

# Prevalence of protective antibody titers for canine distemper virus and canine parvovirus in dogs entering a Florida animal shelter

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**Objective**—To determine the proportion of dogs entering an animal shelter with protective antibody titers (PATs) for canine distemper virus (CDV) and canine parvovirus (CPV) and identify factors associated with having a PAT.

**Design**—Cross-sectional study.

**Animals**—431 dogs admitted to an open-admission municipal animal shelter in north central Florida with a history of infectious disease outbreaks.

**Procedures**—Blood was collected from dogs on the day of admission to the shelter. Antibody titers for CDV and CPV were measured by virus neutralization and hemagglutination inhibition, respectively. Age, sex, neuter status, address of origin, source (stray or previously owned), health status (healthy or not healthy), and outcome (adoption, euthanasia, or reclaimed by owner) data were also collected.

**Results**—Overall, 64.5% (278/431) of dogs had insufficient titers for antibodies against CDV, CPV, or both. A total of 153 (35.5%) dogs had PATs for both CDV and CPV, 33 (7.7%) had PATs for CDV but not CPV, 136 (31.5%) had PATs for CPV but not CDV, and 109 (25.3%) did not have PATs for either virus. Older dogs were more likely to have PATs for CDV and CPV. Neutered dogs were more likely to have PATs for CDV. Factors not associated with having a PAT included source, health status, and type of community from which the dog originated.

**Conclusions and Clinical Relevance**—Most dogs had insufficient antibody titers for CDV, CPV, or both at the time of admission to the animal shelter. Findings support current guidelines recommending vaccination of all dogs immediately upon admission to shelters, regardless of source or physical condition. (*J Am Vet Med Assoc* 2010;236:1317–1321)

Canine distemper virus and CPV are 2 of the most common causes of infectious disease in dogs. Both viruses are highly contagious and associated with high morbidity and mortality rates.<sup>1–5</sup> Dogs that are naturally exposed to these viruses and survive infection are generally considered to be immune to reinfection for life.<sup>3,4</sup> Vaccination against CDV and CPV is highly effective and confers long-lasting immunity, and current guidelines advise routine vaccination of all dogs against these viruses.<sup>2,5</sup> With the development and widespread administration of vaccines against CDV and CPV, outbreaks of disease are uncommon among pet dogs in developed countries. However, CDV and CPV continue to pose an important threat for unvaccinated dogs, particularly those in high-intensity housing such as shelters.<sup>1,5</sup> Dogs entering animal shelters vary in their health status and typically have unknown vaccination histories.<sup>5</sup> Recent-

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## ABBREVIATIONS

CDV	Canine distemper virus
CI	Confidence interval
CPV	Canine parvovirus
OR	Odds ratio
PAT	Protective antibody titer

ly, a number of outbreaks of CDV and CPV have been reported<sup>6–13</sup> in animal shelters in North America, leading to large losses of adoptable dogs secondary to disease, depopulation, and suspension of shelter services. In some cases, dogs in the incubation stage of infection were adopted into new homes or transferred to adoption groups, leading to additional spread of infection in the community. Local newspaper reports have also indicated that euthanasia of dogs infected with or exposed to CDV or CPV has been used to control outbreaks in shelters in California (84<sup>6</sup> and 51 dogs<sup>11</sup> in 2 separate outbreaks), Washington (> 60 dogs),<sup>7</sup> Ohio (34 dogs),<sup>8</sup> Illinois (> 100 dogs),<sup>9</sup> Florida (600 dogs),<sup>10</sup> Georgia (33 dogs),<sup>12</sup> and North Carolina (61 dogs).<sup>13</sup>

Current guidelines recommend vaccination of all dogs against CDV and CPV at the time of admission to animal shelters.<sup>2</sup> However, in many shelters, universal vaccination is considered cost prohibitive, particularly for dogs that are likely to be euthanatized after only

a few days. For this reason, many shelters do not follow the recommendation to routinely vaccinate all dogs immediately on intake. In addition, the proportion of dogs entering animal shelters that are already protected against disease because of prior vaccination or natural exposure is unknown.

