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Association Between Protein Content in Dry Dog Food and Aggression in Golden Retriever Dogs

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ABSTRACT

The objective of this study is to evaluate the relationship between protein content in commercially available dry food and behavioral scores collected via a validated behavior questionnaire. Health and lifestyle factors were obtained from owner-completed questionnaires for golden retrievers participating in a prospective canine health study, eating commercially available dry food as $\geq 80\%$ of the daily intake. Diets were categorized as high ($\geq 30\%$), medium (21–29%), or low ($\leq 20\%$) protein levels. Ten behavioral outcomes from a validated survey were used as outcome measurements. The association of dietary protein level and behavior outcomes were estimated using logistic regression, adjusting for sex, reproductive status, and dog's primary lifestyle. Compared with dogs fed medium-protein diets, dogs fed high-protein diets were 1.3 times more likely to have dog rivalry (95% CI, 1.02–1.78). The dogs fed low-protein diets were 1.4 times more likely to have separation-related behavior (95% CI, 1.01–2.03). When assessing and treating aggression and separation related-behaviors, clinicians should evaluate and weigh the importance of several factors, including the diet being fed. (*J Am Anim Hosp Assoc* 2025; 61:90–95. DOI 10.5326/JAAHA-MS-7477)

Introduction

Behavioral problems are a leading cause of relinquishment to shelters and a break in the human-animal bond, and aggressive behaviors are a commonly cited behavioral reason for euthanasia.¹ A retrospective study of cases seen at the Animal Behavior Clinic at Cornell University between the years 1991 and 2001 found that aggression was diagnosed in more than 70% of the dogs evaluated.² Scientists and owners alike have been interested in the relationship between diet and behavior, leading to various studies that have examined this relationship.

Previous studies have suggested that diets that are higher in protein may be linked to increased aggression in dogs; thus, lower-protein diets have been recommended for dogs displaying aggressive behaviors.^{3–5} It is thought that low dietary protein intake may facilitate the transportation of the amino acid tryptophan across the blood-brain barrier, which would increase serotonin formation, as

tryptophan is one of the precursors of serotonin. Several studies in various species have suggested that serotonin has an inhibitory role in the control of aggressive behavior.⁶ One study found that dogs with territorial aggression had lower owner-reported aggression scores when the dogs were fed low- and medium-protein diets.⁴ Another study evaluated the effect of high- and low-protein diets, with or without tryptophan supplementation, on the behavior of dogs. Owner-reported behavioral scores for territorial aggression and for what was previously called dominance aggression, presently identified as owner-directed aggression, were highest in dogs fed the unsupplemented high-protein diet. Tryptophan-supplemented low-protein diets were associated with lower behavioral scores for aggression compared with unsupplemented low-protein diets. The conclusion of this study was that, for dogs with territorial aggression, tryptophan supplementation of a low-protein diet may be helpful in reducing aggression.³ The majority of these studies were conducted approximately 20 yr ago. In the intervening

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GRLS (Golden Retriever Lifetime Study)

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years, there have been many changes in our understanding and diagnosis of aggression, as well as evolving trends in pet food. As such, it is prudent to revisit this question with contemporary data using a validated behavior questionnaire.

The objective of this study was to evaluate the relationship between protein content in commercially available dry food and behavioral scores in golden retrievers enrolled in the Golden Retriever Lifetime Study (GRLS) via a validated behavior questionnaire. The GRLS is a prospective cohort study investigating nutritional, environmental, lifestyle, and genetic risk factors for cancer and common diseases in dogs.⁷ Based on the results from previous studies, the hypothesis was that golden retrievers fed commercially available dry food with a higher percentage of protein would have higher aggression scores on the validated behavior questionnaire compared with dogs fed diets with a lower percentage of protein.

