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Feline Research

Behavioral associations with breed, coat type, and eye color in single-breed cats

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ABSTRACT

In this study, behavioral characteristics in purebred cats were hypothesized to associate with breed, eye color, coat color, and coat pattern. Owners of 574 single-breed, registered cats completed the Feline Behavioral Assessment and Research Questionnaire, which generates a standardized behavioral profile incorporating 20 factors. Subjects were also screened for evidence of fear-related aggression, territorial aggression and inappropriate social skills, fear of noises, redirected aggression, separation anxiety, and inappropriate elimination. Subject breeds included Abyssinians, Bengals, Birmans, Burmese, Devon rexes, Maine coons, Norwegian Forest cats, Orientals, Persians, Ragdolls, Siamese, and Tonkinese. Coat colors included agouti, black, brown, cinnamon, blue, lilac, fawn, caramel, taupe, red, cream, blue cream, apricot, and white. Phenotypic variants associated with albinism, tabby and tortoiseshell patterning, inhibition of melanin, production of pheomelanin, and white spotting were represented. Statistical analysis revealed significant differences in the Feline Behavioral Assessment and Research Questionnaire scores and frequency of behavior problems in cats of multiple coat colors, coat patterns, and breeds ($P < 0.05$). Interestingly, nearly all associations between behavior and coat type could be attributed to breed-based behavior differences. Associations independent of breed included increased cat aggression in agouti cats and prey interest in red cats, decreased stranger-directed aggression in piebald cats, and increased likelihood of separation anxiety in Siamese and Tonkinese patterned cats.

Introduction

Precedent exists in multiple species for seeking an association between breed and behavior, as well as between appearance and behavior. Breed differences in aggression and trainability have been documented in dogs via use of a standardized behavioral questionnaire (C-BARQ) (Serpell & Hsu, 2005; Duffy et al., 2008; McGreevy et al., 2013; Ghirlanda et al., 2013). Other studies have found breed-related differences in canine emotionality and aggressiveness, the tendency to approach and withdraw in novel situations, activity and playfulness, predatory behavior, social behavior toward humans, and agonistic signaling (Svartberg, 2006). A 25-item rating method in horses, the Horse Personality Questionnaire, has revealed significant differences among breeds, particularly with regard to anxiousness and excitability (Lloyd et al., 2008).

Veterinarians and cat show judges were reported to perceive differences in behavior among feline breeds. Judges characterized Siamese as demanding of attention and outgoing with strangers, while describing Russian Blues as shy and withdrawn. Veterinarians perceived Siamese to be active and vocal, Persians to be less active and destructive, and Oriental Shorthairs to be more excitable and destructive (Mendl & Harcourt, 2000). When assayed on their perceptions of 15 common breeds, feline veterinary practitioners characterized Bengals as most active, most likely to aggress toward human family members, and most likely to urine mark; Persians were felt to be least active and least likely to use the litter box (Hart et al., 2013). Direct observation of owner-cat interactions revealed more vocalization and initiation of contact by Siamese than Persian cats (Mendl & Harcourt, 2000). A faster decline in exploration and locomotion scores occurred during an open field trial in Siamese, Orientals, and Abyssinians, as compared with Norwegian Forest cats (Marchei et al., 2009).

Selection for a particular color phenotype has also been shown to result in significant changes in behavior. In general, selection for

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a given trait may unintentionally result in selection for a genetically linked phenotype; pleiotropy may also occur, as can sensory deficits that alter behavior (Bergsma & Brown, 1971; Mendl & Harcourt, 2000). Gray-coated rats carrying the dominant agouti allele demonstrated significantly increased wildness and "savagery" relative to rats homozygous for the black (nonagouti) allele; gray and black animals differed in their sense of smell (Keeler, 1942). Nonagouti deer mice were also found to be less active, aggressive, and resistant to handling, and the agouti locus has been suggested as an important modulator of neural melanocortins (Hayssen 1997).

Fawn-colored Korean Jindo dogs exhibited significantly less fearful and submissive reactivity, and significantly more scent-marking behavior, than white-colored Jindos (Kim et al., 2010). Using the Campbell Test, aggression was found to be decreasingly likely in golden, black, and particolored Cocker spaniels (Amat et al., 2009). The likelihood of success in guide dog training was significantly different between black and yellow Labrador retrievers (Batt et al., 2008). Although not more reactive in a novel and potentially frightening situation, Icelandic horses with silver-colored coats and expressing the Arg618Cys mutation in the PMEL/SILV gene were significantly more cautious (Brunberg et al., 2013). Silver foxes artificially selected for reduced aggressiveness and fearfulness during human interaction displayed a corresponding increase in yellow-brown mottling and piebaldness (Trut et al., 2004).

Preliminary evidence for associations between coat color and behavior is also found in cats. When 84 British shorthair kittens were handled by an unfamiliar person, the red, cream, and tortoiseshell subjects showed a longer latency to quieting and increased escape attempts compared to kittens with other coat colors (Mendl & Harcourt, 2000). When seven coat color loci were studied in French domestic cats, cats in progressively more rural environs were found to have correspondingly greater frequencies of the dominant red allele. Because rural populations of the domestic cat are characterized by low densities and a polygynous mating system, researchers postulated that reproductive tactics may differ between red and non-red males, leading to the rural-urban allelic cline (Pontier et al., 1995).

