Are cats less stressed in homes than in shelters? A study of personality and faecal cortisol metabolites

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ABSTRACT

Personality is defined by characteristics of individuals and describes and accounts for temporally stable patterns of affect, cognition and behaviour traits. The study of cat behaviour and personality can minimize potential problems in the relationship between cats and their owners and decrease abandonment and maltreatment. People generally adopt animals according to the individual's appearance, age or sex. Personality assessments can help make adoptions successful by identifying ideal subjects for potential owners. A personality assessment called "Meet Your Match®" (MYM), developed by the American Society for the Prevention of Cruelty to Animals (ASPCA) and validated for our cat sample was used in this study. To evaluate stress, we measured faecal cortisol metabolites (FCMs) of cats in shelters and after adoption. In an effort to improve adoption and cat adaptation in new homes, our goals were 1) to evaluate the relationship between personality and cortisol levels; 2) to confirm if MYM assessment is consistent through situations; and 3) to investigate how moving from the shelter to the owners' homes affects FCM levels. The subjects for our first goal were 53 sheltered cats. For the second and the third goals, we followed 15 of the original 53 after the adoption. No correlation was found between personality dimensions (agreeableness p = 0.878; openness p = 0.141; extraversion p = 0.942) and FCM levels. MYM assessment was consistent through different localities. There was a slight, but significant (p = 0.0072), decrease of FCM levels at owners' home. However, most subjects (n = 11) did not present changes that were significantly different from zero. Our study underlined the usefulness of the MYM personality assessment and confirmed a lack of correlation between personality and cortisol levels in cats. It is a further step towards incorporating a more objective approach to the adoption process in shelters to improve the pairing of humans and cats.

1. Introduction

Personality research ranges from invertebrates (Carere et al., 2018) to primates (Freeman and Gosling, 2010). Definitions of personality point to those characteristics of individuals that describe and account for temporally stable patterns of affection, cognition, and behaviour (Siegford et al., 2003; Gosling, 2008; Uher, 2011; Gartner and Weiss, 2013; MacKay and Haskell, 2015). Research in animal personality joined efforts to unravel the dimensions that compose each species' personality traits. Human personality, for example, is composed of five dimensions as shown in the Five Factor Model (John and Srivastava, 1999). Being the most popular pets in households, dogs and cats are also being studied (Jones and Gosling, 2005; Gartner and Weiss, 2013). Most studies are based on surveys with caretakers and focus on personality measurements, genetics and the relationship between personality and its health effects in captive and confined individuals (Gartner, 2015). Recent studies have investigated cat personality dimensions (Gartner and Weiss, 2013; Gartner et al., 2014; Kaleta et al., 2016; Bennett et al., 2017; Ha and Ha, 2017; Litchfield et al., 2017) and, so far, have unfolded a number of them, such as affection, energy, sociability and curiosity (Gartner, 2015).

As complex and intricate as human–animal interactions can be (Bradshaw, 2013), potential issues in the relationship between cats and their owners — such as abandonment or mistreatment (Genaro, 2004) — can be mitigated with the aid of knowledge obtained from studies about cat behaviour and personality, the monitoring of cat populations, and educational actions (Hiby et al., 2014). Unsuccessful adoptions are a multi-causal event and are related to: aggression between cats in

multi-cat households (Ellis et al., 2013; Denenberg, 2015), unacceptable elimination (Heath, 2019), unmet owners' expectations, and allergies or changes in the owners' circumstances (e.g., moving) (Siegford et al., 2003; Shore, 2005; Casey et al., 2009). Regardless of the cause, most unwanted cats go back to shelters (70 % of cats that entered a North American shelter were relinquished by their owners (Kass et al., 2001)), which already receive a large number of stray animals (Marston and Bennett, 2009; Clark et al., 2012). In this scenario, it is safe to affirm that failed adoptions contribute to overpopulation in shelters, directly affecting the welfare of the animals cared for in these institutions (Shore, 2010). People generally adopt or buy pets according to their appearance, age or sex. Relying solely on physical attributes is a result of both the strong emotional component of the decision to have a pet and the lack of a systematic approach to cat personality (Fantuzzi et al., 2010). A program of personality assessments was developed by the American Society for the Prevention of Cruelty to Animals (ASPCA). It is called "Meet Your Match®" (MYM; ASPCA, 2007) and consists of cat personality assessments and interviews with potential owners to enable an adequate match, increasing the adoption rate and decreasing the return of adopted animals (Zeigler-Hill and Highfill, 2010; Moore and Bain, 2013). An exploratory factor analysis was conducted in a modified MYM assessment in a Brazilian shelter sample (Fukimoto et al., 2019) and, unlike the original version (with two dimensions, namely valiance and independent-gregarious), three dimensions were found: agreeableness, openness and extraversion. Efforts have been made towards promoting the implementation of personality assessments that would be beneficial for all parties involved in the process — namely the adopter, the shelter and the cat — as they would identify ideal subjects for potential owners (Gosling, 2008). Experience has proven that, in general, owners present a more positive attitude toward their animals when their behavioural styles complement their own personal styles (Zeigler-Hill and Highfill, 2010; Litchfield et al., 2017).

For some species, personality traits were found to be related to hypothalamic-pituitary-adrenal activity and stress (Capitanio, 2004; Gartner, 2015). "Stress implies exposure to unpleasant conditions with adverse effects" (Broom and Johnson, 1993) and is a physiological response to adverse situations (Möstl and Palme, 2002). Stress responses are adaptive and, therefore, the primary function of stress hormones (e.g. cortisol in cats) is to provide energy mobilization to the individual. But chronic stress may have negative consequences such as tissue atrophy, low immunity and stereotypies (Möstl and Palme, 2002). One way to evaluate stress levels in animals is through the measurement of glucocorticoids. Cortisol can be measured in blood, saliva, hair, urine and faeces (Palme, 2012, 2019). As blood collection can induce stress in the individual, non-invasive methods are preferred (Möstl and Palme, 2002; Young et al., 2004; Rehnberg et al., 2015). The most practical and appropriate matrix in cats would be faeces because it contains more than 80 % of the excreted cortisol metabolites, can be obtained without manipulating the animal and is a rigorously validated method for measuring faecal cortisol metabolites (FCMs) exists (Schatz and Palme, 2001). In cats, three studies investigated the correlation between personality and cortisol levels. One collected invasive blood samples in laboratory cats and assessed personality by applying a Feline Temperament Profile (FTP) (Iki et al., 2011); the other used FCMs and owners' classification of their cats' personalities (Ramos et al., 2013) and the last one used salivary cortisol and an assessment applied by an experimenter (Siegford et al., 2003). None of them found correlations between personality and cortisol levels.

