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*Assessment of temperament traits of white-lipped (*Tayassu pecari*) and collared peccaries (*Pecari tajacu*) during handling in a farmed environment*

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Abstract

*White-lipped (*Tayassu pecari*) and collared (*Pecari tajacu*) peccaries can be farmed as an alternative to subsistence hunting in Neotropical countries. The animals often show high reactivity to handling, usually involving capture with a net, which is a cause for concern because it poses risks to both animals' and keepers' welfare. We aimed to assess the temperament of both peccary species, evaluating animals' reactions during handling, providing an emotional indicator and a new animal selection criterion for peccary farms. Three indicators were used to assess the temperament of 17 white-lipped and 19 collared peccaries: qualitative behaviour assessment (QBA, by using 12 behavioural adjectives); time to drive each animal through a corridor into a chute (TD, s); and flight speed (FS, m s^{-1}). A Principal Components Analysis was performed for the QBA data to define a temperament index (TI). White-lipped peccaries showed TI scores associated with worse temperament traits than collared peccaries. White-lipped peccaries showed higher TD and FS means than collared peccaries. We found a correlation between TD and FS, but not between TD and TI, nor between FS and TI. The lack of correlation between all temperament indicators occurred, probably, because they measure different aspects of peccaries' reactions toward humans and the farm environment during handling. A wide phenotypic variability was found among individuals within both species' populations. The results provide an opportunity to address the role of temperament assessment, improving handling procedures and exploring the possibility of including temperament as a selection criterion in captive breeding programmes.*

Keywords: *animal welfare, domestication, handling, peccary, reactivity, wildlife farming*

Introduction

In Neotropical countries both the white-lipped (*Tayassu pecari*) and collared (*Pecari tajacu*) peccary are threatened by overhunting and habitat fragmentation (Beck *et al* 2010; Keroughilian *et al* 2013). More recently, these species have also been impacted by climate change that has led to greater variation in water levels of Amazonian rivers. This results in extreme flooding and/or dry conditions, contributing to a decline in peccary populations and, consequently, decreased sustainability in the use of these species by local indigenous people (Bodmer 2012). Both species are farmed as an alternative to subsistence/commercial hunting in Brazil (Nogueira & Nogueira-Filho 2011), Trinidad and Tobago (Garcia *et al* 2005), Mexico (Estrella *et al* 2011), and Bolivia (WR Thownsend, personal communication 2014). In Brazil, peccary farms represent 33% of the 226 commercial farms raising wild mammals that are officially recorded (Le Pendu *et al* 2011), most of them adopting confinement and semi-confinement systems (Nogueira-Filho & Nogueira 2004).

White-lipped and collared peccaries show some characteristics that are favourable to domestication, such as flexible diet and gregariousness (Nogueira-Filho & Lavorenti 1997; Sowls 1997; Nogueira-Filho *et al* 1999); however, they also tend to express aggressive behaviour during handling that is cause for concern (Sowls 1997; Nogueira *et al* 2011a). These responses provoke keepers' negative reactions and thus usually reduce the animals' welfare and increase the risk of labour accidents. A non-systematic study has addressed the peccaries' temperament, reporting white-lipped peccary as more aggressive than collared peccary (Dubost 2001). On the other hand, white-lipped peccary seem to show more favourable domestication characteristics, such as more cohesiveness, meaning that all the individuals of the same herd are always seen together whilst foraging or sleeping (Nogueira-Filho & Lavorenti 1997; Nogueira-Filho *et al* 1999), which facilitates their herding during handling procedures. White-lipped peccary also show behavioural neoteny, displaying playful behaviour until adulthood (Nogueira *et al* 2011b), which is often associated with the domestication process (Price 1984).

