

## Supplementary materials

### Unveiling genotype-phenotype associations of GRAM domain proteins using GWAS, PheWAS and literature review in cattle, human, pig, mouse and chicken

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**Supplementary Table S1.** Gene symbols and chromosome locations for *GRAMD* genes in five vertebrate species.

Cattle		Pig		Human		Mouse		Chicken	
Gene symbol	Chromosome	pig	Chromosome	Gene symbol, alias name	Chromosome	Gene symbol, alias name	Chromosome	Gene symbol, alias name	Chromosome
<i>GRAMD1A</i>	18	<i>GRAMD1A</i>	6	<i>GRAMD1A</i> , <i>Aster-A</i>	19	<i>Gramd1a</i>	7	No ortholog	/
<i>GRAMD1B</i>	15	<i>GRAMD1B</i>	9	<i>GRAMD1B</i> , <i>Aster-B</i>	11	<i>Gramd1b</i>	9	<i>GRAMD1B</i>	24
<i>GRAMD1C</i>	1	<i>GRAMD1C</i>	13	<i>GRAMD1C</i> , <i>Aster-C</i>	3	<i>Gramd1c</i>	X	<i>GRAMD1C</i>	1
<i>GRAMD2A</i>	10	<i>GRAMD2A</i>	7	<i>GRAMD2A</i>	15	<i>Gramd2a</i> , <i>Gramd2</i>	9	<i>GRAMD2</i> <i>GRAMD2A</i>	10
<i>GRAMD2B</i>	7	<i>GRAMD2B</i>	2	<i>GRAMD2B</i>	5	<i>Gramd2b</i> , <i>Gramd3</i>	18	<i>GRAMD2B</i>	Z
<i>GRAMD4</i>	5	<i>GRAMD4</i>	5	<i>GRAMD4</i>	22	<i>Gramd4</i>	15	<i>GRAMD4</i>	1

**Supplementary Table S2.** Results of the association analysis between *GRAMD1B* SNP rs41761360 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Teat thickness	-0,0049	0,2945	0,004903	742	1,71276	8,10726	91,88446
Rump angle	-0,00516	0,2945	0,005163	1083	2,49988	9,82959	90,16303
Overall rump	-0,00416	0,2945	0,004156	1211	2,79535	10,86415	89,12859
Rump length	-0,00401	0,2945	0,00401	1901	4,38807	15,87324	84,12025
Heel height	-0,0039	0,2945	0,003898	2959	6,83025	22,02394	77,97037
Rump height	-0,00357	0,2945	0,003574	3042	7,02184	23,25505	76,73931
Rear udder height	-0,00312	0,2945	0,003118	3707	8,55685	25,87893	74,11578
Udder depth	-0,00374	0,2945	0,003745	3736	8,62379	26,35659	73,63816
Longevity	-0,00278	0,2945	0,002783	5201	12,00545	33,59404	66,4013
Top line	-0,00273	0,2945	0,002725	5458	12,59868	34,48244	65,513
Thurl placement	-0,0024	0,2945	0,002404	6568	15,16089	39,60594	60,38981
Overall feet/legs score	-0,00245	0,2945	0,002445	7721	17,82235	44,04748	55,94859
Calving interval	-0,00207	0,2945	0,002072	9503	21,93574	51,44127	48,55523
Foot angle	-0,00237	0,2945	0,002373	9707	22,40663	51,84077	48,15576
Milking speed	-0,0022	0,2945	0,002201	10260	23,68312	53,85248	46,14416
Rear-leg set	0,002052	0,2945	0,002052	11542	26,64235	57,51725	42,47961
Overall frame	-0,00161	0,2945	0,001613	13885	32,05069	65,10607	34,89121
Overall udder score	-0,00142	0,2945	0,001415	17135	39,55265	72,68504	27,31266
Rear teat placement	-0,00132	0,2945	0,001322	17478	40,3444	73,77226	26,22551
Sum (points)	-0,00124	0,2945	0,001237	17644	40,72757	74,07811	25,91967
Fore udder attachment	-0,00098	0,2945	0,000975	21635	49,93998	82,08768	17,91056
Front teat length	0,001132	0,2945	0,001132	23335	53,86409	85,03186	14,96655
Scs (log2n)	0,001051	0,2945	0,001051	24588	56,75638	86,54824	13,45026
Body depth	0,000923	0,2945	0,000923	25214	58,20138	87,79663	12,20197
Protein yield td	-0,00084	0,2945	0,000835	26432	61,01288	89,27908	10,7196
Front teat placement	-0,0008	0,2945	0,000801	26992	62,30553	90,02168	9,97706
Milk yield td	-0,00042	0,2945	0,000419	34312	79,20225	97,09217	2,90717
Rump width	-0,00035	0,2945	0,000353	35100	81,02119	97,5564	2,44301
Chest width	-0,00037	0,2945	0,000367	35419	81,75754	97,71592	2,28349
Hock quality	0,000333	0,2945	0,000333	35605	82,18688	97,83188	2,16755
Udder balance	-0,00017	0,2945	0,000169	39084	90,21744	99,36358	0,63611
Rear teat direction	-0,00013	0,2945	0,000129	40640	93,80915	99,73612	0,26368
Udder cleft depth	-9,7E-05	0,2945	9,71E-05	41332	95,40649	99,85238	0,14748
Fat yield td	4,36E-05	0,2945	4,36E-05	42375	97,81404	99,96647	0,03346
Fore udder length	-1,8E-05	0,2945	1,82E-05	42918	99,06745	99,99418	0,0058
Rear udder width	-1,3E-05	0,2945	1,35E-05	43012	99,28443	99,99678	0,0032

