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1 ***Does the avoidance distance test at the feed barrier have scientific validity for evaluating***  
2 ***reactivity to humans in Limousin breeding bulls?***

3 ***Authors: Louise Bacher<sup>1,2</sup>, Vincent Prieur<sup>3</sup>, Romain Lardy<sup>2</sup>, Xavier Boivin<sup>2</sup>***

4 ***Affiliations:***

5 <sup>1</sup>AgroParisTech, Université Paris-Saclay, 75005 Paris, France

6 <sup>2</sup>Université Clermont-Auvergne, INRAE, VetAgro Sup, UMR Herbivores,  
7 F-63122 St-Genès-Champanelle, France

8 <sup>3</sup>France Limousin Sélection, 87220 Boisseuil, France

9

10 ***Corresponding author:*** Louise Bacher, AgroParisTech, Université Paris-Saclay, 75005 Paris,  
11 France ; INRAE, Vetagro Sup, UMR Herbivores, Université Clermont-Auvergne, F-63122,  
12 Saint-Genès-Champanelle, France.

13 E-mail address : [louise.bacher@inrae.fr](mailto:louise.bacher@inrae.fr); [bacher.louise@gmail.com](mailto:bacher.louise@gmail.com)

14

15 **Abstract**

16 Testing beef bull reactivity to humans is a key challenge for improving beef cattle reactions to  
17 handling, but the process can be dangerous and requires skill in cattle handling. Testing  
18 avoidance distance at the feed barrier (ADF) would be a safer option than test procedures  
19 involving exposure to free moving animals. Here we tested ADF for test re-test consistency  
20 one week apart and for convergent validity with three other tests involving humans where  
21 bulls were free to move. We also tested the relationship between ADF score and growth  
22 performances. This observational study used 115 Limousin bulls evaluated on-farm around  
23 weaning (8 months) and at the French national evaluation and qualification station for  
24 Limousin-breed young bulls, where they were housed from 10 to 15 months of age for a  
25 period of control. Qualitative on-farm behavioural scores (BeF), on-station behavioural scores  
26 (BeS) and on-station docility scores (Do) were collected during the routine pedigree bull  
27 selection process. Three repetitions of the ADF test were performed, in three weeks before the  
28 end of the period of control. Standardised 120-day and 400-day weights were calculated and  
29 correlated to behavioural scores. ADF showed moderate consistency through the three

30 repetitions (overall intraclass correlation coefficient=0.54). Mixed-effect ordinal logistic  
31 regressions were performed to evaluate the links between ADF score and other behavioural  
32 data. ADF score was positively related to other scores collected on-station (ADF–BeS,  
33  $p<0.01$ ; ADF–Do,  $p<0.05$ ). Animals with lower ADF scores also had heavier predicted 120-  
34 day and 400-day weights ( $p<0.01$ ). Our results suggests that ADF shows consistency with  
35 other tests involving humans and is related to key predicted weight outcomes at genetic  
36 selection. The ADF test emerges as a promising option for phenotyping individual  
37 responsiveness to humans.

38 Keywords: Avoidance distance; docility test; beef cattle; temperament; human–animal  
39 relationship

## 40 **1. Introduction**

41 The number of cattle per worker is increasing in many countries, (Gargiulo et al., 2018;  
42 Veysset et al., 2014), potentially reducing the relational proximity between livestock and  
43 farmers. The risk, depending on farmers’ attitudes towards animals, is that if human–animal  
44 interactions essentially only occur during handling, then animals will become increasingly  
45 fearful of humans (Destrez et al., 2018; Hemsworth and Coleman, 2011). For stockpeople,  
46 handling fearful animals is an occupational health and safety hazard (Ceballos et al., 2018;  
47 Gutierrez-Gil et al., 2008), but cattle fear to humans could reduce animal welfare and  
48 productivity (milk yield, growth, feed efficiency, meat quality) (Haskell et al., 2014;  
49 Hemsworth and Boivin, 2011; Olson et al., 2019).

50 The reactivity of cattle to humans results from a dynamic learning process based on prior  
51 human–animal interactions (Waiblinger et al., 2006). This process interacts with genetic  
52 traits: animals show inter-individual behavioural differences to human presence and handling  
53 (calm, docile, distressed, struggling to escape, and so on) that are repeatable over time and  
54 across situations and partly genetically inherited (see Haskell et al., 2014 for review).

