Genetic analysis of a temperament test for working dog breeds in Sweden

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Summary

Dogs of working dog breeds in Sweden are required to participate in the Dog Mentality Assessment (DMA) if they are to be used in breeding. The aim of this study was to define behavioral traits that can be used for genetic evaluation of working dogs in Sweden, and estimate genetic parameters for these traits. Data on 33 behavioral scores from the 10 subtests were used to estimate heritabilities for 12 breeds, with a total of 61,434 records. In order to summarize these 33 variables into fewer traits, a factor analysis was applied to the phenotypes. This resulted in factors that could be named Sociability (SOC), Playfulness (PLAY), Distance Play (DPLAY), Chase-proneness (CH), Curiosity/Fearlessness (C/F), and Aggressiveness (AGGR), with the number of factors identified depending on the breed (e.g., AGGR and DPLAY were identified as factors in only 7 and 6 breeds, respectively). Often Distance Play scores were associated with SOC. To simplify a routine genetic evaluation 6 traits were defined for all breeds: SOC, PLAY, CH, C/F, AGGR and Gunshot Avoidance (GUN), however, the exact definition of new trait phenotypes was breed-specific and guided by the within-breed factor analysis. Previously, the first 4 traits have been combined and called Boldness (Svartberg & Forkman, 2002). Heritability estimates of all 33 scores over all breeds averaged 0.13, ranging from 0.03 to 0.23. Heritabilities averaged around 0.25 for SOC, PLAY, and C/F and around 0.13 for the other 3 traits. These heritabilities were higher than the average of the heritabilities for the individual behavioral scores that were components of these new traits. Overall, SOC, PLAY, CH, and C/F were positively genetically correlated with each other (ca 0.4-0.6), weakly correlated with AGGR and negatively correlated to GUN (ca -0.3 to -0.5). In conclusion, the results show that it should be possible to achieve genetic improvement in Boldness traits and a decreased AGGR and GUN.

Keywords: behavior, canine, breeding program

Introduction

In Sweden, the Swedish Working Dog Association (SWDA) has carried out a behavior test, the Dog Mentality Assessment (DMA), on working dogs since 1989. Although the test was developed for breeding purposes and all breeding animals are required to participate in DMA, it is unclear how well it is used for selecting dogs for breeding. There are no routinely estimated breeding values (EBVs) available for the working dog breeds, with one exception. For the Rough Collie, two rounds of EBVs have been supplied to the breed club so far, based on the development done by Arvelius *et al.* (2004).

Described simply, the DMA consists of 10 subtests or situations during which the dog's

reaction is described in a standardized way, on a 5-step scale. The intention when constructing the scales was to define each step of a scale as objectively as possible and to arrange the steps from low to high intensity of the behavioral reactions; that is, a low score corresponds to low intensity of the reaction. No judgment is made during the test whether a dog shows preferred behaviors or not. DMA tests include several positive situations, e.g., social contact with people, play, and chasing after an object, but also potentially unpleasant situations, e.g., sudden appearance of a dummy, a "ghost" approaching, a metal noise, and gunshots. Several reactions are noted in each subtest, adding up to a total of 33 behavioral scores (Svartberg & Forkman, 2002).

The Swedish Kennel Club (SKK) and SWDA are interested in introducing EBVs as a breeding tool for most, if not all, working dog breeds. To facilitate this in practice, it was deemed useful to reduce the number of traits from the potential 33 scores to a more manageable number of traits that could be understood and accepted by the dog breeders. Previous studies using factor analysis on DMA have found 5 underlying factors, named Sociability, Playfulness, Chase-proneness, Curiosity/Fearlessness, and Aggressiveness. However, the definition of which scores to include in each factor was either based on data based on several breeds jointly (Svartberg & Forkman, 2002) or assessed on one or a two breeds (Saetre *et al.*, 2005, Strandberg *et al.*, 2005, Arvelius *et al.*, 2014). It is possible that the definition of these underlying personality traits may differ across a wider spectrum of breeds.

The aim of this study was to define behavioral traits that can be used for routine genetic evaluation of 12 breeds of working dogs in Sweden, and estimate genetic parameters for these traits.

