

Genome-wide association studies for production, respiratory disease, and immune-related traits in Landrace pigs

Yoshinobu Uemoto^{1*}, Kasumi Ichinoseki^{1†}, Toshimi Matsumoto², Nozomi Oka³, Hironori Takamori³, Hiroshi Kadowaki³, Chihiro Kojima-Shibata³, Eisaku Suzuki³, Toshihiro Okamura⁴, Hisashi Aso¹, Haruki Kitazawa¹, Masahiro Satoh¹, Hirohide Uenishi², Keiichi Suzuki¹

¹Graduate School of Agricultural Science, Tohoku University, Sendai, Miyagi 980-8572, Japan.

²Animal Bioregulation Unit, Division of Animal Sciences, Institute of Agrobiological Sciences, National Agriculture and Food Research Organization (NARO), Tsukuba, Ibaraki 305-8634, Japan

³Miyagi Prefecture Animal Industry Experiment Station, Osaki, Miyagi 989-6445, Japan

⁴Institute of Livestock and Grassland Science, NARO, Tsukuba, Ibaraki 305-0901, Japan

†These authors have contributed equally to this work and share first authorship.

*Correspondence author

Supplementary table

Table S1. The genome-wide suggestive single nucleotide polymorphisms (SNPs) associated with production, respiratory disease, and immune-related traits.

Table S1. The genome-wide suggestive single nucleotide polymorphisms (SNPs) associated with production, respiratory disease, and immune-related traits