In an effort to improve adoptions, facilitate the adaptation of cats in new homes, and expand the knowledge about physiological levels of stress and their relation to personality dimensions, the objectives of the study were: a) to evaluate the relationship between the personality dimensions measured by the modified MYM assessment and stress; b) to confirm if the modified MYM assessment is consistent through localities (shelter vs. owner's home); and c) to evaluate if cats are more stressed in the shelter or in the owner's home. In case a correlation exists between personality dimensions and stress, there will be an additional objective: to examine if cats with different personalities respond physiologically differently to the move to the owner's home. Our hypotheses are: I) there is no correlation between personality dimensions and FCMs, which corroborates the literature (Siegford et al., 2003; Ramos et al., 2013); II) scores of MYM assessment are similar in the shelter and in the owner's home (as personality is defined as stable and consistent through time and situations, we expect the results will be maintained); III) there will be a decrease in FCM levels in the owner's home (since shelters are more stressful environments than households (van den Bos, 1998; Tanaka et al., 2012; Finka et al., 2014)).

2. Method

2.1. Subjects

Subjects were 53 domestic cats (supplementary material), all from Catland, a cat-exclusive shelter in São Paulo, Brazil. The shelter is a 116 m² house with safety nets in all windows. The average occupancy of the shelter is 120 cats (0.96 cats/m²), who are unrestrained at all times (solitary cages are used only when a cat needs to be isolated for health conditions), having access to five indoor areas and one outdoor space. Three indoor areas provide physical enrichment (cat trees, shelves, couches, boxes and different types of beds), bowls of food (5 per room) and water (10 per room) available *ad libitum*. Two indoor areas are smaller and have only litter boxes (7 in each). The outdoor space has different types of beds on sunny spots, 10 litter boxes in one end, and 20 bowls of food and 15 of water in the other end. Also fundamental for the well-being of the animals is the constant presence of trained volunteers who are responsible for cleaning the house, offer food and also provide opportunities for affectionate interaction for cats that demand it. Investigated cats were about 5 months to 12 years of age, 29 female and 24 male, all neutered, and all rescued from the streets or relinquished. The MYM protocol states that an evaluation can be made 18 h after the cat's admission to the shelter. As our subjects were exposed to a multi-cat environment that could offer extra challenges in the beginning, we waited at least one week after admission before proceeding to the evaluation. Cats younger than 5 months were not included because personality is not fully formed until the end of the third month of life (Lowe and Bradshaw, 2001). Individuals were submitted to the MYM assessment twice: once after at least one week in the shelter and once as soon as we were able to visit them, one to three months after the adoption (ASPCA, 2007). As the MYM protocol is based on a single application of the assessment, our hypothesis was that the result would be the same over time and wanted to verify if a more relaxed environment (the owner's home) would influence the cat's response in a way that would alter the test results. The same person (NF) performed the modified MYM assessment at both times for all individuals.

The adoption was conducted by the shelter and, during this process, adopters were informed that the cats were participating in a research study and asked if the researcher could contact them. When consent was granted, the researcher opened a communication channel explaining the purpose of the research and instructing owners on how to collect faecal samples (more details in sub item 2.3). The researcher also asked owners to report the day and time of any unusual activity (e.g. visit to the veterinary clinic; baths; use of vacuum cleaner or any loud equipment; addition, exchange or move of furniture) in their home. Our sample included only single-cat or multi-cat households of 2 cats. 45 of the sampled cats were adopted, 20 of these went to houses that already had two cats (composing a multi-cat households of 3 cats) and were, therefore, excluded from our sample. From the remaining 25 subjects, 15 owners agreed to participate in the study and signed the informed consent form.

Table 1

Summary of the feline personality assessment in the *Meet your Match®* program: each item that should be observed by the researcher; actions that the researcher should engage in and adaptations we had to make in the assessment; list of the behaviours the cat could present in response to each of the researcher' action; and the score given to each behaviour.

Items	Researcher	Listed possible behaviours	Scores
1. Body posture	Observation of the cat's posture when in it's cage	- Soft and relaxed	+1
		- Tense body with twitching tail	+1
		- Flattened body with dilated pupils	−1
	Adaptation: observation of the cat's posture when standing in the shelter		
2. Greeting approach	Observation of the cat's response when the researcher came at the front of the cage	- The cat comes at the front of the cage, soliciting attention by rubbing, chirping, etc	+3
	Adaptation: observation of the cat's response when the researcher came towards and stands in front of him	- Comes to the front of cage after the researcher's encourage	+2
		- Does not approach but meows, chirps or blinks	+1
		- Does not approach	0
		- Attempts to hide	−1
		- Hisses or growls	−2
		- Charges	−3
3. Cage condition	Silently observation of the cage	- Bedding/cage paper moved, cat hiding under	−1
	Adaptation: unrated item	- Cage rearranged, cat on top or not hiding	+1
		- No change	0
		- Other, please describe	0
4. Social response when door is opened	Calmly and slowly opens the door of the cage and observe the cat, no talking	- Remains relaxed and soft, approaches the researcher	+1
		- Remains relaxed and soft, does not approach	0
	Adaptation: put the cat in the carrier, transported it to a novel room, slowly opens the door and observe the cat	- Becomes stiff with tight tail flicks and standing	+1
		- Crouches, body stiff	−1
5. (a-b) Introduction to novel room	Sit in a chair and observe the cat in the novel room for 5 minutes, without interacting	a) Exits carrier in 25 seconds or less with:	
		- tall body posture	+1
		- crouched body posture	+0,5
		- quickly scoots to hiding place, keeping body low to the ground	−0,5
		- does not exit the carrier	0
		b) Time spent with the researcher and for how long:	
		- More than 60 seconds	+0,5
		- 30-60 seconds	1
		- Less than 30 seconds	0
6. Call and approach	Call cat and extend a closed hand, then observe how it responds and whether it approaches	- Makes eye contact	+1
		- Does not make eye contact	−1
		- Approaches	+3
		- Sniffs or head butts	+3
		- Rolls on back or rolls over	+2
		- Meows, purrs and/or chirps	+1
		- Watches with no approach	0
		- Retreats	−1
		- Hisses or growls	−2
7. Open hand	Extend an open hand and observe cat's response	- Sniffs or head butts	+3
		- Licks or rubs on hand	+3
		- Rolls on back or rolls over	+2
		- Meows, purrs and/or chirps	+2
		Retreats/defensive position	−1
		- Hisses and/or growls	−2
		- Swats/attempts to swat hand	−2
		- Bites/attempts to bite hand	−3
8. Stroking	Slowly stroke the cat from head to tail for four or five times	- Rubs against legs or hand	+3
		- Head butts	+3
		- Circles the researcher attentively	+2
		- Meows, purrs and/or chirps	+2
		- Rolls onto back or rolls over	+2
		- Shows initial fear but then relaxes	0
		- Retreats/defensive position	−1
		- Hisses and/or growls	−2
		- Swats or attempts to swat hand	−2
		- Bites or attempts to bite hand	−3
9. Play	Initiate play with the cat, observe the cat's reaction then offer two other toys	- Watches toy intently	+3
		- Chases toy	+3
		- Comes back for stroking	+2
		- Ignores toys	0
		- Attends to something else	−1

