Table S1. Accuracy of genotype imputation from Illumina 50K SNPs to whole genome sequence (WGS) variant genotypes via HD using Fimpute 2.2

	Number of total WGS variant genotypes of 240 animals	Number of correctly imputed WGS variant genotypes of 240 animals	Imputation accuracy	Number of imputed WGS variant genotypes per animal
BTA1	579745680	562381176	0.97	2415607
BTA2	494930160	480738782	0.9713	2062209
BTA3	419358240	405858001	0.9678	1747326
BTA4	441735600	427070290	0.9668	1840565
BTA5	429833520	413270103	0.9615	1790973
BTA6	425628240	412122198	0.9683	1773451
BTA7	386629200	373029804	0.9648	1610955
BTA8	389297760	377097399	0.9687	1622074
BTA9	373340160	361456820	0.9682	1555584
BTA10	367824960	353656505	0.9615	1532604
BTA11	371232240	359010340	0.9671	1546801
BTA12	400109760	372585988	0.9312	1667124
BTA13	296662080	287426524	0.9689	1236092
BTA14	296392560	286832216	0.9677	1234969
BTA15	339638400	326968651	0.9627	1415160
BTA16	309841200	298947370	0.9648	1291005
BTA17	277840560	265963664	0.9573	1157669
BTA18	231474480	221864425	0.9585	964477
BTA19	223123920	213964332	0.9589	929683
BTA20	269202000	261302594	0.9707	1121675
BTA21	261251520	251574275	0.963	1088548
BTA22	214242720	207343689	0.9678	892678
BTA23	243928080	233011283	0.9552	1016367
BTA24	238661280	231785947	0.9712	994422
BTA25	160847520	155123815	0.9644	670198
BTA26	187047.12	180321128	0.964	779363
BTA27	167550240	161171728	0.9619	698126
BTA28	185485440	179423584	0.9673	772856
BTA29	213699120	205252771	0.9605	890413
Whole-genome	9,196,553,760	8,866,555,402	0.9641	38,318,974

Table S2. Functional annotations of 7.8M WGS variants along with the number of variants in each class, classification of SNP functions, percentage of WGS and 9 functional class assignments

Functional class annotation	Number of SNPs	Classification of SNP functions	Proportion*
intergenic_region	5251680	intergenic_region	66.87%
downstream_gene_variant	253163	downstream_gene_variant	3.22%
upstream_gene_variant	285798	upstream_gene_variant	3.64%
non_coding_exon_variant	1953	synonymous_variant	0.41%
synonymous_variant	30066	synonymous_variant	
intron_variant	1987366	intron_variant	25.31%
missense_variant	17654	missense_variant	0.22%
3’UTR_variant	15851	3’UTR_variant	0.20%
5’UTR_variant	2868	5’UTR_variant	0.04%
5’UTR_premature_start_codon_gain_variant	441	5’UTR_variant	
splice_region_variant&intron_variant	4189	Other_regulatory	
missense_variant&splice_region_variant	470	Other_regulatory	
splice_region_variant&synonymous_variant	664	Other_regulatory	
inframe_deletion	98	Other_regulatory	
frameshift_variant	150	Other_regulatory	
splice_donor_variant&intron_variant	118	Other_regulatory	
disruptive_inframe_deletion	52	Other_regulatory	0.08%
splice_region_variant	141	Other_regulatory	
splice_acceptor_variant&intron_variant	116	Other_regulatory	
frameshift_variant&splice_donor_variant&splice_region_variant&intron_variant	3	Other_regulatory	
splice_acceptor_variant&splice_donor_variant&intron_variant	19	Other_regulatory	
splice_region_variant&non_coding_exon_variant	61	Other_regulatory	
stop_retained_variant	19	Other_regulatory	

frameshift_variant&splice_region_variant	13	Other_regulatory	
stop_gained	161	Other_regulatory	
splice_acceptor_variant&splice_region_variant&intron_variant	11	Other_regulatory	
splice_region_variant&stop_retained_variant	3	Other_regulatory	
stop_lost&splice_region_variant	9	Other_regulatory	
start_lost	27	Other_regulatory	
disruptive_inframe_insertion	7	Other_regulatory	
inframe_insertion	13	Other_regulatory	
frameshift_variant&stop_lost&splice_region_variant	1	Other_regulatory	
stop_gained&splice_region_variant	9	Other_regulatory	
stop_lost	3	Other_regulatory	
frameshift_variant&splice_acceptor_variant&splice_region_variant&intron_variant	2	Other_regulatory	
frameshift_variant&stop_gained	1	Other_regulatory	
splice_donor_variant&splice_region_variant&intron_variant	5	Other_regulatory	
stop_gained&inframe_insertion	1	Other_regulatory	
initiator_codon_variant&non_canonical_start_codon	1	Other_regulatory	
frameshift_variant&start_lost&splice_region_variant	1	Other_regulatory	
frameshift_variant&stop_lost	1	Other_regulatory	
frameshift_variant&start_lost	1	Other_regulatory	
disruptive_inframe_deletion&splice_region_variant	1	Other_regulatory	
Total	7853211		100.00%

