Sveriges lantbruksuniversitet
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Linear profiling protocols for 3-year-olds for genetic evaluation of Swedish Warmblood horses

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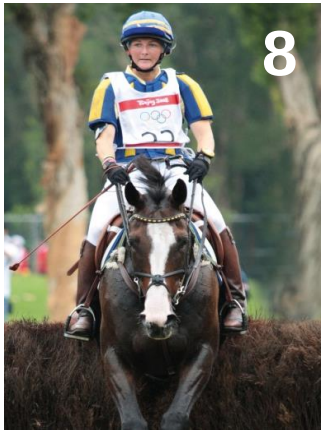
Swedish Warmblood

65,000 horses

3,500 covered mares (2014)

“Internationally competitive horses in dressage, show jumping or eventing”



Test for 3-year-old horses

Introduced in 1999

40% of all 3-year-olds (>17,000 horses)

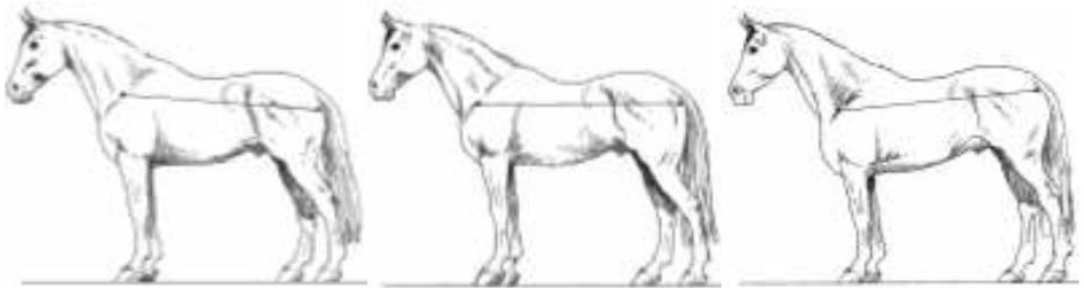
8 traits: conformation, gaits, jumping – scale 1-10

Included in annual genetic evaluation since 2006

Linear profiling protocol introduced in 2013

50 traits

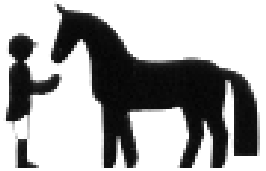
1,889 horses



Linear profiling protocol

Linear profile **Height of withers** _____

	CONFORMATION	Obvious	Average									Obvious	Comment
			A	B	C	D	E	F	G	H	I		
1	Type	refined (i.e. light)	☐	☐	☐	■	■	■	☐	☐	☐	heavy	☐ good proportions
2	Body: shape a	long	☐	☐	☐	■	■	■	☐	☐	☐	short	
3	Body: shape b	long legged	☐	☐	☐	■	■	■	☐	☐	☐	short legged	
4	Body direction	uphill	☐	☐	☐	■	■	■	☐	☐	☐	downhill	
5	Length of neck	long	☐	☐	☐	■	■	■	☐	☐	☐	short	☐ wide connection
6	Position of neck	vertical	☐	☐	☐	■	■	■	☐	☐	☐	horizontal	☐ low connection
7	Shape of neck	arched	☐	☐	☐	■	■	■	☐	☐	☐	straight	☐ heavy head-neck connection
8	Withers	high	☐	☐	☐	■	■	■	☐	☐	☐	low	
9	Position of shoulder	sloping	☐	☐	☐	■	■	■	☐	☐	☐	straight	☐ deep chest
10	Line of back	straight	☐	☐	☐	■	■	■	☐	☐	☐	swayback	
11	Loins	long	☐	☐	☐	■	■	■	☐	☐	☐	short	☐ roached back
12	Shape of croup	sloping	☐	☐	☐	■	■	■	☐	☐	☐	straight	
13	Length of croup	long	☐	☐	☐	■	■	■	☐	☐	☐	short	
14	Foreleg	over at knee	☐	☐	☐	■	■	■	☐	☐	☐	back at knee	☐ tied in ☐paral.displ.can ☐ misplaced cannon bone
15	Foreleg	toed in	☐	☐	☐	■	■	■	☐	☐	☐	toed out	☐ thin legs in prop.to body ☐outward rotated forelimb
16	Pastern, front	upright	☐	☐	☐	■	■	■	☐	☐	☐	weak	☐ long ☐ short
17	Hind leg	sickle	☐	☐	☐	■	■	■	☐	☐	☐	straight	☐ tied in
18	Hind leg	cow hocked	☐	☐	☐	■	■	■	☐	☐	☐	bowlegged	
19	Pastern, hind	upright	☐	☐	☐	■	■	■	☐	☐	☐	weak	☐ long ☐ short
20	Correctness in movement	winging	☐	☐	☐	■	■	■	☐	☐	☐	paddling	
21	Hoofs	big	☐	☐	☐	■	■	■	☐	☐	☐	small	☐ uneven ☐ low heels



21 conformation traits

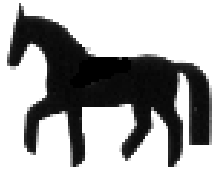
Linear profiling protocol

Linear profile **Height of withers** _____

	CONFORMATION	Obvious	Average								Obvious	Comment
			A	B	C	D	E	F	G	H	I		
1	Type	refined (i.e. light)	☐	☐	☐	☐	☐	☐	☐	☐	☐	heavy	☐ good proportions
2	Body: shape a	long	☐	☐	☐	☐	☐	☐	☐	☐	☐	short	
3	Body: shape b	long legged	☐	☐	☐	☐	☐	☐	☐	☐	☐	short legged	
4	Body direction	uphill	☐	☐	☐	☐	☐	☐	☐	☐	☐	downhill	

