

OVERVIEW OF DIFFERENT BREEDING OBJECTIVES IN VARIOUS COUNTRIES

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INTRODUCTION

For many years, most Holstein breeding schemes worldwide focused exclusively towards increasing milk production. Selection was based initially on improving milk yield, and then moved towards improving protein yield and, outside North America, towards increasing fat and especially protein content. This was true for most countries with the exception of Scandinavian countries, which selected also for health and fertility, and North American countries, which selected for conformation together with production. In the last five years there has been growing interest in broadening selection objectives, including functional, fertility and health traits. Main reasons behind this shift were quota and/or price constraints, together with increasing concerns associated with the deterioration of the health and fertility of dairy cows. Several studies have shown that selection for production alone yields negative effects on udder health (Heringstad et al., 2003) and reproductive performance (Lucy, 2001).

The main objective of this study was to give an overview of national selection indexes currently used in various countries and to show differences in top bull listings worldwide.

MATERIALS AND METHODS

A total of 15 countries provided information and breeding values for this study. Each country provided a brief description of their national selection index, including the relative emphasis of each trait in the overall index. Also, each country provided the August 2003 official top 100 bull list based on their national selection index formula, and, where this list was compiled based on minimum requirements of reliability or number of daughters, a second list was provided without such constraints. In the case of United States and Great Britain, where there are two main indexes in each country, two lists were provided: United States provided top 100 based on Net Merit and on TPI, and Great Britain provided top 100 based on PLI and on TOP. Bull listings were compared to estimate the common number of bulls present in various countries.

In a second analysis, Interbull files from August 2003 were used to compute the top 100 list for protein yield, mammary system and somatic cell score (SCS) in each country. Again, bull listings were then compared to estimate the common number of bulls present in various countries.

OVERVIEW OF NATIONAL SELECTION INDEXES

Table 1 provides the relative emphasis on traits in the national selection index within each country. Based on data from Table 1, Figure 1 shows overall differences among countries. Production is the sum of absolute emphasis of milk, fat and protein yield, as well as fat and protein percentages. Durability includes longevity, type traits, body, live weight and temperament. Health & Fertility includes SCS, mastitis, udder health, milking speed, female fertility, calving interval and calving ease. Average relative emphasis for Production, Durability and Health & Fertility, across all countries, was 59.5%, 27.9% and 12.6%, respectively.

The largest difference was the relative emphasis on Production in various countries. On the higher side Israel led with 80% compared to the lowest Denmark at 34%. Other indexes with large emphasis

on production were the British PLI and the Japanese NTP with 75%. With the exception of Denmark (34%) all countries had at least 50% emphasis on Production component.

The TOP index, one of two indexes in Great Britain, had the largest relative emphasis on Durability (42%), followed closely by the American TPI (41%), German RZG (40%), Canadian LPI (38%) and Spanish ICO (38%). On the other side, Israel did not have any emphasis on the Durability component. Other indexes with a low relative emphasis on durability were the Australian APR (16.5%) and the British PLI (20%).

As expected, the Danish S-Index had the largest relative emphasis on the Health and Fertility component (37%). Second, but well behind Denmark, was the French ISU with 25%, and then the American Net Merit with the Israeli PD01, both at 20%. On the other end, the Japanese NTP did not have any emphasis on the Health & Fertility component, and Spain followed closely with only 3%. Overall, the Danish S-Index appeared to be the most balanced across the three components, with 34% emphasis on Production, 29% on Durability and 37% on Health and Fertility.

Within the Production component (Figure 2), the Japanese NTP had the largest emphasis on protein yield with 55%, followed by the Israeli PD01 (51%) and the British PLI (49%). Lowest emphasis for protein yield was observed for the Danish S-Index (20.4%), followed by German RZG (26%) and Swiss ISEL (27%). The American Net Merit had the largest emphasis for fat yield (22%), while the British TOP had the lowest (6%). Regarding milk yield, the four indexes from North America and Japan did not have any direct emphasis on milk. All other indexes had a negative relative emphasis on milk indirectly through positive emphasis on percentages (ISEL, RZG, PFT and ISU) or directly through a negative weight on milk yield (eight remaining indexes). The Spanish ICO was an exception as it had positive weight on milk yield and protein %.

