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Correlates of Coprophagy in the Domestic Dog (*Canis familiaris)* as Assessed by Owner Reports

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Abstract

Coprophagy is a commonly observed behavior in domestic canids but little is known about the motivational mechanisms for feces eating in dogs. Some animals (rodents and lagomorphs) consume feces to recycle gut bacteria. Other animals do so when food is scarce or to aid predator avoidance through reduced foraging. Coprophagy is also seen in captive zoo animals, where poor welfare, stress and poor diet are believed to cause this behavior. Unfortunately, none of these situations describes the conditions under which coprophagy occurs in otherwise healthy canines.

This study uses a self-administered survey to determine what demographic, environmental, and behavioral variables are correlated with coprophagy, and to improve understanding of the motivational mechanisms behind the behavior. It was concluded that behavior and medical health are better predictors of coprophagy than environmental factors. Neutering drastically increases the prevalence of coprophagy for male dogs but spaying has no effect on females. This study shows that dogs with anxiety or oral disorders (pica and plant eating) engage in coprophagy more than their healthy counterparts, indicating that coprophagy may also be a comfort-seeking or pleasurable act that temporarily alleviates stress.

Introduction

Almost one-half of the domestic canine population consumes feces at some point in their lives (Boze, 2008, pp. 22–28). Coprophagy is not seen in wild canines except when bitches eat the feces of their pups (Houpt, 1982, pp. 683–691), coyotes (*Canis latrans*) eat the feces of an intruder and replace it with their own as a territorial display (Livingston, Gipson, Ballard, Sanchez, & Krausman, 2005, pp. 172–178), or ungulate feces are consumed for their antioxidant and immunostimulant properties (Houpt, 1982, pp. 683–691; Negro et al., 2005, pp. 807–808). The majority of feces-eating acts in domestic canines do not occur under these circumstances, nor does coprophagy aid in digestion or the health of the canine, making this behavior difficult to explain. Coprophagy has not been studied in feral dogs, and coprophagic events documented in wild canines are mentioned only in passing. For example, Zarnke et al. (2001, pp. 740–745), in a study of parvovirus and coronavirus transmission, observed consumption of frozen feces by wolves and suggested it may be the reason for increased antibody loads in the winter but did not explore that behavior.

There are two basic types of feces-eating behavior: caecotrophy, the ingestion of specific feces types (soft or hard pellets from animals whose digestive tract separates material into that which is complete waste and that which retains some nutrients or recyclable material); and coprophagy, a more general term referring to the consumption of feces from animals with only one type of feces. While coprophagy can describe the consumption of all fecal types, it can also be divided into subcategories, including autocoprophagy, where the animal eats its own feces, and allocoprophagy, where feces of a conspecific are consumed (Galef, 1979, pp. 295–299). For simplicity, coprophagy is used in this article to describe the consumption of all feces types, including that of other species.

Despite the frequency of coprophagic behavior in dogs, little is known about the motivating factors associated with it. Many owners, disgusted by feces eating, go to great lengths to prevent it. Owners will systematically add hot sauce or meat tenderizer to excrement to

deter consumption through taste aversion (Boze, 2008, pp. 22–28) or provide oral dietary supplements such as Deter® or Forbid® to aid digestion and make feces less desirable. Others try physical barriers like muzzles to prevent access to feces. Some owners even relinquish their pet or have it euthanized when attempts to prevent feces eating are unsuccessful. Unfortunately, veterinarians lack the necessary resources to advise clients, since the behavioral motivation is so poorly understood.

Myriad hypotheses attempt to explain this behavior, but supporting data are minimal. Adult canine coprophagy may be sustained by influences such as anxiety, boredom, and stress from limited territory or nutritional and psychological deficiencies. An imbalanced diet or pancreatic enzyme deficiency could trigger coprophagy as animals attempt to acquire the proper nutrients (Hart & Hart, 1985, pp. 123–124). In other cases, coprophagy is presumably sustained because the accompanying attention encourages the dog's unwanted behavior (Wells, 2003, pp. 51–53). Coprophagy may also be an exploratory behavior that increases with age.