Canine distemper virus and CPV antibody titers may be used to assess whether individual dogs are protected against infection.<sup>2-4</sup> Minimum PATs have been determined on the basis of resistance to experimentally induced infection.<sup>14-16</sup> The purpose of the study reported here was to determine the proportion of dogs with PATs for CDV and CPV at the time of admission to a Florida animal shelter with a history of outbreaks of CDV and CPV infection.

## Materials and Methods

**Study site**—The study was conducted in an open-admission municipal shelter located in north central Florida from August 1 to September 30, 2007. The population of the county in which the shelter was located was approximately 227,120 in 2006. The total number of animals admitted to the shelter in 2007 was 8,559, of which 4,605 were dogs. The shelter had a history of intermittent outbreaks of CDV and CPV infection, and a CDV outbreak that resulted in euthanasia of 600 dogs as a result of clinical disease or potential exposure to the virus had occurred between April and July 2007.<sup>10</sup>

**Animals**—Dogs entering the shelter between August 1 and September 30, 2007, were enrolled in the study. Information collected for each dog included date of intake, signalment (age, sex, and neuter status), address of origin, source (stray or previously owned), health status at intake (healthy or not healthy), and outcome (adoption, euthanasia, or reclaimed by owner). If the actual age was unknown, shelter staff estimated age as juvenile (< 1 year old), young adult (1 to 2 years old), or mature adult (> 2 years old). Address of origin information was used to determine whether the community from which the dog originated was urban or rural on the basis of population density, number of residents, housing density, income, and land use.<sup>17</sup> Prior vaccination history for owner-relinquished dogs was not known. Health status of dogs was determined by examination by a veterinarian. Dogs were classified as not healthy if any conditions generally associated with neglect (eg, emaciation), illness, injury, or any combination of these factors were identified. Dogs with incomplete information profiles, admitted after normal business hours, or impounded for legal reasons (eg, cruelty or bite quarantine) were excluded from the study. The study protocol was approved by the University of Florida Institutional Animal Care and Use Committee.

**Serologic testing**—Blood was collected via jugular or cephalic venipuncture into plain evacuated tubes at the time of admission to the shelter and prior to vaccination. Serum was separated by centrifugation and stored at  $-20^{\circ}\text{C}$  pending analysis. Serum antibody titers for CDV were measured by use of a virus neutralization method<sup>a</sup>; titers for CPV were measured by use of a hemagglutination inhibition method.<sup>a</sup> The PAT established by the laboratory in which assays were conducted was  $\geq 32$  for CDV and  $\geq 80$  for CPV.

**Statistical analysis**—The PAT prevalence was defined as the percentage of dogs with PATs. Potential factors associated with PAT were evaluated by use of a  $\chi^2$  test; univariate logistic regression was used to calculate ORs and 95% CIs. A value of  $P < 0.05$  was considered significant. Factors identified as significant in univariate logistic regression analyses were evaluated in a multivariate logistic regression model. Those factors that were significantly associated with PAT after adjusting for the influence of other variables were retained. In addition, factors that, when added, caused the ORs of other factors to change by  $> 10\%$  were retained in the model to control for confounding. Interactions between factors were evaluated, and interaction terms were retained if  $P < 0.05$ . The Mann-Whitney  $U$  test was used to compare ages, which were not normally distributed, for dogs with and without PATs. The correlation between CDV and CPV antibody titers was evaluated by use of the Pearson  $r$  statistic. All analyses were performed with statistical software.<sup>b,c</sup>

## Results

Blood samples were collected from 441 dogs. Ten of the dogs were excluded from the study owing to incomplete information profiles. The remaining 431 blood samples included in analyses represented 67.7% of the 637 dogs admitted to the shelter during the study period. Samples were not collected from 196 dogs that were impounded for legal reasons (eg, cruelty or bite quarantine) or that were admitted after hours.

