

1 **Validation of a behavioral ethogram for assessing Livestock Guarding Dogs**  
2 **performance development**  
3

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13  
14 **Abstract**

15 The presence of large predators, such as wolves, bears, and lynx, has progressively increased in  
16 former areas of their presence, leading to the reinforcement or re-establishment of livestock  
17 protection practices. One such practice is the use of Livestock Guarding Dogs (LGDs), which have  
18 become widely employed and efficient over the past thirty years. Despite their popularity, there is  
19 still a significant lack of knowledge of how LGDs behave as independent working dogs. To address  
20 this gap, we developed an ethogram-based protocol to analyze the behavior of a large sample of  
21 LGDs in various situations and stages of their lives. In this study, we validated our ethogram, which  
22 consists of 123 items categorized into 11 main behavioral categories that are specific to LGDs. We  
23 used a statistical method, the inter-operator agreement, to assess the consistency of behavioral  
24 observation among five operators. Our results show that four out of five operators demonstrated

25 reasonably good inter-operator agreement for nine out of eleven behavioral categories, as  
26 measured by Lin's coefficient. We have statistically validated our LGDs ethogram.

27

28 *Keywords:* Ethogram; livestock guarding dogs; inter-operator concordance

29

## 30 **1. Introduction**

31 The use of livestock guarding dogs (LGD) is a traditional method of reducing attacks and  
32 damage associated with attacks by large carnivores (Smith et al. 2000). Their use is a common  
33 approach to mitigate wolf depredation on domestic herds (Coppinger 1988; Rigg 2001; Iliopoulos et  
34 al. 2009; Stoyanov et al. 2014; McConnell et al. 2021). The ability of LGD to efficiently reduce  
35 depredation has been regularly demonstrated (Chapron et al. 2014; Leijenaar et al. 2015; Reinhardt  
36 et al. 2012; Bommel & Johnson 2012; Landry 1999b). However, variations in LGD behavior tend to  
37 modulate their performance in herd protection and may generate potential issues particularly when  
38 they operate near people, such as hikers or bikers. With the numerical and geographical expansion  
39 of large predators, the use of LGD is growing, which may increase human conflicts. Therefore, a  
40 better understanding of how LGD behave outdoors in pastures as independent working dogs is  
41 needed.

42 Currently, the assessment of working dog behaviors is primarily conducted through either  
43 breeder questionnaires or temperament and aptitude tests (Tiira & Lohi 2014; Diederich & Giffroy  
44 2006). These tests expose dogs to a range of controlled test situations that are considered useful  
45 for evaluating specific behavioral traits (Serpell & Hsu 2001; Svartberg 2002; Sherman et al. 2015).  
46 However, a lack of standardization in the methodology of dog testing is often pointed to, guidelines  
47 are nonexistent, and discriminant validity is poorly addressed (Goodloe 1996; Diederich & Giffroy  
48 2006; Jones & Gosling 2005). Consequently, there is a need for greater standardization in tests  
49 designed to evaluate dog behavior as well as for greater investigation in reliability and validity of

50 canine temperament tests. For characterizing behavioral variables, a specific ethogram in relation  
51 to the subject studied is usually established (Eibl-Eibesfeldt 1984; Braude et al. 2002). However, this  
52 behavior catalog is neither necessarily validated by peers nor assessed statistically. Moreover, it  
53 relies on reporting and scoring the frequencies and durations of behaviors either objectively  
54 (Svartberg and Forkman 2002), or subjectively according to the observer's experience (Gosling 2001;  
55 Ruefenacht et al. 2002). Only few behavioral traits have reached consensus among scientists, such  
56 as shyness–boldness continuum (Svartberg 2002; Svartberg 2005; Svartberg et al. 2005).

57 Our presented LGD's ethogram was formulated from the wolf ethogram and enriched from  
58 the existing literature (Goodmann et al. 2002; Frézard and Pape 2003; Mech & Boitani 2003; Ross  
59 2006; Pifarré et al. 2012). A large number, but not all of behaviors traits (items), and their definitions  
60 come from this support. Yet, not all items can be directly translated from the wild species to the  
61 domestic one, such as wild wolf versus domestic dog (Handelman 2012). Ethograms of different  
62 genus of *Canis* group can observe differences in term of presence or absence of behaviors and in  
63 term of quantitative behavior expression, as we can see between the New Guinea Singing Dogs  
64 (*Canis hallstromi*) to wolves (*Canis lupus*) and domestic dogs (*Canis familiaris*) (Koler-Matznick et al.  
65 2005). Dogs have unique selection pressures, both natural and artificial, that have influenced their  
66 morphological (Goodwin et al. 1997; Janssens et al. 2019) and physiological features (Wilkins et al.  
67 2014; Nagasawa et al. 2015) in the past. Domestication has also changed behavioral traits of dogs:  
68 e.g., socio-cognitive skills (Miklósi and Topál 2013), reproductive behavior (Lord et al. 2013),  
69 cooperativeness, aggression (Frank and Frank 1982; Virányi and Range 2014; Range et al. 2019;  
70 Marshall-Pescini et al. 2017), and vocalization (Cohen and Fox 1976; Pongrácz et al. 2010; Pongrácz  
71 2017). In addition, dog breeds evolved in terms of companionship needs of humans or utilitarian  
72 purpose as is the case with the LGD. The different environmental contexts of dogs' lives and their  
73 breeds show quantitative differences of behavior expressions (Turcsán et al. 2011; Takeuchi and  
74 Mori 2006; Duffy 2008; Serpell and Duffy 2014).

75 To assess LGDs behavioral performance, we set up 4 successive standardized tests that  
76 induce a behavioral response related to realistic stimuli: (i) the shepherds, (ii) a hiker, (iii) a biker  
77 and lastly (iv) a wandering dog. During each test, conducted to the dog's usual place of work, the  
78 dogs' behaviors were continuously recorded through videos. They were analyzed by operators  
79 according to our dedicated ethogram. For recording behavioral data from the videos operators had  
80 to make choices of the behavioral items and classify them into categories, which partly depended  
81 on their appreciation. The aim of this paper is to present 1. the LGDs ethogram and its reliability and  
82 reproducibility, 2. the analysis of the quotation process by operators leading on to the inter-  
83 operator concordance.

84

## 85 2. Material and Methods

86

### 87 2.1. LGDs ethogram

88

89 The present ethogram is composed of 124 main items adapted to LGD behavior (see in  
90 Annexes), from 240 items described in the wolf ethogram (Goodman et al. 2002).

91 Items are grouped into eleven larger functional categories (e.g., "contact break" or "appeasement")  
92 or into a non-functional but descriptive larger category (e.g., "regards"). Many items are not  
93 exclusive to a single category and the choice during analysis is based on operators' appreciation of  
94 the context.

95

96 Initially, all ethogram items were grouped into eight primary behavioral categories:  
97 "Aggressive", "Contact break", "Appeasement", "Positive", "Social play", "Exploratory", "Self-  
98 centered" and "Regards". Subsequently, based on the initial analysis and to the authors' working  
99 definitions, three additional categories were added: "Submission", "Vocalization" and "Locomotion".

100 Furthermore, the "Social Play" category was redefined to include all types of playful behavior and  
101 renamed "Play". Certain items with a low occurrence rate, such as "wof" and "grunt", were  
102 combined, while rare but distinctive behaviors, such as "rush" were retained as markers for specific  
103 dogs or situations. Similarly, items like "catch the front paw" and "grab muzzle" were combined  
104 under the category "catch", despite their low occurrence rate.

105

## 106 2.2. LGDs tests

107

108 Each dog is subject to standardized test phases lasting 3 minutes. The test session comprises  
109 4 phases that are conducted in a fixed order, simulating classic and realistic working scenarios : (i)  
110 the shepherds walk calmly around his herd then briskly through, (ii) a hiker walks calmly around the  
111 herd then briskly through, (iii) a biker rides calmly around the herd then briskly through and finally  
112 (iv) a wandering dog goes to the herd. Each test phase is separated by a rest phase lasting 10 minutes,  
113 during which the dog is left undisturbed, without stimuli, with its herd.