In a 1994 study Leitch reported the relative emphasis on traits in some countries. Figure 3 summarizes findings from the Leitch study (1994) with the addition of the American Net Merit formula in 1994 from VanRaden (2002). Six countries had 100% emphasis on Production (DEU, FRA, GBR, ISR, NLD and NZL), three between 67% and 80% (USA TPI and NM, CAN and ITA), and only DNK had a very low emphasis on Production (30%). Of all countries only the Danish S-Index (28%) and the American Net merit (6%) had some emphasis on Health and Fertility component. In short, until 5 to 10 years ago, most countries were selecting solely for production while North America and Italy had some emphasis also on some type traits correlated to longevity. The only country that has not changed significantly the index during this time period was Denmark, whose S-Index anticipated the trend for selection on Durability, Health and Fertility that occurred worldwide in the most recent years.

TOP 100 BULLS IN VARIOUS COUNTRIES

In the same investigation Leitch (1994) reported a relatively high similarity among top bull listings across countries (rank correlation greater than .88). At that time Interbull evaluations were not yet available. Bull comparisons were based on conversion formulae that did not account for genotype by environment interaction. That is to say, there was no re-ranking across countries for the same traits, and differences in top bull listings were solely based on differences in selection indexes. After 1995, the Interbull Centre started using the MACE procedure to compute international evaluations with estimated genetic correlations across countries that were less than one. This meant the differences in top 100 listings was due both to differences in national selection indexes and to the level of genetic correlation within traits across countries.

Tables 2 to 4 report the current genetic correlations for protein, mammary system and SCS among countries considered in the present study (Interbull November 2003 evaluations). Average genetic correlations were .869, .822 and .860 for protein yield, Mammary System and SCS, respectively.

Values ranged from .77 to .95, .48 to .96 and .55 to .97 for protein yield, Mammary System and SCS, respectively. Genetic correlations significantly lower than unity yielded different number of common bulls in top 100 lists for all three traits (Tables 2 to 4). For protein yield, the overall average was 60 common bulls, ranging from 31 (ITA and AUS) to 84 (DEU and DNK). AUS and NZL had the lowest average number of common bulls with 43 and 48, respectively, mainly due to the low average genetic correlations with other countries. The same pattern occurred for Mammary System and SCS.

The number of common bulls decreased even more, however, when top bull lists for national selection indexes were compared (Table 5). The largest number of common bulls was within country between the British PLI and TOP (69) and between the American Net Merit and TPI (54). Excluding within country comparisons in Great Britain and United States, the largest number of common bulls was between the Canadian LPI and American TPI, and between the German RZG and the Danish S-Index, both at 46 common bulls. The most common top 100 list across all countries was the American TPI with an average of 25.1 bulls, followed by the Canadian LPI at 24.6 common bulls. Australia, New Zealand and Ireland registered the lowest average number of common bulls with 2.7, 3.2 and 8.7, respectively. Differences in common bulls within Great Britain and United States listings showed clearly the isolated effect of differences in selection goals, without the negative effect of genetic correlations across countries.

Bulls in Top 100 lists are quite different because of differences among national selection indexes and genetic correlations lower than unity for each trait. Another reason is that many selection indexes include traits for which an Interbull evaluation is not yet available, with longevity, calving ease, fertility and milking speed as examples. National genetic evaluation units try to overcome this problem in various ways: a) estimating prediction formulae from available Interbull traits (type traits and SCS for longevity), b) estimating conversion equations, and c) using breed averages or parent averages for foreign bulls.

Finally, there is one more reason to limit number of common bulls across countries in top bull listings. Most countries use requirements based on reliability, semen availability and/or number of daughters and herds to exclude bulls from officially published top 100 rankings. Table 6 is equivalent to Table 5, but was compiled using no restrictions for all countries that did use such requirements (Australia, France, Germany, Ireland, Italy, Japan, New Zealand, Spain and United States). Number of common bulls increased for most country pairs, especially involving Australia, Italy, Japan and Spain.