***** The proportion was calculated as numbers of SNPs in a class divided by total SNPs/Indel and then multiplied by 100.

Table S3. Functional annotation of all DNA variants (38,318,974) based on DNA variants of the 1000 bulls genome project.

Functional class annotation	Number of SNPs	Classification of SNP functions	Proportion*
intergenic_region	25179655	intergenic_region	65.70%
downstream_gene_variant	1393115	downstream_gene_variant	3.60%
upstream_gene_variant	1591843	upstream_gene_variant	4.20%
non_coding_exon_variant	10973	synonymous_variant	0.43%
synonymous_variant	155200	synonymous_variant	
intron_variant	9693772	intron_variant	25.30%
missense_variant	143708	missense_variant	0.40%
3’UTR_variant	88639	3’UTR_variant	0.20%
5’UTR_variant	16109	5’UTR_variant	0.05%
5’UTR_premature_start_codon_gain_variant	2698	5’UTR_variant	
splice_region_variant&synonymous_variant	3439	Other_regulatory	
stop_gained	3224	Other_regulatory	
splice_region_variant&intron_variant	23960	Other_regulatory	
splice_region_variant	1039	Other_regulatory	
splice_donor_variant&intron_variant	1614	Other_regulatory	
splice_acceptor_variant&intron_variant	1430	Other_regulatory	
missense_variant&splice_region_variant	3949	Other_regulatory	0.12%
inframe_deletion	958	Other_regulatory	
frameshift_variant	1285	Other_regulatory	
inframe_insertion	134	Other_regulatory	
splice_region_variant&non_coding_exon_variant	426	Other_regulatory	
disruptive_inframe_deletion	529	Other_regulatory	
frameshift_variant&stop_gained	19	Other_regulatory	

frameshift_variant&splice_region_variant	133	Other_regulatory
stop_gained&splice_region_variant	152	Other_regulatory
start_lost	173	Other_regulatory
splice_acceptor_variant&splice_donor_variant&intron_variant	182	Other_regulatory
disruptive_inframe_insertion	76	Other_regulatory
splice_donor_variant&splice_region_variant&intron_variant	88	Other_regulatory
splice_acceptor_variant&splice_region_variant&intron_variant	115	Other_regulatory
stop_retained_variant	71	Other_regulatory
disruptive_inframe_deletion&splice_region_variant	11	Other_regulatory
frameshift_variant&splice_acceptor_variant&splice_region_variant&intron_variant	23	Other_regulatory
stop_lost&splice_region_variant	47	Other_regulatory
frameshift_variant&splice_donor_variant&splice_region_variant&intron_variant	28	Other_regulatory
stop_lost	76	Other_regulatory
splice_region_variant&stop_retained_variant	34	Other_regulatory
initiator_codon_variant	21	Other_regulatory
disruptive_inframe_insertion&splice_region_variant	1	Other_regulatory
frameshift_variant&stop_lost	8	Other_regulatory
frameshift_variant&stop_lost&splice_region_variant	4	Other_regulatory
frameshift_variant&start_lost	7	Other_regulatory
stop_gained&inframe_insertion	5	Other_regulatory

frameshift_variant&start_lost&splice_region_variant	1	Other_regulatory	
Total SNP and Indel	38318974		100%

* The proportion was calculated as numbers of SNPs in a class divided by total SNPs/Indel and then multiplied by 100

Table S4. Functional annotations of SNPs in the 50K SNP panel after quality control along with the number of variants in each class, classification of SNP functions, percentage of WGS and 9 functional class assignments