Age of study dogs ranged from 2 months to 14 years. Twenty-seven adult dogs were excluded from age analyses because their estimated age was unknown. Overall, 36.1% (146/404) of the study population was < 1 year old, 45.0% (182/404) was 1 to 2 years of age, and 18.8% (76/404) was  $> 2$  years old. Puppies  $< 5$  months old comprised 73.3% (107/146) of the juvenile category and 26.5% (107/404) of the total population. Of the 200 female and 231 male dogs, 85.4% (368/431) were not neutered. Almost half (13/28 [46.4%]) of the dogs that were reclaimed by their owners were neutered, compared with only 12.4% (50/403) of the dogs that were not reclaimed ( $P < 0.01$ ). Nearly two thirds of the dogs (277/431 [64.3%]) were admitted as strays. More than half of the stray dogs (150/277 [54.2%]) and the previously owned dogs (87/154 [56.5%]) were from urban communities. Most of the dogs (395/431 [91.6%]) were considered healthy at intake; the others were deemed not healthy on the basis of conditions associated with neglect (20 dogs), injury (14 dogs), or illness (2 dogs). Almost half of the dogs (201/431 [46.6%]) were eventually euthanized. The remaining dogs were either adopted (202/431 [46.9%]) or reclaimed by their owners (28/431 [6.5%]; **Table 1**).

Overall, less than half (186/431 [43.2%]) of the dogs admitted had PATs for CDV (**Figure 1**; **Table 1**). Dogs with CDV PATs were significantly ( $P < 0.01$ ) older (mean  $\pm$  SD,  $2.6 \pm 2.3$  years) than dogs without PATs ( $1.1 \pm 1.3$  years). Only 34.1% (112/328) of dogs  $\leq 2$  years old had CDV PATs; for puppies  $< 5$  months old, only 12.1% (13/107) had CDV PATs. Neutered dogs were 8.3 times as likely to have CDV PATs as were sexually intact dogs. There was no difference between

Table 1—Results of univariate logistic regression analysis of factors potentially associated with having a PAT (ie, antibody titer  $\geq 32$ ) for CDV at the time of admission for 431 dogs admitted to a municipal animal shelter.

Factor	Category	No. tested	No. with PATs	Prevalence (%)	OR	95% CI	P value
Age	< 1 y	146	25	17.1	Referent	NA	NA
	1–2 y	182	87	47.8	4.4	2.6–7.4	< 0.01
	> 2 y	76	57	75.0	14.5	7.4–28.5	< 0.01
Neuter status	Sexually intact	368	134	36.4	Referent	NA	NA
	Neutered	63	52	82.5	8.3	4.2–16.4	< 0.01
Source	Stray	277	126	45.5	Referent	NA	NA
	Owned	154	60	39.0	0.8	0.5–1.1	0.19
Community of origin	Rural	192	76	39.6	Referent	NA	NA
	Urban	237	108	45.6	1.3	0.9–1.9	0.21
Intake health status	Healthy	395	171	43.3	Referent	NA	NA
	Not healthy	36	15	41.7	0.9	0.5–1.9	0.90
Outcome	Adopted	202	83	41.1	Referent	NA	NA
	Euthanatized	201	82	40.8	1.0	0.7–1.5	0.95
	Reclaimed by owner	28	21	75.0	4.3	1.7–10.6	< 0.01

CI = Confidence interval. NA = Not applicable. OR = Odds ratio.  
 Twenty-seven adult dogs were excluded from age analyses because estimated ages were unknown; 2 dogs were excluded from community of origin analyses because origins were unknown.