Material and methods

DMA scores were recorded from SKK from January 1997 to September 2016 for 12 working dog breeds: Australian Shepherd (AUS), Boxer (BOX), Briard (BRI), Rough Collie (COL), Doberman (DOB), German Shepherd dog (GSD), Hovawart (HOV), Australian Kelpie (KEL), Malinois (MAL), Rottweiler (ROT), Giant Schnauzer (SCH), and Tervueren (TER). Number of dogs scored ranged from about 1,700 (BRI, KEL) to about 22,000 for GSD. Each of the 33 scores were first standardized within breed before applying an exploratory factor analysis within breed using Proc Factor in SAS software (SAS, 2011) with parameters METHOD=PRIN, MINEIGEN=1, and varimax rotation. A minimum loading of 0.4 was needed for a score to be tentatively included in a factor. The outcome of the factor analysis was used to decide which scores should be included in each of the traits to be used in the breeding program.

The summarized traits Sociability (SOC), Playfulness (PLAY), Distance Play (DPLAY), Chase-proneness (CH), Curiosity/Fearlessness (C/F), and Aggressiveness (AGGR) were defined potentially differently in each breed, depending on the outcome of the factor analysis, as shown in Table 1 and explained later in connection with the results from the factor analysis. Each summarized trait was the average of the relevant standardized scores. Gunshot Avoidance (GUN) was always defined in the same way because it was based on only one score.

Each of the 33 scores were analyzed using a within-breed mixed linear model with fixed effects of sex, test year (1997-2016), test month (Jan-Dec), linear and quadratic regression on age at test, and random effects of litter, judge, occasion, and animal (additive genetic) using software DMU (Madsen & Jensen, 2007). Depending on breed, about 2.4 to 4.5 dogs per

litter were scored and 200-300 judges were included. All known pedigree information was included in the relationship matrix, except for GSD for which it was limited to 5 generations back for computational reasons. Heritability was defined as additive genetic variance over the sum of additive and residual variances. The same model was applied to the summarized traits to estimate heritabilities, however, to estimate genetic correlations between these traits the model was simplified to include only fixed effects and the random effect of animal. For some breeds it was not possible to include all 6 traits simultaneously in the evaluation, thus a series of bivariate analyses were carried out instead.

Results and Discussion

The factor analysis identified 4-6 factors for each breed. The factors CH, C/F, and PLAY were consistently found in all breeds, although for German Shepherd some Distance Play scores loaded together with the two Play situations. For 8 breeds, Sociability was identified as a factor and for 5 of these breeds (AUS, COL, DOB, MAL, TER) Sociability also contained Distance Play scores in addition to Social Contact scores. For 6 breeds (BOX, BRI, HOV, KEL, ROT, and SCH), DPLAY was identified as a stand-alone factor. Surprisingly, Aggressiveness was identified as a factor in only 7 of the breeds (AUS, BRI, COL, KEL, MAL, SCH, TER). These are mostly herding breeds (even SCH was originally used for herding).

Although the exploratory factor analysis resulted in different number of factors for the breeds, in a practical breeding program it was deemed preferable to have a uniform set of traits for routine genetic evaluation for all breeds. Thus, the factor analysis was used as only a basis to define the traits SOC, PLAY, CH, C/F, and AGGR (Table 1). If Distance Play scores were not already associated with SOC, they were included with SOC, unless they were more strongly associated with PLAY. Some breeds also had a score from the Ghost situation associated with SOC. Although some breeds did not have a factor Aggressiveness, a trait AGGR was created for these breeds as well, consisting of the 3 scores termed Aggression.

Heritability estimates for individual scores (N=33) in all breeds are shown in Table 2. The average across all traits and breeds was 0.13 and averages for scores across breeds ranged from 0.03 to 0.23. The proportions of all variance attributable to litter, judge or occasion were on average 0.02, 0.05, and 0.06, respectively.

Heritability estimates for the summary traits (including GUN) are shown in Table 3. Heritabilities averaged around 0.25 for SOC, PLAY, and C/F and around 0.13 for the other 3 traits. These heritabilities were higher than the average of the heritabilities for the individual behavioral scores that were included in the summary traits. For Collie, a previous study on mostly the same data found similar or slightly lower heritabilities of 0.22, 0.25, 0.16, 0.20, 0.14, and 0.10, respectively (same order as in Table 3) (Arvelius *et al.*, 2014). For German Shepherd, heritabilities were reported at 0.24 (PLAY), 0.10 (CH), 0.23 (C/F), and 0.12 (AGGR), again similar to or somewhat lower than current estimates (Strandberg *et al.*, 2005).