Coprophagy is well documented in both wild and captive primates. It is remarkably more prevalent and occurs under more varied circumstances in captive chimpanzees (*Pan troglodytes*) than in wild chimpanzees. This increase is attributed to poor habitat, welfare and lack of environmental stimulation (Fritz et al., 1992, pp. 313–318). Many animals become unresponsive to their captive environment and show decreased motor performance and motivation. To deal with the boredom, some individuals attempt to increase environmental stimulation by engaging in behaviors such as coprophagy (Fritz et al., 1992, pp. 313–318). Evidence suggests that dietary changes can reduce the frequency of coprophagy in captive lowland gorillas (*Gorilla gorilla gorilla*), but the mechanism leading to its development and maintenance is not completely understood (Lukas, 1999, pp. 237–249). While some animals include feces in their diet when food is limited or during certain life stages, others practice coprophagy as a part of their natural metabolic cycle. This is not the case for primates or canines.

This study uses owner-reported observations to identify the behavioral, demographic, and environmental factors associated with coprophagy in the domestic dog (*Canis familiaris*).

Materials and Methods

Participants and Distribution

A self-administered survey containing questions about canine demographics, environment, health, and behavior was completed by 632 dog owners. All 632 surveys were used in analysis and comparative studies. The canine population in this study was assumed healthy based on vaccination records and assessment of several common symptoms that are indicative of digestive disorders (dry heaving, chronic diarrhea or vomiting, pica, and food allergies). Rabies and distemper vaccinations were current in 95% of the dogs, and 85% of the dogs were spayed or neutered. A variety of pure-bred and mixed-breed canines from 2 months to 21 years of age were included in the sample, with slightly more females (56%) than males (44%).

Data were collected from three sources: dog parks, a veterinary hospital, and an online survey. Four hundred and sixty-six responses were received online using SurveyMonkey® software, and 166 were collected at Countryside Animal Hospital, and Pine Ridge and Fossil Creek dog parks in Fort Collins, Colorado.

A web-based electronic link to the survey was distributed through online message boards and chat programs devoted to specific breeds and general dog care. Message boards included Yahoo, Google, and America Online citations, along with www.dog.com, www.forum.dogs.com, and www.ILoveDogs.com.

Surveys were collected at physical sites on both weekdays and weekends, during daylight hours. Every individual who entered the park during an observational period was asked to complete a survey, and every individual asked to

participate did so to completion. Respondents were asked to complete a survey about animal behavior, with no indication the study was about coprophagy. Respondents having more than one dog completed a separate survey for each dog.

Survey Design

The survey contained 52 questions in four general categories (Demographics, Environment, Care and Feeding, and Behavior). A total of 15 questions were open-ended, 25 were multiple choice, and 12 used a rating scale.

Demographics: Owners reported the dog's weight, sex, whether the dog was intact or not, breed, age, number of animals in the household (dog, cat, other), number of dogs in adjacent homes, and number and age of humans in the residence. Because only a few respondents included the age of household members, this question was discarded. Presence of other animals was also removed during analysis because of the small sample sizes for individual types of animals. Owners reported their dog's breed, if known, which was classified by the standard American Kennel Club category for analysis. Other breed differences analyzed include face shape, leg length, herding and nonherding, sight versus scent hounds, dogs bred for guarding, and mixed-breed versus pure-bred dogs.

Environment: Owners reported their residence type and the area (in square feet) of both indoor and outdoor space available to the canine. They further reported the presence of a dog door in the home, percentage of time the dog spent outside, hours the dog spent alone per day, amount of human interaction with the dog (divided into several activity types), time spent exercising, and presence of toys believed to enrich the dog's environment (Houpt, 1985, pp. 248–261; Loveridge, 1998, pp. 101–113).

Care and Feeding: Information was gathered on each dog's vaccination record; presence of common disorders; types, proportions and frequency of feeding (dry or canned food, table scraps, other); and administration of vitamin or enzyme supplements.