114

## 115 2.3. Quotation process

116

117 Video recordings of dogs testing sessions are analyzed by trained operators.

118 For each specific test and stimulus, including rest phases, the duration, occurrence, intensity and  
119 latency of behavioral items exhibited by LGDs towards various targets are recorded. The targets  
120 involved are shepherds, the herd, unfamiliar hiker, unfamiliar biker, wandering dog, the  
121 environment and the observer, who is the person filming the testing sessions. Each session  
122 comprising 4 tests and 4 rest periods was analyzed by a single operator. However, to ensure  
123 consistency in behavioral data coding across various developmental stages of the same dog,  
124 multiple operators were involved in analyzing the different sessions.

125

## 126 2.4. Operators training

127

128 These operators received training through tutorials and behavioral analysis support tools,  
129 such as dedicated ethogram, specific behavioral categories, FAQs, and a video bank of captioned  
130 behavioral items.

131 The training involved processing a set of videos that included 11 tests videos featuring 7 distinct  
132 LGDs at various stages of development, including puppies (2 to 5 months) and teenagers (6 to 10  
133 months). Operators could observe 123 different behavioral items to assign into 11 categories  
134 (aggressive; appeasement; contact break; exploratory; locomotion; looks; play; positive; self-  
135 centered; submission; vocalization).

136

## 137 2.5. Data analysis

138

139 To assess the reliability and reproducibility of the LGDs ethogram and the analysis process,  
140 we have compared quoting of 5 different operators on the 11 different videos sampled. Operators  
141 have been anonymized.

142 The comparison was made thanks to the Lin's concordance correlation coefficient (Lin 1989). The  
143 Lin's coefficient provides a means to assess inter-operator concordance through a unique value  
144 ranging from -1 to 1. Interpretation of this coefficient is provided on table 1.

145

Table 1: Lin's coefficient interpretation
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CC Lin	Interprétation
< 0,50	Inacceptable
0,51-0,60	Poor
0,61-0,70	Mediocre
0,71-0,80	Satisfactory
0,81-0,90	Fairly good
0,91-0,95	Very good
> 0,95	Excellent

146

147 The Lin's coefficient was computed separately for each behavioral category, against both the  
 148 duration quotation and the occurrence quotation. The Lin's coefficient was computed for all  
 149 possible pairs of operators (10 pairs) and for each of the 11 behavioral categories.

150

151 At that point, each of the 5 operators is described by 88 concordance measurements (44 for  
 152 the duration quotation and 44 for the occurrence quotation) for each behavioral category. The  
 153 mean and distribution of these concordance measurements were then compared between  
 154 operators, for the duration quotation and for the occurrence quotation respectively, to estimate  
 155 global operator's accordancy and possibly identify globally discordant operators.

156

157 Once the global concordance between operators has been estimated, the mean of the Lin's  
 158 coefficient was computed between concordant operators for each category in order to assess the  
 159 reproducibility of each behavioral category.

160

### 161 3. Results

162

#### 163 3.1. Raw Lin's coefficients

164

165 The computed Lin's coefficient for each pair of operators on the ten videos for each  
 166 behavioral category are presented on table 2 and 3 for occurrence and duration respectively.  
 167

Table 2: Lin's coefficient for each operator couple and each behavioral category computed against occurrence quotation

Category	Obs3/Obs5	Obs3/Obs2	Obs5/Obs2	Obs1/Obs4	Obs1/Obs5	Obs1/Obs2	Obs1/Obs3	Obs4/Obs3	Obs4/Obs2	Obs4/Obs5	Mean
<b>Aggressive</b>	0.33	0.50	0.92	0.98	0.92	0.79	0.25	0.27	0.78	0.89	<b>0.663</b>
<b>Appeasement</b>	0.05	0.41	0.12	-0.33	-0.08	0.44	0.08	-0.14	-0.26	-0.15	<b>0.014</b>
<b>Contact break</b>	0.18	0.48	0.35	0.58	0.36	0.23	0.37	0.05	-0.10	0.54	<b>0.304</b>
<b>Exploratory</b>	0.48	0.50	0.85	0.93	0.78	0.87	0.17	0.28	0.88	0.70	<b>0.644</b>
<b>Locomotion</b>	0.12	0.43	0.11	0.42	0.52	0.50	0.51	0.20	0.34	0.33	<b>0.348</b>
<b>Looks</b>	0.07	0.07	0.95	0.72	0.78	0.72	0.16	0.16	0.56	0.67	<b>0.486</b>
<b>Play</b>	0.83	0.90	0.98	0.97	0.91	0.96	0.98	0.91	0.98	0.95	<b>0.937</b>
<b>Positive</b>	0.74	0.71	0.82	0.88	0.97	0.79	0.61	0.71	0.89	0.89	<b>0.801</b>
<b>Self-centered</b>	-0.07	0.72	0.31	0.89	0.31	0.97	0.72	0.49	0.89	0.62	<b>0.585</b>
<b>Submission</b>	0.08	0.19	0.86	0.70	0.49	0.74	0.14	0.07	0.64	0.55	<b>0.446</b>
<b>Vocalization</b>	0.08	0.11	0.84	0.72	0.72	0.90	0.16	0.09	0.76	0.70	<b>0.508</b>

168

169



Table 3: Lin's coefficient for each operator couple and each behavioral category computed against duration quotation

Category	Obs3/Obs5	Obs3/Obs2	Obs5/Obs2	Obs1/Obs4	Obs1/Obs5	Obs1/Obs2	Obs1/Obs3	Obs4/Obs3	Obs4/Obs2	Obs4/Obs5	Mean
<b>Aggressive</b>	0.44	0.45	0.98	0.94	0.70	0.75	0.19	0.29	0.90	0.84	<b>0.648</b>
<b>Appeasement</b>	0.03	0.43	0.18	-0.01	-0.05	0.03	-0.04	-0.04	-0.07	-0.02	<b>0.044</b>
<b>Contact break</b>	0.32	0.55	0.70	0.62	0.13	0.18	0.32	0.08	0.07	0.22	<b>0.319</b>
<b>Exploratory</b>	0.61	0.56	0.75	0.89	0.79	0.97	0.68	0.50	0.93	0.64	<b>0.732</b>
<b>Locomotion</b>	0.75	0.77	0.50	0.57	0.58	0.87	0.73	0.42	0.58	0.27	<b>0.604</b>
<b>Looks</b>	0.15	0.18	0.78	0.35	0.53	0.80	0.28	0.09	0.08	0.17	<b>0.341</b>
<b>Play</b>	0.78	0.94	0.61	0.93	0.67	0.99	0.97	0.99	0.89	0.81	<b>0.858</b>
<b>Positive</b>	0.72	0.83	0.70	0.90	0.75	0.92	0.90	0.85	0.84	0.94	<b>0.835</b>
<b>Self-centered</b>	-0.07	0.84	0.18	0.94	0.13	0.95	0.81	0.74	0.98	0.26	<b>0.576</b>
<b>Submission</b>	0.37	0.28	0.66	0.58	0.18	0.67	0.09	0.08	0.55	0.29	<b>0.375</b>
<b>Vocalization</b>	0.13	0.12	0.99	0.75	0.97	0.99	0.11	0.17	0.76	0.76	<b>0.575</b>

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### 3.2. Lin's coefficients distribution by operator

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Figures 1 and 2 present the distribution of computed Lin's coefficient for each operator. The