CONCLUSION

Selection goals have evolved worldwide, shifting the focus on production to a more balanced selection goal of improving production, especially protein yield and percentage, as well as longevity, udder health, functional conformation and fertility.

The broadening of selection goals through recent changes to selection indexes had a clear effect on decreasing the similarities of top bull listings in various countries. When Interbull will provide new international evaluations for longevity, calving ease and fertility, a slightly higher number of common bulls can be expected. A low number of common bulls among top bull listings might create some problem for AI organizations, as they are under pressure to have top bulls in many country rankings. On the other side, a low number of bulls in common also means that there will be a higher number of selected bloodlines, thus, slowing down the rate of inbreeding in the global Holstein population.

ACKNOWLEDGMENTS

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Table 1. Relative emphasis on traits in selection indexes for 15 major dairying countries.

	Index	Milk Yield	Fat Yield	Protein Yield	Fat %	Protein %	Longevity	Body Size	SCS	Temperature	Milking Speed	Fertility	Calving Ease	Mammary System	Feet & Legs	Final Score	Type Traits	Oth
AUS	APR	-.186	.120	.363			.085	-.040	.052	.040	.032	.082						
CAN	LPI		.143	.428			.076	.038	.045		.005			.152	.114			
CHE	ISEL		.140	.270	.030	.090	.070		.100			.060					.240	
DEU	RZG		.090	.260	.050	.100	.250		.050			.050					.150	
DNK*	S-Index	-.034	.102	.204			.060	-.020	.160	.020	.060	.090	.060	.090	.050			.05
ESP	ICO	.120	.120	.320		.030	.030		.030					.160	.100	.090		
FRA	ISU		.095	.355	.025	.025	.125		.125			.125					.125	
GBR	PLI	-.164	.095	.491			.150		.050						.050			
GBR	TOP	-.109	.063	.328			.020	.080	.080					.180	.140			
IRL	EBI	-.190	.080	.420			.230					.080						
ISR	PD01	-.110	.180	.510					.110			.090						
ITA	PFT		.120	.420	.020	.030	.080		.100					.130	.060	.040		
JPN	NTP		.203	.548										.213	.038			
NLD	DPS	-.170	.070	.340			.260		.040			.040	.080					
NZL	BW	-.170	.080	.410			.050	-.190				.100						
USA	NM		.220	.330			.110	-.030	.090			.070	.040	.070	.040			
USA	TPI		.180	.360			.110		.050					.100	.050	.150		
Mean		.074	.124	.374	.007	.016	.100	.023	.064	.004	.006	.046	.011	.064	.038	.016		

*SCS field for Denmark includes udder health (.14) and other health traits (.02)

Figure 1. Relative emphasis on Production, Durability and Health & Fertility components.

