The EnviroCow index and its impact on the UK dairy industry's carbon footprint

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Abstract

Since 2021, the UK has published the EnviroCow index, derived from genetic evaluations for production traits, calf survival, cow longevity, fertility, and Feed Advantage. The goal of the index is to reduce carbon emissions per kg of product produced, and importantly reflect the lifetime environmental efficiency by incorporating survival traits. The index uses carbon emission equivalents, estimated for the traits in the index based on their feed requirements for a unit change of the trait. Feed intake in turn has been shown to affect enteric methane production. A recent analysis of lifetime efficiency was conducted on approximately 475K females by comparing their EnviroCow genetic index to their phenotypic performance for milk, fat and protein over their lifetimes, age at first calving, number of lactations, mature weight (derived from proxies as liveweight itself is not routinely recorded) and stature (where available). The data showed that each point increase in EnviroCow, on average gave animals that produced 10% less methane per kg milk, through enteric emissions, consumed 10% less feed, while producing 33% higher weight of fat and protein in their lifetime. Genetic trend data estimates that the carbon footprint per kg milk in the UK is predicted to reduce by around 1% each year due to genetic gains achieved in the population.

Key words: DMI, GHG emissions, genetic index, EnviroCow

Introduction

Recent global political events and concomitant increases in energy costs have pulled efficiency of dairy production into very sharp focus, accelerating further a previously increasing trend of increased efficiency through dilution of maintenance and improved health and longevity. Rising global temperatures and a focus on mitigation strategies has drawn attention to greenhouse gas (GHG) emissions from farmed ruminants. This has rapidly led to a shift in priorities in dairy farming towards reduced environmental impact whilst maintaining profitability, a strategy that could be described as creating sustainability. This shift is not driven by dairy farmers but by retailers, government and societal pressures. Whilst dairy farmers are not currently rewarded for reduced GHG emissions, the general expectation is that either social pressure, retailer intervention or government legislation will demand a reduction in GHG emissions and will require a tool do that and to monitor resultant changes.

Selection for reduced methane emissions has been proposed for some time (e.g. Jones et al. 2008, Wall et al, 2010) and reviewed by Pickering et al (2015), de Haas et al (2021) who describe how genetic selection can contribute to a reduction of methane emissions through appropriate phenotype collection and genotyping. Direct selection requires large numbers of methane measurements on 25,000 genotyped cattle from over 100 farms for at least 2 years (de Haas et al, 2021).

Most industrialised dairying nations have a range of genetically evaluated traits and most combine a subset of the economically most important of these traits into an overall index either as an economic index, a desired gains index or a combination of both (Miglior et al, 2005). In the UK this index is called Profitable Lifetime Index (£PLI) expressed in monetary units as £PLI. It incorporates many traits, broadly covering production traits, survival (calf, cow), fertility, udder health, leg health, calving ability, maintenance, and feed efficiency, all weighted by their economic value per unit change in that trait. Available bull lists are ranked on this index with individual traits printed alongside allowing users to select bulls that have specifically good values for traits they are interested in out of the top bulls ranked for overall economic merit.

Wall et al. (2010) showed that selection using existing traits will reduce GHG emissions indirectly through improvements in these traits but they also pointed out that selection is also useful in breeding animals that are resilient to the inevitable changes that will occur to weather patterns such that GHG emissions from cattle are reduced and not subsequently increased by environmental changes.

To create a tool that farmers could use to explicitly reduce their GHG emissions intensity and to have a strategy that is welcomed by retailers, milk buyers and society, a new index was developed and derived from the existing £PLI that could serve most interest groups purposes, including farmers. This does not rely on direct measures of methane but uses proxy traits to demonstrate the predicted contribution of each trait to methane emissions expressed as Carbon Dioxide equivalents (CO_2e). This work is aimed at providing an index that UK farmers can use to begin their journey to select for reduced methane emissions which capitalises on their historic recording activities and allows them to start selection now until direct measures of methane can be incorporated into the index in future.

Materials and Methods

Since August 2021 AHDB has published the EnviroCow genetic index to enable dairy animals to be selected for improved carbon emissions per kg product. The methodology for assigning relative carbon weights to traits was described by Amer et al. (2017) and Zhang et al. (2019) and is based on predicted feed intake requirements associated with individual trait changes. These feed intake requirements, which have shown to affect enteric methane production, can subsequently be converted to CO_2 equivalents using a simple conversion factor. Gross emissions are finally converted to methane intensity values by calculating the change in product for each unit change in the traits included in the index. Similar to Amer et al. (2017) the product was determined as £ value for each trait unit compared to the value of protein.

