly in this parameter.).

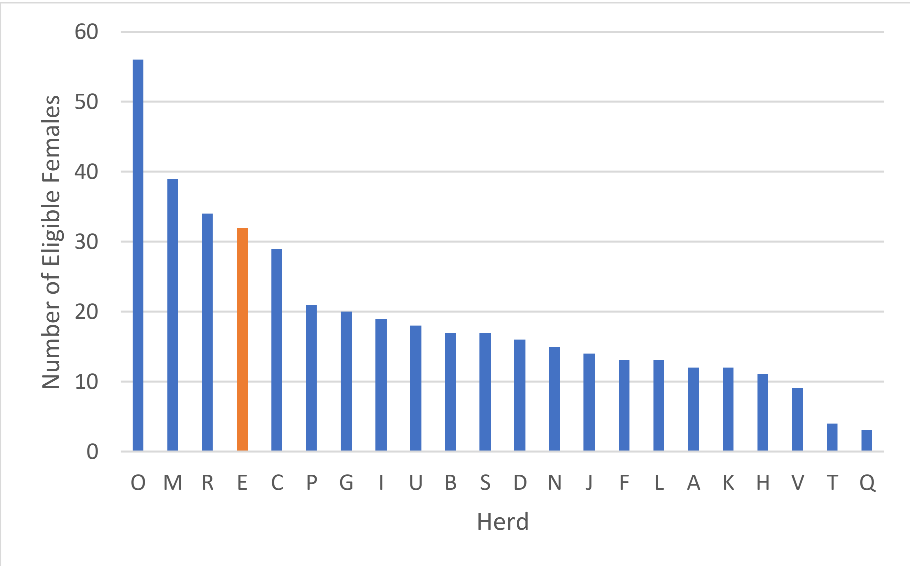


Figure 9. Number of eligible females

Only 66% of eligible females calved in 2020 **(Figure 10)**. The calving interval also had a weak negative correlation with percentage calved/eligible females (rho=-0.251, p-value=0.2607).

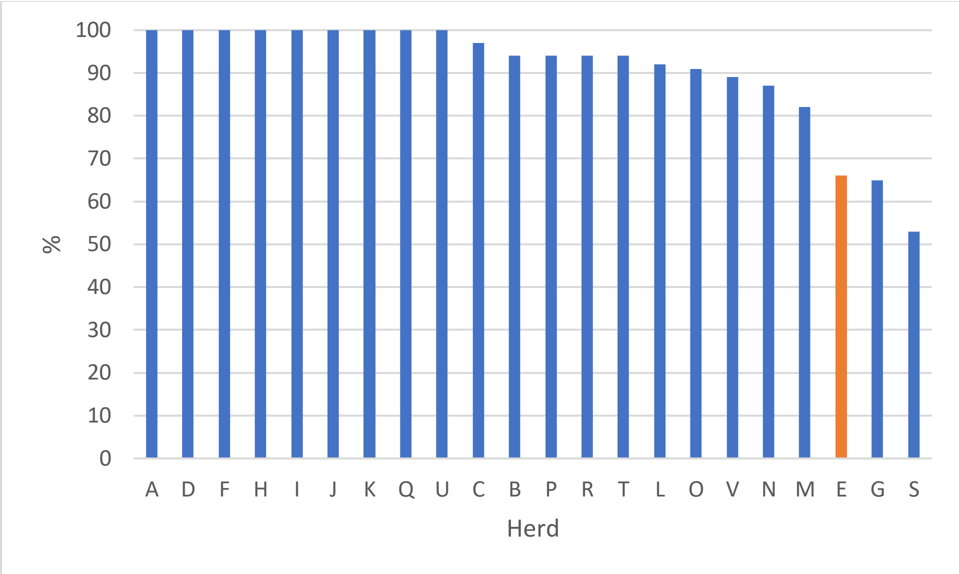


Figure 10. Percentage of cows calved from eligible females

Cows not calved in the period

The mean rate was 8.4±11.9% with a median of 6%. Herd E had a rate of 12.5%, this coincides with the poor calving period profile. This was due to repeated heats and recycled cows. Recycled cows rate had a mean of 23.9±27.5% and a median of 15.5%. Herd E had a recycled cow rate of 15%, 5 cows in the herd did not calve in Spring (**Figure 11**).

Increasing empty culling rate to reduce calving interval is expensive, it may not be sustainable, and in any case will not in isolation solve a herd fertility problem (Patton, 2012).