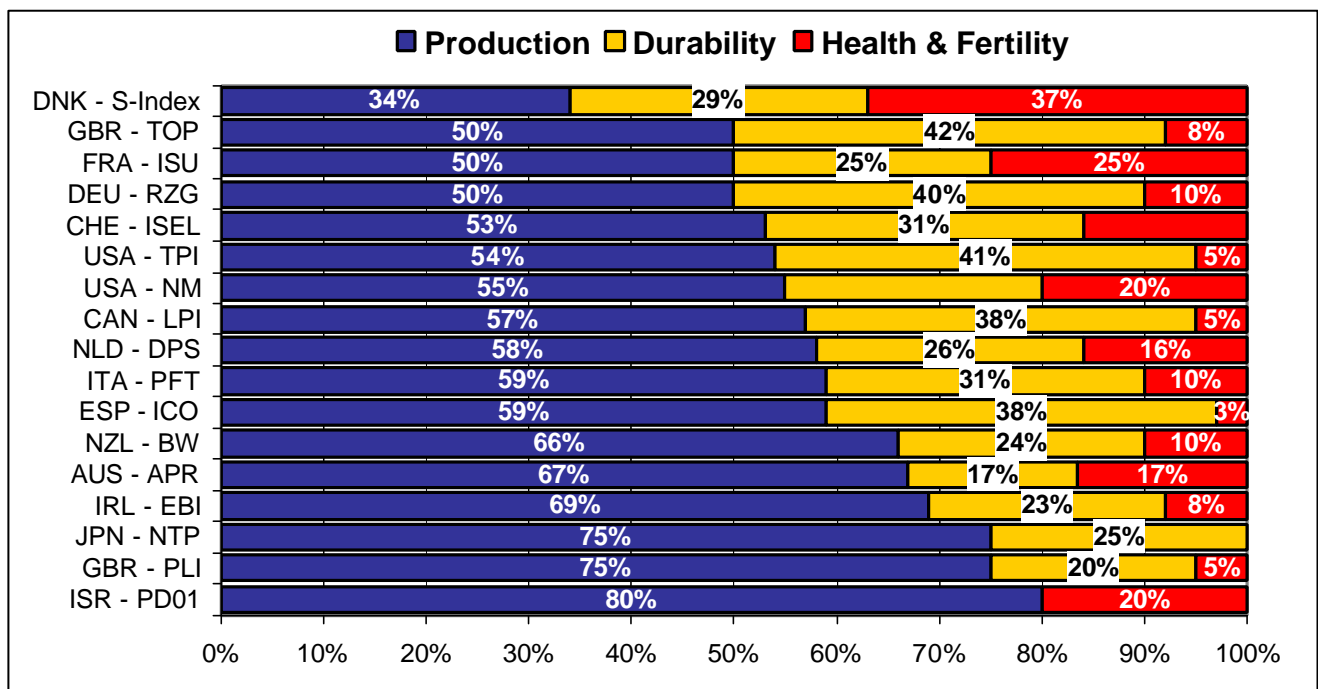


Figure 2. Relative emphasis of production traits in national selection index.

