Response of feral cats to vaccination at the time of neutering

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Objective—To determine whether administration of inactivated virus or modified-live virus (MLV) vaccines to feral cats at the time of neutering induces protective serum antiviral antibody titers.

Design—Prospective study.

Animals—61 feral cats included in a trap-neuter-return program in Florida.

Procedures—Each cat received vaccines against feline panleukopenia virus (FPV), feline herpes virus (FHV), feline calicivirus (FCV), FeLV, and rabies virus (RV). Immediately on completion of surgery, vaccines that contained inactivated RV and FeLV antigens and either MLV or inactivated FPV, FHV, and FCV antigens were administered. Titers of antiviral antibodies (except those against FeLV) were assessed in serum samples obtained immediately prior to surgery and approximately 10 weeks later.

Results—Prior to vaccination, some of the cats had protective serum antibody titers against FPV (33%), FHV (21%), FCV (64%), and RV (3%). Following vaccination, the overall proportion of cats with protective serum antiviral antibody titers increased (FPV [90%], FHV [56%], FCV [93%], and RV [98%]). With the exception of the FHV vaccine, there were no differences in the proportions of cats protected with inactivated virus versus MLV vaccines.

Conclusions and Clinical Relevance—Results suggest that exposure to FPV, FHV, and FCV is common among feral cats and that a high proportion of cats are susceptible to RV infection. Feral cats appeared to have an excellent immune response following vaccination at the time of neutering. Incorporation of vaccination into trap-neuter-return programs is likely to protect the health of individual cats and possibly reduce the disease burden in the community. (*J Am Vet Med Assoc* 2007;230:52–58)

Feral cats have successfully adapted to almost every ecologic niche in the world, including rural and urban settings, extremes of desert and Antarctic conditions, and areas populated by or devoid of humans.[1] The population of unowned feral cats in the United States is suspected to rival that of the owned cat population (the latter estimated as 90.5 million in 2006)[2] and may be the most important source of cat overpopulation.[3] The impact of feral cats on animal welfare, public health, and the environment is an increasingly controversial topic, and there is little agreement among policy makers and opinion leaders regarding the best methods for the control of feral cat populations.[1,4–7]

Attempted control of feral cat populations through TNR programs is an increasingly popular alternative to mass euthanasia.[8] These programs involve capture and neutering of the cats, followed by their return to their colonies to live out their normal life spans. Depend-

ABBREVIATIONS	
TNR	Trap-neuter-return
MLV	Modified-live virus
TKX	Tiletamine, zolazepam, ketamine, and xylazine
RV	Rabies virus
FPV	Feline panleukopenia virus
FHV	Feline herpesvirus
FCV	Feline calicivirus
FVRCP-FeLV vaccine	Multivalent vaccine against FPV, FHV, FCV, and FeLV
IQ range	The range from the 25th to the 75th percentiles of the data
CDV	Canine distemper virus
CPV	Canine parvovirus

ing on the program involved, a variety of other services may also be provided for the cats, including assessment for infectious diseases, treatment of illnesses and injuries, vaccination, regular feeding, parasite treatment, and removal of socialized cats for adoption.[8,9]

Many public health care guidelines concerning both humans and animals advise against vaccine administration during anesthesia or surgery,[10,11] whereas some guidelines do not mention vaccination in these

circumstances.[12] Other guidelines encourage perioperative vaccinations when nosocomial risks are high, in emergency situations, or when compliance with vaccination at a later time is deemed unlikely.[13] Safety is 1 consideration because anesthesia may mask the signs of acute adverse reactions and thus impede necessary emergency intervention. The efficacy of vaccination under such conditions is also questioned because psychologic stress, anesthesia, and surgery all have marked impacts on innate immune responses such as leukocyte trafficking, cytokine elaboration, phagocyte function, and mitogenesis and on acquired immune responses including delayed-type hypersensitivity reactions, B- and T-cell proliferation, and antibody production.[14–25] Vaccines are not tested in the context of anesthesia and surgery during licensing studies, so efficacy remains undetermined in such circumstances. Despite these uncertainties, the limitations associated with delivering veterinary care to wild populations (such as feral cats) dictate that deviations from standards of care designed for pets are sometimes required.