**Supplementary Table S3.** Results of the association analysis between *GRAMD1B* SNP rs109709275 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Fat yield td	-0,00369	0,7502	0,003694	2617	6,04081	20,21531	79,77879
Calving interval	0,003241	0,7502	0,003241	3430	7,91746	25,12208	74,87245
Rump height	0,003402	0,7502	0,003402	3515	8,11366	25,86083	74,1338
Rump angle	0,003581	0,7502	0,003581	4028	9,29782	27,62449	72,37039
Milk yield td	-0,00327	0,7502	0,003273	4104	9,47325	28,24709	71,74782
Overall udder score	-0,0029	0,7502	0,002905	5036	11,62458	32,79526	67,20002
Front teat length	0,003357	0,7502	0,003357	5047	11,64997	33,40014	66,59515
Fore udder attachment	-0,00233	0,7502	0,002325	6808	15,71488	40,98461	59,01119
Fore udder length	-0,00268	0,7502	0,002676	6938	16,01496	41,25329	58,74258
Top line	0,002233	0,7502	0,002233	8403	19,39661	46,64559	53,35067
Overall rump	0,001994	0,7502	0,001994	9703	22,3974	51,74095	48,25557
Rear udder width	-0,00218	0,7502	0,002184	10419	24,05014	53,97597	46,02069
Protein yield td	-0,00208	0,7502	0,002081	10780	24,88343	55,28863	44,70809
Milking speed	-0,00213	0,7502	0,002127	10854	25,05424	55,80904	44,18772
Hock quality	0,001782	0,7502	0,001782	11983	27,66031	58,88893	41,10803
Longevity	-0,00176	0,7502	0,001764	12529	28,92064	60,73292	39,26412
Rump width	-0,00171	0,7502	0,001706	12806	29,56004	61,65832	38,33879
Thurl placement	0,001561	0,7502	0,001561	13824	31,90988	64,43125	35,56599
Scs (log2n)	-0,00171	0,7502	0,001709	15949	36,81501	69,75879	30,23877
Rump length	0,001326	0,7502	0,001326	18264	42,15872	75,23024	24,76761
Teat thickness	0,001239	0,7502	0,001239	18554	42,82812	76,23165	23,76626
Heel height	0,001378	0,7502	0,001378	19671	45,40649	78,19852	21,79947
Front teat placement	-0,00111	0,7502	0,001108	21816	50,35779	82,25086	17,7474
Rear teat direction	-0,00103	0,7502	0,00103	23646	54,58197	85,22757	14,77085
Overall feet/legs score	-0,00087	0,7502	0,000872	25604	59,10161	88,05863	11,93997
Rear teat placement	-0,0008	0,7502	0,000799	25931	59,85642	88,69103	11,30762
Rear udder height	-0,00068	0,7502	0,000675	28601	66,01957	91,87504	8,12381
Udder balance	-0,00051	0,7502	0,00051	30888	71,29865	94,40238	5,5967
Foot angle	0,000604	0,7502	0,000604	31409	72,50127	94,83624	5,16288
Udder depth	-0,0006	0,7502	0,000598	32094	74,08245	95,3957	4,60346
Overall frame	0,000478	0,7502	0,000478	32354	74,68261	95,68689	4,3123
Rear-leg set	-0,00051	0,7502	0,000508	32936	76,02604	96,02775	3,97148
Udder cleft depth	-0,00031	0,7502	0,00031	36766	84,86681	98,45448	1,54505
Sum (points)	-9E-05	0,7502	9,03E-05	41071	94,80403	99,81904	0,1808
Body depth	6,08E-05	0,7502	6,08E-05	42046	97,05461	99,94091	0,05899
Chest width	5,17E-05	0,7502	5,17E-05	42173	97,34777	99,95302	0,0469

**Supplementary Table S4.** Results of the association analysis between *GRAMD1B* SNP rs41763278 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Front teat length	0,007855	0,3886	0,007855	192	0,44319	2,44891	97,54007
Rump angle	-0,00467	0,3886	0,004672	1667	3,84793	13,92687	86,06645
Fore udder length	-0,00404	0,3886	0,004045	2190	5,05517	17,47833	82,51543
Udder cleft depth	-0,00354	0,3886	0,003538	3522	8,12982	25,31198	74,68266
Calving interval	0,002588	0,3886	0,002588	6110	14,10369	38,18258	61,81305
Udder balance	-0,00209	0,3886	0,002088	8506	19,63437	47,51701	52,47923
Overall rump	-0,00209	0,3886	0,002091	8912	20,57153	48,92107	51,07527
Teat thickness	0,002062	0,3886	0,002062	9499	21,9265	51,55637	48,44015
Longevity	-0,00176	0,3886	0,001765	12524	28,9091	60,71813	39,27891
Rear-leg set	0,001877	0,3886	0,001877	13141	30,33332	62,31431	37,68282
Thurl placement	-0,00153	0,3886	0,001532	14155	32,67393	65,33541	34,66188
Hock quality	0,001426	0,3886	0,001426	16198	37,38978	70,36038	29,63719
Rump width	-0,00127	0,3886	0,001272	18261	42,15179	75,28681	24,71104
Milking speed	-0,00127	0,3886	0,001274	20081	46,35289	79,13516	20,8629
Sum (points)	0,000905	0,3886	0,000905	23082	53,28009	84,4924	15,50597
Fat yield td	-0,00092	0,3886	0,00092	24740	57,10724	86,94225	13,05628
Top line	-0,00081	0,3886	0,000814	26008	60,03416	88,58572	11,41291
Front teat placement	-0,00081	0,3886	0,000815	26735	61,71229	89,69413	10,30459
Body depth	0,000771	0,3886	0,000771	27798	64,16601	91,13021	8,86862
Rear udder height	-0,00069	0,3886	0,000687	28369	65,48405	91,60722	8,39162
Rear teat direction	-0,00074	0,3886	0,000745	28376	65,50021	91,65208	8,34677
Fore udder attachment	-0,00063	0,3886	0,000626	28437	65,64101	91,81882	8,18005
Chest width	0,000657	0,3886	0,000657	29676	68,50099	93,06243	6,93653
Foot angle	0,000705	0,3886	0,000705	29690	68,53331	93,19225	6,80672
Overall udder score	-0,00059	0,3886	0,000593	30621	70,68233	93,98686	6,01217
Overall feet/legs score	0,000519	0,3886	0,000519	32291	74,53719	95,48365	4,51551
Scs (log2n)	0,000514	0,3886	0,000514	33526	77,38793	96,42768	3,57158
Milk yield td	-0,00031	0,3886	0,000314	36501	84,25511	98,34068	1,65883
Protein yield td	0,000273	0,3886	0,000273	37447	86,43876	98,74971	1,24986
Rear udder width	-0,00028	0,3886	0,000276	37521	86,60957	98,79139	1,20819
Rump length	-0,00026	0,3886	0,000258	37612	86,81963	98,81386	1,18572
Rump height	0,00026	0,3886	0,00026	37704	87,03199	98,85671	1,14287
Udder depth	-0,00019	0,3886	0,000185	39662	91,55164	99,52878	0,47096
Overall frame	-7,1E-05	0,3886	7,05E-05	41574	95,9651	99,89483	0,10506
Heel height	-3,8E-05	0,3886	3,76E-05	42563	98,248	99,97806	0,02189
Rear teat placement	2,08E-05	0,3886	2,08E-05	42883	98,98666	99,99198	0,00798