We hypothesized that associations would be found between behavior and breed in purebred cats. In addition, we hypothesized that associations independent of breed would be found between behavior and coat color, coat pattern, and eye color.

Materials and methods

Selection of breeds and phenotypes

Included breeds comprised those recognized by 3 major international cat registries: The International Cat Association, the World Cat Federation, and The Cat Fanciers' Association. Physical characteristics included coat color, coat pattern, and eye color. Each characteristic was subdivided into phenotypes with a known genetic basis. Coat colors reflected allelic variation at the agouti, black/brown (Lyons et al., 2005a; Schmidt-Kuntzel et al., 2005), red (Schmidt-Küntzel et al., 2009), white (Bergsma & Brown, 1971), dilution (Ishida et al., 2006), and dilution modifier loci (Robinson, 1991; Robinson, 1991). These loci are responsible for the agouti, black, brown, cinnamon, blue, lilac, fawn, caramel, taupe, red, cream, blue cream, apricot, and white colors recognized in domestic cats. In addition, coat patterns were selected to represent variation at the following loci: albinism (Thompson et al., 1943; O'Brien et al., 1986; Lyons et al., 2005b; Schmidt-Kuntzel et al. 2005; Imes et al., 2006), tabby patterning (Lomax & Robinson, 1988; Eizirik et al., 2010; Kaelin & Barsh, 2010; Kaelin et al., 2012), inhibition of melanin (Eizirik et al., 2003), production of pheomelanin (Peterschmitt et al., 2009), tortoiseshell patterning (Centerwall & Benirschke 1973), and piebaldness or white spotting (Cooper et al., 2006). See the Supplementary Materials (Item A) for a full list of included patterns, and Figure 1 for representative images. Eye color phenotypes included the copper, orange, amber, yellow, gold, hazel, and green common to most patterns and coat colors (Robinson, 1991). The eye color category also distinguished the blue and odd eyes of cats with a dominant W allele at the white locus (Bergsma & Brown, 1971), as well as blue, chartreuse, aquamarine, albino pink (Robinson, 1991), and albino blue eyes resulting from variation at the albinism locus (Turner et al., 1981).

Characterization of behavioral phenotypes

Behavioral phenotypes for each subject cat were generated via use of a retrospective survey. The basis for this survey constituted the Feline Behavioral Assessment and Research Questionnaire (Fe-BARQ), which uses 100 questionnaire items to generate a standardized behavioral profile composed of 20 discreet factors (Serpell, 2013). See the Supplementary Materials (Item B) for a complete list of factors. These factors, or behavior traits, were previously extracted by factor analysis from cat owners' responses to 149 questions intended to identify the behavior of the subject in multiple common scenarios. Scores represented the frequency of a behavior's occurrence, with increasing scores representing increasing frequency of the behavior addressed by a given question (0 = never, 1 = seldom, 2 = sometimes, 3 = usually, 4 = always). To generate a factor score, the scores for each question contributing to that factor were summed and divided by the number of contributing questions. An "unknown" response was also available for each question; such responses did not contribute to the factor score, and the sum of the contributing scores was divided by 1 less.

In addition to the 20 Fe-BARQ factor scores, the survey was modified to screen for the presence of common behavior pathologies (see Supplementary Materials Item D for the modified Fe-BARQ). None of the original Fe-BARQ questions were altered, but questions consistent with 6 behavior pathologies were identified, and several additional questions were incorporated. Question selection was based on the clinical signs reported for each of the following pathologies: fear-related aggression (Beaver, 2004; Moesta & Crowell-Davis, 2011), territorial aggression or inappropriate play behavior (Landsberg et al., 2003b; Crowell-Davis et al., 2004; Houpt, 2011; Houpt, 2011), redirected aggression (Heath, 2012), fear of noises (Levine, 2012), separation anxiety (Schwartz, 2002; Horowitz, 2012), and inappropriate elimination (both marking and toileting) (Landsberg et al., 2003a; Herron, 2010). To shorten the questionnaire, some pathologies for which clinical signs may overlap were combined. For instance, inappropriate toileting and marking may both result in urination outside of the litter box, and cats with either territorial aggression or inappropriate play behavior may stalk or ambush other household cats, without displaying distance-increasing vocalizations. See the Supplementary Materials (Item C) for a list of questions used to identify each pathology. For simplicity's sake, a subject was considered to exhibit a pathology if an answer other than "never" was returned for any of the contributing questions.

Data collection

The Fe-BARQ, modified as described to collect information about clinical behavior pathologies and physical appearance, was established as an open-access, online survey. The link to this survey was disseminated to the members of the World Cat Congress, which comprises The International Cat Association, the WCF, the CFA, and 4 additional international registries. These registries were asked to share the survey link with their members. In addition, the survey was promoted on social media (Facebook). Participants were asked to