Behavior: Owners reported the presence or absence of coprophagic behavior, their level of concern about the coprophagy, and the frequency with which their dog attempted to consume various types of feces.

Statistical Analysis

A chi-square test for categorical data showed no difference in presence of coprophagy between data collection locations ($\chi^2 3 = 3.270$, $p = 0.351$), and data were pooled for analysis. The focal animals of this research are coprophagic canines, with noncoprophagic canines serving as a control. Unless stated otherwise, binary regression was used to test the effects of continuous variables on the presence of coprophagy, and multiple logistic regression was used to test the effect of several variables on each other and coprophagy at the same time. All statistical analyses were carried out using SPSS for Windows (Version 11.5).

Results

Demographics

Both pure-bred and mixed-breed canines between the ages of 2 months and 21 years, with a mean age of 4.8 ± 3.48 years (N = 632), were included in this study. Logistic regression analysis showed that age was not a good predictor of coprophagy ($p = 0.763$, odds ratio = 1.001), with approximately equal proportions of coprophagic and noncoprophagic dogs in different age categories (see below). The hypothesis that puppies engage in exploratory coprophagy more frequently than adult canines is not supported by these data. Nor is there support for the hypothesis that coprophagy is more common in older dogs. Percentages of coprophagic canines in five age categories, with confidence intervals, are shown in Figure 1.