55 A number of genetic selection programmes use protocols to evaluate cattle reactivity to  
56 humans (Haskell et al., 2014; Phocas et al., 2006). These protocols feature various tests of  
57 responses to humans and to handling involving direct human presence, but also responses to  
58 restraint in handling facilities (Haskell et al., 2014; see Waiblinger et al., 2006 for reviews).  
59 For example, in France, young Limousine breeding bulls are first evaluated on their reaction  
60 to human approach in their original farm (Vénot et al, 2015). They are then gathered in  
61 Lanaud station where a routine-practice “docility test” is performed to select breeding bulls  
62 and improve reactivity to humans (Le Neindre et al., 1995, Phocas et al., 2006). The docility  
63 test, performed since 1992, involves direct exposure to human presence after a short period of  
64 social separation, where an experienced but unfamiliar handler attempts to restrain the bull in  
65 a corner of a corral pen. However, this test is time-consuming, stressful, and poses a safety  
66 hazard with risk of injury for both the handler and the animal (Sant’Anna and Paranhos da  
67 Costa, 2013). Moreover, it requires skills in cattle handling, especially with bulls, and a  
68 specific testing area.

69 Safer tests, possibly performed without moving the animals, would be by far a better option.  
70 For example, Waiblinger et al. (2003) developed a test called “avoidance distance at the  
71 feeding rack” (ADF) for evaluating the human–dairy cattle relationship. This test evaluates  
72 the distance to an unknown human approaching from outside the freestall before a cow shows  
73 an avoidance reaction (head, leg). It has been transformed in a four-point scale to evaluate the  
74 human–animal relationship in the protocol for Welfare Quality® assessment on dairy and  
75 fattening cattle. This avoidance distance test has been used for dairy cattle (see Ebinghaus et  
76 al., 2017, for review), but more rarely for bulls (see Windschnurer et al., 2009, on fattening  
77 bulls). As for dairy cattle, Windschnurer et al. (2009) reported that the test scores can be  
78 related at farm level to stockperson attitudes and behaviour towards the animals. For breeding  
79 bulls, there is still a lack of key proof of its scientific validity at an individual level as

80 described by Waiblinger et al, (2006) (i.e. relationship with other tests where animals are free  
81 to move in human presence, and other elements). Here, to address this gap, we evaluated the  
82 test-retest consistency of avoidance distance test at the feed barrier (ADF) and its convergent  
83 validity with other handling situations routinely performed in the Limousin breed selection  
84 process. Relationships between cattle reactivity and productivity have already been  
85 demonstrated in other studies, so we also assumed a negative relationship between ADF and  
86 weight and growth performances.

## 87 **2. Animals, materials and methods**

88 This observational study was performed between February and June 2018 at the Lanaud  
89 station (Boisseuil, France) for the Limousin beef breed. Every year, this national breed station  
90 evaluates about 750 candidate young bulls pre-selected early based on morphological criteria.  
91 These candidate animals come from a network of a thousand private farms across all of  
92 France and Luxembourg. Data were obtained on a subsample of 115 bulls present during the  
93 whole observation period and evaluated via routine practices already performed in the  
94 Limousin breed selection process. Our study did not specifically impose stressful situations  
95 for the animals, and so, institutional animal care and use committee approval was not required  
96 under European regulations.

97 The bulls were originally born within 83 different farms and were the products of 104  
98 different sires. Bulls entered at station at  $303 \pm 27$  days of age and  $445 \pm 48$  kg body weight.  
99 These data were in line with the mean age ( $300 \pm 22$  days of age) and body weight ( $449 \pm 43$   
100 kg) of the four last year of station controls (personal communication). They were then housed  
101 on-station a period of five months in  $5\text{m} \times 8\text{m}$  freestalls in groups of 6 to 8 animals that were  
102 never more than six days old apart. Diet was composed of 22% straw, 22% hay, 14% barley,  
103 14% triticale, 6% liquid protein nitrogen feed, and 22% nonprotein nitrogen supplement that  
104 included minerals. The average daily gain (ADG) goal was 1300 g a day. Rations were

105 distributed two times a day, at between 08:30–10:00 and between 16:30–17:30. During feed  
106 distributions, bulls were headlocked at the feed barrier for half an hour, and the stall floor was  
107 covered with straw. Straw was brought with a tractor, then scattered around by humans who  
108 used this time to check whether bulls were uninjured or ill and deliver any care needed.  
109 Visitors were regularly present in the barns, but always outside the rearing pens and never  
110 approaching close to the bulls.

### 111 *2.3. Testing procedure*

112 The testing procedure is presented here in a way that reflects the objective of this study, and  
113 not the chronology of events. The interested reader can see Figure 1 for a chart setting out the  
114 timeline chronology of the testing procedure and Table 1 for a summary of the behavioural  
115 tests performed.

#### 116 *2.3.1. Avoidance distance at the feed barrier (ADF)*

117 During the fourth month at the station, an avoidance distance test at the feed barrier was  
118 performed three times (ADF1, ADF2, ADF3), each at one-week intervals. Bulls were  $395 \pm$   
119 27 days old when the first ADF was performed (Fig.1).