**Supplementary Table S5.** Results of the association analysis between *GRAMD1B* SNP rs41756499 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Rump length	-0,00505	0,2524	0,005048	749	1,72891	7,55279	92,43902
Chest width	-0,00335	0,2524	0,003348	3611	8,33526	25,46208	74,53259
Overall frame	-0,00289	0,2524	0,002893	4639	10,70819	31,61881	68,37632
Rump height	-0,00269	0,2524	0,002686	6389	14,7477	39,53287	60,46289
Front teat length	-0,00288	0,2524	0,002879	7221	16,66821	42,8829	57,11306
Body depth	-0,00255	0,2524	0,002547	7872	18,17091	45,31182	54,6843
Protein yield td	-0,00239	0,2524	0,00239	8396	19,38045	46,91373	53,0825
Foot angle	-0,00253	0,2524	0,002533	8615	19,88597	47,93148	52,06481
Fat yield td	-0,0023	0,2524	0,002297	8731	20,15373	48,29675	51,69958
Teat thickness	-0,00214	0,2524	0,002135	8933	20,62001	49,55157	50,44482
Scs (log2n)	0,002526	0,2524	0,002526	8940	20,63617	48,9073	51,0891
Fore udder length	-0,00231	0,2524	0,002306	9293	21,45099	50,29307	49,70337
Udder depth	-0,00234	0,2524	0,002341	10723	24,75186	55,12187	44,87485
Heel height	-0,00211	0,2524	0,002107	11844	27,33946	58,54204	41,45489
Milk yield td	-0,00195	0,2524	0,001953	12137	28,01579	59,70466	40,2923
Longevity	0,001725	0,2524	0,001725	12943	29,87628	61,94373	38,05338
Sum (points)	-0,00123	0,2524	0,001231	17735	40,93763	74,27983	25,71795
Overall rump	-0,00123	0,2524	0,001234	18222	42,06177	75,34868	24,64916
Overall udder score	-0,00129	0,2524	0,001288	18791	43,37519	76,31112	23,68679
Rear udder width	0,001369	0,2524	0,001369	18945	43,73067	76,67186	23,32605
Overall feet/legs score	-0,00093	0,2524	0,000932	24568	56,71022	86,55517	13,44333
Fore udder attachment	-0,00079	0,2524	0,000791	24999	57,70509	87,43791	12,56067
Top line	0,000754	0,2524	0,000754	27084	62,51789	89,9984	10,00034
Rear teat placement	-0,00068	0,2524	0,000685	28159	64,99931	91,47823	8,52061
Thurl placement	-0,00051	0,2524	0,000507	31304	72,2589	94,7159	5,2832
Rear teat direction	0,000398	0,2524	0,000398	35011	80,81575	97,45993	2,53946
Rump width	-0,00031	0,2524	0,000313	36007	83,11481	98,06763	1,93184
Milking speed	-0,00028	0,2524	0,000284	37334	86,17792	98,71248	1,28709
Rump angle	-0,00029	0,2524	0,000291	37682	86,98121	98,83123	1,16836
Calving interval	0,000206	0,2524	0,000206	38413	88,66857	99,15222	0,84744
Rear-leg set	-0,00023	0,2524	0,000232	38524	88,9248	99,15689	0,84275
Rear udder height	0,00018	0,2524	0,00018	39146	90,36056	99,35574	0,64396
Front teat placement	0,000186	0,2524	0,000186	39284	90,6791	99,41652	0,58319
Udder cleft depth	-0,00015	0,2524	0,000148	40195	92,78196	99,64137	0,35841
Udder balance	0,000117	0,2524	0,000117	40339	93,11435	99,68638	0,31341
Hock quality	-3,5E-05	0,2524	3,49E-05	42532	98,17645	99,97641	0,02353

**Supplementary Table S6.** Results of the association analysis between *GRAMD1B* SNP rs41757840 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Overall udder score	-0,00473	0,6411	0,004727	982	2,26675	9,24628	90,74605
Fore udder attachment	-0,00411	0,6411	0,004109	1156	2,66839	10,6162	89,37639
Overall feet/legs score	-0,0042	0,6411	0,004199	1593	3,67712	13,46867	86,52458
Udder depth	-0,00469	0,6411	0,004695	1732	3,99797	14,66067	85,33275
Sum (points)	-0,00361	0,6411	0,003612	1886	4,35345	15,50036	84,49315
Rump length	-0,00399	0,6411	0,003995	1928	4,45039	16,04848	83,94504
Fore udder length	-0,00402	0,6411	0,004024	2218	5,1198	17,65284	82,34095
Overall frame	-0,00305	0,6411	0,003046	4048	9,34398	28,66318	71,33169
Milking speed	-0,00273	0,6411	0,002735	6739	15,55561	40,69088	59,30496
Rump height	-0,00245	0,6411	0,002447	7728	17,83851	44,95219	55,04395
Teat thickness	0,002067	0,6411	0,002067	9449	21,81109	51,38202	48,61449
Calving interval	0,001954	0,6411	0,001954	10475	24,1794	54,74396	45,25274
Chest width	-0,00208	0,6411	0,002081	10550	24,35252	54,29817	45,69852
Protein yield td	-0,00196	0,6411	0,001962	11794	27,22404	58,5176	41,47931
Milk yield td	-0,00192	0,6411	0,001924	12381	28,57901	60,44028	39,55672
Overall rump	-0,00163	0,6411	0,001631	13294	30,68649	63,09113	36,90602
Body depth	-0,00174	0,6411	0,001741	14523	33,52338	66,6166	33,38075
Foot angle	-0,00178	0,6411	0,00178	14839	34,2528	67,28193	32,71547
Front teat length	0,001827	0,6411	0,001827	14955	34,52057	67,84849	32,14894
Udder balance	-0,00142	0,6411	0,001424	15109	34,87604	68,08566	31,91177
Udder cleft depth	-0,00165	0,6411	0,001649	15731	36,3118	69,46926	30,52824
Rump angle	0,001588	0,6411	0,001588	17481	40,35132	73,43787	26,55986
Rear udder width	0,001371	0,6411	0,001371	18925	43,6845	76,63002	23,36788
Front teat placement	-0,00128	0,6411	0,001279	19298	44,5455	77,51528	22,4827
Heel height	-0,00136	0,6411	0,001361	19892	45,91662	78,64013	21,35788
Fat yield td	-0,00115	0,6411	0,001153	20995	48,46267	80,74599	19,25216
Hock quality	-0,00105	0,6411	0,001052	21615	49,89382	81,74564	18,25256
Rear teat placement	0,000926	0,6411	0,000926	23630	54,54503	85,34924	14,64919
Scs (log2n)	0,000943	0,6411	0,000943	26264	60,62509	88,93005	11,06861
Rear udder height	-0,00075	0,6411	0,000754	27052	62,44402	89,99812	10,0006
Thurl placement	0,000625	0,6411	0,000625	28786	66,44661	92,19796	7,80093
Rump width	-0,00043	0,6411	0,000433	33417	77,13633	96,43794	3,56133
Rear teat direction	0,000328	0,6411	0,000328	36441	84,11662	98,25774	1,74176
Rear-leg set	-0,00025	0,6411	0,000249	38171	88,10997	99,02709	0,97253
Top line	3,21E-05	0,6411	3,21E-05	42608	98,35188	99,98049	0,01946
Longevity	-2,8E-05	0,6411	2,78E-05	42660	98,47191	99,9848	0,01515

