

Analysis of Singlestep GTa-BLUP for Nordic Holstein cattle

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Based on Nordic Holstein cattle several analyses are made to examine how well singlestep GTa-BLUP perform.

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Singlestep is run with a GTa-BLUP where foreign information is included. There are three models:

- Full model with all information
- Reduc: Daughters after Viking bulls (Status 1) born after 2011 not included with own record
- Reduc2: Females calved after 2016 own record removed.

1. Most extreme cases of difference between single-step GEBV and EBV

For non-genotyped cows with own record born after 2009 the difference between single-step and EBV is calculated and the most extreme cases are examined.

Most extreme cases of difference for Chest width:

	nav_id	ssGEBV3	EBV3	ssGEBV20	EBV20	Stature	Body de	Chest wi	Dairy for	Top line	Rump wi	Rump ar	Rear leg	Rear leg	Hock qu	Bone qu	Foot ang	Fore udc	Rear udc	Rear udc	Udder cl	Udder de	Test len	Test thic	Test pla	Test pla	Udder balance
	1011558224	114	97	99	100	1	8	17	-4	-1	7	1	-3	6	-6	-7	-3	10	-1	3	-5	-1	-1	-3	3	2	-1
	1310051631	105	91	88	93	1	4	14	-2	-4	-3	-3	0	-3	-4	-9	3	3	-2	2	4	-5	2	4	1	3	-3
	1014870581	126	113	96	100	0	6	13	-2	-5	-2	5	1	-2	1	-3	4	0	-2	2	2	-4	4	4	-4	-3	-3
	1016372259	112	98	100	103	3	2	13	-2	-5	1	-6	-8	0	-9	-9	1	3	-4	-1	-2	-2	-1	-2	-2	0	0
	1308957680	105	93	87	87	2	9	12	-4	3	1	4	2	-5	-2	-5	-4	2	-4	0	2	0	-4	-3	4	3	4
	1309604409	126	114	78	81	1	4	12	-5	4	0	-1	-5	-3	-8	-10	1	5	1	6	-1	-2	0	1	-2	-2	-1
	1310349533	103	91	107	107	1	6	11	2	-5	-2	0	-3	-3	-5	-5	3	6	4	3	3	1	-1	0	6	4	6
	1015133848	101	90	87	90	2	9	11	0	-1	5	-1	-8	10	1	-5	1	-1	5	5	4	-3	1	4	2	0	9
	1013018414	118	107	91	93	0	3	11	-1	0	2	3	0	-1	-7	-3	6	2	1	2	6	-2	0	6	2	3	8
	1012376188	110	100	95	92	0	3	11	0	-3	0	3	-5	6	-5	-5	1	3	4	-2	-2	3	0	-1	0	0	2

	nav_id	ssGEBV3	EBV3	ssGEBV20	EBV20	Stature	Body de	Chest wi	Dairy for	Top line	Rump wi	Rump ar	Rear leg	Rear leg	Hock	qu	Bone	qu	Foot	ang	Fore	udc	Rear	udc	Rear	udc	Udder	cl	Udder	de	Test	len	Test	thic	Test	pla	Test	pla	Udder	bal		
	1211097106	87	101	98	96	-1	-8	-14	2	2	-5	2	7	-3	7	8	-3	-1	1	4	-1	2	4	-1	0	2	7															
	1210135505	86	99	102	97	3	-10	-13	-3	0	0	4	-3	-9	6	1	3	-2	0	-6	-1	5	4	-1	4	3	2															
	1309225382	83	95	90	90	1	-5	-12	6	-1	-2	7	6	-4	4	8	-4	-8	1	2	7	1	0	1	-1	2	3															
	1015647496	101	113	100	97	0	-6	-12	4	1	-1	2	5	-6	3	0	-5	-1	4	0	2	3	-2	-2	3	6	-2															
	1211348785	86	98	102	102	-2	-5	-12	1	6	-10	-6	-4	-8	3	5	-1	-2	1	-2	2	0	-2	2	2	0	-5															
	1211770202	91	102	98	100	1	-1	-12	3	-4	-2	-7	4	-1	3	3	3	1	-4	2	6	-3	3	1	3	3	-2															
	1210142265	95	107	88	85	-2	-10	-12	3	1	-8	1	4	0	4	5	-2	-4	6	2	5	3	3	3	3	2	4	1														
	1210204236	79	91	99	100	2	-6	-11	4	2	-7	5	7	-2	6	10	0	-3	3	-2	-2	-1	0	7	-1	1	-6															
	1015651172	84	95	99	98	0	-3	-11	2	2	-4	0	-1	-2	7	1	0	-3	3	0	8	0	-3	-2	2	5	5															
	1014188670	91	102	109	107	-1	-3	-11	4	-2	0	4	1	-2	4	5	3	3	9	2	-5	2	-6	-9	0	-1	1															

1310051631 The mother is genotyped and have a big diff3

1308957680 This cow has two daughters which are genotyped and have big diff3

1012376188 This cow has three daughters, and two of those are genotyped and have big diff3

Most extreme cases for udder depth:

nav_id	ssGEBV3	EBV3	ssGEBV20	EBV20	Stature	Body de	Chest wi	Dairy for	Top line	Rump wi	Rump ar	Rear leg	Rear leg	Hock qu	Bone qu	Foot ang	Fore udc	Rear udc	Rear udc	Udder cl	Udder de	Test len	Test thic	Test pla	Test pla	Udder bal
1210732963	100	102	99	85	3	-6	-2	0	1	-3	-2	3	5	2	-1	-2	4	8	3	-2	13	-5	-4	5	6	7
1310240508	92	90	106	95	0	-1	1	6	7	2	0	1	-7	-1	4	4	3	3	-2	1	12	0	9	2	4	4
1308978333	98	105	112	102	3	-7	-7	0	2	-5	3	-6	-5	3	1	6	0	1	-3	2	10	1	1	4	7	1
1013071278	108	112	102	93	2	-5	-4	3	5	0	-4	-3	2	3	1	2	5	5	1	-4	10	0	0	-1	-1	1
1211527460	113	115	96	86	2	-5	-1	2	0	1	3	0	6	1	3	2	1	7	3	-2	10	0	-2	3	1	1
1211794001	102	99	116	106	4	-5	3	-1	0	5	-3	-4	-1	-8	-2	4	7	5	3	-3	10	2	1	2	-1	3
1212105222	105	101	110	100	3	-5	3	-1	0	5	-3	-4	0	-7	-2	5	7	5	3	-3	10	2	1	2	0	3
1309498078	104	102	105	96	5	0	2	2	-2	4	-6	-4	0	-7	-1	5	12	6	0	-7	9	2	3	-3	-2	8
1309114208	87	91	104	95	2	-10	-4	0	7	1	0	-1	-5	3	3	0	4	-1	-5	0	9	-4	-3	-4	-2	-4
1309420912	90	94	88	79	5	-9	-4	2	1	2	-1	-4	-3	7	6	3	7	7	0	0	9	0	-2	0	1	-1

nav_id	ssGEBV3	EBV3	ssGEBV20	EBV20	Stature	Body de	Chest wi	Dairy for	Top line	Rump wi	Rump ar	Rear leg	Rear leg	Hock	qu Bone	qu Foot	ang	Fore udc	Rear udc	Rear udc	Udder cl	Udder de	Test len	Test thic	Test pla	Test pla	Udder bal
1308940346	94	101	84	92	-2	0	-7	-1	1	-1	0	1	1	4	4	2	-9	1	-1	5	-8	1	0	2	-1	-3	
1310028429	108	107	91	99	-8	-1	0	-1	-2	-3	5	5	7	1	-2	-9	-2	-1	8	1	-8	-3	4	5	-2	0	
1308899157	112	109	86	94	-3	4	3	-4	0	0	0	-4	-5	-4	-3	3	-5	-4	-2	-1	-8	-1	-1	1	-1	3	
1013177152	94	89	79	86	1	6	5	2	0	-3	-1	1	2	-2	-3	-9	-8	-5	-2	-3	-8	-3	-2	-5	-4	-5	
1014463698	114	112	96	104	-2	6	2	0	-3	0	4	6	1	3	2	0	2	-2	3	1	-8	-3	1	2	0	-2	
1016229042	103	100	84	92	-3	6	3	0	0	1	-5	7	3	0	-1	-3	-1	-5	2	3	-8	-1	2	-4	1	-3	
1011601723	125	125	83	92	-5	5	0	-4	-6	6	-3	4	4	1	1	-3	1	-6	-2	-1	-8	-2	-8	-3	-1	-10	
1212007082	99	102	102	111	-3	3	-4	5	4	0	-4	-1	3	-3	-2	2	-3	-6	-3	6	-8	-3	2	-1	4	-3	
1211915440	87	92	93	100	-2	0	-5	3	-1	-3	-2	7	2	8	5	-3	-5	-2	-1	-2	-8	-3	-1	0	1	-5	
1310544402	113	113	101	108	1	6	0	1	0	1	3	4	3	4	-1	1	-9	-4	-2	-2	-7	0	-1	-1	-1	-3	

As shown in those four tables there are some cows (without genotype, with own records) where the difference between singlestep GEBV and EBV are either strongly positive or strongly negative. When looking into some of the cases it turns out that those cows have close relatives with a genotype and with high difference. In a single-step this can affect both if it is a daughter or if it is the mother – thus both directions. Furthermore, there is a correlation between some traits, and therefor being highly negative for chest width also shows highly negative diff for “body depth” and “Rear legs, back rear view” (as an example).

2. Comparison of GTa-BLUP and twostep

Singlestep GEBV's are compared with GEBV's from a twostep model.
The pedigree is the same in all models.

Bulls are divided in four status groups

- status1 are Viking bulls
- status2 are international bulls
- status3 are bulls, which are tested but not selected
- status 4 has unknown status.

Results includes mean GEBV, STD of mean GEBV and correlations, and all results are shown both as table and as graph and for four groups of cattle.

UDKAST

Selected bulls (status1)

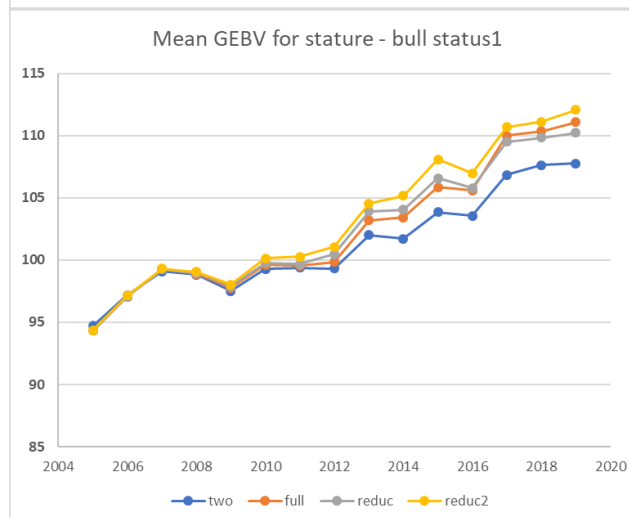
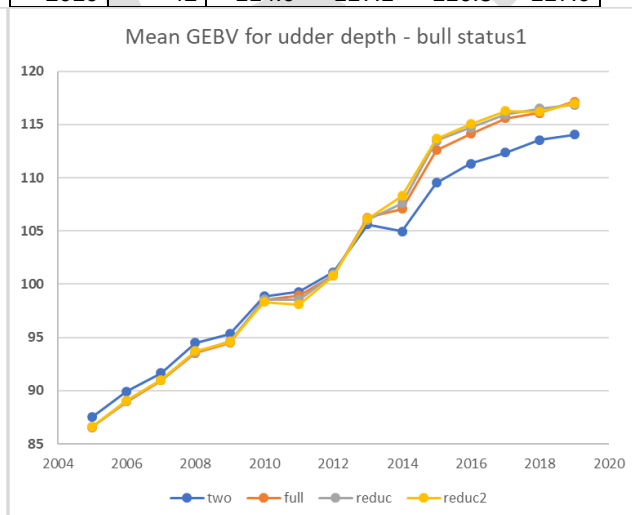
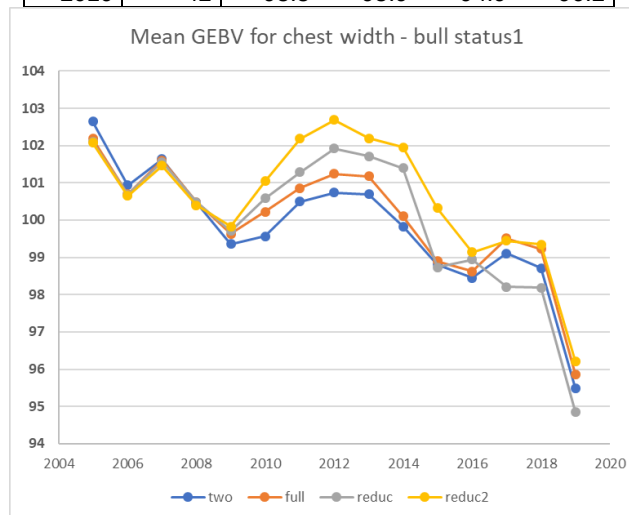
There is a tendency for bull (status1) that mean GEBV for twostep is lower than for singlestep for chest width and for udder depth. This is however not the case for udder depth in the period 2005-2012, where mean GEBV for twostep is higher than singlestep.

Table1.1: Chest Width: Mean GEBV for bulls Status1

b_year	N	Two	full	reduc	reduc2
2005	334	102.6	102.2	102.1	102.1
2006	383	100.9	100.7	100.7	100.6
2007	334	101.6	101.6	101.6	101.5
2008	293	100.5	100.5	100.5	100.4
2009	269	99.4	99.6	99.7	99.8
2010	226	99.6	100.2	100.6	101.0
2011	167	100.5	100.9	101.3	102.2
2012	172	100.7	101.2	101.9	102.7
2013	120	100.7	101.2	101.7	102.2
2014	104	99.8	100.1	101.4	102.0
2015	80	98.8	98.9	98.7	100.3
2016	66	98.4	98.6	98.9	99.1
2017	65	99.1	99.5	98.2	99.4
2018	89	98.7	99.2	98.2	99.3
2019	42	95.5	95.9	94.9	96.2

Table1.2: Udder Depth: Mean GEBV for bulls Status1

b_year	N	Two	full	reduc	reduc2
2005	334	87.5	86.5	86.6	86.6
2006	383	89.9	89.0	89.0	89.1
2007	334	91.7	91.0	91.0	91.0
2008	293	94.5	93.6	93.6	93.7
2009	269	95.3	94.5	94.7	94.6
2010	226	98.9	98.5	98.6	98.3
2011	167	99.3	98.9	98.6	98.1
2012	172	101.1	100.8	100.9	100.8
2013	120	105.6	106.3	106.0	106.1
2014	104	105.0	107.1	107.6	108.3
2015	80	109.5	112.6	113.5	113.6
2016	66	111.3	114.1	114.7	115.0
2017	65	112.3	115.6	115.9	116.3
2018	89	113.6	116.1	116.5	116.2
2019	42	114.0	117.1	116.8	117.0



There is a tendency that twostep is having lower STD of mean GEBV than singlestep. However, there are also exceptions of this tendency.

Table1.3: Chest Width: STD for Mean GEBV for bulls Status1

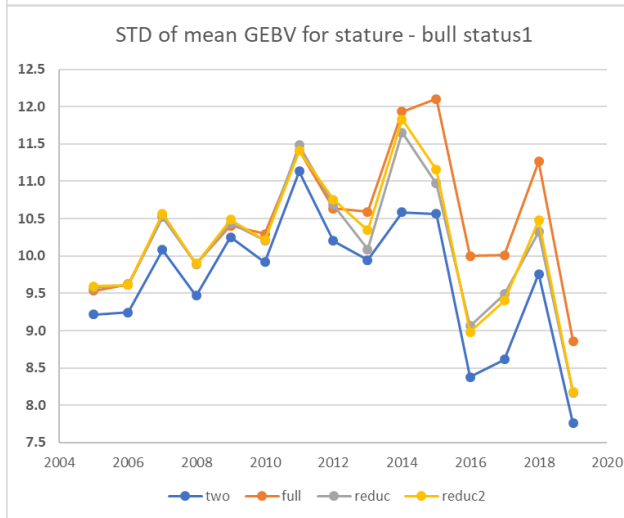
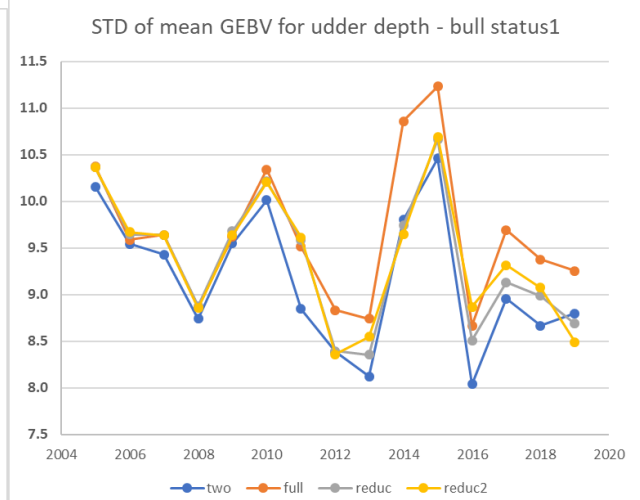
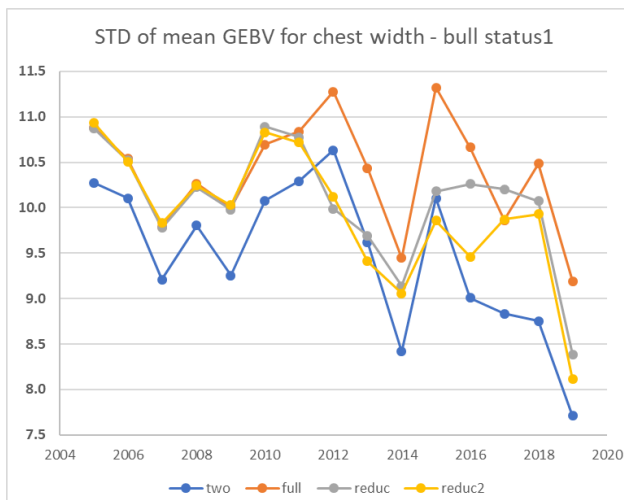
b_year	N	Two	full	reduc	reduc2
2005	334	10.3	10.9	10.9	10.9

Table1.4: Udder Depth: STD for Mean GEBV for bulls Status1

b_year	N	Two	full	reduc	reduc2
2005	334	10.2	10.4	10.4	10.4

2006	383	10.1	10.5	10.5	10.5
2007	334	9.2	9.8	9.8	9.8
2008	293	9.8	10.3	10.2	10.2
2009	269	9.3	10.0	10.0	10.0
2010	226	10.1	10.7	10.9	10.8
2011	167	10.3	10.8	10.8	10.7
2012	172	10.6	11.3	10.0	10.1
2013	120	9.6	10.4	9.7	9.4
2014	104	8.4	9.4	9.1	9.1
2015	80	10.1	11.3	10.2	9.9
2016	66	9.0	10.7	10.3	9.5
2017	65	8.8	9.9	10.2	9.9
2018	89	8.8	10.5	10.1	9.9
2019	42	7.7	9.2	8.4	8.1

2006	383	9.5	9.6	9.6	9.7
2007	334	9.4	9.6	9.6	9.6
2008	293	8.7	8.9	8.9	8.9
2009	269	9.5	9.6	9.7	9.6
2010	226	10.0	10.3	10.2	10.2
2011	167	8.8	9.5	9.6	9.6
2012	172	8.4	8.8	8.4	8.4
2013	120	8.1	8.7	8.4	8.5
2014	104	9.8	10.9	9.7	9.6
2015	80	10.5	11.2	10.7	10.7
2016	66	8.0	8.7	8.5	8.9
2017	65	9.0	9.7	9.1	9.3
2018	89	8.7	9.4	9.0	9.1
2019	42	8.8	9.3	8.7	8.5



The correlation between twostep and singlestep full model is stable and high for the period 2005 to 2020 for both traits, whereas the correlation for twostep/reduc and twostep/reduc2 is high until 2011 and then it decreases.