Figure 1

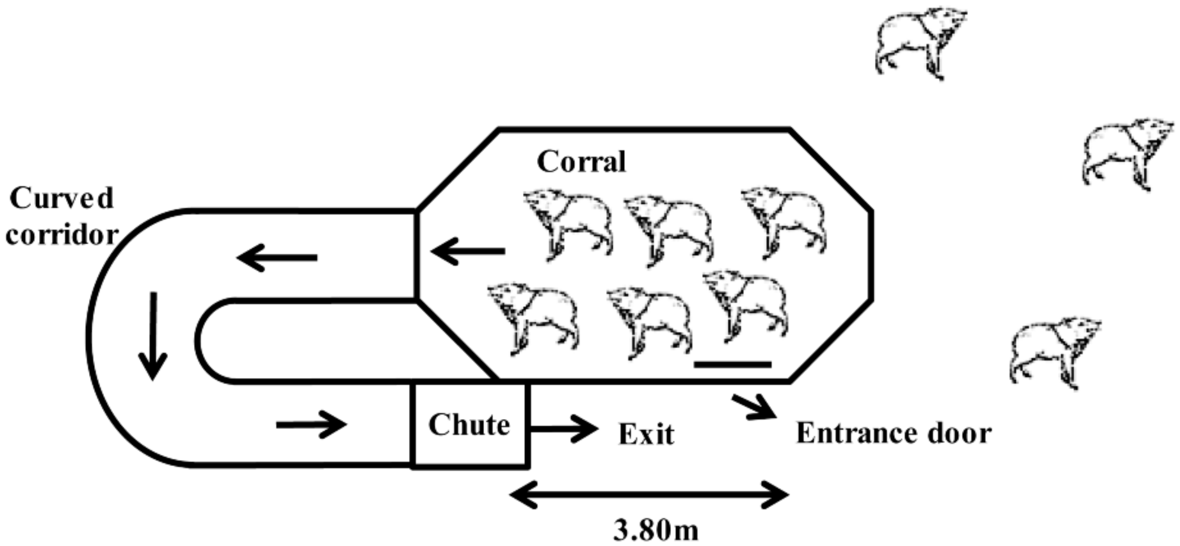

Diagram showing facilities used for white-lipped (*Tayassu pecari*) and collared (*Pecari tajacu*) peccary handling.

It is expected that stable behavioural differences will be found among individuals within the populations in the way that animals react to the environment, offering tools for selective breeding. These consistent behavioural variations are the bases of the concept of temperament, and their assessment could explain part of the peccaries' reactions towards handlers and the environment during handling procedures. Temperament for domestic farm animals has often been defined operationally as the behavioural responses of animals to being handled by humans (Burrow 1997). The identification of individuals with a desirable temperament during handling, therefore, could be a means to achieve successful captive peccary breeding by selecting individuals with lower levels of aggression and/or reactivity toward humans. Moreover, the selection of animals better adapted to the farming environment is an alternative approach to improving animals' welfare (Malmkvist & Hansen 2001).

There are several validated methods for conducting a temperament assessment; most of them focus on one or several aspects of these traits, such as fear, agitation, reactivity, and curiosity (Kilgour *et al* 2006). Among the available methods, we highlight one that uses a quantitative measure, the flight speed test, mainly described as a measure of general fear and agitation (Petherick *et al* 2002; Kilgour *et al* 2006; MacKay *et al* 2013). This test, however, may also reveal aspects of social motivation, as observed in beef cattle (Müller & von Keyserlingk 2006). Another way to evaluate temperament is measuring the time required to move an individual through any section of a handling facility, because some farm animals tend to consider the handling procedure as an aversive process, increasing the animal's fear and reducing its welfare (Pajor *et al* 2000).

Another alternative method to assess the animals' temperament is to use the qualitative behaviour assessment (QBA) method (Wemelsfelder 2001) to assess the animals' body language as an indicator of temperament. This method has already been validated to assess the welfare of several domestic species, such as pigs (*Sus scrofa*) (Wemelsfelder *et al* 2000), sheep (*Ovis aries*) (Wickham *et al* 2012), cattle (*Bos taurus*) (Rousing & Wemelsfelder 2006; Stockman *et al* 2012), horses (*Equus caballus*) (Napolitano *et al* 2008), and water buffalo (*Bubalus bubalis*) (Napolitano *et al* 2012); and recently QBA has been tested as a temperament indicator in Nellore cattle (Sant'Anna & Paranhos da Costa 2013), providing useful information on this subject. Therefore, we aimed to assess the temperament variability within and across species (see Gosling 2001), using both collared and white-lipped peccaries.

Materials and methods

This work followed the Principles of Laboratory Animal Care (NIH publication No 86-23, revised 1985) and was approved by the Committee of Ethics for Animal Use (CEUA) at the Universidade Estadual de Santa Cruz (proc #012/11).