**Supplementary Table S7.** Results of the association analysis between *GRAMD1C* SNP rs41616212 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Heel height	0,005595	0,6091	0,005595	695	1,60427	6,95771	93,03413
Rump width	0,004754	0,6091	0,004754	784	1,8097	7,71795	92,27401
Udder depth	0,005486	0,6091	0,005486	940	2,1698	9,05763	90,93467
Sum (points)	0,004112	0,6091	0,004112	1145	2,643	10,37791	89,61471
Top line	-0,00412	0,6091	0,004124	1450	3,34703	12,43097	87,56212
Rump height	0,004398	0,6091	0,004398	1503	3,46937	13,70097	86,29209
Longevity	0,003792	0,6091	0,003792	2000	4,61659	16,34464	83,649
Rear teat direction	0,004011	0,6091	0,004011	2280	5,26291	18,15226	81,84157
Chest width	0,003708	0,6091	0,003708	2576	5,94617	19,6705	80,3236
Rear udder height	0,00347	0,6091	0,00347	2650	6,11698	19,99245	80,00166
Overall udder score	0,003436	0,6091	0,003436	3133	7,23189	23,06419	76,93023
Foot angle	0,003291	0,6091	0,003291	4763	10,99441	31,68567	68,30952
Overall frame	0,002705	0,6091	0,002705	5455	12,59175	35,46346	64,53198
Rear teat placement	0,002542	0,6091	0,002542	6386	14,74078	39,36344	60,63227
Thurl placement	-0,00241	0,6091	0,002406	6555	15,13088	39,55071	60,44504
Calving interval	-0,00248	0,6091	0,002479	6728	15,53022	40,82598	59,16983
Overall feet/legs score	0,002381	0,6091	0,002381	8153	18,81954	45,72183	54,27434
Fore udder attachment	0,002099	0,6091	0,002099	8328	19,22349	47,03459	52,96163
Milking speed	0,002329	0,6091	0,002329	9346	21,57333	50,69987	49,29658
Rump length	0,002062	0,6091	0,002062	10273	23,71312	53,65072	46,34594
Rump angle	-0,0023	0,6091	0,002301	10680	24,6526	54,72527	45,27144
Hock quality	-0,00188	0,6091	0,001884	10962	25,30354	55,7029	44,29389
Overall rump	0,001504	0,6091	0,001504	14724	33,98735	67,0042	32,99317
Udder cleft depth	-0,00172	0,6091	0,001716	14988	34,59674	67,57623	32,42117
Scs (log2n)	-0,00174	0,6091	0,001741	15631	36,08098	68,97657	31,02094
Protein yield td	0,001522	0,6092	0,001522	16379	37,80758	71,0121	28,9855
Body depth	0,001536	0,6091	0,001536	16726	38,60856	72,10791	27,88975
Front teat placement	0,001464	0,6091	0,001464	16865	38,92941	72,2579	27,73979
Udder balance	0,00118	0,6091	0,00118	18413	42,50265	75,82119	24,17668
Fat yield td	-0,00119	0,6091	0,001189	20432	47,1631	79,69128	20,30682
Rear udder width	0,001258	0,6091	0,001258	20462	47,23235	79,70948	20,2886
Milk yield td	0,001063	0,6091	0,001063	22877	52,80689	84,17851	15,81983
Teat thickness	0,000936	0,6091	0,000936	23367	53,93795	85,02839	14,97003
Rear-leg set	0,000964	0,6091	0,000964	24775	57,18803	86,92212	13,07641
Fore udder length	0,000468	0,6091	0,000468	33468	77,25405	96,47507	3,52421
Front teat length	7,73E-05	0,6091	7,73E-05	41812	96,51447	99,91615	0,08374

**Supplementary Table S8.** Results of the association analysis between *GRAMD2A* SNP rs109872173 and 36 traits in cattle.

Trait	Snp Effect	Base Freq	Snp W	Rang	Prang	Sum Up	Sum Down
Calving interval	0,004068	0,2468	0,004068	1587	3,66327	13,878	86,11513
Thurl placement	-0,00298	0,2468	0,002978	3839	8,86155	26,73915	73,25559
Body depth	-0,00308	0,2468	0,003079	5164	11,92004	33,77483	66,22048
Longevity	0,002645	0,2468	0,002645	5876	13,56355	36,66471	63,33086
Hock quality	-0,00219	0,2468	0,002186	8380	19,34352	46,76992	53,22636
Protein yield td	-0,00229	0,2469	0,002285	9133	21,08167	49,62742	50,36898
Fore udder length	-0,0022	0,2468	0,002197	10084	23,27686	53,04201	46,9546
Rump length	-0,00205	0,2468	0,002045	10424	24,06168	54,15365	45,84303
Rear udder width	-0,00214	0,2468	0,00214	10776	24,8742	55,15326	44,84348
Top line	0,001904	0,2468	0,001904	11178	25,80213	56,22273	43,77408
Heel height	0,001727	0,2468	0,001727	15578	35,95864	68,95489	31,04259
Fat yield td	-0,00156	0,2468	0,001556	15621	36,05789	69,18412	30,8134
Scs (log2n)	0,001663	0,2468	0,001663	16443	37,95531	70,94681	29,05082
Udder depth	0,001662	0,2468	0,001662	16845	38,88325	72,09125	27,90642
Milk yield td	-0,00138	0,2468	0,001376	18402	42,47726	75,73241	24,26545
Sum (points)	-0,00112	0,2468	0,001121	19402	44,78556	77,80114	22,19684
Overall feet/legs score	-0,00119	0,2468	0,001191	20508	47,33853	79,64257	20,35551
Rear-leg set	0,000913	0,2468	0,000913	25579	59,0439	88,07483	11,92377
Rump height	-0,00081	0,2468	0,000806	26773	61,80001	89,79705	10,20167
Fore udder attachment	0,000696	0,2468	0,000696	26895	62,08162	89,98238	10,01637
Chest width	-0,00079	0,2468	0,000792	27212	62,81335	90,22173	9,77701
Teat thickness	-0,0007	0,2468	0,000701	27798	64,16601	91,14249	8,85632
Rump angle	0,000672	0,2468	0,000672	30651	70,75158	93,99549	6,00355
Front teat length	0,000609	0,2468	0,000609	31676	73,11758	95,11958	4,87956
Rear udder height	-0,00044	0,2468	0,000438	33391	77,07631	96,37261	3,62665
Foot angle	0,000429	0,2468	0,000429	34773	80,26638	97,36745	2,63192
Front teat placement	-0,0004	0,2468	0,000395	34842	80,42565	97,39315	2,60622
Rear teat direction	-0,00036	0,2468	0,000357	35835	82,71779	97,93789	2,06156
Rump width	0,000285	0,2468	0,000285	36695	84,70292	98,41518	1,58434
Rear teat placement	-0,00024	0,2468	0,000239	37770	87,18434	98,86902	1,13058
Overall frame	-0,0002	0,2468	0,000195	38681	89,2872	99,25017	0,7495
Overall rump	-0,00016	0,2468	0,000159	39442	91,04381	99,45685	0,54287
Udder cleft depth	-0,00013	0,2468	0,00013	40591	93,69604	99,7247	0,2751
Overall udder score	5,6E-05	0,2468	5,6E-05	42160	97,31776	99,94531	0,0546
Milking speed	-3,9E-05	0,2468	3,86E-05	42503	98,10951	99,97632	0,02363
Udder balance	1,76E-06	0,2468	1,76E-06	43272	99,88459	99,99991	0,00009