Table1.5: Chest Width: Corr between Twostep and Singlestep (full/reduc/reduc2) for bulls Status1

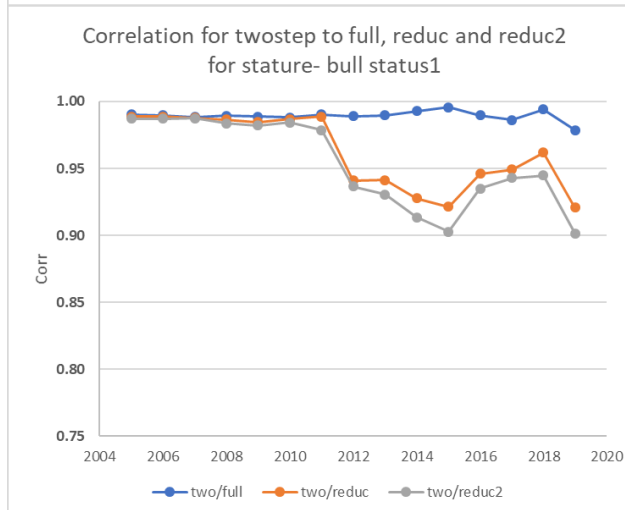
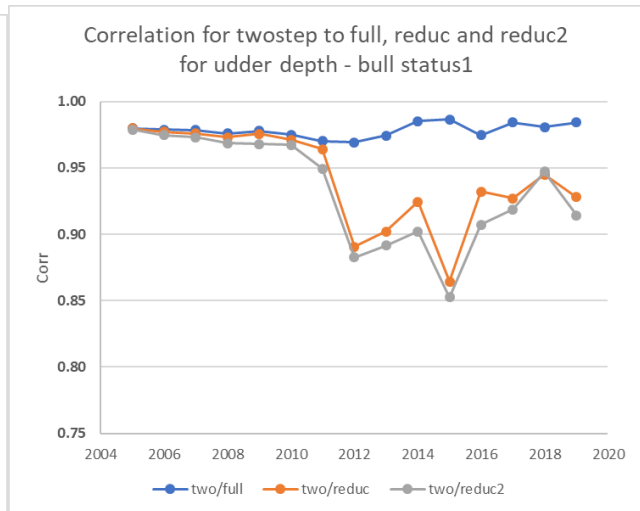
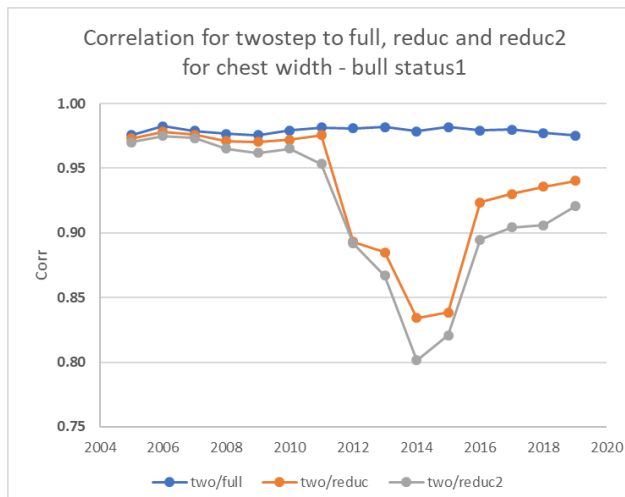
b_year	N	full	reduc	reduc2
2005	334	0.976	0.973	0.970
2006	383	0.983	0.978	0.975
2007	334	0.979	0.976	0.973
2008	293	0.977	0.971	0.965
2009	269	0.976	0.970	0.962
2010	226	0.979	0.972	0.965

Table1.6: Udder Depth: Corr between Twostep and Singlestep (full/reduc/reduc2) for bulls Status1

b_year	N	full	reduc	reduc2
2005	334	0.980	0.980	0.979
2006	383	0.979	0.977	0.975
2007	334	0.979	0.976	0.973
2008	293	0.976	0.973	0.968
2009	269	0.978	0.976	0.968
2010	226	0.975	0.971	0.967

2011	167	0.981	0.976	0.953
2012	172	0.981	0.893	0.892
2013	120	0.982	0.885	0.867
2014	104	0.979	0.834	0.801
2015	80	0.982	0.839	0.821
2016	66	0.979	0.924	0.895
2017	65	0.980	0.930	0.904
2018	89	0.977	0.936	0.906
2019	42	0.975	0.940	0.921

2011	167	0.970	0.964	0.949
2012	172	0.969	0.891	0.883
2013	120	0.974	0.902	0.892
2014	104	0.985	0.925	0.902
2015	80	0.986	0.864	0.852
2016	66	0.975	0.932	0.907
2017	65	0.984	0.927	0.919
2018	89	0.981	0.945	0.947
2019	42	0.984	0.928	0.914



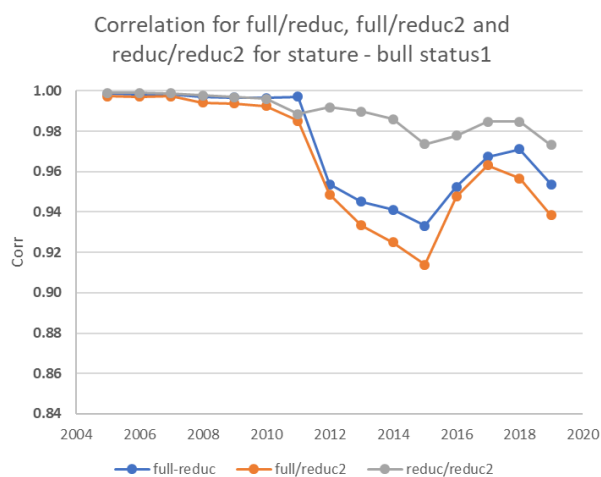
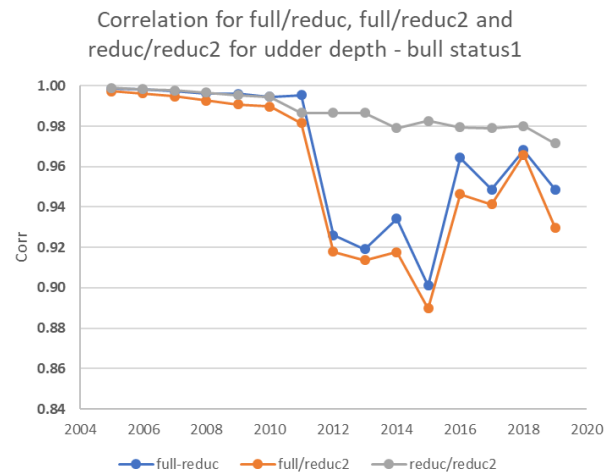
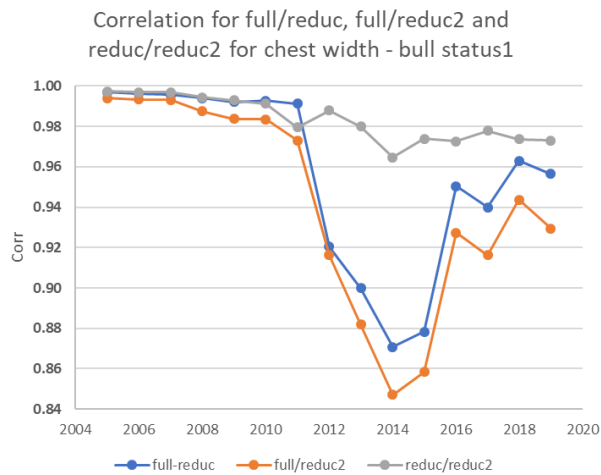
Correlations of mean GEBV between the three singlestep models show similarly high values until 2011. Then the correlation between full/reduc and between full/reduc2 decreases.

Table1.7: Chest Width: Corr between Singlestep (full/reduc og full/reduc2 and reduc/reduc2) for bulls Status1

b_year	N	full-reduc	full/re-duc2	reduc/re-duc2
2005	334	0.997	0.994	0.997
2006	383	0.996	0.993	0.997
2007	334	0.996	0.993	0.997
2008	293	0.994	0.988	0.994
2009	269	0.992	0.984	0.993
2010	226	0.993	0.984	0.991
2011	167	0.991	0.973	0.980
2012	172	0.920	0.916	0.988
2013	120	0.900	0.882	0.980
2014	104	0.871	0.847	0.965
2015	80	0.878	0.858	0.974
2016	66	0.950	0.927	0.973
2017	65	0.940	0.916	0.978
2018	89	0.963	0.944	0.974
2019	42	0.956	0.930	0.973

Table1.8: Udder Depth: Corr between Singlestep (full/reduc og full/reduc2 and reduc/reduc2) for bulls Status1

b_year	N	full-reduc	full/re-duc2	reduc/re-duc2
2005	334	0.999	0.997	0.999
2006	383	0.998	0.996	0.998
2007	334	0.997	0.995	0.998
2008	293	0.996	0.993	0.997
2009	269	0.996	0.991	0.995
2010	226	0.995	0.990	0.995
2011	167	0.995	0.981	0.987
2012	172	0.926	0.918	0.987
2013	120	0.919	0.914	0.987
2014	104	0.934	0.918	0.979
2015	80	0.901	0.890	0.983
2016	66	0.964	0.946	0.979
2017	65	0.949	0.941	0.979
2018	89	0.968	0.966	0.980
2019	42	0.949	0.930	0.971



Bulls Status134 (thus excl. Status2)

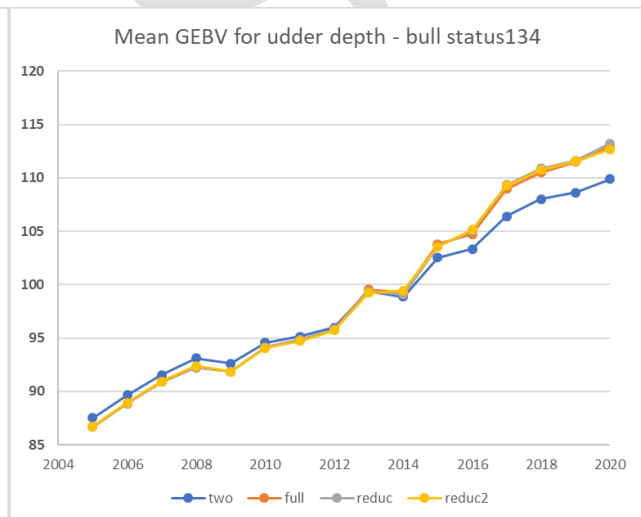
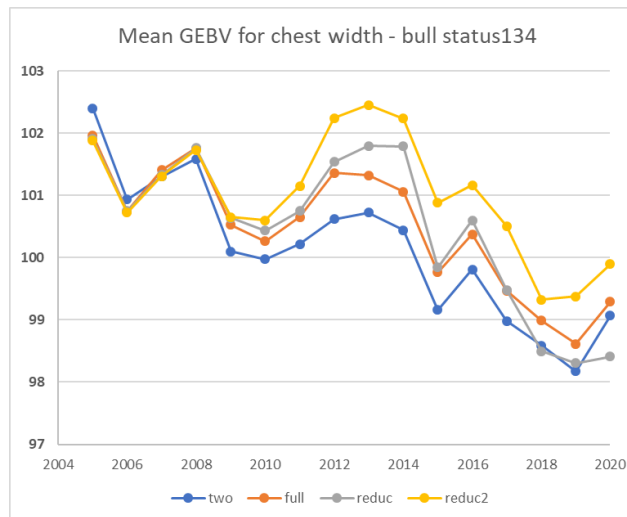
Mean GEBV for twostep is slightly lower than singlestep for chest width in period 2008-2020 and for udder depth in period 2013-2020. For chest width the reduc2 is having the highest mean GEBV.

Table2.1: Chest Width: Mean GEBV for bulls Status134

b_year	N	Two	full	reduc	reduc2
2005	361	102.4	102.0	101.9	101.9
2006	419	100.9	100.7	100.8	100.7
2007	480	101.3	101.4	101.3	101.3
2008	808	101.6	101.8	101.8	101.7
2009	1077	100.1	100.5	100.6	100.7
2010	1090	100.0	100.3	100.4	100.6
2011	1655	100.2	100.6	100.8	101.1
2012	2095	100.6	101.4	101.5	102.2
2013	2304	100.7	101.3	101.8	102.4
2014	3136	100.4	101.1	101.8	102.2
2015	2718	99.2	99.8	99.8	100.9
2016	2892	99.8	100.4	100.6	101.2
2017	3146	99.0	99.5	99.5	100.5
2018	2978	98.6	99.0	98.5	99.3
2019	3082	98.2	98.6	98.3	99.4
2020	815	99.1	99.3	98.4	99.9

Table2.2: Udder Depth: Mean GEBV for bulls Status134

b_year	N	Two	full	reduc	reduc2
2005	361	87.5	86.7	86.7	86.7
2006	419	89.7	88.8	88.9	88.9
2007	480	91.5	90.9	90.9	90.9
2008	808	93.1	92.2	92.3	92.4
2009	1077	92.6	91.8	91.9	91.8
2010	1090	94.6	94.1	94.1	94.1
2011	1655	95.1	94.8	94.8	94.7
2012	2095	96.0	95.8	95.8	95.7
2013	2304	99.4	99.6	99.3	99.3
2014	3136	98.9	99.3	99.1	99.4
2015	2718	102.6	103.8	103.6	103.6
2016	2892	103.3	104.7	105.0	105.2
2017	3146	106.4	109.0	109.3	109.3
2018	2978	108.0	110.5	110.9	110.7
2019	3082	108.6	111.5	111.6	111.6
2020	815	109.9	112.9	113.2	112.7



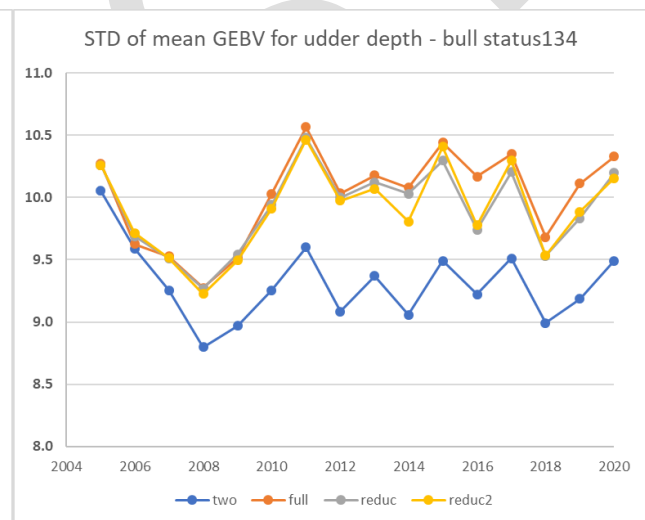
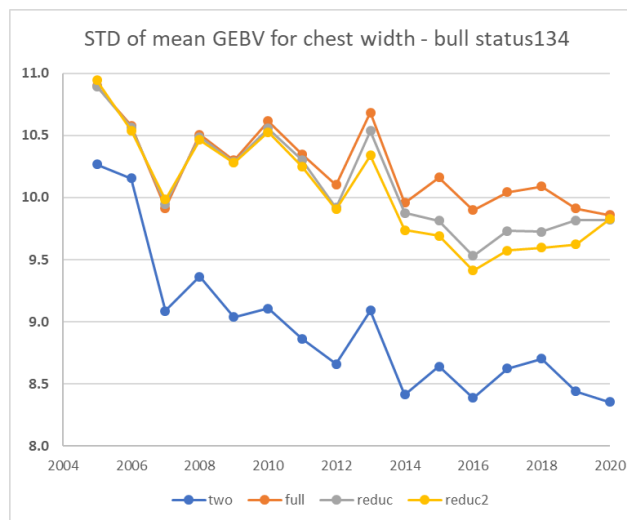
The STD of mean GEBV is lower for twostep than for singlestep for both traits.

Table2.3: Chest Width: STD for Mean GEBV for bulls Status134

b_year	N	Two	full	reduc	reduc2
2005	361	10.3	10.9	10.9	10.9
2006	419	10.2	10.6	10.6	10.5
2007	480	9.1	9.9	9.9	10.0
2008	808	9.4	10.5	10.5	10.5
2009	1077	9.0	10.3	10.3	10.3
2010	1090	9.1	10.6	10.6	10.5
2011	1655	8.9	10.4	10.3	10.3
2012	2095	8.7	10.1	9.9	9.9
2013	2304	9.1	10.7	10.5	10.3
2014	3136	8.4	10.0	9.9	9.7
2015	2718	8.6	10.2	9.8	9.7
2016	2892	8.4	9.9	9.5	9.4
2017	3146	8.6	10.0	9.7	9.6
2018	2978	8.7	10.1	9.7	9.6
2019	3082	8.4	9.9	9.8	9.6
2020	815	8.4	9.9	9.8	9.8

Table2.4: Udder Depth: STD for Mean GEBV for bulls Status134

b_year	N	Two	full	reduc	reduc2
2005	361	10.1	10.3	10.3	10.3
2006	419	9.6	9.6	9.7	9.7
2007	480	9.3	9.5	9.5	9.5
2008	808	8.8	9.3	9.3	9.2
2009	1077	9.0	9.5	9.5	9.5
2010	1090	9.3	10.0	9.9	9.9
2011	1655	9.6	10.6	10.5	10.5
2012	2095	9.1	10.0	10.0	10.0
2013	2304	9.4	10.2	10.1	10.1
2014	3136	9.1	10.1	10.0	9.8
2015	2718	9.5	10.4	10.3	10.4
2016	2892	9.2	10.2	9.7	9.8
2017	3146	9.5	10.4	10.2	10.3
2018	2978	9.0	9.7	9.5	9.5
2019	3082	9.2	10.1	9.8	9.9
2020	815	9.5	10.3	10.2	10.2



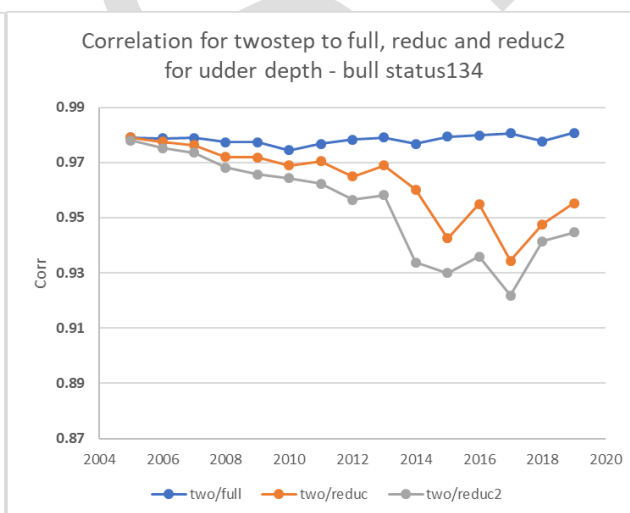
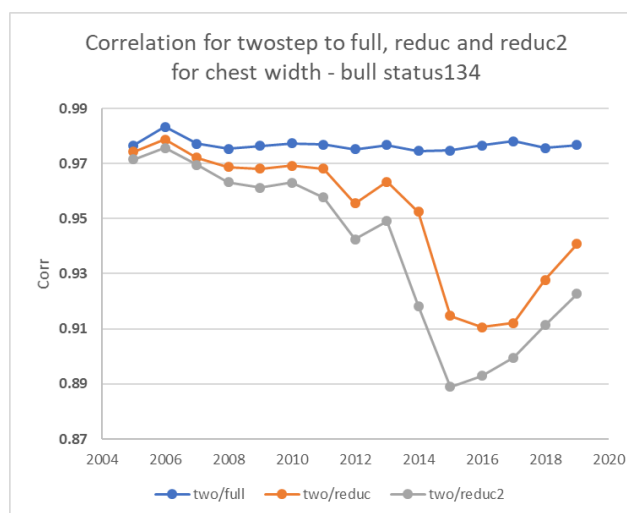
The correlation between twostep and full is stable and high for the period 2005-2020 for both traits. The correlation twostep/reduc and twostep/reduc2 is decreasing after 2011. It is decreasing more for chest width than for udder depth.

Table2.5: Chest Width: Corr between Twostep and Singlestep (full/reduc/reduc2) for bulls Status134

b_year	N	full	reduc	reduc2
2005	361	0.977	0.974	0.972
2006	419	0.983	0.979	0.976
2007	480	0.977	0.972	0.969
2008	808	0.975	0.969	0.963
2009	1077	0.976	0.968	0.961
2010	1090	0.977	0.969	0.963
2011	1655	0.977	0.968	0.958
2012	2095	0.975	0.956	0.943
2013	2304	0.977	0.963	0.949
2014	3136	0.975	0.952	0.918
2015	2718	0.975	0.915	0.889
2016	2892	0.977	0.911	0.893
2017	3146	0.978	0.912	0.900
2018	2978	0.976	0.928	0.911
2019	3082	0.977	0.941	0.923
2020	815	0.971	0.935	0.921

Table2.6: Udder Depth: Corr between Twostep and Singlestep (full/reduc/reduc2) for bulls Status134

b_year	N	full	reduc	reduc2
2005	361	0.979	0.979	0.978
2006	419	0.979	0.977	0.975
2007	480	0.979	0.976	0.973
2008	808	0.977	0.972	0.968
2009	1077	0.977	0.972	0.966
2010	1090	0.974	0.969	0.964
2011	1655	0.977	0.970	0.962
2012	2095	0.978	0.965	0.956
2013	2304	0.979	0.969	0.958
2014	3136	0.977	0.960	0.934
2015	2718	0.979	0.942	0.930
2016	2892	0.980	0.955	0.936
2017	3146	0.981	0.934	0.922
2018	2978	0.978	0.948	0.941
2019	3082	0.981	0.955	0.945
2020	815	0.982	0.956	0.932



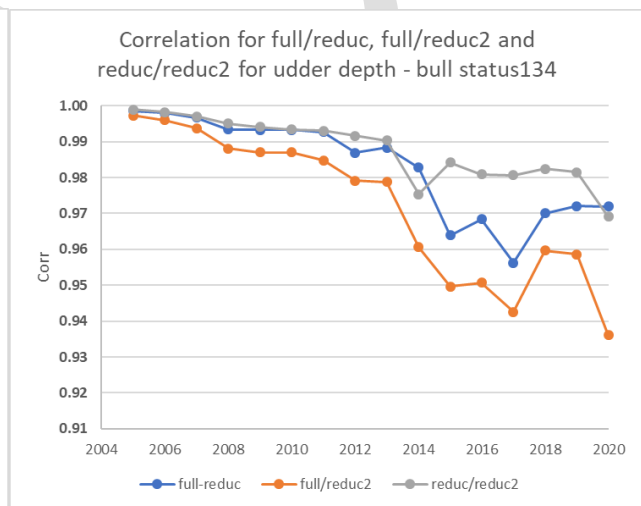
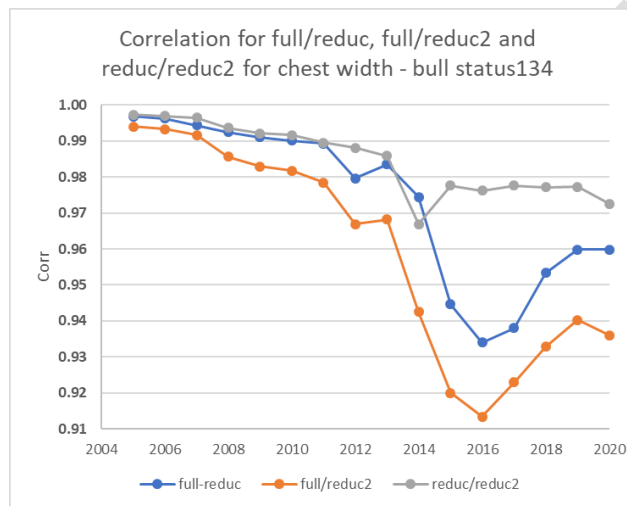
The highest correlations are seen between reduc/reduc2, while full/reduc2 is showing the lowest correlations. Generally, there is a decreasing correlation by year.

Table2.7: Chest Width: Corr between Singlestep (full/reduc and full/reduc2 and reduc/reduc2) for bulls Status134

b_year	N	full-reduc	full/re-reduc2	reduc/re-reduc2
2005	361	0.997	0.994	0.997
2006	419	0.996	0.993	0.997
2007	480	0.994	0.992	0.996
2008	808	0.992	0.986	0.994
2009	1077	0.991	0.983	0.992
2010	1090	0.990	0.982	0.992
2011	1655	0.989	0.978	0.990
2012	2095	0.980	0.967	0.988
2013	2304	0.984	0.968	0.986
2014	3136	0.974	0.943	0.967
2015	2718	0.945	0.920	0.978
2016	2892	0.934	0.913	0.976
2017	3146	0.938	0.923	0.978
2018	2978	0.953	0.933	0.977
2019	3082	0.960	0.940	0.977
2020	815	0.960	0.936	0.973

Table2.8: Udder Depth: Corr between Singlestep (full/reduc and full/reduc2 and reduc/reduc2) for bulls Status134

b_year	N	full-reduc	full/re-reduc2	reduc/re-reduc2
2005	361	0.999	0.997	0.999
2006	419	0.998	0.996	0.998
2007	480	0.997	0.994	0.997
2008	808	0.993	0.988	0.995
2009	1077	0.993	0.987	0.994
2010	1090	0.993	0.987	0.993
2011	1655	0.993	0.985	0.993
2012	2095	0.987	0.979	0.992
2013	2304	0.988	0.979	0.990
2014	3136	0.983	0.961	0.975
2015	2718	0.964	0.950	0.984
2016	2892	0.968	0.951	0.981
2017	3146	0.956	0.943	0.981
2018	2978	0.970	0.960	0.982
2019	3082	0.972	0.959	0.981
2020	815	0.972	0.936	0.969



Genotyped females

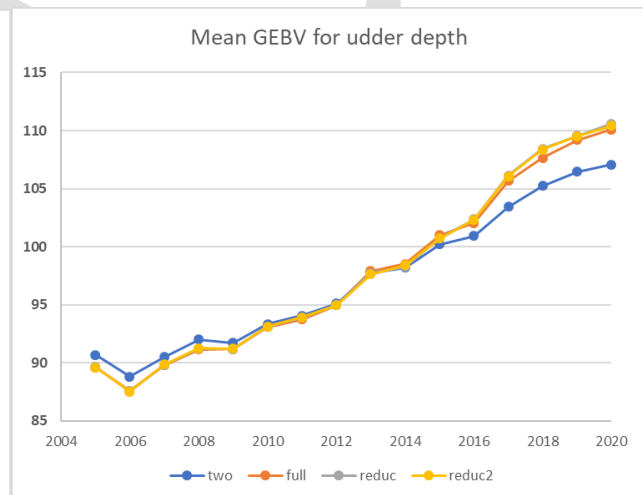
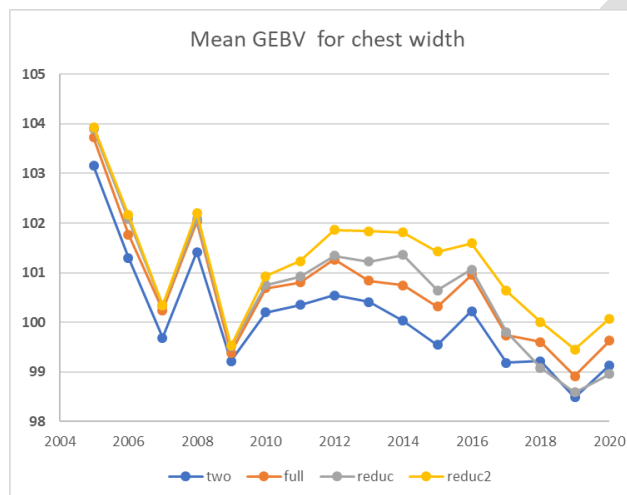
The mean GEBV's for twostep are comparable with singlestep (full/reduc/reduc2) for both chest width and udder depth. However, there is a tendency that singlestep is having higher means than twostep. Full model singlestep are close to twostep but reduc and especially reduc2 are higher than twostep. For 2005-2012 for udder depth the mean GEBV's of twostep is actually higher than singlestep.