Linear profiling protocol

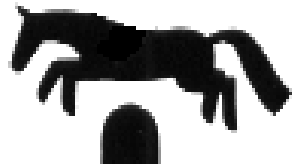
	MOVEMENT	Obvious	Average	Obvious	Comment
			A B C D E F G H I		
22	Walk: cadence	even	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	uneven	
23	Walk: stride length	long	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	short	
24	Walk: suppleness	supple	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	stiff	
25	Walk: elasticity	elastic	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	unelastic	
26	Trot: length of stride	long	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	short	☐ irregular
27	Trot: elasticity	elastic	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	unelastic	☐ movement tight to the ground
28	foreleg activity	shoulder free	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	Short	
29	Trot: hind leg position	under the body	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	behind the body	
30	Trot: hind leg activity	active	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	Inactive	
31	Canter: rhythm	even	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	Uneven	
32	Canter: stride length	Long	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	Short	
33	Canter: action	round	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	Flat	
34	Canter: elasticity	elastic	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	stiff	
35	Canter: balance	well balanced	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	unbalanced	
36	Movement: direction	uphill	☐ ☐ ☐ ■ ■ ■ ☐ ☐ ☐	downhill	



15 movement traits

Linear profiling protocol

	JUMPING	Obvious	Average									Obvious	Comment
			A	B	C	D	E	F	G	H	I		
37	Take off	powerful	☐	☐	☐	■	■	■	☐	☐	☐	weak	
38	Take off: quickness	quick	☐	☐	☐	■	■	■	☐	☐	☐	slow	
39	Take off: direction	upwards	☐	☐	☐	■	■	■	☐	☐	☐	forwards	
40	Technique: foreleg	bent	☐	☐	☐	■	■	■	☐	☐	☐	hanging	☐ under the body ☐ stretched out
41	Technique: back	rounded	☐	☐	☐	■	■	■	☐	☐	☐	hollow	
42	Technique: haunches	open	☐	☐	☐	■	■	■	☐	☐	☐	tight	
43	Scope	much	☐	☐	☐	■	■	■	☐	☐	☐	little	
44	Elasticity	elastic	☐	☐	☐	■	■	■	☐	☐	☐	stiff	
45	Care	too careful	☐	☐	☐	■	■	■	☐	☐	☐	not careful	
46	Distance estimation	secure	☐	☐	☐	■	■	■	☐	☐	☐	insecure	
47	Balance	balanced	☐	☐	☐	■	■	■	☐	☐	☐	unbalanced	
48	Reaction	quick	☐	☐	☐	■	■	■	☐	☐	☐	slow	
49	Approach to assign.	focused	☐	☐	☐	■	■	■	☐	☐	☐	unfocused	
50	Behaviour	relaxed	☐	☐	☐	■	■	■	☐	☐	☐	tense	