**Supplementary Table S9.** Results of the association analysis between *GRAMD2B* SNP rs43504641 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Rump height	-0,00444	0,2784	0,004441	1451	3,34934	13,33795	86,65504
Front teat placement	0,0043	0,2784	0,0043	1598	3,68866	14,13251	85,86071
Rump width	-0,00368	0,2784	0,003676	2229	5,14519	17,77977	82,21402
Rump angle	-0,004	0,2784	0,003995	2926	6,75407	21,67199	78,3223
Chest width	-0,00356	0,2784	0,003565	2942	6,79101	21,78594	78,20838
Calving interval	0,003415	0,2784	0,003415	2943	6,79332	22,38867	77,60557
Milking speed	-0,00369	0,2784	0,003692	3083	7,11648	23,12246	76,87191
Rump length	-0,00292	0,2784	0,002922	4959	11,44684	32,60745	67,38781
Overall frame	-0,00261	0,2784	0,002609	5940	13,71128	37,63238	62,36323
Overall feet/legs score	0,002511	0,2784	0,002511	7302	16,85518	42,38001	57,61596
Udder cleft depth	-0,00257	0,2784	0,002569	7764	17,92161	44,52149	55,47462
Fore udder length	0,002008	0,2784	0,002008	11613	26,80624	57,99762	41,99928
Sum (points)	-0,00156	0,2784	0,001562	13451	31,04889	63,5949	36,4023
Overall rump	-0,0016	0,2784	0,001596	13657	31,5244	64,11452	35,88269
Rear udder width	0,001762	0,2784	0,001762	14371	33,17252	65,80172	34,19559
Body depth	-0,00176	0,2784	0,001755	14382	33,19791	66,24134	33,75599
Fore udder attachment	0,001423	0,2784	0,001423	15000	34,62444	67,86412	32,13331
Thurl placement	-0,00145	0,2784	0,001451	15168	35,01223	68,00449	31,99294
Fat yield td	0,001522	0,2784	0,001522	16005	36,94428	70,12904	29,86852
Rear teat placement	0,001394	0,2784	0,001394	16512	38,11458	71,55889	28,43876
Protein yield td	0,001263	0,2784	0,001263	19661	45,38341	78,20493	21,79308
Front teat length	0,001406	0,2784	0,001406	19707	45,48959	78,58365	21,41437
Longevity	0,00109	0,2784	0,00109	21219	48,97973	81,18189	18,81628
Top line	-0,00105	0,2784	0,00105	22058	50,91639	82,43318	17,56506
Rear udder height	-0,00101	0,2784	0,001005	22539	52,02668	83,28534	16,71295
Milk yield td	0,001075	0,2784	0,001075	22678	52,34754	83,84759	16,15074
Udder depth	-0,00119	0,2784	0,001188	22716	52,43525	83,77737	16,22096
Hock quality	0,000831	0,2784	0,000831	25473	58,79922	87,92456	12,07402
Rear teat direction	0,000723	0,2784	0,000723	28816	66,51586	92,14891	7,84998
Heel height	0,000575	0,2784	0,000575	32059	74,00166	95,37894	4,62023
Scs (log2n)	0,000499	0,2784	0,000499	33784	77,98347	96,61423	3,38506
Teat thickness	-0,00016	0,2784	0,000163	39463	91,09229	99,47388	0,52585
Rear-leg set	0,000175	0,2784	0,000175	39698	91,63474	99,52119	0,47854
Udder balance	0,000113	0,2784	0,000113	40436	93,33826	99,70647	0,29332
Overall udder score	-4,8E-05	0,2784	4,81E-05	42360	97,77942	99,96216	0,03776
Foot angle	-3,6E-05	0,2784	3,57E-05	42518	98,14413	99,97839	0,02156

**Supplementary Table S10.** Results of the association analysis between *GRAMD2B* SNP rs110898337 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Thurl placement	0,004059	0,8508	0,004059	1280	2,95462	11,24702	88,74581
Overall rump	0,003077	0,8508	0,003077	3648	8,42066	25,83136	74,16326
Milking speed	-0,00327	0,8508	0,003269	4396	10,14727	30,05163	69,94339
Udder depth	0,002916	0,8508	0,002916	7034	16,23655	41,61432	58,38159
Top line	0,002415	0,8508	0,002415	7183	16,58049	41,89628	58,09967
Rear-leg set	-0,00249	0,8508	0,002488	8161	18,838	45,86568	54,13052
Fore udder length	-0,00225	0,8508	0,002245	9733	22,46665	51,83846	48,15807
Overall frame	0,001864	0,8508	0,001864	11321	26,13222	57,617	42,37986
Rear udder height	0,00174	0,8508	0,00174	12541	28,94834	60,49012	39,50693
Rump length	0,001673	0,8508	0,001673	14036	32,39924	64,99677	35,00052
Rump height	0,001574	0,8508	0,001574	15516	35,81552	69,10508	30,89244
Front teat length	0,001553	0,8508	0,001553	17953	41,44084	74,94691	25,05091
Fore udder attachment	0,001204	0,8508	0,001204	17994	41,53548	74,94868	25,04915
Scs (log2n)	0,001526	0,8508	0,001526	18041	41,64397	74,57743	25,42039
Teat thickness	0,001238	0,8508	0,001238	18568	42,86044	76,26092	23,73699
Rear teat direction	-0,00129	0,8508	0,00129	19739	45,56346	78,27283	21,72519
Rear teat placement	0,001043	0,8508	0,001043	21663	50,00462	82,08372	17,91452
Udder cleft depth	-0,00096	0,8508	0,000956	24941	57,57121	87,34595	12,6526
Front teat placement	0,000871	0,8508	0,000871	25741	59,41785	88,37205	11,62658
Fat yield td	-0,00084	0,8508	0,000837	26199	60,47505	88,99072	11,00794
Rump angle	0,000915	0,8508	0,000915	26543	61,2691	89,34584	10,65286
Udder balance	0,00059	0,8508	0,00059	29197	67,39532	92,72554	7,2734
Longevity	0,00063	0,8508	0,00063	29391	67,84313	92,84785	7,1511
Foot angle	0,000708	0,8508	0,000708	29646	68,43174	93,14682	6,85215
Calving interval	0,000561	0,8508	0,000561	30555	70,52998	94,11286	5,88619
Overall feet/legs score	0,000484	0,8508	0,000484	33010	76,19685	96,06318	3,93604
Rump width	-0,00042	0,8508	0,000416	33774	77,96039	96,694	3,3053
Overall udder score	-0,00043	0,8508	0,000427	34019	78,52592	96,78894	3,21037
Rear udder width	-0,00045	0,8508	0,000445	34026	78,54208	96,86524	3,13408
Protein yield td	-0,0002	0,8508	0,000197	39094	90,24052	99,35923	0,64046
Body depth	0,00012	0,8508	0,00012	40842	94,27543	99,77702	0,2228
Chest width	-8,6E-05	0,8508	8,57E-05	41416	95,60039	99,86994	0,12992
Heel height	8,17E-05	0,8508	8,17E-05	41644	96,12668	99,89835	0,10153
Hock quality	-6,8E-05	0,8508	6,83E-05	41744	96,35751	99,90817	0,09171
Milk yield td	-5,1E-05	0,8508	5,13E-05	42197	97,40317	99,95464	0,04528
Sum (points)	8,36E-06	0,8508	8,36E-06	43103	99,49448	99,99824	0,00174