Table 1 (*continued*)

		- Avoids eye contact	−1
10. Hug	Stroke the cat a few times, pick him up upright, the side of his body against the researcher's chest for two seconds and return him to the floor	- The cat is relaxed	+3
		- Extends paw to the researcher's neck or shoulder in an affiliative manner	+3
		- Meows, purrs and/or chirps	+2
		- Accepts hold but remains a bit tense	+2
		- Struggles to escape	−1
		- Hisses/growls	−2
		- Stiffens and extends claws	−2
		- Swats/attempts to swat	−3
		- Bites/attempts to bite	−3
11. Sensitivity	Stroke the cat along the base of the tail, pull up just enough to almost, lift his back feet off the floor and hold for one second	- Rolls onto back or rolls over	+3
		- Shows no reaction	+3
		- Meows, purrs and/or chirps	+1
		- Struggles/tries to escape	0
		- Hisses/growls	−1
		- Swats/attempts to swat	−2
		- Bites/attempts to bite	−3

2.2. Personality assessment: modified meet your match

The MYM personality assessment ASPCA (2007) was designed for North American shelters. In this study, we used a validated version of the MYM assessment modified for application in Brazilian shelters (exploratory factor analysis and exploratory hierarchical cluster analysis; see Fukimoto et al., 2019 for details). The assessment consists of 11 experimental circumstances (that will be referred to as "items" for the remainder of the article) that should be presented to the subject, a list of behaviours that should be observed and measured during these procedures, and their respective scores. Each item scores points to one of the three dimensions assessed (agreeableness – items 5b, 6, 7, 8; openness – items 1, 4, 5a; and extraversion – items 2, 9, 10, 11) (Table 1).

The novel room used to perform the assessment was a bathroom to which cats did not have access. After being rehomed, cats continued to be assessed in bathrooms. These rooms offered better conditions for the human–cat interaction because there were fewer places for the animals to hide, few stimuli and, in the shelter, less odour from other cats.

2.3. Faecal samples

Faecal samples were collected in the shelter from August 2016 to April 2017. Litter boxes were observed by the researcher (NF) and two research assistants every weekday in the morning (from 8:00 a.m. – after the shelter staff cleaned the litter boxes – to 11:00 a.m.). Faecal collection happened immediately after defecation. All samples were identified with the subjects' name and date/time of collection. We collected a total of 466 samples from the 53 subjects, with an average of eight samples per subject.

On average, collaborating owners started the collection three months after the adoption (ranging from one to three months) and ended it three months later. They were instructed to collect samples immediately after defecation two to three times a week; identify them with name, date and time; and immediately stored in a freezer (−20 °C) until the researcher withdrew them. A total of 137 samples were collected by the owners, with an average of 10 samples per subject. Owners collected samples until October 2017. After being withdrawn, the frozen faeces were transported in a Styrofoam box with ice to the Laboratory of Behavioural Endocrinology at the Institute of Psychology of the University of São Paulo where they were kept frozen until FCM extraction and analysis.

2.4. Measurement of faecal cortisol metabolites (FCM)

Extraction was performed following the protocol described by Palme et al. (2013). Briefly, 2 mL of methanol 80 % were added to an aliquot of 0.2 g of homogenized sample, shaken in a multivortex for 30 min and then centrifuged for 10 min at 1500 rpm. The supernatant was stored at −20 °C until assayed. FCM was measured in a 50 μL aliquot of the extract (diluted 1:10 with assay buffer) with an 11-oxoaetiocholanolone enzyme immunoassay (EIA), validated for domestic cats (*Felis silvestris catus*) by Schatz and Palme (2001). For logistics reasons, we carried out the analysis in two laboratories: at the Department of Preventive Veterinary Medicine and Animal Health of School of Veterinary Medicine and Animal Science of University of São Paulo and at the Laboratory of Experimental Endocrinology at the Institute of Psychology of the University of São Paulo. Intra- and inter-assay coefficients of variation of pool samples were < 10 % and < 15 %, respectively. All samples were assayed in duplicate. Concentrations of hormone metabolites are expressed as nanograms per gram of wet faecal matter.

2.5. Ethics and data collection procedures

This research complied with protocols approved by the Animal Research Ethics Committee of the Institute of Psychology of the University of São Paulo (CEUA/IPUSP nº 2309091116) and with the current Brazilian laws on ethical standards, as well as with the rules issued by the National Council for Control of Animal Experimentation (CONCEA). This research also complied with protocols approved by the Operational Standard of CNS/CONEP on 01/2013 and Ethics Committee in Research with Human Beings - CEPH-IPUSP with the Certificate of Presentation for Ethical Consideration CAAE: 64700817.8.0000.5561. The study followed the ethical guidelines of the National Institutes of Health for the care and use of laboratory animals (NIH Publications No. 8023, revised 1978) for conducting research with animals.