Study animals and facilities

The study was carried out with 17 white-lipped peccary, nine males and eight females, and 19 collared peccary, ten males and nine females, at the Laboratório de Etologia Aplicada (LABET – 14º47'39.8''S, 39º10'27.7''W), Universidade Estadual de Santa Cruz (UESC), Ilhéus, Bahia state, Brazil. All individuals were born and raised in captive conditions, aged between three and eight years old, and were identified with plastic ear-tags of different shapes. White-lipped peccary individuals originated from the same herd, as did the collared peccaries; all the peccaries used in this study represent the fifth generation in captivity.

Food was delivered twice a day, at 0800 and 1600h, being composed of a mixture of ground corn, soybean meal, and

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mineral supplements, providing 120 g kg^{-1} of crude protein and 14.5 MJ kg^{-1} of digestible energy, on a dry matter basis, following the recommendations of Nogueira-Filho *et al* (2006); water was available *ad libitum*. Each species was housed in independent paddocks with an area of 600 m^2, surrounded by a wire fence, 1.5 m high, and connected to the test area by a wooden gate. The paddocks had dirt floors with the presence of high and medium-sized trees and bushes, which provided natural shade and hiding places. The test area was 380 m^2 (14.0 × 27.0 m; length × width) with a handling facility — the corral trap — of 12.0 m^2 (6.0 × 2.0 m) made from a 1.8-m high wire fence, supported by wooden poles (Figure 1). The corral trap was linked to a curved corridor (6.5 × 0.70 × 1.0 m; length × width × height) that was connected to the chute (1.8 × 0.7 × 1.0 m). The corridor and the chute sidewalls were made from the same material as the corral trap (wire fencing supported by wooden poles), and the sides and ceiling of both parts were closed by the wire fence. Each connection between test area, corral trap, curved corridor, and chute was divided by a wooden guillotine door. The corridor and the chute were previously used to restrain the experimental animals for health monitoring, weighing and occasional administration of drugs. We consider that both the corridor and the chute could cause aversion in the animals, because animals remained isolated from the rest of the herd members and trapped, providing a good opportunity to test their temperament.

Temperament assessment

The temperament assessment was performed once for each individual of both species. This strategy was adopted, taking into account previous studies that reported moderate to high repeatability for temperament traits (Petherick *et al* 2002; Curley *et al* 2006; Müller & von Keyserlingk 2006; Turner *et al* 2011). We applied all tests to all individuals in the white-lipped herd on the same day. After an interval of seven days, trying to prevent possible behavioural influences on the next assessment section, we applied all tests to all individuals of the collared peccary herd. On the day before each test, the keeper attracted all individuals from the chosen paddock to the test area by using food and vocal commands. At 0800h on the following day, three people drove all individuals to the corral trap using vocal commands and nets to guide them to begin the temperament evaluation tests, which lasted 30 min for the entire herd. The tests began when the keeper opened the gate connecting the corral trap and the curved corridor (Figure 1), using the following methods.

Time to drive each animal through the corridor into a chute (TD)

Prior to the test we prepared a random sequential order to test the individuals, avoiding the dominant/bold individuals passing through first. The keeper led the selected animal from the corral trap to the corridor using a net, and just after shutting the access gate the time to drive test (TD) began. During the TD evaluation every animal had the opportunity to pass spontaneously through the corridor, and enter the chute on its own within 20 s. If the animal had not moved through the corridor once this time had elapsed, the keeper approached the animal from behind and stimulated it to walk, using an increasing intensity of stimuli, beginning with a voice command (also for 20 s) followed by the use of a net touching the animal's back, to encourage it to go into the chute. The total time spent from the closing of the access gate until the animal entered the chute was recorded with a digital stopwatch with 1/100-s precision (Vollo, VL512, São Paulo, Brazil). This test was carried under the assumption that individuals with higher TD were less docile than those walking though the corridor spontaneously, taking more time to get into the chute.