Table3.1: Chest Width: Mean GEBV for females

b_year	N	Two	full	reduc	reduc2
2005	203	103.2	103.7	103.9	103.9
2006	352	101.3	101.8	102.1	102.2
2007	455	99.7	100.2	100.3	100.3
2008	794	101.4	102.0	102.1	102.2
2009	1194	99.2	99.4	99.5	99.5
2010	1695	100.2	100.7	100.8	100.9
2011	3353	100.3	100.8	100.9	101.2
2012	5278	100.5	101.3	101.3	101.9
2013	8825	100.4	100.8	101.2	101.8
2014	10274	100.0	100.7	101.4	101.8
2015	12823	99.5	100.3	100.6	101.4
2016	19535	100.2	101.0	101.1	101.6
2017	29371	99.2	99.7	99.8	100.6
2018	41226	99.2	99.6	99.1	100.0
2019	42765	98.5	98.9	98.6	99.5
2020	6980	99.1	99.6	99.0	100.1

Table3.2: Udder Depth: Mean GEBV for females

b_year	N	Two	full	reduc	reduc2
2005	203	90.7	89.6	89.6	89.6
2006	352	88.8	87.6	87.5	87.5
2007	455	90.5	89.8	89.8	89.9
2008	794	92.0	91.1	91.2	91.3
2009	1194	91.7	91.2	91.2	91.2
2010	1695	93.3	93.1	93.1	93.1
2011	3353	94.1	93.7	93.9	93.9
2012	5278	95.1	95.0	95.0	95.0
2013	8825	97.7	97.9	97.7	97.6
2014	10274	98.2	98.5	98.3	98.4
2015	12823	100.2	101.0	100.7	100.7
2016	19535	100.9	102.0	102.4	102.3
2017	29371	103.5	105.7	106.1	106.1
2018	41226	105.2	107.7	108.5	108.4
2019	42765	106.4	109.2	109.6	109.5
2020	6980	107.1	110.1	110.6	110.4



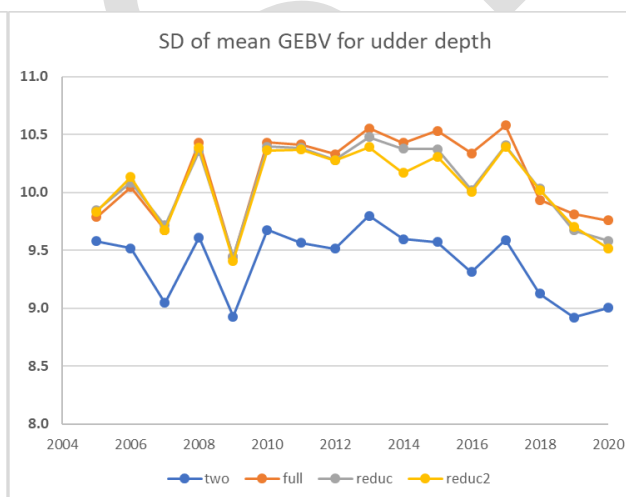
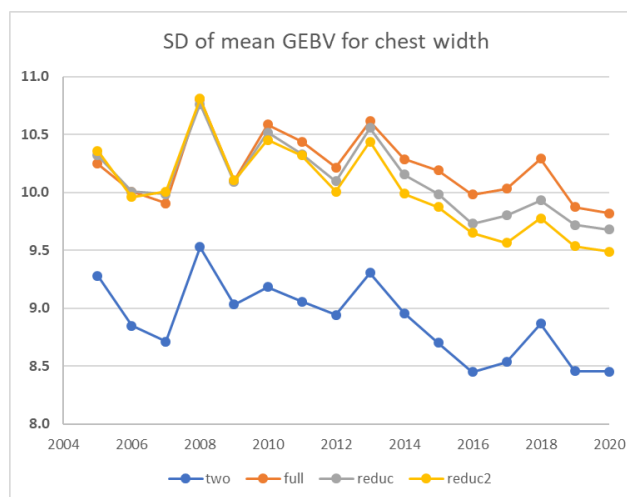
The SD of the mean are lower for twostep than for singlestep for both traits. The level of SD of the mean is not having a clear tendency by year.

Table3.3: Chest Width: STD for Mean GEBV for females

b_year	N	Two	full	reduc	reduc2
2005	203	9.3	10.2	10.3	10.4
2006	352	8.9	10.0	10.0	10.0
2007	455	8.7	9.9	10.0	10.0
2008	794	9.5	10.8	10.8	10.8
2009	1194	9.0	10.1	10.1	10.1
2010	1695	9.2	10.6	10.5	10.5
2011	3353	9.1	10.4	10.3	10.3
2012	5278	8.9	10.2	10.1	10.0
2013	8825	9.3	10.6	10.6	10.4
2014	10274	9.0	10.3	10.2	10.0
2015	12823	8.7	10.2	10.0	9.9
2016	19535	8.5	10.0	9.7	9.7
2017	29371	8.5	10.0	9.8	9.6
2018	41226	8.9	10.3	9.9	9.8
2019	42765	8.5	9.9	9.7	9.5
2020	6980	8.5	9.8	9.7	9.5

Table3.4: Udder Depth: STD for Mean GEBV for females

b_year	N	Two	full	reduc	reduc2
2005	203	9.6	9.8	9.8	9.8
2006	352	9.5	10.0	10.1	10.1
2007	455	9.0	9.7	9.7	9.7
2008	794	9.6	10.4	10.4	10.4
2009	1194	8.9	9.4	9.4	9.4
2010	1695	9.7	10.4	10.4	10.4
2011	3353	9.6	10.4	10.4	10.4
2012	5278	9.5	10.3	10.3	10.3
2013	8825	9.8	10.6	10.5	10.4
2014	10274	9.6	10.4	10.4	10.2
2015	12823	9.6	10.5	10.4	10.3
2016	19535	9.3	10.3	10.0	10.0
2017	29371	9.6	10.6	10.4	10.4
2018	41226	9.1	9.9	10.0	10.0
2019	42765	8.9	9.8	9.7	9.7
2020	6980	9.0	9.8	9.6	9.5



The correlation between twostep and singlestep (full model) is close to 0.98 in the period 2004 to 2020. However, the correlation for twostep/reduc and twostep/reduc2 are decreasing from 2013. The lowest correlations are seen in 2015-2017.

Table3.5: Chest Width: Corr between Twostep and Singlestep (full/reduc/reduc2) for females

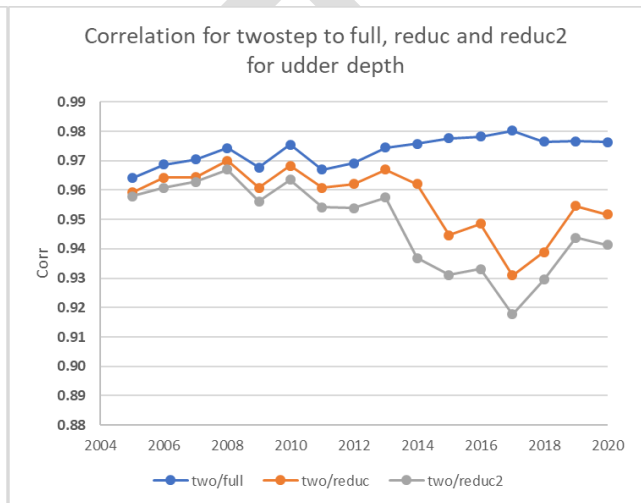
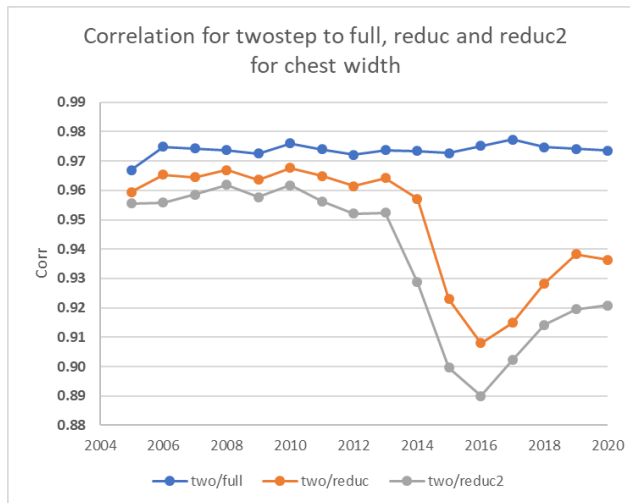
b_year	N	full	reduc	reduc2
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Table3.6: Udder Depth: Corr between Twostep and Singlestep (full/reduc/reduc2) for females

b_year	N	full	reduc	reduc2
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2005	203	0.967	0.959	0.956
2006	352	0.975	0.965	0.956
2007	455	0.974	0.965	0.959
2008	794	0.974	0.967	0.962
2009	1194	0.973	0.964	0.958
2010	1695	0.976	0.968	0.962
2011	3353	0.974	0.965	0.956
2012	5278	0.972	0.961	0.952
2013	8825	0.974	0.964	0.952
2014	10274	0.973	0.957	0.929
2015	12823	0.973	0.923	0.900
2016	19535	0.975	0.908	0.890
2017	29371	0.977	0.915	0.902
2018	41226	0.975	0.928	0.914
2019	42765	0.974	0.938	0.920
2020	6980	0.974	0.936	0.921

2005	203	0.964	0.959	0.958
2006	352	0.969	0.964	0.961
2007	455	0.970	0.964	0.963
2008	794	0.974	0.970	0.967
2009	1194	0.968	0.961	0.956
2010	1695	0.976	0.968	0.964
2011	3353	0.967	0.961	0.954
2012	5278	0.969	0.962	0.954
2013	8825	0.974	0.967	0.957
2014	10274	0.976	0.962	0.937
2015	12823	0.978	0.945	0.931
2016	19535	0.978	0.949	0.933
2017	29371	0.980	0.931	0.918
2018	41226	0.977	0.939	0.930
2019	42765	0.977	0.955	0.944
2020	6980	0.976	0.952	0.941



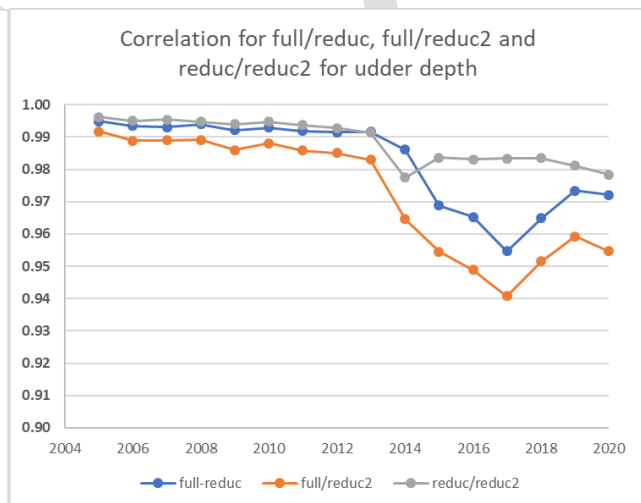
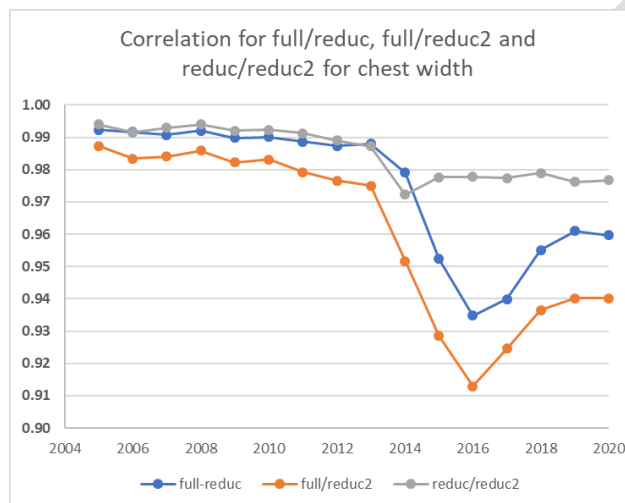
Looking at the correlation between the three singlestep models, the correlations for especially full/reduc and reduc/reduc2 are high until 2013. In the period 2015-2017 the correlations decrease, and full/reduc2 is decreasing the most while reduc/reduc2 is showing minor decrease.

Table3.7: Chest Width: Corr between Singlestep (full/reduc og full/reduc2 and reduc/reduc2) for females

b_year	N	full-reduc	full/re-duc2	reduc/re-duc2
2005	203	0.992	0.987	0.994
2006	352	0.992	0.983	0.992
2007	455	0.991	0.984	0.993
2008	794	0.992	0.986	0.994
2009	1194	0.990	0.982	0.992
2010	1695	0.990	0.983	0.992
2011	3353	0.989	0.979	0.991
2012	5278	0.987	0.977	0.989
2013	8825	0.988	0.975	0.987
2014	10274	0.979	0.952	0.972
2015	12823	0.952	0.929	0.978
2016	19535	0.935	0.913	0.978
2017	29371	0.940	0.925	0.977
2018	41226	0.955	0.937	0.979
2019	42765	0.961	0.940	0.976
2020	6980	0.960	0.940	0.977

Table3.8: Udder Depth: Corr between Singlestep (full/reduc og full/reduc2 and reduc/reduc2) for females

b_year	N	full-reduc	full/re-duc2	reduc/re-duc2
2005	203	0.995	0.992	0.996
2006	352	0.993	0.989	0.995
2007	455	0.993	0.989	0.995
2008	794	0.994	0.989	0.995
2009	1194	0.992	0.986	0.994
2010	1695	0.993	0.988	0.995
2011	3353	0.992	0.986	0.994
2012	5278	0.991	0.985	0.993
2013	8825	0.992	0.983	0.991
2014	10274	0.986	0.965	0.977
2015	12823	0.969	0.955	0.984
2016	19535	0.965	0.949	0.983
2017	29371	0.955	0.941	0.983
2018	41226	0.965	0.952	0.983
2019	42765	0.973	0.959	0.981
2020	6980	0.972	0.955	0.978



3. Comparison of EBV's from two different models- one model where herd year is a random effect (official model) or another model without fixed 5 year period but fixed herd year.

Nordic Holstein cows are divided into four groups:

- genotyped and with own record
- non-genotyped with own record
- genotyped without own record
- non-genotyped without own record

Results are showing means of EBV's from full, reduc and reduc2 models with herd year as random effect or with herd year as fixed effect but without fixed 5 year period. Only results for udder depth are shown and only if mean EBV is based on minimum 10 individuals.

Table 6.1 Udder depth: Mean EBV for genotyped cows with own record. Herd year effect as random (r), or fixed (f).

	N-full	N-reduc	N-reduc2	r full	f full	r-reduc	f-reduc	r-reduc2	f-reduc2
2005	184	184	184	90.4	90.5	90.5	90.6	90.4	90.5
2006	262	262	262	90.0	90.1	89.9	90.0	89.9	90.0
2007	328	328	328	92.0	92.1	92.0	92.1	92.0	92.0
2008	551	551	551	92.6	92.7	92.6	92.8	92.6	92.7
2009	864	864	864	92.3	92.4	92.3	92.4	92.2	92.3
2010	1254	1254	1254	94.0	94.1	94.0	94.1	93.8	93.9
2011	2340	2340	2340	94.1	94.2	94.2	94.3	93.9	93.9
2012	3563	3563	3557	95.3	95.6	95.3	95.6	94.8	95.0
2013	5957	5957	5134	98.2	98.5	97.9	98.2	97.2	97.4
2014	6711	5121	195	98.6	98.9	98.2	98.4	96.6	96.5
2015	7699	1585		100.7	101.0	98.4	98.8		
2016	11043	468		101.3	101.6	99.2	99.6		
2017	12361	383		103.8	104.3	100.5	100.9		
2018	626	15		105.4	106.1	99.2	99.5		
2019									
2020									

Table 6.2 Udder depth: Mean EBV for genotyped cows without own record. Herd year effect as random (r), or fixed (f).

	N-full	N-reduc	N-reduc2	r full	f full	r-reduc	f-reduc	r-reduc2	f-reduc2
2005	19	19	19	83.5	83.8	83.5	83.8	83.4	83.8
2006	90	90	90	84.3	84.1	84.3	84.2	84.1	84.0
2007	127	127	127	86.4	86.4	86.5	86.4	86.3	86.3
2008	243	243	243	88.9	88.9	89.0	89.0	89.0	89.0
2009	330	330	330	90.0	90.1	90.0	90.1	90.0	90.0
2010	441	441	441	92.6	92.8	92.7	92.8	92.5	92.7
2011	1013	1013	1013	93.0	93.2	93.1	93.3	92.8	92.9
2012	1715	1715	1721	94.8	95.0	94.7	94.9	94.2	94.3
2013	2868	2868	3691	97.2	97.5	96.9	97.2	96.5	96.7
2014	3563	5153	10079	98.0	98.3	97.3	97.5	96.7	96.9
2015	5124	11238	12823	100.2	100.6	98.3	98.3	96.6	96.8
2016	8492	19067	19535	100.7	101.0	98.6	98.8	97.0	97.2
2017	17010	28988	29371	103.8	104.3	100.2	100.4	98.2	98.4
2018	40600	41211	41226	104.2	104.7	100.7	100.8	98.3	98.5
2019	42765	42765	42765	104.0	104.3	100.9	101.0	98.4	98.6
2020	6980	6980	6980	104.5	105.0	101.0	101.2	98.4	98.7

Table 6.3 Udder depth: Mean EBV for non-genotyped cows with own record. Herd year effect as random (r), or fixed (f).

	N-full	N-reduc	N-reduc2	r_full	f_full	r-reduc	f-reduc	r-reduc2	f-reduc2
2005	89663	89663	89663	83.7	83.7	83.7	83.7	83.7	83.7
2006	100233	100233	100233	83.9	83.9	83.9	83.9	84.0	83.9
2007	96518	96518	96518	85.3	85.3	85.3	85.3	85.3	85.3
2008	98445	98445	98445	86.7	86.7	86.7	86.8	86.8	86.8
2009	101397	101397	101397	87.8	87.8	87.8	87.9	87.8	87.9
2010	94572	94572	94572	89.2	89.3	89.3	89.4	89.3	89.3
2011	89009	89009	89009	91.1	91.2	91.2	91.3	91.0	91.1
2012	86200	86200	86163	93.0	93.2	93.1	93.2	92.6	92.7
2013	83998	83931	72220	95.3	95.5	95.1	95.3	94.5	94.6
2014	79906	61348	2061	96.9	97.1	96.9	97.1	94.9	95.0
2015	71998	20403		98.7	99.1	97.7	98.0		
2016	64686	6143		99.9	100.2	99.7	99.9		
2017	42957	2964		102.5	102.9	101.0	101.3		
2018	1417	95		104.7	105.3	103.6	103.6		
2019									
2020									

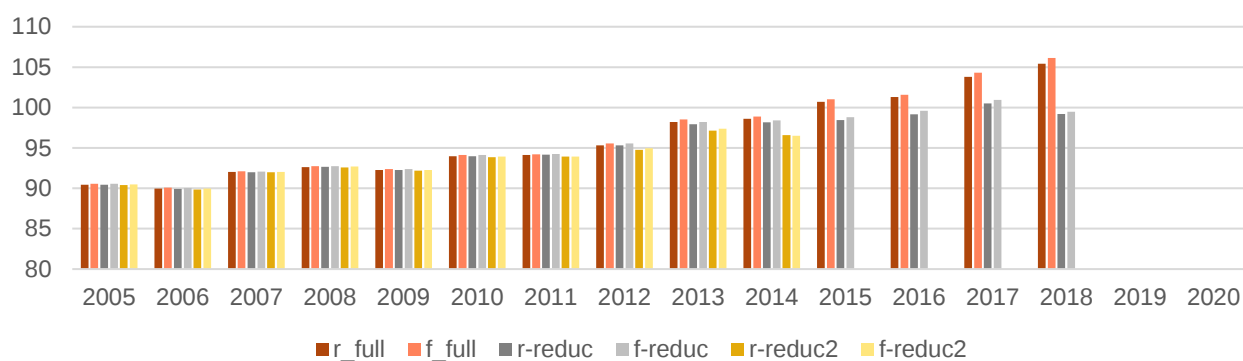
Table6.4: Udder depth: Mean EBV for non-genotyped cows without own record. Herd year effect as random(r), or fixed(f).

	N-full	N-reduc	N-reduc2	r_full	f_full	r-reduc	f-reduc	r-reduc2	f-reduc2
2005									
2006									
2007									
2008									
2009									
2010									
2011									
2012			41					94.5	94.6
2013		70	11781			91.9	91.9	94.5	94.6
2014		18561	77848			94.0	94.2	95.4	95.5
2015		51596	71999			96.8	96.8	95.6	95.8
2016		58546	64689			97.6	97.9	96.3	96.4
2017		39994	42958			99.4	99.6	97.5	97.7
2018		1322	1417			100.8	101.0	98.9	99.0
2019									
2020									

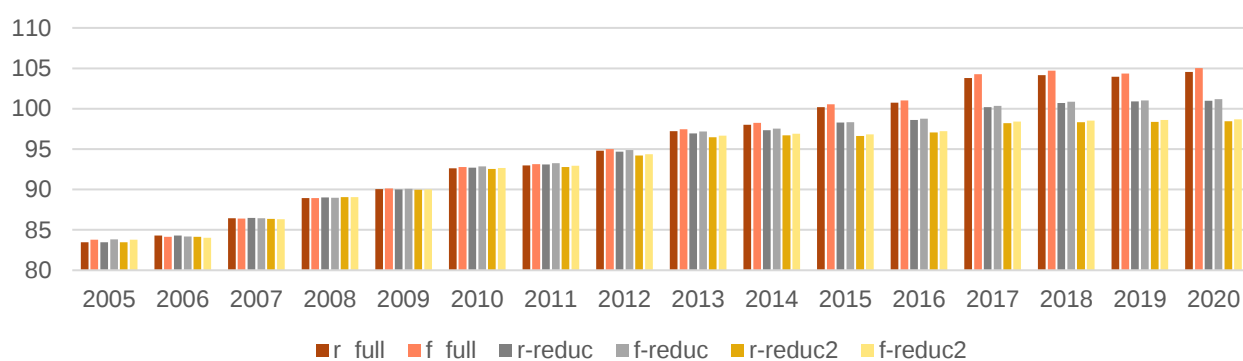
Overall there is a similar trend for EBVs no matter if herd year is included in the model as random or fixed effect.