The vaccination policies of TNR programs vary according to the resources available to the programs and to the beliefs of the supervising veterinarians regarding the effectiveness and necessity of vaccination under the conditions of a TNR clinic.[8] Many TNR programs do not vaccinate cats because of the belief that a single dose of vaccine administered under the stressful conditions of capture, transport, anesthesia, and surgery is likely to be ineffective. The purpose of the study reported here was to determine whether administration of inactivated virus or MLV vaccines to feral cats at the time of neutering effectively induces protective serum antiviral antibody titers. In addition, we intended to compare the serologic responses to the inactivated virus and MLV vaccines.

Materials and Methods

Cats—Sixty-one cats collected from 12 colonies in north and south Florida from March to July 2005 were included in the study. All cats were feral; free roaming; to our knowledge, unowned; and unaccustomed to being handled. To the caretaker's knowledge, none of the cats had received veterinary care previously, but because the history of most cats was unknown, this could not be confirmed. Cats were captured for surgery in wire traps[a] that were baited with canned fish by colony caretakers and captured again approximately 10 weeks after surgery for reevaluation. Veterinary care, including anesthesia, neutering, vaccination, and parasiticide treatment, was provided by a nonprofit TNR program according to its usual practices.[b] The research protocol was approved by the University of Florida Institutional Animal Care and Use Committee and was conducted in facilities accredited by the Association for Assessment and Accreditation of Laboratory Animal Care International.

Anesthesia—Each cat was anesthetized via IM injection of a combination of tiletamine[c] (9.6 mg), zolazepam[c] (9.6 mg), ketamine[d] (19.2 mg), and xylazine[e] (4.8 mg) while still confined in the trap.[26,27] Isoflurane[f] was administered via face mask, or an additional dose of TKX was administered if needed to maintain a surgical plane of anesthesia. After surgery and when all procedures had been completed, anesthesia was partially reversed with yohimbine[g] (0.6 mg, IV). A rectal body temperature measurement was made at the time of anesthetic reversal. Cats were then returned to their wire traps for recovery. Time from injection of TKX to injection of yohimbine was recorded as total duration of anesthesia.

Sample collection—After anesthesia was achieved, 6 mL of blood was collected via jugular venipuncture and placed into a serum separator tube. Samples were allowed to clot for at least 30 minutes and then centrifuged for 20 minutes. Serum was collected and stored at −20°C pending analysis.

Surgery and treatment—Once anesthetized, each cat was briefly examined and recordings made of body weight, physical findings, and age estimate (based on body weight and dentition). Cats that weighed > 2 kg (4.4 lb) with deciduous canine teeth were judged to be 4 to 6 months of age (juveniles), and cats with permanent canine teeth were judged to be > 6 months of age (adults). Only cats estimated to be at least 4 months of age were included in the study to avoid interference of immune responses attributable to passive transfer of maternal antibodies. Each cat was prepared for surgery by applying lubricant to each eye, administration of a single dose of penicillin G benzathine-procaine[h] (100,000 units [50,000 units in juveniles], SC), removal of the tip of the left ear for visual identification of its neutered status, clipping of the hair from the incision site, and cleaning of the skin with povidone-iodine scrub solution and alcohol. Ovariohysterectomy or castration was performed by standard techniques. The presence of concurrent conditions, such as lactation and pregnancy, as well as the administration of additional anesthetic agents to maintain surgical plane of anesthesia were recorded. After surgery, an identification microchip[i] was implanted SC in the interscapular area and a parasiticide (selemectin[j]) was applied to the skin prior to reversal of anesthesia. The cats were held in their traps for 24 hours after surgery, then released back to their colonies.

Vaccination—Vaccines were administered immediately after surgery by use of a 3-mL syringe with a 22-gauge needle. In each cat, an inactivated RV vaccine that is licensed for 3-year duration of immunity[k] was administered SC in the right hind limb just distal to the stifle joint. Each cat also received 1 of 2 formulations of an FVRCP-FeLV vaccine administered SC in the left hind limb just distal to the stifle joint. For approximately half of the cats, the FVRCP component of the vaccine contained inactivated viruses[l]; and for the remaining cats, the FVRCP component of the vaccine contained MLVs.[m] The FeLV in both types of FVRCP-FeLV vaccine was inactivated.