2.6. Data analysis

We performed a Spearman rank correlation between the three dimensions of personality and FCMs. For that test, we used personality and FCM data collected in the shelter from 53 subjects. Personality dimension data was inserted as the sum of values received in each item composing that dimension. Median FCM concentrations were calculated for all samples of each subject in the shelter. This statistical analysis was performed using SPSS® (IBM® version 23).

To investigate the correlation between locality and cortisol level, we used a subset of 15 individuals that were sampled from the shelter and owner's home. Using these individuals, we ran two linear mixed models using FCMs as response variables. Model 1 included a fixed effect

predictor for locality (shelter and home), representing the change in FCM levels between the two localities, and random intercepts and slopes to account for the repeated measures for each individual and to provide an individual level estimate of the cortisol change. Model 2 was identical to model 1, but it also included predictors for the three personality traits. Before fitting the models, FCM data was log-transformed and both log-FCM data and personality dimension data were scaled to zero mean and unit variance. Both models were fit in the R statistical computing environment using the rstanarm package with standard priors. We compared these models using leave-one-out (loo) cross-validation (Vehtari et al., 2017) using the loo package (Vehtari et al., 2018). After fitting the models for the full data, we noticed that two individuals adopted by the same owner showed anomalous changes in FMC levels, suggesting some shared unmeasured environmental factors that affected the results (later we found that an aggressive cat moved in with these two subjects during sample collection). Because of this anomaly, we also fitted the models excluding these individuals. We show both fits in the results.

To assess the possible changes in personality between the two localities, we used a regression model for each personality trait, using locality as a predictor. The code used to produce all statistical analysis is included in the supporting information.

3. Results

3.1. Correlations between personality dimensions and faecal cortisol metabolite levels

No correlations were found between the three dimensions of personality (agreeableness: rs(51) = 0.022, p = 0.878; openness: rs(51) = 0.205, p = 0.141; extraversion: rs(51) = 0.010, p = 0.942) and levels of FCMs in Spearman correlation tests.

3.2. Comparison of models using cross-validation

Leave-one-out cross-validation showed that both models had very similar predictive performance, with the simpler model (that used only locality) being slightly better (expected log pointwise predictive density difference of -0.62, a statistic comparable to AIC difference). Given that predictive performance was equivalent and the coefficients related to personality traits were not significantly different from zero, we opted to use the results from the model without personality traits.

3.3. Faecal cortisol metabolite levels: shelter vs. owner's home

When we used model 1 to compare the same individuals in the shelter and in the owner's home the mean difference in FCM levels was negative (lower levels in the home), but not statistically significant (posterior mean difference: *effect size = -0.37, N = 15, P = 0.068*). As for individual level estimates, most subjects (n = 11 out of 15) showed a lower FCM level in their homes, but only two (Brigith and Provolone) of these had a change significantly different from zero (Fig. 1). Two subjects showed an increase in their FCM levels (Judith and Ursula). We speculated that some unmeasured environmental factors were causing this increase, and conducted a second analysis without these two subjects. In the new analysis, FCM levels differed significantly between the shelter and the owner's home (posterior mean difference: *effect size = -0.60, N = 15, P = 0.0072*), but most parameter estimates were unaffected (Fig. 2).

3.4. Consistency of MYM assessment through localities

The personality dimensions of assessed subjects did not change when they moved from the shelter to the owner's home – all personality dimensions presented small, non-significant changes in the regression models (agreeableness: p = 0.31, openness: p = 0.15, extraversion:
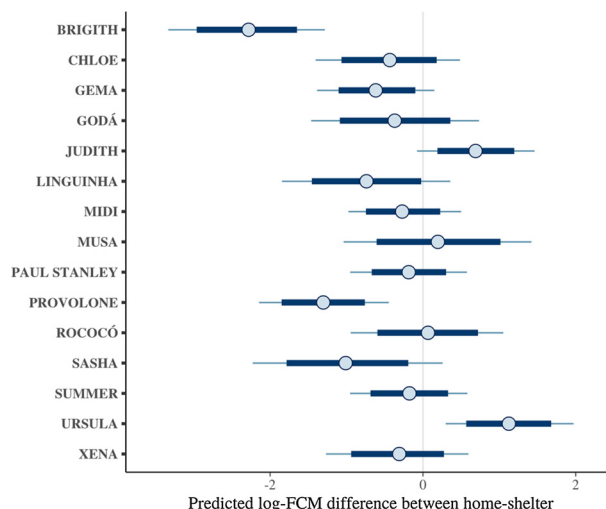

Fig. 1. Estimated individual differences in faecal cortisol metabolites (log-FCM) levels between shelter and owner's home (circles), for all 15 cats followed in the shelter and owner's home. Negative values indicate smaller levels in the home when compared to the shelter. Thick bars show 80 % posterior credibility intervals and thin bars show 95 % intervals.
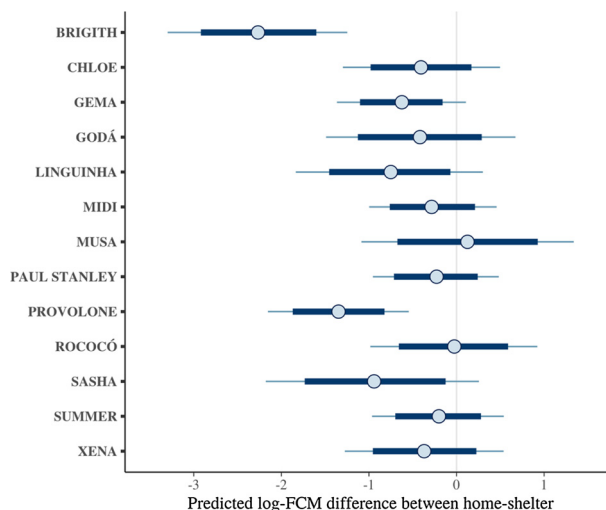

Fig. 2. Estimated individual difference in faecal cortisol metabolites (log-FCM) levels between shelter and owner's home (circles), without the two cats that had an unexpected stressor during data collection in the owner's home. Negative values indicate smaller levels in the home when compared to the shelter. Thick bars show 80 % posterior credibility intervals and thin bars show 95 % intervals.

p = 0.2, Fig. 3).