120 The test procedure followed the Welfare Quality® assessment protocol for cattle (2009).  
121 ADF1, ADF2 and ADF3 were performed at between 09:00–10:00 in the morning, at least 10  
122 minutes after the feed delivery. Animals were headlocked at the feed-rack system (Confort S,  
123 Cosnet®). The feed-rack system allowed the bulls to show avoidance and make head  
124 movements but not to move away from the human (Fig. 2). A single experimenter wearing the  
125 same dark green overalls and rubber boots each time performed all three tests. She was  
126 unfamiliar to the bulls but trained to perform the ADF testing in a standard manner (regular  
127 walking manner, distance score evaluation; Welfare Quality, 2009). After waiting to see  
128 whether the tested animal looked at her, she approached it at a speed of one step per second,  
129 starting face-on from a distance of 3 m, with one arm at 45° in front of the body and the back

130 of the hand facing the bull. The experimenter stopped walking as soon as the bull showed  
131 avoidance or let itself be touched on the nose/muzzle. Avoidance was defined as stepping  
132 back or turning the head more than 45°. Avoidance distance was defined as the distance  
133 between the experimenter's hand and the bull's muzzle. The bulls were scored on the one-to-  
134 four scale as defined in the Welfare Quality® assessment protocol for cattle (Welfare Quality,  
135 2009). Bulls that were touched were scored 1, bulls that let the experimenter approach to  
136 within under 0.50 m were scored 2, bulls that let the experimenter approach to between 0.50  
137 m and 1 m were scored 3, and bulls that did not let the experimenter approach any closer than  
138 1 m were scored 4. One in every two animals was tested first, and then the remaining ones  
139 were tested. The animal was retested later if its reaction was unclear or if its neighbours  
140 showed avoidance before the tested animal reacted.

#### 141 *2.3.2. Evaluation of behaviours towards a human being during the on-farm morphological* 142 *assessment (BeF)*

143 At  $227 \pm 32$  days old (Fig. 1), within the farms the young bulls on their 'home' farms were  
144 scored under the classic national body scoring evaluation process (Idele and FGE, 2014). An  
145 unknown trained technician visually assessed and recorded their conformation, size and health  
146 of limbs, as well as their behaviour (BeF) while he/she moved around the animal. Other key  
147 parameters were collected, i.e. whether the animal was weaned, whether the test was  
148 conducted on-pasture or in-freestall, and whether the bull's dam was present. Assessments  
149 were performed within the group of bulls, and 39 purpose-trained technicians collected  
150 behavioural measures. The different behaviours and their associated scores are described in  
151 Vénot et al. (2015) and reported in Table 2.

152

#### 153 *2.3.3. Evaluation of the behaviours towards a human being during the on-station* 154 *morphological assessment (BeS)*

155 Four months after admission to the station (at  $424 \pm 27$  days old; Fig.1), the bulls were  
156 evaluated for morphology and for behaviour (BeS) following the same process as for BeF.  
157 During this second evaluation, one unfamiliar technician individually led the animal for tested  
158 to a  $10\text{m} \times 2.5\text{m}$  pen built within the freestall. A partially-opened metal fence separated this  
159 pen from the freestall where the animal's in-group peers remained visible. The test was  
160 performed without coercion on the animals, i.e. bulls were free to move while technicians  
161 performed the body scoring assessment. Three trained technicians observed each animal's  
162 behaviour and gave it a consensus score based on the most common behaviour shown  
163 according to Table 2. BeF and BeS have been routinely performed since 2011 (Vénot et al.,  
164 2015).

#### 165 *2.3.4. Docility test*

166 The station has performed a docility test (Do) as part of routine practice since 1992.  
167 The current test, which was adapted from the one developed by Le Neindre et al (1995), is  
168 used to eliminate the most dangerous animals. Here the docility test was conducted three  
169 weeks after the bulls arrived at the evaluation station (at  $323 \pm 27$  days old; Fig.1). For each  
170 test, the bull was separated from its peers and led into a  $4\text{m} \times 4\text{m}$  pen. Two solid panels  
171 formed one corner of this pen whereas the rest of the pen was made with partially-open  
172 panels. For the test, the animal was left alone in the pen for the first 10 seconds, then the  
173 technician entered and stood motionless in the centre of the pen. After 30 seconds stood  
174 motionless, the technician tried to contain the bulls for 3 seconds in the  $2\text{m} \times 2\text{m}$  corner of the  
175 pen that was formed by the solid panels opposite the peers' pen. The technician had 60  
176 seconds to try to corner the bull, and then went to the opposite corner and stood still for 30  
177 seconds. After these 30 seconds, the technician re-attempted to contain the bull in the corner.  
178 The test was then over. The bull was given two scores corresponding to the two handling  
179 phases. The scores range from 1 to 4, with half-points possible in cases of intermediate



180 reaction. The bull was scored 1 if the technician contained it in the corner, 2 if the bull never  
181 stopped slowly shuffling around, 3 if the bull never stopped quickly shuffling around, and 4 if  
182 the bull charged the technician or attempted to escape by jumping over the pen fencing. The  
183 final score is the average of the two stages. The test was performed alternately by three  
184 trained technicians unfamiliar to the bulls but experienced in handling beef cattle. The  
185 technicians performed this test for all bulls entering the evaluation station. One technician  
186 tested 6 to 8 animals before switching for another technician to take over. Tests were stopped  
187 if there was a clear risk of injury to a technician or the bull if a bull attacked or tried to  
188 violently escape from the testing area. Seven animals that scored '4' were eliminated from the  
189 controls at this step and returned to their farms, and therefore were ruled out of inclusion in  
190 the analysed dataset.