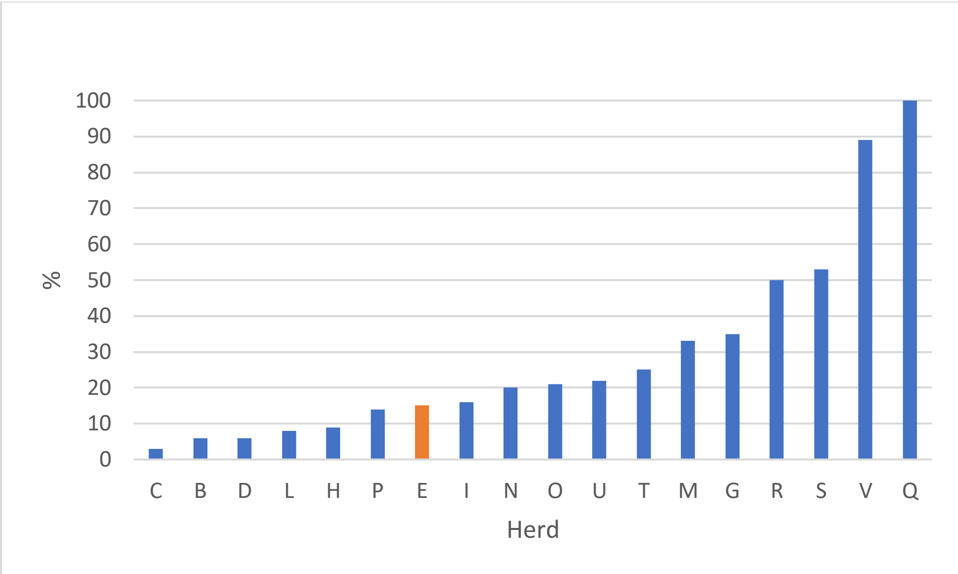


Figure 11. Recycled cows

Rate of AI sired calves

There was a mean rate of 50.6%±38.9% and a median of 53%. Herd E performed poorly, with only 33% of calves with an AI sire (**Figure 12)**. This is due to the failure to use additional heat detection methods such as a vasectomised bull or scratch cards. It is especially difficult to have a high conception rate when the only method of heat detection used was inspecting them once or twice a day. Good breeding records are an integral part of breeding management and are always the first port of call in the investigation of a herd infertility problem (O'Kiely and Ferguson, 2015). Previous AI serves should be referred to when servicing a cow and looking at her calving statistics and calf profile.

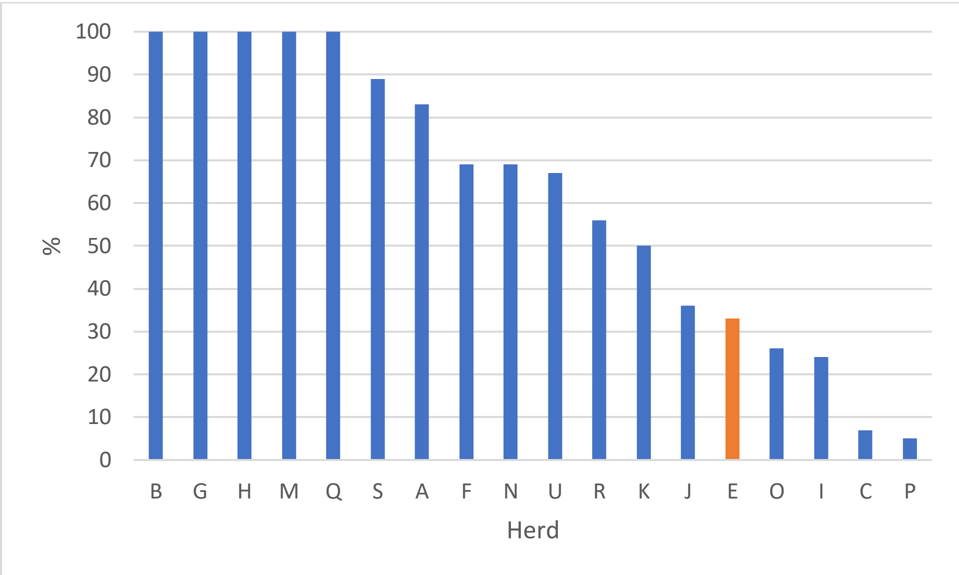


Figure 12. Rate of AI sired calves

5.4 Difficult calving and calf mortality

There was a very weak negative correlation between the herd size and mortality rates at 28 days of age (rho=-0.054, p-value=0.8104). Only five herds had a mortality rate, suggesting there is little correlation between herd size and mortality rate at 28 days of age. Although cause of mortality is unknown, death due to dystocia and difficult calvings can be a prominent cause. The leading infectious causes of calf mortality before 28 days of age is calf pneumonia and pneumonia-enteritis complex. If calves are born indoors, it is very important to disinfect the umbilicus, herd E uses an iodine solution to help prevent infections via the umbilicus (O'Shaughnessy *et al.*, 2013). Special attention needs to be paid to biosecurity on the farm, especially around calving season. Proper management of body condition score (BCS) during pregnancy can reduce risk at birth. Choosing a suitable sire with a low calving difficulty can also have an effect. Herd E had no deaths of calves at day 28. Before insemination, the AI technician would score the cow according to age, size and previous services. This practice should continue, in the next breeding season, herd E should use four- and five-star bulls to increase suckler beef value.