Qualitative behaviour assessment (QBA)

Once the animal was in the chute, the gate behind was closed and the animal remained trapped for 20 s, to simulate routine handling on commercial peccary farms, where the animals are handled rapidly. During this time, the reaction of each animal was videotaped (JVC camcorder, GZ-HD500, Tokyo, Japan), and these videos were evaluated for the QBA assessment. Four observers, with practical experience of peccaries and that were not present at the peccaries' facilities during the handling procedures, performed the QBA assessment by watching the video. The observers judged the intensity of the behavioural expressions of each individual when restrained in the chute. They were instructed to mark on visual analogue scales, represented by a line of 125 mm above each of 12 adjectives: 'relaxed', 'calm', 'bored', 'apathetic', 'satisfied', 'docile', 'aggressive', 'agitated', 'alert', 'nervous', 'anxious', and 'distressed'. These descriptive terms contained the same number of positive and negative expressions and were defined according to collared and white-lipped peccaries' ethograms, described by Byers and Bekoff (1981) and Nogueira-Filho *et al* (1999), respectively, and validated by two peccary researchers and one keeper who considered these adjectives to be suitable in describing white-lipped and collared peccaries' temperament. For each adjective, the minimum value (0) represented the absence of the behavioural expression, while the maximum value (125) was its most intense manifestation. The temperament evaluation of each species was carried out during different viewing sessions to avoid cross-species comparisons at the time of assessment with the aim of reducing or avoiding observer bias regarding the behaviour of the different species (see Gosling 2001).

Flight speed (FS)

After the end of QBA data collection, the keeper opened the chute exit gate and released the peccary. The animals always ran forward, in the direction of the test area (Figure 1). An external observer recorded the time each animal took to cover a distance of 3.8 m from the chute door to a marked fence pole (Figure 1). Based on these measures (time and distance), the flight speed (m s^{-1}) was calculated. The animals remained in the test area until the end of data collection of their herd, and then they were driven back to their original paddock.

Table 1 Mean (± SD) temperament indicators of collared (n = 19) and white-lipped peccary (n = 17).

Species	Sex	N	Time to drive* (s)	Flight speed (m s^{-1})	Temperament index
Collared peccary	Male	10	23.2 (± 4.1)[a]	0.8 (± 0.7)[a]	–0.2 (± 1.0)[a]
Collared peccary	Female	9	8.9 (± 2.5)[a]	2.1 (± 0.7)[b]	–0.5 (± 0.9)[a]
White-lipped peccary	Male	9	61.1 (± 32.4)[b]	2.2 (± 1.0)[b]	0.1 (± 0.8)[b]
White-lipped peccary	Female	8	49.8 (± 22.0)[b]	2.3 (± 1.1)[b]	0.7 (± 1.0)[b]

* Original non-transformed means.
Means within columns followed by different superscripts differ at $P < 0.05$ by Tukey's test.
Temperament index — score received for each animal in the first component of the Principal Component Analysis.

Statistical analysis

We tested the agreement among the four judges for each QBA adjective using the Kendall's coefficient of concordance (W). Due to the high inter-judge reliability between the observers ($W \geq 0.72$), we performed the subsequent analyses using the means across the four observers for each descriptive adjectives.

A Principal Components Analysis (PCA) was performed for QBA data to combine the adjectives into fewer components. This method joins p variables in a data matrix to identify associations among them, and generates indexes that are the principal components (PC), describing the variation present in the data (Manly & Dias 2008). The values of each QBA term were combined in a matrix of animals (i) and adjectives (j). Using the auto vectors (or loadings) we assessed the contribution of each term to the information of the principal components. The plot of individuals in the PC1 and PC2 was used to evaluate the discrimination of both species. Since the first principal component (PC1) represented the greatest proportion of the data variation in the dataset (higher eigenvalue) we used the scores received for each animal in this factor as a temperament index (TI), following the approach described by Sant'Anna and Paranhos da Costa (2013). The individual scores were generated by the PCA, with no additional calculation.

We compared each one of the temperament indicators — TD, FS, and TI — of both species using factorial ANOVAs, followed by *post hoc* Tukey tests when appropriate. In the statistical model, we included the temperament indicators — TI, TD, and FS — as dependent variables, and sex, species and their interaction as independent variables. We performed a Pearson correlation matrix to assess the associations between all temperament indicators. All but time to drive (TD) data fulfilled parametric requirements of normality of residuals and homogeneity of variance. Therefore, we normalised the TD data using log-transformation. All results are presented as means (± SD). The software Statistica 7.0 (StatSoft, Inc 1984–2004) was used for all analysis, considering a < 0.05 significance level.