#### 191 2.4. *Growth performance*

192 Animals were weighed at the beginning (at age  $331 \pm 27$  days) and at the end (at age  
193  $421 \pm 27$  days) of the evaluation period. Average daily gain (ADG) over this period was  
194 calculated. Behavioural data was cross-compared against the key weight values for genetic  
195 selection rather than using actual weights (France Génétique Elevage, 2009). The key weights  
196 i.e. the 120-day weight and 400-day weight were calculated using the following formula.

$$197 \quad Weight = \left( \frac{(A - A2)(W2 - W1)}{A2 - A1} + W2 \right)$$

198 where  $A$  is the reference age in days (120 or 400),  $A1$  is real age at the first weighing,  
199  $A2$  is real age at the second weighing, and  $W$  is weight at the first ( $W1$ ) and the second  
200 weighing ( $W2$ ).

#### 201 2.5. *Statistical analyses*

202 Data were analysed using R software version 3.5.0 (R Core Team, 2018).

203 Wilcoxon–Mann–Whitney or Kruskal-Wallis tests were used to study the influence of dam’s  
204 presence (absence/presence), housing conditions (pasture/indoor) or weaning status on BeF  
205 and the technician identity effect on docility score. The farm or technician effects were not  
206 tested for BeF because the number of bulls evaluated per farm or by each technician was too  
207 low.

208 ADF test-retest consistency was assessed by calculating the intraclass correlation coefficient  
209 (ICC) of ordinal logistic regressions with random effects. The fixed effect was the test number  
210 (one to three) and the random effect was the animal identifier. On-station freestalled bull  
211 groups and age were also tested but showed no significant effects on ADF and were not  
212 considered in the final model. The model was run using the ‘ordinal’ package (Christensen,  
213 2019), and ICC was calculated with the ‘performance’ package (Lüdecke et al., 2020).

214 Relationships between ADF and routinely collected behavioural data were evaluated using  
215 ordinal logistic regressions with random effects run using the ordinal package. The fixed  
216 effect was test number and behavioural test (BeF, Do or BeS) and the random effect was  
217 animal identifier. We checked for normality of the residuals using a quantile–quantile plot,  
218 and we checked the homogeneity of the variance graphically (residuals vs. fitted values plot  
219 and square root of the residuals vs. fitted values plot).

220 Multiple linear regressions were performed to evaluate the relationships between performance  
221 data and mean ADF score (mADF). Age at the first ADF test was added to these regressions  
222 as a fixed effect. On-station freestalled bull groups were also tested as a random effect but had  
223 no significant effects and were not considered in the final model. Normality and homogeneity  
224 of the variance were checked graphically.

### 225 **3. Results**

#### 226 *3.1. Description of the dataset from the behavioural tests*

227 Figures 3 to 5 give the distribution for each recorded variable. All variables covered nearly  
228 the whole range of the score scales. Median ADF score was 2 (Fig. 3).

229 The behavioural scores (BeS, BeF) had similar distributions between the on-farm and on-  
230 station performance tests (Fig. 4), with immobility being the most common behaviour (Be=2).  
231 BeF ranged from 1 (i.e. slowly approaching) to 4 (i.e. walking away fast). BeS ranged from 1  
232 to 6 (i.e. a state of heightened alertness), but very few animals were scored over 4. BeF scores  
233 were unaffected by weaning status ( $W_{23,92}=1192.5$ ,  $p=0.30$ ), place of test (pasture *vs* freestall,  
234  $W_{76,39}=1395.5$ ,  $p=0.57$ ) and presence *vs* absence of the bull's dam ( $W_{35,80}=1496.5$ ,  $p=0.62$ ).

235 In the docility test, about 60% of bulls were rated 2 or less, which corresponds to animals that  
236 either let themselves be cornered in the pen or at least moved slowly during the first attempt  
237 (Fig. 5). Observed animal reactions covered the full scale: about 30% of bulls let themselves  
238 be cornered (scores 1 and 1.25) while 20% systematically showed fearful reactions during the  
239 test. Technician identity had no influence on docility score ( $K=2.204$ ,  $p=0.33$ ).