Functional class annotation	Number of SNPs	Classification of SNP functions	Proportion*
intergenic_region	18313	intergenic_region	60.73%
downstream_gene_variant	1138	downstream_gene_variant	3.77%
upstream_gene_variant	1308	upstream_gene_variant	4.34%
non_coding_transcript_exon_variant	15	synonymous_variant	1.75%
synonymous_variant	513	synonymous_variant	
intron_variant	8528	intron_variant	28.28%
missense_variant	68	missense_variant	0.23%
3’UTR_variant	193	3’UTR_variant	0.64%
5’UTR_premature_start_codon_gain_variant	4	5’UTR_variant	0.10%
5’UTR_variant	26	5’UTR_variant	
initiator_codon_variant&non_canonical_start_codon	1	Other_regulatory	
missense_variant&splice_region_variant	3	Other_regulatory	0.16%
splice_region_variant	1	Other_regulatory	
splice_region_variant&intron_variant	27	Other_regulatory	

splice_region_variant&non_coding_transcript_exon_variant	2	Other_regulatory	
splice_region_variant&synonymous_variant	13	Other_regulatory	
stop_retained_variant	2	Other_regulatory	
total	30155		100.00%

***** The proportion was calculated as numbers of SNPs in a class divided by total SNPs/Indel and then multiplied by 100

Table S5. List of lead SNPs that were overlapped with QTLs published in Cattle QTL database within 1M bp up or 1M bp downstream for RFI, DMI, ADG, and MWT, where the last column shows a list of QTL ids with reference numbers in square brackets. Overlapped QTLs within 70k bp up or 70k bp downstream were highlighted in bold. References were listed at the end of the file.

Trait	SNP	Chr	bp	No. of overlapped QTLs	Overlapped QTL ids [reference]
RFI	rs109479784	1	121176492	1	121956[7]
RFI	rs110523019	3	6835555	1	21045[27]
RFI	rs382972340	12	54262083	1	21067[27]
RFI	Chr15:82875910	15	82875910	3	131319[2], 131337[2], **56460[14]**
DMI	rs384466084	6	31945021	1	23691[22]
DMI	rs463483203	6	32301275	1	23691[22]
DMI	rs384405067	6	39719047	1	23734[22]
DMI	rs383608859	6	39967379	1	23734[22]
DMI	rs110280465	6	40041892	1	23734[22]
DMI	rs136513257	6	40422038	1	23734[22]

DMI	rs110650030	6	41213430	1	23734[22]
DMI	rs210962809	6	41333075	1	23734[22]
DMI	rs110785425	10	70651353	1	23800[22]
ADG	rs382130743	2	36556122	1	23641[22]
ADG	Chr4:112725016	4	112725016	1	20670[28]
ADG	rs137822220	5	106247266	13	**131017[2], 131018[2], 131034[2], 131035[2], 131036[2], 131038[2], 131039[2], 131040[2], 131042[2], 131043[2], 131044[2], 131045[2], 56473[14]**
ADG	rs380377923	6	31546181	2	102120[8], **22808[23]**
ADG	rs136764476	6	31656705	2	102120[8], 22808[23]
ADG	rs110967603	6	35951727	5	102117[8], 102118[8], 102122[8], 102124[8], **25113[18]**
ADG	rs378678939	6	36714098	1	25113[18]
ADG	rs385661392	6	37389583	1	102014[9]
ADG	rs133323815	6	37790429	33	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124053[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124067[5], 124068[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30]
ADG	Chr6:37862012	6	37862012	47	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30]

ADG	rs381043912	6	37957342	55	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30]
ADG	rs383638885	6	38031945	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs210353492	6	38107063	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs207550149	6	38180681	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]

ADG	rs209915052	6	38259595	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs382462900	6	38429007	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], **124074[5]**, 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs385289515	6	38509747	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], **124048[5]**, 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], **124074[5]**, 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	Chr6:38606864	6	38606864	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], **124048[5]**, 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], **124070[5]**, 124071[5], 124073[5], 124074[5], **124079[5]**, 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]

ADG	rs381763403	6	38681815	56	**124027[5], 124028[5]**, 124029[5], **124030[5]**, 124031[5], **124032[5]**, **124033[5]**, 124034[5], **124035[5]**, 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], **124044[5], 124045[5], 124046[5], 124047[5],** 124048[5], **124049[5]**, 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], **124067[5]**, **124068[5]**, 124069[5], **124070[5]**, **124071[5], 124073[5]**, 124074[5], **124079[5]**, 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs110302982	6	38760889	56	**124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5]**, 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], **124044[5], 124045[5], 124046[5], 124047[5]**, 124048[5], **124049[5], 124050[5], 124051[5], 124052[5], 124053[5]**, 124054[5], 124055[5], 124057[5], **124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5]**, 124064[5], 124065[5], **124067[5], 124068[5]**, 124069[5], 124070[5], **124071[5], 124073[5]**, 124074[5], 124079[5], 102014[9], **20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30]**, 20097[30], 20099[30], 20101[30]
ADG	rs109696064	6	38837730	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], **124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5]**, 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], **124050[5], 124051[5], 124052[5]**, 124053[5], **124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5],** 124067[5], **124068[5], 124069[5]**, 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], **20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30]**, 20101[30]
ADG	rs110995268	6	38914196	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], **124040[5], 124041[5], 124042[5], 124043[5]**, 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], **124054[5], 124055[5]**, 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], **124065[5]**, 124067[5], 124068[5], **124069[5]**, 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], **20097[30], 20099[30]**, 20101[30]