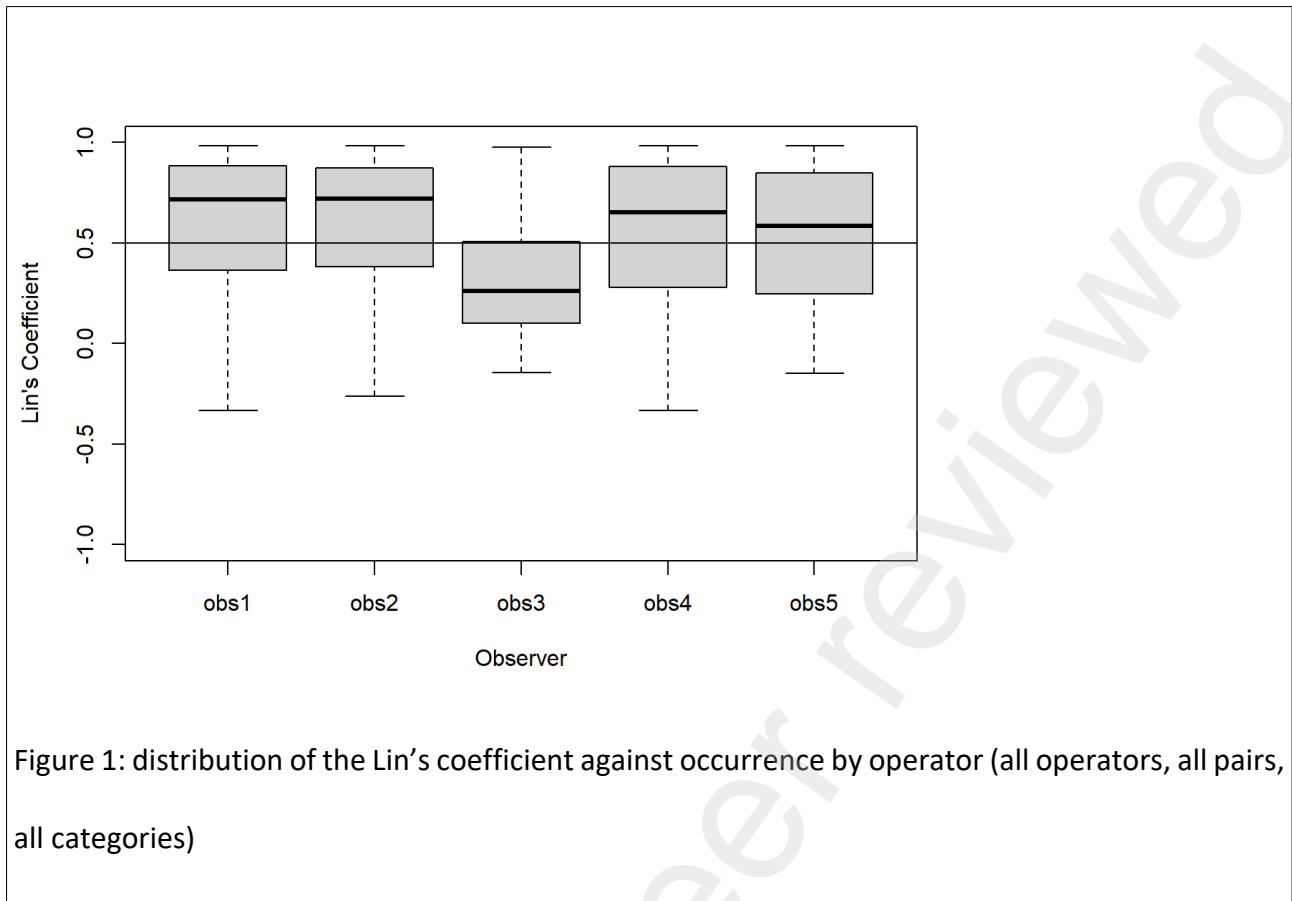
175

median of the distribution is represented as the central line. The whiskers extend to the most

176

extreme data point which is no more than 1.5 times the interquartile range from the box.

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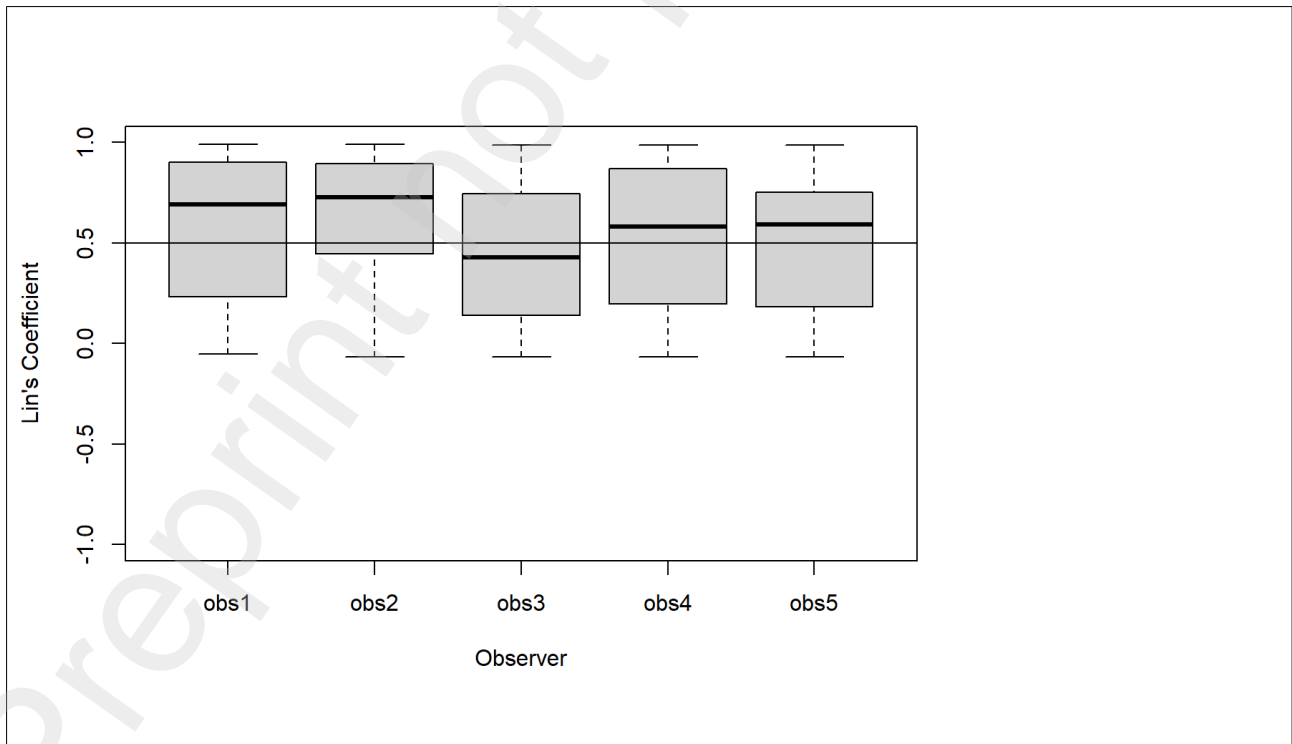


Figure 2: distribution of the Lin's coefficient against duration by operator (all operators, all pairs, all categories)

180

181 Lin's coefficient computed against occurrence are globally higher than Lin's coefficient  
182 computed against duration. Moreover, operator 3 displays significantly lower Lin's coefficient  
183 than the other operators (test Wilcoxon, p-value =  $3.10^{-6}$ ) in both quotations. For that reason, we  
184 considered that operator 3 has developed unusual quotation habits and that its quotations should  
185 not be used to analyze inter-operator concordance.

186

187 Figures 3 and 4 display the distribution of computed Lin's coefficient for each operator after  
188 operator 3 has been removed from the operator's set. The distributions change for all operators  
189 because all of them previously shared concordance coefficient with operator 3.