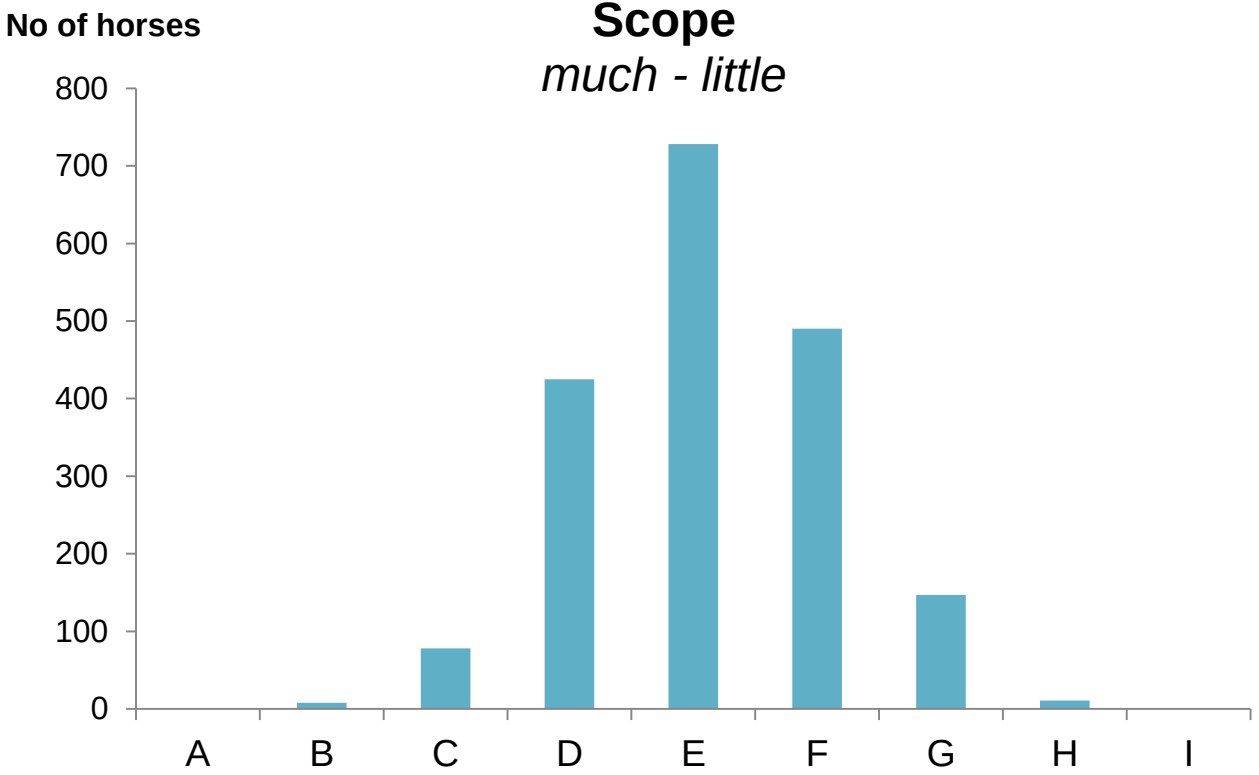
14 jumping traits

Aim of this study

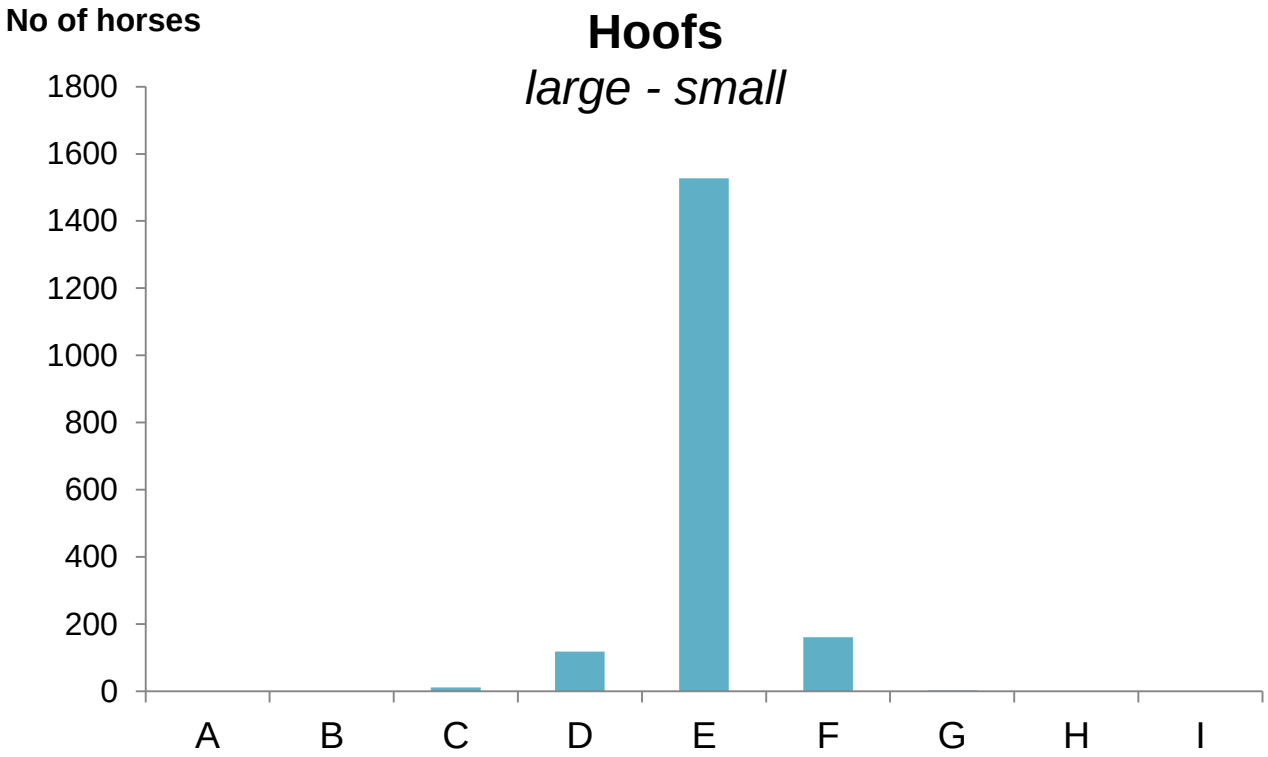
Investigate suitability of linear scored traits in genetic evaluation by estimating

- genetic parameters for linear traits
- genetic correlations between linear scored traits and traditionally scored traits