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ADG	rs110987922	6	39113335	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs110218841	6	39214342	56	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 102014[9], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs110747048	6	39353897	55	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124074[5], 124079[5], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]

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ADG	rs133877406	6	39571260	54	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124048[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124079[5], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs385370479	6	39642714	53	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124035[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124047[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124070[5], 124071[5], 124073[5], 124079[5], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs384405067	6	39719047	48	124027[5], 124028[5], 124029[5], 124030[5], 124031[5], 124032[5], 124033[5], 124034[5], 124036[5], 124037[5], 124038[5], 124039[5], 124040[5], 124041[5], 124042[5], 124043[5], 124044[5], 124045[5], 124046[5], 124049[5], 124050[5], 124051[5], 124052[5], 124053[5], 124054[5], 124055[5], 124057[5], 124058[5], 124059[5], 124060[5], 124061[5], 124062[5], 124063[5], 124064[5], 124065[5], 124067[5], 124068[5], 124069[5], 124073[5], 20086[30], 20088[30], 20089[30], 20091[30], 20094[30], 20095[30], 20097[30], 20099[30], 20101[30]
ADG	rs382149180	6	39947443	3	102116[8], 102121[8], 20101[30]
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ADG	rs109823986	6	40702520	2	102116[8], 102121[8]
ADG	rs385648596	6	40900316	2	102116[8], **102121[8]**
ADG	rs134606084	6	40970705	2	102116[8], 102121[8]
ADG	rs43464551	6	41047507	2	102116[8], 102121[8]
ADG	rs135202983	6	41229657	3	102116[8], 102121[8], 124076[5]
ADG	rs43466307	6	42370579	2	124076[5], 22810[23]
ADG	rs209393630	6	42510243	2	124076[5], 22810[23]
ADG	rs381205796	6	42636544	2	124076[5], 22810[23]
ADG	Chr6:43316828	6	43316828	1	**22810[23]**
ADG	Chr6:44029020	6	44029020	1	22810[23]
ADG	rs137370999	6	44133101	1	22810[23]
ADG	rs135988356	6	46224508	1	23755[22]
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ADG	rs110990855	6	46460427	1	**23755[22]**
ADG	rs381809466	6	46569119	1	**23755[22]**
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ADG	rs379061965	6	46871416	1	23755[22]
ADG	rs134663272	6	47128886	1	23755[22]
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ADG	rs109901274	7	93244933	55	**131019[2], 131020[2], 131021[2], 131022[2], 131023[2], 131024[2], 131025[2], 131026[2], 131027[2], 131028[2], 131029[2]**, 131037[2], 131041[2], 131046[2], 131047[2], 131048[2], 131049[2], **131050[2], 131051[2],** 131052[2], 131055[2], **131056[2], 131057[2], 131058[2], 131059[2], 131060[2]**, 131063[2], 131064[2], 131072[2], 131073[2], 131074[2], 131075[2], 131076[2], 131077[2], 131078[2], 131079[2], 131080[2], 131081[2], 131082[2], 131083[2], 131095[2], 131096[2], 131097[2], 131099[2], 131100[2], 131101[2], 131110[2], 131112[2], 131119[2], 131120[2], 131123[2], **101982[9]**, **22785[23]**, 131098[2], **56474[14]**
ADG	rs41681899	13	18998047	1	23831[22]
ADG	rs41693642	13	45111501	1	23220[19]
ADG	Chr13:45255892	13	45255892	1	23220[19]
ADG	rs42853892	13	45349576	1	23220[19]
ADG	rs208583895	14	24153141	2	102021[9], 20873[25]
ADG	rs110220085	14	24235302	3	102021[9], 20873[25], 20848[26]
ADG	rs211486269	14	24508890	8	102021[9], 20873[25], 20848[26], 20849[26], 20850[26], 20851[26], 20852[26], 20853[26]
ADG	rs41724405	14	24626845	8	102021[9], 20873[25], 20848[26], 20849[26], 20850[26], 20851[26], 20852[26], 20853[26]
ADG	rs110144371	14	24895889	8	102021[9], 20873[25], 20848[26], 20849[26], 20850[26], 20851[26], 20852[26], 20853[26]
ADG	rs134215421	14	25006125	8	**102021[9]**, **20873[25],** 20848[26], 20849[26], 20850[26], 20851[26], 20852[26], 20853[26]
ADG	rs109060535	14	26223578	6	20848[26], 20849[26], 20850[26], 20851[26], 20852[26], 20853[26]
ADG	rs210931678	20	4277046	3	130810[2], 22839[23], 22840[23]
ADG	rs41933279	20	4583717	2	22839[23], 22840[23]
ADG	rs43349801	20	4662257	2	22839[23], 22840[23]
ADG	rs43349740	20	4778613	2	**22839[23],** 22840[23]
ADG	rs42661323	20	4916731	2	**22839[23], 22840[23]**
ADG	rs473496654	20	5006104	2	**22839[23], 22840[23]**
ADG	rs448890458	25	40587255	2	101999[9], 102041[9]
MWT	rs110358394	5	106266665	1	140481[1]

