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The relationship between individual behavioural styles, dominance rank and cortisol levels of cats living in urban social groups

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ABSTRACT

Individual animals show differences in temperament, often correlated with ecologically important behavioural patterns such as dominance, and with physiological responses to environmental perturbations, such as cortisol levels. Identifying these temperaments in animals may reveal adaptive patterns of behaviour and physiology that could be used to improve their fitness and welfare in human-controlled environments. We examined the possible relationship between individual temperaments, social dominance levels and cortisol levels in regularly fed urban groups of free-roaming domestic cats (*Felis catus* L.) that are routinely subjected to the Trap-Neuter-Release procedure (TNR). We designed three behavioural tests that aimed at assessing the cats' boldness levels and determining the individual temperaments using a principle component analysis. Individual social dominance rank was determined from observations of social encounters before and during feeding. Cortisol levels were measured from hair samples collected from the cats. Significant differences were exclusive to females, with the intact females scoring higher on the boldness factor compared to the neutered females (median of 0.47 ± 0.981 and -0.168 ± 1.015, respectively, Post hoc Chi square, $P < 0.05$). A positive correlation was found between cortisol levels and dominance scores in the intact females: the more dominant an individual intact female was the higher her cortisol level was ($n = 14$, Pearson correlation, $R^2 = 0.592$, $P < 0.05$). No correlation was found between dominance rank and boldness or between boldness and food dominance. In summary, our results suggest that in urban cat feeding groups, where cats are dependent on a regular food source and where their individual survival does not absolutely depend on their dominance rank, their social status was independent from their individual boldness. The differences found in the behavioural tests, between the neutered and the intact females are probably rooted in different motivation levels rather than different temperaments.

1. Introduction

The importance of an individual animal's particular temperament and characteristics to its fitness and survival during stressful events, and to its ability to adapt to changing environmental conditions (Dingemanse and Réale, 2005; Ruiz-Gomez et al., 2011; Montiglio et al., 2012), has been receiving increased attention in recent years (Koolhaas et al., 1999; Janczak et al., 2003; Natoli et al., 2005; David et al., 2011). Individuals, over time and under varying situations, differ in their propensity to take risks, particularly in novel or challenging situations, and this propensity is measured along the boldness–shyness axis (Svartberg, 2002), a fundamental personality trait in humans and other species (Wilson et al., 1994; Dingemanse and de Goede, 2004; Svartberg and Forkman, 2005). Researchers use terms such as *bold* vs. *shy* (Natoli et al., 2005; Svartberg and Forkman, 2005) and *proactive* vs. *reactive* (Koolhaas et al., 1999) to define the two poles of individual behavioural styles. Bold individuals will be active and more aggressive, and will manipulate their environment where possible according to their needs, while shy individuals will be more passive, show low activity levels, tend to avoid social conflicts (Jensen et al., 1995) and try to cope within their existing environment.

Temperament differences are involved in and may even predict social dominance in feeding contexts (Verbeek et al., 1999; David et al., 2011), and can therefore affect reproduction and fitness in certain species (Coleman and Wilson, 1998). Several studies have explored the relationship between an individual's temperament and its dominance rank, in birds (Dingemanse and de Goede, 2004; Fox et al., 2009; David et al., 2011), pigs (Bolhuis et al., 2005), coyotes (Mettler and Shivik, 2007) and wolves (Macdonald, 1983). In wolves, for example, dominant or aggressive individuals are generally considered to take more risks in challenging or novel situations (Macdonald, 1983).

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In the domestic cat, the relationship between dominance and individual behavioural differences has been little explored (Durr and Smith, 1997; Natoli et al., 2005). Natoli et al. (2005) showed that in groups of free-roaming urban domestic cats, higher-ranking male cats were found to be bolder than lower-ranking males. In an earlier study, however, in a laboratory setting, Durr and Smith (1997) did not find a significant correlation between dominance and fear of a novel object. Domestic cat groups exhibit social dominance patterns with regard to feeding order (Yamane et al., 1997; Bonanni et al., 2007; Knowles et al., 2004). Neutering may also have an effect on dominance patterns related to feeding, since neutered cats are generally less aggressive in feeding situations (Finkler et al., 2011a).

It is important to establish whether differences in individual personality might also be linked to the acquisition of dominance, as has been suggested for some bird (Verbeek et al., 1999) and fish (David et al., 2011) species.

Individual behavioural styles are also expressed in different physiological responses, such as corticosteroid levels (Janczak et al., 2003), heart rate and body temperature (Koolhaas et al., 1999; Carere and van Oers, 2004) and immunity to disease (Koolhaas et al., 1999; Natoli et al., 2005), and thus reflect inter-individual variations in the manner in which animals cope with stressors (Starling et al., 2010). Specific to free-roaming cats, Natoli et al. (2005) explored this connection and showed that the bold temperament appears to be the more successful strategy in urban male cats, at least in terms of reproductive success, but that this boldness was also linked to a high probability to be infected by the Feline Immunodeficiency Virus (FIV).