6 CONCLUSION

In the study of the 22 herds in the local SPA, the main differences were seen as follows;
Herd size varied from 3 to 56 eligible females. This has an immediate effect on productivity but also highlights differences in farm size and infrastructure availability.
Calving interval varies from 343 to 686 days. This highlighted the management or mismanagement of reproduction in the different herds. Even though there was no data in relation to heat detection methods, I would assume that the herds with a shorter calving interval, used extra detection methods.
Calves per cow per year, herd E, belonging to the author, did not perform well in this aspect. For every cow, only 0.67 calves were produced, this has a significant effect on productivity and in turn, income. The aim for beef farms is 0.95 calves per cow per year.
The sooner heifers calve to the 22-26 months of age, the better it is for productivity. However, there is reluctance among some farmers because they believe they were not mature enough, and if they produce a calf at 2 years of age, they would not have a calf in their third year. This has been proven otherwise and it is encouraged to put them in calf around 15 months of age.
Action plan for herd E: the lack of extra heat detection methods is a cause of concern and explains the poor performance for calves per cow. Dry cows cost up to €700 a year to keep, and herd E had eleven empty females, this a huge expense regardless of the herd size. The long calving period of 25 weeks and 6 days is mirrored in this result. Missed heats and repeated AI serves should be addressed.
Farmers need to realise in order to make a profit, quality genetics are key. The herd does not need to replace the entire breeding herd with four- and five-star cows and sires. They could serve the highest quality cows in the herd with high performing sires. The heifers that result from this can replace the lower quality females, and over a number of breeding seasons, the breeding profile can be improved.

7 SUMMARY

Ireland performs below the average standards of beef reproduction in the European Union failing to reach key reproductive targets consistent with the sustainable and profitable methods of beef production. Reproductive efficiency is the key to profit on beef enterprises and without the product of a calf from every eligible female, the producer is losing income and can increase costs by keeping the dry cow. In this study, 21 ICBF member herds from Special Protection Areas (SPA) in the South West of Ireland, in County Kerry were analysed, focusing on reproductive parameters over the period of 12 months. The main reproductive parameters were tested, calving interval, age at first calving, average age of calving, calving difficulty, and calving periods amongst others. These farms were then compared with a non ICBF member SPA herd (Herd E), belonging to the author of this thesis. This comparison was performed to highlight reproductive strengths and weaknesses of rural beef herds in specific protection areas. There was a strong negative correlation between herd size and 6-week spring calving rates (rho=-0.530, p-value=0.0161), however in Herd E, it was the worst performer in both Spring and Autumn calving periods when compared to the other herds by graphical methods. Despite having the fourth highest number of eligible females in the study, Herd E only calved 66% of their eligible females. Non ICBF herd E had significant differences in terms of calving period and productivity. Herd E had the longest calving period of 25 weeks and 6 days, this has a drastic impact on productivity. The ICBF herds outperformed Herd E in the management of breeding season. By keeping a structured calving period, together with calving surveys, can be a vital aid in improving reproductive parameters year-on-year. Although the non ICBF herd performed well in terms of calving interval rate and age a first calving, Herd E performed poorly in terms of productivity; calves per cows per year. This emphasises difficulties that certain beef producers encounter, especially in specific protection areas and disadvantaged areas, need to focus their approach to productivity, beginning with reproductive efficiency. This Kerry special protection area is a unique high value natural farmland, there are many small herds that face similar challenges in relation to reproductive statistics. There needs to be a plan of action, by defining a calving period and setting down clear objectives in regards to calving interval and heat detection. Working towards these targets will take a number of years, it is important not to expect a complete transformation of the herd profile in a year.

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- *present the knowledge base of the University of Veterinary Medicine Budapest and its partners in a focussed way in order to improve the prestige of the Hungarian veterinary profession, and the competitiveness of the organizations in question;*
- *facilitate professional relations and collaboration;*
- *support open access.*

Supervisor counter-signature form

We hereby confirm that we are familiar with the content of the thesis entitled *Reproductive performance of beef herds in an Irish Special Protection Area* written by Bríd Lenihan, which we deem suitable for submission and defence.

Budapest, 16 November 2020

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dr. István Fodor

Ceva-Phylaxia Co. Ltd.

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dr. Dorottya Ivanyos

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