Materials and Methods

Study Population

This study was conducted using data from the GRLS cohort. Detailed recruitment and data collection for participants have been described previously.⁷ Briefly, privately owned pedigree-confirmed golden retriever dogs between 6 mo and 2 yr of age were recruited from the continental United States from 2012 to 2015. Annual data collection includes an owner questionnaire (GRLS Annual Owner Questionnaire; <https://www.morrisanimalfoundation.org/sites/default/files/filesync/GRLS-Annual-Owner-Questionnaire.pdf>), veterinarian examination and questionnaire, and laboratory sample collection and banking. Only participating dogs with both an owner- and veterinarian-completed questionnaire completed between 4.5 and 5.5 yr of age were eligible for inclusion in this study. The GRLS study protocol was reviewed and approved by Morris Animal Foundation's Animal Welfare Advisory Board, and all participating owners and veterinarians completed written informed consent.

Variables of Interest

Signalment, diet, behavior, lifestyle, and supplement data were obtained from owner questionnaires. Detailed information about the diets included the brand, formulation, and guaranteed analysis of crude protein, fat, fiber, and moisture content. We categorized the guaranteed analysis crude protein minimum percentages based on prior studies, with low-protein measured as $\leq 20\%$, medium-protein 21–29%, and high-protein $\geq 30\%$.^{3,4}

Behavioral questions were assessed via the previously validated 100-question Canine Behavioral Assessment & Research Questionnaire.^{8,9} For our study, 10 of the 14 factors were investigated: stranger-directed aggression, owner-directed aggression, dog-directed

aggression, dog rivalry (defined as threatening or hostile responses to other familiar dogs in the same household), nonsocial fear (such as sudden or loud noises, unfamiliar objects or situations), stranger-directed fear, dog-directed fear, separation-related behaviors, attachment and attention seeking, and touch sensitivity (defined as fearful or wary responses to potentially painful procedures such as grooming). Factors contain 4 to 10 questions, with each question scored as 0–4. Depending on the question, these scales were either never to always or none to severe. To receive a score for a factor, owners had to have answered 80% or more of the related questions.

Data on potential confounding variables were considered, including sex, spay/neuter status, age at spay/neuter (<1 yr, ≥ 1 yr), owner-reported primary activity (companion/pet versus other), and where the dog was acquired (breeder versus other). In addition, we evaluated the history of any musculoskeletal disease diagnoses as reported on the annual veterinarian questionnaires, as pain could influence patient behavior.¹⁰ Information on behavior-modifying medications or supplements, such as antianxiety medications and nutraceuticals, was obtained from both owner and veterinarian questionnaires.

Statistical Analysis

We selected dogs who were currently eating commercially available dry dog food for at least 80% of their diet. Dogs were excluded if they were fed a prescription diet to treat liver or kidney disease or received daily behavior medications or supplements.

For each behavior factor, the maximum score across all questions within a factor was used for analysis. The maximum score was subsequently categorized as none (maximum score 0) versus any (maximum score 1–4). Dogs with a missing score for a factor were excluded from the corresponding analysis (Table 1).

Odds ratios and 95% CIs from multivariable logistic regression models were used to approximate the relative risks for the association of dietary protein content and each behavior factor. Separate models were evaluated for each behavior factor (any versus none). A backward stepwise approach was used to determine model covariates, with $P < .05$ considered significant.

Results

We initially identified 2427 dogs that met the initial inclusion criteria. Those dogs who were not currently eating commercially available dry food as $\geq 80\%$ of their diet ($n = 791$), were fed a prescription liver or kidney diet ($n = 3$), and/or had daily behavioral supplements or medications ($n = 15$) were eliminated from the study, resulting in 1618 dogs in our analytic data set.