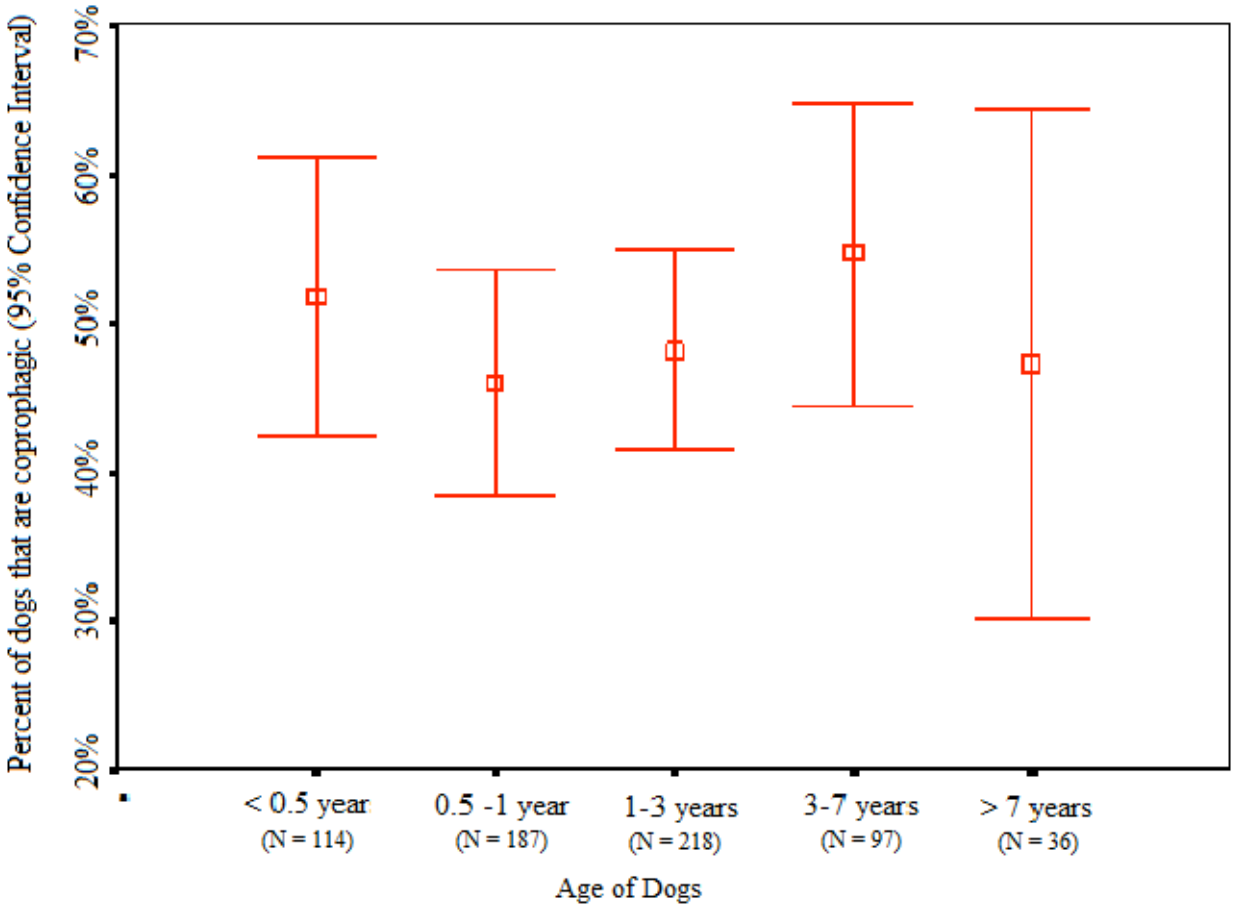

Figure 1. Proportion of coprophagic dogs within five age categories.

Coprophagy correlates positively with sex and sexual status. The proportion of intact female dogs currently engaging in coprophagy is greater than that for intact males. Neutering appears to increase the proportion of coprophagic dogs from 34% to 55.8%; while spaying does not alter the proportion of coprophagy in female dogs (Figure 2). The effect of sex and sexual status on the presence of coprophagy was tested using multilayered chi-square analysis.

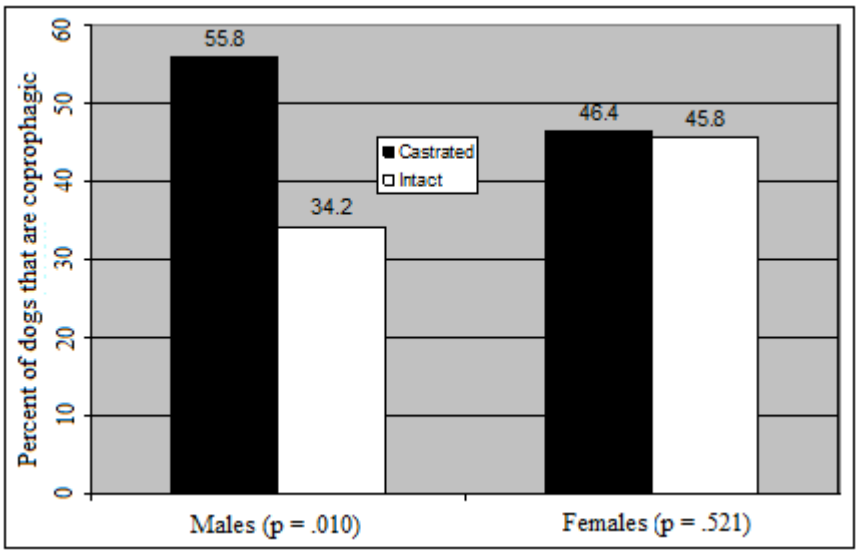

Figure 2. Frequency of coprophagy in castrated versus intact dogs (N = 632).

Although logistic regression shows that a dog's weight is a significant predictor of coprophagy, it does not follow a linear trend. An in-depth analysis, with weight categories based on pharmaceutical standards (0–10, 11–25, 26–50, 51–100, and 101+ pounds), provides better detail (Table 1). Coprophagic dogs, averaging 53 pounds, are slightly heavier than noncoprophagic dogs, averaging 46 pounds. Of the 51–100-pound dogs, 59.2% are coprophagic, compared with 43.8% ± .02% of other dogs.

Table 1. Percentage of coprophagic dogs by weight category (N = 632).

Weight (pounds)	Number of dogs	Percentage coprophagic
0–10	62	43.6
11–25	158	40.5
26–50	125	44.8
51–100	239	59.2
Above 100	48	45.2

Two individual breed groups were analyzed to test for obesity versus size. Golden retrievers (N = 22) and labrador retrievers (N = 21) were the most common breeds in the study and were pooled for analysis. Individuals within these two categories that exceeded the standard weight specified for breed and sex were compared with those in the normal range (60–80 pounds for males, 55–70 pounds for females). There was no significant difference in coprophagy between overweight and average-weight dogs ($p = 0.270$, N = 23).