190

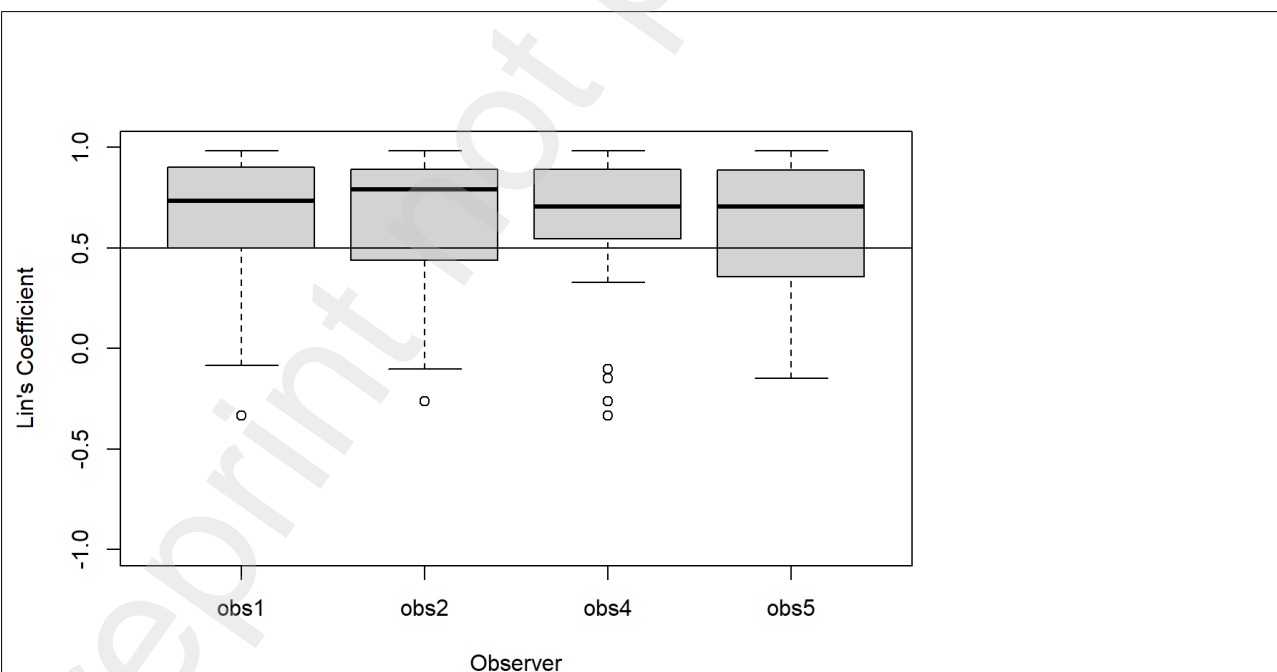


Figure 3: distribution of the Lin's coefficient against occurrence by operator, except operator 3 (all pairs, all categories)

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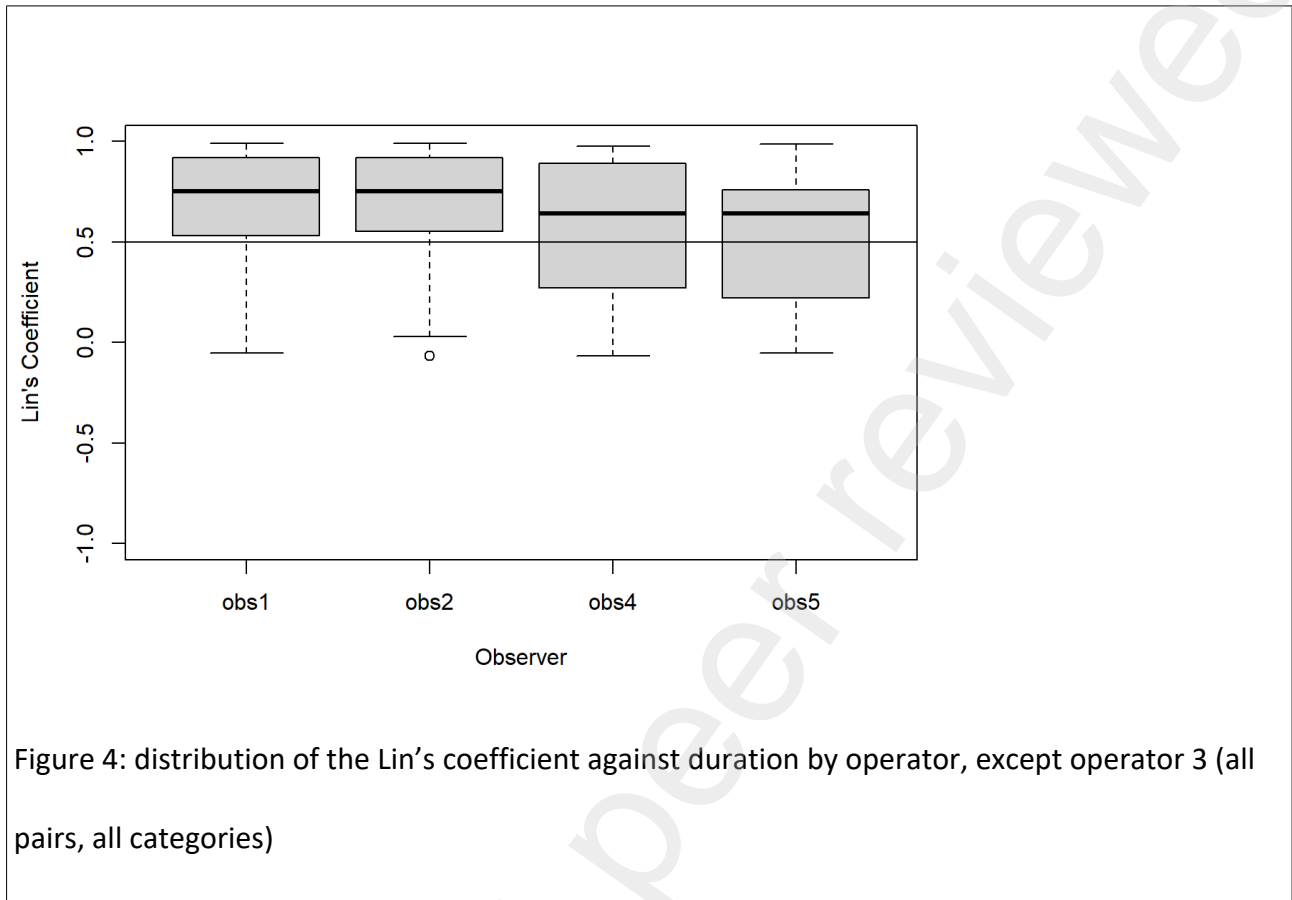


Figure 4: distribution of the Lin's coefficient against duration by operator, except operator 3 (all pairs, all categories)

193

194 The distributions of Lin's coefficients after removing results from operator 3 are significantly  
195 higher both in occurrence and duration. In occurrence, the operators' mean range is from 0.7 to 0.8  
196 which corresponds to satisfactory results (cf. Figure 1).

197

### 198 3.3. Lin's coefficients distribution by categories

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200 Table 4 and Table 5 display the Lin's Coefficient by categories once operator 3 results have  
201 been excluded from the analysis.

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Table 4: Lin's coefficient for each operator couple (operator 3 excluded) and each behavioral category computed against occurrence quotation

Category	Obs5/Obs2	Obs1/Obs4	Obs1/Obs5	Obs1/Obs2	Obs4/Obs2	Obs4/Obs5	Mean
Aggressive	0.92	0.98	0.92	0.79	0.78	0.89	0.8800000
Appeasement	0.12	-0.33	-0.08	0.44	-0.26	-0.15	-0.0433333
Contact break	0.35	0.58	0.36	0.23	-0.10	0.54	0.3266667
Exploratory	0.85	0.93	0.78	0.87	0.88	0.70	0.8350000
Locomotion	0.11	0.42	0.52	0.50	0.34	0.33	0.3700000
Looks	0.95	0.72	0.78	0.72	0.56	0.67	0.7333333
Play	0.98	0.97	0.91	0.96	0.98	0.95	0.9583333
Positive	0.82	0.88	0.97	0.79	0.89	0.89	0.8733333
Self-centered	0.31	0.89	0.31	0.97	0.89	0.62	0.6650000
Submission	0.86	0.70	0.49	0.74	0.64	0.55	0.6633333
Vocalization	0.84	0.72	0.72	0.90	0.76	0.70	0.7733333

204

205

Table 5: Lin's coefficient for each operator couple (operator 3 excluded) and each behavioral category computed against duration quotation

Category	Obs5/Obs2	Obs1/Obs4	Obs1/Obs5	Obs1/Obs2	Obs4/Obs2	Obs4/Obs5	Mean
Aggressive	0.98	0.94	0.70	0.75	0.90	0.84	0.8516667
Appeasement	0.18	-0.01	-0.05	0.03	-0.07	-0.02	0.0100000
Contact break	0.70	0.62	0.13	0.18	0.07	0.22	0.3200000
Exploratory	0.75	0.89	0.79	0.97	0.93	0.64	0.8283333
Locomotion	0.50	0.57	0.58	0.87	0.58	0.27	0.5616667
Looks	0.78	0.35	0.53	0.80	0.08	0.17	0.4516667
Play	0.61	0.93	0.67	0.99	0.89	0.81	0.8166667
Positive	0.70	0.90	0.75	0.92	0.84	0.94	0.8416667
Self-centered	0.18	0.94	0.13	0.95	0.98	0.26	0.5733333
Submission	0.66	0.58	0.18	0.67	0.55	0.29	0.4883333
Vocalization	0.99	0.75	0.97	0.99	0.76	0.76	0.8700000

206

207 For each category, we computed the mean of Lin's coefficient, both for occurrence and  
 208 duration. Two categories show a mean that is inferior to 0.5 both in occurrence and duration, with  
 209 most of the distribution below 0.5: appeasement and contact break.