TABLE 1**Multivariable Logistic Regression Results for the Association of Dietary Protein Level and Behavioral Factors of Interest**

Behavioral Factor	Total*	Low-Protein Number	Low-Protein Percentage	Low-Protein OR†	Low-Protein (95% CI)	P Value	High-Protein Number	High-Protein Percentage	High-Protein OR†	High-Protein (95% CI)	P Value
Stranger-directed aggression	1562			1.19	(0.82–1.72)	.357			0.97	(0.76–1.25)	.840
Any		93	10%				199	21%			
None		50	8%				142	23%			
Owner-directed aggression	1596			1.21	(0.76–1.92)	.419			1.39	(1.00–1.94)	.051
Any		26	11%				60	25%			
None		120	9%				288	21%			
Dog-directed aggression	1486			1.10	(0.76–1.59)	.616			1.20	(0.92–1.56)	.187
Any		88	10%				205	22%			
None		51	9%				113	20%			
Dog rivalry	1360			1.15	(0.77–1.73)	.502			1.35	(1.02–1.78)	.037
Any		40	9%				108	25%			
None		78	8%				184	20%			
Nonsocial fear	1563			1.01	(0.63–1.60)	.982			0.85	(0.64–1.14)	.287
Any		115	9%				255	21%			
None		25	8%				87	27%			
Stranger-directed aggression	1581			1.26	(0.85–1.85)	.249			0.71	(0.52–0.97)	.029
Any		43	12%				61	16%			
None		100	8%				287	24%			
Dog-directed fear	1485			1.31	(0.86–1.97)	.208			1.12	(0.85–1.47)	.435
Any		103	10%				222	21%			
None		34	8%				99	22%			
Separation-related behavior	1593			1.43	(1.01–2.03)	.044			0.65	(0.50–0.85)	.001
Any		77	12%				112	17%			
None		69	7%				232	25%			
Touch sensitivity	1553			1.44	(0.99–2.10)	.056			0.94	(0.73–1.21)	.634
Any		92	11%				178	20%			
None		47	7%				163	24%			

*Total number of dogs that had a nonmissing score for that factor.

†ORs and 95% CIs are shown. All models are adjusted for owner reported primary activity (companion/pet (ref) versus working) and sex and age at spay/neuter (female spayed <1 yr (ref), female spayed ≥1 yr, female intact, male neutered <1 yr, male neutered ≥1 yr, male intact). ORs for low- and high-protein diets are compared with medium-protein diets.

OR, odds ratio.

Primary activity and where the dog was acquired were highly correlated, and because primary activity was a stronger predictor of diet fed, we used that variable for the analysis. Of the dogs in our analytic data set, 149 were fed a low-protein diet, 349 ate a high-protein diet, and 1120 ate a medium-protein diet. More than 75% of the dogs were spayed or neutered ($n = 1258$), the majority before 1 yr of age ($n = 755$; 46.6%). The vast majority of the dogs in this study were acquired from breeders ($n = 1528$; 94.4%) and had a primary role of companionship ($n = 1429$; 88.3%) (Table 2). The remaining 11.7% ($n = 189$) of dogs were considered working, which includes roles in therapy or as a service animal, show dogs, or for breeding purposes. Dogs who were classified as working were more likely to be fed a high-protein diet than companion dogs. Many people believe that a working dog needs more protein; however, this only applies to certain types of work, such as high-endurance and high-intensity activities.¹¹

When behavior scores were evaluated for each factor, there were very few dogs with scores of 3 or 4 in any category, so we elected to dichotomize as “any” (maximum score 1–4) versus “none” (maximum score 0) for analysis. The attachment and attention-seeking factor was an exception to this; 97% ($n = 1575$) of dogs had moderate to severe (maximum score 2–4) attachment and attention seeking, so we were unable to perform statistical analyses on this factor (Supplementary Table 1).

After backward stepwise selection, all models adjusted for primary activity (companion/pet versus working) and a combination of sex and age at spay or neuter variable (female spayed <1 yr/female spayed ≥ 1 yr/female intact/male neutered <1 yr/ male neutered ≥ 1 yr/male intact). Compared with dogs fed medium-protein diets, dogs fed high-protein diets were 1.3 times more likely to have dog rivalry (95% CI, 1.02–1.78), 0.71 times as likely to have stranger-directed fear (95% CI, 0.52–0.97), and 0.65 times as likely to have separation-related behavior (95% CI, 0.50–0.85) (Table 1). Dogs fed low-protein diets, when compared with dogs fed medium-protein diets, were 1.4 times more likely to have separation-related behavior (95% CI, 1.01–2.03). There was no statistically significant association between dietary protein level and stranger-directed aggression, owner-directed aggression, dog-directed aggression, nonsocial fear, dog-directed fear, or touch sensitivity.