MWT	rs210609295	6	31853453	1	131411[2]
MWT	rs384466084	6	31945021	1	**131411[2]**
MWT	rs386082192	6	32467576	1	131411[2]
MWT	rs109672376	6	35634137	1	25112[18]
MWT	Chr6:35727960	6	35727960	1	25112[18]
MWT	rs463408175	6	35815378	1	25112[18]
MWT	rs109168002	6	35892044	1	**25112[18]**
MWT	rs135391932	6	35985958	1	**25112[18]**
MWT	Chr6:36063637	6	36063637	1	25112[18]
MWT	Chr6:36142577	6	36142577	1	25112[18]
MWT	rs207985227	6	36217568	1	25112[18]
MWT	Chr6:36358198	6	36358198	1	25112[18]
MWT	rs110173598	6	36430643	1	25112[18]
MWT	rs207995078	6	36597371	1	25112[18]
MWT	rs137290140	6	37007648	1	130915[2]
MWT	rs208802803	6	37312750	2	130915[2], 25114[18]
MWT	rs385661392	6	37389583	2	130915[2], 25114[18]
MWT	rs211048534	6	37461131	2	130915[2], 25114[18]
MWT	rs109100620	6	37595062	3	131414[2], 130915[2], 25114[18]
MWT	Chr6:37666690	6	37666690	3	131414[2], 130915[2], 25114[18]
MWT	rs110111900	6	37791785	4	131414[2], **130915[2]**, 25114[18], 23717[22]
MWT	rs383473904	6	37872592	4	131414[2], **130915[2]**, 25114[18], 23717[22]
MWT	Chr6:37959886	6	37959886	5	131414[2], 130915[2], 25114[18], 23717[22], 23723[22]
MWT	rs383638885	6	38031945	5	131414[2], 130915[2], **25114[18]**, 23717[22], 23723[22]
MWT	rs210353492	6	38107063	5	131414[2], 130915[2], **25114[18]**, 23717[22], 23723[22]

MWT	rs207550149	6	38180681	5	131414[2], 130915[2], 25114[18], 23717[22], 23723[22]
MWT	rs379490408	6	38253085	9	131388[2], 131389[2], 131393[2], 131394[2], 131414[2], 130915[2], 25114[18], 23717[22], 23723[22]
MWT	rs382462900	6	38429007	18	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 130915[2], 25114[18], 23717[22], 23723[22]
MWT	rs385289515	6	38509747	18	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], **131414[2],** 130915[2], 25114[18], 23717[22], 23723[22]
MWT	rs134828344	6	38587035	18	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], **131414[2],** 130915[2], 25114[18], 23717[22], 23723[22]
MWT	rs109355965	6	38657124	18	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 130915[2], 25114[18], **23717[22]**, 23723[22]
MWT	rs109843602	6	38750035	18	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 130915[2], 25114[18], **23717[22]**, 23723[22]
MWT	rs109732906	6	38872172	17	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 25114[18], 23717[22], **23723[22]**
MWT	rs110369727	6	38947564	17	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 25114[18], 23717[22], **23723[22]**
MWT	rs378858709	6	39020582	17	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 25114[18], 23717[22], 23723[22]
MWT	Chr6:39111019	6	39111019	16	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 23717[22], 23723[22]
MWT	rs109658371	6	39213566	16	**131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2]**, 131414[2], 23717[22], 23723[22]