| Traits ^a | SNP information ^b | | | | SNP effect | | | Gene symbol within the SNP ±200 kbp region | | |
|---------------------------|------------------------------|--------------|---------------------|-------------|------------|---------------|-------------------------|--|--|---|
| | SSC | Position(bp) | refSNP variation ID | EA | EAF | β^c | Proportion ^d | | <i>p</i> -value | |
| Production traits | | | | | | | | | | |
| TDG | 2 | 1,267,622 | rs81243163 | G | 0.19 | 17.04 (3.68) | 0.03 | 4.27E-06 | IFITM10,CTSD,SYT8,TNNI2,LSP1,PRR33,TNNT3 | |
| | 12 | 60,871,978 | rs81288566 | A | 0.06 | -27.89 (5.81) | 0.03 | 1.87E-06 | TOMIL2,SREBF1,RAI1,PEMT,RASD1,MED9,NT5M,COPS3,FLCN,PLD6 | |
| BF | 12 | 61,215,277 | rs81255656 | A | 0.06 | -27.28 (5.78) | 0.03 | 2.78E-06 | COPS3,FLCN,PLD6,MPRIIP,TNFRSF13B,USP22,DHRS7B,TMEM11,NATD1,MAP2K3 | |
| | 14 | 13,891,794 | rs80983361 | A | 0.06 | -26.92 (6.04) | 0.03 | 9.34E-06 | MSRA,PRSS55,C8orf74,SOX7,XKR6 | |
| | 1 | 147,654,193 | rs81240401 | A | 0.45 | 1.21 (0.27) | 0.06 | 1.20E-05 | GALR1,MBP,ZNF236 | |
| | 1 | 148,327,912 | rs81349009 | G | 0.47 | 1.27 (0.27) | 0.07 | 4.15E-06 | - | |
| | 1 | 148,387,133 | rs81251179 | A | 0.47 | 1.27 (0.27) | 0.07 | 4.15E-06 | - | |
| | 1 | 148,497,978 | rs81349012 | A | 0.22 | -1.56 (0.37) | 0.07 | 2.56E-05 | - | |
| | 1 | 148,839,311 | rs81349042 | A | 0.31 | 1.38 (0.29) | 0.07 | 3.43E-06 | TSHZ1,ZADH2 | |
| | 1 | 155,492,432 | rs80986448 | G | 0.21 | -1.71 (0.38) | 0.08 | 7.30E-06 | CDH19 | |
| | 1 | 157,498,487 | rs81349201 | C | 0.49 | -1.22 (0.28) | 0.06 | 1.41E-05 | - | |
| | 1 | 162,105,226 | rs80991377 | C | 0.44 | -1.30 (0.29) | 0.07 | 1.05E-05 | ZNF532,MALT1,ALPK2 | |
| | 1 | 162,147,201 | rs80978205 | G | 0.49 | -1.21 (0.28) | 0.06 | 1.32E-05 | ZNF532,MALT1,ALPK2 | |
| | 1 | 162,192,627 | rs81349302 | G | 0.50 | -1.25 (0.27) | 0.06 | 6.60E-06 | MALT1,ALPK2,NEDD4L | |
| | Respiratory disease traits | 1 | 162,372,950 | rs80896334 | A | 0.48 | -1.26 (0.29) | 0.07 | 1.28E-05 | ALPK2,NEDD4L |
| 1 | | 163,382,446 | rs80864027 | A | 0.22 | -1.75 (0.40) | 0.09 | 1.69E-05 | CLPX,CILP,PARP16,IGDCC3,IGDCC4,DPP8,HACD3,INTS14 | |
| 0.00 | | | | | | | | | | |
| MPS score | | 2 | 136,232,960 | rs81222517 | A | 0.45 | -0.13 (0.03) | 0.04 | 2.18E-05 | C5orf15,TCF7 |
| | | 7 | 107,229,684 | rs336042505 | A | 0.44 | 0.13 (0.03) | 0.04 | 2.30E-05 | - |
| | | 8 | 24,735,805 | rs81398421 | C | 0.06 | -0.25 (0.06) | 0.03 | 2.06E-05 | - |
| 0.00 | | | | | | | | | | |
| Immune-related traits | | | | | | | | | | |
| PA_7w | | 8 | 6,537,938 | rs81343316 | A | 0.46 | 0.05 (0.01) | 0.01 | 2.03E-05 | SLC2A9,WDR1,ZNF518B,CLNK |
| | | 13 | 140,375,976 | rs322548798 | G | 0.31 | 0.06 (0.01) | 0.02 | 5.76E-06 | GSK3B,NR1I2 |
| | | 13 | 140,376,953 | rs331134940 | G | 0.31 | 0.06 (0.01) | 0.02 | 7.31E-06 | GSK3B,NR1I2 |
| | | 13 | 140,411,493 | rs81448510 | A | 0.31 | 0.06 (0.01) | 0.02 | 7.31E-06 | GSK3B,NR1I2,COX17,POPDC2 |
| | | 13 | 140,452,426 | rs80842494 | A | 0.31 | 0.06 (0.01) | 0.02 | 7.31E-06 | GSK3B,NR1I2,COX17,POPDC2,PLA1A |
| | 13 | 140,474,261 | rs80796660 | C | 0.31 | 0.06 (0.01) | 0.02 | 7.31E-06 | GSK3B,NR1I2,COX17,POPDC2,PLA1A | |
| | CAPA_105 | 13 | 160,080,510 | rs80802927 | A | 0.17 | 0.07 (0.02) | 0.01 | 2.61E-05 | DCBLD2,ST3GAL6 |
| | | 3 | 26,483,338 | rs81475132 | C | 0.06 | -0.15 (0.03) | 0.03 | 2.11E-06 | TMC5,TMC7,COQ7,ITPRIPL2,SYT17,SMG1 |
| | | 3 | 26,981,476 | rs81475348 | A | 0.06 | -0.15 (0.03) | 0.03 | 2.11E-06 | XYLT1 |
| | WBC_105 | 3 | 27,180,639 | rs81243013 | A | 0.06 | -0.15 (0.03) | 0.03 | 2.11E-06 | XYLT1 |
| | | 2 | 58,888,838 | rs81487680 | G | 0.30 | -0.02 (0.01) | 0.04 | 4.75E-06 | MEF2B,TMEM161A,ARMC6,SUGP2,DDX49,UPF1,COMP,CRTC1 |
| | | 2 | 59,738,035 | rs322217417 | A | 0.29 | -0.02 (0.01) | 0.04 | 2.53E-05 | RAB3A,MPV17L2,IFI30,MAST3,IL12RB1,ARRDC2,KCNN1,CCDC124,SLC5A5,JAK3,INSL3,B3GNT3 |