Follow-up procedures—The cats were recaptured approximately 2 months later, and their identification was confirmed by interrogation of the microchip. Cats were briefly sedated with medetomidine (100 μg/kg [45 μg/lb], IM). A blood sample (6 mL) was collected from each cat and processed (as described), and a body

weight measurement was obtained. A booster injection of FVRCP-FeLV vaccine[m] was administered, and sedation was reversed with atipamazole (0.125 mg, SC). The cats were replaced in their traps and returned to their colonies the same day.

Serologic assessments—Laboratory personnel who performed sample testing were unaware of the type of vaccine administered and the timing of the sample collection. Antiviral antibody titers in the paired serum samples were determined via hemagglutination inhibition (antibodies against FPV),[n] virus neutralization (antibodies against FHV and FCV),[n] and virus neutralization by the rapid fluorescent focus inhibition test (antibodies against RV).[o] Previous correlation of titers with protection against virulent challenge has established that the reciprocal serum antibody titer that was protective against FPV, FHV, and FCV was 40, 16, and 32, respectively; these titers have been accepted as an indication of adequate response to vaccination.[28,29] A serum anti-RV antibody titer < 25 is consistent with nonspecific serum antiviral activity, whereas a titer ≥ 25 is considered to be indicative of effective immunization against RV, although the actual protective titer has not been determined for cats.[30] For the purposes of statistical analysis, a titer of ≥ 25 was considered adequate for protection against RV. Because serum antibody titers are not correlated with protection against FeLV, these were not measured; however, the serum sample obtained prior to vaccination was also tested for FeLV antigen and FIV antibody by use of an ELISA.[p]

Statistical analysis—For the groups receiving inactivated or MLV vaccines, duration of anesthesia; postoperative rectal temperature; body weight at the time of surgery, body weight at the time of recapture, and change in body weight; interval between release and recapture; and serum antiviral antibody titers were compared by use of the Mann-Whitney rank sum test. By use of χ^2 tests, the proportions of cats in each group with regard to age, sex, and development of protective antiviral antibody titers were compared. A value of $P < 0.05$ was considered significant.

Results

Cats—Sixty-one feral cats were enrolled in the study; the population comprised 35 (57%) females and 26 (43%) males, of which 56 (92%) were adults and 5 (8%) were juveniles (**Table 1**). The cats were randomized to receive inactivated virus vaccines (n = 32) or MLV vaccines (29). There was no significant difference in the proportion of female cats between the 2 groups, but the MLV vaccine group contained a higher proportion ($P = 0.02$) of juveniles (5/29 [17%] cats) than the inactivated-virus vaccine group (0/32 [0%] cats). There were no differences ($P > 0.5$) in any of the variables other than age between the inactivated-virus and the MLV vaccine groups. Eight cats were pregnant (5 in the inactivated-virus vaccine group and 3 in the MLV vaccine group), and 5 cats were lactating (3 cats in the inactivated-virus vaccine group and 2 cats in the MLV vaccine group). One male cat in the inactivated-virus vaccine group was seropositive for anti-FIV antibody, and 1 male cat in the MLV vaccine group was seropositive for both FeLV antigen and anti-FIV antibody. Additional anesthesia was provided to 1 cat in each group via inhalation of isoflurane and to 3 cats in the MLV vaccine group by additional administration of TKX. Mean ± SD duration of anesthesia for all cats was 44 ± 25 minutes, and mean temperature at the time of anesthetic reversal was 36.4 ± 1.1°C (97.6 ± 2.0°F).

Among all 61 cats, the mean interval between release after surgery and recapture was 10.1 ± 2.7 weeks. Mean body weight was 2.95 ± 0.71 kg (6.5 ± 1.6 lb) at the time of surgery and 3.34 ± 0.75 kg (7.3 ± 1.7 lb) at the time of recapture. The cats' body weight significantly ($P = 0.008$) increased (a mean difference of 14 ± 13%) between the 2 time points. Among the 61 cats, 51 (84%) gained weight, 3 (5%) had no change in weight, and 7 (11%) lost weight.

Serum anti-FPV antibody titers—Among the 61 cats, 28 (46%) had serum antibodies against FPV (median titer, 0; IQ range, 0 to 800) at the time of surgery, indicating previous exposure or vaccination, but only 20 (33%) had titers in the protective range. Prior to vaccination, median titer and proportion of cats protected

Table 1—Characteristics of 61 anesthetized feral cats that received an FVRCP-FeLV vaccine (either inactivated viruses [n = 32] or MLVs [29]) in addition to an inactivated virus vaccine against RV at the time of neutering.