EBV's for full models are having higher means than EBV's for reduc and reduc2 models especially in the later years.

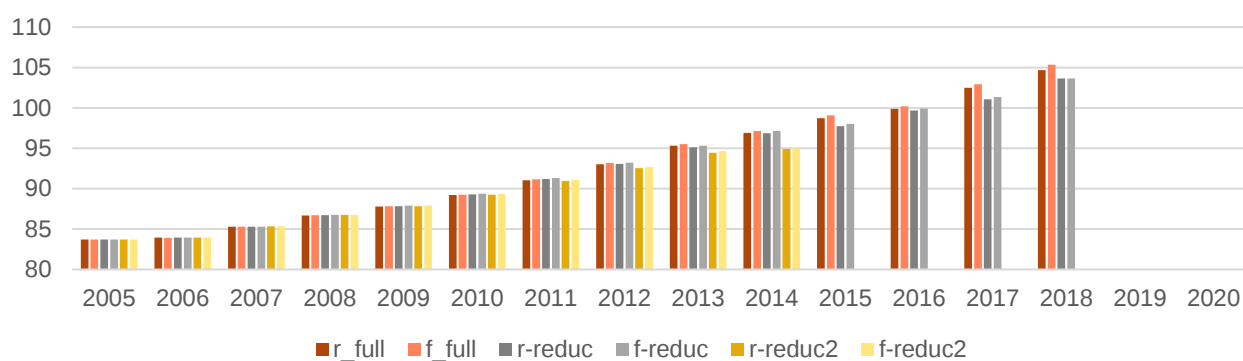
Mean EBV's for genotyped cows with own records



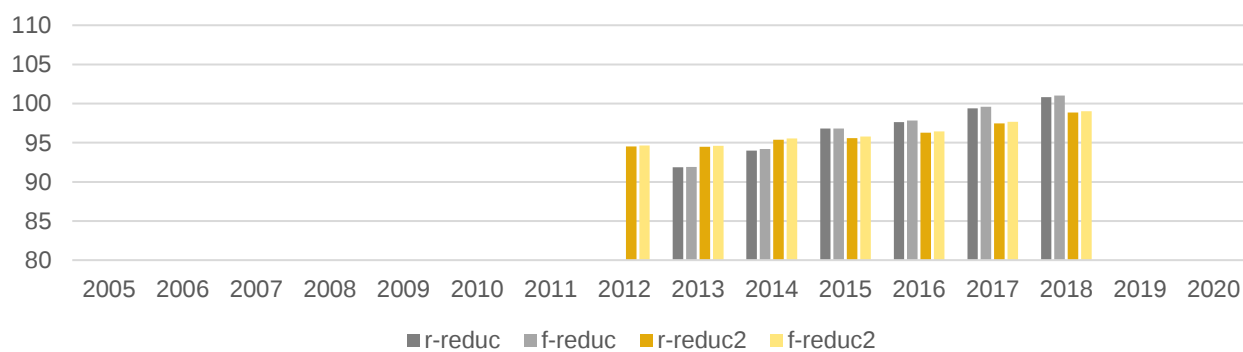
Mean EBV's for genotyped cows without own records



Mean EBV's for non-genotyped cows with own records



Mean EBV's for non-genotyped cows without own records



4. Comparison of EBV and GEBV from GTa-BLUP for genotyped and non-genotyped cows with and without own records.

Nordic Holstein cows are divided into four groups:

- genotyped and with own record
- non-genotyped with own record
- genotyped without own record
- non-genotyped without own record

Results are showing means of EBV's from full, reduc and reduc2 models and means of GEBV from GTa-full, GTa-reduc and GTa-reduc2. Only results where means are based on minimum 10 individuals are shown. Results are shown for udder depth.

Here groups are not at equal size over full and reduc and reduc2.

Table 5.1 Udder depth: number of records and Mean EBV and GEBV for genotyped cows with own record.

	N- full	N- reduc	N- reduc2	EBV- full	GTa- full	EBV- reduc	GTa- reduc	EBV- reduc2	GTa- reduc2
2005	184	184	184	90.4	90.1	90.5	90.1	90.4	90.0
2006	262	262	262	90.0	89.1	89.9	89.0	89.9	89.0
2007	328	328	328	92.0	91.5	92.0	91.5	92.0	91.6
2008	551	551	551	92.6	92.3	92.6	92.3	92.6	92.4
2009	864	864	864	92.3	91.7	92.3	91.7	92.2	91.7
2010	1254	1254	1254	94.0	93.7	94.0	93.7	93.8	93.7
2011	2340	2340	2340	94.1	94.4	94.2	94.5	93.9	94.5
2012	3563	3563	3557	95.3	95.4	95.3	95.5	94.8	95.4
2013	5957	5957	5134	98.2	98.5	97.9	98.3	97.2	98.1
2014	6711	5121	195	98.6	98.9	98.2	98.4	96.6	97.6
2015	7699	1585		100.7	101.5	98.4	98.9		
2016	11043	468		101.3	102.4	99.2	100.1		
2017	12361	383		103.8	105.7	100.5	101.7		
2018	626	15		105.4	107.7	99.2	100.6		
2019									
2020									

Table 5.2: Udder depth: Number of records and Mean EBV and GEBV for genotyped cows without own record.

	N- full	N- reduc	N- reduc2	EBV- full	GTa- full	EBV- reduc	GTa- reduc	EBV- reduc2	GTa- reduc2
2005	19	19	19	83.5	84.8	83.5	84.8	83.4	85.1
2006	90	90	90	84.3	83.2	84.3	83.2	84.1	83.3
2007	127	127	127	86.4	85.3	86.5	85.5	86.3	85.5
2008	243	243	243	88.9	88.5	89.0	88.7	89.0	88.8
2009	330	330	330	90.0	89.9	90.0	89.9	90.0	89.9
2010	441	441	441	92.6	91.4	92.7	91.6	92.5	91.5
2011	1013	1013	1013	93.0	92.2	93.1	92.4	92.8	92.4
2012	1715	1715	1721	94.8	94.0	94.7	94.0	94.2	94.0
2013	2868	2868	3691	97.2	96.7	96.9	96.5	96.5	96.9
2014	3563	5153	10079	98.0	97.8	97.3	98.1	96.7	98.4
2015	5124	11238	12823	100.2	100.3	98.3	101.0	96.6	100.7
2016	8492	19067	19535	100.7	101.5	98.6	102.4	97.0	102.3
2017	17010	28988	29371	103.8	105.7	100.2	106.2	98.2	106.1
2018	40600	41211	41226	104.2	107.7	100.7	108.5	98.3	108.4
2019	42765	42765	42765	104.0	109.2	100.9	109.6	98.4	109.5
2020	6980	6980	6980	104.5	110.1	101.0	110.6	98.4	110.4

Table 5.3: Udder depth: Number of records and Mean EBV and GEBV for non-genotyped cows with own record.

	N- full	N- reduc	N- reduc2	EBV- full	GTa- full	EBV- reduc	GTa- reduc	EBV- reduc2	GTa- reduc2
2005	89663	89663	89663	83.7	83.7	83.7	83.7	83.7	83.7
2006	100233	100233	100233	83.9	83.9	83.9	83.9	84.0	83.9
2007	96518	96518	96518	85.3	85.2	85.3	85.3	85.3	85.3
2008	98445	98445	98445	86.7	86.6	86.7	86.7	86.8	86.7
2009	101397	101397	101397	87.8	87.7	87.8	87.7	87.8	87.7
2010	94572	94572	94572	89.2	89.0	89.3	89.1	89.3	89.1
2011	89009	89009	89009	91.1	90.8	91.2	91.0	91.0	90.9
2012	86200	86200	86163	93.0	92.8	93.1	92.9	92.6	92.6
2013	83998	83931	72220	95.3	95.1	95.1	95.0	94.5	94.8
2014	79906	61348	2061	96.9	96.8	96.9	96.8	94.9	95.5
2015	71998	20403		98.7	98.9	97.7	97.6		
2016	64686	6143		99.9	100.5	99.7	99.4		
2017	42957	2964		102.5	103.7	101.0	100.7		
2018	1417	95		104.7	106.4	103.6	103.8		
2019									
2020									

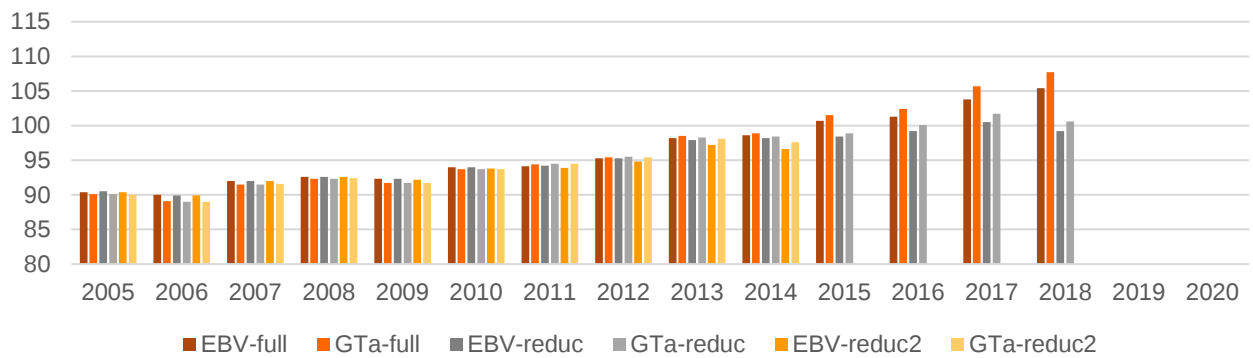
Table 5.4: Udder depth: Number of records and Mean EBV and GEBV for non-genotyped cows without own record.

	N- full	N- reduc	N- reduc2	EBV- full	GTa- full	EBV- reduc	GTa- reduc	EBV- reduc2	GTa- reduc2
2005									
2006									
2007									
2008									
2009									
2010									
2011									
2012			41						94.3
2013		70	11781			91.9	93.0	94.5	94.9
2014		18561	77848			94.0	95.9	94.5	96.5
2015		51596	71999			96.8	99.1	95.4	98.4
2016		58546	64689			97.6	100.9	95.6	100.6
2017		39994	42958			99.4	103.9	96.3	103.6
2018		1322	1417			100.8	107.5	97.5	107.1
2019									
2020									

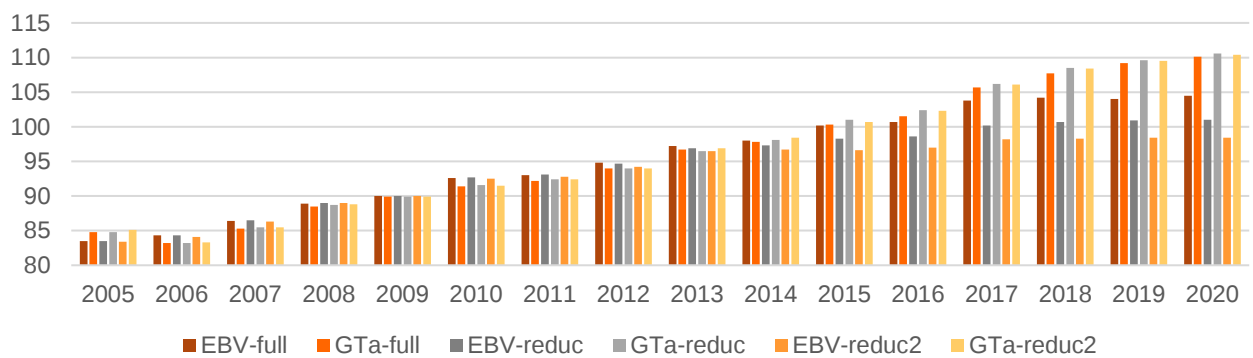
Until 2013 there is a high similarity of mean EBV's and mean GEBV's from GTa no matter the group of cows for both full, reduc and reduc2 models. After 2013 GEBV from GTa is higher than EBV's and the difference is bigger for reduc and reduc2 than for full models. The biggest difference between EBV and GEBV is seen for genotyped cows without own record in the latest years.

From 2005 until 2013 the mean breeding value is higher for genotyped cows with own records than for the other three groups of cows.

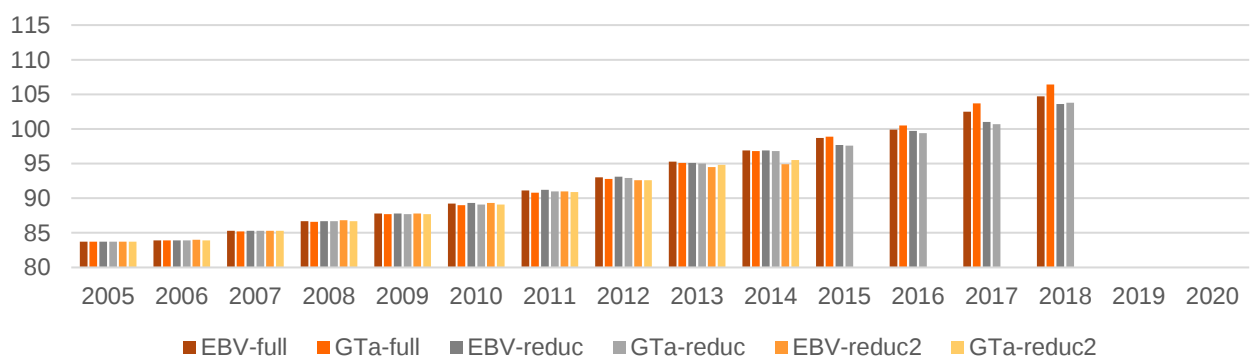
Mean EBV's and GTa for genotyped cows with own records



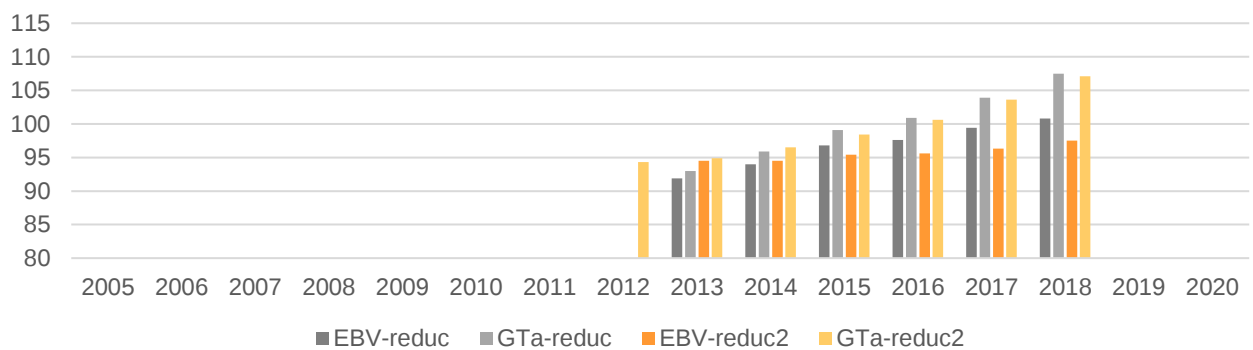
Mean EBV's and GTa for genotyped cows without own records



Mean EBV's and GTa for non-genotyped cows with own records



Mean EBV's and GTa for non-genotyped cows without own records



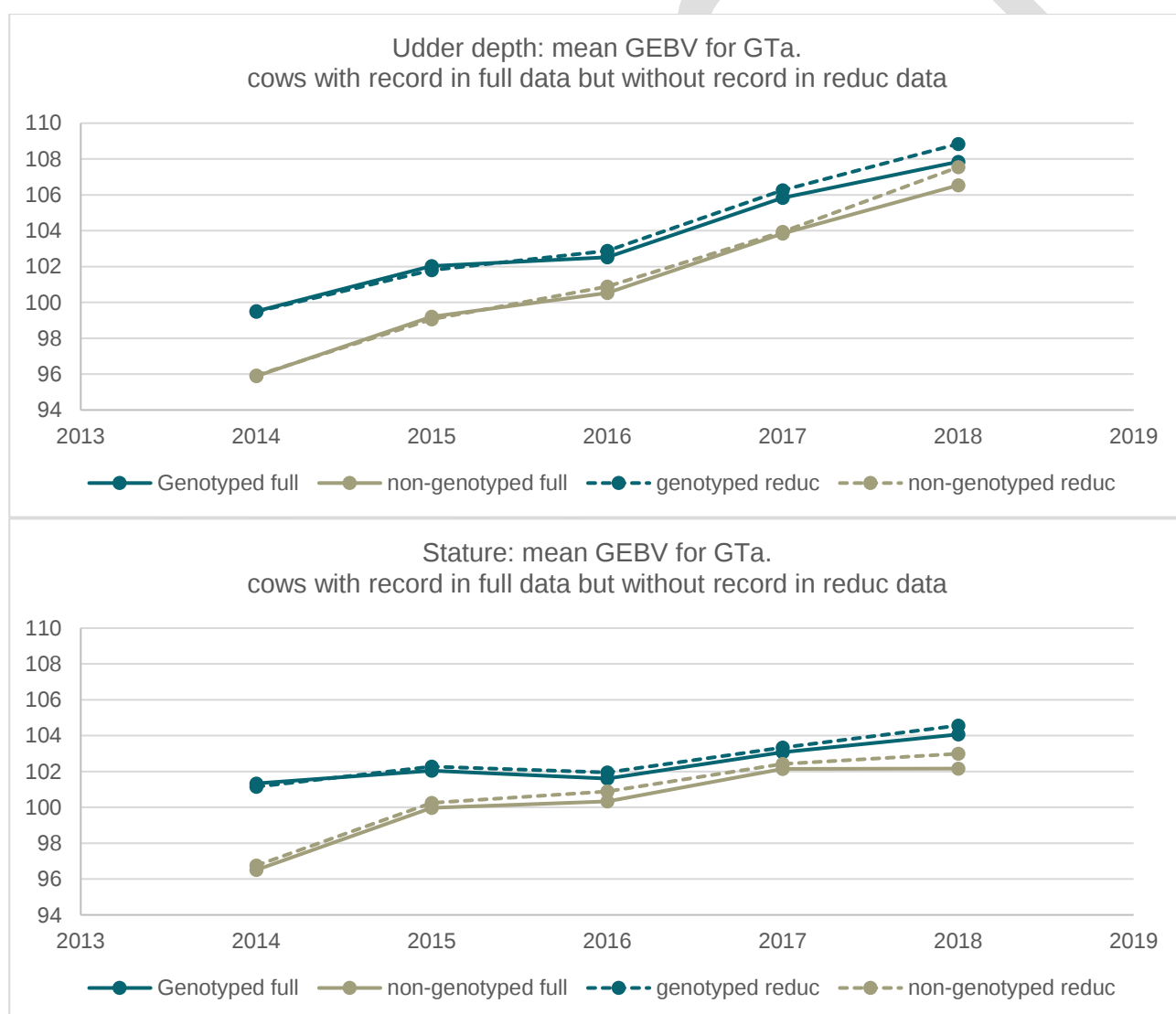
5. Genetic trend for equal groups of cows

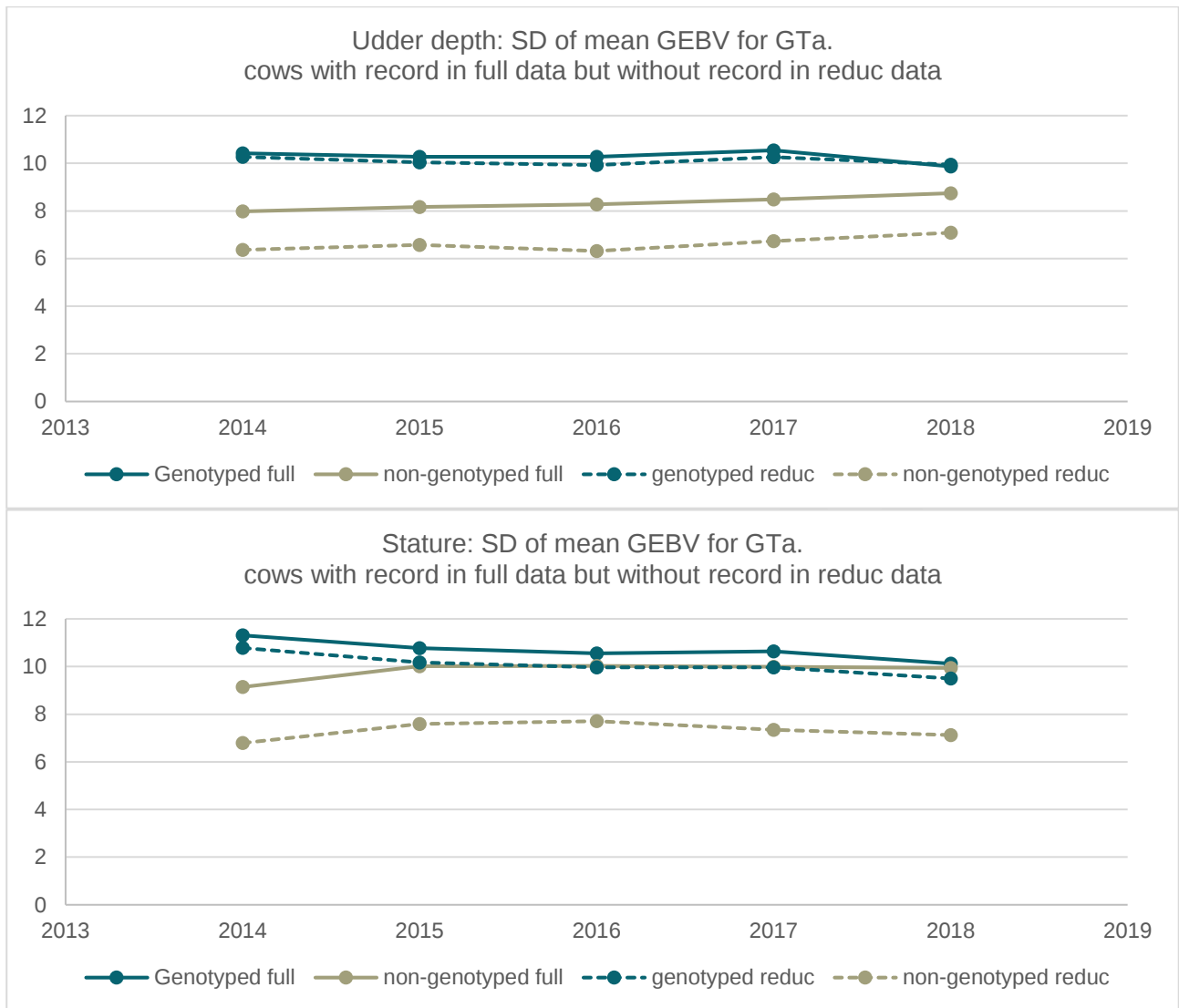
Here only cows which has records for full GTa but not for reduc GTa are included in the analysis. Those cows are divided into genotyped and non-genotyped cows.

