

Research Article

The Impact of housing and husbandry on the personality of cheetah (*Acinonyx jubatus*)

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Abstract

This study aimed to assess the effects of husbandry regimes on the personality of zoo-housed cheetahs (*Acinonyx jubatus*). 35 individual cheetahs from 7 zoos in the UK and Ireland were rated on 25 trait adjectives and 23 observable behaviours. Data on housing and husbandry variables were also collected. Behavioural observations during the addition of a novel object (a traffic cone) were also carried out. 11 of the personality and behaviour traits were determined as reliable using Intra Class Correlation coefficients (ICC[3, k]). Principal Components Analysis (PCA) using these traits resulted in the emergence of three personality dimensions, Dominance, Sociability and Keeper-directed Sociability. Animals' scores on the Dominance dimension were significantly negatively correlated with the frequency of touching the novel object and total time spent in contact with the novel object. Generalised linear mixed models were used to assess the effect of sex, age and husbandry variables on cheetahs' scores on each of the personality dimensions. Males scored significantly higher than females on the Dominance and Sociability dimensions. Age had no significant relationship with the personality dimensions. Three of the husbandry variables had significant relationships with personality dimensions. If the keeper entered the cheetah enclosure on a daily basis animals were scored significantly lower on the Dominance dimension. If prey was in sight animals scored higher on the Sociability and Keeper-directed Sociability dimensions. The percentage of barrier fence that the public had access to had a significant relationship with Keeper-directed Sociability, however the nature of this relationship was unclear potentially due to it being a confounded variable.

Data collected during this study resulted in the identification of three personality dimensions which are comparable with previous animal personality research. The personality dimensions showed some evidence of validity in correlations with behavioural measures; however the usefulness of novel object tests in validating personality assessments should be considered in future research. The study demonstrates that there may be important relationships between housing and husbandry variables and cheetah personality. Of particular importance may be the value of Keeper Animal Relationships (KARs) which have been identified in previous studies.

Introduction

The study of individual differences in non-human animals (here on referred to as animals) whether defined as personality, temperament, behavioural syndromes, or behavioural phenotypes, has received increased attention from researchers in recent years. Gosling's (2001) review identified a range of research documenting individual differences in behaviour that could constitute personality in species ranging from cephalopods to great apes. Although there are inherent difficulties in assessing personality dimensions within a range of species (Uher 2008), certain dimensions, such as Sociability have been identified repeatedly across species (Gosling 2001), and appear to readily translate within species across multiple situations (King *et al.* 2005; Weiss *et al.* 2007).

Historically research has focused on species held in laboratory (Capitanio 2011; Coleman 2011), and domestic (Anderson *et al.* 1999) environments and research topics have covered, amongst others, methodology (e.g. Stevenson-Hinde and Zunz 1978), health (see Cavigelli 2005 for a review), productivity (e.g. Muller and von Keyserlingk 2006) and welfare (e.g. Coleman 2011).

While the benefits of zoo based personality research for conservation have been identified (Bremner-Harrison *et al.* 2004; Watters and Meehan 2007; Powell and Gartner 2010), perhaps its most valuable use of personality assessments in the zoo setting is as a tool for animal husbandry and management. A survey of the personality of black rhinoceros (*Diceros bicornis*) in USA zoos suggests that personality can be affected by enclosure features, for example in males of the species there is a positive correlation with the percentage of public access (the percentage of the outdoor enclosure perimeter that allowed the public an unobstructed view of the enclosure) and the scores on a Fearfulness personality dimension. In addition personality may impact on breeding success as male rhinos' scores on Dominant and Olfactory personality dimensions were negatively related to breeding success, whilst females breeding success was negatively related to a personality dimensions labelled Chasing / Stereotypy / Mouthing. (Carlstead *et al.* 1999; Carlstead, Fraser *et al.* 1999).

One aspect of management that consistently reoccurs in Zoos is the introduction of new animals or the formation of new groups of animals. Kuhar *et al.* (2006) suggested that personality assessment of gorillas (*Gorilla gorilla*) may assist the

Species Survival Plan (SSP) breeding programme coordinators to make informed choices about the composition of new gorilla groups, especially all-male groups. They surveyed male gorillas in the AZA population, repeating the methodology used in an earlier study (Gold and Maple 1994) and found that individuals that were housed solitarily had significantly lower scores on an Understanding personality dimension than those in heterosexual groups. It is unclear, however, whether solitary individuals are rated lower on this dimension because they are solitary or whether they are housed solitarily because of some social component predictable by the Understanding factor. The authors suggest that if the Understanding factor is predictive of males that must be solitarily housed, the GBI would be a valuable tool for assessing social competence for establishing all-male gorilla groups.