Variable	Vaccine group	
	Inactivated virus*	MLV†
No. of cats	32	29
Female cats (%)	63	52
Adult cats (%)	100‡	83
Duration of anesthesia (min)	42 ± 18	47 ± 31
Rectal temperature after surgery (°C [°F])	36.4 ± 0.9 (97.5 ± 1.7)	36.4 ± 1.3 (97.6 ± 2.3)
Body weight before surgery (kg [lb])	3.08 ± 0.65 (6.7 ± 1.4)	2.84 ± 0.76 (6.2 ± 1.7)
Body weight at recapture (kg [lb])	3.43 ± 0.77 (7.5 ± 1.7)	3.25 ± 0.72 (7.2 ± 1.6)
Body weight gain (%)	12 ± 11	16 ± 15
Recapture interval (wk)	9.8 ± 1.6	10.4 ± 3.6

*FVRCP-FeLV (inactivated viruses) and RV (inactivated virus) vaccines. †FVRCP-FeLV (MLVs; inactivated FeLV) and RV (inactivated virus) vaccines. ‡ Significant ($P < 0.05$) difference in this variable between vaccine groups.

were not significantly ($P = 0.06$) different between the inactivated-virus and MLV vaccine groups (**Tables 2 and 3**). Median titer (640; IQ range, 160 to 2,560) and proportion of cats that had protective anti-FPV antibody titers (55/61 [90%] cats) increased significantly ($P < 0.001$) following vaccination. The proportion of cats with protective anti-FPV antibody titers after vaccination did not differ significantly ($P = 0.2$) between the inactivated-virus and MLV vaccine groups. However, cats in the MLV vaccine group had higher ($P < 0.001$) median titers after vaccination, compared with cats in the inactivated-virus vaccine group.

Serum anti-FHV antibody titers—Among the 61 cats, 17 (28%) had serum antibodies against FHV (median titer 0; IQ range, 0 to 4), indicating previous exposure or vaccination, but only 13 (21%) had titers in the protective range. Prior to vaccination, median titer and proportion of protected cats were not significantly ($P = 0.3$) different between the inactivated-virus and MLV vaccine groups (Tables 2 and 3). Median titer (24; IQ range, 4 to 48) and proportion of cats that had protective anti-FHV antibody titers (34/61 [56%]) increased significantly ($P < 0.001$) following vaccination. The proportion of cats with protective anti-FHV antibody titers after vaccination was significantly ($P < 0.001$) higher in the inactivated-virus vaccine group than in the MLV vaccine group. Compared with values before surgery, the proportion of protected cats increased significantly ($P < 0.001$) following administration of the inactivated virus vaccine, but there was no change ($P = 1.0$) in the proportion of protected cats following administration of the MLV vaccine. Also, the median titer after vaccination for cats in the inactivated-virus vaccine group was higher ($P < 0.001$) than the value for cats in the MLV vaccine group.

Serum anti-FCV antibody titers—Among the 61 cats, 55 (90%) had antibodies against FCV (median titer, 256; IQ range, 8 to 2,048), indicating previous exposure or vaccination, but only 39 (64%) had titers in the protective range. Prior to vaccination, the median titer in the inactivated-virus and MLV vaccine groups was not significantly ($P = 0.8$) different, but the proportion of cats with protective titers was significantly ($P = 0.02$) higher in the inactivated-virus vaccine group (Tables 2 and 3). Median titer (768; IQ range, 176 to 4,096) and the proportion of cats that had protective anti-FCV antibody titers (57/61 [93%]) increased significantly ($P = 0.003$) following vaccination. The median titer and proportion of cats with protective anti-FCV antibody titers did not differ significantly ($P = 0.6$) between the inactivated-virus and MLV vaccine groups.