4. Discussion

Our study aimed at elucidating whether there is a correlation between personality dimensions and FCM levels, finding out how moving from the shelter to the owner's home affects FCM levels and verifying if MYM assessment results are consistent through localities. We found no correlation between personality dimensions and FCM levels. There was a slight, but significant decrease of FCM levels at the owner's home and MYM assessment was consistent through localities.

The lack of a correlation between personality dimensions and FCM levels corroborates the findings of the following studies: Ramos et al. (2013) found that faecal cortisol metabolites did not vary in relation to cat personality; Iki et al. (2011) did not find a correlation between a Feline Temperament Profile (FTP) and cat blood cortisol levels and
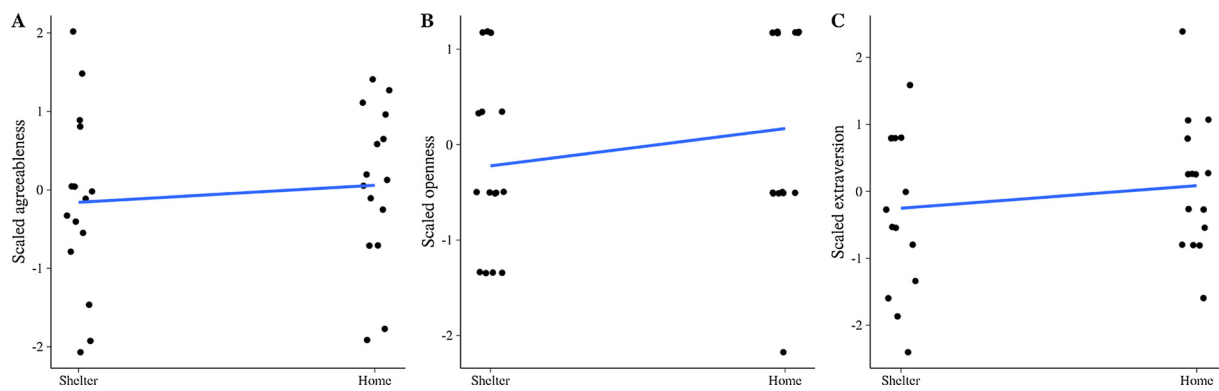
Fig. 3. Scaled scores of each personality dimension (agreeableness, openness and extraversion) of all 15 assessed individuals in both locations (shelter and home). Lines connect the means in each location. None of the personality dimensions showed significant differences between locations.

Siegford et al. (2003) did not find a relationship between the FTP and cat basal salivary cortisol concentrations. It is still unclear why there is no correlation between basal cortisol levels and personality in domestic cats. For a wild feline (clouded leopards, *Neofelis nebulosa)*, Wielebnowski et al. (2002) found evidence of correlations between personality traits and glucocorticoid levels. They found higher FCM levels in nervous types of clouded leopards compared to calm ones. It is interesting to note that studies with domestic cats are done with confined, neutered subjects, with predictability of resources and affection. That can explain, in part, the non-correlation between FCM levels in our study. Also, the measured dimensions might not be related to stress and basal adrenocortical activity. Another limitation was that our sample did not include extremely unsociable cats, which resulted in many personality assessments having similar results among the subjects. Possibly, for confined cats, cortisol can relate to other factors, such as human activity (Bradshaw, 2016) and the number of people living in the household (Lichtsteiner and Turner, 2008).

When we compare the two models for the change in FCM levels between localities (shelter vs. owner's home), models 1 and 2 had very similar results, indicating that personality traits (included in model 2) did not relate to FCM levels. This was in accordance with data from 53 subjects (collected only in the shelter) where FCM did not correlate with personality dimension, highlighting that personality did not influence FCM levels of the subjects of this research.

The mixed models aimed to investigate how moving from the shelter to the owner's home would interfere in the animal's stress levels and how they would adapt physiologically to the new environment. The variation of FCM levels would show us whether the owner's home was a stressful environment or not. For the two subjects that presented increased FCM levels between the shelter and the owner's home, our data points to an external stressor (other than adoption and moving to a new environment – see Results for details) as the cause of this increase in our sample. One possibility (the new cat which arrived in the middle of sample collection showed aggression towards the other two adopted cats) is that maybe there were not enough resources and places for them to hide and avoid encounters, which would have reduced FCM levels. In general, cats may coexist in the same household, but that does not mean they belong to the same social grouping (Ellis et al., 2013; Heath, 2019). They can cohabit successfully if a new member is introduced in the right way (Heath, 2019). The environment should be adapted to welcome the extra individuals, with additional resources provided (food, water and litter trays) as well as opportunities to escape and hide (Amat et al., 2009; Souza-Dantas et al., 2009; Ellis et al., 2013). As cats have a stable dominance hierarchy, aggression rates among group-living cats are low (Knowles et al., 2004; Dantas-Divers et al., 2011). However, we think that future research should help to reveal if other cats also increase their FCM levels in the owner's home (not as an adaptation strategy during the first days or weeks, but, as we found

here, months after the adoption) regardless of external stressors.

In the second analysis (without the two subjects discussed above), there was a significant difference between FCM levels in the shelter and in the homes. There was a slight tendency of reduction in FCM levels between localities, with lower FCM levels in the owner's home than in the shelter. Two individuals had a greater reduction in FCM levels, which suggests that, for them, at least physiologically, homes are a less challenging environment than the shelter, where they had to cope with several people working and numerous cats sharing the space. However, for the other 11 individuals that had unchanged FCM levels, differences between the shelter and their owner's home were not significantly different from zero. This unfolds at least three possibilities: 1) these individuals may have coping mechanisms that minimize the impact of potentially stressful environments — in other words, they can adapt to different types of environments and maintain their cortisol levels unchanged (Lichtsteiner and Turner, 2008); 2) this particular shelter provides environmental conditions that enable animals to cope well with potential stressors (e.g. a lot of people working, lots of visitors, high density of animals) and 3) all 11 homes were as stressful as the shelter. It seems more plausible to us that, despite the high density of cats in this shelter and a large number of people working there, the shelter provides favourable conditions for the general well-being of sheltered cats (McCobb et al., 2005), namely environmental enrichment, places to hide, affectionate volunteers and a certain routine regarding eating and cleaning.