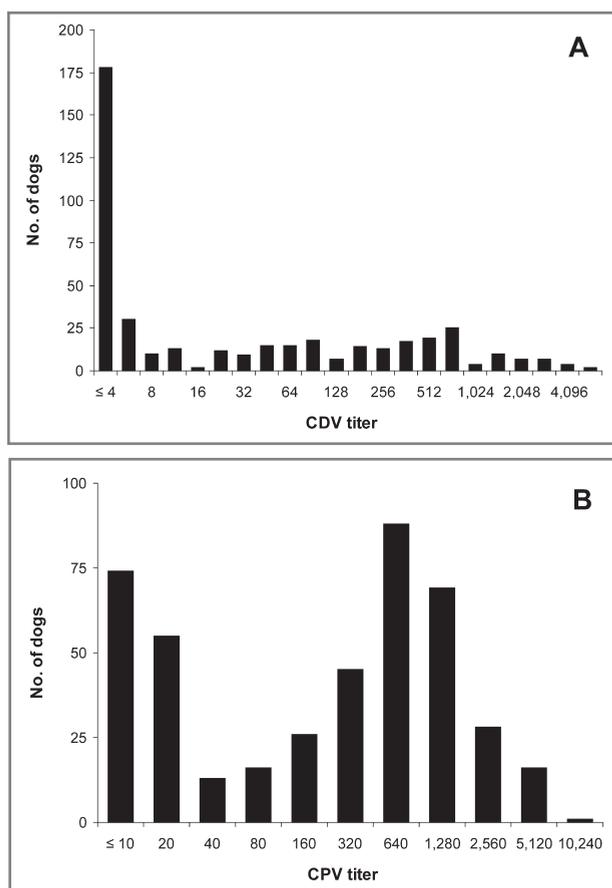


Figure 1—Distribution of antibody titers for CDV (A) and CPV (B) in 431 dogs at entry into a municipal animal shelter. For CDV, antibody titers  $\geq 32$  were considered protective. For CPV, antibody titers  $\geq 80$  were considered protective.

the proportions of stray dogs (54.5%) and previously owned dogs (61.0%) without CDV PATs. That is, dogs surrendered by their owners were as likely as stray dogs to have insufficient CDV antibody titers at admission. However, dogs reclaimed by their owners were 4.3 times as likely to have CDV PATs as were unclaimed dogs that were eventually adopted. There was no differ-

ence in the prevalence of CDV PATs between dogs that were healthy versus unhealthy at the time of admission to the shelter.

In contrast to the results for CDV, more than half (289/431 [67.1%]) of the dogs had PATs for CPV (Figure 1; Table 2). Dogs with CPV PATs were significantly ( $P < 0.01$ ) older (mean  $\pm$  SD,  $2.2 \pm 2.0$  years) than dogs without PATs ( $1.0 \pm 1.4$  years). For dogs  $\leq 2$  years old, 60.1% (197/328) had CPV PATs; however, only 23.4% (25/107) of puppies  $< 5$  months old had CPV PATs. Neutered dogs were 3.4 times as likely to have CPV PATs as were sexually intact dogs. There was no difference between the proportions of stray dogs (33.6%) and owned dogs (31.8%) that did not have PATs for CPV. However, dogs reclaimed by their owners were 5.9 times as likely to have CPV PATs as were dogs that were eventually adopted. Unhealthy dogs were 3.3 times as likely to have CPV PATs as were dogs that were healthy at the time of admission; however, unhealthy dogs were significantly ( $P < 0.01$ ) older ( $2.9 \pm 3.1$  years) than healthy dogs ( $1.7 \pm 1.8$  years).

Several factors remained associated with having PATs for CDV and CPV when entered into a multivariate analysis model. Age, neuter status, and CPV PAT were associated with whether dogs had a CDV PAT (Table 3). Dogs at least 1 year old, neutered dogs, and dogs with a CPV PAT were more likely to have a CDV PAT. Age and CDV PAT were associated with whether dogs had a CPV PAT (Table 4). Dogs at least 1 year old and those with a CDV PAT were more likely to have a CPV PAT. Factors that were not associated with having a PAT for either virus in multivariate logistic regression analyses were the source of the dog, the type of community from which the dog originated, health status at intake, and outcome (ie, adoption, euthanasia, or reclaimed).