**Supplementary Table S11.** Results of the association analysis between *GRAMD4* SNP rs109247065 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Top line	-0,006	0,2415	0,006004	219	0,50552	2,58355	97,4064
Fat yield td	-0,00456	0,2415	0,004563	1177	2,71686	10,85216	89,14055
Chest width	0,004185	0,2415	0,004185	1661	3,83408	13,9462	86,04714
Hock quality	-0,00368	0,2415	0,003676	2088	4,81972	16,98123	83,01251
Milk yield td	-0,00326	0,2415	0,003259	4164	9,61174	28,55191	71,44302
Overall feet/legs score	-0,00307	0,2415	0,003073	4420	10,20267	29,53943	70,45563
Teat thickness	-0,00276	0,2415	0,002761	5108	11,79078	33,90669	66,08865
Front teat length	-0,00329	0,2415	0,003293	5311	12,25936	34,63167	65,36371
Thurl placement	0,002633	0,2415	0,002633	5338	12,32168	34,14145	65,8539
Rump length	0,00271	0,2415	0,00271	5930	13,6882	37,03202	62,96358
Fore udder attachment	0,002397	0,2415	0,002397	6405	14,78464	39,26954	60,72614
Milking speed	-0,00251	0,2415	0,002508	8106	18,71105	46,13798	53,8582
Rump height	0,002286	0,2415	0,002286	8798	20,30839	48,94498	51,05141
Rear-leg set	0,002352	0,2415	0,002352	9047	20,88315	49,14348	50,85293
Longevity	-0,00206	0,2415	0,002064	9777	22,56821	51,92475	48,07179
Rump width	0,002037	0,2415	0,002037	9798	22,61668	52,17862	47,81794
Udder depth	0,00239	0,2415	0,00239	10365	23,92549	53,93328	46,06337
Protein yield td	-0,00195	0,2415	0,001951	11894	27,45487	58,82581	41,17112
Rear udder height	-0,00169	0,2415	0,001688	13043	30,1071	61,94929	38,04785
Foot angle	-0,00162	0,2415	0,001623	16544	38,18845	71,51955	28,47808
Rear udder width	-0,00134	0,2415	0,001339	19349	44,66322	77,50616	22,4918
Overall frame	0,001168	0,2415	0,001168	19664	45,39033	78,53185	21,46618
Sum (points)	-0,00106	0,2415	0,001063	20387	47,05923	79,73408	20,26401
Body depth	0,001142	0,2415	0,001142	21892	50,53322	82,58648	17,41179
Rear teat direction	0,001112	0,2415	0,001112	22353	51,59734	83,09784	16,90045
Udder cleft depth	-0,00091	0,2415	0,000908	25703	59,33013	88,42139	11,57724
Overall rump	0,000761	0,2415	0,000761	26152	60,36656	89,01194	10,98673
Scs (log2n)	-0,00093	0,2415	0,000927	26536	61,25294	89,29266	10,70601
Calving interval	-0,00045	0,2415	0,000454	32780	75,66594	96,02067	3,97857
Rear teat placement	-0,00036	0,2415	0,000365	34880	80,51337	97,40401	2,59538
Front teat placement	-0,00036	0,2415	0,000362	35486	81,91219	97,77801	2,22142
Udder balance	0,000177	0,2415	0,000177	38879	89,74424	99,29962	0,70006
Rump angle	-0,00014	0,2415	0,000141	40587	93,68681	99,72645	0,27335
Fore udder length	5,09E-05	0,2415	5,09E-05	42203	97,41702	99,95645	0,04347
Heel height	-3,7E-05	0,2415	3,74E-05	42571	98,26647	99,9785	0,02145
Overall udder score	2,1E-05	0,2415	2,1E-05	42912	99,0536	99,99305	0,00692

**Supplementary Table S12.** Results of the association analysis between *GRAMD4* SNP rs109726105 and 36 traits in cattle.

Trait	SNP Effect	Base Freq	SNP W	Rang	Prang	Sum Up	Sum Down
Scs (log2n)	-0,006	0,3806	0,005998	617	1,42422	6,42073	93,57072
Rump length	0,005082	0,3806	0,005082	732	1,68967	7,4131	92,57866
Rear teat direction	-0,00524	0,3806	0,005245	781	1,80278	7,72927	92,26266
Rear udder width	0,004796	0,3806	0,004796	1175	2,71225	10,81256	89,18012
Rear teat placement	-0,00422	0,3806	0,004223	1389	3,20622	12,5021	87,49078
Milk yield td	0,004326	0,3806	0,004326	1639	3,7833	13,95545	86,03782
Milking speed	0,004029	0,3806	0,004029	2309	5,32986	18,58294	81,41092
Body depth	0,00405	0,3806	0,00405	2350	5,4245	18,76158	81,23226
Udder cleft depth	-0,00359	0,3806	0,003588	3384	7,81127	24,56727	75,4273
Rump height	0,003281	0,3806	0,003281	3889	8,97696	27,83442	72,1604
Teat thickness	0,003002	0,3806	0,003002	4090	9,44093	28,95911	71,03582
Fat yield td	0,003135	0,3806	0,003135	4292	9,90721	29,30906	70,68593
Udder depth	-0,00356	0,3806	0,003555	4356	10,05494	29,53162	70,4634
Hock quality	0,00287	0,3806	0,00287	4513	10,41734	30,3221	69,67301
Overall frame	0,002909	0,3806	0,002909	4573	10,55584	31,29616	68,69894
Foot angle	-0,00329	0,3806	0,003289	4768	11,00596	31,70972	68,28547
Calving interval	-0,00286	0,3806	0,002863	4805	11,09136	32,19292	67,80224
Protein yield td	0,002762	0,3806	0,002762	6203	14,31836	38,03942	61,95623
Top line	0,002539	0,3806	0,002539	6470	14,93468	38,93771	61,05804
Front teat placement	-0,00253	0,3806	0,002528	7334	16,92904	43,19536	56,80065
Longevity	-0,00228	0,3806	0,002281	8118	18,73875	45,89553	54,10065
Heel height	-0,00219	0,3806	0,002191	11130	25,69133	56,30323	43,69357
Fore udder length	0,002064	0,3806	0,002064	11143	25,72134	56,51954	43,47727
Thurl placement	-0,00147	0,3806	0,001473	14897	34,38669	67,30426	32,69314
Front teat length	0,001769	0,3806	0,001769	15555	35,90554	69,36226	30,63526
Chest width	0,001365	0,3806	0,001365	18245	42,11486	75,03747	24,96036
Fore udder attachment	0,001039	0,3806	0,001039	20573	47,48857	80,159	19,83913
Udder balance	-0,00098	0,3806	0,000976	21786	50,28854	82,36778	17,63046
Overall udder score	-0,00106	0,3806	0,00106	22231	51,31573	82,84649	17,15179
Rump width	0,000964	0,3806	0,000964	23161	53,46244	84,50476	15,49361
Rear udder height	0,000907	0,3806	0,000907	24247	55,96925	86,05008	13,94838
Sum (points)	0,000827	0,3806	0,000827	24463	56,46785	86,64415	13,35436
Overall rump	0,000538	0,3806	0,000538	30724	70,92009	94,19113	5,80792
Rear-leg set	0,000508	0,3806	0,000508	32918	75,98449	96,01377	3,98546
Rump angle	-0,00024	0,3806	0,000244	38575	89,04252	99,17252	0,82713
Overall feet/legs score	-0,00021	0,3806	0,000214	38614	89,13254	99,17099	0,82866