The Predicted Transmitting Abilities (PTA) for the following traits are included in the EnviroCow index; Milk (kg), Fat (kg), Protein (kg), Lifespan (days), Calf survival (%), Non-Return rate (%), Calving Interval (days), Body Condition Score (point), and Feed Advantage (kg Dry matter).

Feed Advantage is the UK's genetic index for improving feed efficiency and is based on a combination of maintenance feed cost based on cow size, combined with genomic predictions for feed efficiency. The evaluations were described in more detail by Li et al. (2021).

The EnviroCow index is published as a carbon intensity index and standardised to a standard deviation of 1.0.

For this analysis, genetic evaluations from the April 2023 release were available along with lifetime performance data. Performance recording data was available from the milk recording organisations providing data to the UK's dairy cattle genetic evaluations (National Milk Records (NMR), Cattle Information Services (CIS), DaleFarm and Quality Milk Management Services (QMMS). Linear type data were available for animals classified by Holstein UK.

The Holstein cows in the study had to have a death date recorded in order that their completed lifespan and lifetime yields can calculated. Therefore, cows born between 2008 and 2011 were used in the study. These years were chosen for being both the most representative of today's herd and having a recorded death date for the majority of the year cohort. Any remaining alive within this cohort – because of their long lifespans – are not included in the dataset, creating a likely small downward bias.

For each animal the following performance metrics were calculated; Age at first calving (months), total lifetime milk (kg), fat (kg), protein (kg), fat (%), protein (%), Number of calvings (lactation), age at death (days), daily lifetime yields ([kg fat + protein] / age at death (days)), Stature score (linear 1-9), estimated liveweight (kg).

Cows which had lifetime performance available were then matched up with their genetic index for EnviroCow from the official April 2023 release in order to compare their genetic index to their lifetime phenotypic performance.

For the given performance metrics, estimates for lifetime dry matter requirements were calculated, and these were used to determine CO2 equivalents (CO2e), based on the assumption that a linear relationship exists between methane emissions from enteric emissions and dry matter intake (DMI). The value of 583 grams of CO2e per kg of DMI was used, following Amer et al. (2017). The lifetime estimates for a cow in the study included both her rearing and productive life but excluded the impact of any offspring. Carbon dioxide intensity was estimated as the total CO2e divided by the total Fat and Protein corrected Milk. These were calculated as (Milk(kg) x [0.337 + 0.116 x fat% + 0.06 x protein%]).

To enable us to establish the impact of genetic selection over time, the genetic trends for Holstein females were calculated.

Results & Discussion

A total of 475,060 Holstein cows were included in the analysis, which had their completed lifetime performance available and had an EnviroCow index evaluated.

The results shown in table 1 groups cows by their genetic index for EnviroCow and then averages their recorded phenotypic performance for a range of traits. It also shows their projected CO2e intensity based on their expected enteric methane production. Note that enteric emissions represent around 46% of the total carbon footprint of a typical litre of milk in the UK, which therefore implies that the total carbon footprint estimated in this study is on average 534 grams / 0.46 = 1180 grams CO2e per litre. This total is close to those reported by Arla (1130 grams CO2) based on a more recently born group of cows (Arla, 2021).

The table shows clearly how well EnviroCow is working as the top 10% cows with the best [highest] score for EnviroCow estimated to produce the least methane for each kg of fat and protein corrected milk (FPCM). The reason they have a low environmental footprint per litre is because these higher EnviroCow index cows have, on average, higher lifetime yields of FPCM, a younger age at first calving (AFC), more lactations and longer lifespans, and so offer an excellent combination of traits required for efficient dairy production.

The fact that these cows were also of a smaller stature and lower predicted liveweight is expected, as the bigger animals would have a higher maintenance feed cost.

The bottom row in the table, showing cows with the worst 10% EnviroCow scores, is a stark demonstration of just how inefficient and polluting these are compared to the best genetics. This group has on average the tallest, heaviest cows with a late AFC and a shorter lifespan. These animals lasted just 2.57 lactations on average and are projected to produce 12% more methane than average per kg

Table 1. Relationship between EnviroCow (deviated from mean) and the lifetime performance of Age at first calving (AFC), total lifetime milk (kg), fat (%), protein (%), Number of calvings (lact.), age at death (AaD), daily lifetime yields (DLY), Stature score (ST)), estimated liveweight (LW), CO2e Intensity (CO2eI) and the deviations of Methane from the average (%). (Each row in the table represents the average of the decile group)