Serum anti-RV antibody titers—Cats in both treatment groups received the same inactivated RV vaccine. Only 2 (3%) cats had antibodies against RV (titer, ≥ 25), indicating previous exposure or vaccination (Tables 2 and 3). For 5 other cats, titers < 25 were detected, which is consistent with nonspecific serum virus neutralizing activity. Median titer (5,300; IQ range, 1,400 to 9,075) and the proportion of cats that had protective anti-RV antibody titers (60/61 [98%]) increased significantly ($P < 0.001$) following vaccination. Only 1 cat

Table 2—Median (IQ range) serum antiviral antibody titers in 61 anesthetized feral cats before and approximately 10 weeks after administration of an FVRCP-FeLV vaccine (either inactivated viruses [n = 32] or MLVs [29]) in addition to an inactivated vaccine against RV.

Serum antiviral antibody titer	Vaccine group	
	Inactivated virus*	MLV†
FPV		
Before vaccination	0 (0–10)	10 (0–1,280)
After vaccination	160 (60–640)‡,§	2,560 (1,280–3,200)§
FHV		
Before vaccination	0 (0–4)	0 (0–16)
After vaccination	40 (16–48)‡,§	4 (0–32)§
FCV		
Before vaccination	512 (80–1,536)	24 (8–4,096)
After vaccination	768 (448–3,584)§	768 (60–6,144)§
RV		
Before vaccination	0 (0–0)	0 (0–0)
After vaccination	5,850 (2,400–13,812)§	2,400 (1,025–8,500)§

§Value significantly ($P < 0.05$) different from the value before vaccination for this variable.
See Table 1 for remainder of key.

Table 3—Proportion of anesthetized feral cats (n = 61) that received an FVRCP-FeLV vaccine (either inactivated viruses or MLVs) in addition to an inactivated virus vaccine against RV and that had protective serum antiviral antibody titers before and approximately 10 weeks after vaccination.

Serum antiviral antibody titer	No. of cats (%)	
	Inactivated virus vaccine group* (n = 32)	MLV virus vaccine group† (29)
FPV		
Before vaccination	7 (22)	13 (45)
After vaccination	27 (84)§	28 (97)§
FHV		
Before vaccination	5 (16)	8 (28)
After vaccination	26 (81)‡,§	8 (28)
FCV		
Before vaccination	25 (78)‡	14 (48)
After vaccination	30 (94)	27 (93)§
RV		
Before vaccination	1 (3.1)	1 (3.5)
After vaccination	32 (100)§	28 (97)§

See Tables 1 and 2 for key.

failed to develop an acceptable anti-RV antibody titer following vaccination; this male cat was infected with both FeLV and FIV.

In most cats, failure to respond to 1 antigen did not correlate with failure to respond to other antigens that were administered at the same time. One cat, a pregnant female, failed to respond to any of the FPV, FHV, FCV antigens, yet had an excellent response to RV. Another cat, a male infected with both FeLV and FIV, had no response to RV and remained seronegative for that virus. This cat had protective serum antibody titers against FPV, FHV, and FCV at the time of surgery, but at the time of reevaluation, there was no detectable booster effect associated with vaccine administration.

Discussion

In the present study, a substantial number of the 61 feral cats that underwent neutering had serologic evidence of previous exposure to or vaccination against FPV (46%), FHV (28%), and FCV (90%). This

is consistent with previous reports of seropositivity in unvaccinated feral cats for FPV (8% to 79%), FHV (11% to 19%), and FCV (54% to 77%) in diverse locales including Wisconsin,[q] Australia,[31] Saudi Arabia,[32] and Vietnam.[33] Although it is possible that some cats in the study reported here received previous FVRCP-type vaccines without the knowledge of the caretakers, the marked variation in seropositivity for the 3 viruses suggests that natural exposure was common. Seven (11%) cats had virus neutralizing activity against RV prior to vaccination, but only 2 (3%) had titers that were high enough to be considered specific for anti-RV antibodies. Low seropositivity rates have been determined for other species living in rabies-endemic areas and indicate nonspecific assay reactions, previous vaccination, or nonfatal exposure to RV.[34,35]

Although assessment of serum antibodies is only 1 measure of disease resistance, the additional contributions of age-related natural resistance, cell-mediated immunity, and timing and virulence of challenge exposure are more difficult to quantify. Based on serologic findings alone, it appears that more than half of the cats in the present study may have been susceptible to FPV, FHV, and RV infections. In contrast, most cats had protective serum anti-FCV antibody titers prior to vaccination. Thus, it appears that a substantial proportion of feral cats are susceptible to infection and that feral cats have a high risk of natural exposure to preventable viral diseases.