210

### 211 3.4. Final distribution by operators

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213 Figures 5 and 6 display the distribution of Lin's coefficient against occurrence and duration  
 214 respectively by operators, except operator 3, once the categories "Contact break" and  
 215 "Appeasement" have been removed from the analysis.

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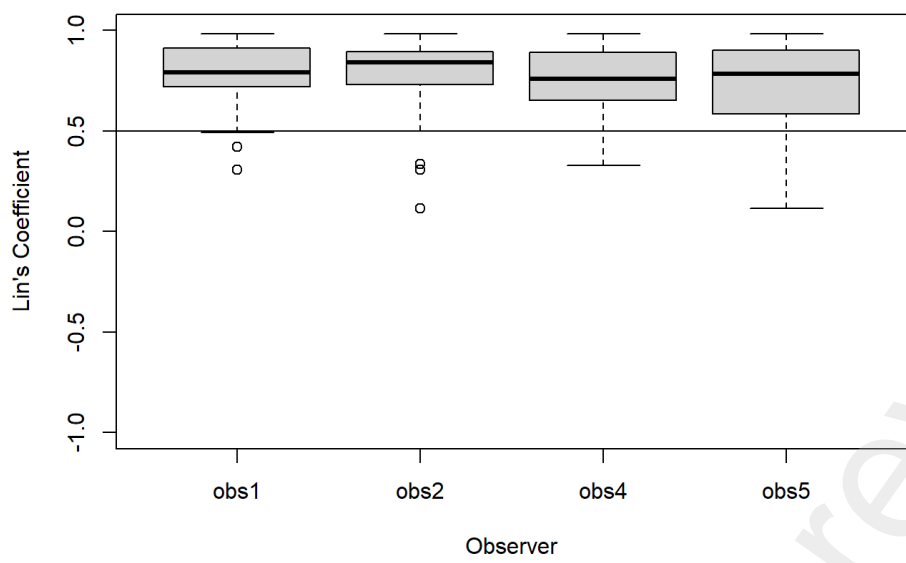


Figure 5: distribution of the Lin's coefficient against occurrence by operator, except operator 3 and categories 10 & 11.

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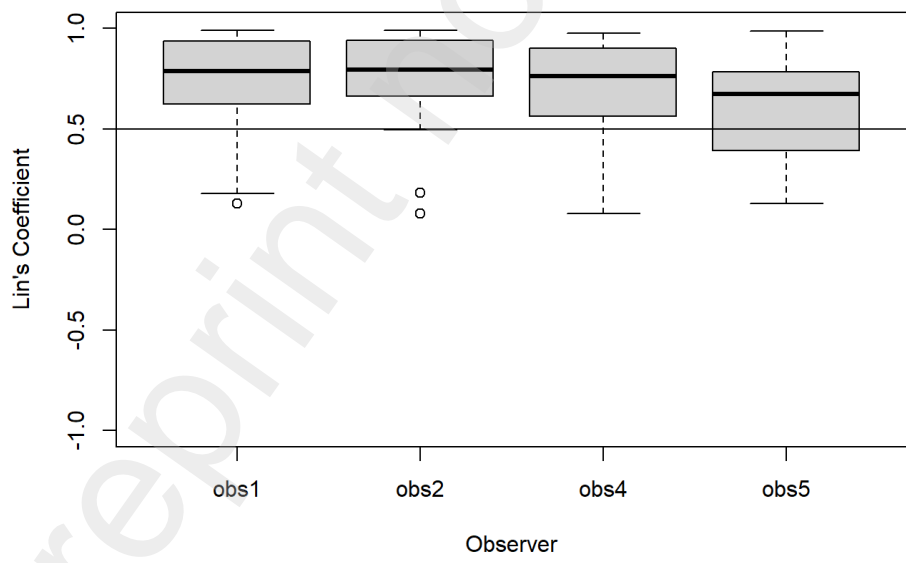


Figure 6: distribution of the Lin's coefficient against duration by operator, except operator 3 and categories 10 & 11.

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221 Means of the Lin's coefficient range from 0.8 to 0.9 both in occurrence and duration  
222 therefore displaying a fairly good inter-operator concordance.

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226

#### 227 **4. Discussion**

228

229 According to the Lin's coefficient measure, four out of five operators showed fairly good  
230 inter-operator concordance for nine out of eleven behavioral categories. The videos tests contain  
231 observable behaviors which are objectifiable independently of operators, namely: aggressive,  
232 exploratory, locomotion, play, positive, glance or gaze, self-centered, submission and vocalization  
233 behaviors. Two out of the 11 categories could not be validated through the Lin's Coefficient measure,  
234 namely contact break and appeasement. This doesn't mean these categories are not objectifiable  
235 but rather that the data available could not prove they were. In particular, these two categories  
236 were the least frequent among all the others in the tested videos. Therefore, the use of new videos



237 showing these behaviors more frequently are necessary to determine whether these categories can  
238 be validated for further use.

239

240 Another category with low representativeness while LGDs are tested (Marking behaviors)  
241 needs to be added with extra analyses on rest phases rather than test phases. Indeed, during test  
242 phases dogs are disturbed by a stimulus target (shepherd, hiker, biker or wandering dog), so they  
243 may be less prone to show marking behavior rather than just after stimulation, during rest phases.

244

245 We also can conclude that the 11 chosen categories to group the different behavior items  
246 are identified the same way from each context by trained operators.

247

248 Many items are not exclusive to a category and the choice during analysis is based on  
249 operators' appreciation of the context and influenced by the training session. Items and categories  
250 are adapted to LGD from the wolf's ethogram as we explained in the introduction. It would be  
251 interesting to test if a same behavior observable in wolves and dogs corresponded statistically to  
252 the same functional behavior. This could permit us to adjust the categories attribution in LGDs. For  
253 example, territory notion in dogs is questioned by some authors (Allen et al. 2016; Bommel &  
254 Johnson 2015). Indeed, marking behavior (urinate, scrape, defecate, see ethogram items definitions  
255 in Annexes) might have a different function in dogs than in wolves, so the marking category should  
256 be redefined for domestic dogs, or the terminology should be changed to avoid confusion. It is  
257 documented that wolves' faeces are olfactory cues used as territory markers (Vilà et al., 1994),  
258 which is not yet determined in dogs. Nor is there a consensus about dominance in domestic dogs.  
259 Some authors describe the dominance as a personality trait and think that the desire "to be  
260 dominant" drives behavior, especially aggression behaviors, in the domestic dog (Schilder et al.  
261 2014). Other authors think that dominance relationships provide a form of associative learning and

262 the factor which could escalate aggression (or not) might turn the resource value into a competitive  
263 resource rather than the traditional concept of dominance (Bradshaw et al. 2009; Bradshaw et al.  
264 2016). In our study, to avoid error of interpretation, we have chosen to not use a dominance  
265 category to define certain of agonistic behaviors (e.g., toward an unknown human or dog disturbing  
266 the livestock, see protocol), but we have chosen to allocate agonistic behaviors between 4 possible  
267 categories: “aggressive”, “submission”, “appeasement” or “contact break”. The aggressive category  
268 permits better objectivity in the interpretation hypothesis concerning the behavior drives or  
269 motivations.

270

271 A statistical analysis could explore the behavior combinations permitting to choose the  
272 corresponding category throughout a context. Because the attribution category depends on the  
273 context, it is necessary to be prudent when transposing this ethogram to companion dogs.

274

275 Ratings by human observers (operators) is used by animal scientists and veterinarians to  
276 assess certain physical traits, behavior and welfare variables. This offers several advantages:  
277 practical e.g., money-saving, and scientific in integrating multimodal information across time and  
278 situations (Meagher 2009). But observer rating involves also subjective judgements as they rely on  
279 an individual's perception and can therefore be influenced by experience or personal views  
280 (Meagher 2009). One operator out of five showed significantly lower Lin's coefficient than others.  
281 This showed that one operator has developed unusual quotation habits and that his/her quotations  
282 should not be used for further analysis.