### 240 *3.2. Consistency of ADF*

241 ADF scores were unaffected by age or freestall groups ( $P>0.10$ ). ADF decreased significantly  
242 through the repetitions (table 3) but the three repeated measures were significantly related  
243 ( $P<0.001$ , table 3) and the overall ICC was 0.54. Therefore, we used the mean of the three  
244 repetitions (mADF) in order to test its relationship with the performance data.

### 245 *3.3. Consistency between ADF and other behavioural tests*

246 Table 3 reports the results of the mixed-effect ordinal logistic regressions between each  
247 routinely-collected behavioural data and ADF. ADF score was positively related to docility  
248 score ( $p=0.018$ ) and to BeS ( $p=0.0060$ ) but not to BeF ( $p=0.99$ ).

### 249 *3.4. Relationship between ADF and weight performances*

250 Table 4 reports the results of regressions between performances and mADF. mADF  
251 was slightly but significantly negatively linked to 120-day weight and 400-day weight  
252 ( $p < 0.01$ ), i.e. heavier animals have lower ADF scores. There was no significant relationship  
253 between ADG and ADF.

## 254 **Discussion**

255 Our study shows that the ADF test is discriminant among young Limousin bulls at the  
256 testing station and is moderately consistent over at least a three-week period. ADF test data  
257 also shows degrees of consistency with other data routinely collected on-station on  
258 behavioural reactions that involve human interaction with free-to-move animals. ADF test  
259 data also appears slightly but positively related to indicators of higher growth performances  
260 classically used in the genetic selection process.

261 Consistency and scientific validity are two important aspects to consider when developing a  
262 test to evaluate animal reactions to humans (Waiblinger et al., 2006). The levels of  
263 consistency are moderate in our study but similar to those observed in other studies in dairy  
264 cattle or fattening bulls (Ebinghaus et al., 2017; Windschnurer et al., 2009). This result  
265 suggests that the ADF can be fairly confidently used to characterise bulls' responses when  
266 approached by a human in a standardised manner. Individual response to the test could have  
267 been socially influenced by the neighbouring bulls (Munksgaard et al., 2001). However, as  
268 prescribed in the Welfare Quality® assessment protocol (2009), we tested every two animals  
269 in order to limit potential social influences, as test was performed in their home pens. In  
270 addition, we did not observe a freestall-group effect in our statistical models, which further  
271 confirms that we effectively evaluated individual reactivity to human approach.

272 Our results highlight that animals with lower ADF scores were also easier to handle during  
273 tests performed individually on-station (docility test and morphological assessment (BeS)).

274 The number of studies investigating the relations between several tests involving direct  
275 human presence in different contexts remain very limited. Most relevant studies in beef cattle  
276 have compared different handling situations (exit velocity score, animal reaction to restraint in  
277 a crush, etc.; see Haskell et al., 2014, for review) without clearly controlling human  
278 proximity. The relationships between avoidance distance and docility test in our study  
279 confirmed a preliminary study conducted in the same conditions with bulls just arriving at the  
280 station (Windschnurer et al., 2008b). Our findings are also in line with Windschnurer et al.  
281 (2008a) and Ebinghaus et al. (2017) who observed moderate-to-high correlations between  
282 ADF test scores and other tests involving tactile contact with free dairy cattle. This study  
283 therefore brings argument for scientific convergent validity of the ADF for evaluating beef  
284 bull response to humans.

285 Convergent validity implies convergence across independent measures that are conceptually  
286 related, in this case reactivity to humans (Waiblinger et al, 2006). The conceptual  
287 convergence between the tests performed in our study is based on the concept of flight  
288 distance, defined by Grandin (2015) as an individual surrounding area within which intrusion  
289 provokes a flight reaction. The BeS test involved technicians turning the bull around to  
290 observe it, and the docility test involved a technician attempting to approach and restrain the  
291 bull in a corner of the pen. The calmest animals during all these tests can be considered as  
292 animals that will accept human proximity in all other situations. It is also instructive to note  
293 that significant relations between tests were observed not only between ADF and BeS  
294 performed within one month before the end of the testing process but also with the docility  
295 test performed three months earlier. This result suggests consistency in bull responses to  
296 humans over the on-station bull-testing period, in line with Curley et al. (2006) who  
297 demonstrated test–retest (120-days apart) consistency in beef cattle reactivity in a handling  
298 facility.

299 Behavioural responses to humans were also collected earlier during morphological assessment  
300 at the animals' farms of origin (BeF). However, our results did not suggest a significant  
301 relationship between ADF and BeF. This could result from the diversity in environmental  
302 testing contexts (83 farms providing 115 animals) or among technicians (n=39), and thus a  
303 lack of standardisation in the environment or among technician-led processes despite regular  
304 training. However, we did find no significant influence of a number of potential  
305 environmental effects (Waiblinger et al., 2006 for review), such as weaning status (yes or no),  
306 presence of the dam near the calf during testing, or housing conditions (pasture vs indoors).  
307 This could also simply be due to the delay between the on-farm BeF tests and the following  
308 tests performed much later on-station. Whatever the reasons, the BeF performed at early age  
309 did not appear predictive of on-station ADF scores.