To test for effect of size within breeds, dogs were divided into the standard American Kennel Club groupings (hound, herding, toy, working, sporting, nonsporting, and terrier). Sporting dogs, the most common class in the 51–100-pound range, were more likely to be coprophagic than other dogs in the study, with a frequency of coprophagy of 67%. Other breeds demonstrated a consistent frequency of coprophagy, averaging 45.9%.

Environment

Coprophagy does not appear to be a territorial behavior for domestic canines. When tested as single variables, coprophagy is not altered by the presence of other canines in the dog's primary residence ($\chi^2 6 = 4.617$, $p = 0.929$) or in adjacent households ($p = 0.229$, odds ratio = 1.038). The hypothesis that dogs engage in same-species coprophagy when feces are more readily available is not supported. Neither the amount of time spent outside ($p = 0.85$, odds ratio = 0.99) nor the frequency of feces removal from the yard ($\chi^2 4 = 2.860$, $p = 0.75$), both of which increase canine encounter rates with feces, is significantly related to coprophagy.

Care and Feeding

The majority (89%) of domestic dogs in this study were fed dry food with supplemental wet food, table scraps or fresh meat. Dogs fed on a schedule (537 of 632, 84.9%) versus those that free-fed ate an average of 1.9 ± 0.53 times per day. There was no difference in the presence of coprophagy based on feeding schedule alone ($\chi^2 4 = 2.47$, $p = 0.89$); see Table 2. There was also no difference in coprophagy based on regular vitamin or enzyme supplements in the diet ($\chi^2 1 = 0.32$, $p = 0.57$), suggesting that coprophagy is not a dietary disorder.

Table 2. Percentage coprophagy based on feeding schedule.

Times fed per day	1	2	3	4 or more	Free feeding
Percentage coprophagic	43.1	50.8	53.6	42.8	46.0

Coprophagy appears to be associated with oral and digestive disorders. Coprophagic dogs also engage in pica, a disorder in which an animal has an appetite for nonfood items. Ten percent of coprophagic dogs consume foreign objects, compared with 4.7% of noncoprophagic dogs. While plant eating is considered a type of pica, it was separated from pica in this study and found to be more common in coprophagic dogs.

Anxiety disorders, often associated with pica, were reported more frequently in dogs consuming feces of other canines. This does not hold true for general feces eaters or canines who consumed herbivorous animal feces. The causes of anxiety in dogs who consumed canine feces are unknown. Table 3 shows the relationship of coprophagy with several symptoms associated with digestive disorders and unwanted behaviors (dry heaving, chronic diarrhea, vomiting, plant eating, food allergies, pica and anxiety disorders).

Table 3. Relationship between coprophagy and common disorders in *Canis familiaris*.

Disorder	All feces-eating dogs (N = 632) *p* (% coprophagic with disorder, % noncoprophagic with disorder)	Dogs eating dog feces (N = 162) *p* (% coprophagic with disorder, % noncoprophagic with disorder)	Dogs eating feces of herbivores (N = 138) *p* (% coprophagic with disorder, % noncoprophagic with disorder)
Dry heaving	0.115 (5.1, 8.4)	0.038 (1.4, 9.1)	0.081 (2.7, 10.9)
Diarrhea	0.571	0.734	1.00
Vomiting	0.205	1.00	1.00
Plant eating	0.017 (17.7, 11.2)	0.289 (12.5, 6.9)	0.313 (16.2, 9.4)
Food allergy	0.159	0.155	0.631
Pica	0.006 (10.6, 4.7)	0.734 (6.6, 4.6)	0.339 (9.5, 4.7)
Anxiety	0.559 (14.1, 12.5)	0.037 (20.0, 8.0)	0.637 (13.5, 17.2)

Note. Shaded boxes indicate significant relationships ($p < 0.05$) between coprophagy and given disorder. *p*-values are for one-way analysis of variance.