Results

Time to drive (TD)

The TD means (log-transformed) ranged from 0.9 to 1.8 s (Table 1), and white-lipped had higher TD means than collared peccary (1.7 [± 1.5] versus 1.2 [± 0.9] s, respectively, $F_{1,32} = 6.1$; $P = 0.02$). There was no difference in TD means between the sexes ($F_{1,32} = 0.2$; $P = 0.65$), and there was no significant interaction between species and sex ($F_{1,32} = 0.8$; $P = 0.38$).

Qualitative behaviour assessment (QBA)

The QBA ratings generated scores from each individual for the 12 behaviour-based adjectives (Table 2). The PC analysis revealed that the first principal component (PC1) represented 88.2% of the data variation between the peccaries, with an eigenvalue of 9.7 (Table 3). This first component (PC1) showed higher positive loadings for the adjectives relaxed (0.95), calm (0.94), and satisfied (0.93), while the higher negative loadings were for anxious (–0.97), distressed (–0.97), and nervous (–0.97) (Figure 2[a]). The score received for each animal in the PC1 ranged from: –5.6 (worst temperament traits) to 4.6 (best temperament traits) (Figure 2[b]). The second principal component (PC2) had an eigenvalue of 0.4 and explained just a small percentage of the variation (3.6%) in the data set, showing the adjective bored along with higher loadings for the PC2 (Table 3).

The ANOVA of the PC1 factor scores (temperament index; TI), as shown in a plot of the first two PC factors scores (Figure 2[b]), showed white-lipped peccary with lower TI than collared peccaries (–1.3 [± 3.0] versus 1.2 [± 2.9], respectively, $F_{1,32} = 6.4$; $P = 0.02$), despite the wide intra-specific variability among individuals within species for this trait (Table 1). This suggested that the white-lipped peccary received the lowest scores for TI and, consequently, showed a worse temperament. There was no difference in TI between sexes ($F_{1,32} = 0.3$; $P = 0.58$), and there was no significant interaction between species and sex ($F_{1,32} = 2.4$; $P = 0.13$).

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Table 2 Descriptive statistics of the behavioural-based adjectives used for the QBA of collared (n = 19) and white-lipped (n = 17) peccary. Kendall's coefficient is for inter-observer reliability.

Term	Mean (± SD)	Minumum	Maximum	SEM	*W* Kendall
Active	50.2 (± 34.4)	5.3	107.3	5.8	0.89 ($P < 0.001$)
Stressed	49.9 (± 33.1)	3.3	111.0	5.6	0.88 ($P < 0.001$)
Agitated	44.9 (± 34.1)	3.3	112.3	5.9	0.88 ($P < 0.001$)
Nervous	48.1 (± 34.2)	4.7	115.3	5.8	0.82 ($P < 0.001$)
Anxious	58.2 (± 29.4)	14.3	114.7	5.0	0.82 ($P < 0.001$)
Calm	32.5 (± 25.4)	0.0	75.3	4.0	0.81 ($P < 0.001$)
Aggressive	32.3 (± 28.3)	2.0	100.0	4.9	0.78 ($P < 0.001$)
Tense	51.6 (± 27.2)	11.3	109.3	4.8	0.77 ($P < 0.001$)
Relaxed	25.8 (± 21.8)	1.7	68.0	3.6	0.75 ($P < 0.001$)
Alert	66.6 (± 23.2)	9.3	109.7	4.0	0.74 ($P < 0.001$)
Docile	30.0 (± 20.6)	0.0	61.0	3.4	0.71 ($P < 0.001$)
Satisfied	22.0 (± 31.6)	0.0	100.0	3.4	0.62 ($P < 0.001$)
Bored	9.4 (± 15.6)	0.0	114.0	1.9	0.59 ($P < 0.01$)
Apathetic	11.3 (± 20.8)	0.0	99.0	2.2	0.52 ($P < 0.05$)
Fearful	45.2 (± 34.2)	0.0	124.0	3.4	0.31 ($P > 0.05$)

Flight speed (FS)

White-lipped showed higher FS means than collared peccary (2.2 [± 1.0] versus 1.4 [± 1.0] m s^{-1}, respectively, $F_{1,32} = 7.3$; $P = 0.01$). There was a significant interaction between species and sex in FS ($F_{1,32} = 4.5$; $P = 0.04$), and the *post hoc* test showed male collared peccary had the lowest FS means ($P_s < 0.05$; Table 1).