In summary, 64.5% (278/431) of the dogs did not have PATs for 1 or both viruses at the time of entry into the shelter. A total of 153 (35.5%) dogs had PATs for both CDV and CPV, 33 (7.7%) had a PAT for CDV but not CPV, 136 (31.5%) had a PAT for CPV but not CDV, and 109 (25.3%) did not have PATs for either virus. Dogs that had a PAT for one virus were 3.7 times as likely to have a PAT for the other virus (95% CI, 2.4

Table 2—Results of univariate logistic regression analysis of factors potentially associated with having a PAT (ie, antibody titer  $\geq 80$ ) for CPV at the time of admission for 431 dogs admitted to a municipal animal shelter.

Factor	Category	No. tested	No. with PATs	Prevalence (%)	OR	95% CI	P value
Age	< 1 y	146	53	36.3	Referent	NA	NA
	1–2 y	182	144	79.1	6.6	4.1–10.9	< 0.01
	> 2 y	76	66	86.8	11.6	5.5–24.4	< 0.01
Neuter status	Sexually intact	368	235	63.9	Referent	NA	NA
	Neutered	63	54	85.7	3.43	1.6–7.1	< 0.01
Source	Stray	277	184	66.4	Referent	NA	NA
	Owned	154	105	68.2	1.1	0.7–1.7	0.71
Community of origin	Rural	192	121	63.0	Referent	NA	NA
	Urban	237	166	70.0	1.4	0.9–2.1	0.13
Intake health status	Healthy	395	258	65.3	Referent	NA	NA
	Not healthy	36	31	86.1	3.3	1.3–8.7	0.02
Outcome	Adopted	202	102	50.5	Referent	NA	NA
	Euthanatized	201	163	81.1	4.2	2.7–6.6	< 0.01
	Reclaimed by owner	28	24	85.7	5.9	2.0–17.6	< 0.01

See Table 1 for key.

Table 3—Results of multivariate logistic regression analysis of factors associated with having a PAT for CDV at the time of admission for 404 dogs admitted to a municipal animal shelter.

Factor	Category	OR	95% CI	P value
Protective CPV titer	No	Referent	NA	NA
	Yes	1.8	1.0–3.0	0.04
Neuter status	Sexually intact	Referent	NA	NA
	Neutered	4.5	2.2–9.3	< 0.01
Age	< 1 y	Referent	NA	NA
	1–2 y	3.1	1.8–5.5	< 0.01
	> 2 y	7.6	3.7–15.9	< 0.01

Twenty-seven adult dogs were excluded from the analysis because estimated ages were unknown.  
See Table 1 for remainder of key.

Table 4—Results of multivariate logistic regression analysis of factors associated with having a PAT for CPV at the time of admission for 404 dogs admitted to a municipal animal shelter.

Factor	Category	OR	95% CI	P value
Protective CDV titer	No	Referent	NA	NA
	Yes	1.8	1.1–3.1	0.02
Age	< 1 y	Referent	NA	NA
	1–2 y	5.7	3.4–9.4	< 0.01
	> 2 y	8.4	3.8–18.5	< 0.01

See Tables 1 and 3 for key.

to 5.8;  $P < 0.01$ ). The magnitude of the CDV antibody titer was positively correlated with that of the CPV antibody titer (Pearson  $r$ , 0.28;  $P < 0.01$ ). The proportion of dogs reclaimed by their owners with PATs for both CDV and CPV (20/28 [71.4%]) was significantly ( $P < 0.01$ ) higher than the proportion of unclaimed dogs with PATs for both viruses (133/403 [33.0%]). The proportion of neutered dogs with PATs for both viruses (44/63 [69.8%]) was significantly ( $P < 0.01$ ) higher than the proportion of sexually intact dogs with PATs for both viruses (109/368 [29.6%]). There was also a significant ( $P < 0.01$ ) progressive increase in the proportion of dogs with PATs for both viruses with increasing age. Only 8.9% (13/146) of dogs < 1 year old had PATs for both CDV and CPV, compared with 41.8% (76/182) of dogs between 1 and 2 years old and 62.1% (64/103) of

dogs > 2 years old. Of the dogs without PATs for either virus, 74.3% (81/109) were < 1 year old, and most of these were < 5 months old (71/81 [87.7%]).