Although human interaction is extremely important to the health and wellbeing of domestic canines (Houpt, 1985, pp. 248–261), no type or amount of human interaction—including exercise, training, or play—is significantly related to the presence of coprophagy (Table 4).

Table 4. Regression results for human interaction variables and their effect on coprophagy.

Type of human interaction	Odds ratio	Significance (*p*-value)
Time dog spends alone	0.934	0.218
Interaction time with human (independent of interaction type)	1.00	0.738
Amount of exercise	1.004	0.124
Amount of training	1.002	0.423
Time playing fetch	1.000	0.900
Time playing tug	1.002	0.398

Discussion

Behavioral and medical indicators appear to be better predictors of coprophagy than environmental ones. A survey-based study is limited to identifying correlated variables and cannot identify or prove causation of coprophagy.

Behavioral

Dominant behaviors are known to decrease in castrated males (Hart, 1991, pp. 1204–1205). However, coprophagic behavior did not seem to change with castration in males. Future research should address coprophagy in the context of dominant or control-seeking behavior, with physical observation of temperament and associated anxiety-related disorders in coprophagic dogs. Alternative experiments could be done in other species exhibiting well-established social hierarchies or easily observable aggression (cockroaches, rabbits, rats, etc).

The hypothesis that puppies engage in coprophagy as an exploratory behavior more frequently than older dogs (McKeown, Luescher, & Machum, 1988, pp. 849–850) is not supported. If age were a motivating factor for coprophagy, dogs less than 6 months of age and 6 months to 1 year would have exhibited greater

coprophagic behavior, but this was not the case (Figure 1). It is possible that puppies engaging in this behavior prior to 8 weeks of age would not have been captured by this study.

Environmental

None of the environmental indicators studied were significant predictors of coprophagy. Neither lack of human interaction nor poor environment (defined as lack of toys, minimal exercise and play) correlated with coprophagy. While sociality with humans (Houpt, 1982, pp. 683–691), availability of manipulatable toys (Houpt 1985, pp. 248–261; Loveridge, 1998, pp. 101–113), available space (Beerda, Schilder, Van Hoof, de Vries, & Mol, 1999, pp. 233–242), and exercise do not show positive correlation with coprophagy, they are important to general canine health and wellbeing. The results were surprising because data on treatments and prevention of coprophagy indicate that human interaction—through preventing access to feces, rewarding good behavior, and distraction—are the most effective ways to prevent coprophagy (Boze, 2008, pp. 22–28). However, the dog owners in this study were at a dog park, a veterinary office or an online email list about dogs, possibly biasing the sample toward more dedicated pet owners. This sample may not adequately represent the lower end of the spectrum, and another sampling methodology may better represent the more barren environments and less-than-ideal pet care practices.

It is difficult to determine if opportunity or availability of feces best predicts coprophagy because opportunity was defined as the frequency with which feces were removed from the yard. Opportunity is presumed to be inversely related to the frequency with which feces are removed. However, many owners remove dog feces from their yard, but other animals' feces may be encountered outside the yard and/or on walks, which is unrelated to the rate of removal. It is therefore possible that availability and opportunity data only address the consumption of canine feces and not those of other animals. Data did show that dogs living with cats were more likely to consume feces (regardless of type) than those who do not live with cats. This is not seen in the previous test for opportunity because cats frequently excrete in different locations from dogs. Thus, opportunity may predict coprophagy but it cannot be systematically evaluated based on the frequency of feces removal from the yard. Because dogs consume many types of feces, future research should focus on types of feces and the locations in which dogs would have access to them.

Diet and feeding schedule are frequently regarded as primary causes of coprophagy (Hart & Hart, 1985, pp. 123–124; Meriweather & Johnson, 1980, pp. 774–775; Read & Harrington, 1981, pp. 984–991). More recent research on diet and coprophagy is limited. Westermark and Wiberg (2006, pp. 225–229) focused on pancreatic enzyme deficiency but found no relationship. The lack of relationship between enzyme supplements and coprophagy in this study is consistent with Westermark and Wiberg's findings. There was also no difference in coprophagy based on the frequency of feeding. It is possible, of course, that diet affects coprophagy in ways that cannot be addressed by this dataset (e.g. nutritional content of food).