In the present study, serologic responses of feral cats that were vaccinated immediately after surgery while still under anesthesia were evaluated. Although most cats appeared healthy, several had coexisting conditions such as pregnancy, lactation, and retroviral infection; generally, the study cats were representative of feral cats admitted to large-scale TNR programs in the United States.[8,36] After surgery, the cats were returned to their natural environments and then recaptured approximately 10 weeks later to determine serologic responses to vaccination. Overall, a high percentage of cats developed protective titers of serum antibodies against FPV (90%), FHV (56%), FCV (93%), and RV (98%). Vaccination of feral cats at the time of neutering may protect them for much of their remaining life span because immunity that develops following vaccination has been shown to persist for a minimum of 3 to 7 years in most cats.[28,29,37–39] Ideally, feral cats should be recaptured and receive booster vaccinations, particularly with a vaccine against RV, according to the guidelines established by the American Association of Feline Practitioners.[40]

The 2 FVRCP-FeLV vaccines used in the present study contained inactivated viruses or MLVs, and both induced protective antiviral antibody titers in most cats. An exception was the failure of the MLV vaccine to increase the proportion of cats protected against FHV (28% before and after vaccination). In contrast, the inactivated virus vaccine increased the proportion of cats with protective anti-FHV antibody titers from 16% to 81%. However, administration of the MLV vaccine resulted in higher anti-FPV antibody titers and a higher proportion of cats protected against FPV, compared with the inactivated virus vaccine, although the latter

difference was not significant. In our study, vaccines from only 1 vaccine manufacturer were used. Because differences in vaccine composition are likely to exist among the various vaccine preparations that are currently available, caution should be used when extrapolating findings to vaccines from other manufacturers. In addition, serologic evaluation of the cats was performed at only 1 time point after vaccination. Although acceptable serologic responses were detected in most cats, it is not possible to project the kinetics of the immune response over time. It is possible that serologic responses in the inactivated-virus and MLV vaccine groups would be different at other time points if the initial immune response and antibody titer decay rates are not the same for both types of vaccine.

Failure to develop acceptable titers following vaccination against RV was reported for 2.8% (62/2,188) of pet cats participating in the Pet Travel Scheme monitoring program required for importation of cats to the United Kingdom.[30] The failure rate was highest when cats were tested 8 weeks after vaccination, compared with findings at shorter intervals. Interestingly, sexually intact male cats were most likely to fail to respond to RV vaccination. On the basis of these results, it appears that feral cats vaccinated against RV at the time of surgery have a similar response rate as pet cats undergoing routine vaccination in veterinary clinics. In addition to individual variation in serologic responsiveness to specific antigens, other reasons for vaccine failures include damaged vaccines; improper administration (such as mistakenly injecting the vaccine into a cat's hair); and individual patient responses that are influenced by age, sex, genetic background, and health status.

Several studies[41–44] have evaluated the effect of anesthesia and surgery on responses to vaccination in dogs, but no reports of similar studies in cats are known to the authors. In 1 study,[41] healthy dogs aged 4 to 6 months were vaccinated against CDV without other treatments (control dogs) or during a standardized anesthetic and surgery procedure in which the abdominal cavity was opened, the viscera were manipulated, and then the incision site was closed. All dogs developed protective anti-CDV antibody titers within 14 days, and there was no difference in the mean antibody titer between the groups. In another study,[42] 6-week-old puppies were vaccinated against CPV and RV either without anesthesia (control dogs) or during an anesthetic event. Maternal antibodies were present against both CPV and RV at the time of vaccination, which would be expected to interfere with response to vaccination in some of the puppies. Mean antibody titer was increased in both groups at 10 and 20 days after vaccination; anti-CPV antibody titers were similar in control and anesthetized puppies, but mean anti-RV antibody titers were higher in the control group. In a third report,[43] client-owned dogs were vaccinated from 10 days before to 3 days after surgery; at 2 weeks after vaccination, serum titers of antibodies against CPV and CDV were increased from baseline values. The effect of immunosuppressive doses of corticosteroids on immune responses to vaccination in dogs was evaluated in young Beagles that received a tapering dose of prednisolone for 3 weeks, starting at a dosage of 2 to 20 mg/kg/d (0.9 to 9.1 mg/lb/d).[44] They

were vaccinated with an MLV vaccine against CDV at the end of the prednisolone treatment period, then challenged with virulent CDV 3 days later. Vaccinated dogs were resistant to CDV infection despite the preceding prednisolone treatment and the short interval between vaccination and challenge.