Scores of MYM personality assessment in the shelter and in the owner's home were not significantly different. Even though the assessments were applied only twice (once in the shelter and once in the owner's home), the results show little change (not statistically different) between localities, which suggests that MYM can be a robust assessment for reviewing personality dimensions. Studies using other methods also found consistency between reassessments (Siegford et al., 2003 — with the FTP after 3 and 6 months; Lowe and Bradshaw, 2001 — with behavioural records after 1 and 2 years). As personality is defined as stable individual characteristics, with consistency through time and situations, it was important that the results found in the shelter were maintained in the owner's home.

All efforts to consider the welfare of cats (sheltered or homed) are valid and necessary because cat presence in residences is growing quickly (Stavisky et al., 2012; Worldwide Pet Ownership, 2016). It is important to consider improving the compatibility between owner and cat and the adaptation in new environments, thus enriching their quality of life and benefiting all parties involved. We showed that MYM is consistent between localities, achieving one of the precepts in a personality assessment. We also corroborate other studies regarding a non-correlation between personality and FCM levels (Iki et al., 2011; Ramos et al., 2013). Furthermore, cats seem to be very resilient and fit well both in the shelter and in the owner's home. This experience also

suggests that a very inadequate environment is needed for the animals to show physiological evidence of psychological/emotional stress (with higher levels of FCM) when they are adopted. Therefore, it is essential that owners who already own a cat consider its sociability with conspecifics before adopting another one. This way coexistence can be advantageous for both. From our sample of fifteen, only six individuals were adopted alone and moved to homes with no more cats. For the remaining nine, two of them were adopted together and all the others moved to homes that already had a cat. In general, most cats of our sample showed physiological and behavioural signs that they coped well after being adopted — even those who moved in with other cats. However, the two subjects that moved in with a non-socialized cat showed negative changes in their physiological indicators of well-being.

Although it was not the case in our sample, relinquishment is a real difficulty (New et al., 2000; Kass et al., 2001). Fortunately, there are measures to be taken in order to minimize mismatches that result in abandoned animals. Data from shelters that used the MYM program (ASPCA, 2007) shows they witnessed a reduction of 11 % in return rates in the first month after implementation. With a systematic implementation of this protocol, assessing not only cats but also future owners, it is possible to minimize risks of incompatibility on the adoption and frustration on the adaptation to the new household.

4.1. Conclusions

The potential of MYM to reduce rates of relinquishments in North American shelters' has already been demonstrated. The present study — besides expanding the current literature regarding cat personality, welfare and cortisol levels — is a first step towards incorporating a more objective approach to the adoption process in a Brazilian shelter, aiming ultimately at improving the pairing of humans and cats. Following studies should focus on the owner's attributes, such as commitment and expectation towards the adoption, a better match between cat personality and potential owner's lifestyle, and more information on cat welfare in order to enhance our knowledge of which variables are more relevant for a successful pairing.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

Acknowledgments

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.applanim.2019. 104919.

References

Amat, M., de la Torre, J.L.R., Fatjó, J., Mariotti, V.M., Van Wijk, S., Manteca, X., 2009. Potential risk factors associated with feline behaviour problems. Appl. Anim. Behav. Sci. 121 (2), 134–139. https://doi.org/10.1016/j.applanim.2009.09.012.

ASPCA, 2007. Meet Your Match Feline-ality Adoption Program. Available in: https://www.aspcapro.org/research-meet-your-match/feline-ality (Accessed 08 October 2019.

Bennett, P.C., Rutter, N.J., Woodhead, J.K., Howell, T.J., 2017. Assessment of domestic cat personality, as perceived by 416 owners, suggests six dimensions. Behav. Processes 141, 273–283. https://doi.org/10.1016/j.beproc.2017.02.020.

Bradshaw, J., 2013. Cat Sense: How the New Feline Science Can Make You a Better Friend to Your Pet. Basic Books (AZ).

Bradshaw, J.W., 2016. Sociality in cats: a comparative review. J. Vet. Behav. Clin. Appl. Res. 11, 113–124. https://doi.org/10.1016/j.jveb.2015.09.004.

Broom, D.M., Johnson, K.G., 1993. Stress and strain, welfare and suffering. In: Broom, D.M., Johnson, K.G. (Eds.), Stress and Animal Welfare. Springer, Dordrecht, pp. 57–86 https:::doi.org/10.1007/978-94-024-0980-2_4.

Capitanio, J.P., 2004. Personality factors between and within species. In: In: Thierry, B., Singh, M., Kaumanns, W. (Eds.), Macaque Soc. Model Study Soc. Organ. 41. Cambridge University Press, pp. 13–32.

Carere, C., Audebrand, C., Rödel, H.G., d'Ettorre, P., 2018. Individual behavioural type and group performance in Formica fusca ants. Behav. Processes 157, 402–407. https://doi.org/10.1016/j.beproc.2018.07.009.

Casey, R.A., Vandenbussche, S., Bradshaw, J.W.S., Roberts, M.A., 2009. Reasons for relinquishment and return of domestic cats (Felis silvestris catus) to rescue shelters in the UK. Anthrozos 22 (4), 347–358. https://doi.org/10.2752/089279309X12538695316185.

Clark, C.C., Gruffydd-Jones, T., Murray, J.K., 2012. Number of cats and dogs in UK welfare organisations. Vet. Rec. https://doi.org/10.1136/vr.100524. vetrec-2011.

Dantas-Divers, L.M., Crowell-Davis, S.L., Alford, K., Genaro, G., D'Almeida, J.M., Paixao, R.L., 2011. Agonistic behavior and environmental enrichment of cats communally housed in a shelter. J. Am. Vet. Med. Assoc. 239, 796–802. https://doi.org/10.2460/javma.239.6.796.

Denenberg, S., 2015. Animal behavior case of the month. J. Am. Vet. Med. Assoc. 246 (2), 194–196. https://doi.org/10.2460/javma.246.2.194.

Ellis, S.L., Rodan, I., Carney, H.C., Heath, S., Rochlitz, I., Shearburn, L.D., Westropp, J.L., 2013. AAFP and ISFM feline environmental needs guidelines. J. Feline Med. Surg. 15 (3), 219–230. https://doi.org/10.1177/1098612X13477537.