283

284 Despite some challenges, qualitative operator rating can be a legitimate and useful scientific  
285 method. The latter is not less valid than another, especially if data are obtained from multiple  
286 observers (Meagher 2009). From now on, inter-operator concordance through Lin's Coefficient will

287 be used for validating operators quoting process on training videos before they will be allowed to  
288 analyze other LGD videos. This method will permit to validate or invalidate the level of other future  
289 operators and adapt our training sessions to compel operators to analyze in a homogeneous way.  
290 This paper, in agreement to other studies, demonstrates that operator ratings can be both reliable  
291 and valid.

292  
293 After having the training session and during the rest of the behavior analysis, operators  
294 probably continue to acquire experience in coding behavior. It would be interesting to investigate if  
295 the operators could obtain a better judgment after having coded a certain number of videos. Testing  
296 the operators' scores at different steps of the study could permit us to define the optimal training  
297 session duration to obtain the best Lin's concordance correlation coefficient.

298  
299 Presented here is the initial iteration of our LGD ethogram, which remains subject to  
300 modification based on its application.

## 302 **6. Conclusion**

303  
304 We utilized a statistical approach, the inter-operator agreement method, to assess the  
305 consistency of behavioral data coding among operators. This evaluation enables the training of  
306 multiple operators in a standardized manner for the same study until an acceptable level of inter-  
307 operator concordance is reached.

308  
309 Based on the validated ethogram, our study aims to investigate "How to know what a good  
310 LGD is?" Temperament and environmental influences are determined by examining the predictive  
311 value of observable puppy behaviors, or by taking into consideration temperament traits, and

312 environmental contexts. Specifically, we aim to identify reliable indicators that can accurately  
313 forecast LGD efficacy in protecting herds when they reach adulthood.

314 When this study is completed, we will then be able to compare the LGD ethogram we have  
315 established with that of Canis genus and to confirm or invalidate the existence of all, or part, of the  
316 behavioral items we identified in LGDs. Finally, we will be able to test the behavioral functions  
317 (functional categories) of the several and varied items observed in LGDs.

318

319

320

321

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323

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525

526

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527 **Annex: Livestock Guarding Dog Ethogram**

528

529 **Absent:** ABS Replacement marker representing dog absent during test. Dog is not with the flock,  
530 not visible (exploration, hunt, ran away, unknown). Indication of absent dog is  
531 important information and must be included.

532 **Agonistic Pucker:** AP Vertical retraction of the lips. Self-confident animal will simultaneously bring  
533 the corners of the mouth forward so only the canines and incisors are exposed. Fearful animal will  
534 draw the corners of the mouth back, exposing the corners of the mouth back, exposing some pre-  
535 molars.

536 **Amble:** AMB To walk at a leisurely pace, slowly, unhurried. Indirect Approach IND APP.

537 **Approach:** APP To move toward another individual at a walk or trot. Often used as part of threat or  
538 sexual behaviors (Aggressive, Submission, Play, Positive).

539 **Avert Gaze:** AV Breaking eye contact. May or may not involve turning the head as well. Often seen as  
540 part of aggressive, threatening interactions. (Submission, Contact-break, Appeasement)

541 **Avoid:** AV Walking away from an animal or situation. Faster gaits used for the same purpose are  
542 called escape. (Contact-break, Appeasement, Locomotion)

543 **Bark:** BK Loud vocalization issued in response to excitement, aggression, fear,  
544 frustration. (Vocalization)

545 **Being petted:** BP The dog accepts soft and affectionate gestures from people and will not pull or  
546 run away. (People friendly, Positive).

547 **Bite Muzzle-Soft:** BMS Holding another animal's muzzle gently in the mouth. This is sometimes part  
548 of greeting or food begging sequences. (Positive, Play, Submission)

549 **Bite:** BT To close jaws and teeth on another. Indicates an uninhibited bite which often causes  
550 wounds. (Aggressive, Play if puppies)

551 **Bounce:** BNC To jump up and down in place. Sometimes the hind feet remain on the ground as the  
552 animal bounces with its forepaws only. (Play, Self-centered)

553 **Bow or Play-bow:** BW To bend into a general bow shape; the animal lowers the front part of its  
554 torso while keeping the hind part upright. The most common bow is known as the play bow, which  
555 is used to solicit play behaviors. (Play, Aggressive)

556 **Canter:** The canter is a three-beat gait. One foot is always on the ground. (Locomotion)

557 **Chase:** CS Running in pursuit of another individual. (Aggressive, Play)

558 **Chew:** CH To bite and chew persistently at something, often reducing it gradually to a particular  
559 state. (Play, Self-Centered)

560 **Circle:** CIR To walk around an object or another individual. (Positive, Aggressive, Play).

561 **Climb:** CL To move to a higher elevation. It includes walking, trotting, running up a slope, and, by  
562 careful placement of paws on branches or steps, going up into a tree or a flight of stairs. (Aggressive,  
563 Exploratory, Play)

564 **Crawl:** To move forward by some pulling with the forelegs and pushing with the hind legs. The  
565 sternum and belly touch, or almost touch, the ground. (Submission, Play)

566 **Creep:** A crouch superimposed on a gait, typically the walk. (Submission)

567 **Critical Reaction:** Crit-R Intense aggressive behavior – usually defensive and elicited. Can escalate  
568 into an all-out attack. Exhibited in wolves unable/unwilling to retreat – can be due to the lack of an  
569 avenue of retreat from an approaching animal/human who are not intending a threat. (Aggressive)

570 **Crouch:** CH To stay down close to the ground with legs bent, waiting to spring or run forward. The  
571 back is often arched, and the tail is usually held in T4 position. (Submission)

572 **Defecate:** DF Excrete feces. A fearful animal may defecate during a ritualized fight or when receiving  
573 an offensive threat. the feces may be runny - a sign of stress. (Submission, self-centered)

574 **Dig & Tail Wag:** DG & TW A form of play in which the animal appears to become excited while  
575 digging. It may be a SOLITARY or a SOCIAL type of play. (Play)

576 **Dig:** DG To break up and move ground with the forepaws and to make a hole by doing so.  
577 (Exploratory)

578 **Drink/Eat:** To ingest water. To ingest substances, usually but not always food. (Self-centered)

579 (1) **Ears Back:** EB Ears lowered and folded back against the sides of the head. The ears have a flatten  
580 appearance.

581 (2) **Airplane Ears:** AE Ears held out to the side, inner surface down, like the wings of an airplane. Can  
582 be seen in grooming solicitation to humans or wolves, stalking or ambush.

583 (3) **Ears Pricked:** EP Ears erect and turned forward.

584 (4) **Ears Pricked, Turned Sideways:** EPTS Ears erect, with the inner surfaces directed out to the sides.  
585 This usually indicates some degree of tension.

586 (5) **Ears Turned Sideways and Slanted Back:** ETSB Apparently a combination, or superposition, or  
587 ears back and ears pricked, turned sideways.

588 A relaxed way of looking or looking around is scanning. (Looking, Viewing, Watching)

589 **Escape:** ESC To get away. To succeed in avoiding an attack, mobbing, or harassment. Escaping is  
590 done at a fast trot or a run, which distinguishes it from avoiding, which may be done at a walk or  
591 slow trot. (Contact-break, Submission, Play)

592 **Explore:** EXP to investigate the environment - possibly incorporating manipulation of parts of the  
593 environment. (Exploratory)

594 **Follow:** FOL To gate behind another animal, orienting to it specifically and changing direction as  
595 needed to stay behind it (Positive, Aggressive)

596 **Foreleg Grab:** FG Take another animal's foreleg into the mouth. (Play, Aggressive)

597 **Freeze:** Freezes are moments during which a canid stops all intentional movement of voluntary  
598 muscles due to surprise or fear. (Submission, Appeasement)

599 **Gape:** Open mouth threat, ears back, oriented toward other animal, lips retracted back both  
600 horizontally and vertically. (Aggressive, Submission)

601 **Give Eye:** G-EYE Staring intently, often accompanied by orienting, stalking, and herding. In social  
602 encounters can be considered a threat. (Aggressive, Play, Regard)

603 **Gnaw:** GN To chew at something persistently; usually the molars and premolars are primarily used.  
604 (Self-centered)

605 **Grab:** GB To grasp something quickly, suddenly, or forcefully and hold on firmly. (Aggressive, Play,  
606 Positive)

607 **Greet:** GR A general term. To interact in a friendly manner, characterized by ears back, grinning with  
608 lips relaxed, much tail wagging and perhaps including whining. The animals orient to each other's  
609 faces and may lick, sniff, and muzzle grab-softly. (Positive)

610 **Grin:** The lips are drawn back, but not up. In friendly submissive, and greeting interactions, the  
611 corners of the mouth may turn up. When the interaction is of a defensive or threatening nature, the  
612 corners of the mouth may turn down. The lips may be closed or open. (Positive, Play, Submission,  
613 Aggressive)

614 **Groom:** GM To care for the coat and skin by licking, nibbling, and to some extent by scratching the  
615 coat free of dirt, irritating substances or parasites. Also includes wound care. (Self-centered)

616 **Growf:** GRO A combination of growl, agonistic pucker, and snap, all performed very rapidly. May be  
617 augmented by a lunge and a tongue flick, as well as threat stares. Hackles may also be raised.  
618 (Aggressive).