Even though the average heritabilities for SOC, PLAY, and C/F was around 0.25, for some breeds heritability was substantially lower, closer to 0.1. Therefore, the expected response to selection for these breeds would be much lower and it would be even more important to include information from relatives. This also applies to CH, AGGR, and GUN.

Litter had only a small effect on the traits studied, 2-4%. Judge had a larger effect, especially for SOC and AGGR, traits that thus seem to be harder to evaluate similarly. Occasion had the largest effect, with the highest estimate found for CH at 9%.

Average genetic correlations (and SD) among these traits are shown in Table 4. Overall,

SOC, PLAY, CH, and C/F were positively genetically correlated with each other (ca 0.4-0.6), weakly correlated with AGGR and negatively correlated with GUN (ca -0.3 to -0.5). The interpretation is that genetically more social dogs are also more playful, curious and more likely to chase after an object, and at the same time are less fearful, less afraid of gunshots and slightly less aggressive. The 4 traits SOC, PLAY, CH, and C/F have previously been defined as one personality trait, Boldness (Svartberg & Forkman, 2002). The genetic correlations among these Boldness traits were somewhat more consistent across breeds than correlations between these traits and AGGR or GUN, however, the low correlation between AGGR and GUN was quite consistent.

For almost all breeds the genetic correlation between C/F and AGGR was negative, meaning that more curious and less fearful dogs showed less aggressiveness. However, for Collie the genetic correlation was moderate and positive at 0.3. Collie has the lowest average level of C/F and also the lowest AGGR of all studied breeds (not shown). There was a slight curvilinear relationship between (single trait) breeding values for C/F and AGGR (Figure 1). It means that with decreasing curiosity or increasing fearfulness there are also decreasing signs of aggressiveness. Anecdotally, these dogs tend to “freeze” instead of showing aggressiveness in potentially threatening situations. With a higher level of curiosity there was no relation to aggressiveness. If this curvilinear relation is extended further, it might also explain the negative correlation found in breeds with higher levels of C/F, but this is difficult to corroborate. However, this would mean that increasing C/F is not necessarily expected to give rise to more AGGR in the long term, as might be indicated by the (linear) genetic correlation.

Conclusion

For most breeds, the results showed that it should be possible to achieve genetic improvement in Boldness traits (SOC, PLAY, CH, and C/F) and a decreased AGGR and GUN, however, for some breeds with lower heritabilities it could be more challenging.

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Table 1. Description of the definition of five factors, described as Sociability (SOC), Playfulness (PLAY), Chase-proneness (CH), Curiosity/Fearlessness (C/F), and Aggressiveness (AGGR). The numbers indicate how many breeds have a particular test score included in a given trait (the sign indicating if the weight is positive or negative).

	Trait				
DMA item	SOC	PLAY	CH	C/F	AGGR
SOCIAL CONTACT - Greeting	12	0	0	0	0
SOCIAL CONTACT – Cooperation	12				
SOCIAL CONTACT – Handling	12	0	0	0	0
PLAY1 – Interest in play		12			
PLAY1 – Grabbing	0	12	0	0	0
PLAY1 – Tug of war		12			
CHASE – Following 1	0	0	12	0	0
CHASE – Following 2			12		
CHASE – Grabbing 1	0	0	12	0	0
CHASE – Grabbing 2			12		
Passive situation – Activity	0	0	0	0	0
DISTANCE PLAY – Interest					
DISTANCE PLAY – Aggression	0	0	0	0	12
DISTANCE PLAY - Exploration	9	3			
DISTANCE PLAY – Tug of war	9	3	0	0	0
DISTANCE PLAY – Play invitation	9	3			
SUDDEN APPEARANCE – Startle reaction	0	0	0	-12	0
SUDDEN APPEARANCE – Aggression					12
SUDDEN APPEARANCE – Exploration	0	0	0	12	0
SUDDEN APPEARANCE – Remaining avoidance				-12	
SUDDEN APPEARANCE – Remaining approach	0	0	0	0	0
METALLIC NOISE – Startle reaction				-12	
METALLIC NOISE – Exploration	0	0	0	12	0
METALLIC NOISE – Remaining avoidance				-12	
METALLIC NOISE – Remaining approach	0	0	0	0	0
GHOSTS – Aggression					12
GHOSTS – Attention	0	0	0	0	3
GHOSTS – Avoidance					
GHOSTS – Exploration	0	0	0	11	0
GHOSTS – Greeting	5			1	
PLAY 2 – Interest in play	0	12	0	0	0
PLAY 2 – Grabbing		12			
GUNSHOT – Avoidance	0	0	0	0	0