**Supplementary Table S13.** QTLs overlapping the *GRAMD1B* gene in QTLdb.

Data Type	Abbreviation	QTL ID	Trait Name	Chromosome	Breed	SNPs	Trait Class>>Type>>Trait Ontology
QTL	SEMVOL	9924	Semen volume	15:10848754-34870995 bp	Holstein		Reproduction>>semen quality>>Semen volume CMO:semen volume"
QTL	HEIGHT	10993	Body height"	15:29415621-42069918 bp	Angus		Production>>Growth>>Body height VT:body height CMO:body height"
QTL	SIGG	66191	Immunoglobulin G level	15:24184972-37358459 bp	Charolais, Holstein		Health>>Immune capacity>>Immunoglobulin G level VT:blood immunoglobulin G amount CMO:blood immunoglobulin G level"
QTL	FA-C13:0	19626	Tridecylic acid content	15:20-59060134 bp	Angus	rs41662110; rs81159416; rs81159430	Meat and Carcass>>Fatty acid content>>Tridecylic acid content PT:meat fatty acid C13:0 content"
QTL	RANG	1699	Rump angle	15:12367579-42062169 bp			Exterior>>conformation>>Rump angle VT:rump angle"
QTL	MFI	4836	Myofibrillar fragmentation index	15:24184972-37358459 bp			Meat and Carcass>>Sensory characteristics>>Myofibrillar fragmentation index PT:meat tenderness"
QTL	PP	21547	Milk protein percentage	15:27896796-47037097 bp	Holstein		Milk>>Milk composition - protein>>Milk protein percentage VT:milk protein amount PT:milk protein content CMO:milk protein percentage"
QTL	KPHCW T	1335	Kidney, pelvic, and heart fat percentage	15:16273131-53468859 bp			Meat and Carcass>>Fatness>>Kidney, pelvic, and heart fat percentage VT:internal adipose amount"
Association	MFA-C13:0	155975	Milk tridecylic acid content	15:34161889-34161893 bp	Holstein	rs385648690	Milk>>Milk composition - fat>>Milk tridecylic acid content PT:milk fatty acid C13:0 content"
Association	BWG	68783	Body weight gain	15:34205210-34205214 bp	Charolais, Gelbvieh, Hereford, Limousin, Pinzgauer, Red angus, Red poll, Simmental, Angus	rs41756499	Production>>Growth>>Body weight gain VT:postnatal growth trait CMO:body weight gain"
QTL	SCS	3416	Somatic cell score	15:27121885-37358459 bp			Health>>Mastitis>>Somatic cell score VT:milk somatic cell quantity PT:milk somatic cell count CMO:milk somatic cell score"
QTL	HDPH	3431	Heel depth	15:13948398-37358459 bp			Exterior>>Limb traits>>Heel depth VT:heel depth"
QTL	FERIND	62361	Fertility index	15:34139603-34139607 bp	Ayrshire, Danish red, Swedish Red-and-White	rs385244975; rs41763261; rs110960719	Reproduction>>Fertility>>Fertility index VT:female fertility trait"
Association	FERIND	62407	Fertility index	15:34139603-34139607 bp	Ayrshire, Danish red, Swedish Red-and-White	rs41763261	Reproduction>>Fertility>>Fertility index VT:female fertility trait"
Association	INSINT	62411	Interval from first to last insemination	15:34139603-34139607 bp	Ayrshire, Danish red, Swedish Red-and-White	rs41763261	Reproduction>>Fertility>>Interval from first to last insemination VT:female fertility trait"
Association	CALEST	62410	Interval to first estrus after calving	15:34164294-34164298 bp	Ayrshire, Danish red, Swedish Red-and-White	rs41763326	Reproduction>>Fertility>>Interval to first estrus after calving VT:female fertility trait"

Association	CONCEPT	62408	Inseminations per conception	15:34199597-34199601 bp	Ayrshire, Danish red, Swedish Red-and-White	rs110670590	Reproduction>>Fertility>>Inseminations per conception VT:fertility trait"
QTL	SB	5039	Stillbirth	15:34072836-34227818 bp	Ayrshire		Reproduction>>Fertility>>Stillbirth VT:stillborn offspring quantity"
QTL	LMA	10995	Longissimus muscle area	15:29415621-42069918 bp	Angus		Meat and Carcass>>Anatomy>>Longissimus muscle area VT:longissimus thoracis muscle area"
QTL	CWT	10994	Carcass weight	15:29415621-42069918 bp	Angus		Meat and Carcass>>Anatomy>>Carcass weight PT:dressed carcass weight CMO:carcass weight"
QTL	LIVP	12195	Liver percentage	Chr.15:30275772-57056696 bp	Jersey, Limousin		Liver percentage VT:liver mass CMO:liver weight to body weight ratio"

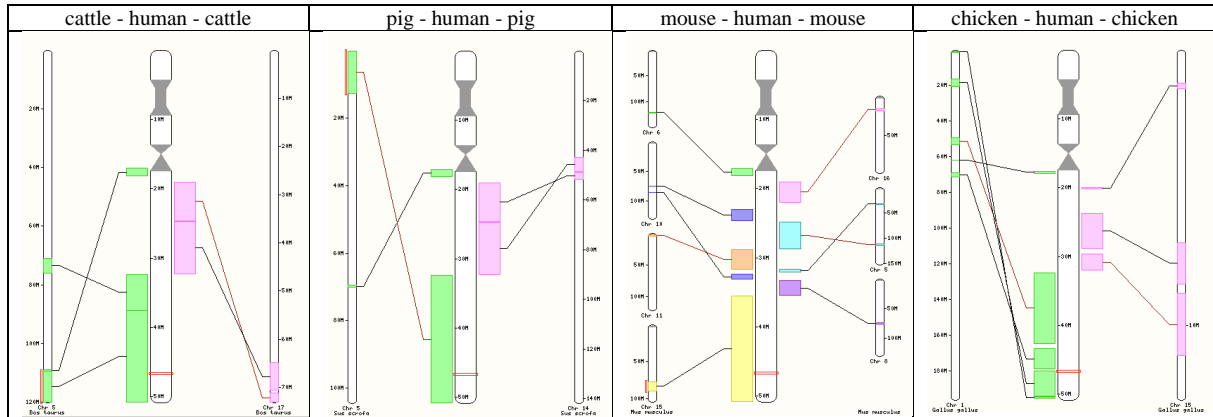
Legend: QTL: Quantitative trait locus

**Supplementary Table S14.** Gene ontology terms for six *GRAMD* genes in five vertebrate species: cattle (C), human (H), mouse (M), pig (P), chicken (Ch).