Medical

Vaccination histories were incomplete since unvaccinated dogs are indistinguishable from dogs with unknown medical histories. It could be assumed that owners who did not know if their dog had never been vaccinated would not affect the other variables significantly. Because this was used only for determining general health, it should not affect the analysis of coprophagy and its correlated behavioral and environmental factors.

Houpt (1982, pp. 683–691) demonstrated that it is not uncommon for female canines to eat the feces of their young, whereas males rarely do. This research found no effect of sex on coprophagy when tested as a single variable. It has been previously shown that spayed and neutered dogs demonstrate behavioral characteristics associated with normal sex roles (Hart, 1991, pp. 1204–1205). However, behaviors minimized with castration are more pronounced in males than females and can include urine marking, mounting other animals,

and aggressive fighting (Hart, 1991, pp. 1204–1205). Behaviors not altered by neutering include barking, hunting, playfulness, and affection seeking (Hart, 1991, pp. 1204–1205). Sexual status (castrated versus intact), like sex, when tested alone, did not affect the frequency of coprophagy. When sexual status and sex are tested as interaction variables, data support Hart's 1991 finding that castration affects males more than spaying affects females. Castration increased the percent of comprophagic males dogs from 34% to 55%, while spaying caused only a small, insignificant change in females.

Neutered males more affected by the hormonal changes associated with castration (Hart, 1991, pp. 1204–1205) may use coprophagy to search for testosterone. While beyond the scope of this research, the effect of testosterone on motivation for coprophagy could be tested with physical assays of testosterone levels in feces and consumption preference of both neutered and intact males.

In order to test for effects of medical health on coprophagy, dog owners were asked to report the presence of seven symptoms or behaviors that could indicate gastrointestinal and overall health (dry heaving, chronic diarrhea, chronic vomiting, ingestion of plant or dirt material, food allergies, pica, and anxiety or stress disorders). Definitions of stress disorders, while usually self-explanatory, were left open to owner interpretation. Because owners reported only the presence of a symptom or disorder, correlations with intensity were not possible; this may be illuminating in future studies.

Anxiety and stress disorders were more common in coprophagic dogs. The most common disorder was separation anxiety (a strong attachment to a single individual and distress when separated from that individual), often considered an extreme manifestation of the dog's social nature (King et al., 2004, pp. 233–242). Dogs exhibited distress through increased urination/defecation, vocalization, and destruction. This research supports the inclusion of coprophagy to that list.

Behaviors associated with anxiety in dogs are similar to those of submission. Both anxious and submissive dogs will avoid encounters with other dogs and stay close to an individual they see as a "protector." Future research should observe the focal canines and ask the owners about behaviors that represent anxiety and submission.

Dogs with oral disorders frequently engaged in coprophagy. Pica and plant eating are more common in coprophagic dogs. Within the more specific groups (dog-feces eaters, herbivorous-feces eaters), a similar but nonsignificant trend was seen, perhaps because of the small sample size. Literature suggests that the causes of pica are similar to those of coprophagy, but neither behavior is well studied. Suggested causes of pica include dietary deficiencies, boredom, an extension of juvenile behaviors, or attention seeking. None of these hypotheses have been experimentally tested. Beecroft, Bach, and Turnstall (1998, pp. 638–641) suggest that pica is related to cognitive and neuropsychological deficits and may be a symptom of anxiety as well. To fully understand coprophagy, additional investigation of pica and its relation to anxiety, submission, and boredom are necessary.

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References

Beecroft, N., Bach, L., & Turnstall N. (1998). Case report: an unusual case of pica. *International Journal of Geriatric Psychiatry*, *13*, 638–641.