Table 2. Heritability estimates for 33 DMA scores for 12 breeds

	Breed[1]												
DMA score	AUS	BOX	BRI	COL	DOB	GSD	HOV	KEL	MAL	ROT	SCH	TER	Mean
SOCIAL CONTACT - Greeting	0.13	0.07	0.07	0.23	0.20	0.06	0.11	0.17	0.18	0.10	0.07	0.23	**0.13**
SOCIAL CONTACT – Cooperation	0.03	0.08	0.05	0.17	0.14	0.09	0.13	0.08	0.13	0.07	0.08	0.11	**0.10**
SOCIAL CONTACT – Handling	0.18	0.05	0.14	0.17	0.13	0.09	0.09	0.10	0.17	0.10	0.09	0.22	**0.13**
PLAY1 – Interest in play	0.25	0.27	0.11	0.30	0.09	0.18	0.17	0.19	0.38	0.12	0.21	0.22	**0.21**
PLAY1 – Grabbing	0.24	0.07	0.07	0.25	0.07	0.16	0.10	0.15	0.52	0.09	0.19	0.27	**0.18**
PLAY1 – Tug of war	0.22	0.12	0.04	0.16	0.21	0.23	0.14	0.18	0.38	0.12	0.21	0.26	**0.19**
CHASE – Following 1	0.13	0.12	0.08	0.14	0.12	0.09	0.05	0.15	0.08	0.11	0.14	0.15	**0.11**
CHASE – Following 2	0.11	0.08	0.06	0.11	0.11	0.09	0.09	0.12	0.06	0.10	0.17	0.05	**0.09**
CHASE – Grabbing 1	0.13	0.09	0.07	0.09	0.14	0.09	0.05	0.16	0.12	0.10	0.05	0.15	**0.10**
CHASE – Grabbing 2	0.09	0.06	0.03	0.07	0.11	0.08	0.09	0.09	0.09	0.11	0.13	0.05	**0.08**
Passive situation – Activity	0.08	0.07	0.04	0.14	0.08	0.12	0.08	0.11	0.10	0.11	0.15	0.13	**0.10**
DISTANCE PLAY – Interest	0.11	0.04	0.08	0.10	0.13	0.11	0.02	0.07	0.15	0.07	0.14	0.10	**0.09**
DISTANCE PLAY – Aggression	0.09	0.05	0.04	0.05	0.00	0.05	0.04	0.03	0.14	0.06	0.20	0.03	**0.07**
DISTANCE PLAY - Exploration	0.18	0.18	0.13	0.21	0.20	0.19	0.15	0.26	0.33	0.17	0.22	0.20	**0.20**
DISTANCE PLAY – Tug of war	0.24	0.16	0.18	0.25	0.23	0.25	0.13	0.22	0.40	0.17	0.24	0.32	**0.23**
DISTANCE PLAY – Play invitation	0.20	0.13	0.15	0.23	0.16	0.20	0.11	0.21	0.31	0.14	0.16	0.21	**0.18**
SUDDEN APPEARANCE – Startle reaction	0.18	0.13	0.13	0.18	0.09	0.14	0.30	0.11	0.27	0.11	0.21	0.17	**0.17**
SUDDEN APPEARANCE – Aggression	0.21	0.16	0.17	0.14	0.12	0.12	0.13	0.15	0.13	0.12	0.22	0.16	**0.15**
SUDDEN APPEARANCE – Exploration	0.24	0.14	0.15	0.15	0.14	0.16	0.15	0.12	0.12	0.17	0.19	0.15	**0.16**
SUDDEN APPEARANCE – Remaining avoidance	0.11	0.07	0.08	0.13	0.07	0.10	0.17	0.09	0.05	0.10	0.11	0.22	**0.11**
SUDDEN APPEARANCE – Remaining approach	0.04	0.03	0.05	0.04	0.11	0.05	0.09	0.00	0.06	0.07	0.05	0.03	**0.05**
METALLIC NOISE – Startle reaction	0.17	0.12	0.15	0.16	0.08	0.16	0.14	0.20	0.23	0.10	0.15	0.16	**0.15**
METALLIC NOISE – Exploration	0.22	0.09	0.11	0.18	0.08	0.12	0.13	0.14	0.08	0.11	0.19	0.12	**0.13**
METALLIC NOISE – Remaining avoidance	0.09	0.10	0.07	0.10	0.13	0.08	0.09	0.09	0.03	0.02	0.10	0.08	**0.08**
METALLIC NOISE – Remaining approach	0.05	0.06	0.01	0.04	0.03	0.03	0.02	0.01	0.05	0.07	0.01	0.02	**0.03**
GHOSTS – Aggression	0.08	0.15	0.07	0.15	0.09	0.12	0.15	0.13	0.15	0.10	0.19	0.00	**0.12**
GHOSTS – Attention	0.02	0.06	0.02	0.06	0.05	0.06	0.05	0.06	0.07	0.04	0.17	0.01	**0.06**
GHOSTS – Avoidance	0.19	0.08	0.09	0.15	0.13	0.14	0.21	0.13	0.17	0.14	0.09	0.14	**0.14**
GHOSTS – Exploration	0.15	0.10	0.12	0.12	0.08	0.13	0.19	0.14	0.15	0.15	0.15	0.23	**0.14**
GHOSTS – Greeting	0.13	0.08	0.12	0.17	0.13	0.10	0.11	0.13	0.12	0.12	0.20	0.15	**0.13**
PLAY 2 – Interest in play	0.27	0.08	0.05	0.20	0.09	0.23	0.10	0.17	0.43	0.14	0.25	0.16	**0.18**
PLAY 2 – Grabbing	0.22	0.12	0.04	0.16	0.11	0.17	0.12	0.18	0.34	0.10	0.22	0.16	**0.16**
GUNSHOT – Avoidance	0.22	0.12	0.07	0.14	0.06	0.10	0.12	0.15	0.14	0.08	0.16	0.22	**0.13**