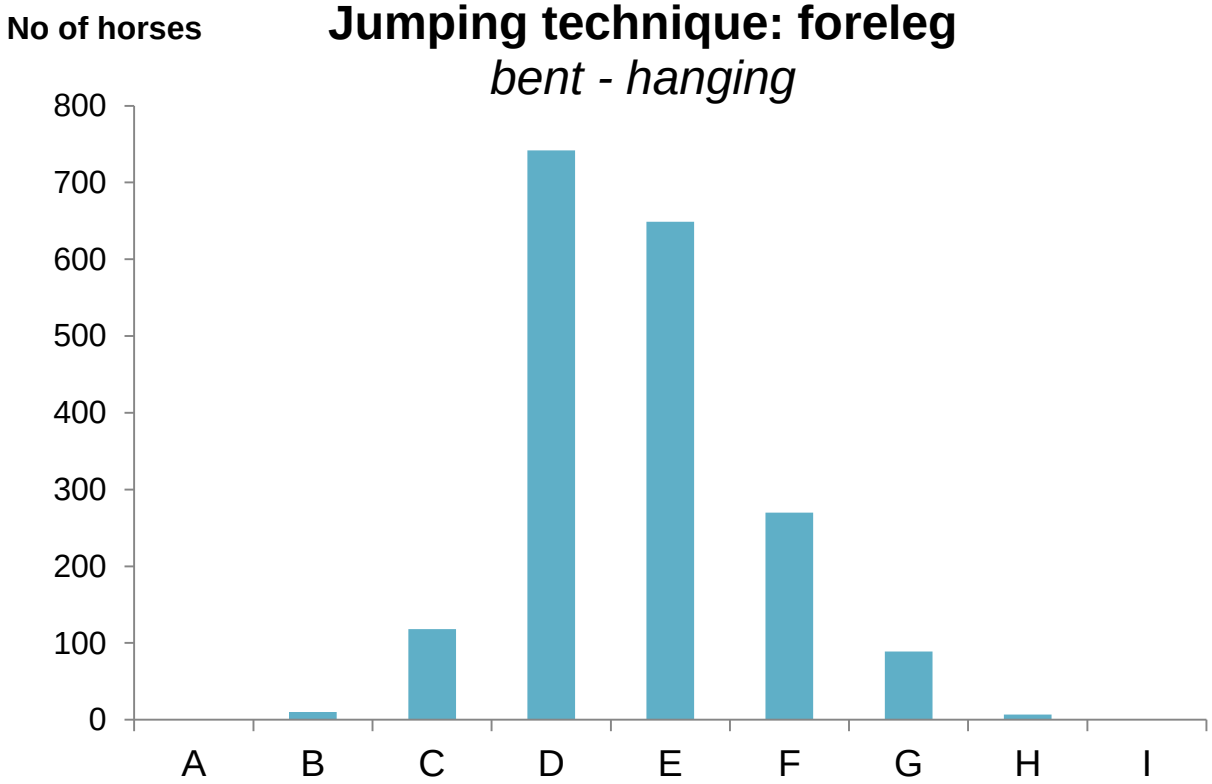
Distribution of linear traits



Distribution of linear traits



Distribution of linear traits

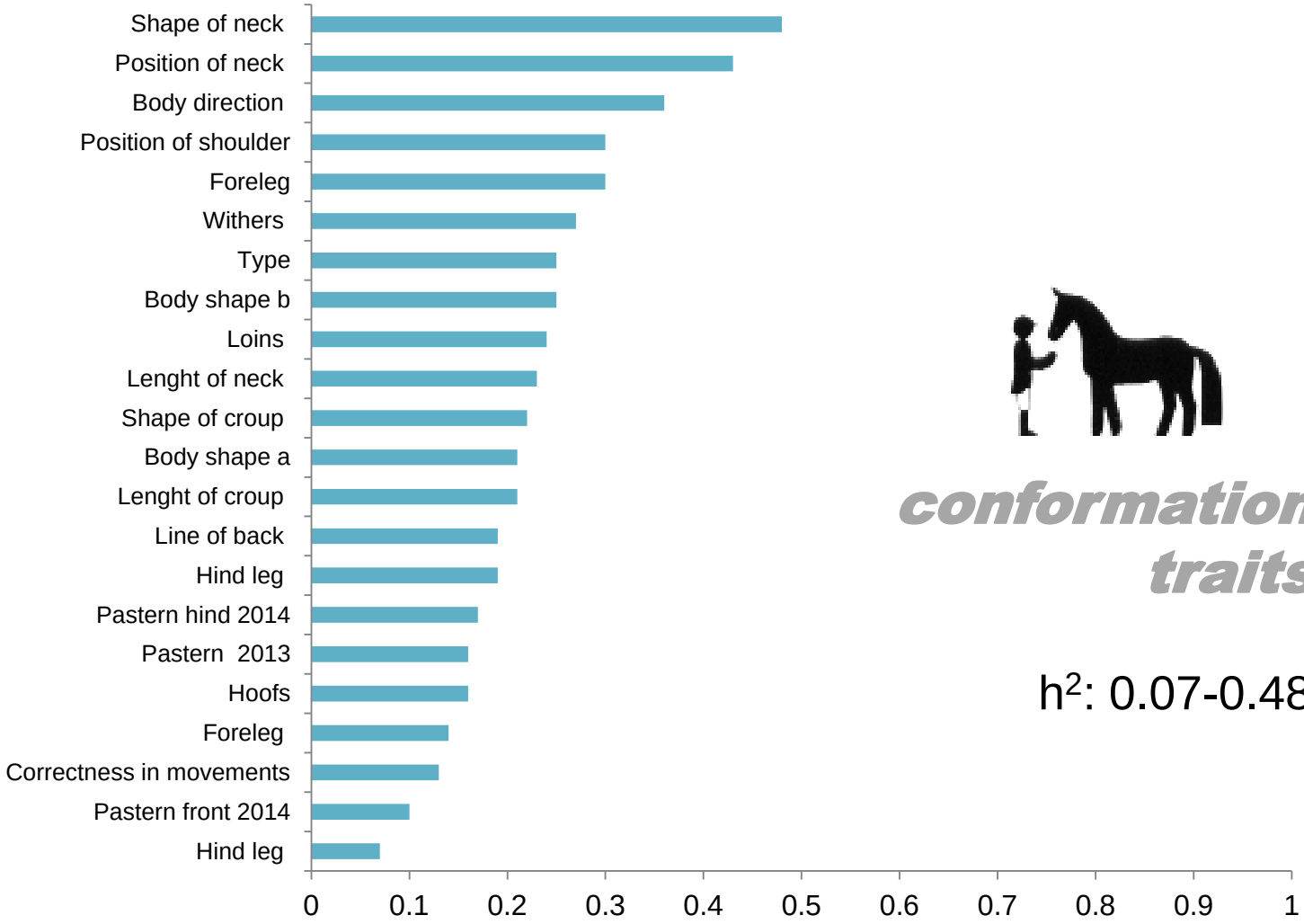


Genetic analyses

A – I ⟶ 1 - 9

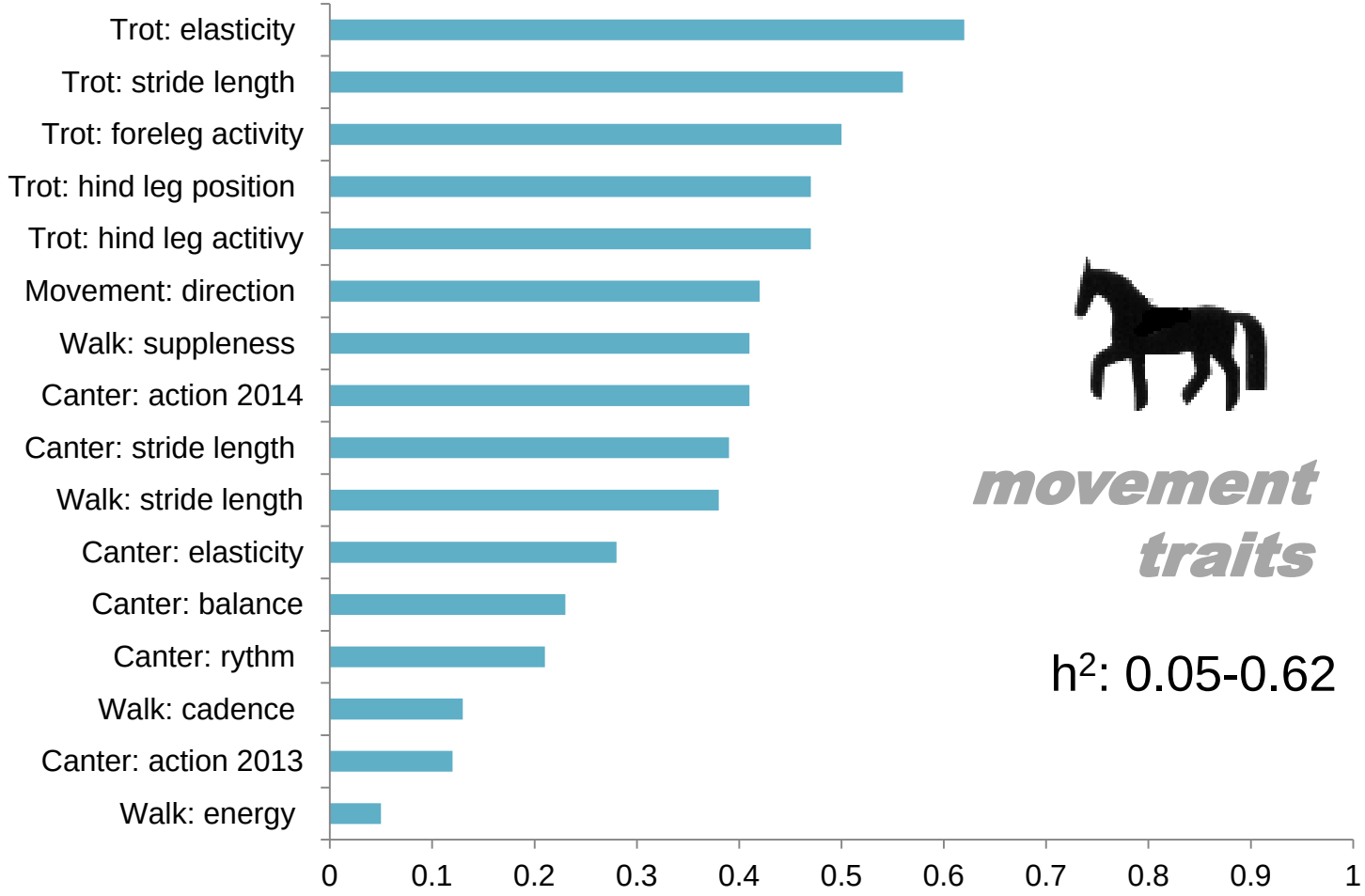
BLUP Animal Model

$y_{ijk} = sex_i + event_j + horse_k + residual_{ijk}$