Immunization of anesthetized animals has also been evaluated in a variety of noncompanion animal species. Disease control programs in wildlife frequently require a stressful episode of capture and chemical immobilization for various treatments, including vaccination. Wild-caught skunks and raccoons that were immobilized for vaccination against RV[45] and servals that were vaccinated against FeLV during anesthesia[46] developed adequate serum antiviral antibody titers. Chickens that were vaccinated against multiple antigens during anesthesia (which continued for as long as 3 hours) with halothane had antibody responses that were equivalent to those of unanesthetized birds.[47] Anesthetized mice that were vaccinated against influenza virus and meningococcus intranasally generated higher antibody titers than mice that were vaccinated while they were awake,[48] and rats vaccinated against meningococcus at the time of splenectomy had similar antibody titers as rats vaccinated 3 weeks before or after surgery and rats that did not undergo surgery.[49]

Overall, the results of the present study of feral cats have indicated that vaccination against various viruses at the time of neutering appears to induce excellent immune responses as determined by assessment of serum antiviral antibody titers approximately 10 weeks later. There is serologic evidence that exposure to FPV, FHV, and FCV is common among feral cats. On the basis of serum antibody titers less than the values that are considered to be protective, it also appears that a high proportion of feral cats may be susceptible to these infections as well as to RV infection. Incorporation of FVRCP-type vaccines and vaccines against RV into TNR programs is likely to protect the health of individual cats and possibly reduce the disease burden in the feral cat community. During anesthesia and surgery, it is advisable to administer vaccines as the final procedure prior to recovery to lessen the chance that anesthesia might obscure an adverse vaccine reaction that requires medical intervention.

Despite evidence that feral cats respond favorably to vaccination, large-scale TNR programs often take a herd health approach to feral cat management, and management decisions are influenced by issues of cost and practicality. Although it may be ideal to vaccinate all cats admitted to TNR programs, the ultimate goal of controlling the feral cat population may require that services in some programs are focused on neutering, at the expense of other treatments. If universal vaccination is not feasible, an intermediate approach would be to vaccinate the subsets of cats deemed to be at highest risk of disease, such as kittens and cats living in colonies with a history of disease. All cats should be vaccinated against RV because of the substantial public heath risk associated with this virus.[50]

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a. Model 106, Tomahawk live trap, Tomahawk, Wis.
b. Operation Catnip, Gainesville, Fla.

c. Telazol, Fort Dodge Animal Health, Fort Dodge, Iowa.
d. Ketaset, Fort Dodge Animal Health, Fort Dodge, Iowa.
e. Xyla-Ject, Phoenix Pharmaceutical Inc, St Joseph, Mo.
f. Isoflo, Abbott Laboratories, North Chicago, Ill.
g. Yobine, Lloyd Laboratories, Shenandoah, Iowa.
h. Sterile penicillin G benzathine and penicillin G procaine, GC Hanford Manufacturing Co, Syracuse, NY.
i. AVID microchip identification system, AVID Identification Systems Inc, Folsom, La.
j. Revolution, Pfizer Animal Health, New York, NY.
k. Rabvac 3 TF, Fort Dodge Animal Health, Fort Dodge, Iowa.
l. Fel-O-Vax-Lv-K III, Fort Dodge Animal Health, Fort Dodge, Iowa.
m. Fel-O-Guard Plus 3 and Fel-O-Vax-Lv-K, Fort Dodge Animal Health, Fort Dodge, Iowa.
n. Animal Health Diagnostic Center, College of Veterinary Medicine, Cornell University, Ithaca, NY.
o. Department of Diagnostic Medicine and Pathobiology, College of Veterinary Medicine, Kansas State University, Manhattan, Kan.
p. SNAP FIV antibody/FeLV antigen combo test, IDEXX Laboratories, Westbrook, Me.
q. Haase C, Larson LJ, Peek L, et al. Feral cats in Dane County, Wisconsin, are found to have exceptionally low prevalence of infectious diseases (abstr), in *Proceedings*. Conf Res Workers Anim Dis 84th Annu Meet 2003;88.

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