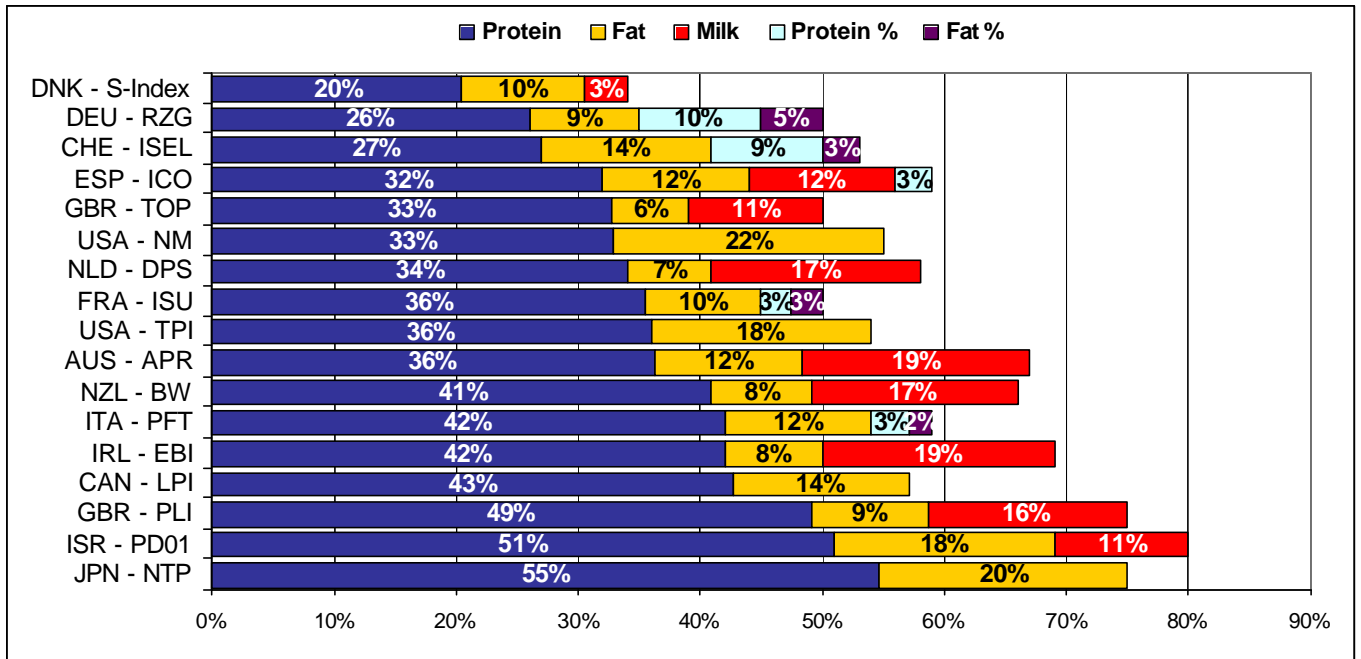


Figure 3. Relative emphasis on Production, Durability and Health & Fertility components based on selection indexes in 1994 (Leitch, 1994; VanRaden, 2002).

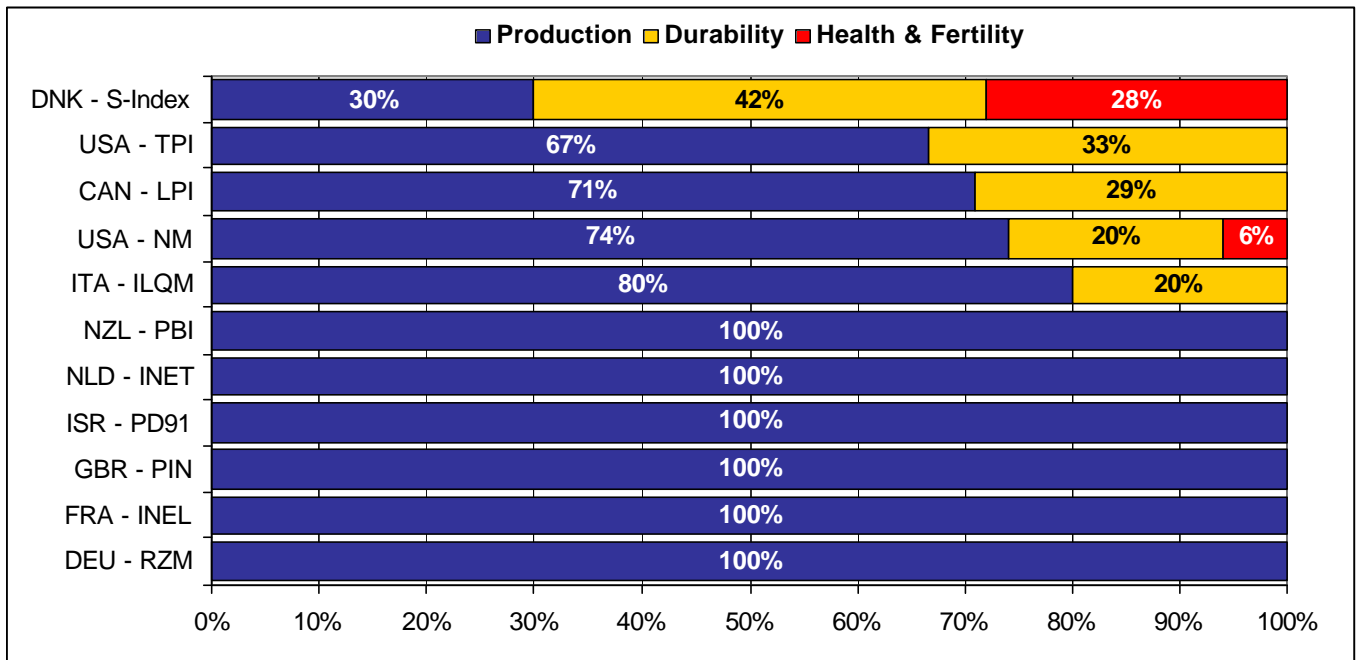


Table 2. Genetic correlations (above diagonal) and number of common bulls from top bull listings (below diagonal) for protein yield (Interbull, November 2003)