310 This study found slight but significant relationships between ADF test results and 120-day  
311 and 400-day liveweights. These weights at precise ages indicate the growth potential of the  
312 animal, which makes them valuable for evaluating genetic potential (Bishop, 1992; Pabst et  
313 al., 1977). To our knowledge, this is the first time these parameters have been related to  
314 animal responsiveness to humans. Our results linking weights to avoidance distance concur  
315 with another study linking the flight speed test to growth performance in 1,350 purebred and  
316 crossbreed Nellore cattle (Braga et al., 2018). This favourable relationship in term of  
317 performances could be explained by the fact that the most reactive animals lose energy by  
318 reacting more frequently to environmental stimuli, to the detriment of their growth (Llonch et  
319 al., 2016). Fearfulness of humans may also affect animals in several situations, for example,  
320 when human presence reduces animal ability to eat sufficiently (Haskell et al, 2014). As  
321 relationship with ADF was found only with key weights but not with ADG, we hypothesised  
322 that early factors before the admission of animals in station, such as genetic or initial farming

323 conditions (e.g., indoor or free-range system) had consequences on growth and reactivity to  
324 human (see Haskell et al, 2014 for review).

### 325 Limitations of this study

326 This observational study is based on correlations, with about one hundred animals coming  
327 from a large number of farms and large number of sires. On the basis of age and body weight  
328 at animals' entry in station these last four years, our sampling appears reasonably  
329 representative of Limousin bulls tested at the Lanaud station. The Lanaud station is purpose-  
330 designed for evaluating bulls in standardised conditions. The farms that provide the bulls to  
331 the station differ in herd size, housing, and human proximity from many other countries  
332 around the world. In addition, some bulls had to be eliminated (essentially due to over-  
333 aggressivity in the docility test) before the whole on-station dataset was compiled. The ADF  
334 test would be particularly interesting if it could also discriminate the most dangerous animals.  
335 A preliminary study found evidence that the ADF test performed on arrival at the station  
336 could discriminate aggressive animals (Windschnurer et al., 2008b), but this needs to be  
337 confirmed.

338 Repeating samplings over several years, testing bulls (including non-selected bulls) at the feed  
339 barrier, possibly on-farm or before performing the on-station docility test would be very  
340 useful and could also allow us to better explore environmental factors that influence beef bull  
341 reactions toward humans (Waiblinger et al., 2006). It could be also interesting to explore the  
342 variability among technicians that regularly test calves on-farm in order to confirm (or  
343 disconfirm) the absence of relationship between avoidance and BeF, and maybe also to  
344 further improve their training.

345 Finally, studies have shown heritabilities for the docility test and for behaviours collected  
346 during performance tests (Le Neindre et al., 1995; Vénot et al., 2015). A recent study found

347 significant a heritability ( $h^2 = 0.27 \pm 0.06$ ) for avoidance distance in dairy cattle (Santos, 2017)  
348 but to our knowledge no heritability has been calculated for the ADF test in beef cattle. A  
349 large-scale study is now needed to check the feasibility of fitting the ADF test to needs of  
350 real-world genetic selection that involves rapidly testing thousands of animals (Haskell et al.,  
351 2014). Without moving the animals, and with the presence of a head gate for feeding, the  
352 ADF can be done quickly and is safer for use with bulls that can sometimes prove highly  
353 reactive during handling. This study highlights the potential value of the ADF test to quickly  
354 and safely phenotype breeding bull reactivity to humans, but this can only be confirmed by  
355 testing a larger population.

## 356 **Conclusion**

357 This observational study finds that the avoidance distance test at the feed barrier shows test–  
358 retest consistency and some scientific elements of validity for evaluating the individual  
359 reactivity of Limousin breeding bulls to humans, and may even also be predictive of  
360 individual growth. However, many questions remain to be resolved before the test can be  
361 proposed for bull selection as a tool to usefully replace other tests that are less safe for  
362 stockpeople and for the animals.

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371 **Declarations of interest**

372 None

373 **References**

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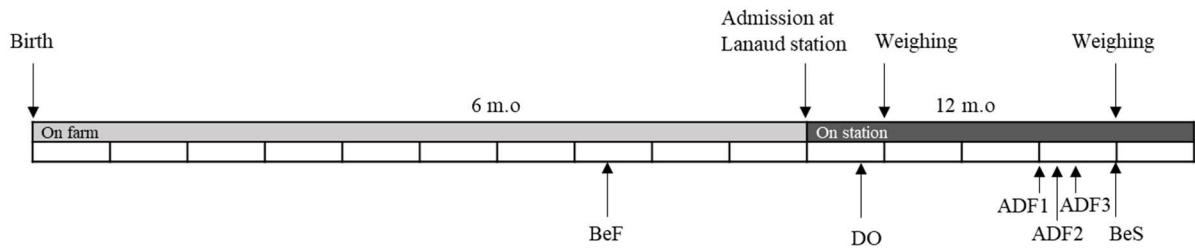


Figure 1. Chronology of the behavioural measures and weighing on animals in farm and during their presence on-station. Each square represents a month. BeF is the behaviour test at farm morphological assessment, DO is the docility test, ADF1, ADF2 and ADF3 are the three avoidance distance tests at the feed barrier, and BeS is the behaviour test at on-station morphological assessment. BeF, DO and BeS are collected routinely and ADF were added for this study.