Comparison of temperament indicators

We found a correlation between TD and FS ($r_{34} = 0.51$; $P < 0.05$), but not between TD and TI ($r_{34} = 0.12$; $P > 0.05$), and not between FS and TI ($r_{34} = 0.11$; $P > 0.05$).

Discussion

The temperament index (TI) indicated the most distressed/anxious/nervous individuals, as well as the most relaxed/calm/satisfied ones when restrained in the chute. These results were similar to the ones obtained in studies in pigs (Wemelsfelder *et al* 2000), Holstein-Friesian dairy cows (Rousing & Wemelsfelder 2006), horses (Napolitano *et al* 2012), and Nellore beef cattle (Sant'Anna & Paranhos da Costa 2013), which revealed the first principal component ranging from relaxed/calm to nervous/agitated states.

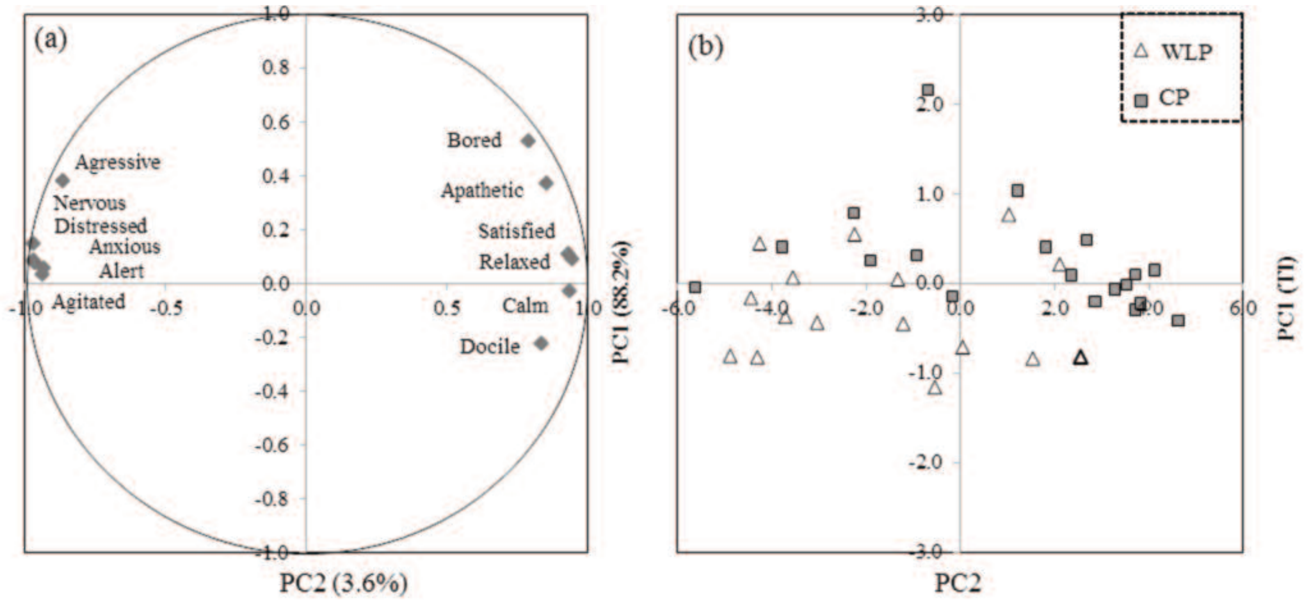
Dominance/submissive behavioural patterns regulate competition among herd members of both peccary species (Nogueira-Filho *et al* 1999; Dubost 2001). Thus, we expected that some kind of hierarchy could influence the individuals' responses during the drive test, in which a dominant or bold animal might pass through first, for instance. Therefore, as explained in the *Materials and methods*, we prepared a random sequential order to test the individuals, avoiding such hierarchical ranking bias during data collection.