MWT	rs109840670	6	39364500	16	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 23717[22], 23723[22]
MWT	rs109433941	6	39444050	16	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 23717[22], 23723[22]
MWT	rs133877406	6	39571260	16	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 131414[2], 23717[22], 23723[22]
MWT	rs385370479	6	39642714	16	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 23717[22], 23723[22], 23733[22]
MWT	rs384405067	6	39719047	15	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 23723[22], 23733[22]
MWT	rs381670901	6	39868660	15	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 23723[22], 23733[22]
MWT	rs382149180	6	39947443	14	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 23733[22]
MWT	rs378255303	6	40029961	14	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 23733[22]
MWT	rs43456300	6	40141451	14	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131393[2], 131394[2], 131395[2], 131398[2], 23733[22]
MWT	rs111031148	6	40245181	14	131382[2], 131383[2], 131384[2], 131385[2], 131388[2], 131389[2], 131390[2], 131391[2], 131392[2], 131394[2], 131395[2], 131398[2], 23733[22], 23738[22]
MWT	rs43070338	6	40421678	2	23733[22], 23738[22]
MWT	rs385648596	6	40900316	2	23733[22], 23738[22]
MWT	rs43461215	6	41190295	2	23733[22], **23738[22]**
MWT	rs385048356	6	41705949	1	23738[22]
MWT	Chr6:41779679	6	41779679	1	23738[22]
MWT	rs381611273	6	49301672	1	131345[2]

MWT	rs385825767	6	49388298	1	131345[2]
MWT	rs211227700	20	4110200	14	131135[2], 131137[2], 131138[2], 131146[2], 131173[2], 131174[2], 131190[2], 131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]
MWT	Chr20:4205219	20	4205219	14	131135[2], 131137[2], 131138[2], 131146[2], 131173[2], 131174[2], 131190[2], 131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]
MWT	rs210931678	20	4277046	14	131135[2], 131137[2], 131138[2], 131146[2], 131173[2], 131174[2], 131190[2], 131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]
MWT	rs41934045	20	4563925	14	131135[2], **131137[2], 131138[2]**, 131146[2], **131173[2], 131174[2]**, 131190[2], 131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]
MWT	rs43349810	20	4637730	14	131135[2], **131137[2], 131138[2]**, 131146[2], **131173[2], 131174[2]**, 131190[2], 131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]
MWT	rs43349740	20	4778613	14	131135[2], 131137[2], 131138[2], 131146[2], 131173[2], 131174[2], 131190[2], 131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]
MWT	rs41574252	20	4863507	14	**131135[2]**, 131137[2], 131138[2], **131146[2]**, 131173[2], 131174[2], **131190[2]**, **131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]**
MWT	rs41574253	20	4964834	14	**131135[2]**, 131137[2], 131138[2], 131146[2], 131173[2], 131174[2], **131190[2], 131191[2]**, 131410[2], 131412[2], 131415[2], 131416[2], **131417[2]**, 131418[2]
MWT	rs211028837	20	5043189	14	131135[2], 131137[2], 131138[2], 131146[2], 131173[2], 131174[2], 131190[2], 131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]
MWT	rs483267895	20	5375886	14	131135[2], 131137[2], 131138[2], 131146[2], 131173[2], 131174[2], 131190[2], 131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]
MWT	rs207865196	20	5482087	15	130854[2], 131135[2], 131137[2], 131138[2], 131146[2], 131173[2], 131174[2], 131190[2], 131191[2], 131410[2], 131412[2], 131415[2], 131416[2], 131417[2], 131418[2]
MWT	rs42517118	20	5983010	1	130854[2]

List of references for QTLs in the Cattle QTL Database for feed efficiency related traits

Reference Number	Title	Description	Details	ShortDetails	Identifiers
1	The genetic and biological basis of feed efficiency in mid-lactation Holstein dairy cows.	Hardie LC, VandeHaar MJ, Tempelman RJ, Weigel KA, Armentano LE, Wiggans GR, Veerkamp RF, de Haas Y, Coffey MP, Connor EE, Hanigan MD, Staples C, Wang Z, Dekkers JCM, Spurlock DM.	J Dairy Sci. 2017 Nov;100(11):9061-9075. doi: 10.3168/jds.2017-12604. Epub 2017 Aug 23.	J Dairy Sci. 2017	PMID:28843688
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