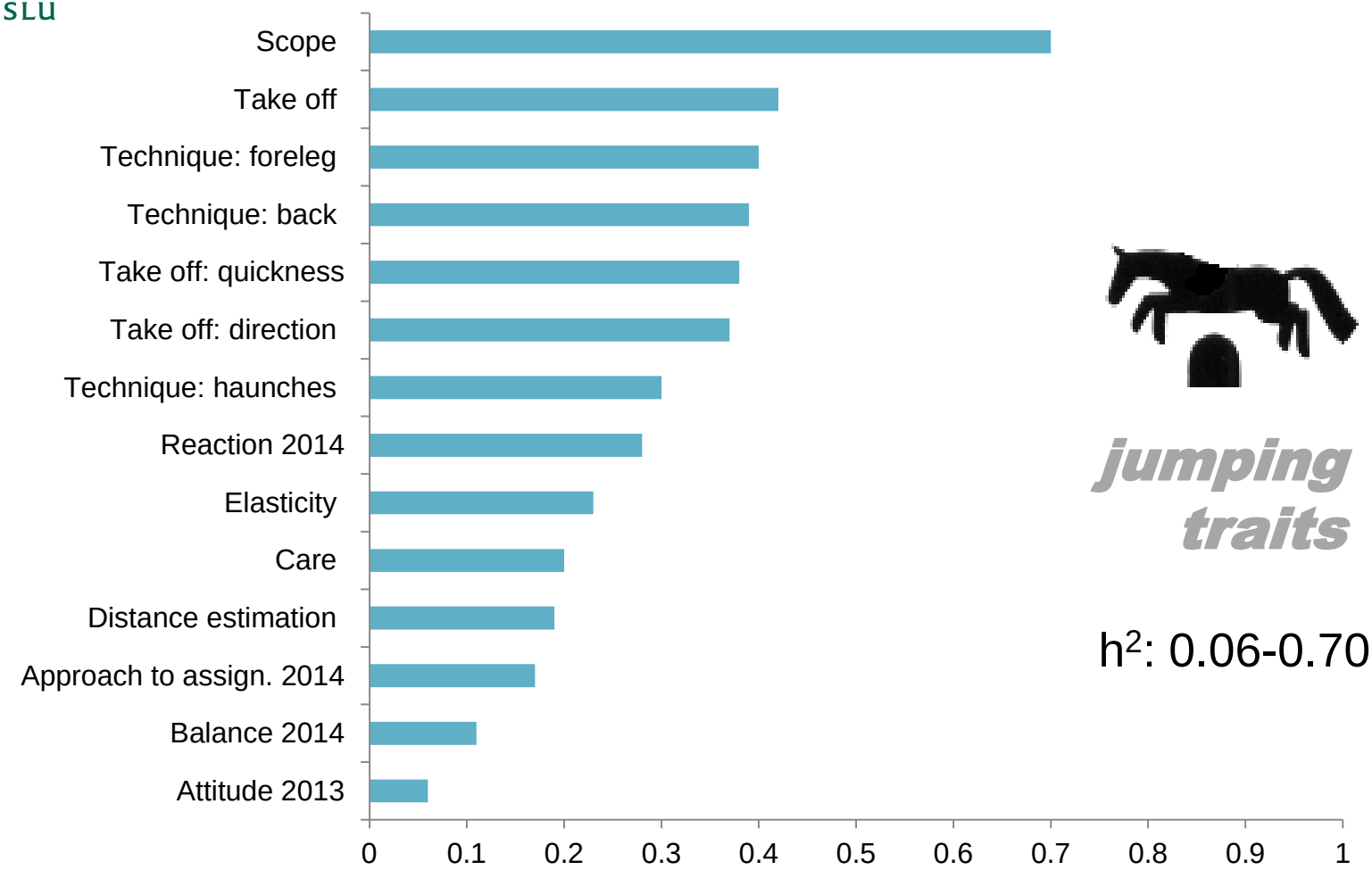
conformation traits

h^2: 0.07-0.48



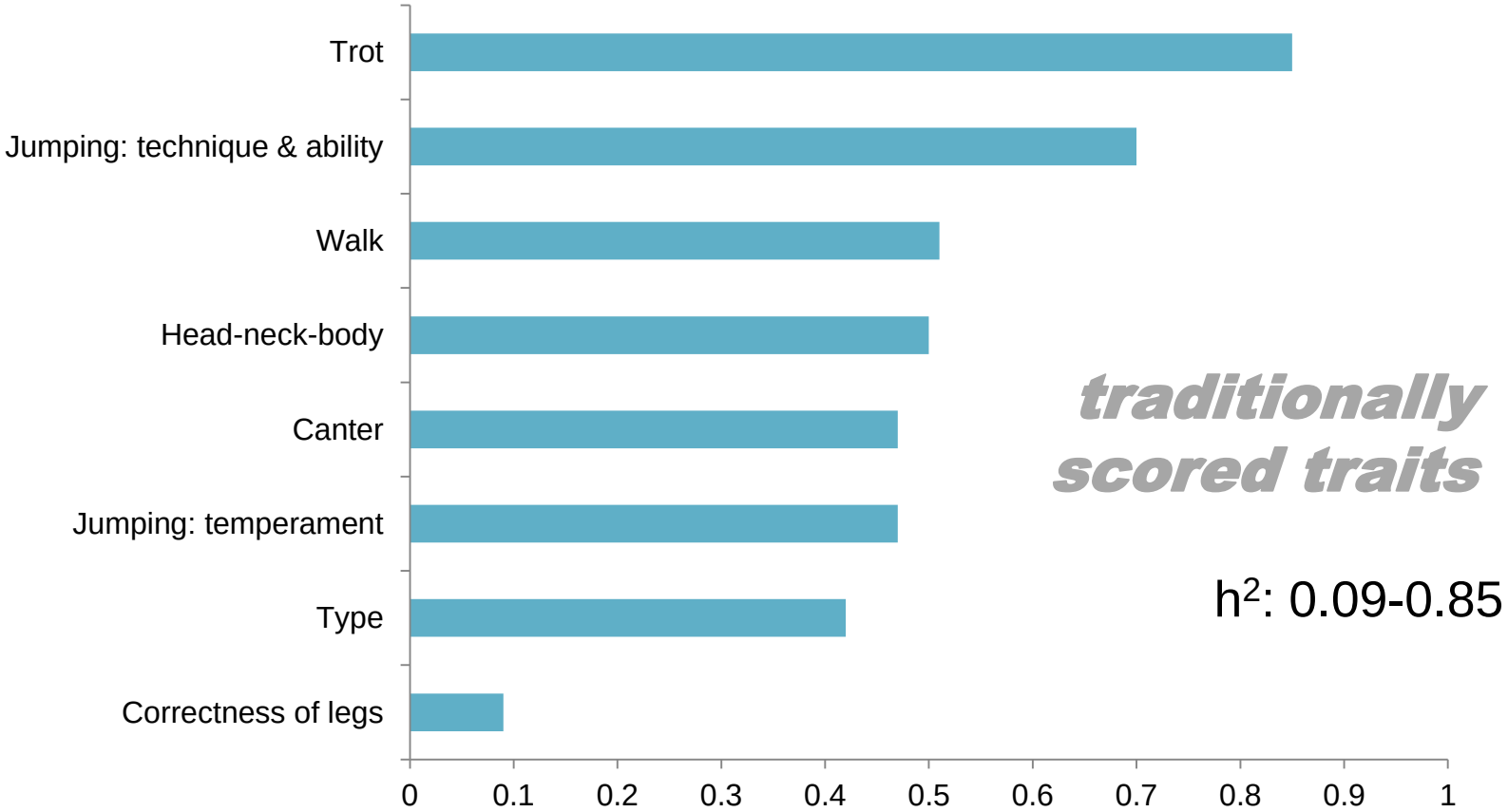
movement traits

h^2: 0.05-0.62



jumping traits

h^2: 0.06-0.70



traditionally scored traits

h^2: 0.09-0.85

Genetic correlations

traditionally scored traits – linear traits

Traditional traits	Weakest corr.	Strongest corr.
Walk	-0.67 energy (*hurried – slow*)	(< -0.99) cadence *(even – uneven)*
Trot	-0.94 hind leg activity *(active – inactive)*	(< -0.99) hind leg position (*under body - behind body)*
Canter	-0.83 stride lenght *(long – short)*	-0.94 elasticity *(elastic – stiff)*
Jumping techn.	-0.65 foreleg *(bent – hanging)*	(< -0.99) scope *(much – little)*