Wielebnowski (1999) surveyed 44 adult captive born cheetahs in four North American breeding facilities and identified three major personality components (Tense-fearful, Vocal-excitabile, and Aggressive). It was found that females scored higher on the Tense-fearful component than males, leading the authors to suggest that a high level of fearfulness maybe an important adaptive trait, particularly in an open habitat and where lion density is high. An analysis of the breeding success of the sample population revealed that non-breeders of both sexes scored significantly higher on the Tense-Fearful component than breeders. Wielebnowski suggests that these results may therefore also allow us to predict an individual's ability to reproduce in a captive environment; implying that animals that score more highly on the Tense-fearful may not be as adaptive to a captive environment, and may need more secluded enclosures and provision of hiding places in order to breed successfully.

In captive small felids there is a significant positive relationship between reproductive success and the time keepers spend interacting with their animals (Mellen 1991). These results suggest that animals learn to be comfortable with the inevitable presence of their human caretakers, and may therefore score less highly on the tense-fearful dimension. In effect a positive Keeper Animal Relationship (KAR) can benefit both the animal and the keeper. This has not been extensively researched in zoo animals (although see Claxton 2011), despite a growing amount of literature in domesticated animals (Carlstead 2009).

While there is a growing body of personality research occurring within the zoo world (Carlstead *et al.* 1999a, 1999b; Powell and Svoke 2008; Weiss *et al.* 2007), there is a feeling that greater knowledge of an individual animal's personality will allow us to not only to assess an animal's needs, but also to tailor situations or roles in captivity to suit an individual animal's personality (Watters and Powell 2011). In order to achieve this we need to have a greater understanding of the relationship between an animal's environment and its personality.

The aims of this study were to *i)* survey the personalities of the UK population of cheetah to see if we can identify similar behavioural components to the Wielebnowski study and *ii)* to evaluate whether there are any relationships between housing and husbandry factors and *A. jubatus* personality.

Materials and Methods

Study Design

Questionnaires were sent to 11 zoos in the UK and Ireland holding cheetah as recorded by ISIS (International Species Information System) at the end of 2002. Seven institutions returned questionnaires, a response rate of 64%, providing data on a total of 34 individual cheetahs (16 males and 18 females). Behavioural observations during novel object tests for validation purposes were conducted at 6 institutions on 29 individuals (15 males and 14 females).

Questionnaires

A questionnaire was constructed in order to evaluate cheetah per-

sonality. The questionnaire had three sections. Section 1, consisted of 25 trait adjectives with accompanying behavioural definitions, e.g. 'Cautious - Approaches novel objects/ situations with care and wariness'. Section 2, consisted of 23 observable behaviours e.g. faecal marking or sharpening claws. Raters had to rate each adjective/behaviour on a scale from 1 (does not apply to the cheetah in question) to 7 (applies strongly to the cheetah in question). The third section gathered information of the environment of the cheetahs, including details on housing and husbandry. The questionnaires were accompanied by detailed instructions for the raters to ensure they were filled out as accurately as possible.

Novel Object Tests

At the six zoos used for behavioural data collection, a novel object test was used to validate the questionnaire data; a small traffic cone was used as a novel object. After the object had been placed in the enclosure instantaneous scan sampling at one-minute intervals was carried out for 30 minutes. Latency to approach the object was recorded as was the frequency of contacts, and the total time spent in contact with the object. Due to the nature of housing and husbandry routines some individuals were tested alone while others were tested in social groups although data was collected for all individuals.

Data analysis

Inter-observer reliability

To determine the within-subject reliability the Intra Class Correlation (ICC [3,k]) scores were calculated using each individual cheetah's ratings (Shrout and Fleiss 1979). An ICC [3,k] of > 0.60 indicates good agreement between observers (Shrout and Fleiss 1979) therefore any animals that had an ICC [3,k] below this value were discarded from further analysis. To determine across-subject reliability the data for 32 animals at six zoos that were rated by more than one observer were used to calculate ICC coefficients for each trait. An average ICC value for each trait was then calculated and any trait that had a mean value below 0.60 was removed from further analysis.