GO term	GO term name	<i>GRAMD1A</i>	<i>GRAMD1B</i>	<i>GRAMD1C</i>	<i>GRAMD2A</i>	<i>GRAMD2B</i>	<i>GRAMD4</i>
	<b>Biological process</b>						
GO:0006869	lipid transport	C, H, M, P	C, H, M, P	H, M, P, Ch			
GO:0006914	autophagy	H, M					
GO:0006915	apoptotic process						C, H, M, P, Ch
GO:0015918	sterol transport		C, H	C, P			
GO:0032366	intracellular sterol transport	C, H, M, P	C, H, M, P	H, M			
GO:0034164	negative regulation of toll-like receptor 9 signaling pathway						C, H, M, P, Ch
GO:0042632	cholesterol homeostasis		C, H, M, P				
GO:0043280	positive regulation of cysteine-type endopeptidase activity involved in apoptotic process						H
GO:0061817	endoplasmic reticulum-plasma membrane tethering				C, H, M, Ch		
GO:0071397	cellular response to cholesterol	C, H, M	C, H, M, P	C, H, M, P, Ch			
GO:0120009	intermembrane lipid transfer	C, H, M, P	C, H, M, P	C, H, M, P			
GO:2001256	regulation of store-operated calcium entry				C, H, M, Ch		
	<b>Cellular component</b>						
GO:0005739	mitochondrion						C, H, M, P, Ch
GO:0005776	autophagosome	H, M					
GO:0005783	endoplasmic reticulum	H, M	C, H, M, P	H, M	H, M		H, M
GO:0005789	endoplasmic reticulum membrane	C, H, M, P	C, H, M, P	C, H, M, P, Ch	C, H, M, Ch		H, M
GO:0005829	cytosol	CHMP					
GO:0005881	cytoplasmic microtubule					C, H, M, P, Ch	
GO:0005886	plasma membrane	C, H, M, P	C, H, M, P	C, H, M, P, Ch	C, H, M, Ch		
GO:0016020	membrane	C, H, M, P	C, H, M, P	C, H, M, P, Ch	C, H, M	C, P	C, H, M, P
GO:0031234	extrinsic component of cytoplasmic side of plasma membrane				C, H, M		
GO:0031410	cytoplasmic vesicle	H, M					
GO:0031966	mitochondrial membrane						H, M
GO:0043231	intracellular membrane-bounded organelle		C, H, M, P				
GO:0044232	organelle membrane contact site	C, H, M, P	C, H, M, P	H, M, P, Ch	C, H, M, Ch		
GO:0140268	endoplasmic reticulum-plasma membrane contact site	C, H, M, P	C, H, M, P	C, H, M, P, Ch			
	<b>Molecular function</b>						
GO:0001786	phosphatidylserine binding		C, H, M, P				
GO:0003674	molecular function					M	H
GO:0005515	protein binding	H		H	H	H	H, M
GO:0005546	phosphatidylinositol-4,5-bisphosphate binding				C, H, M, Ch		
GO:0008289	lipid binding	H, M	H, M	H, M	H, M		
GO:0015485	cholesterol binding	C, H, M, P	C, H, M, P	C, H, M, P, Ch			
GO:0035091	phosphatidylinositol binding				C, H, M, Ch		
GO:0042802	identical protein binding					C, H, M, P, Ch	

GO:0070300	phosphatidic acid binding		C, H, M, P				
GO:0120020	cholesterol transfer activity	C, H, M, P	C, H, M, P	C, H, M, P, Ch			

**Supplementary Figure S1.** Synteny between human chromosome 22 with *GRAMD4* gene and chromosomes in cattle, pig, mouse and chicken. Legend: Syntenic blocks are shown in different colors (pink, green, purple, turquoise, orange, and yellow), red line denotes the location of the *GRAMD4* gene.



**Supplementary Figure S2.** Nucleotide sequence of the transcript ENSBTAT00000074465.2 (*GRAMD1B-205*). (from 5' UTR to intron 2). rs109709275 is in intron 1 (orange color).

		gcccgggtgctctgatccctctccccgggctgcctgactgccacagcctatccccggtgccccgggtgaaatgggccagagaggaagcggtagtgcactgcgagcagagcggcctgtccctgtggcaggaaacctagagtgatgaatgggcccggatgaagtcacctgtctctccaatcaggctgtccagagagatccaggggctctgcagatccagcgggtgcgggtgct
ENSBTAE00000607223	109	CTCATGTACCTTTAGACAGGCTGTGAGTCTCTGGGAGTGGAGTGGGGGGTGCAGCCGCCGCCCCGCTCCTGTGTAGCCCTCAGTCAGTCTGAATGTATTGCAAG
Intron 1-2	586	gtgagtggtctaccgggctattcctctccctctgcattctcggccttgctgcccggcctgtggtctctggcactccttgacagcacttctgcttccatctgaggcctgccccttcttctgagcttctcacaccgcacccaccgcccctcagccttctccctcttgctacccccggaactgtcagcaccggccagctggcctctcccacgagctcccctgcctgacctgtgggtaccaattggcccgggtgatgggagggcagggccttcatctctgtgagctctccccagcagggggagccctggcgagaCctgcaacttaactcctgggaagaagggcccttgactcagcccgaagtgggctctgtgggaaacacgggcaggccccgcacatgcccgggggacccaaggtctttgtctcccacccdcagccgagggaggtcccgggccaagcttggaaacaggtctctcattcccagccttcagaggggtgctgttcttctgtgggtggactttgtgactctgctttctctcttcttcttggagggcgcgctgccccttag
ENSBTAE00000625991	76	GCCAAGCCGCAATCATGGAGCCGGCTGATATGGCGACAGCAAAGGTAGGATGGAAATGCTGCCGGCCGCACTGTGC
Intron 2-3	66,969	gtaagtggcttgccttggcgagttctacctcgttcacttctctcctcctctgtcccacagcccctccctccgggagagtaccagggaccgtgtcagagtggaggggaaatggcagaagtgagcctcggaggggaggaaggccggcctccagtgcactgcctcactctgtgtgctggaagcctggggggggggcggtgactgtactgtgattggctgacctgtgtgtgcatgtcttctcttagctttgcctcggtttccttgaccttatacctgtgtcttttctcacccttctcccttattctctctgctcctcccgcactgcagtgctgtct



**Supplementary Figure S3.** Multispecies alignment of the nucleotide sequence flanking the SNP rs109709275 (genomic location 15:34109932- 34109992).



**Supplementary Figure S4.** Location of the *GRAMD1B* SNP rs109709275 within constrained element with the score 576.40 and extending 164 bp.