Beerda, B., Schilder, M. B., Van Hoof, J. A., de Vries, H. W., & Mol, J. A. (1999). Chronic stress in dogs subjected to social and spatial restriction. I. Behavioral responses. *Physiology and Behavior*, *66*(2), 233–242.

Boze, B. (2008). A comparison of common treatments for coprophagy in *Canis familiaris*. *Journal of Applied Companion Animal Behavior*, *2*(1), 22–28.

Fritz, J., Macki, S., Nash, L., Martin, T., & Matevia, M. (1992). The relationship between forage material and levels of coprophagy in captive chimpanzees. *Zoo Biology*, *11*, 313–318.

Galef, B. G. (1979). Investigation of the function of coprophagy in juvenile rats. *Journal of Comparative Physiological Psychology*, *93*, 295–299.

Hart, B. L., & Hart, L. A. (1985). *Canine and feline behavioral therapy* (pp. 123–124). Lea and Febiger, Philadelphia.

Hart, B. L. (1991). Effects of neutering and spaying on the behavior of dogs and cats: Questions and answers about practical concerns. *Journal of the American Veterinary Medical Association*, *198*(7), 1204–1205.

Houpt, K. (1982). Ingestive behavior problems of dogs and cats. *Veterinary Clinics of North America: Small Animal Practice*, *12*(4), 683–691.

Houpt, K. (1985). Companion animal behavior: A review of dog and cat behavior in the field, the laboratory and the clinic. *Cornell Vet*, *75*, 248–261.

King, J. N., Simpson, B. S., Overall, K. L., Appleby, D., Pageat, P., Ross, C., Chaurand, J. P., Heath, S., Beata, C., Weiss, A. B., Muller, G., Paris, T., Bataille, B. G., Parker, J., & Petit, S. (2004). Treatment of separation anxiety in dogs with clomipramine: Results of a follow-up investigation to a clinical trail testing the efficacy of clomipramine in the treatment of separation anxiety in dogs. *Applied Animal Behaviour Science*, *89*(4), 233–242.

Livingston, T. R., Gipson, P. S., Ballard, W. B., Sanchez, D. M., & Krausman, P. R. (2005). Scat removal: a source of bias in feces-related studies. *Wildlife Society Bulletin*, *33*(1), 172–178.

Loveridge, G. G. (1998). Environmentally enriched dog housing. *Applied Animal Behavior Science*, *59*, 101–113.

Lukas, K. E. (1999). A review of nutritional and motivational factors contributing to the performance of regurgitation and reingestion in captive lowland gorillas (*Gorilla gorilla gorilla*). *Applied Animal Behavior Science*, *63*(3), 237–249.

McKeown, D., Luescher, A., & Machum, M. (1988). Coprophagia: food for thought. *Canadian Veterinary Journal*, *28*, 849–850.

Meriweather D., & Johnson, M. K. (1980). Mammalian prey digestibility by coyotes. *Journal of Mammalogy*, *61*, 774–775.

Negro, J. J., Grande, J. M., Tella, J. L., Garrido, J., Hornero, D., Donazar, J. A., Sanchez-Zapata, J. A., Benitez, J. R., & Barcell, M. (2005). An unusual source of essential carotenoids. *Nature*, *416*, 807–808.

Read, D. H., & Harrington, D. D. (1981). Experimentally induced thiamine deficiency in beagle dogs: Clinical observations. *American Journal of Veterinary Research*, *42*(6), 984–991.

Wells, D. L. (2003). Comparison of two treatments for preventing dogs eating their own faeces. *Veterinary Record*, *153*, 51–53.

Westermark, E., & Wiberg, M. E. (2006). Effects of diet on clinical signs of exocrine pancreatic insufficiency in dogs. *Journal of American Veterinary Medical Association*, *228*(2), 225–229.

Zarnke, R. L., Evermann, J., VerHoef, J. M., McNay, M. E., Boertje, R. D., Gardner, C. L., Adams, L. G., Dale, B. W., & Burch, J. (2001). Serologic survey for canine coronavirus in wolves from Alaska. *Journal of Wildlife Diseases*, *37*, 740–745.