619 **Growl:** GRL A throaty rumbling vocalization, usually low in pitch. It may be used in aggressive or  
620 defensive interactions. (Aggressive)

621 **Growl-Bark:** G-BK Barks and growls closely interspersed among or superimposed on each other.  
622 (Aggressive)

623 **Hackles 1-4:** HA Piloerection of the fur along the spine, which tends to make the animal look larger  
624 than it actually is. **Hackles:** **1**=scruff/withers, **2**=back, **3**=rump and **4**=tail. Hackles are a good  
625 indicator of the animal's mood, since they are an epiphenomenon and not under the animal's



626 deliberate control. Raised hackles indicate degree of aggressive arousal. Usually, the further down  
627 the back the hair is piloerected, the more aroused the animal is. In the most extreme cases, even  
628 the tail fur is puffed up.

629 **Harass:** HR To make repeated threats, or mock attacks on an animal. (Play, Aggressive)

630 **Head Shake:** HSH After a grab, the animal shakes its head vigorously from side to side. Depending  
631 on whether muscle as well as hide is thus grabbed, on how much pressure is applied, and how  
632 violent the shaking is, the victim may sustain no injury, moderate to serious bruising, or even  
633 extensive muscle tearing and internal organ damage.

634 **Herd:** HE Staring and following another animal persistently, so that the followed animal is displaced  
635 and sometimes literally herded. (Aggressive)

636 **Hide and Seek:** H&S Inviting chase with dodging behind obstacles, possibly some peek-a-boo,  
637 ambushing, and pouncing. Characterized by a lot of peeking from behind obstacles. Chases are likely  
638 to be around obstacles. (Play)

639 **Hipslam** HSL Pivoting on the forelegs and slamming into the opponent with the hindquarters. (Play).

640 **Hook:** HOO To crook the foreleg around something and pull it toward oneself. May also be used to  
641 trip or attempt to trip another animal during wrestling. (Aggressive, Play)

642 **Howl:** HL A long, drawn-out tonal vocalization. (Vocalization)

643 **Hurtle:** HU To jump repeatedly at another animal (usually a human), ostensibly to greet face to face  
644 at first. (Aggressive, Play)

645 **Ignore:** IG To be able to see another's actions yet make no observable response to them.  
646 (Submission, Appeasement)

647 **Indirect Approach:** IND APP A nonlinear approach often made via a meandering path, a series of  
648 curves, or some casting around or back and forth as if the animal could be either searching for  
649 something or experiencing approach avoidance conflict. The animal may have its ears somewhat

650 back and sniff the ground. It may look as if mere coincidence brings it into the social space of another.

651 (Positive)

652 **Inguinal Presentation:** ING-P Standing animal rotates one hind leg out, making it easy for another

653 animal to insert its nose behind the stifle and sniff the abdominal area. An animal lying down in

654 passive submission lifts the uppermost hind leg, exposing the belly. It may half roll onto its back as

655 well. (Positive, Submission)

656 **Inhibited Bite:** IB A bite without sufficient pressure to wound. (Aggressive, Play)

657 **Invite Chase:** IC Often prefaced by a play bow, the chase invitation is characterized by running

658 rapidly while spaying the paws out from body side to side. (Play)

659 **Jump:** Springing into the air, over or onto something, can be specifically directed at an object or a

660 person. (Exploratory, Play)

661 **Lateral Display:** LAT-DISP An animal stands broadside to another, standing tall, head up, ears pricked,

662 T1 or T2, usually some hackles and it may try to force eye contact. (Aggressive, Play)

663 **Leave:** LV Depart; to go away from a place or another animal. (Contact-break)

664 **Lick Intention:** LKI An extension and flicking of the tongue between the lips; a licking motion

665 performed at a distance too great to reach its intended target. May manifest as a single small flick

666 or several slurps of almost the full length of the tongue (length of tongue extension and number of

667 repetitions will vary with context). Teeth may or may not be additionally bared. (Submission)

668 **Lip Licking:** LL To pass the tongue across the surface of the lips; used for individual and social

669 grooming, greeting, and food begging (related to hunger, diet, enticing smell). At times this behavior

670 may be accompanied by other appeasement signals, like yawning. (Self-centered, Appeasement)

671 **Lick:** LK To pass the tongue over. Used for individual and social grooming, greeting, food begging.

672 (Self-centered, Submission, Positive)

673 **Look:** LO To direct the eyes, ears, and nose toward something. Quick look if less than 3 seconds (a

674 glance). Longer than 6 seconds is to stare. (Regards) (Look short time, Watch longer time)

675 **Mouth (put into):** M To hold with the mouth, repeatedly changing grip. To manipulate with the  
676 mouth. (Play, Exploratory, Self-centered)

677 **Muzzle Nudge:** MN slight lift of nose to touch another animal. (Affiliative)

678 **Muzzle Punch:** The muzzle punch occurs when an animal uses his muzzle as a weapon in a stabbing  
679 motion to the body of another animal or a human. (Aggressive)

680 **Orient:** OR To direct the eyes, ears, and nose toward something. (Regards)

681 **Panting:** The mouth open and the tongue hanging out. Panting is a function of the respiratory  
682 system, playing an important role in regulation of body temperature. Panting, drooling and  
683 evaporation help with cooling the body. It can also be a sign of stress. (Self-centered,  
684 Appeasement.)

685 **Paw:** PW To extend or wave the paw, using it to touch another or stroking the air in front of another.  
686 Sometimes, as with an intimidated animal, the foreleg is held up and the paw given a limited wave  
687 from the knee to the foot. (Submission, Positive)

688 **Peek-A-Boo:** PAB To bob the head above or around some obstacle, looking briefly at another animal,  
689 and ducking behind the obstacle. The other animal may do the same and the sequence is often  
690 rapidly repeated a variable number of times. (Play)

691 **Play Face:** PF Lips horizontally retracted, jaws slightly open, ears pulled straight up and back, or  
692 simply folded flat back. (Play)

693 **Play Run:** PL-RN The animal runs with its head up, and a play face expression. It tends to run in a  
694 circular path with frequent changes of direction. (Play)

695 **Play-Solicit:** PL-SOL Prancing and bowing in front of another animal, with a play face. (Play)

696 **Pull & Fall (Down):** P&F To pull on another animal and fall down. A learned behavior used to solicit  
697 grooming. It appears to incorporate greeting and passive submission with grabbing. The pulling  
698 animal usually holds on the animal it is soliciting during the first few minutes of being groomed.  
699 (Submission, Positive)

700 **Pull**: **PU** To grab another animal and draw it along, without the pulled animal being recumbent. The  
701 animal being pulled typically remains on its feet and may brace and resist being pulled or may try to  
702 make the puller let go by struggling and biting. (Aggressive, Play)

703 **Quick Look (a glance)**: **QL** A short fast (less than 3 seconds) look at an object, to take note. If longer  
704 it becomes orient, or stare, or give-eye. (Regard)

705 **Rebuff**: **RB** A general term for rejecting a suitor and driving him or her away. (Aggressive)

706 **Refuge**: **REF** To seek shelter. A defensive behavior often used when an animal is mobbed or  
707 attacked. (Submission)

708 **Rest, Back**: **RB** Resting or sleeping on the back, belly exposed with paws extended or folded on the  
709 chest.

710 **Rest, Curl**: **RC** Lying down with legs tucked close to the body, the back is curved, and the tail often  
711 covers the paws and nose.