Number of cows in each group

	Genotyped full	non-genotyped full	genotyped reduc	non-genotyped reduc
2013		67		67
2014	1590	18558	1590	18558
2015	6114	51595	6114	51595
2016	10575	58543	10575	58543
2017	11978	39993	11978	39993
2018	611	1322	611	1322

Genotyped cows are having higher means than non-genotyped cows. GTa-full and GTa-reduc is having high similarity. For non-genotyped cows the SD of mean GEBV is higher for full than reduced data. This fits well with the expectation that when more data is available (in full) then the accuracy increases and then the SD of mean GEBV increases. However, this tendency is not clear for genotyped cows, where the SD of mean GEBV is at similar level for full and reduc. This is a concern for singlestep.





6. Comparison of parent average and GTa-BLUP

For each individual the parent average of GTa-full GEBV is calculated based on the GTa-full for the dam and the sire. Only individuals where both parents have a GTa-full value is included.

For bulls with status1, it is examined if the GTa-full GEBV for the individual differs from the parent average GTa-full GEBV. For cows, first it is shown mean and SD of mean for all cows. Second, it is shown mean and SD of mean for genotyped and non-genotyped (with and without own records) cows which parents are genotyped.

Bulls

For bulls the GTa-full own GEBV is close to the GTa-full parent average GEBV for both chest width and udder depth. There is though a tendency that own GEBV is slightly higher than PA GEBV for udder depth for the later years.

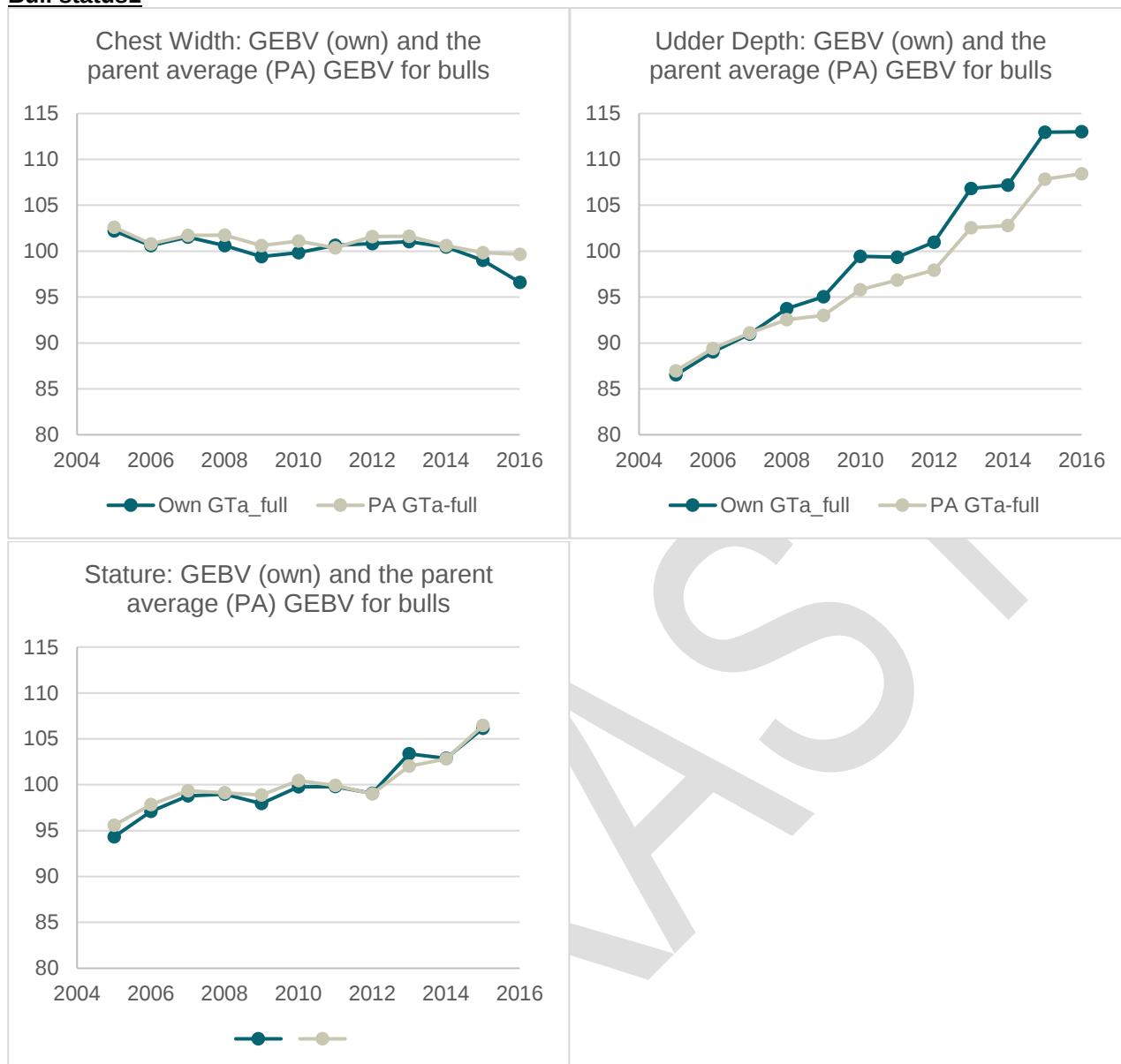
Table 7.1 Chest Width: mean GEBV (own solution) and the parent average (PA) GEBV for bulls status1.

b_year	N	Own GTa_full	PA GTa-full
2005	333	102.2	102.6
2006	376	100.6	100.8
2007	298	101.5	101.7
2008	246	100.6	101.8
2009	204	99.4	100.6
2010	173	99.8	101.1
2011	135	100.6	100.4
2012	137	100.8	101.6
2013	105	101.0	101.6
2014	96	100.5	100.6
2015	71	99.0	99.8
2016	13	96.6	99.7

Table 7.2 Udder Depth: mean GEBV (own solution) and the parent average (PA) GEBV for bulls status1

b_year	N	Own GTa_full	PA GTa-full
2005	333	86.5	87.0
2006	376	89.0	89.4
2007	298	91.0	91.1
2008	246	93.7	92.6
2009	204	95.0	93.0
2010	173	99.4	95.8
2011	135	99.3	96.9
2012	137	101.0	97.9
2013	105	106.8	102.5
2014	96	107.2	102.8
2015	71	112.9	107.8
2016	13	113.0	108.4

Bull status1



The standard deviation (SD) of mean GEBV for own GTa-full and parent average GTa-full is not equal, as it is shown that SD for own GTa-full is higher than SD for PA GTa-full.

Table 7.3 Chest Width: SD of mean GEBV (own solution) and the parent average (PA) GEBV for bulls status1.

b_year	N	Own GTa_full	PA GTa-full
2005	333	10.9	7.2
2006	376	10.6	6.4
2007	298	9.9	6.6
2008	246	10.5	7.0
2009	204	10.1	7.0
2010	173	11.0	8.0
2011	135	11.0	6.9
2012	137	11.5	6.6
2013	105	10.2	6.9
2014	96	9.5	6.9
2015	71	11.4	7.7

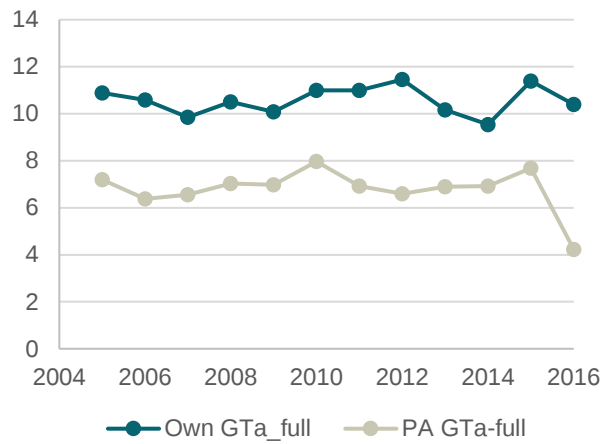
Table 7.4 Udder Depth: SD of mean GEBV (own solution) and the parent average (PA) GEBV for bulls status1

b_year	N	Own GTa_full	PA GTa-full
2005	333	10.4	6.0
2006	376	9.6	5.5
2007	298	9.7	5.5
2008	246	8.9	5.2
2009	204	9.7	5.7
2010	173	10.0	6.5
2011	135	9.4	6.7
2012	137	8.9	5.9
2013	105	8.2	5.9
2014	96	11.1	7.4
2015	71	11.5	6.6

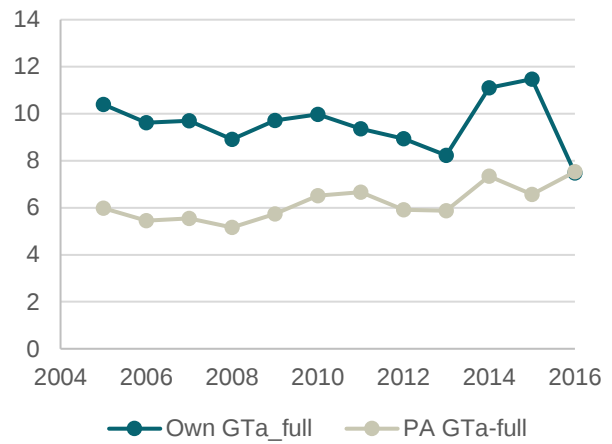
2016	13	10.4	4.2
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2016	13	7.5	7.5
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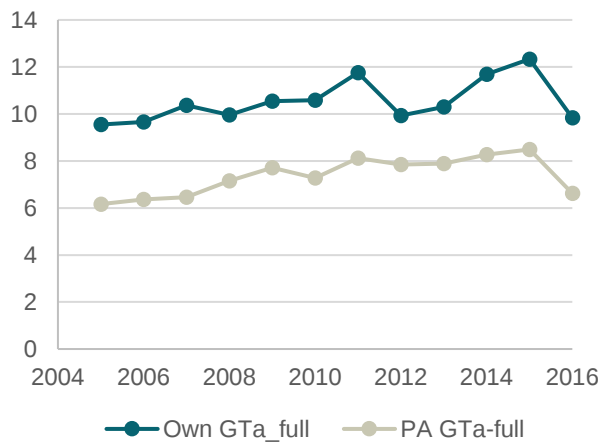
Chest Width: SD of mean GEBV (own) and the parent average (PA) GEBV for bulls



Udder Depth: SD of mean GEBV (own) and the parent average (PA) GEBV for bulls



Stature: SD of mean GEBV (own) and the parent average (PA) GEBV for bulls



All cows

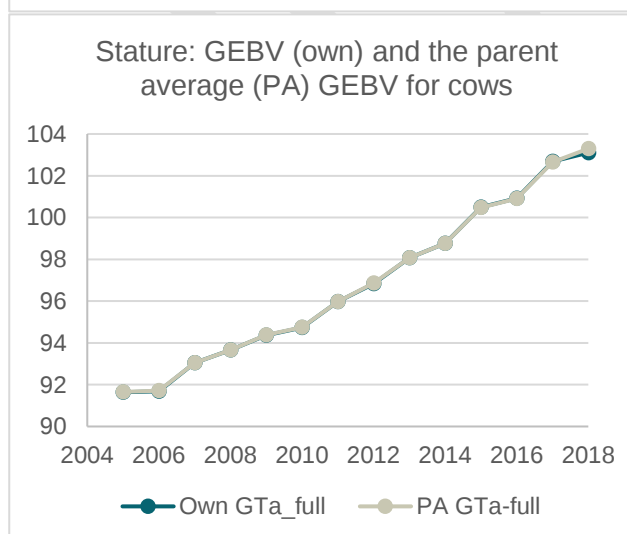
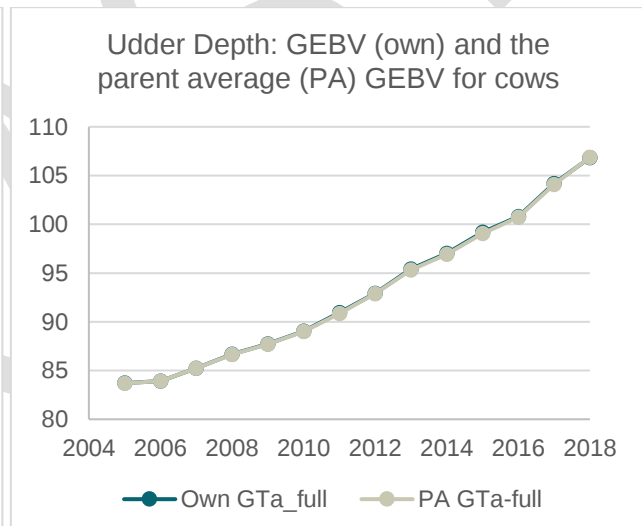
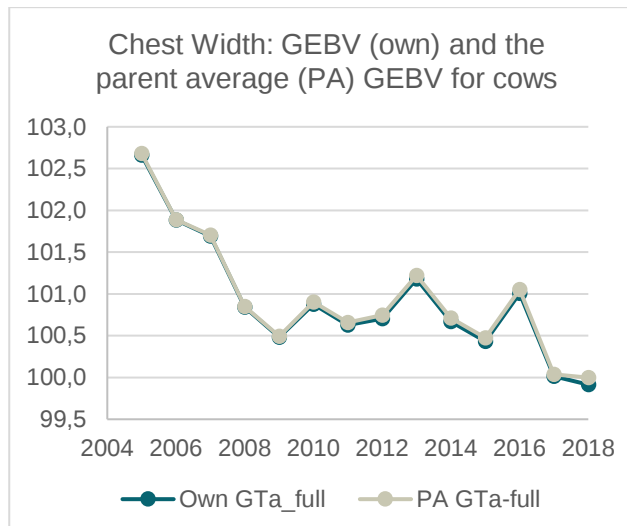
For cows the GTa-full own GEBV is equal to the GTa-full parent average GEBV for both chest width and udder depth and stature.

Table 7.5 Chest Width: mean GEBV (own solution) and the parent average (PA) GEBV for cows.

b year	N	Own GTa_full	PA GTa-full
2005	88204	102.7	102.7
2006	98497	101.9	101.9
2007	94978	101.7	101.7
2008	97116	100.8	100.8
2009	100449	100.5	100.5
2010	94023	100.9	100.9
2011	89820	100.6	100.7
2012	88392	100.7	100.7
2013	88775	101.2	101.2
2014	85518	100.7	100.7
2015	78817	100.4	100.5
2016	74877	101.0	101.1
2017	54826	100.0	100.0
2018	2036	99.9	100.0

Table 7.6 Udder Depth: mean GEBV (own solution) and the parent average (PA) GEBV for cows

b year	N	Own GTa_full	PA GTa-full
2005	88204	83.7	83.7
2006	98497	83.9	83.9
2007	94978	85.2	85.2
2008	97116	86.7	86.6
2009	100449	87.7	87.7
2010	94023	89.0	89.0
2011	89820	90.9	90.9
2012	88392	92.9	92.9
2013	88775	95.4	95.3
2014	85518	97.0	96.9
2015	78817	99.2	99.0
2016	74877	100.8	100.7
2017	54826	104.2	104.1
2018	2036	106.8	106.9



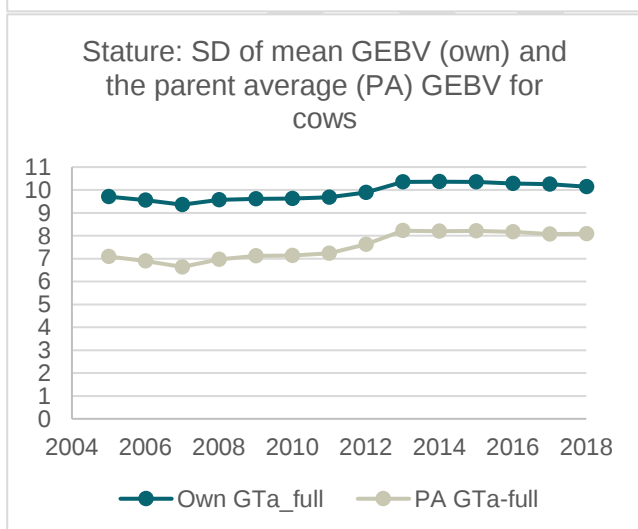
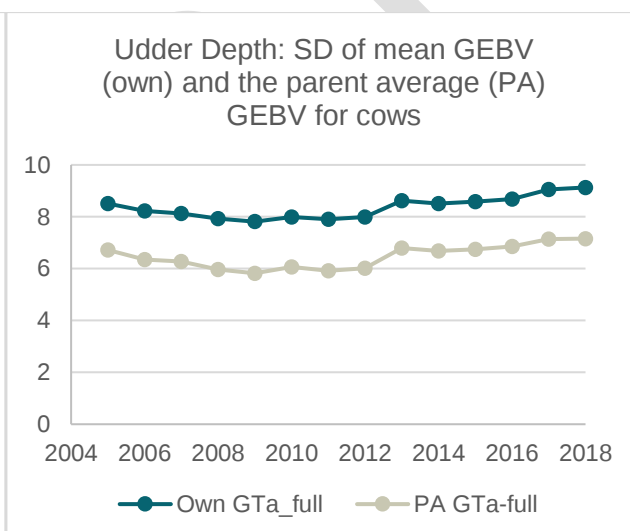
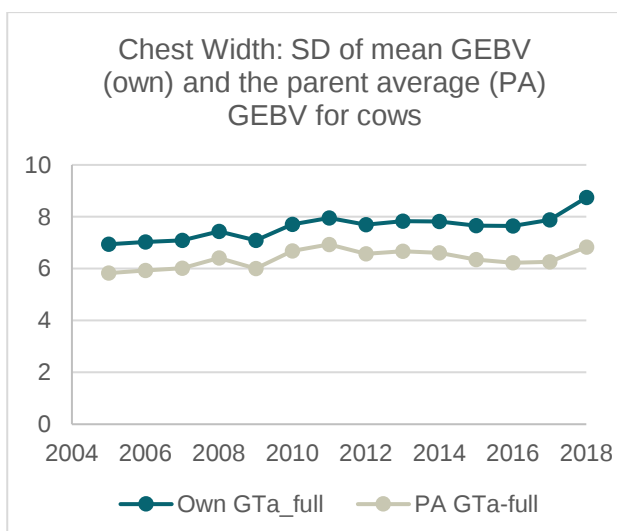
The standard deviation (SD) of mean GEBV for own GTa-full and parent average GTa-full is not equal, as it is shown that SD for own GTa-full is higher than SD for PA GTa-full.

Table 7.7 Chest Width: SD of mean GEBV (own solution) and the parent average (PA) GEBV for cows.

b year	N	Own GTa_full	PA GTa-full
2005	88204	6.9	5.8
2006	98497	7.0	5.9
2007	94978	7.1	6.0
2008	97116	7.4	6.4
2009	100449	7.1	6.0
2010	94023	7.7	6.7
2011	89820	8.0	6.9
2012	88392	7.7	6.6
2013	88775	7.8	6.7
2014	85518	7.8	6.6
2015	78817	7.7	6.4
2016	74877	7.6	6.2
2017	54826	7.9	6.3
2018	2036	8.7	6.8

Table 7.8 Udder Depth: SD of mean GEBV (own solution) and the parent average (PA) GEBV for cows

b year	N	Own GTa_full	PA GTa-full
2005	88204	8.5	6.7
2006	98497	8.2	6.3
2007	94978	8.1	6.3
2008	97116	7.9	6.0
2009	100449	7.8	5.8
2010	94023	8.0	6.1
2011	89820	7.9	5.9
2012	88392	8.0	6.0
2013	88775	8.6	6.8
2014	85518	8.5	6.7
2015	78817	8.6	6.7
2016	74877	8.7	6.9
2017	54826	9.0	7.1
2018	2036	9.1	7.2



Cows with genotyped parents

Results for cows, which parents are genotyped. The cows are divided into four groups

- genotyped and with own record
- non-genotyped with own record
- genotyped without own record
- non-genotyped without own record

Means of own GTa-reduc and means of parent average (PA) of GTa-full are compared.

Means are shown for each year from 2005 and forward for data where the mean is calculated on 10 individuals or more. First the results for chest width are shown, and then results for udder depth are shown lastly figures for stature are shown. Results are presented both as table and figures.

Chest width

For chest width the mean GEBV is similar for own GTa-reduc and PA GTa-full for the four groups of cows.

Table7.9 Chest Width: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.
Cows, which are genotyped and have own records.

b_year	N	Own GTa_reduc	PA GTa-full
2005			
2006	26	100.4	102.5
2007	41	100.6	99.9
2008	141	103.8	103.5
2009	220	101.7	101.2
2010	334	100.5	100.9
2011	350	100.3	101.0
2012	577	100.3	101.2
2013	1129	101.4	100.9
2014	1269	101.5	100.9
2015	449	101.0	100.9
2016	94	101.7	100.4
2017	57	104.3	104.3
2018			

Table7.10 Chest Width: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.
Cows, which are non-genotyped and have own records.