Discussion

The goal of this study was to assess the association between protein content in commercially available dry dog food and dog behavior via a large-scale study of golden retriever dogs. The results of our study demonstrated that, compared with dogs fed medium-protein diets, dogs fed high-protein diets were more likely to have dog rivalry and less likely to have separation-related behavior or stranger-directed fear. Dogs fed low-protein diets, when compared with the dogs fed

TABLE 2

Study Population Demographics, Stratified by Dietary Protein Level

Variables	Overall ($n = 1618$)	Overall Percentage	Low-Protein ($n = 149$)*	Low-Protein Percentage*	Medium-Protein ($n = 1120$)	Medium-Protein Percentage	High-Protein ($n = 349$)	High-Protein Percentage
Sex and age at spay/neuter								
Female <1 yr	423	26.1%	51	34.2%	312	27.9%	60	17.2%
Female ≥ 1 yr	221	13.7%	19	12.8%	151	13.5%	51	14.6%
Female intact	160	9.9%	5	3.4%	106	9.5%	49	14.0%
Male <1 yr	332	20.5%	41	27.5%	234	20.9%	57	16.3%
Male ≥ 1 yr	282	17.4%	20	13.4%	197	17.6%	65	18.6%
Male intact	200	12.4%	13	8.7%	120	10.7%	67	19.2%
Musculoskeletal disease present	96	5.9%	12	8.1%	67	6.0%	17	4.9%
Primary activity								
Companion/pet	1429	88.3%	138	92.6%	1000	89.3%	291	83.4%
Working	189	11.7%	11	7.4%	120	10.7%	58	16.6%
Where acquired								
Breeder/self-bred	1528	94.4%	137	91.9%	1054	94.1%	337	96.6%
Other	90	5.6%	12	8.1%	66	5.9%	12	3.4%

*Protein level was categorized based on guaranteed analysis: crude protein minimum percentage as low ($\leq 20\%$), medium (21–29%), or high ($\geq 30\%$). All dogs were between 4.5 and 5.5 yr of age at the time of survey completion.

medium-protein diets, were more likely to have separation-related behavior.

Our results support our hypothesis that dogs fed commercially available dry food with a high protein percentage ($\geq 30\%$) have higher aggression scores compared with dogs fed a medium protein percentage, in this population of golden retrievers at this one point in time when the questionnaire was being completed for the year. Specifically, we observed an increase in household dog rivalry among dogs fed high-protein diets. We also saw a trend toward increased owner-directed aggression; however, this did not reach our threshold for statistical significance. These results are in agreement with previous studies on territorial aggression.^{3,4} We found that dogs fed high-protein diets were less likely to have stranger-directed fear and there were no statistically significant associations between dietary protein levels and stranger-directed aggression, dog-directed fear, or unfamiliar dog-directed aggression. The previous studies did not examine stranger-directed fear. We are now identifying aggression as more likely being fear-based as opposed to the previous diagnostic description of “dominance aggression,”¹² but not all dogs with fear develop aggression. Fear is an emotional state that allows an individual to perform adaptive behaviors to manage perceived threats. In response to threatening stimuli, dogs may freeze to avoid detection, flee to escape the situation, or fight by showing aggression. Dogs who are not severely triggered will elect to freeze or flee.^{13,14}

