**Comparison of pure Holsteins to crossbred Holsteins with Norwegian Red cattle in first and second generations**

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**Supplemental Table S1** Numbers of herds, herd-year-seasons and sires of cows for the milk production traits in the F-1 and backcross (BC) generations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Generation | Parity | Number of | | | |  |
|  |  | Herds | Herd-year-seasons | Sires | | |
|  |  |  |  | NRF | Holstein | Total |
| F-1 | 1 | 50 | 179 | 42 | 248 | 290 |
|  | 2 | 50 | 176 | 41 | 247 | 288 |
|  | 3 | 49 | 164 | 41 | 240 | 281 |
|  |  |  |  |  |  |  |
| BC | 1 | 45 | 136 |  |  | 207 |
|  | 2 | 42 | 119 |  |  | 197 |
|  | 3 | 28 | 67 |  |  | 138 |

**Supplemental Table S2** Mean conception rates for nulliparous purebred Holstein and F-1 cows

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Holstein | F-1 | Difference1 | Model effect2 |
| Means (%) | 55.9 | 57.0 | -1.1 | -1.0 |
| Number of inseminations | 27 657 | 4488 |  |  |
| Number of cows | 16 977 | 4488 |  |  |

1"Difference" is the simple difference in the means of the two groups.

2"model effect" is the difference between the Holstein and F-1 effects effects in the Proc Glimmix analysis model. The effect was not significant, p < 0.05.

**Supplemental Table S3** Means rates of abortion for purebred Holstein cows inseminated by Holstein and NRF bulls

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Number of cows | | Means | |  |  |  |
| Parity | Holstein | F-1 | Holstein | F-1 | Difference1 | Model effect2 | *P-*value |
| 1 | 12 722 | 4843 | 8.76 | 6.71 | 2.05 | 1.67 | *P<0.05* |
| 2 | 2634 | 606 | 11.35 | 8.75 | 2.60 | 2.39 | *NS* |
| 3 | 1653 | 339 | 12.95 | 12.98 | -0.03 | 1.18 | *NS* |

1"Difference" is the simple difference in the means of the two groups,

2"Model effect" is the difference between the Holstein and F-1 effects in the Proc Glimmix analysis model.

**Supplemental Table S4** Mean rates of abortion for purebred Holsteins and F-1 cows by parity

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Number of cows | | Means | |  |  |
| Parity | Holstein | F-1 | Holstein | F-1 | Difference1 | Model effect2 |
| 1 | 12 363 | 2358 | 8.32 | 7.85 | 0.48 | 0.15 |
| 2 | 7601 | 1485 | 11.72 | 10.17 | 1.55 | 0.62 |
| 3 | 2706 | 513 | 13.38 | 14.04 | -0.66 | -0.35 |

1"Difference" is the simple difference in the means of the two groups,

2"Model effect" is the difference between the cow model effect in the Proc Glimmix analysis model. None of the differences were significantat p < 0.05.**Supplemental Table S5** Mean body condition score values for purebred Holstein and F-1 cows recorded after freshening, at peak production and prior to drying-off for parities 1-3

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Number of cows | | Means | |  |  |  |  |
| Parity | Time scored | Holstein | F-1 | Holstein | F-1 | Difference1 | Model effect2 | SED | *P-*value |
| 1 | At freshening | 5354 | 1305 | 3.11 | 3.31 | -0.2 | -0.18\*\*\* | 0.02 | *P<0.001* |
|  | At peak |  |  | 2.7 | 2.95 | -0.25 | -0.24\*\*\* | 0.02 | *P<0.001* |
|  | calving – peak |  |  | -0.41 | -0.36 | -0.05 | -0.04\*\* | 0.02 | *P<0.01* |
|  | prior to drying-off | 4212 | 973 | 3.23 | 3.46 | -0.23 | -0.24\*\*\* | 0.02 | *P<0.001* |
| 2 | At freshening | 2818 | 791 | 3.11 | 3.38 | -0.27 | -0.24\*\*\* | 0.02 | *P<0.001* |
|  | At peak |  |  | 2.6 | 2.9 | -0.3 | -0.27\*\*\* | 0.03 | *P<0.001* |
|  | calving – peak |  |  | -0.51 | -0.48 | -0.03 | -0.03 | 0.02 | *NS* |
|  | prior to drying-off | 1829 | 437 | 3.4 | 3.73 | -0.32 | -0.37\*\*\* | 0.04 | *P<0.001* |
| 3 | At freshening | 823 | 238 | 3.34 | 3.64 | -0.29 | -0.28\*\*\* | 0.04 | *P<0.001* |
|  | At peak |  |  | 2.76 | 3.07 | -0.31 | -0.28\*\*\* | 0.04 | *P<0.001* |
|  | calving – peak |  |  | -0.58 | -0.57 | -0.01 | 0 | 0.04 | *NS* |
|  | prior to drying-off | 395 | 103 | 3.48 | 3.82 | -0.34 | -0.35\*\*\* | 0.07 | *P<0.001* |

1"Difference" is the simple difference in the means of the two groups,

2"Model effect" is the difference between the Holstein and F-1 effects in the Proc Mixed analysis model.