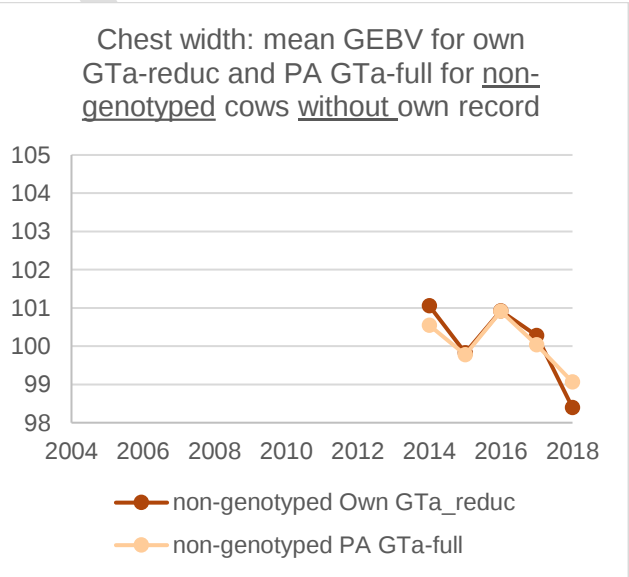
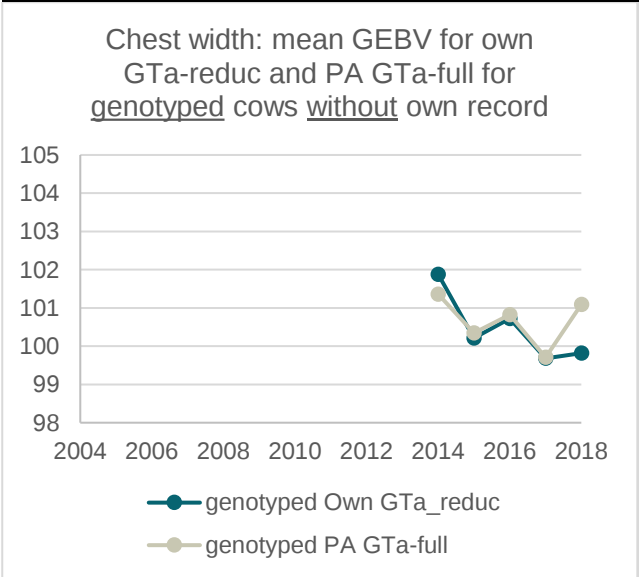
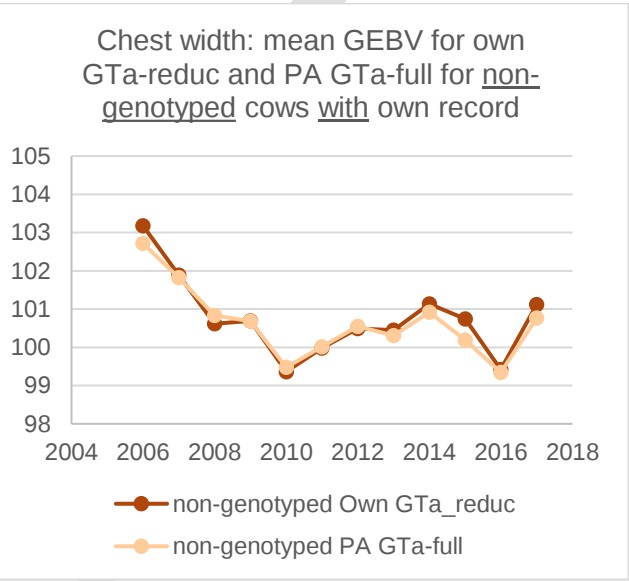
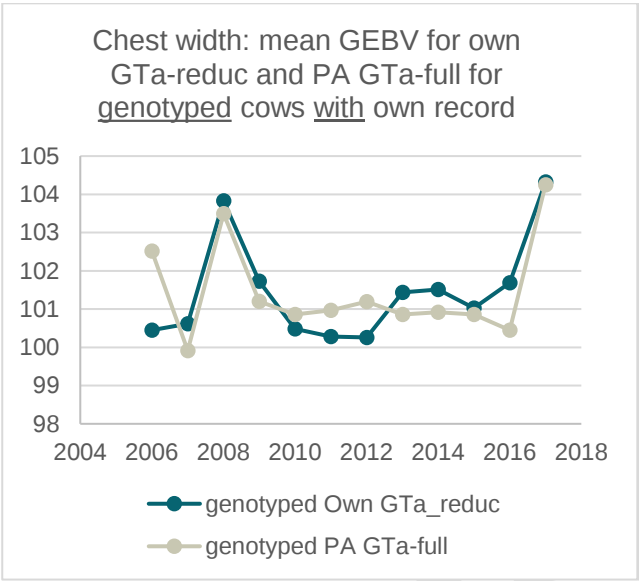
b_year	N	Own GTa_reduc	PA GTa-full
2005			
2006	47	103.2	102.7
2007	114	101.9	101.8
2008	175	100.6	100.8
2009	248	100.7	100.7
2010	367	99.4	99.5
2011	432	100.0	100.0
2012	579	100.5	100.6
2013	674	100.5	100.3
2014	739	101.1	100.9
2015	321	100.7	100.2
2016	86	99.4	99.3
2017	52	101.1	100.8
2018			

Table7.11 Chest Width: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.
Cows, which are genotyped and have no records.

b_year	N	Own GTa_reduc	PA GTa-full
2014	475	101.9	101.4
2015	2109	100.2	100.3
2016	3222	100.7	100.8
2017	3451	99.7	99.7
2018	163	99.8	101.1

Table7.12 Chest Width: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.
Cows, which are non- genotyped and have no records.

b_year	N	Own GTa_reduc	PA GTa-full
2014	211	101.1	100.5
2015	1003	99.8	99.8
2016	1411	100.9	100.9
2017	1043	100.3	100.0
2018	28	98.4	99.1



SD of mean GEBV for own GTa-reduc is higher than SD of mean GEBV for PA GTa-full for all of the four groups of cows.

Table 7.13 Chest width: SD of mean GEBV for own GTa-reduc and PA GTa-full for four groups of cows.

	Genotyped cows				Non-genotyped cows			
	With own record		Without own record		With own record		Without own record	
	Own GTa_reduc	PA GTa-full	Own GTa_reduc	PA GTa-full	Own GTa_reduc	PA GTa-full	Own GTa_reduc	PA GTa-full
2005								
2006	10.0	5.9			6.9	6.6		
2007	11.5	8.8			6.6	5.9		
2008	12.0	7.7			7.9	7.3		
2009	9.3	6.9			8.1	7.5		
2010	10.6	7.7			8.7	7.9		
2011	9.6	7.1			8.0	7.4		
2012	9.8	6.9			8.3	7.7		
2013	10.6	7.8			8.5	7.8		
2014	10.2	7.3	10.1	6.8	7.6	7.1	7.8	7.4
2015	9.7	7.1	9.8	7.3	7.7	6.8	7.4	7.4
2016	10.4	6.5	9.8	7.0	7.1	6.4	7.0	7.1
2017	10.7	7.2	9.8	6.9	8.2	7.0	6.8	7.1
2018			9.7	7.3			6.9	7.3

Udder depth

For udder depth the mean for own GTa-reduc and PA GTa-full are comparable for all four groups. However, the level of the GEBV differs between groups. Cows without records have higher breeding values than cows with record no matter if genotyped or not.

Table 7.14 Udder Depth: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.
Cows, which are genotyped and have own records

b year	N	Own GTa_reduc	PA GTa-full
2005			
2006	26	91.2	90.1
2007	41	93.1	93.3
2008	141	93.6	93.2
2009	220	93.2	92.8
2010	334	97.2	96.7
2011	350	99.4	98.3
2012	577	99.3	98.9
2013	1129	100.8	100.9
2014	1269	99.7	99.8
2015	449	100.7	101.0
2016	94	101.2	101.7
2017	57	102.7	103.2
2018			

Table 7.15 Udder Depth: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.
Cows, which are non-genotyped and have own records

b year	N	Own GTa_reduc	PA GTa-full
2005			
2006	47	86.8	86.9
2007	114	91.1	90.6
2008	175	92.2	91.8
2009	248	92.4	92.0
2010	367	92.6	92.6
2011	432	95.2	94.6
2012	579	95.8	95.6
2013	674	97.9	97.8
2014	739	99.1	99.1
2015	321	100.4	100.7
2016	86	102.0	101.8
2017	52	103.1	104.6
2018			

Table 7.16 Udder Depth: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.
Cows, which are genotyped and have no records

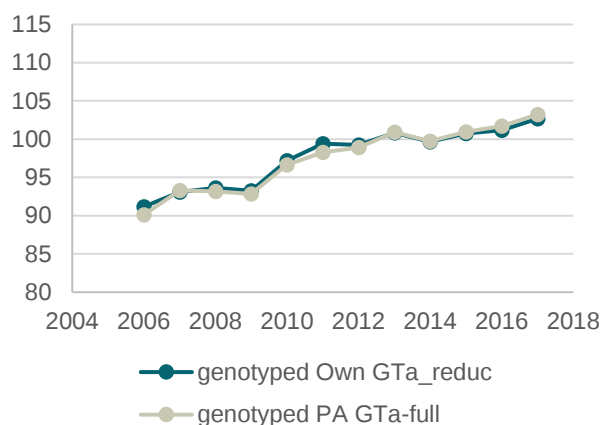
Table 7.17 Udder Depth: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.

Cows, which are non-genotyped and have no records

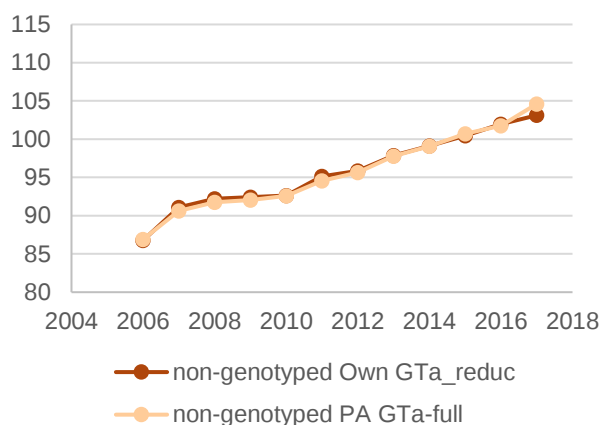
b_year	N	Own GTa_reduc	PA GTa-full
2014	475	102.5	102.0
2015	2109	104.0	103.4
2016	3222	104.5	104.1
2017	3451	107.8	107.2
2018	163	110.5	109.2

b_year	N	Own GTa_reduc	PA GTa-full
2014	211	99.3	99.4
2015	1003	101.9	102.2
2016	1411	103.0	102.6
2017	1043	106.3	105.7
2018	28	110.3	109.7

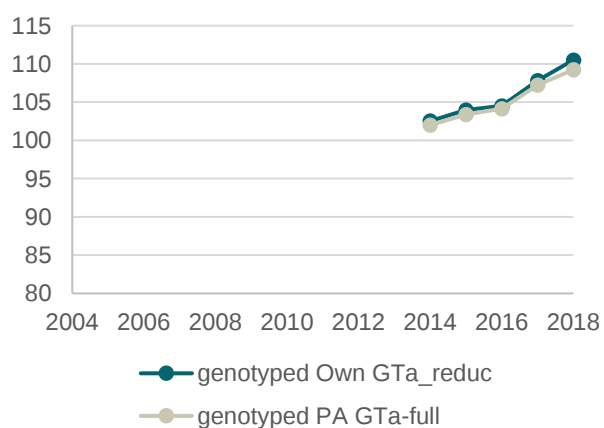
Udder depth: mean GEBV for own GTa-reduc and PA GTa-full for genotyped cows with own record



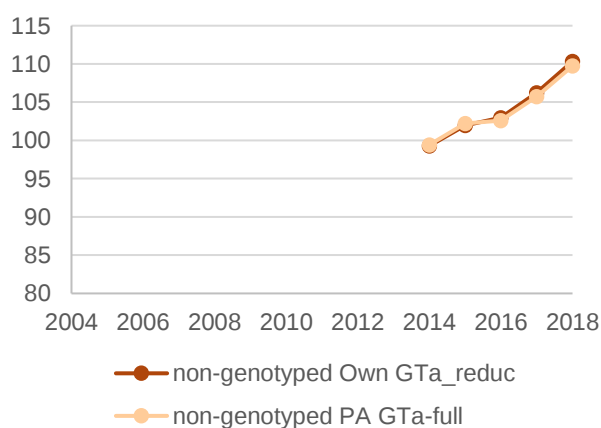
Udder depth: mean GEBV for own GTa-reduc and PA GTa-full for non-genotyped cows with own record



Udder depth: mean GEBV for own GTa-reduc and PA GTa-full for genotyped cows without own record



Udder depth: mean GEBV for own GTa-reduc and PA GTa-full for non-genotyped cows without own record



SD of mean GEBV for own GTa-reduc is higher than SD of mean GEBV for PA GTa-full for all of the four groups of cows.

Table 7.18 Udder depth: SD of mean GEBV for own GTa-reduc and PA GTa-full for four groups of cows.

	Genotyped cows				Non-genotyped cows			
	With own record		Without own record		With own record		Without own record	
	Own GTa_reduc	PA GTa-full	Own GTa_reduc	PA GTa-full	Own GTa_reduc	PA GTa-full	Own GTa_reduc	PA GTa-full
2005								
2006	9.7	5.2			7.5	5.0		
2007	7.8	5.3			7.1	5.4		
2008	9.8	6.6			7.4	5.5		
2009	9.1	6.6			7.5	5.3		
2010	10.2	7.0			8.4	7.2		
2011	10.3	7.6			8.5	7.2		
2012	9.5	6.6			8.4	7.0		
2013	10.4	7.2			8.7	7.5		
2014	10.1	7.2	9.7	7.2	8.5	7.3	7.6	7.1
2015	10.7	7.3	9.8	7.2	8.4	7.5	7.2	7.1
2016	9.7	7.2	9.6	7.4	9.3	8.2	7.2	7.4
2017	9.3	7.2	10.1	7.7	8.9	8.5	7.7	7.8
2018			9.2	7.0			8.1	7.5

Stature

Table 7. Stature: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.

Cows, which are genotyped and have own records

b_year	N	Own GTa reduc	PA GTa-full
2005			
2006	26	100.0	98.2
2007	41	99.1	100.1
2008	141	102.0	101.9
2009	220	100.6	99.7
2010	334	102.7	102.1
2011	350	103.3	102.8
2012	577	103.3	103.2
2013	1129	102.5	102.4
2014	1269	101.6	101.4
2015	449	102.2	101.8
2016	94	104.3	104.0
2017	57	108.0	108.8
2018			

Table 7. Stature: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.

Cows, which are non-genotyped and have own records

b_year	N	Own GTa reduc	PA GTa-full
2005			
2006	47	97.3	97.1
2007	114	99.8	99.4
2008	175	99.0	98.9
2009	248	99.4	99.2
2010	367	98.4	98.6
2011	432	100.3	100.0
2012	579	100.6	100.6
2013	674	100.8	100.5
2014	739	101.3	101.5
2015	321	101.7	102.3
2016	86	106.1	106.1
2017	52	111.8	110.9
2018			

Table 7. Stature: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.

Cows, which are genotyped and have no records

b_year	N	Own GTa reduc	PA GTa-full
2014	475	104.6	104.7
2015	2109	104.4	103.9
2016	3222	103.0	102.8
2017	3451	104.5	104.1
2018	163	106.3	105.2

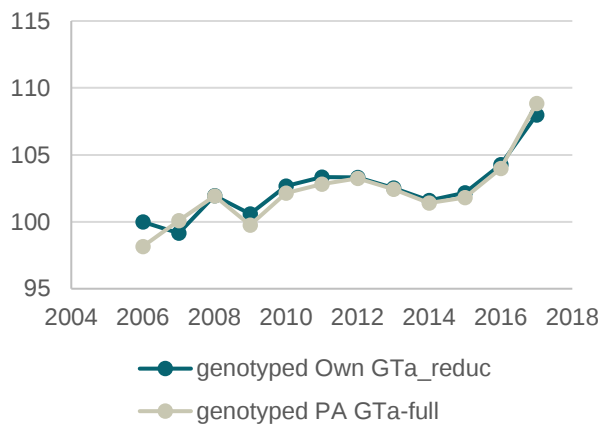
Table 7. Stature: mean GEBV (own reduc solution) and the parent average (PA) GEBV for cows, where parents are genotyped.

Cows, which are non-genotyped and have no records

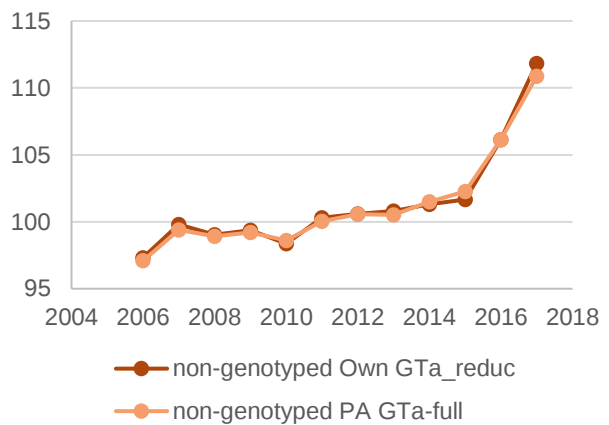
b_year	N	Own GTa reduc	PA GTa-full
2014	211	100.8	100.6
2015	1003	102.5	102.3
2016	1411	102.6	102.3
2017	1043	104.2	103.9
2018	28	103.9	103.3

The mean GEBV for stature is increasing rapidly the last two years, which rises a minor concern. There is a high degree of similarity between own GTa-reduc and PA GTa-full.

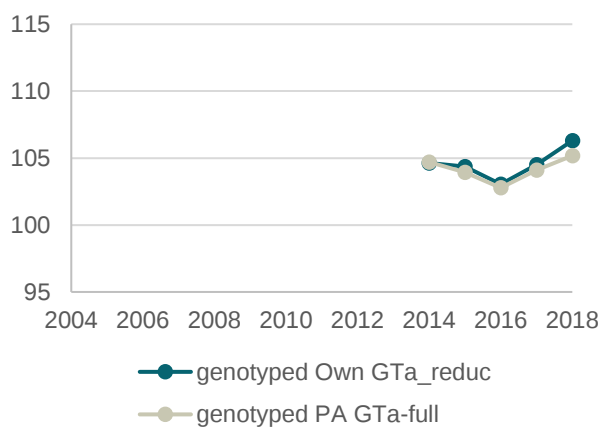
Stature: mean GEBV for own GTa-reduc and PA GTa-full for genotyped cows with own record



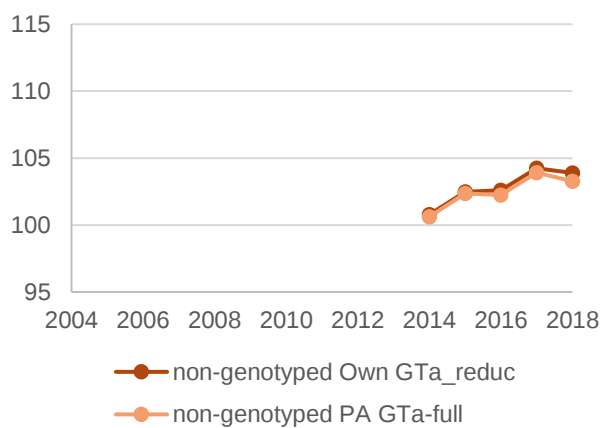
Stature: mean GEBV for own GTa-reduc and PA GTa-full for non-genotyped cows with own record



Stature: mean GEBV for own GTa-reduc and PA GTa-full for genotyped cows without own record



Stature: mean GEBV for own GTa-reduc and PA GTa-full for non-genotyped cows without own record



7. Comparison of PA GEBV and own GEBV for cows with records in full but not in reduc

These cows are having a record in full data but not in reduc data. Furthermore, only this includes only cows, where both parents are genotyped and have GEBV. Then parent average (PA) of GEBV full-GTa is calculated and compared with the cows own GEBV full-GTa and own GEBV reduc-GTa. Thus, the groups (full and reduc) of cows are equal size. Cows are divided into genotyped and non-genotyped cows

Chest width:

Genotyped cows

	full_GTa	reduc_GTa	PA full_GTa	N
2014	101.1	101.9	101.4	475
2015	100.0	100.2	100.3	2109
2016	100.6	100.7	100.8	3222
2017	99.6	99.7	99.7	3451
2018	100.7	99.8	101.1	163

Non-genotyped cows

	full_GTa	reduc_GTa	PA full_GTa	N
2014	100.4	101.1	100.5	211
2015	99.7	99.8	99.8	1002
2016	100.9	100.9	100.9	1410
2017	100.0	100.3	100.0	1043
2018	99.3	98.4	99.1	28

Udder depth:

Genotyped cows

	full_GTa	reduc_GTa	PA full_GTa	N
2014	102.6	102.5	102.0	475
2015	104.2	104.0	103.4	2109
2016	104.3	104.5	104.1	3222
2017	107.6	107.8	107.2	3451
2018	109.9	110.5	109.2	163

Non-genotyped cows

	full_GTa	reduc_GTa	PA full_GTa	N
2014	99.4	99.3	99.4	211
2015	102.3	102.0	102.2	1002
2016	102.5	103.0	102.6	1410
2017	105.7	106.3	105.7	1043
2018	110.1	110.3	109.7	28

Stature:

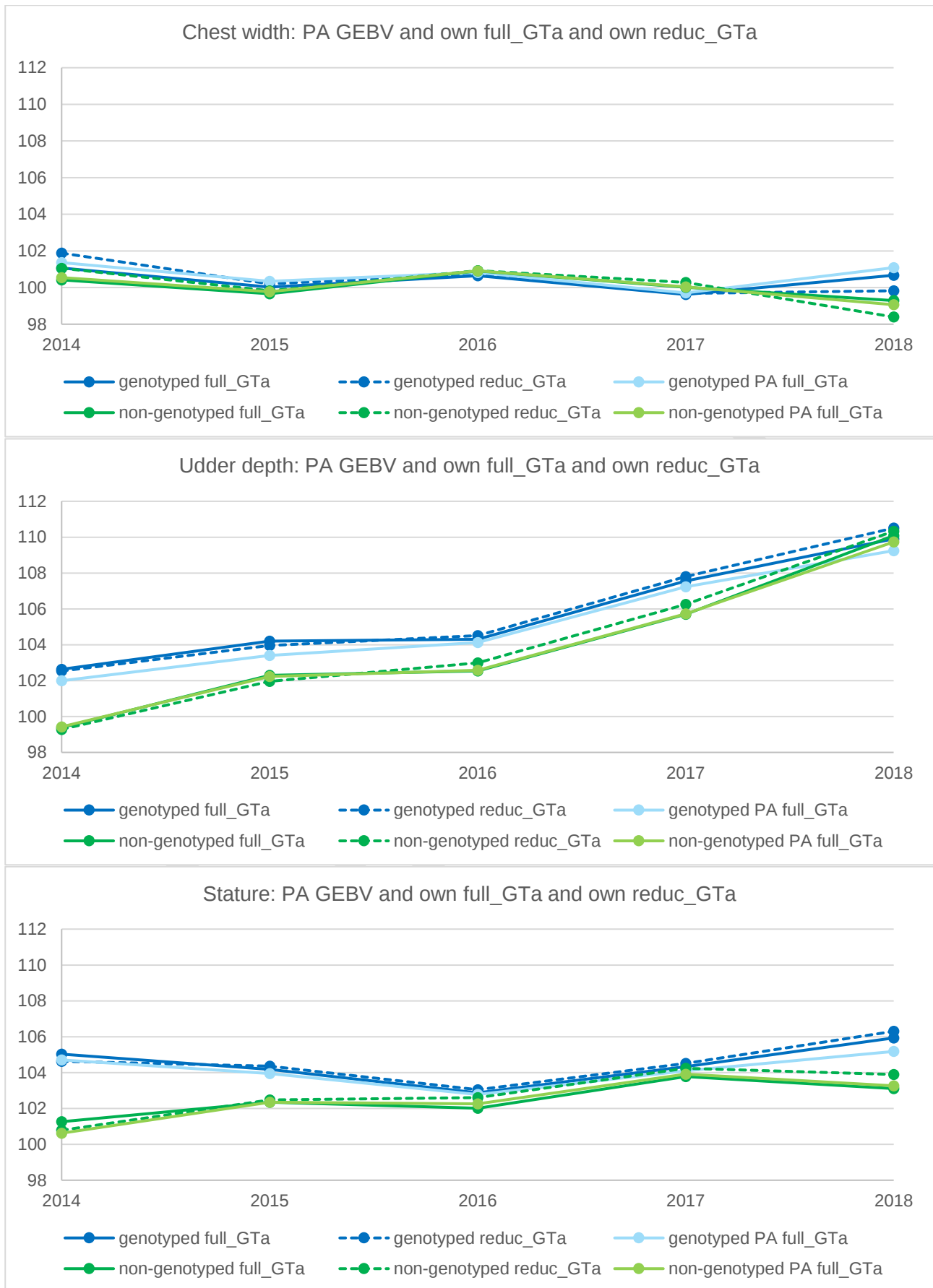
Genotyped cows

	full_GTa	reduc_GTa	PA full_GTa	N
2014	105.0	104.6	104.7	475
2015	104.2	104.4	103.9	2109
2016	102.9	103.0	102.8	3222
2017	104.3	104.5	104.1	3451
2018	105.9	106.3	105.2	163

Non-genotyped cows

	full_GTa	reduc_GTa	PA full_GTa	N
2014	101.3	100.8	100.6	211
2015	102.4	102.5	102.3	1002
2016	102.0	102.6	102.3	1410
2017	103.8	104.2	103.9	1043
2018	101.3	100.8	100.6	28

For these three traits there is a high similarity between own full-GTa, own reduc-GTa and Pa full-GTa.