Principal Components Analysis

All the reliable traits were entered into an Exploratory Principal Components Analysis (PCA) using the statistical computer programme SPSS vs. 17. Oblique (direct Oblimin) rotation was used as this is an exploratory analysis and there is reason to believe that factors may be correlated. The Eigenvalues above one, interpretation of the scree plot and parallel analysis were used to establish the number of components that should be retained (O'Connor 2002). The pattern matrix output was used for interpretation of component loadings.

Validity analysis

A score for each animal on each of the personality dimensions from the PCA analysis was calculated by averaging their scores on each of the individual traits that had salient (>0.40) loadings on a particular dimension (for negatively loaded traits a reverse score was calculated by taking the original score from 8). If a trait had salient loadings on more than one dimension then it was assigned to the dimension on which it had the higher loading. Pearson product-moment correlations were then used to examine the relationship between personality dimensions and the behaviour measures recorded during the novel object test.

Relationship between personality and environmental variables

The effects of housing and husbandry on the personality factors were analysed with Generalised Linear Mixed Models using SPSS 19 statistical software (SPSS 2010, IBM, Chicago, IL, U.S.A.). All factors were run on a normal distribution (residuals were tested for normality and no significant differences were found). Fixed factors included age, gender, percentage of the enclosure barrier that is solid (solid barrier), percentage of the barrier that the public have access

to (public perimeter), whether a prey species was in sight of the cheetahs and whether the keepers enter the enclosure with the animals daily (keeper enters daily).

The model was fitted using a backwards stepwise process to find the minimum adequate model for explaining the variance observed in the response variable (Bolker *et al.* 2009). Only significant explanatory variables were retained and the models with the lowest Akaike's Information Criterion were interpreted. All tests are two-tailed. For appropriate significant results post-hoc pairwise comparisons with Bonferroni corrections were carried out.

Results

Inter-observer reliability

ICC values for each individual animal ranged from 0.63 to 0.98 (Table 1). No animal had an ICC value below 0.60 therefore all animals' data was used in further analysis. ICC values for each trait that met the mean >0.60 threshold are presented in Table 2. 11 traits were found to reach the criterion. While the reliability analysis could only be done using the data from six zoos (32 animals) due to the sampling constraints, if the traits were found to be reliable they were assumed to be reliable across all seven zoos, so that all the personality data could be entered into the PCA analysis.

Zoo	Number of raters	Sex	Age (years)	ICC [3,k]
Fota Wildlife Park, Ireland	2	Female	11.6	.94
		Female	9.8	.92
		Female	2.4	.81
		Female	5.8	.93
		Male	9.8	.98
		Male	2.4	.90
		Male	1.1	.93
		Male	5.8	.94
		Male	4.0	.94
		Male	5.8	.98
Marwell Wildlife, UK	2	Male	12.9	.82
		Female	3.8	.72
		Female	10.9	.86
Paignton Zoo Environmental Park, UK	2	Male	4.3	.83
		Male	4.3	.93
		Female	3.8	.89
		Female	3.8	.65
Colchester Zoo, UK	2	Female	7.8	.95
		Female	1.8	.92
		Male	1.8	.92
		Male	1.8	.94
		Male	1.8	.92
Belfast Zoological Gardens, UK	1	Male	4.9	-
		Female	1.5	-
		Female	1.5	-
Hamerton Zoo Park, UK	2	Male	3.5	.82
		Female	4.8	.63
		Male	6.2	.65
		Female	6.8	.68
		Male	1.7	.68
Whipsnade Zoo, UK	2	Female	11.0	.96
		Female	13.3	.97
		Female	10.6	.94

Table 1. Summary of study animals and within subject reliability ICC [3,k] .

Principal Components Analysis

The 11 reliable traits were entered into an exploratory Principal Components Analysis (PCA). Based on the component retention criteria three factors were retained which accounted for 63.12% of the variance (Table 3). Based on the individual items that loaded onto each component (from now on referred to as personality dimensions) they were labelled, Dominance, Sociability and Keeper-directed Sociability (traits loading on this last dimension refer only to the cheetah's interactions with keepers).

Trait	Institution*						Mean
	I	II	III	IV	V	VI	
Friendly to you	.95	.82	.99	.94	.99	.67	.90
Aggressive to you	.84	.86	.85	.00	.93	.75	.71
Assertive	.93	.89	.76	.30	.93	.89	.78
Dominant to conspecifics	.98	.94	.38	.89	.84	.97	.83
Playful	.98	.86	.86	.59	.84	.86	.83
Timid/shy	.98	.63	.00	.40	.80	.99	.63
Head rubbing	.93	.86	.87	.59	.49	.99	.79
Close follow	.98	.86	.57	.00	.75	.99	.69
Contact aggression	.95	.86	.57	.00	.76	.92	.68
Chirp-fear	.78	.67	-.25	.87	.80	.77	.61
Stutter	.85	.99	.73	.36	.00	.98	.65

*Institutions: I=Fota; II=Marwell; III=Colchester; IV=Paignton; V=Hamerton; VI=Whipsnade

Table 2. Intra-Class Correlation Coefficients ICC[3,k] for all traits with a mean ICC >0.60.