Fantuzzi, J.M., Miller, K.A., Weiss, E., 2010. Factors relevant to adoption of cats in an animal shelter. J. Appl. Anim. Welf. Sci. 13, 174–179. https://doi.org/10.1080/10888700903583467.

Finka, L.R., Ellis, S.L., Stavisky, J., 2014. A critically appraised topic (CAT) to compare the effects of single and multi-cat housing on physiological and behavioural measures of stress in domestic cats in confined environments. BMC Vet. Res. 10 (1), 73. https://doi.org/10.1186/1746-6148-10-73.

Freeman, H.D., Gosling, S.D., 2010. Personality in nonhuman primates: a review and evaluation of past research. Am. J. Primatol. 72 (8), 653–671. https://doi.org/10.1002/ajp.20833.

Fukimoto, N., Howat-Rodrigues, A.B., Mendonça-Furtado, O., 2019. Modified Meet your Match® Feline-alityTM validity assessment: An exploratory factor analysis of a sample of domestic cats in a Brazilian shelter. Appl. Anim. Behav. Sci. 215, 61–67. https://doi.org/10.1016/j.applanim.2019.03.013.

Gartner, M.C., Weiss, A., 2013. Personality in felids: a review. Appl. Anim. Behav. Sci. 144, 1–13. https://doi.org/10.1016/j.applanim.2012.11.010.

Gartner, M.C., Powell, D.M., Weiss, A., 2014. Personality structure in the domestic cat (Felis silvestris catus), Scottish wildcat (Felis silvestris grampia), clouded leopard (Neofelis nebulosa), snow leopard (Panthera uncia), and African lion (Panthera leo): a comparative study. J. Comp. Psychol. 128, 414. https://doi.org/10.1037/a0037104.

Gartner, M.C., 2015. Pet personality: a review. Pers. Individ. Dif. 75, 102–113. https://doi.org/10.1016/j.paid.2014.10.042.

Genaro, G., 2004. Comportamento felino: Organizacão social e espacial, comunicacão intra-específica e conflitos com a vida doméstica. MEDVEP Revista Científica de Medicina Veterinária 2 (5), 61–66.

Gosling, S.D., 2008. Personality in non-human animals. Soc. Personal. Psychol. Compass 2, 985–1001. https://doi.org/10.1111/j.1751-9004.2008.00087.x.

Ha, D., Ha, J., 2017. A subjective domestic cat (Felis silvestris catus) temperament assessment results in six independent dimensions. Behav. Processes 141, 351–356. https://doi.org/10.1016/j.beproc.2017.03.012.

Heath, S., 2019. Common feline problem behaviours: Unacceptable indoor elimination. J. Feline Med. Surg. 21 (3), 199–208. https://doi.org/10.1177/1098612X19831202.

Hiby, E., Eckman, H., MacFarlaine, I., 2014. Cat population management. In: Turner, D.C., Bateson, P. (Eds.), The Domestic Cat: The Biology of Its Behaviour, Third edition. Cambridge University Press, pp. 215–230.

Iki, T., Ahrens, F., Pasche, K.H., Bartels, A., Erhard, M.H., 2011. Relationships between scores of the feline temperament profile and behavioural and adrenocortical responses to a mild stressor in cats. Appl. Anim. Behav. Sci. 132, 71–80. https://doi.org/10.1016/j.applanim.2011.03.008.

John, O.P., Srivastava, S., 1999. The Big five trait taxonomy: history, measurement, and theoretical perspectives. Handbook of personality: Theory and research 2, 102–138.

Jones, A.C., Gosling, S.D., 2005. Temperament and personality in dogs (Canis familiaris): a review and evaluation of past research. Appl. Anim. Behav. Sci. 95 (1-2), 1–53. https://doi.org/10.1016/j.applanim.2005.04.008.

Kaleta, T., Borkowska, N., Goral-Radziszewska, K., 2016. The study of domestic cat (Felis catus) personality based on survey in Poland. Annals of Warsaw University of Life Sciences-SGGW. Anim. Sci. 55. http://annals-wuls.sggw.pl/?q=node/384.

Kass, P.H., New Jr, J.C., Scarlett, J.M., Salman, M.D., 2001. Understanding animal companion surplus in the United States: Relinquishment of nonadoptables to animal shelters for euthanasia. J. Appl. Anim. Welf. Sci. 4 (4), 237–248. https://doi.org/10.1207/S15327604JAWS0404_01.

Knowles, R.J., Curtis, T.M., Crowell-Davis, S.L., 2004. Correlation of dominance as determined by agonistic interactions with feeding order in cats. Am. J. Vet. Res. 65,

1548–1556. https://doi.org/10.2460/ajvr.2004.65.1548.

Lichtsteiner, M., Turner, D.C., 2008. Influence of indoor-cat group size and dominance rank on urinary cortisol levels. Anim. Welf. 17, 215–237.

Litchfield, C.A., Quinton, G., Tindle, H., Chiera, B., Kikillus, K.H., Roetman, P., 2017. The 'Feline Five': an Exploration of Personality in Pet Cats (*Felis Catus*). PLoS One 12, e0183455. https://doi.org/10.1371/journal.pone.0183455.

Lowe, S.E., Bradshaw, J.W., 2001. Ontogeny of individuality in the domestic cat in the home environment. Anim. Behav. 61, 231–237. https://doi.org/10.1006/anbe.2000.1545.

MacKay, J.R.D., Haskell, M.J., 2015. Consistent individual behavioral variation: the difference between temperament, personality and behavioral syndromes. Animals 5, 455–478. https://doi.org/10.3390/ani5030366.

Marston, L.C., Bennett, P.C., 2009. Admissions of cats to animal welfare shelters in Melbourne, Australia. J. Appl. Anim. Welf. Sci. 12 (3), 189–213. https://doi.org/10.1080/10888700902955948.

McCobb, E.C., Patronek, G.J., Marder, A., Dinnage, J.D., Stone, M.S., 2005. Assessment of stress levels among cats in four animal shelters. J. Am. Vet. Med. Assoc. 226, 548–555. https://doi.org/10.2460/javma.2005.226.548.