8. Comparison of status1 bulls divided into four groups based on number of daughters with records in full data

For each bull with status 1, it is counted how many daughters he has, where the daughters have records in full data but no records in reduc dataset. Group1 is having most daughters while group5 is having fewest daughters.

	Group1	Group2	Group3	Group4	Group5
Number of daughters for the bull	[101; -]	[71;100]	[46;70]	[10;45]	[- ;9]
Number of bulls	181	86	88	32	34

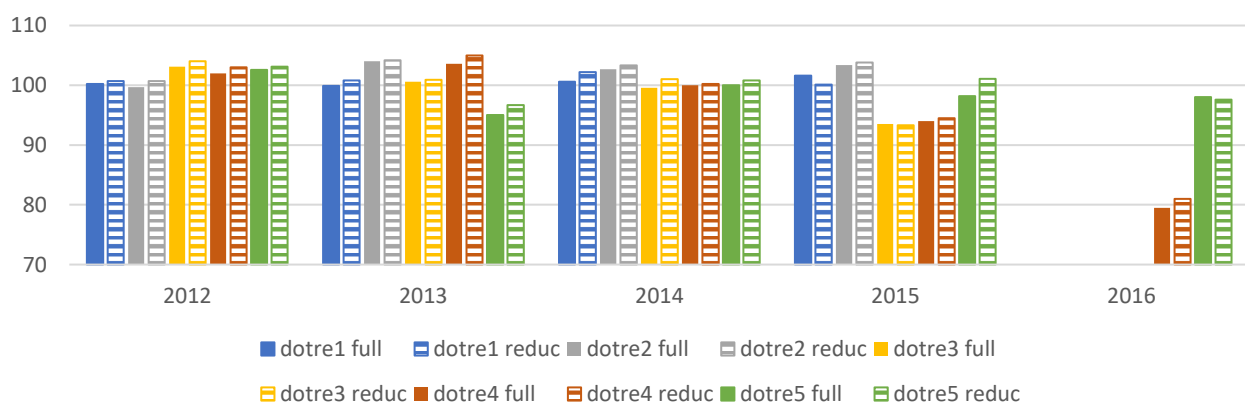
Chest width: mean GEBV for bulls status1 divided into 5 groups based on number of daughters with records in full data but no records in reduc data.

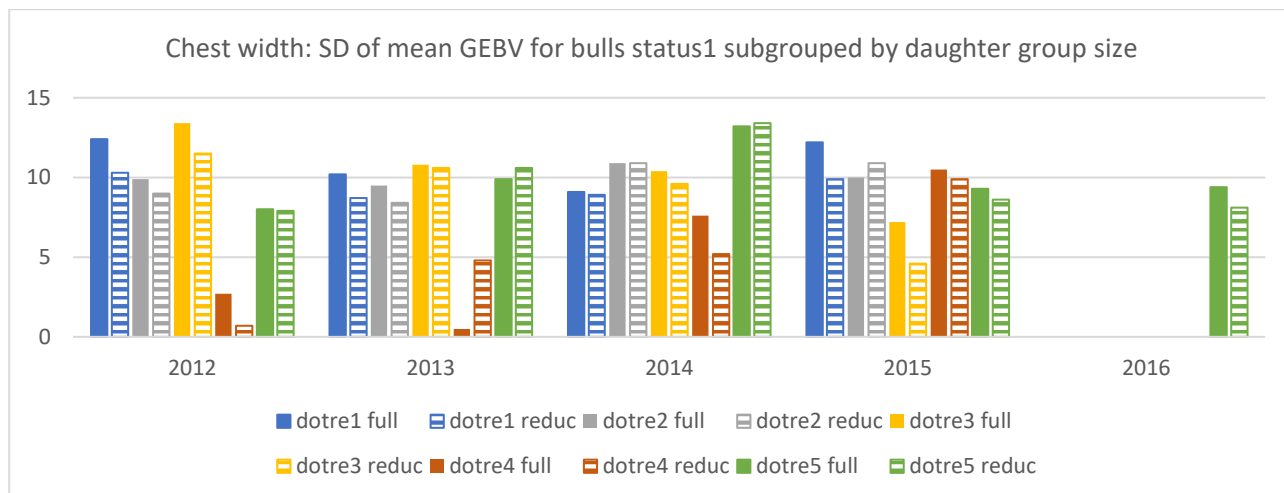
	1		2		3		4		5		N				
	full	reduc	full	reduc	full	reduc	full	reduc	full	reduc	1	2	3	4	5
2012	100.2	100.7	99.7	100.7	103.1	104.0	102.0	103.0	102.6	103.1	55	44	27	4	6
2013	99.9	100.8	104.0	104.2	100.6	100.9	103.6	105.0	95.0	96.7	42	26	32	2	3
2014	100.6	102.2	102.7	103.3	99.6	101.0	100.0	100.2	100.0	100.8	50	9	25	7	5
2015	101.6	100.1	103.4	103.8	93.5	93.3	94.0	94.5	98.2	101.1	34	7	4	18	8
2016							79.5	81.0	98.0	97.6				1	12
											181	86	88	32	34

Chest width: SD of mean GEBV for bulls status1 divided into 5 groups based on number of daughters with records in full data but no records in reduc data.

	1		2		3		4		5		N				
	full	reduc	full	reduc	full	reduc	full	reduc	full	reduc	1	2	3	4	5
2012	12.4	10.3	9.9	9.0	13.4	11.5	2.7	0.7	8.0	7.9	55	44	27	4	6
2013	10.2	8.7	9.5	8.4	10.8	10.6	0.5	4.8	9.9	10.6	42	26	32	2	3
2014	9.1	8.9	10.9	10.9	10.4	9.6	7.6	5.2	13.2	13.4	50	9	25	7	5
2015	12.2	9.9	10.0	10.9	7.2	4.6	10.5	9.9	9.3	8.6	34	7	4	18	8
2016									9.4	8.1				1	12
											181	86	88	32	34

Chest width: mean GEBV for bulls status1 subgrouped by daughter group size

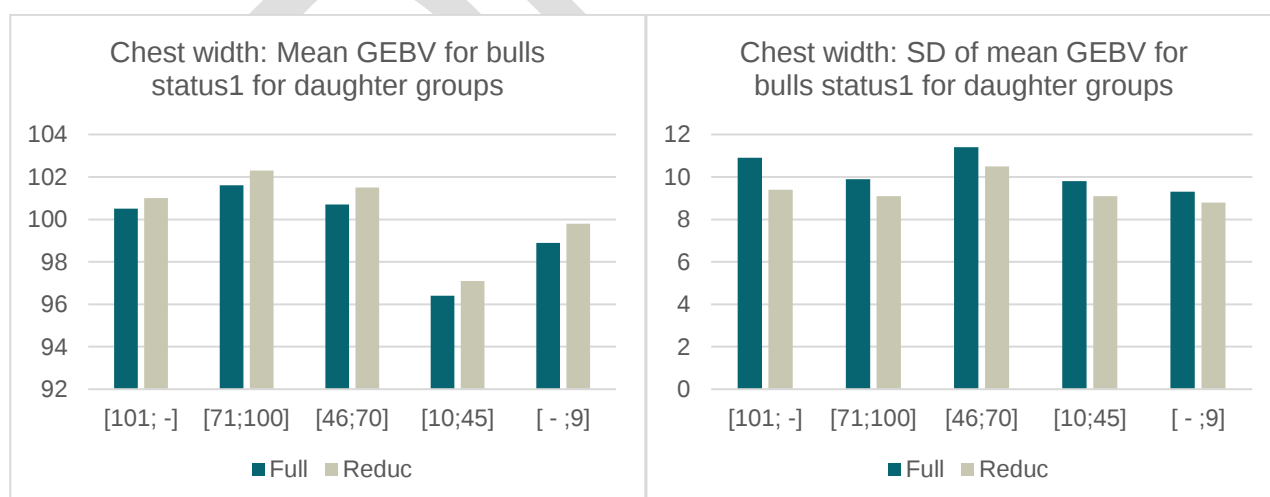




Since there is almost no genetic trend for chest width in this time period, it is reasonable to compare groups without looking at birth year for the bulls. This is advantageously, because of the low number of bulls in each group year.

The mean GEBV-full is lower than mean GEBV-reduc for the five groups, while the SD of the mean GEBV is higher for full than for reduc.

Group	N daughters	N bulls	Mean GEBV		SD of mean GEBV		diff
			Full	Reduc	Full	Reduc	
1	[101; -]	181	100.5	101.0	10.9	9.4	1.5
2	[71;100]	86	101.6	102.3	9.9	9.1	0.8
3	[46;70]	88	100.7	101.5	11.4	10.5	0.9
4	[10;45]	32	96.4	97.1	9.8	9.1	0.7
5	[- ;9]	34	98.9	99.8	9.3	8.8	0.5



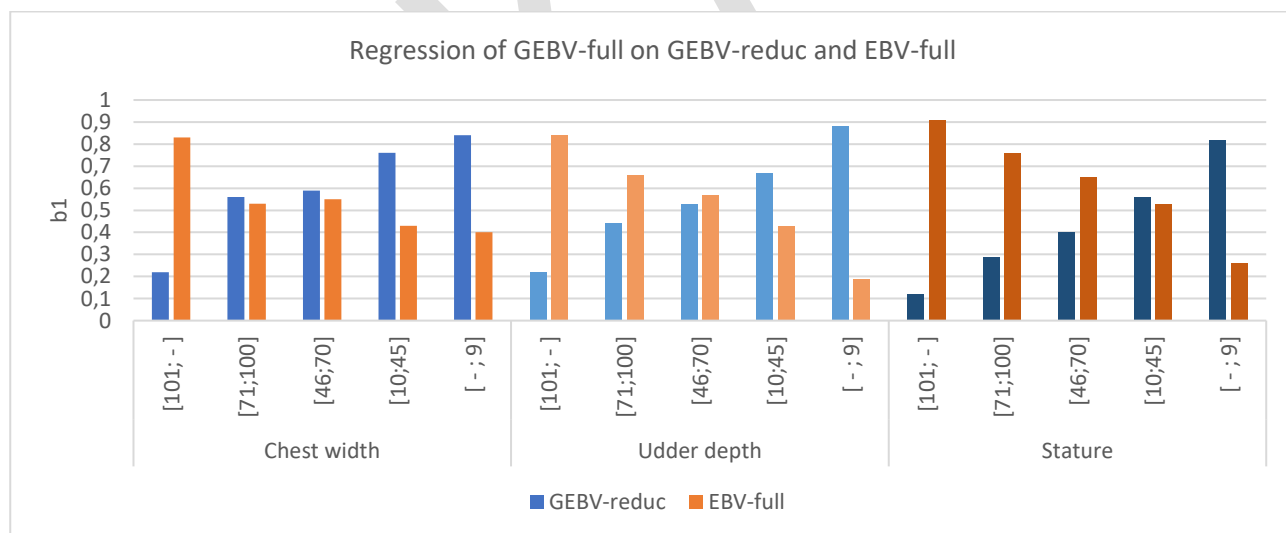
9. Regression of GEBV_full on GEBV_reduc and Trad_full for status1 bulls divided into daughter groups

For bulls status1 divided into groups based on number of daughters with records in full but not in reduc data. Traditional breeding values EBV's for chest width and udder depth are from a model with all animals (also international bulls) but stature is from a model without international bulls. This should have no effect since international bulls should not affect the breeding value.

b1 values for GEBV-reduc is low in group1 (many daughters) and high in group4 (few daughters) and b1 values for EBV-full is highest for group1 and lower for group4 for chest width, udder depth and stature. Thus, as expected, bulls with many daughters are less depending on genomic value and more depending on phenotypes from daughters, while for bulls with few daughters, the genotype is more important than the phenotypes from the daughters.

b1 values for GEBV-reduc and EBV-full in a regression model for GEBV-full for bulls status1 with daughters with own record in full data but not in reduc data. Bulls are divided into groups based on number of daughters.

		Group 1	Group 2	Group 3	Group 4	Group 5
	N daughters/bull	[101; -]	[71;100]	[46;70]	[10;45]	[- ; 9]
	Number of bulls	181	86	88	32	34
Chest width	GEBV_reduc	0.22	0.56	0.59	0.76	0.84
	Trad_full	0.83	0.53	0.55	0.43	0.40
	R-Square	0.99	0.98	0.97	0.94	0.93
Udder depth	GEBV_reduc	0.22	0.44	0.53	0.67	0.88
	Trad_full	0.84	0.66	0.57	0.43	0.19
	R-Square	0.99	0.99	0.98	0.97	0.96
Stature	GEBV_reduc	0.12	0.29	0.40	0.56	0.82
	Trad_full	0.91	0.76	0.65	0.53	0.26
	R-Square	0.99	0.99	0.99	0.97	0.96



10. Comparison of own GEBV and parent average GEBV where cows are divided into four groups by PA GEBV.

Those cows are cows where parents are genotyped. Furthermore, cows are having records in full data but not in reduc. And based on PA GEBV cows are (by birth year) divided into four groups of PA, where PA1 are cows with the highest PA GEBV, and PA4 are cows with the lowest PA GEBV. Therefore, by birth year the number of cows in each PA group is similar. Thereafter the cows are divided into genotyped and non-genotyped cows. The aim is to check if different level of PA affects the trend for GEBV. Those results are for stature only.

Number of cows in each group by birth year

	PA1	PA2	PA3	PA4
2014	171	171	172	172
2015	777	779	778	777
2016	1158	1158	1158	1158
2017	1123	1124	1124	1123
2018	48	48	48	47

Stature: Genotyped cows with own record in full, but without own record in reduc.

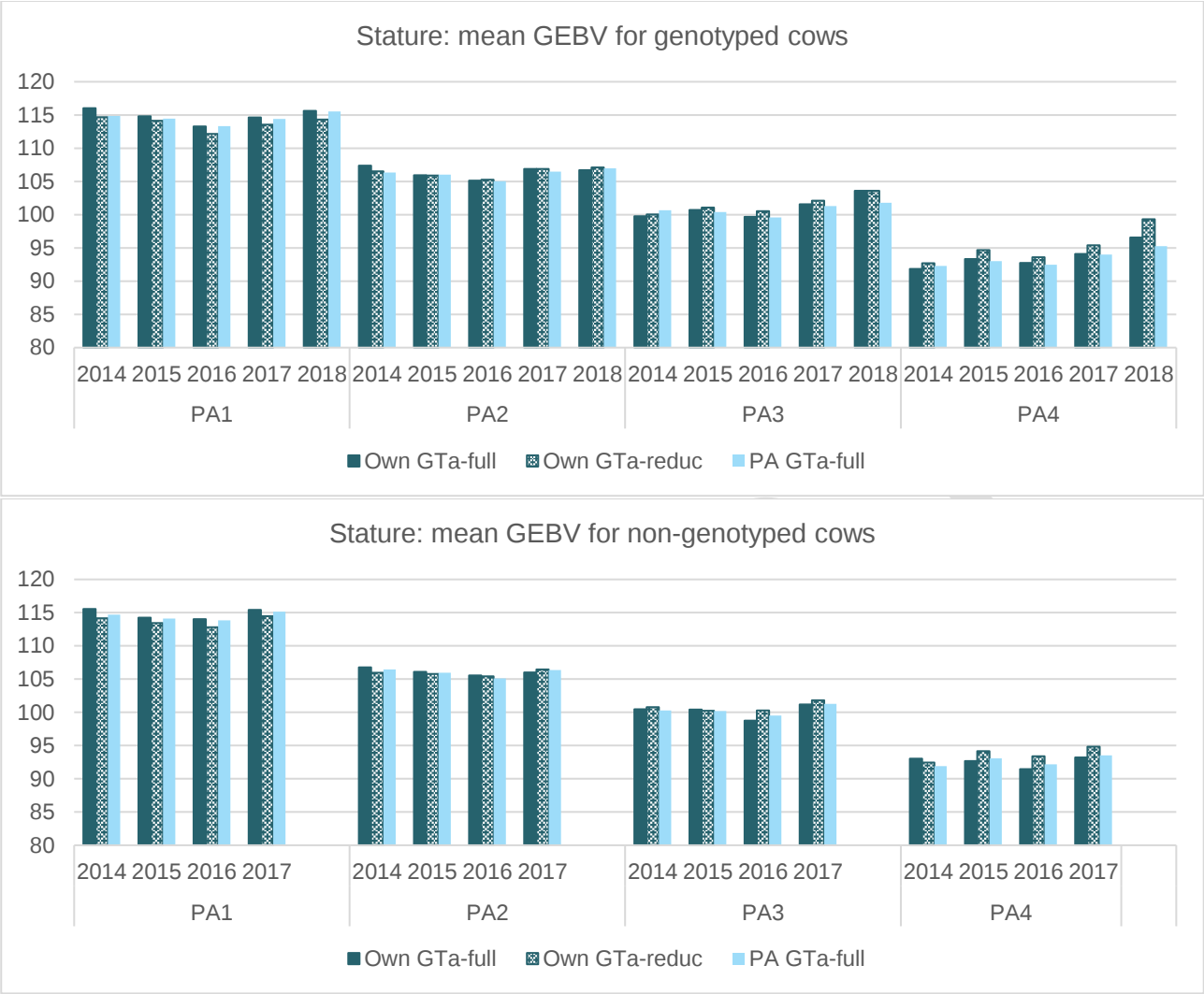
group	b-year	Own GTa-full	Own GTa-reduc	PA GTa-full	N
PA1	2014	116.0	114.7	114.9	140
	2015	114.8	114.1	114.4	570
	2016	113.3	112.2	113.3	818
	2017	114.6	113.5	114.4	878
	2018	115.6	114.3	115.5	42
PA2	2014	107.4	106.5	106.4	130
	2015	106.0	105.9	106.0	556
	2016	105.1	105.3	105.1	829
	2017	106.9	106.9	106.5	860
	2018	106.7	107.1	107.0	41
PA3	2014	99.8	100.0	100.7	108
	2015	100.7	101.1	100.4	488
	2016	99.7	100.6	99.6	805
	2017	101.6	102.1	101.3	847
	2018	103.6	103.6	101.8	44
PA4	2014	91.9	92.7	92.3	97
	2015	93.3	94.7	93.0	495
	2016	92.8	93.6	92.5	770
	2017	94.1	95.4	94.0	866
	2018	96.6	99.3	95.3	36

Stature: Non-genotyped cows with own record in full, but without own record in reduc.

group	b-year	Own GTa-full	Own GTa-reduc	PA GTa-full	N
PA1	2014	115.5	114.2	114.7	31
	2015	114.2	113.5	114.1	207
	2016	114.0	112.8	113.9	340
	2017	115.4	114.5	115.1	245
	2018	112.5	116.3	116.6	6
PA2	2014	106.8	106.0	106.4	41
	2015	106.1	105.8	105.9	223
	2016	105.5	105.4	105.1	329
	2017	106.0	106.5	106.4	264
	2018	108.4	106.4	106.2	7
PA3	2014	100.5	100.8	100.3	64
	2015	100.4	100.2	100.2	290
	2016	98.7	100.3	99.5	353
	2017	101.2	101.8	101.3	277
	2018	100.6	102.3	101.7	4
PA4	2014	93.0	92.4	91.9	75
	2015	92.6	94.2	93.1	282
	2016	91.5	93.4	92.2	388
	2017	93.2	94.9	93.5	257
	2018	95.5	96.1	94.7	11

No matter the PA group there is a positive trend for stature for the period 2014 until 2018.

Overall there is a great similarity of level of own GEBV GTa-full, own GEBV GTa-reduc and PA GEBV GTa-full.



11. GTa-reduc2 for 2017, 2018, 2019 and 2020 for bulls

For bulls status1 GEBV for GTa-full and GTa-reduc2 and GTa-reduc2 for years 2017 to 2020. This means that each year more data are available.

For chest width, udder depth and stature the full, reduc2, reduc2_2017, reduc2_2018, reduc2_2019 and reduc2_2020 are showing similar levels inside each birth year for bulls with status1. For the later years the twostep value is lower than the singlestep values.

