**Prediction of effects of beef selection indexes on greenhouse gas emissions**

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**Supplementary Material**

Table S1 *Expected changes in trait unit per change in Maternal Replacement and Terminal index value as estimated from regression analysis on groups of AI and young bulls within and across breeds, and weighted aggregate value*

|  |  |  |  |
| --- | --- | --- | --- |
|  | AI Bulls | Young Bulls |  |
| Index, Trait | within breed1 | across breed2 | within breed1 | across breed2 | Weighted aggregate3 |
| Maternal Replacement |  |  |  |  |  |
| Offspring feed intake | 0.0003 | 0.0007 | 0.0005 | 0.0004 | 0.0005 |
| Offspring mortality | -0.0021 | -0.0027 | -0.0018 | -0.0022 | -0.0023 |
| Offspring carcass weight | 0.0133 | -0.0476 | 0.0352 | -0.0922 | -0.0205 |
| Offspring carcass conformation | 0 | -0.0033 | 0.0004 | -0.0039 | -0.0017 |
| Offspring carcass Fat | 0.0003 | 0.0022 | 0.0001 | 0.0030 | 0.0013 |
| Cow live weight | -0.0434 | -0.1684 | -0.0134 | -0.2574 | -0.1147 |
| Heifer live weight | -0.0434 | -0.1684 | -0.0134 | -0.2574 | -0.1147 |
| Cow calving interval | -0.0267 | -0.0314 | -0.0242 | -0.0289 | -0.0283 |
| Cow age at first calving | -0.0643 | -0.0181 | -0.1107 | 0 | -0.0454 |
| Cow survival | 0.0162 | 0.0210 | 0.0187 | 0.0232 | 0.0193 |
| Cow carcass weight | -0.0262 | -0.1203 | 0 | -0.1764 | -0.0777 |
|  |  |  |  |  |  |
| Terminal |  |  |  |  |  |
| Offspring feed intake | 0.0006 | -0.0041 | 0.0026 | -0.0042 | -0.0015 |
| Offspring mortality | 0.0003 | 0.0015 | -0.0002 | 0.0011 | 0.0007 |
| Offspring carcass weight | 0.2691 | 0.2282 | 0.2923 | 0.2416 | 0.2541 |
| Offspring carcass conformation | 0.0111 | 0.0142 | 0.0075 | 0.0136 | 0.0120 |
| Offspring carcass Fat | -0.0042 | -0.0088 | -0.0036 | -0.0096 | -0.0065 |

1 Slope of linear regression fitting fixed breed effect. Non-zero values significant at P<0.05.

2 Slope of linear regression without breed effect. Non-zero values significant at P<0.05.

3 Weighted sum of four estimates; AI Bull values weight=0.35; Young Bull values weight=0.15.



**Figure S1** Predictions of relative responses in Maternal Replacement Index and Emissions Intensity Index to selection on Combined index a = (Maternal Replacement Index) – α × (Emissions Intensity Index) for a range of Emissions Intensity Index weightings (α), as predicted by absolute correlations between individual bulls’ Combined Index values and Replacement or Emissions Intensity values. Correlations are weighted averages from AI and young bulls.

**Table S2** *Genetic gain in Maternal Replacement index value per year, percent reduction in annual CO2e after 5 and 20 years, and total kt CO2e reduced after 5 and 20 years from three breeding scenarios maintaining fixed production of 154 757 kt meat/year*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Index Progress | % annual CO2e reduction | Total kt CO2e reduced |
|  BDGP Scenario | euro / year | 5 years | 20 years | 5 years | 20 years |
| A. Replacement index | 1.67 | -0.4% | -1.5% | -34 | -481 |
| B. Replacement index + genomics + increased AI | 4.91 | -1.9% | -5.4% | -229 | -1952 |
| C. Replacement index + genomics + maximum AI | 9.04 | -3.1% | -9.5% | -350 | -3335 |

**Table S3** *Assumed values for breeding scenario predictions*

|  |  |
| --- | --- |
| Parameter | value |
| Change in kg CO2e / kg meat / breeding cow / year per 1 euro increase in Maternal Replacement Index value | -0.0089 |
| Current total system-wide kg CO2e emissions per average breeding cow per year (*∑eMR*) | 3 475.5 |
| Current total system-wide kg meat / average breeding cow per year (*∑mMR*) | 175.9 |
| Current system-wide emissions intensity kg CO2e / kg meat (EI) | 19.76 |
| Current number of breeding cows in national herd  | 880 000 |
| Current population total t CO2e emissions from breeding cows per year | 3 058 466 |
| Current population total t meat from breeding cows per year | 154 757 |