[1]Australian Shepherd (AUS), Boxer (BOX), Briard (BRI), Rough Collie (COL), Dobermann (DOB), German Shepherd (GSD), Hovawart (HOV), Australian Kelpie (KEL), Malinois (MAL), Rottweiler (ROT), Giant Schnauzer (SCH), and Tervueren (TER).

Table 3. Heritability estimates for the 6 defined summary traits in the various breeds and the average across breeds; proportion of variance attributable to litter, judge, and test occasion as a proportion of total variance, average over all breeds.

	Trait[1]					
	SOC	PLAY	CH	C/F	AGGR	GUN
Breed						
Australian shepherd	0.27	0.34	0.14	0.31	0.16	0.22
Boxer	0.10	0.21	0.12	0.17	0.18	0.12
Briard	0.26	0.09	0.08	0.19	0.13	0.07
Collie	0.37	0.31	0.14	0.28	0.14	0.14
Dobermann	0.34	0.17	0.17	0.12	0.10	0.06
German shepherd dog	0.13	0.32	0.12	0.24	0.14	0.10
Hovawart	0.18	0.20	0.11	0.28	0.11	0.12
Kelpie	0.28	0.23	0.16	0.25	0.11	0.15
Malinois	0.44	0.58	0.11	0.25	0.17	0.14
Rottweiler	0.23	0.19	0.14	0.22	0.14	0.08
Giant Schnauzer	0.25	0.32	0.17	0.26	0.26	0.16
Tervueren	0.36	0.31	0.14	0.27	0.09	0.22
Average	0.27	0.27	0.13	0.24	0.14	0.13
Variance component						
Litter	0.02	0.04	0.03	0.02	0.03	0.03
Judge	0.06	0.04	0.03	0.04	0.07	0.03
Occasion	0.05	0.05	0.09	0.04	0.04	0.05

[1]Traits are Sociability (SOC), Playfulness (PLAY), Chase-proneness (CH), Curiosity/Fearlessness (C/F), Aggressiveness (AGGR), and Gunshot avoidance (GUN).

Table 4. Average of genetic correlations between the 6 summary traits (above diagonal) and standard deviation of estimates (under diagonal) over the 12 breeds. Correlations above |0.3| are marked in bold.