Chest width:

Chest width: mean GEBV for singlestep and twostep for bulls status1

b_year	N	Twostep	Full	Reduc2	Reduc2_2017	Reduc2_2018	Reduc2_2019	Reduc2_2020
2005	334	102.6	102.2	102.1	102.0	102.1	102.1	102.2
2006	383	100.9	100.7	100.6	100.7	100.7	100.7	100.7
2007	334	101.6	101.6	101.5	101.5	101.5	101.6	101.6
2008	293	100.5	100.5	100.4	100.4	100.4	100.5	100.5
2009	269	99.4	99.6	99.8	99.7	99.6	99.7	99.7
2010	226	99.6	100.2	101.0	100.7	100.4	100.3	100.3
2011	167	100.5	100.9	102.2	101.7	101.2	101.1	101.0
2012	172	100.7	101.2	102.7	102.5	102.2	101.8	101.4
2013	120	100.7	101.2	102.2	102.1	102.1	102.0	101.4
2014	104	99.8	100.1	102.0	102.2	101.7	101.2	100.5
2015	80	98.8	98.9	100.3	100.1	99.8	99.7	99.5
2016	66	98.4	98.6	99.1	99.7	99.3	99.4	99.0
2017	65	99.1	99.5	99.4	99.6	99.9	99.9	99.8
2018	89	98.7	99.2	99.3	99.8	99.6	100.0	99.8
2019	42	95.5	95.9	96.2	96.5	96.5	97.1	96.6

Chest width: SD of mean GEBV for singlestep and twostep for bulls status1

b_year	N	Twostep	Full	Reduc2	Reduc2_2017	Reduc2_2018	Reduc2_2019	Reduc2_2020
2005	334	10.3	10.9	10.9	10.9	10.9	10.9	10.9
2006	383	10.1	10.5	10.5	10.5	10.5	10.5	10.5
2007	334	9.2	9.8	9.8	9.8	9.9	9.8	9.8
2008	293	9.8	10.3	10.2	10.2	10.2	10.2	10.3
2009	269	9.3	10.0	10.0	10.0	10.0	10.0	10.0
2010	226	10.1	10.7	10.8	10.9	10.8	10.7	10.6
2011	167	10.3	10.8	10.7	10.7	10.8	10.8	10.8
2012	172	10.6	11.3	10.1	10.9	11.2	11.3	11.3
2013	120	9.6	10.4	9.4	9.5	10.3	10.4	10.4
2014	104	8.4	9.4	9.1	9.1	8.9	9.6	9.4
2015	80	10.1	11.3	9.9	9.8	10.5	10.6	11.2
2016	66	9.0	10.7	9.5	9.7	10.0	10.4	10.5
2017	65	8.8	9.9	9.9	9.7	9.5	10.0	9.7
2018	89	8.8	10.5	9.9	9.9	10.1	10.2	10.3
2019	42	7.7	9.2	8.1	8.1	8.5	8.8	9.1

Udder depth:

Udder depth: mean GEBV for singlestep and twostep for bulls status1

b_year	N	Twostep	Full	Reduc2	Reduc2_2017	Reduc2_2018	Reduc2_2019	Reduc2_2020
2005	334	87.5	86.5	86.6	86.6	86.6	86.5	86.6

2006	383	89.9	89.0	89.1	89.0	89.0	89.0	89.0
2007	334	91.7	91.0	91.0	91.0	91.1	91.1	91.0
2008	293	94.5	93.6	93.7	93.6	93.6	93.6	93.6
2009	269	95.3	94.5	94.6	94.8	94.7	94.6	94.6
2010	226	98.9	98.5	98.3	98.7	98.9	98.8	98.7
2011	167	99.3	98.9	98.1	98.6	99.2	99.3	99.2
2012	172	101.1	100.8	100.8	100.4	100.9	101.0	101.2
2013	120	105.6	106.3	106.1	106.3	106.3	106.4	106.8
2014	104	105.0	107.1	108.3	108.2	108.4	107.4	107.6
2015	80	109.5	112.6	113.6	114.3	114.7	114.3	113.2
2016	66	111.3	114.1	115.0	115.1	115.4	114.5	114.9
2017	65	112.3	115.6	116.3	116.8	117.0	117.1	116.5
2018	89	113.6	116.1	116.2	116.6	117.2	116.5	116.7
2019	42	114.0	117.1	117.0	117.5	118.0	117.9	117.8

Udder depth: SD of mean GEBV for singlestep and twostep for bulls status1

b_year	N	Twostep	Full	Reduc2	Reduc2_2017	Reduc2_2018	Reduc2_2019	Reduc2_2020
2005	334	10.2	10.4	10.4	10.4	10.4	10.4	10.4
2006	383	9.5	9.6	9.7	9.7	9.6	9.6	9.6
2007	334	9.4	9.6	9.6	9.6	9.6	9.6	9.6
2008	293	8.7	8.9	8.9	8.9	8.8	8.9	8.9
2009	269	9.5	9.6	9.6	9.7	9.7	9.7	9.6
2010	226	10.0	10.3	10.2	10.3	10.3	10.3	10.4
2011	167	8.8	9.5	9.6	9.6	9.6	9.6	9.5
2012	172	8.4	8.8	8.4	8.6	8.7	8.8	8.9
2013	120	8.1	8.7	8.5	8.4	8.7	8.9	8.8
2014	104	9.8	10.9	9.6	9.8	10.2	10.9	10.9
2015	80	10.5	11.2	10.7	10.8	10.7	10.6	11.3
2016	66	8.0	8.7	8.9	8.7	8.8	8.7	8.6
2017	65	9.0	9.7	9.3	9.4	9.4	9.8	9.8
2018	89	8.7	9.4	9.1	8.8	9.0	9.3	9.4
2019	42	8.8	9.3	8.5	8.6	8.7	8.9	9.1

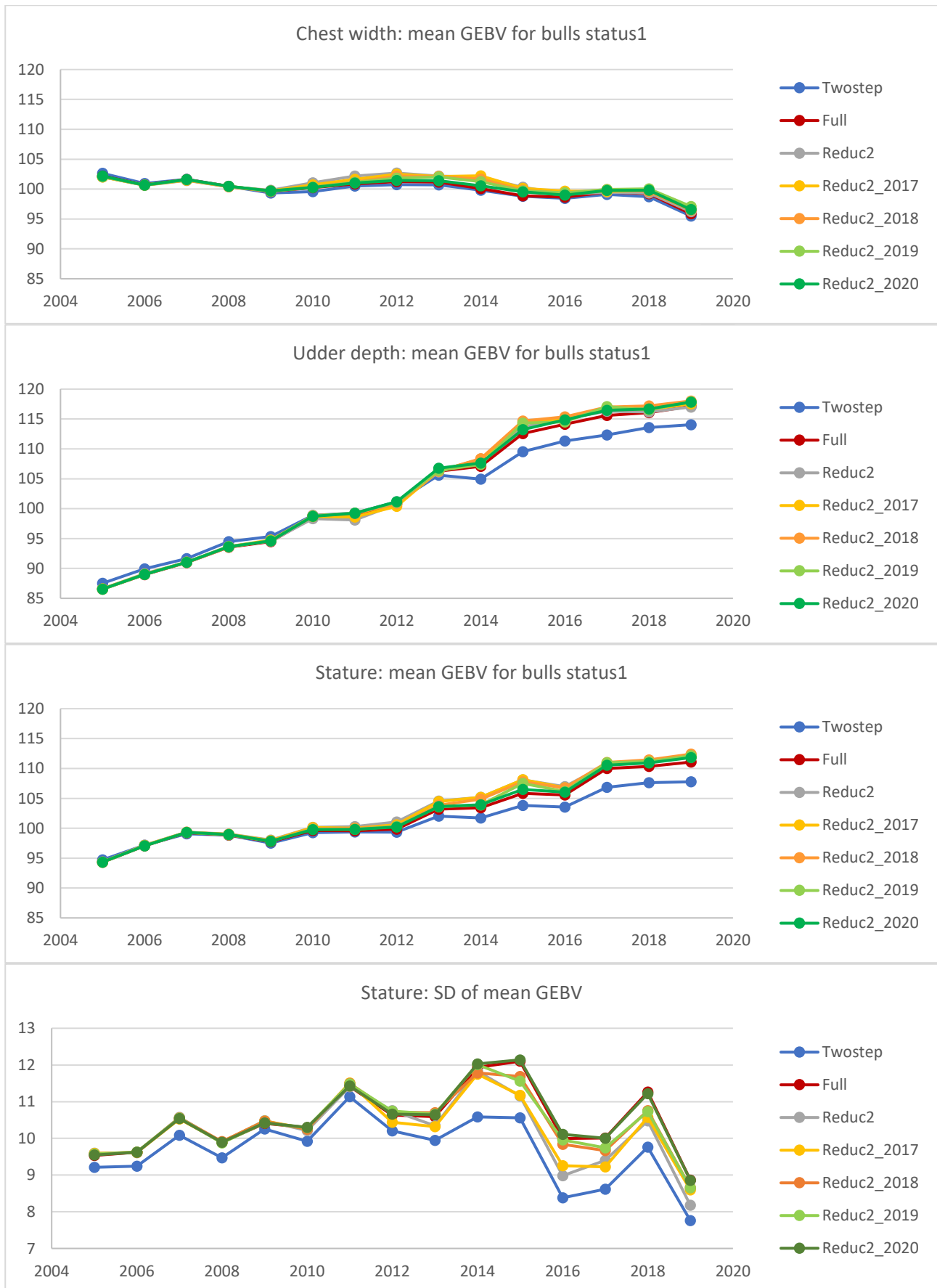
Stature:

Stature: mean GEBV for singlestep and twostep for bulls status1

b_year	N	Twostep	Full	Reduc2	Reduc2_2017	Reduc2_2018	Reduc2_2019	Reduc2_2020
2005	334	94.7	94.3	94.4	94.3	94.3	94.3	94.3
2006	383	97.2	97.0	97.2	97.1	97.1	97.1	97.1
2007	334	99.1	99.3	99.3	99.3	99.3	99.3	99.3
2008	293	98.8	98.9	99.0	99.0	98.9	98.9	98.9
2009	269	97.5	97.8	98.0	98.0	97.9	97.8	97.8
2010	226	99.3	99.6	100.1	100.1	99.9	99.8	99.8
2011	167	99.4	99.6	100.3	100.0	100.0	99.8	99.8
2012	172	99.3	99.9	101.0	100.6	100.3	100.3	100.2
2013	120	102.0	103.2	104.5	104.5	103.9	103.6	103.6
2014	104	101.7	103.4	105.2	105.2	104.9	103.9	103.9
2015	80	103.8	105.9	108.1	108.1	107.8	107.5	106.5
2016	66	103.5	105.6	107.0	106.8	106.7	106.1	106.0
2017	65	106.9	110.0	110.7	110.6	111.0	111.0	110.6
2018	89	107.6	110.3	111.1	111.1	111.4	111.1	110.9
2019	42	107.8	111.1	112.1	111.9	112.4	112.1	111.8

Stature: SD of mean GEBV for singlestep and twostep for bulls status1

b_year	N	Twostep	Full	Reduc2	Reduc2_2017	Reduc2_2018	Reduc2_2019	Reduc2_2020
2005	334	9.2	9.5	9.6	9.6	9.6	9.6	9.5
2006	383	9.2	9.6	9.6	9.6	9.6	9.6	9.6
2007	334	10.1	10.5	10.6	10.5	10.6	10.6	10.5
2008	293	9.5	9.9	9.9	9.9	9.9	9.9	9.9
2009	269	10.3	10.4	10.5	10.5	10.5	10.4	10.4
2010	226	9.9	10.3	10.2	10.3	10.3	10.3	10.3
2011	167	11.1	11.4	11.4	11.5	11.5	11.5	11.4
2012	172	10.2	10.6	10.8	10.4	10.7	10.7	10.7
2013	120	9.9	10.6	10.3	10.3	10.7	10.7	10.6
2014	104	10.6	11.9	11.8	11.8	11.8	12.0	12.0
2015	80	10.6	12.1	11.2	11.2	11.7	11.6	12.1
2016	66	8.4	10.0	9.0	9.3	9.8	10.0	10.1
2017	65	8.6	10.0	9.4	9.2	9.7	9.7	10.0
2018	89	9.8	11.3	10.5	10.6	10.8	10.7	11.2
2019	42	7.8	8.9	8.2	8.6	8.7	8.7	8.9



12. GTa-reduc2 for 2017, 2018, 2019 and 2020 for cows

Number of cows with records in each dataset by birth year

	full	reduc2	reduc2_17	reduc2_18	reduc2_19	reduc2_20
2005	89847	89847	89847	89847	89847	89847

2006	100495	100495	100495	100495	100495	100495
2007	96846	96846	96846	96846	96846	96846
2008	98996	98996	98996	98996	98996	98996
2009	102261	102261	102261	102261	102261	102261
2010	95826	95826	95826	95826	95826	95826
2011	91349	91349	91349	91349	91349	91349
2012	89763	89720	89763	89763	89763	89763
2013	89955	77354	89914	89955	89955	89955
2014	86617	2256	75381	86585	86617	86617
2015	79697	0	1946	68761	79657	79697
2016	75729	0	0	1889	65522	75721
2017	55318	0	0	0	1724	54297
2018	2043	0	0	0	0	1147
2019	0	0	0	0	0	0
2020	0	0	0	0	0	0

Mean GEBV and SD of mean GEBV for cows with records in 2019 but not in 2018 where cows are divided into genotyped and non-genotyped cows.

Overall there is high similarity of mean GEBV for reduc2_18 and reduc2_19 for both genotyped and non-genotyped cows for each trait.

However, it is a minor concern that the SD for reduc2_18 and reduc2_19 is similar for genotyped cows. It was expected that the SD for reduc2_19 should be higher than for reduc2_18, since accuracy is increased. This is not a concern for non-genotyped cows, where SD for reduc2_19 is higher than reduc2_18.

Chest width:

Chest width: mean GEBV and SD of mean GEBV for genotyped cows for 2018 and 2019.

b-year	N	Mean GEBV		SD of mean GEBV	
		reduc2_18	reduc2_19	reduc2_18	reduc2_19
2014	2	99.3	99.4	1.0	1.3
2015	1093	101.6	101.7	9.8	9.9
2016	9249	101.4	101.7	9.6	9.9
2017	330	101.7	101.8	10.0	10.1

Chest width: mean GEBV and SD of mean GEBV for non-genotyped cows for 2018 and 2019.

b-year	N	Mean GEBV		SD of mean GEBV	
		reduc2_18	reduc2_19	reduc2_18	reduc2_19
2014	30	102.1	101.0	7.7	8.8
2015	9803	101.3	101.2	6.2	7.1
2016	54384	101.6	101.8	6.1	7.2
2017	1394	101.5	101.5	5.6	6.7

Udder depth:

Udder depth: mean GEBV and SD of mean GEBV for genotyped cows for 2018 and 2019.

b-year	N	Mean GEBV		SD of mean GEBV	
		reduc2_18	reduc2_19	reduc2_18	reduc2_19
2014	2	110.9	111.4	11.7	15.6
2015	1093	102.8	102.8	10.6	10.6
2016	9249	102.7	102.4	10.0	10.2
2017	330	104.7	104.3	10.4	10.6

Udder depth: mean GEBV and SD of mean GEBV for non-genotyped cows for 2018 and 2019.

b-year	N	Mean GEBV		SD of mean GEBV	
		reduc2_18	reduc2_19	reduc2_18	reduc2_19
2014	30	95.1	94.9	6.4	6.3

2015	9803	99.7	99.8	6.8	8.4
2016	54384	100.7	100.5	6.6	8.3
2017	1394	102.8	102.4	6.9	8.3

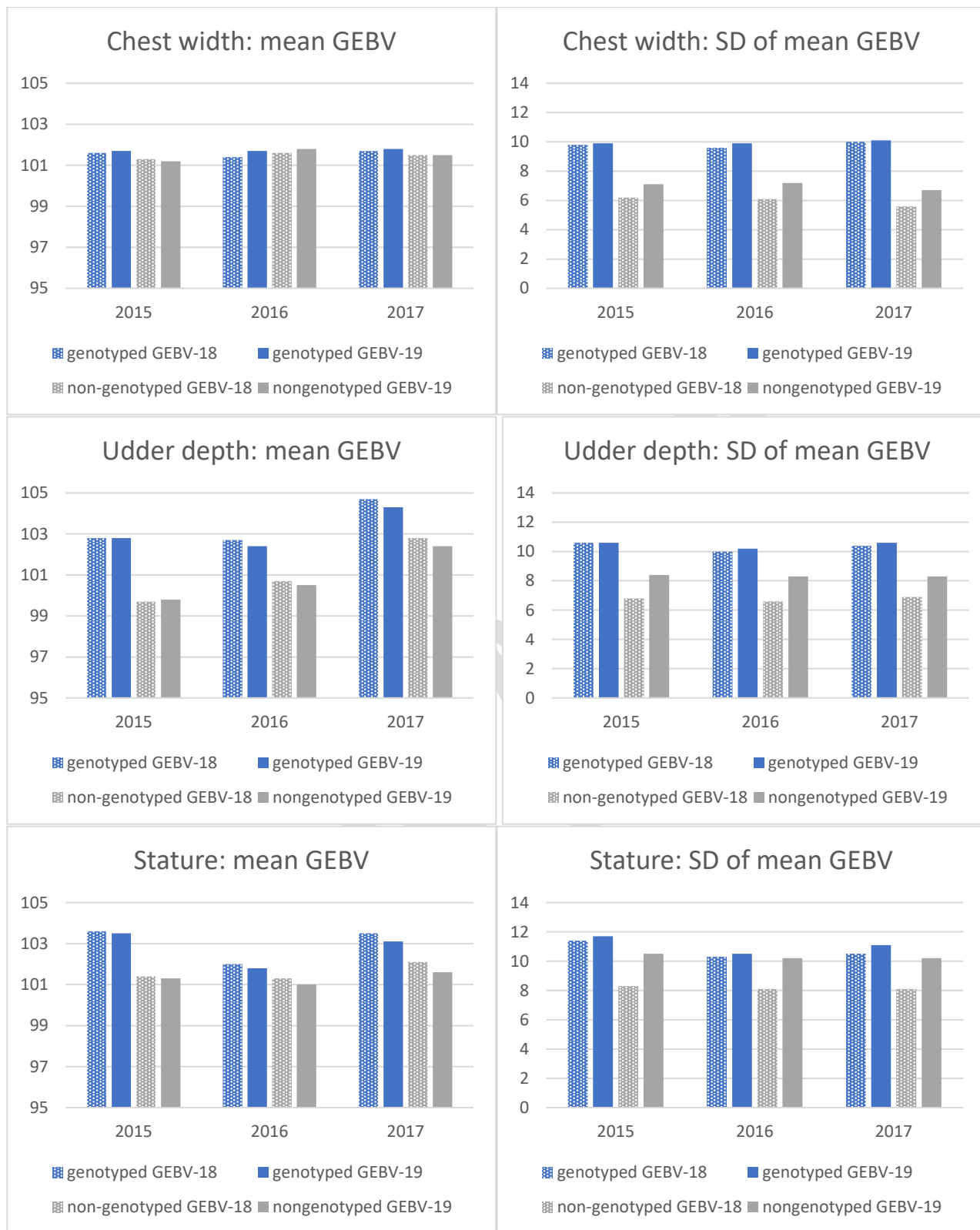
Stature:

Stature: mean GEBV and SD of mean GEBV for genotyped cows for 2018 and 2019.

b-year	N	Mean GEBV		SD of mean GEBV	
		reduc2_18	reduc2_19	reduc2_18	reduc2_19
2014	2	119.5	118.9	8.6	8.3
2015	1093	103.6	103.5	11.4	11.7
2016	9249	102.0	101.8	10.3	10.5
2017	330	103.5	103.1	10.5	11.1

Stature: mean GEBV and SD of mean GEBV for non-genotyped cows for 2018 and 2019.

b-year	N	Mean GEBV		SD of mean GEBV	
		reduc2_18	reduc2_19	reduc2_18	reduc2_19
2014	30	96.4	99.6	6.8	10.1
2015	9803	101.4	101.3	8.3	10.5
2016	54384	101.3	101.0	8.1	10.2
2017	1394	102.1	101.6	8.1	10.2



Correlation between GTa-reduc2_18 and GTa-reduc2_19 for cows with record in 2019 but not in 2018. Divided into birth year and genotyped /non-genotyped.

b-year	Chest width		Udder depth		Stature	
	genotyped	non-genotyped	genotyped	non-genotyped	genotyped	non-genotyped
2014		0.64		0.93		0.57
2015	0.98	0.78	0.99	0.86	0.98	0.80
2016	0.97	0.77	0.97	0.84	0.97	0.80
2017	0.96	0.79	0.97	0.81	0.97	0.79

Number of cows in each interval of diff where diff=GTa-reduc2_19- GTa_reduc2_18.

diff	Chest width		Udder depth		Stature	
	genotyped	non-genotyped	genotyped	non-genotyped	genotyped	non-genotyped
[-41;-80]						10
[-36;-40]						2
[-31;-35]				1		9
[-26;-30]				10		25
[-21;-25]		1		44		119
[-16;-20]		15		208	2	610
[-11;-15]		350		1395	5	2664
-10		305	1	700	3	1121
-9		456	4	996	9	1456
-8	10	761	7	1410	29	1777
-7	36	1272	23	1733	61	2257
-6	84	1891	84	2407	136	2681
-5	210	2627	240	2991	294	3193
-4	389	3483	488	3653	557	3718
-3	708	4573	867	4406	904	3904
-2	1099	5772	1351	4997	1260	4171
-1	1596	6557	1744	5384	1561	4245
0	1778	6903	2047	5362	1644	4187
1	1612	6804	1653	5332	1509	4197
2	1317	5988	1089	5024	1143	3985
3	841	5077	598	4594	730	3446
4	514	4106	263	3940	441	3124
5	283	3135	143	3188	214	2795
6	116	2292	46	2405	95	2469
7	52	1432	19	1707	46	2102
8	19	817	5	1232	19	1701
9	10	470	2	866	4	1415
10		264		568	4	1108
[11;15]		253		972	4	2555
[16;20]		7		76		481
[21;25]				10		72
[26;30]						9
[31;35]						1
[36;40]						1
[41;45]						1
sum	10674	65611	10674	65611	10674	65611

13. Interbull validation for GTa (and two-step) for udder depth

For interbull validation the data contains Nordic Holstein bulls born after 2011 and minimum of 25 daughters in the GTa-full model and no daughters in reduc dataset. The dataset contains 489 bulls.

Deregressed proof is set for each bull.

Based on the sire and the maternal grandsire the pedigree index is set.

Furthermore, the interbull validation for two-step model is mentioned for comparison.

Regression 1: deregressed proof on GTa-reduc

Regression 2: deregressed proof on pedigree index

Based on a regression model the R-square and the parameter estimate (b1) is solved.

The R-square is higher for GTa-reduc than for pedigree index, and the slope is closer to 1 for GTa-reduc than for pedigree index.

Thus, the GTa-reduc better fits the value for deregressed proof than the pedigree index does.

	R-square	Parameter estimate
Single-step		
Deregressed proof on GTa-reduc	0.67	0.84
Deregressed proof on pedigree index	0.15	0.73
Two-step		
Deregressed proof on GEBV-reduc	0.65	0.86
Deregressed proof on pedigree index	0.14	0.72

14. Legarra Reverter regression for GTa (and two-step) for udder depth

The Legarra Reverter regression examines how well the GTa-full and GTa-reduc/GTa-reduc2 are fitted. The Legarra Reverter regression is based on the same dataset as used in the interbull validation.

Regression 1: GTa-full on GTa-reduc

Regression 2: GTa-full on GTa-reduc2

Based on a regression model the R-square and the parameter estimate (b1) is solved.

The R-square is nearly similar for GTa-reduc and GTa-reduc2.

The b1 values are high for both GTa-reduc and GTa-reduc2, and close to 1.

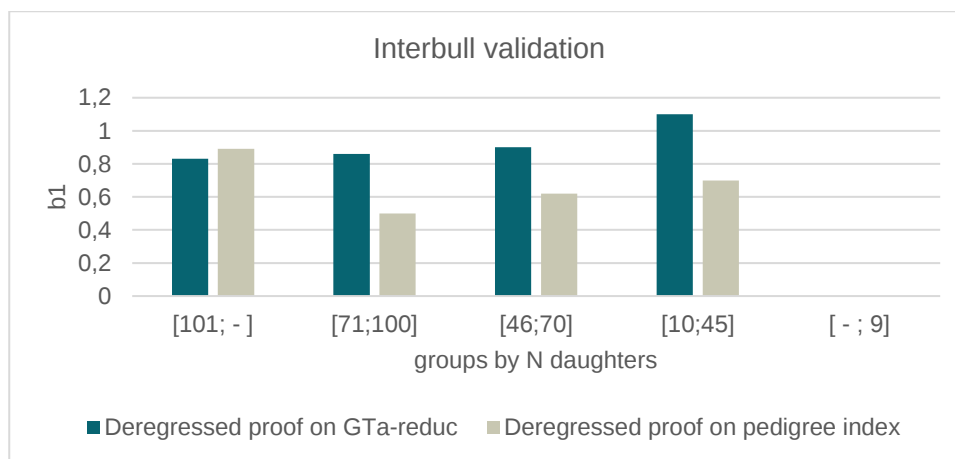
	R-square	Parameter estimate
Single-step		
GTa-full on GTa-reduc	0.84	0.95
GTa-full on GTa-reduc2	0.83	0.93
Two-step		
GEBV-full on GEBV-reduc	0.82	0.91

15. Interbull validation for status1 bulls sub-grouped by number of daughters

Bulls from the interbull validation mentioned earlier is sub-grouped by the number of daughters, as earlier described as dotre_groups.

Udder depth:

	Group 1	Group 2	Group 3	Group 4	Group 5
N daughters/bull	[101; -]	[71;100]	[46;70]	[10;45]	[- ; 9]
Number of bulls	172	85	87	20	0
Deregressed proof on GTa-reduc	0.83	0.86	0.90	1.10	-
R-Square	0.71	0.66	0.58	0.78	-
Deregressed proof on pedigree index	0.89	0.50	0.62	0.70	-
R-Square	0.22	0.07	0.11	0.11	-



16. Legarra Reverter regression for status1 bulls sub-grouped by number of daughters.

Same bulls as in Interbull validation above.

There seems to be some disturbances in group3 as it does not fit the tendency either for b1 or for R-square. So far there is no explanation for this.

Udder depth:

	Group 1	Group 2	Group 3	Group 4	Group 5
N daughters/bull	[101; -]	[71;100]	[46;70]	[10;45]	[- ; 9]
Number of bulls	172	85	87	20	0
GTa-full on GTa-reduc	0.95	0.97	0.86	1.06	-
R-Square	0.82	0.86	0.66	0.92	-