| | WBC_7w | 2 | 60,108,314 | rs81359730 | G | 0.30 | -0.02 (0.01) | 0.04 | 4.46E-06 | JAK3,INSL3,B3GNT3,FCHO1,MAP1S,COLGALT1,FAM129C,SLC27A1,NXNL1,MVB12A,BST2 |
| 2 | | 62,246,385 | rs80992257 | G | 0.30 | -0.02 (0.01) | 0.04 | 2.79E-06 | CYP4F22,PGLYRP2,RASAL3,AKAP8L,AKAP8,BRD4,EPHX3,NOTCH3,ILVBL,SYDE1 | |
| 2 | | 39,149,929 | rs81357548 | A | 0.45 | 0.02 (0.01) | 0.03 | 3.80E-06 | PRMT3,HTATIP2,DBX1,NAV2 | |
| RGL_105 | 2 | 39,217,661 | rs81357600 | A | 0.42 | 0.02 (0.01) | 0.02 | 1.87E-05 | PRMT3,HTATIP2,DBX1,NAV2 | |
| | 2 | 52,791,773 | rs81237218 | G | 0.13 | -0.03 (0.01) | 0.02 | 1.27E-05 | - | |
| | 7 | 18,172,398 | rs80807040 | G | 0.06 | -0.08 (0.02) | 0.02 | 1.52E-05 | - | |
| CORT_105 | 7 | 18,645,244 | rs80981748 | A | 0.10 | -0.06 (0.01) | 0.02 | 3.58E-06 | - | |
| | 7 | 19,658,767 | rs80932009 | A | 0.21 | -0.05 (0.01) | 0.03 | 2.23E-06 | TDP2,ACOT13,C6orf62,GMNN,ARMH2 | |
| | 9 | 124,790,147 | rs81417044 | A | 0.37 | 0.04 (0.01) | 0.03 | 2.03E-05 | NMNAT2,SMG7,NCF2,ARPC5,RGL1,APOBEC4 | |
| CORT_7w | 1 | 11,684,450 | rs80923830 | A | 0.39 | 0.08 (0.02) | 0.03 | 1.67E-05 | NOX3,TFB1M,CLDN20,TIAM2 | |
| | 5 | 80,818,426 | rs81245792 | G | 0.34 | 0.09 (0.02) | 0.03 | 3.58E-06 | NT5DC3 | |
| | 5 | 80,820,281 | rs81339682 | G | 0.34 | 0.09 (0.02) | 0.03 | 4.58E-06 | NT5DC3 | |
| IFN- γ | 9 | 22,071,228 | rs81343906 | G | 0.27 | 0.09 (0.02) | 0.04 | 5.69E-06 | GRM5 | |
| | 9 | 22,573,159 | rs81336772 | G | 0.48 | 0.07 (0.02) | 0.03 | 1.76E-05 | GRM5,TYR,NOX4 | |
| | 9 | 22,763,662 | rs81321075 | G | 0.23 | 0.09 (0.02) | 0.03 | 5.53E-06 | TYR,NOX4,FOLH1B | |
| TNF- α | 9 | 43,420,493 | rs81410136 | G | 0.16 | -0.10 (0.02) | 0.03 | 1.22E-05 | - | |
| | 9 | 43,705,584 | rs81410215 | G | 0.16 | -0.10 (0.02) | 0.03 | 6.48E-06 | - | |
| | 9 | 43,739,452 | rs81410233 | A | 0.17 | -0.10 (0.02) | 0.04 | 3.42E-06 | - | |
| AP | 9 | 86,743,853 | rs341975939 | G | 0.28 | 0.10 (0.02) | 0.03 | 1.54E-05 | AHR | |
| | 15 | 108,645,898 | rs80990650 | G | 0.25 | 0.10 (0.02) | 0.03 | 2.37E-05 | PARD3B | |
| | 12 | 7,283,888 | rs81437363 | G | 0.17 | -0.24 (0.06) | 0.04 | 2.49E-05 | - | |
| IL-17 | 12 | 10,974,664 | rs81439586 | A | 0.50 | 0.22 (0.05) | 0.05 | 2.09E-05 | MAP2K6,ABCA5 | |
| | 12 | 11,004,527 | rs81439595 | G | 0.40 | -0.22 (0.05) | 0.05 | 1.31E-05 | MAP2K6,ABCA5 | |
| | 12 | 13,502,838 | rs81440208 | A | 0.25 | 0.28 (0.06) | 0.07 | 5.96E-06 | CACNG5,CACNG4,CACNG1,HELZ | |
| Multi-trait meta-analysis | 14 | 3,711,824 | rs81327634 | G | 0.50 | -0.17 (0.04) | 0.08 | 1.35E-05 | - | |
| | 14 | 17,600,242 | rs341122035 | C | 0.47 | -0.19 (0.04) | 0.09 | 2.40E-06 | - | |
| | 16 | 68,422,227 | rs81461701 | G | 0.17 | 0.22 (0.05) | 0.07 | 1.27E-05 | MRPL22,GEMIN5,CNOT8,FAXDC2,LARP1 | |
| Multi-trait meta-analysis | 16 | 68,425,822 | rs81347008 | A | 0.17 | 0.22 (0.05) | 0.07 | 1.27E-05 | MRPL22,GEMIN5,CNOT8,FAXDC2,LARP1 | |
| | 2 | 1,267,622 | rs81243163 | | | | | 1.37E-05 | IFITM10,CTSD,SYT8,TNNI2,LSP1,PRR33,TNNT3 | |
| | 2 | 60,108,314 | rs81359730 | | | | | 2.16E-05 | JAK3,INSL3,B3GNT3,FCHO1,MAP1S,COLGALT1,FAM129C,SLC27A1,NXNL1,MVB12A,BST2 | |
| | 3 | 26,483,338 | rs81475132 | | | | | 1.36E-06 | TMC5,TMC7,COQ7,ITPRIPL2,SYT17,SMG1 | |
| | 3 | 26,981,476 | rs81475348 | | | | | 1.36E-06 | XYLT1 | |
| | 3 | 27,180,639 | rs81243013 | | | | | 1.36E-06 | XYLT1 | |
| | 4 | 7,783,321 | rs80920273 | | | | | 1.65E-05 | ST3GAL1 | |
| Multi-trait meta-analysis | 7 | 115,550,783 | rs80918930 | | | | | 1.04E-05 | ISG12(A),PPP4R4,SERPINA6,SERPINA1,SERPINA11,UABP-2,SERPINA12 | |
| | 10 | 63,410,258 | rs81236875 | | | | | 2.53E-05 | GATA3,TAF3,ATP5F1C,KIN | |

^aAbbreviations of traits are shown in Table 2.^bSSC: Sus Scrofa chromosome, EA: Effect allele, EAF: Effect allele frequency.^cStandard errors are shown in parentheses.^dThe proportion of adjusted phenotypic variance explained by the SNP effects.