Breed differences in behaviors, including aggression, have been previously identified. Golden retrievers have been shown to have lower aggression scores when compared with other breeds.^{15–18} Although golden retrievers may show fewer aggressive behaviors, they may display more distress behaviors. One study showed that golden retrievers demonstrated more distress behaviors when separated from their owners when compared with labrador retrievers.¹⁹ In our study, dogs fed low-protein diets were 1.4 times more likely to have separation-related behaviors, whereas dogs fed high-protein diets were less likely to have separation-related behaviors. These behaviors include vocalization and/or destructiveness, as well as autonomic signs of anxiety such as restlessness, loss of appetite, trembling, and excessive salivation. We have not identified any research linking dietary protein content and separation-related behaviors, but one study assessed the effect of tryptophan supplementation on anxiety-related behaviors, including owner separation. After 8 wk of eating the tryptophan-supplemented diet, the dogs’ responses in the behavioral tests were unaffected.²⁰

Working dogs and intact dogs were more likely to be fed a high-protein-content diet, which is why we adjusted for these categories in our analysis. Although difficult to elucidate from primary resources, reasons for this could include the culture in the show and working dog world and the types of diets that are recommended by

breeders, trainers, and other owners in those domains. Most breeders do not consult with a veterinarian or PhD-educated nutritionist when deciding what to feed their dogs, and more than 96% of breeders make specific diet recommendations to the people who purchase their puppies.^{21,22} It is also possible that working and show dogs may be more likely to be fed a nontraditional type of diet, such as homemade or raw, which could have higher protein. This is something we did not investigate, and none of the dogs included in our study were fed homemade or raw diets.

A limitation in our study was that we used the labeled crude protein content, which may not be directly comparable across diets owing to variations in moisture content. However, this is a commonly used measurement and is consistent with prior studies.^{3,4} In addition, there are other dietary factors to consider, including specific amino acids such as tryptophan, which is a precursor to serotonin. Low brain serotonin concentration has been implicated in aggression in clinical studies of humans and dogs.^{23–25} Previous studies examining the effects of tryptophan supplementation on behavior have suggested that supplementation of this amino acid may be correlated to lower levels of certain types of aggression. Tryptophan competes with other, large neutral amino acids for transportation across the blood-brain barrier and is found in low concentration in most protein sources. Thus, the lower the protein level in the diet, the higher the ratio of tryptophan to large neutral amino acids and tryptophan transport to the brain.⁵ We did not investigate what role specific amino acid composition may play in behavioral scores. However, we did exclude dogs that were receiving behavioral supplements, some of which contained tryptophan. Because the study by DeNapoli et al³ did not find differences in the plasma concentration of tryptophan despite different dietary concentrations, future studies that analyze tryptophan and serotonin levels will need to investigate the timing of sampling and/or consider different analytic methods.

For our study, it is important to note that these dogs were not our patients, nor were the clients surveyed specifically for problem behaviors; thus, none received a specific behavioral diagnosis. However, these dogs visited their veterinarian yearly for a complete examination and laboratory tests, the behavioral survey has been validated and used numerous times in research, and surveys have been found to be an effective manner to identify problem behaviors. The Canine Behavioral Assessment & Research Questionnaire scores have been shown to correlate with the veterinary behaviorist diagnoses of fear-related aggression directed toward unfamiliar people and unfamiliar conspecifics as well as separation-related distress behaviors.^{9,26–28}

Other limitations include the lack of specific information about the individual environment and training history for the dogs in the study. The GRLS does not include questions about training methods

implemented by owners. Whereas many owners may use reward-based training techniques, those who use directly confrontational techniques reported a response of aggression from their dogs,²⁹ which could influence how an owner might respond to aggression inquiries on a questionnaire.

Conclusion

The results of this study indicate that high levels of dietary protein are associated with household dog-directed rivalry in golden retrievers. Further research on other breeds is needed. There are numerous sources of information owners may seek and discover when making decisions about the health and well-being of their dogs. Ideally, this information will come from their veterinarian, who can consider all the various factors that may influence the physical and emotional health of the individual patient. When assessing, diagnosing, and treating aggression, anxiety, and separation-related behaviors, as well as other behavioral problems, clinicians must evaluate and weigh the importance of several factors including the history, environment, prior treatment or training, and owner goals. ■

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