	AUS	CAN	CHE	DEU	DNK	ESP	FRA	GBR	IRL	ISR	ITA	JPN	NLD	NZL	USA
AUS		.79	.79	.77	.80	.80	.79	.84	.83	.78	.77	.79	.80	.90	.79
CAN	32		.90	.91	.93	.92	.92	.91	.86	.84	.92	.93	.92	.78	.95
CHE	41	61		.86	.90	.87	.89	.89	.89	.86	.88	.87	.89	.78	.90
DEU	33	68	50		.91	.87	.87	.87	.86	.85	.86	.91	.91	.78	.90
DNK	38	72	60	84		.94	.93	.94	.90	.87	.90	.92	.95	.79	.93
ESP	49	72	68	63	77		.89	.88	.88	.87	.89	.92	.91	.78	.90
FRA	45	64	64	52	63	76		.91	.88	.86	.92	.91	.91	.80	.92
GBR	51	65	73	59	71	78	69		.91	.86	.89	.91	.93	.82	.92
IRL	55	51	63	51	62	71	62	69		.85	.86	.84	.88	.84	.88
ISR	43	66	65	62	74	79	70	72	67		.85	.85	.87	.79	.87
ITA	31	66	66	52	57	63	65	60	52	62		.88	.89	.77	.95
JPN	42	72	57	71	79	80	63	67	59	77	58		.92	.77	.91
NLD	43	64	57	70	76	74	61	74	60	66	52	70		.77	.92
NZL	67	39	49	38	43	48	53	55	65	49	39	43	45		.77
USA	33	74	62	60	65	64	59	64	50	68	72	64	57	38	
M1	.80	.89	.87	.87	.90	.88	.89	.89	.87	.85	.87	.88	.89	.80	.89
M2	43	62	60	58	66	69	62	66	60	66	57	64	62	48	59

M1=average correlation, M2=average number of common bulls

Table 3. Genetic correlations (above diagonal) and number of common bulls from top bull listings (below diagonal) for mammary system (Interbull, November 2003)

	AUS	CAN	CHE	DEU	DNK	ESP	FRA	GBR	ITA	JPN	NLD	NZL	USA
AUS		.68	.66	.72	.48	.68	.48	.83	.68	.77	.73	.76	.68
CAN	48		.96	.83	.86	.87	.82	.82	.90	.93	.83	.86	.92
CHE	44	88		.82	.91	.90	.88	.82	.92	.90	.83	.86	.96
DEU	48	56	57		.73	.86	.74	.92	.87	.88	.93	.78	.83
DNK	36	72	76	54		.86	.91	.68	.88	.75	.72	.79	.90
ESP	43	68	74	57	66		.86	.84	.95	.80	.88	.77	.93
FRA	30	55	64	52	60	72		.67	.90	.72	.73	.78	.88
GBR	54	56	56	72	49	60	53		.84	.89	.91	.83	.82
ITA	44	70	77	60	72	89	74	60		.87	.87	.79	.95
JPN	53	78	68	64	57	51	41	57	54		.85	.80	.87
NLD	48	53	57	81	50	59	53	67	61	56		.81	.86
NZL	53	64	60	53	54	52	39	60	52	60	53		.86
USA	42	73	82	58	69	77	67	58	81	57	58	56	
M1	.68	.86	.87	.83	.79	.85	.78	.82	.87	.84	.83	.81	.87
M2	45	65	67	59	60	64	55	59	66	58	58	55	65

M1=average correlation, M2=average number of common bulls

Table 4. Genetic correlations (above diagonal) and number of common bulls from top bull listings (below diagonal) for somatic cell score (SCS) (Interbull, November 2003)