**Table S4** *Predictions of population average Maternal Replacement Index value (MRI), emissions intensity (EI), change in annual emissions (ΔEpop), and % reduction in annual emissions for three breeding scenarios, maintaining fixed 154 757 kt meat/year over 20 years. Scenarios are A = Maternal Replacement Index selection only; B = Index selection + genomics + increased use of AI; C = Index selection + genomics + maximum use of AI.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Replacement Index value(€) | Emissions Intensity(kg CO2e/kg meat)1 | Change in population annual emissions (t CO2e)2 | % change in population annual emissions |
| **Year** | **A** | **B** | **C** | **A** | **B** | **C** | **A** | **B** | **C** | **A** | **B** | **C** |
| 1 | 1.67 | 27.19 | 40.95 | 19.75 | 19.52 | 19.40 | -2 290 | -37 285 | -56 144 | -0.07% | -1.22% | -1.84% |
| 2 | 3.34 | 27.45 | 40.95 | 19.73 | 19.52 | 19.40 | -4 580 | -37 642 | -56 144 | -0.15% | -1.23% | -1.84% |
| 3 | 5.01 | 31.23 | 47.15 | 19.72 | 19.49 | 19.35 | -6 870 | -42 818 | -64 657 | -0.22% | -1.40% | -2.11% |
| 4 | 6.68 | 36.62 | 57.92 | 19.70 | 19.44 | 19.25 | -9 160 | -50 207 | -79 412 | -0.30% | -1.64% | -2.60% |
| **5** | **8.35** | **42.26** | **68.61** | **19.69** | **19.39** | **19.16** | **-11 449** | **-57 941** | **-94 078** | **-0.37%** | **-1.89%** | **-3.08%** |
| 6 | 10.02 | 47.36 | 77.84 | 19.67 | 19.34 | 19.07 | -13 739 | -64 939 | -106 738 | -0.45% | -2.12% | -3.49% |
| 7 | 11.69 | 52.29 | 86.99 | 19.66 | 19.30 | 18.99 | -16 029 | -71 697 | -119 273 | -0.52% | -2.34% | -3.90% |
| 8 | 13.36 | 57.41 | 96.79 | 19.64 | 19.25 | 18.91 | -18 319 | -78 724 | -132 711 | -0.60% | -2.57% | -4.34% |
| 9 | 15.03 | 62.61 | 106.56 | 19.63 | 19.21 | 18.82 | -20 609 | -85 848 | -146 115 | -0.67% | -2.81% | -4.78% |
| 10 | 16.70 | 67.75 | 116.15 | 19.62 | 19.16 | 18.73 | -22 899 | -92 896 | -159 270 | -0.75% | -3.04% | -5.21% |
| 11 | 18.37 | 72.84 | 125.74 | 19.60 | 19.12 | 18.65 | -25 189 | -99 873 | -172 413 | -0.82% | -3.27% | -5.64% |
| 12 | 20.04 | 78.92 | 135.57 | 19.59 | 19.06 | 18.56 | -27 479 | -108 214 | -185 885 | -0.90% | -3.54% | -6.08% |
| 13 | 21.71 | 83.77 | 145.11 | 19.57 | 19.02 | 18.48 | -29 768 | -114 871 | -198 978 | -0.97% | -3.76% | -6.51% |
| 14 | 23.38 | 88.98 | 154.75 | 19.56 | 18.97 | 18.39 | -32 058 | -122 007 | -212 189 | -1.05% | -3.99% | -6.94% |
| 15 | 25.05 | 94.28 | 164.42 | 19.54 | 18.93 | 18.31 | -34 348 | -129 279 | -225 449 | -1.12% | -4.23% | -7.37% |
| 16 | 26.72 | 99.58 | 174.08 | 19.53 | 18.88 | 18.22 | -36 638 | -136 537 | -238 689 | -1.20% | -4.46% | -7.80% |
| 17 | 28.39 | 104.82 | 183.72 | 19.51 | 18.83 | 18.14 | -38 928 | -143 723 | -251 908 | -1.27% | -4.70% | -8.24% |
| 18 | 30.06 | 110.05 | 193.36 | 19.50 | 18.79 | 18.05 | -41 218 | -150 905 | -265 134 | -1.35% | -4.93% | -8.67% |
| 19 | 31.73 | 115.31 | 203.01 | 19.48 | 18.74 | 17.96 | -43 508 | -158 118 | -278 371 | -1.42% | -5.17% | -9.10% |
| **20** | **33.40** | **120.58** | **212.66** | **19.47** | **18.69** | **17.88** | **-45 798** | **-165 333** | **-291 603** | **-1.50%** | **-5.41%** | **-9.53%** |
|  |  |  |  |  | **5 y cumulative** | **-34 348** | **-229 413** | **-350 435** |  |  |  |
|  |  |  |  |  | **20 y cumulative** | **-480 875** | **-1 952 377** | **-3 335 161** |  |  |  |

1 EI = 19.76 × MRI

2 ΔEpop = (EI × 154 757) – 3 058 466. Cumulative values are sums of changes over 5 and 20 years.