Moore, A.M., Bain, M.J., 2013. Evaluation of the addition of in-cage hiding structures and toys and timing of administration of behavioral assessments with newly relinquished shelter cats. J. Vet. Behav. Clin. Appl. Res. 8, 450–457. https://doi.org/10.1016/j.jveb.2011.10.003.

Möstl, E., Palme, R., 2002. Hormones as indicators of stress. Domest. Anim. Endocrinol. 23, 67–74. https://doi.org/10.1016/S0739-7240(02)00146-7.

New Jr, J.C., Salman, M.D., King, M., Scarlett, J.M., Kass, P.H., Hutchison, J.M., 2000. Characteristics of shelter-relinquished animals and their owners compared with animals and their owners in US pet-owning households. J. Appl. Anim. Welf. Sci. 3 (3), 179–201. https://doi.org/10.1207/S15327604JAWS0303_1.

Palme, R., 2012. Monitoring stress hormone metabolites as a useful, non-invasive tool for welfare assessment in farm animals. Anim. Welf. 21, 331–337. https://doi.org/10.7120/09627286.21.3.331.

Palme, R., Touma, C., Arias, N., Dominchin, M.F., Lepschy, M., 2013. Steroid extraction: Get the best out of faecal samples. Wiener Tierärztliche Monatsschrift – Veterinary Medicine Austria 100, 238–246.

Palme, R., 2019. Non-invasive measurement of glucocorticoids: advances and problems. Physiol. Behav. 199, 229–243. https://doi.org/10.1016/j.physbeh.2018.11.021.

Ramos, D., Reche-Junior, A., Fragoso, P.L., Palme, R., Yanasse, N.K., Gouvêa, V.R., Mills, D.S., 2013. Are cats (*Felis catus*) from multi-cat households more stressed? Evidence from assessment of fecal glucocorticoid metabolite analysis. Physiol. Behav. 122, 72–75. https://doi.org/10.1016/j.physbeh.2013.08.028.

Rehnberg, L.K., Robert, K.A., Watson, S.J., Peters, R.A., 2015. The effects of social interaction and environmental enrichment on the space use, behaviour and stress of owned housecats facing a novel environment. Appl. Anim. Behav. Sci. 169, 51–61. https://doi.org/10.1016/j.applanim.2015.06.002.

Schatz, S., Palme, R., 2001. Measurement of faecal cortisol metabolites in cats and dogs: a non-invasive method for evaluating adrenocortical function. Vet. Res. Commun. 25,

271–287. https://doi.org/10.1023/A:1010626608498.

Siegford, J.M., Walshaw, S.O., Brunner, P., Zanella, A.J., 2003. Validation of a temperament test for domestic cats. Anthrozos 16, 332–351. https://doi.org/10.2752/089279303786991982.

Shore, E.R., 2005. Returning a recently adopted companion animal: adopters' reasons for and reactions to the failed adoption experience. J. Appl. Anim. Welf. Sci. 8 (3), 187–198. https://doi.org/10.1207/s15327604jaws0803_3.

Shore, E.R., 2010. Returning a recently adopted companion animal: adopters' reasons for and reactions to the failed adoption experience. J. Appl. Anim. Welf. Sci. 8, 187–198. https://doi.org/10.1207/s15327604jaws0803_3.

Souza-Dantas, L.M., Soares, G.M., D'Almeida, J.M., 2009. Epidemiology of domestic cat behavioral and welfare issues: a survey of Brazilian referral animal hospitals in 2009. Intern J Appl Res Vet Med 7-3, 130–137.

Stavisky, J., Brennan, M.L., Downes, M., Dean, R., 2012. Demographics and economic burden of un-owned cats and dogs in the UK: results of a 2010 census. BMC Vet. Res. 8 (1), 163. https://doi.org/10.1186/1746-6148-8-163.

Tanaka, A., Wagner, D.C., Kass, P.H., Hurley, K.F., 2012. Associations among weight loss, stress, and upper respiratory tract infection in shelter cats. J. Am. Vet. Med. Assoc. 240 (5), 570–576. https://doi.org/10.2460/javma.240.5.570.

van den Bos, R., 1998. Post-conflict stress-response in confined group-living cats (*Felis silvestris catus*). Appl. Anim. Behav. Sci. 59 (4), 323–330. https://doi.org/10.1016/S0168-1591(98)00147-6.

Vehtari, A., Gelman, A., Gabry, J., 2017. Practical Bayesian model evaluation using leave-one-out cross-validation and WAIC. Stat. Comput. 27, 1413–1432. https://doi.org/10.1007/s11222-016-9696-4.

Vehtari, A., Gabry, J., Yao, Y., Gelman, A., 2018. "Loo: Efficient Leave-one-out Cross-validation and WAIC for Bayesian Models." R Package Version 2.0.0. available in: https://CRAN.R-project.org/package=loo (Accessed 10 October 2019). .

Wielebnowski, N.C., Fletchall, N., Carlstead, K., Busso, J.M., Brown, J.L., 2002. Noninvasive assessment of adrenal activity associated with husbandry and behavioral factors in the North American clouded leopard population. Zoo Biol. 21, 77–98. https://doi.org/10.1002/zoo.10005.

Young, K.M., Walker, S.L., Lanthier, C., Waddell, W.T., Monfort, S.L., Brown, J.L., 2004. Noninvasive monitoring of adrenocortical activity in carnivores by fecal glucocorticoid analyses. Gen. Comp. Endocrinol. 137, 148–165. https://doi.org/10.1016/j.ygcen.2004.02.016.

Worldwide Pet Ownership, 2016. Pet Ownership Worldwide in 2016, by Country. (Accessed 10 October 2019). https://www.statista.com/statistics/961098/worldwide-pet-ownership-by-type-by-country/.

Zeigler-Hill, V., Highfill, L., 2010. Applying the interpersonal circumplex to the behavioral styles of dogs and cats. Appl. Anim. Behav. Sci. 124, 104–112. https://doi.org/10.1016/j.applanim.2010.02.012.

Uher, J., 2011. Individual behavioral phenotypes: An integrative meta-theoretical framework. Why "behavioral syndromes" are not analogs of "personality". Dev. Psychobiol. 53, 521–548. https://doi.org/10.1002/dev.20544.