Figure 2. Young limousin bulls at the feed-rack system ("Confort S", Cosner®).

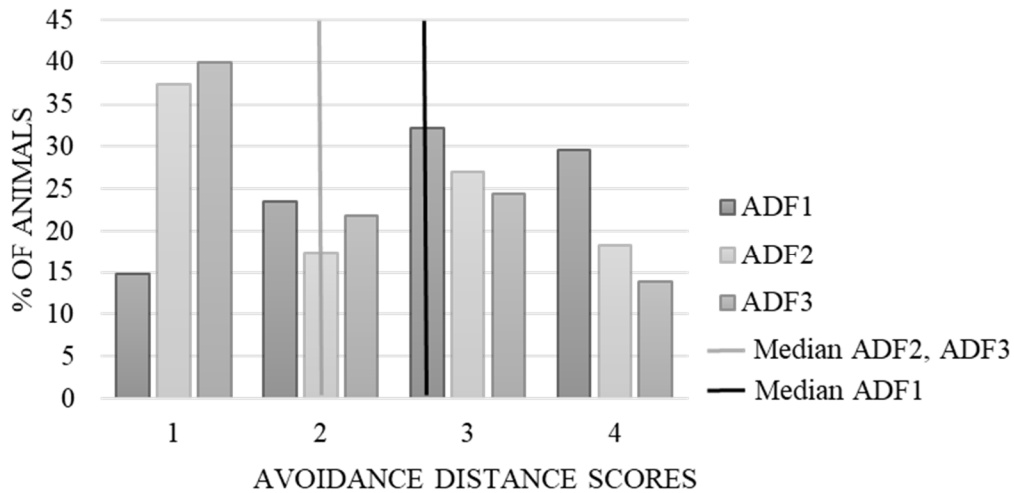


Figure 3. Distribution of the avoidance distance at the feed barrier (ADF) scores for the three repetitions (ADF1, ADF2 and ADF3).

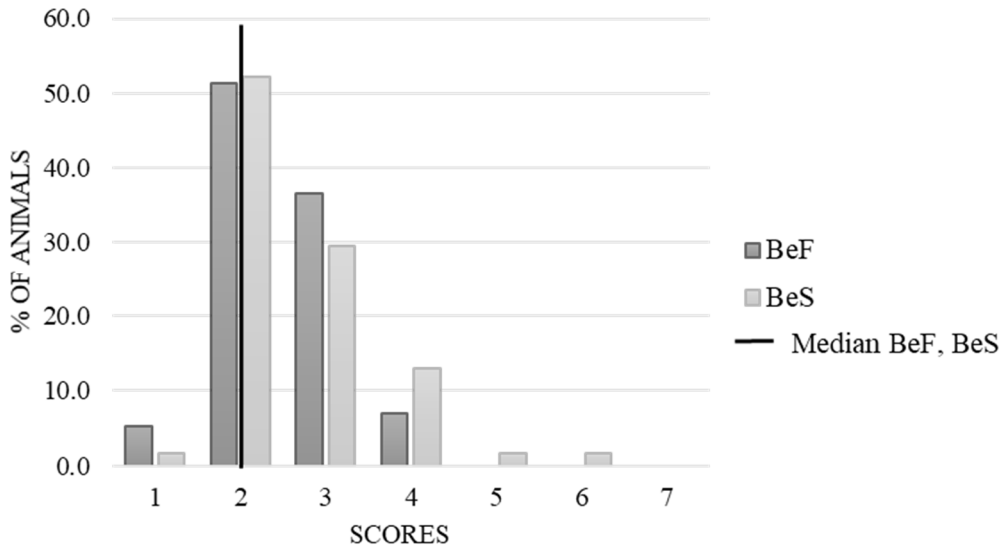


Figure 4. Distribution of the behavioural scores collected during morphological assessment on farm (BeF) and on-station (BeS)