EnviroCow (PTA)	AFC (month)	Milk (kg)	Fat (%)	Prot (%)	Lact.	AaD (days)	DLY (kg/d)	**ST**	LW (kg)	CO2eI (gram)	Methane (%)
0.9	27.5	42 688	4.08	3.28	4.05	2 377	1.32	4.7	665	487	-9%
0.6	27.7	39 695	4.02	3.24	3.85	2 317	1.24	5.0	670	500	-6%
0.4	27.8	37 704	3.99	3.23	3.71	2 266	1.20	5.1	674	508	-5%
0.2	27.9	35 584	3.96	3.22	3.56	2 209	1.16	5.2	676	518	-3%
0.1	27.9	33 612	3.95	3.21	3.41	2 150	1.12	5.3	678	526	-2%
-0.1	28.0	31 583	3.93	3.20	3.25	2 090	1.08	5.4	680	536	0%
-0.2	28.1	30 046	3.92	3.19	3.12	2 040	1.05	5.4	682	544	2%
-0.4	28.1	28 255	3.89	3.18	3.00	1 988	1.01	5.5	685	555	4%
-0.6	28.2	26 148	3.87	3.17	2.83	1 920	0.96	5.7	688	569	7%
-1.0	28.3	22 742	3.83	3.15	2.57	1 817	0.87	5.9	694	599	12%

FPCM. Since animals which were still alive and cohorts of the analysed birth years were excluded from the data, it is highly likely that the positive links between EnviroCow and actual emissions which have been demonstrated here, are likely to be even stronger.

Genetic trends

The average yearly genetic gain for Holstein cows over the past 10 years (2012-2022) was 0.22 points EnviroCow index PTA. Over the last five years, this was slightly higher at 0.26 points. The UK dairy cattle population is achieving a favorable positive trend due to the fact that there is a strong positive correlation between the main profit index (£PLI) and EnviroCow. However, not all traits in the index show a favourable trend. Cows are increasing in size which limits the benefits from selection for other traits in the index, something which the UK and many other countries have begun to address.

Regressing the CO2e Intensity on the average EnviroCow gives a slope of 57 grams CO2e per point EnviroCow. This means that the 0.22 points gain per year is equivalent to (0.22 x 57 = 12.5gram CO2e reduction per year. Given that the average cow in our study had an estimated CO2e intensity of 534 grams, means that the percentage gain per year could be as high as 12.5/534 = 2.3%. It has to be noted however, that the relationship between EnviroCow and CO2eI in this summary review was non-linear, and this estimate is therefore a likely over-estimate.

Never-the-less, previous model estimates of the impact of genetics on the reduction of CO2e for milk were estimated at around 1% per year (Winters, 2022), providing a resemblance to these newly estimated effects of this study. With the knowledge that genetic improvements are both permanent and cumulative, the impact of genetics over time will be substantial, whichever estimate is used.

Conclusions

The analysis clearly demonstrated a strong association between improved genetics (EnviroCow), and lifetime enteric emissions (methane). Although enteric emissions of methane are the largest contributor of greenhouse gases in dairy farming – accounting for around 46% of total farm emissions – they are only part of the picture. And it is not unreasonable to assume that cows which eat less are also indirectly affecting a farm’s total carbon footprint through a variety of other factors. This includes the smaller amount of feed bought or grown which carries its own carbon footprint, whether through fertiliser, fuel or other factors, and the smaller amount of manure and its associated emissions from these higher EnviroCow rated animals.

Although many of the traits included in EnviroCow are already improving favourably over time, noticeably cows are still getting bigger which is unfavourable. The maintenance feed index was introduced in 2016 to attempt to halt this trend and is included in £PLI. Since 2021 a renewed focus on Feed Advantage (inc. Maintenance) might be more effective in achieving a reduction in cow size. The UK continues to explore how to select for reduced cow size in an effort to save more feed and reduce GHG emissions from dairy herds. However, with now close to 80% of Holstein cows being inseminated with dairy sexed semen (AHDB, 2023), there is a rapid growth in beef from the dairy herd. In order to manage the beef from dairy sustainably, the discussion of dairy cow size is gaining renewed interest. The current EnviroCow index ignores progeny impact, but this may be considered in future updates. A number of proxy traits are being developed since very few farmers weigh mature cows.

Although the EnviroCow index used in this analysis does not include a direct methane genetic index, there is substantial benefit to be had by breeding for existing traits already. In time, direct methane measured PTAs may become available, which could help to further fine-tune the EnviroCow index.

Despite the fact that there is not yet a standard agreement on how CO2e on farm is calculated and expressed, the technology to routinely record CO2e on farm is not well developed, this study provides a reassuring picture of environmental outcomes from existing practices, using existing selection traits but it is not surprising as that is exactly what the EnviroCow index was designed to deliver. However, the fact that this analysis clearly shows the extent of the benefits in practice will hopefully encourage producers and the wider industry to make sure that genetic improvements are considered as part of the process to reach Net Zero for the dairy sector.

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