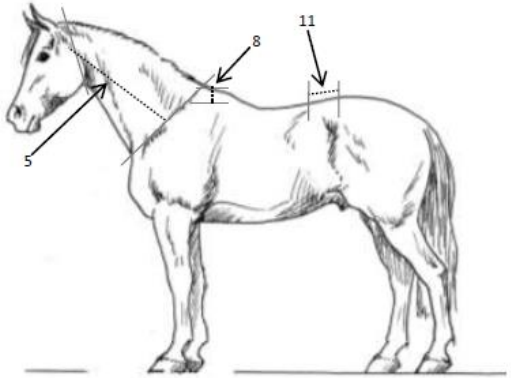
Conclusions

Possible to include in genetic evaluation

Good complement to traditional scoring

Useful for breeders

Can be used in genomic studies



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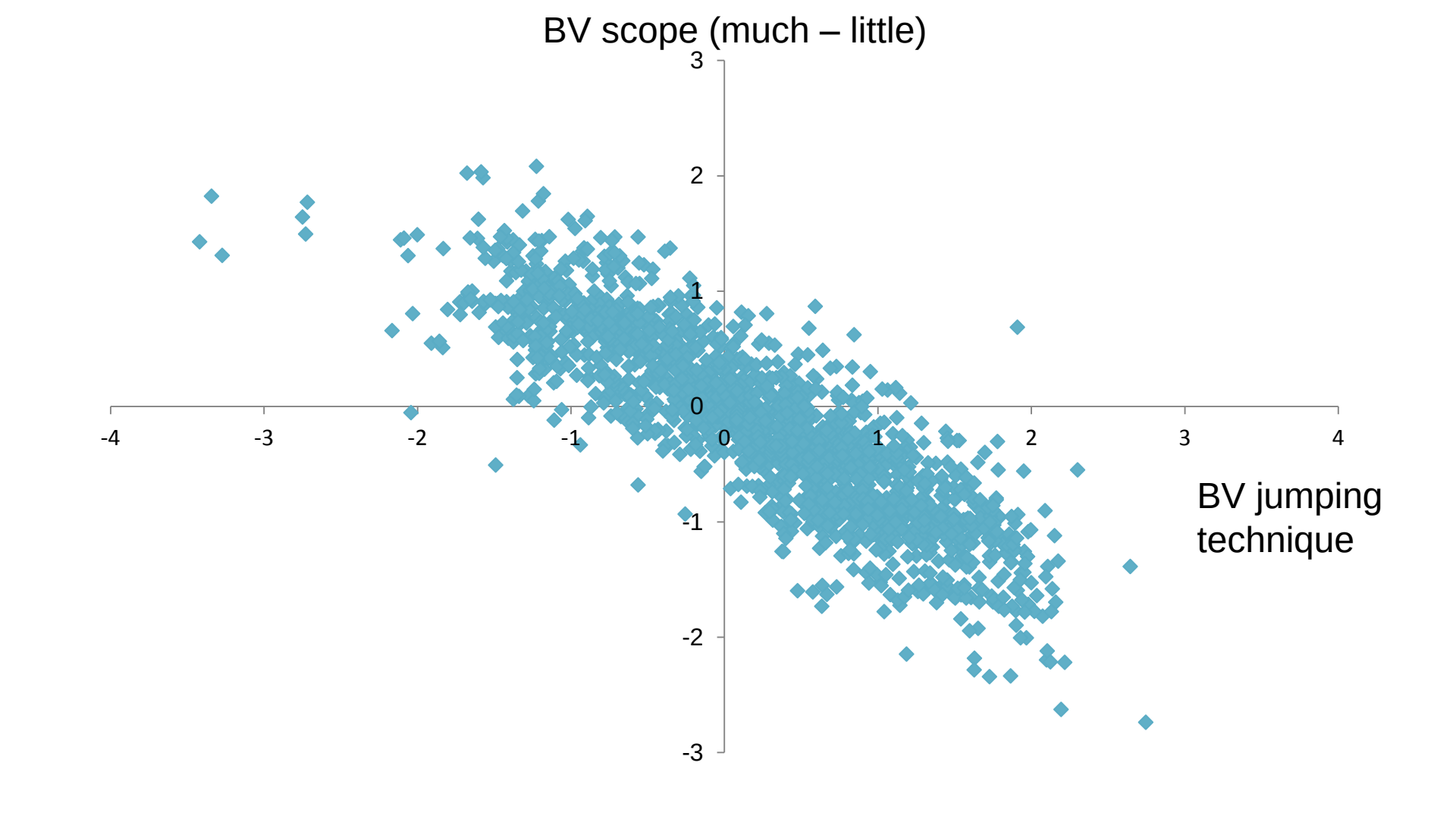
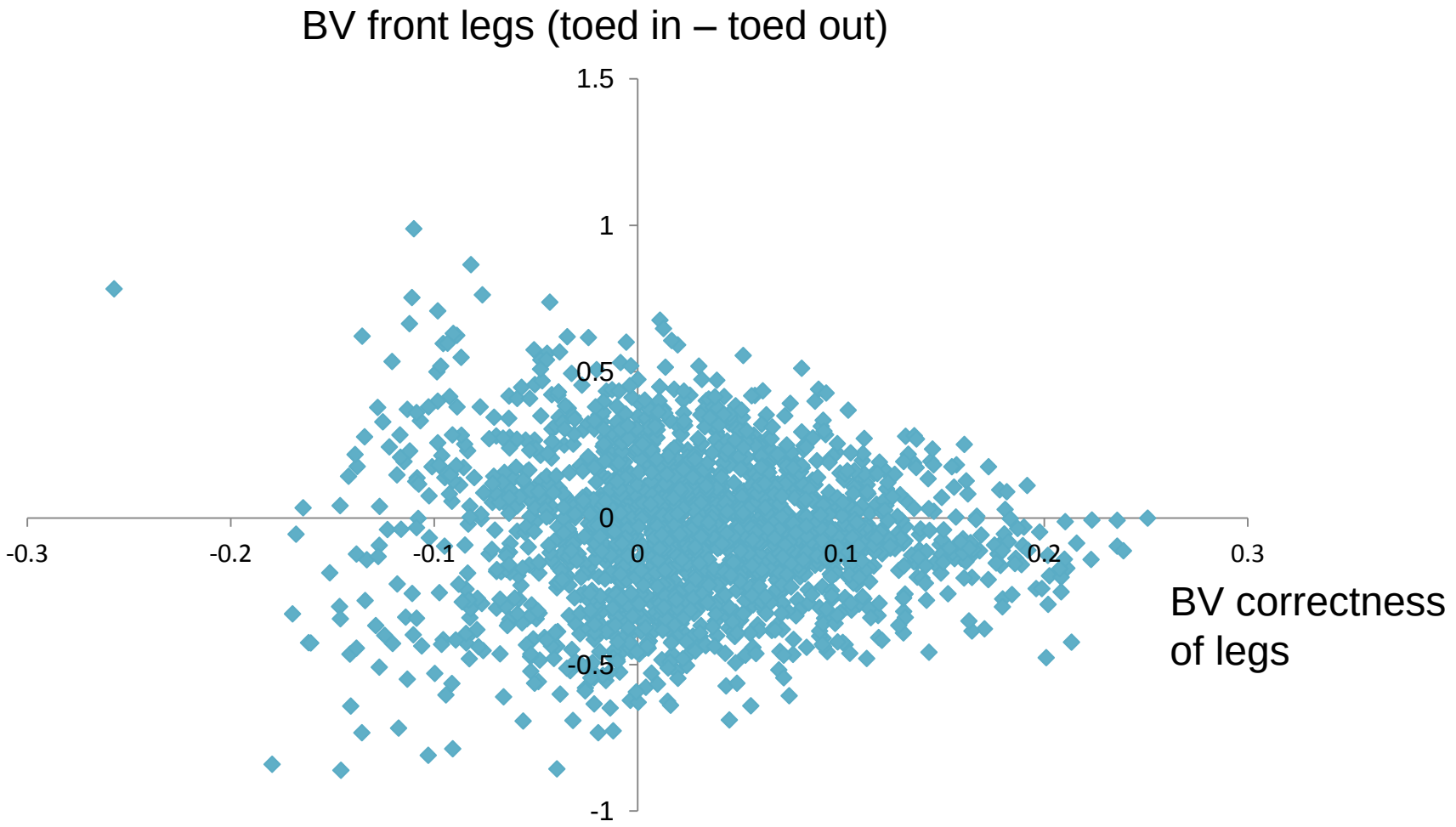

BV scope (much – little)
3
2
1
0
-1
-2
-3
-4
-3
-2
-1
0
1
2
3
4
BV jumping technique


BV front legs (toed in – toed out)
1.5
1
0.5
0
-0.5
-1
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
BV correctness of legs

Trait	Mean	SD
Conformation	4.6 - 5.2	0.4 – 0.9
Movement	4.7 - 5.2	0.5 – 0.9
Jumping	4.6 - 5.2	0.6 – 1.1
Trad. scores	6.9 - 7.8	0.5 – 1.2