	Trait					
Trait	SOC	PLAY	CH	C/F	AGGR	GUN
Sociability (SOC)	-	**0.59**	**0.40**	**0.42**	-0.15	**-0.32**
Playfulness (PLAY)	0.10	**-**	**0.50**	**0.41**	0.00	**-0.42**
Chase-proneness (CH)	0.15	0.10	-	**0.37**	0.06	-0.29
Curiosity/Fearlessness (C/F)	0.14	0.07	0.12	-	-0.12	**-0.47**
Aggressiveness (AGGR)	0.17	0.14	0.28	0.17	-	-0.08
Gunshot avoidance (GUN)	0.22	0.14	0.21	0.11	0.09	-

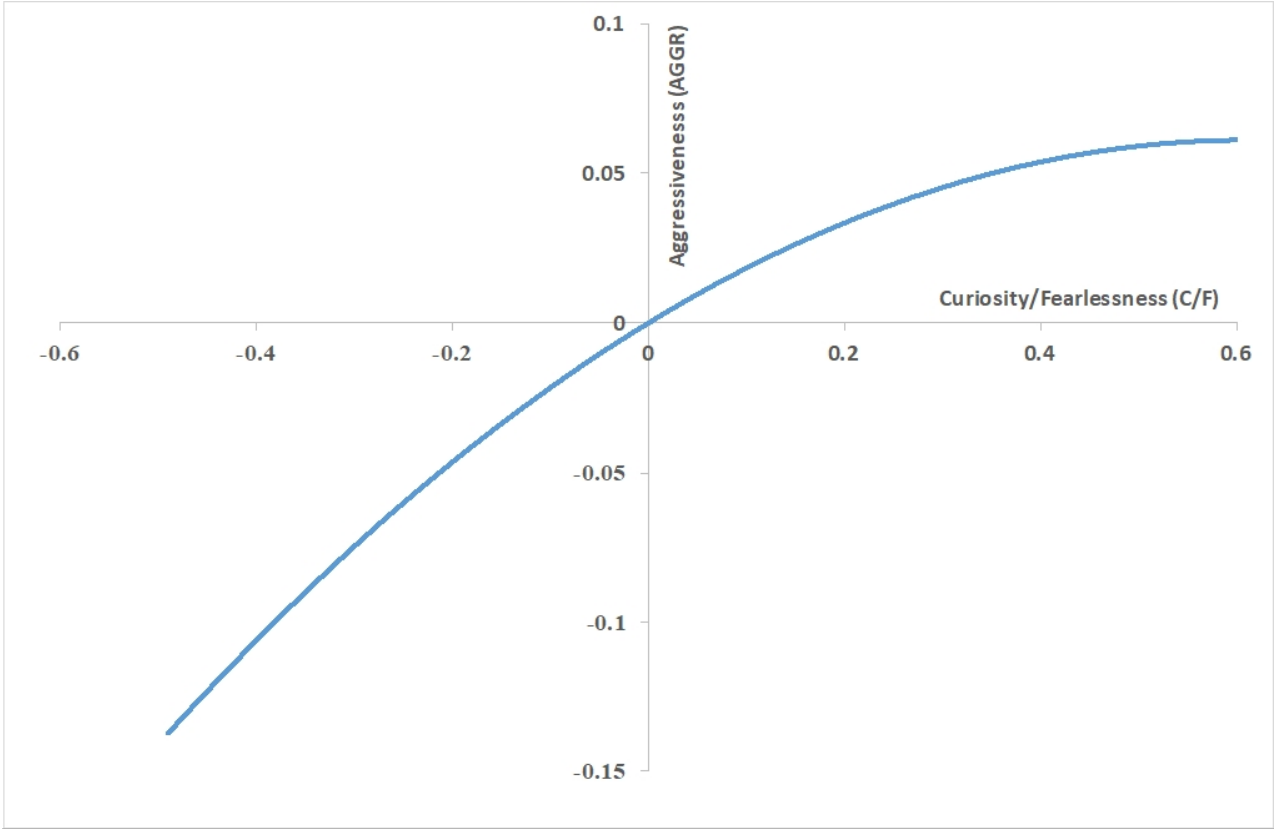

Figure 1. Relationship between estimated breeding values for Aggressiveness (AGGR) and Curiosity/Fearlessness (C/F) for Rough Collie.