Trait	Dominance	Sociability	Keeper-directed Sociability
% Variance explained	30.80	18.03	14.32
Contact aggression	.89	.16	-.08
Assertive	.74	.44	.07
Dominant to conspecifics	.69	.23	.06
Chirp-fear	.66	-.12	-.02
Stutter	.63	.01	.01
Head rub	.03	.86	.05
Timid/shy	-.13	-.79	.22
Playful	.60	.60	.04
Close follow	.16	.53	.15
Stutter bark	.41	.51	-.19
Aggressive to you	.11	.11	-.91
Friendly to you	.02	.01	.90

Table 3. Results of the principle components analysis. Salient loadings >0.4 are in bold.

Validity Analysis

Dominance personality scores were negatively correlated with the frequency of contacts ($r = -0.537$, $n = 29$, $p < 0.01$) and total time in contact with the novel object ($r = -0.64$, $n = 29$, $p < 0.01$). Sociability and Keeper-directed Sociability scores were not significantly correlated with any of the behavioural measures.

Sex, Age, Housing and Husbandry Analysis

Dominance

There was a significant effect of gender on Dominance score (Wald's $\chi^2 = 5.41$, $df = 1$, $p = 0.02$), with males scoring more highly than females (means: males= 3.59, females = 2.88). There was a significant effect of whether the keepers enter daily (Wald's $\chi^2 = 12.35$, $df = 1$, $p < 0.01$), with individuals where the keeper does not enter daily scoring more highly than individuals where the keeper does enter daily (means: keeper does not enter daily = 3.82, keeper enters daily = 2.64). There was also a significant effect of whether prey was in sight (Wald's $\chi^2 = 18.99$, $df = 1$, $p < 0.01$), with individuals where prey is in sight scoring more highly than individuals where prey is not in sight (means: prey in sight = 4.02, prey not in sight = 2.44).

Sociability

There was a significant effect of gender on sociability (Wald's $\chi^2 = 7.89$, $df = 1$, $p = 0.01$), with males scoring more highly than females (means: males = 3.99, females = 3.03).

Keeper-directed Sociability

There was a significant effect of whether prey was in sight on keeper-directed sociability (Wald's $\chi^2 = 10.47$, $df = 1$, $p = 0.01$), with individuals where prey is in sight scoring more highly than those where

prey is not in sight (means: prey in sight = 3.55, prey not in sight = 1.93). There was also a significant effect of the amount of perimeter that the public had access to (Wald's $\chi^2 = 47.14$, $df = 6$, $p < 0.01$). However pairwise post-hoc tests did not reveal any easily describable relationships between percentage of perimeter and keeper-directed Sociability.

Discussion

The results suggest that keepers can reliably assess individual cheetahs on a range of personality and behaviour traits. Using these ratings three personality dimensions were identified within the surveyed population of cheetah, Dominance, Sociability and Keeper-directed Sociability. One of these dimensions, Dominance, demonstrated good construct validity as individual dimension scores had significant correlations with behavioural measures recorded during novel object tests.

Structure of personality dimensions

Dominance was the strongest personality dimension to emerge from the PCA analysis accounting for 31 % of the variance in the data. Animals rating highly on this dimension scored higher on the individual behavioural traits contact aggression, assertive, dominant to con-specifics, chirp-fear and stutter. Analogous personality dimensions have been found in a wide range of animals including for example the Dominance dimension in chimpanzees (*Pan troglodytes*) (King and Figueredo 1997), and the Assertiveness dimension in hyenas (*Crocuta crocuta*) (Gosling 1998). The Dominance dimension in the current study is not directly comparable with any one dimension in the Wielebnowski (1999) study however it most closely resembles the Aggressive dimension as it contains traits relating to aggressiveness. One of the potential reasons for not finding dimensions directly comparable with the Wielebnowski study is the trait list that was used. The trait list in the current study was generated using an eclectic approach (Uher 2008), this involved first using the Wielebnowski trait list as a starting point for trait generation but traits were added based on other animal personality research and the behavioural repertoire of cheetah. Therefore a greater range of traits was used; 48 traits in the current study compared to 18 in the Wielebnowski study. This finding stresses the importance of the trait lists that are used for personality studies, a topic which has been highlighted in primate research. When a trait list designed for rhesus macaques (*Macaca mulatta*) (Stevenson-Hinde and Zunz 1978) trait list was used to assess personality in *P. troglodytes* three personality dimensions emerged (Murray 1998), however in the same species when using a trait list derived from that of the human Five Factor Model (FFM), six personality dimensions emerged (King and Figueredo 1997). Uher and Asendorpf (2008) suggest that empirical differences were not caused by species personality differences but by the personality dimensions that were covered by the list of trait adjectives. The current study demonstrates that trait list generation is also an important factor when interpreting results from felid personality research.