**Supplemental Table S6** Causes of cow culling in first and second parities

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Holstein | | |  | | F-1 | | |
|  | No. cows | Percent of cows | | |  | No. cows | Percent of cows | |
| Cause |  | culled | total | |  |  | culled | total |
| Death | 51 | 3.2 | 1.3 | |  | 7 | 1.6 | 0.8 |
| Selection | 435 | 27.3 | 11.1 | |  | 164 | 38.8 | 18.1 |
| Dystocia | 33 | 2.1 | 0.8 | |  | 3 | 0.7 | 0.3 |
| Abortion | 207 | 13.0 | 5.3 | |  | 52 | 12.3 | 5.7 |
| Non-conception | 384 | 24.1 | 9.8 | |  | 102 | 24.1 | 11.3 |
| Mastitis | 65 | 4.1 | 1.7 | |  | 11 | 2.6 | 1.2 |
| Other diseases | 196 | 12.3 | 5.0 | |  | 33 | 7.8 | 3.6 |
| Other | 222 | 13.9 | 5.6 | |  | 51 | 12.1 | 5.6 |
| **Total** | **1,593** | **100.00** | **40.5** | |  | **423** | **100.00** | **46.7** |

**Supplemental Table S7** Mean conception rates for nulliparous purebred Holstein and backcross (BC) calves

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Number of: | | Means (%) | | |  |  |
|  | Holstein | BC | | Holstein | BC | Difference1 | Model effect2 |
| Inseminations | 22 365 | 2178 | | 55.4 | 56.7 | -1.3 | 0.3 |
| Cows | 13 544 | 1292 | |  |  |  |  |

1"Difference" is the simple difference in the means of the two groups.

2"Model effect" is the difference between the Holstein and BC effects in the Proc Glimmix analysis model. The effect was not significant, p < 0.05.

**Supplemental Table S8** Mean conception status and mean conception status estimated breeding values (EBV) for purebred Holstein and backcross (BC) cows in parities 1-3

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Number of cows | | Means (%) | |  | Mean EBV1 | |  |  |  |
| Parity | Holstein | F-1 | Holstein | F-1 | Difference2 | Holstein | F-1 | Model effect3 | SED | *P-*value |
| 1 | 5512 | 665 | 52.6 | 53.6 | -1.0 | 1.3 | 2.4 | -1.5 | 0.3 | *P<0.001* |
| 2 | 2952 | 317 | 46.6 | 47.6 | -1.1 | 0.9 | 2.2 | -1.8 | 0.4 | *P<0.001* |
| 3 | 1010 | 83 | 45.2 | 50.4 | -5.2 | 1.1 | 3 | -2.5 | 0.3 | *P<0.001* |

1All cows with valid first parity records were included for computation of mean EBV.

2"Difference" is the simple difference in the means of the two groups.

3"Model effect" is the difference between the Holstein and BC effects in the Proc Mixed analysis model.

**Supplemental Table S9** Mean culling rates, number of days to culling and number of lactations of purebred Holstein and backcross (BC) cows from birth through first parity

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Holstein | BC | Difference1 | Model effect2 |
| Culling rate | 20.2 | 16.9 | 3.3 | 2.7 |
| Days from birth to culling | 1033 | 1007 | 27 |  |
| Days from first calving to culling | 294 | 277 | 17 |  |
| Number of lactations | 2.14 | 2.06 | 0.08 |  |
| Number of cows | 1922 | 219 |  |  |

1"Difference" is the simple difference in the means of the two groups.

2"Model effect" is the difference between the Holstein and BC effects in the Proc Glimmix analysis model.The effect was not significant, p < 0.05.

**Supplemental Table S10** Mean body condition score values for purebred Holstein and backcross (BC) cows recorded after freshening, at peak production and prior to drying-off for parities 1-2

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Number of cows | | Means | |  |  |  |  |
| Parity | Time scored | Holstein | BC | Holstein | BC | Difference1 | Model effect2 | SED | *P-*value |
| 1 | At freshening | 2739 | 350 | 3.12 | 3.2 | -0.08 | -0.08 | 0.02 | *P<0.001* |
|  | At peak |  |  | 2.74 | 2.81 | -0.07 | -0.06 | 0.03 | *P<0.05* |
|  | calving - peak |  |  | -0.38 | -0.38 | -0.01 | 0.03 | 0.03 | *NS* |
|  | prior to drying-off | 1619 | 188 | 3.23 | 3.46 | -0.23 | -0.08 | 0.04 | *P<0.05* |
| 2 | At freshening | 813 | 87 | 3.07 | 3.17 | -0.10 | -0.09 | 0.04 | *P<0.05* |
|  | At peak |  |  | 2.59 | 2.67 | -0.08 | -0.08 | 0.05 | *NS* |
|  | calving - peak |  |  | -0.48 | -0.5 | 0.02 | 0.02 | 0.07 | *NS* |
|  | prior to drying-off | 397 | 30 | 3.25 | 3.32 | -0.06 | -0.06 | 0.10 | *NS* |

1"Difference" is the simple difference in the means of the two groups.

2"Model effect" is the difference between the Holstein and BC effects in the Proc Mixed analysis model.