Table 3 Principal Component Analysis (PCA) of the behavioural-based adjectives used for the QBA of collared (n = 19) and white-lipped (n = 17) peccaries' QBA terms.

Variables	PC1	PC2
Active	–0.94	0.02
Relaxed	0.93	–0.18
Agitated	–0.95	0.09
Calm	0.94	–0.16
Tense	–0.92	0.18
Docile	0.89	0.35
Alert	–0.94	0.09
Nervous	–0.96	–0.10
Aggressive	–0.89	–0.39
Anxious	–0.98	0.07
Stressed	–0.99	0.02
Eigenvalue	9.7	0.4
Total variance	88.2	3.6
Cumulative (%)	88.2	91.8

The worst TI was associated with white-lipped peccary, which are anecdotally reported as more aggressive than collared peccary (Sowls 1997; Nogueira-Filho *et al* 1999; Dubost 2001). The more irascible individuals are usually resistant during restraint procedures, and express negative emotions involving fear and distress (Fina *et al* 2006); such

Figure 2



Results of the Principal Component Analysis applied to QBA terms showing (a) loading plot for the behavioural-based adjectives on the first and second principal components (PC1 and PC2) and (b) scores of collared (n = 19) and white-lipped (n = 17) peccary on the PC1 and PC2, where different symbols represent the species. WLP: White-lipped peccary; CP: Collared peccary.

behavioural features are not desirable for farming purposes. The domestication process, however, involves captive animals adapting to man and the available environment (Price 1999). Thus, it was expected that farmed peccaries' behaviour would change through the time they are maintained in captivity. However, even in the fifth captive generation most white-lipped peccary were still considered distressed, anxious, and nervous during handling procedures.

White-lipped peccaries had higher average time to drive and flight speeds than collared peccary. As explained before, the time to drive test was carried out assuming that individuals taking more time to get into the chute were less docile than those walking though the corridor spontaneously. Moreover, in beef cattle, the faster an individual leaves the crush, the more frightened and nervous it is assumed to be (Burrow *et al* 1988; Petherick *et al* 2002; Turner & Lawrence 2007). Thus, in these traits, white-lipped peccaries were also seen to be more reactive and harder to handle than collared peccaries.

In contrast, collared peccary showed higher values for TI, which were associated with the relaxed, calm, and docile temperament traits. Collared peccary also showed lower time to drive and flight speed means. These results suggest that collared peccary have a more suitable temperament during handling for farming purposes than white-lipped peccary.

The lack of correlation between all temperament indicators, probably, indicates that time to drive (TD), flight speed (FS), and QBA measure different aspects of peccaries' reactions to humans during handling. Both TD and FS point out coherent reactions of peccary towards humans. The TD possibly indicates the more docile animals, whilst the FS points to the more reactive individuals. The QBA method, in turn, seemed to be useful to assess the most stressed/anxious/nervous individuals when restrained. Based on these findings and practical applicability of these methods, we propose the combined use of the three traits to assess peccaries' temperament, on-farm.

The wide intra-specific variability in the QBA, time to drive, and flight speed suggests phenotypic variations in the temperament traits within the species. In some farmed species, such as pigs and cattle, it was verified that certain temperament traits are heritable (D'Eath *et al* 2009; Sant'Anna *et al* 2013), and hence could respond to selection. A similar situation was found for the behavioural responses of mink (*Mustela vison*) to humans, which were changed by selection in less than ten generations (Malmquist & Hansen 2001). Besides genetic aspects, the environment experiences can shape an individual's temperament (Dingemanse *et al* 2009; Stamps & Groothuis 2010). Therefore, some individual's previous negative experiences in the corral trap or chute may also explain the temperament variability found in this study. Considering the wide phenotypic variability found in this study, we hypothesise that the population of both species would respond to a selective breeding programme looking for animals less reactive towards humans and the farm environment.

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Animal welfare implications and conclusion

The results provide an opportunity to address the role of temperament assessment in improving handling procedures for the welfare of peccary and other wild species involved in domestication. Furthermore, the results obtained highlight the possibility of including temperament as a selection criterion in peccary captive breeding programmes. According to all evaluated behavioural aspects, collared peccary present better temperament traits for farming proposals than white-lipped peccary.

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