	AUS	CAN	CHE	DEU	DNK	FRA	GBR	ISR	ITA	JPN	NLD	USA
AUS		.91	.88	.81	.79	.88	.89	.55	.75	.82	.87	.72
CAN	48		.91	.91	.91	.91	.91	.91	.91	.91	.91	.91
CHE	57	66		.94	.89	.96	.93	.77	.84	.89	.93	.88
DEU	51	59	78		.81	.93	.91	.78	.81	.81	.95	.86
DNK	46	57	64	51		.90	.89	.70	.85	.94	.87	.87
FRA	57	71	86	75	64		.96	.74	.86	.90	.94	.91
GBR	56	72	78	71	66	84		.70	.82	.90	.97	.88
ISR	40	51	64	65	52	61	57		.79	.68	.77	.83
ITA	37	41	49	47	55	53	44	58		.80	.81	.86
JPN	46	65	61	48	73	64	68	43	35		.88	.88
NLD	54	72	77	77	61	80	90	61	47	63		.86
USA	44	78	64	54	62	68	66	59	50	65	64	
M1	.81	.91	.90	.87	.85	.90	.88	.75	.83	.85	.89	.86
M2	49	62	68	61	59	69	68	56	47	57	68	61

M1=average correlation, M2=average number of common bulls

Table 5. Number of common bulls among official top 100 listings.

	AUS APR	CAN LPI	CHE ISEL	DEU RZG	DNK S-Index	ESP ICO	FRA ISU	GBR PLI	GBR TOP	IRL EBI	ISR PD01	ITA PFT	JPN NTP	NLD DPS	NZL BW	USA NM	USA TPI	
AUS	APR																	
CAN	LPI	1																
CHE	ISEL	2	23															
DEU	RZG	1	27	33														
DNK	S-Index	1	32	38	46													
ESP	ICO	3	33	16	32	23												
FRA	ISU	2	35	37	34	35	19											
GBR	PLI	5	30	30	27	22	19	36										
GBR	TOP	4	33	28	28	21	24	32	69									
IRL	EBI	6	5	13	9	7	3	10	9	5								
ISR	PD01	2	17	35	27	28	12	34	20	20	14							
ITA	PFT	2	38	13	16	19	30	26	23	30	1	11						
JPN	NTP	2	27	8	8	11	21	14	17	15	1	6	31					
NLD	DPS	5	15	34	40	33	16	32	18	17	15	39	6	2				
NZL	BW	6	0	1	0	0	0	1	2	1	36	3	0	0	1			
USA	NM	0	32	10	11	17	11	18	20	21	2	11	33	30	6	0		
USA	TPI	1	46	22	29	31	35	25	27	29	3	12	44	31	12	0	54	
	Mean	2.7	24.6	21.4	23.0	22.8	18.6	24.4	23.6	23.4	8.7	18.2	20.2	14.0	18.2	3.2	17.3	25.1

Table 6. Number of common bulls among top 100 listings, without restriction on minimum requirements.

		AUS APR	CAN LPI	CHE ISEL	DEU RZG	DNK S-Index	ESP ICO	FRA ISU	GBR PLI	GBR TOP	IRL EBI	ISR PD01	ITA PFT	JPN NTP	NLD DPS	NZL BW	USA NM	USA TPI
AUS	APR																	
CAN	LPI	8																
CHE	ISEL	21	23															
DEU	RZG	17	35	36														
DNK	S-Index	10	32	38	47													
ESP	ICO	10	65	26	37	35												
FRA	ISU	24	37	38	38	36	36											
GBR	PLI	14	30	30	29	22	30	34										
GBR	TOP	9	33	28	30	21	35	30	69									
IRL	EBI	30	7	16	11	9	7	12	10	6								
ISR	PD01	24	17	35	30	28	17	35	20	20	17							
ITA	PFT	10	64	24	38	34	59	37	28	31	6	17						
JPN	NTP	10	43	27	33	25	40	30	30	33	6	19	40					
NLD	DPS	25	15	34	42	33	18	32	18	17	20	39	16	20				
NZL	BW	27	5	10	6	5	5	8	8	7	32	12	5	5	9			
USA	NM	10	32	22	28	38	27	34	23	20	7	35	34	28	24	3		
USA	TPI	7	55	27	36	38	48	35	28	29	6	19	59	41	14	5	46	
	Mean	16.0	31.3	27.2	30.8	28.2	30.9	31.0	26.1	26.4	12.6	24.0	31.4	26.9	23.5	9.5	25.7	30.8