Animals rating highly on Sociability scored higher on the individual behavioural traits head rub, playful, close follow, stutter bark, and lower on the trait timid/shy. Of the three dimensions identified in the Wielebnowski (1999) study the Sociability dimension in the current study most closely resembles the Vocal-excitable dimension which has high positive loadings on variables such as playful and active. Sociability is one of the most commonly assessed personality dimensions in animal personality research and has been found across a wide range of taxa, including felid species (Freeman and Gosling 2010; Gosling 2001). Therefore we would expect to find a sociability type dimension in cheetah.

Animals rating highly on Keeper-directed Sociability scored higher on the individual trait friendly to you and lower on the individual trait aggressive to you. There are very few published studies that

have included keeper-directed traits in animal personality research however a human-directed Agreeableness factor has been found in spotted hyenas (*C. crocuta*) (Gosling 1998); and a Friendly to keeper dimension was found in zoo housed black rhino (*D. bicornis*) (Carlstead *et al.* 1999a). In the Wielebnowski (1999) study the trait Aggressive to people trait loaded highly on an Aggressive personality dimension in zoo-housed cheetahs (*A. jubatus*) (Wielebnowski 1999). Gosling (1998) suggests that, in the case of hyenas (*C. crocuta*), the presence of a human-directed Agreeableness dimension may be "manifestations of individual differences in the more general domain of social sensitivity" (p. 113), as hyena exhibit complex social relationships. We may therefore expect to find similar dimensions in other carnivore species that exhibit any kind of social relationships. In addition this dimension has a plausible connection with the Keeper Animal Relationship (KAR) (Claxton 2011) which can be extremely important in the management of captive carnivores (Mellen 1991). The current study did not include any analyses of KARs but this may be an important area of future research.

Validity of identified personality dimensions

Of the three personality dimensions revealed in this study Dominance was the only one to show significant correlations with any of the behavioural measures recorded during novel object tests. Animals scoring highly on the Dominance dimension had fewer bouts of contact with the novel object and spent less overall time in contact with the object than animals scoring lower on this dimension. We might expect that animals rating highly on this dimension would spend more time inspecting novel objects due to their high rating on the individual trait assertive, i.e. they may be more inclined than their low Dominance counterparts to investigate novel, potentially threatening, stimuli. The choice of novel object in the current study may be an important factor when interpreting this result further, a traffic cone, while novel, may not be particularly threatening therefore Dominant animals may be more inclined to ignore this object when it is presented to them. Carter *et al.* (2012) assessed Boldness in wild chacma baboons (*Papio ursinas*) using response to two different objects; a model puff adder (*Bitis arietans arietans*), and a novel food item. They found that animals' behavioural responses to the two different objects did not correlate across the two contexts and that responses were potentially indicative of anxiety rather than Boldness. This study highlights the importance of choosing novel objects which are relevant to the particular dimension of interest, potentially future studies should first explore the personality dimensions and then design behavioural tests for validation purposes.

The effect of housing and husbandry on personality traits

Housing and husbandry routines had a significant impact on two of the identified personality dimensions, Dominance and Keeper-directed Sociability. Dominance scores were significantly lower if keepers entered the enclosure with the cheetahs on a daily basis. In comparison Wielebnowski (1999) found that it was the Tense/Fearful dimension that was significantly affected by the keepers entering the enclosure, with animals being less Tense/Fearful when entering the enclosure with the animal was part of the day to day husbandry routine. Although a Tense/Fearful dimension was not identified in this research, it is reasonable to assume that cheetahs housed where the keepers enter the enclosure score less on the Dominance dimension because they are less fearful of the keepers. Freeman and Gosling's (2010) review of studies in primate personality found that Dominance related traits were classified under Fearfulness, Dominance or Independence dimensions by various authors, and that Fearfulness and Dominance frequently overlapped. Within this research, aggressive behaviours loaded on the Dominance dimension but it has been well documented in several species that fearful animals may respond in an aggressive manner (e.g. dogs, King *et al.* 2003). Animals (particularly small felids) which develop a positive relationship with their keepers and show a less fearful response will often demonstrate improved responses to envi-

ronmental change in the enclosure and increased breeding success (Mellen 1991).