## Discussion

A substantial proportion (278/431 [64.5%]) of dogs in the present study had insufficient antibody titers for CDV, CPV, or both at the time of admission to a municipal animal shelter with a history of infectious disease outbreaks. Insufficient CDV titers were more common than were insufficient CPV titers, and older dogs, neutered dogs, and dogs reclaimed by their owners were more likely to have PATs for CDV or CPV.

The finding that more dogs in the present study had PATs for CPV than CDV may be related to the durability of CPV in the environment, providing more opportunities for natural exposure.<sup>4</sup> In contrast, CDV is relatively unstable outside of the host; thus, there may be less opportunity for dogs to acquire immunity by exposure to contaminated environments.<sup>3,18</sup> Dogs that survive natural exposure to CPV typically develop and maintain high antibody titers.<sup>3,4</sup> Older dogs may also have had more time for virus exposure via vaccination or natural infection. Neutering may be a surrogate marker for routine veterinary care, including vaccination; however, some neutered dogs in the present study lacked PATs, suggesting failure to receive sufficient vaccinations to induce protective immunity. Most of the dogs entering the shelter without PATs for CDV and CPV were < 5 months old. In these puppies, passively acquired maternal antibody titers were below the threshold for protection. The presence or absence of PATs for CDV or CPV was not associated with source (stray or previously owned), health status at intake (healthy or not healthy), or origin (urban or rural) in the present study. Therefore, we suggest that these factors should not be used to determine an individual dog's need for vaccination at the time of admission to a shelter.

Individual responses to multivalent vaccines are variable; some dogs may develop high antibody titers for some antigens, yet remain anergic to others administered at the same time, even after administration of several booster vaccine doses.<sup>19–22</sup> In 1 study,<sup>23</sup> the an-

tibody response to modified-live CDV administered in a multivalent vaccine was inferior to the response elicited with a monovalent vaccine containing CDV only, but dogs vaccinated with either product were protected against viral challenge. Although there may be differential responses to various antigens, most vaccinated dogs develop PATs for all components of multivalent vaccines.<sup>24–26</sup>

Although maximal immunity induced by vaccination may take several weeks to develop, the immune response begins immediately and may provide substantial protection within the first few days. Dogs vaccinated against CPV developed detectable antibodies within 2 to 4 days and persistent high titers after 1 to 2 weeks when immunized with modified-live virus vaccines but not when inactivated vaccines were used.<sup>14,15,27</sup> Even a single vaccine dose has been shown to protect against death from CDV when vaccination was provided at the time of experimental challenge or at the time of admission to a contaminated environment.<sup>5,28</sup> Puppies treated with immunosuppressive doses of corticosteroids for 3 weeks prior to CDV vaccination were still protected against clinical disease when challenged with virus just 3 days after vaccination.<sup>29</sup> This early protection likely occurs via stimulation of innate and cell-mediated immunity prior to the development of detectable seroconversion.<sup>3,29</sup> Activation of these components of the immune system contributes to the resistance to infection exhibited by some vaccinated dogs that fail to seroconvert. Thus, while PATs are associated with resistance to infection, lower antibody titers do not necessarily indicate susceptibility to infection.<sup>22,29</sup>

Effective infectious disease control programs in shelters require appropriate vaccination, disinfection, and segregation of healthy and unhealthy animals. Results of the present study suggest that many dogs entering a shelter will have insufficient antibody titers against fatal but preventable diseases. These findings support published guidelines that recommend vaccination of all dogs against CDV and CPV on admission, even those that are not expected to remain in the shelter for more than a few days.<sup>2</sup> Restricting vaccination to some dogs while excluding others on the basis of source, health status, potential outcome, or any other criteria contributes to the risk of transmission of infectious diseases within the shelter.

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