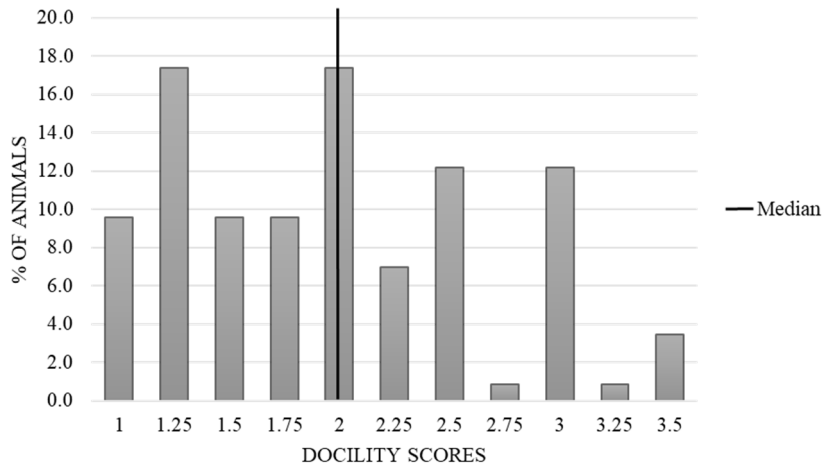


Figure 5. Distribution of the docility scores

Table 1. Summary of the behavioural tests performed routinely during the selection process of the Limousin bulls (BeF, BeS and DO) or added in this study (ADF)

Full name of the test	Initial of the test	Location of the test	Age at the test (days)	References
Behaviours towards a human being during the morphological assessment	BeF	On farm	227 ± 32	Vénot et al, 2015
	BeS	On station	424 ± 27	
Dociility test	DO	On station	323 ± 27	Adapted from Le Neindre et al, 1995; Boivin et al, 2006.
Avoidance distance at the feed-barrier	ADF	On station	395, 402 and 409 ± 27	Welfare Quality, 2009

Table 2. Scoring scale for on-farm behaviour assessment (BeF).

Score	Associated behaviour
1	Slowly approaches the technician
2	Motionless, indifferent to the experimenter
3	Walks away
4	Walks away fast
5	Runs
6	State of heightened alertness (head movements, gaze fixed on the experimenter)
7	Charges

Table 3. Results of mixed-effect ordinal logistic regressions<sup>1</sup> between avoidance distance at the feed barrier and other behavioural scores. Example of the R formula for BeF: *clmm*(ADF~ BeF + TestNumber + (1|animal))

N=115			Estimate	Threshold coefficients	P
ADF~BeF	BeF		0.00 ± 0.13	0 1 -1.33 ± 0.34 1 2 -0.49 ± 0.33 2 3 0.68 ± 0.33	0.993
	TestNumber	test 1	reference		
		test 2	-0.74 ± 0.16		<0.001 ***
		test 3	-0.94 ± 0.16		<0.001 ***
	Animal		1.17 ± 1.08		
ADF~BeS	BeS		0.42 ± 0.15	0 1 -0.64 ± 0.29 1 2 0.20 ± 0.29 2 3 1.37 ± 0.30	0.006 **
	TestNumber	test 1	reference		
		test 2	-0.74 ± 0.16		<0.001 ***
		test 3	-0.94 ± 0.16		<0.001 ***
	Animal		1.05 ± 1.02		
ADF~Do	Do		0.40 ± 0.17	0 1 -0.53 ± 0.37 1 2 0.31 ± 0.36 2 3 1.47 ± 0.37	0.018 *
	TestNumber	test 1	reference		
		test 2	-0.74 ± 0.16		<0.001 ***
		test 3	-0.94 ± 0.16		<0.001 ***
	Animal		1.07 ± 1.04		



Table 4. Relationships between growth performances and avoidance distance at the feed barrier scores. Linear model of growth performances  $\sim$  mADF + age, where mADF is the mean of the three ADF repetitions.

	<b>R<sup>2</sup></b>	<b>Model parameters</b>		<b>Estimate</b>	<b>T value</b>	<b>P value</b>
<b>ADG</b>	0.044	F <sub>2,112</sub> = 3.61 (P=0.030)	<b>Intercept</b>	746 ± 267	2.80	0.006 **
			<b>mADF</b>	11.1 ± 20.3	0.55	0.58
			<b>Age (days)</b>	1.8 ± 0.7	2.62	0.010 *
<b>120-day liveweight (kg)</b>	0.071	F <sub>2,112</sub> = 5.34 (P=0.006)	<b>Intercept</b>	268 ± 29.2	9.19	< 0.001 ***
			<b>mADF</b>	-5.9 ± 2.2	-2.66	0.010 **
			<b>Age (days)</b>	-0.1 ± 0.1	-1.85	0.068
<b>400-day liveweight (kg)</b>	0.087	F <sub>2,112</sub> = 6.42 (P=0.002)	<b>Intercept</b>	676 ± 51.1	13.26	< 0.001 ***
			<b>mADF</b>	-12.4 ± 3.9	-3.18	0.002 **
			<b>Age (days)</b>	-0.2 ± 0.1	-1.58	0.12