However, to date, there is still no unequivocal answer as to whether individuals with higher corticosteroid levels tend to exhibit bold or dominant personality characteristics and those with lower levels exhibit shyness or submissiveness, or vice versa (Sapolsky, 2005). In addition, to the best of our knowledge, other than Natoli et al. (2005) study, the relationship between physiological indicators of stress or disease and patterns of individual behaviour has not been examined in free-roaming domestic cats. We wish to build on this paucity of knowledge and add more information about this relationship in current settings of urban cat feeding groups that are subjected to Trap-Neuter-Release procedures, in many cities worldwide.

Our aim in the present study was thus to examine the possible relationship between the individual temperaments of the cats, their social dominance levels and their cortisol levels. We designed an experiment to test individual boldness and shyness levels of several urban groups of free-roaming domestic cats, and correlate these findings with the cats' dominance ranks and hair cortisol levels.

We hypothesized that the more dominant cats would be bolder in their reaction to a novel object and in competition over food, and thus display a higher boldness score. We also hypothesized that the cortisol levels of the bold cats would be significantly higher compared to those of the shy cats.

2. Materials and methods

2.1. Study site and experimental subjects

The study was conducted in seven cat feeding groups (total number of cats was 193) in seven different neighbourhoods in Tel Aviv, Israel, as part of a larger ecological study. All the groups were located in the backyards of multi-apartment buildings. The groups had been regularly fed by a caretaker for several years, at least once a day. All groups (multi-male and multi-female) had a stable social organization, usually consisting in a fixed core of several females and their offspring, and were composed of both neutered and intact cats.

2.2. Behavioural testing procedures

In order to classify the cats as bold or shy, we focused on the three following tests, which comprised a desirable food item, a novel object, or both. The assumption was that the bolder individuals will show the least hesitation and a higher propensity to explore and investigate the novel stimuli (Fox, 1972) or approach the food item. The tests were all performed during the regular feeding hours of the cats, in their familiar surroundings (Durr and Smith, 1997), so as not to disturb the animals' regular routine. All tests were performed after the cat feeder came and the cats were already at the feeding area, waiting to be fed. Although in total 193 cats were seen during the study, not all were seen at each feeding. After omitting the cats that were not present in all tests, the behaviours of 139 cats, inhabitants of the seven cat groups, were finally recorded in those tests.

2.2.1. The novel object test

We initially performed a pilot test involving a novel stimulus, using a remote-controlled toy car, adapted from Durr and Smith (1997), but as this test did not elicit any response from the cats, we replaced it with a cage containing a live molerat, *Spalax ehrenbergi*, as our novel object. The cage, 26 cm × 41 cm × 18 cm, with the mole rat inside, was placed in the centre of the cats' feeding area. As molerats tend to dig through the wood shavings provided as bedding, we predicted that the cats would be drawn to the animal's movements.

2.2.2. The food bowl test

On the morning preceding the two food tests (food bowl, and meat-in-the-box [see next test]), the cat caretakers were requested not to feed the cats, to ensure a state of hunger (Durr and Smith, 1997). A round plastic bowl (20 cm diameter, 15 cm deep) containing commercial moist cat food, a familiar and desirable food for the cats, was placed in the centre of the cats' feeding area, where all the cats could see and approach it.

2.2.3. The meat-in-the-box test

The same plastic food bowl used in the food bowl test, but now containing an even more desirable food item (the item was a sausage cut into 1 cm pieces, a treat the cats never receive from the feeder), was placed in the centre of the cats' feeding area, but this time inserted into a novel object (a cardboard box, 40 cm × 50 cm × 90 cm). In order to obtain the sausage pieces the cats needed to jump into the box.

The three tests were filmed in real-time mode, using a video camera (Sony Corporation, SONY DCR-HC23, Japan) and analyzed using the Observer XT software (Noldus Information Technologies, Wageningen, the Netherlands). A total of 485 min (approximately 8 h) of behavioural testing were recorded and analyzed for the seven cat groups. The cat behaviours coded by the observer software comprised the following: approaches to and explorations of the objects; latency to approach; and minimal distance that each cat maintained from the object. Here are the definitions for each behavioural variable:

Approach: we determined the test area as the radius of 3 m surrounding the object. If a cat started walking towards the object, within this radius, but in a radius not smaller than 1 m (i.e. between 3 and 1 m), this cat was defined as 'approaching'. If a cat left the radius or was on the 3 m "line" and walked again towards the object, this cat was 'approaching' again.

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