712 **Rest, Sphinx**: Resting on the ground with forepaws extended in front of the chest, hind legs tucked  
713 close to one side, body erect, and head up.

714 **NB**: If the dog is resting but remains alert (looking around), the vigilance will be notated as “regard”.  
715 (Self-centered).

716 **Rest**: **RT** To restore energy by sleeping or relaxing.

717 **Rest; Side**: **RSD** Resting flat on one side with the body stretched out.

718 **Ride Up**: **RU** Resting forelegs or paws on or across the back of another animal, from the side (as  
719 distinguished from mounting, “riding up” from the rear) (Aggressive, Play)

720 **Roll on Back**: **ROB** Lying down on the side and rotating the body to rest on the dorsal surface.  
721 (Submission, Positive, Play, Self-centered)

722 **Roll**: **RO** To alternate positions repeatedly from side back to side. (Self-centered, Submission,  
723 Positive)

724 **Rub On: RUBO** The animal presses against, then slides along a companion or an object such as a  
725 fence, rock, tree. (Self-centered, Positive)

726 **Run: RN** Moving rapidly (faster than a canter). The body appears almost parallel to the ground.  
727 (Locomotion).

728 **Rush: RU** A short run directed at another animal, an object, or prey, as if the lunge were lengthened  
729 by several yards. (Aggressive, Positive, Play)

730 **Scrape: SCP** Forceful scratching backward against the ground with the hind legs and sometimes with  
731 the front ones too. (Marking)

732 **Scratch: SCR** To rub the skin or fur with the claws, especially to relieve itching or discomfort. (Self-  
733 centered)

734 **Scratching: SCR** Clawing the floor or the wall to escape or to open a door; often whining at the same  
735 time. (Contact-break)

736 **Shake: SHA** The body appears to oscillate vigorously on its longitudinal axis. This behavior has the  
737 effect of removing excess water, detritus, snow or sometimes ice from fur. (Self-centered)

738 **Shiver: SHI** The animal trembles rapidly. Quivering may extend to its legs as well as the torso and  
739 head. Reasons vary: animal may be cold because wet, because not enough fur and/or body fat for  
740 cold weather, or due to fear. (Self-centered; Submission)

741 **Sitting: SIT** Sit down and quietly remain sitting. This is a stop signal. (Self-centered)

742 **Snap: SN** A rapid bite that has a little contact with its object. As the animal's jaws come together,  
743 the teeth make an audible sound. (Aggressive)

744 **Sneeze: SN** A very abrupt clearing of the nasal passages, often preceded by a quick inhalation, or  
745 even a gasp, and a facial grimace which superficially resembles an agonistic pucker. (Self-centered,  
746 Appeasement towards a human being.)

747 **Sniff Genitals: SNF-GN** Sniffing directed towards the genitals of another animal. This is done  
748 frequently during courtship and is also done during greeting and mutual investigation. (Positive)

749 **Sniff Noses:** SNF-N To sniff noses during greeting or as animals come together after a neutral  
750 approach. (Positive)

751 **Sniff:** SF To smell or inhale through the nose. (Exploratory)

752 **Squeal:** SQ A shrill vocalization made with one long exhalation lacking the “sobbing” of a whimper.  
753 A squeal is also more drawn out than a “whine”, or “yipe”. Not as loud as a shriek

754 **Squirm:** SM To writhe, wriggle, fidget or move nervously; to extricate itself from confinement. (Play,  
755 Submission, Aggressive)

756 **Stalk:** ST To crouch with a level back on any gait- used as a means of stealthy approach. Typically,  
757 the ears are pricked forward. The animal usually stares intently at what it is stalking. (Aggressive,  
758 Play)

759 **Stand in the way:** STIW To create a barrier by standing between an animal/human and the flock.

760 **Stand Tall:** ST An animal draws itself up to its full height. The neck is often arched, and the ears  
761 pricked. It may stare at another animal. The tail, if not already carried high, may rise. Its effect is  
762 sometimes enhanced by raised hackles. (Aggressive, Play)

763 **Stare:** STA An intense fixed gaze. In social encounters, the stare may have a “hard” quality.  
764 (Aggressive, Regard)

765 **Startle:** STL To move or jump suddenly as in surprise or alarm. (Self-centered)

766 **Stretch:** Stretch, Bow STRBW After getting up from resting, a slow drawn-out bowing stretch may  
767 occur. Stretch, Fore and Aft STRFA A bow stretch that moves into a hind leg stretch. Stretch,  
768 Humpback STRHB A stretch that seems to be the reverse of a bow stretch; the back is arched in a  
769 catlike manner. (Self-centered)

770 **Submission-Active:** S-A Persistent licking of another dog’s muzzle while crouching with tail tucked  
771 in (T4) or wagging. The tail may be wagging while tucked. Also, the dog paws at the other’s face.  
772 (Submission)

773 **Submission-Obnoxious:** S-O Behavior is ostensibly submissive or greeting but they do it so  
774 vigorously and persistently that they may displace a higher-ranking animal. Sometimes the  
775 submissive animal pursues the higher-ranking animal. (Submission)

776 **Submission-Passive:** S-P **1.** Falling or laying on the side or back, often raising a hind leg to inguinal  
777 present. The ears are flattened, and the tail may be between the legs (T4) **2.** Sometimes the dog sits  
778 or crouches, again attempting an inguinal presentation, but does not attempt any greeting behavior  
779 or active appeasement. (Submission)

780 T1 in a circle=tail curved over back in a circle- not as tight as a sled dog's tail curve

781 **Tail positions: T1-4:**

782 **T1**=Tail above the level of the back **T2**=Tail level with the back

783 **T3**=Tail below the level of the back **T3.5**=Tail brushing the hocks

784 **T4**=Tail between the legs. It may touch the belly in some cases.

785 **Tail Wag:** TW A tail may be wagged from side to side, in circles, or by thumping on the ground by a  
786 resting animal. When greeting, a tail may be wagged so hard that the animal's hindquarters wag  
787 too. A tail wagged in a circle almost always means friendliness. A tail level with or above the back  
788 indicates excited, often aggressive arousal. A tail held between the legs indicates fear and  
789 submission. (Submission, Positive, Appeasement, Play)

790 **Threaten:** TH A general term useful when action is so fast that some detail must be sacrificed.  
791 Includes but is not limited to behaviors such as staring, growling, agonistic puckers, lateral displays,  
792 hackles, lunges, snaps, and ambushes. (Aggressive, Play, Submission)

793 **Trot:** TRT A diagonal, two-beat gait in which the left rear and right front legs move together, and  
794 the left fore and right hind legs move together. It is an extremely efficient traveling gait.  
795 (Locomotion)

796 **Tug:** TG Short pulling movements, during which the dog's head is pulled back and its legs are braced  
797 against the direction of the pull. (Aggressive, Play)

798 **Urinate:** U To excrete urine. Raised leg urination, squat urination, and standing urination are the  
799 typical postures. A fearful, submissive dog, and submissive young pups, may lose sphincter control  
800 and urinate involuntarily in a variety of postures, including passive submission. (Submission, Self-  
801 centered, Marking)

802 **Urine Mark:** UM The excretion of urine to mark an item (food or territory) for oneself. Postures and  
803 scraping may follow the marking to add visual display to the olfactory one. Typically, a urine mark  
804 involves the deposit of only a small quantity of urine. (Marking)

805 **Walk:** W To move along on foot, advancing by steps. If the animal is also sniffing, exploratory.

806 **Wander:** WAN Meandering around, often sniffing things, with no observable goal, although  
807 wandering appears to be low-intensity appetitive behavior. (Locomotion)

808 **Whimper:** WHIP A fairly constant high-pitched monotone which appears to be a series of rapid  
809 exhalations or “pushes” from the diaphragm. (Vocalization)

810 **Whine:** WN Repeated, relatively brief, “exhalation vocalizations” of falling pitch. Often used to call  
811 puppies or get attention. (Vocalization)

812 **Woof:** WF One of the three types of barks. It may sound soft and breathy like a cough or be louder  
813 and more explosive. (Vocalization)

814 **Yap:** Y Puppy bark. Puppies make squeaky high pitched short barks. (Vocalization)

815 **Yawn:** YW A wide gape with deep inhalation. The eyes may be slits or closed. The tongue often  
816 protrudes and curls upward. (Self-centered, Appeasement)

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818