It should be noted that keeper perceptions of animals may be an important factor when interpreting the above results. It is reasonable to assume that whether keepers enter the enclosure daily is dictated by traditional husbandry routines at individual zoos rather than because keepers believe that individual cheetahs are more or less Dominant. Certainly there were no replies to the questionnaire suggesting that keepers would choose to enter with some cheetahs over others based on the Dominance behaviour of the individual animal. This may mean that because the keepers enter the enclosure daily they perceive their animals in a different way to keepers that do not carry out this management practice. In the current study we do not believe that keeper perceptions of animals is affecting the results as if this was the case we would expect to see similar relationships with other personality dimensions, especially the Keeper-directed Sociability dimension.

Dominance and Keeper-directed Sociability scores were both also significantly affected by the housing of a prey species in sight of the cheetahs. Individuals that could see prey species scored more highly on both these dimensions. There is very little published data on the behavioural impact of housing a prey species in view of a predator and there is no immediately obvious reason why these relationships should occur. In the case of Dominance potentially there may be increased levels of frustration through not being able to perform a natural behaviour for which there is a high motivation (Dawkins 1988) i.e. viewing a prey species but not being able to hunt, and it may be reasonable to suggest that higher levels of Dominance behaviours may result from the frustration of not being able to get to a potential prey item. In the case of Keeper-directed Sociability cheetahs may associate keepers with food so watching a prey species may promote excitability towards the keepers. Potentially it could be a misinterpretation of behaviour on the keepers' part. The cheetah may be generally more excitable when housed within sight of the prey species, the keepers may only be aware of this from observing their behaviour as they approach the enclosure. Certainly it has been documented that housing felid species in view of potential prey species can increase levels of activity, more often stalking behaviour (Lyons *et al.* 1997).

Although there is an effect of the percentage of the perimeter fence on the level of Keeper-directed Sociability, there is not a clear relationship. Percentage of the perimeter fence that public have access to is potentially a confounded variable as it shows a correlation with other variables such as enclosure size. It is therefore not possible from these data to explore this relationship further.

The effect of age and gender

There was no significant effect of age on any personality dimensions. This contrasts to previous research with other felid species (e.g. snow leopards, *Uncia uncia*, Gartner and Powell 2011), however does agree with results from the U.S. cheetah population (Wielebnowski 1999). This non-significance in the current research may be due to the small sample size so further study would need to be done to confirm this finding.

There were significant effects of gender on the Dominance and Sociability dimensions. In both cases males score more highly on the dimensions than the females. This indicates that males are both more dominant and more sociable than females. Male cheetahs are known to only associate with females during oestrous where they will monopolise them to prevent multiple matings (Gotelli *et al.* 2007). Additionally cheetahs are known to be unusual amongst big cats due to the existence of permanent male coalitions coupled with the defence of small portions of a female's home range (Gotelli *et al.* 2007). It is therefore reasonable to assume that male cheetahs would score more highly on both the Dominance and Sociability dimensions than females.

However it must be noted that within our relatively small sample size different zoos implement different social housing conditions, for

example during the time of data collection Fota Wildlife Park held ten animals, six of which were male and housed together, four of which were female and were rotated individually on exhibit for breeding purposes. Inherently this means that the males within our test sample would have been housed in a situation that would encourage sociability to a greater extent than the housing of the females.

Implications for management

One of the main issues facing cheetah management in captivity is the lack of breeding success. While we have not looked specifically at this due to the small sample size of successful breeding groups within the data set, our results could be used as a starting point for future management recommendations. For example our results suggest that building a relationship with your animals can reduce Dominance personality scores and therefore associated behaviours, but housing them in sight of prey can increase Dominance personality scores. However further research on the effect of Dominance personality scores on breeding success is needed before firm recommendations can be made.

One other important recommendation from the current research is the development of a trait list that is tested for reliability and validity across a range of felid species would be beneficial. This could consist of a short list of core personality traits (that are established to be reliable and valid), so cross-study and cross-species comparisons can be made, and an additional list of species-specific traits if they are needed by the researcher.

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