ORIGINAL ARTICLE

Rabies Prevention and Management of Cats in the Context of Trap–Neuter–Vaccinate–Release Programmes

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Impacts

- Trap–neuter–vaccinate–return (TNVR) programmes are growing in popularity as alternatives to euthanizing feral cats
- Their ability to adequately address disease threats and population growth within managed cat colonies is not clear
- Appropriate animal control laws including removal of stray or unwanted cats should be enforced rather than relying on indirect population management strategies (e.g. trap-neuter-vaccinate-release programmes) in order to control feral cat populations and reduce the risk of zoonotic diseases such as rabies.

Keywords:
Cat; vaccination; TNR; release; trap

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Summary

Domestic cats are an important part of many Americans' lives, but effective control of the 60–100 million feral cats living throughout the country remains problematic. Although trap–neuter–vaccinate–return (TNVR) programmes are growing in popularity as alternatives to euthanizing feral cats, their ability to adequately address disease threats and population growth within managed cat colonies is dubious. Rabies transmission via feral cats is a particular concern as demonstrated by the significant proportion of rabies post-exposure prophylaxis associated with exposures involving cats. Moreover, TNVR has not been shown to reliably reduce feral cat colony populations because of low implementation rates, inconsistent maintenance and immigration of unsterilized cats into colonies. For these reasons, TNVR programmes are not effective methods for reducing public health concerns or for controlling feral cat populations. Instead, responsible pet ownership, universal rabies vaccination of pets and removal of strays remain integral components to control rabies and other diseases.

Introduction

The relationship between humans and domestic cats originated 10 000 years ago when modern cats diverged from wildcat ancestors to live among *Homo sapiens* in the Middle East (South-West Asia) (Driscoll et al., 2009). These cat ancestors spread throughout the Old World and eventually were brought to the Americas, where they are not native, by European settlers less than 500 years ago (Lipinski et al., 2008). Today, domestic cats persist in the United States as popular and beloved pets; however, effective control of the 60–100 million feral cats living throughout the country remains problematic (Jessup, 2004). While removal of unowned ('stray') domestic animals has been the historical approach, these animal control programmes are criticized for euthanizing cats that are not, or cannot, be adopted (Alley Cat Allies, 2012a). Recent focus has turned to trap–neuter–release (TNR), trap–neuter–vaccinate–return (TNVR) and other similarly named programmes as alternatives to euthanasia. These programmes involve humane trapping of feral cats, sterilization surgery and return to the environment, often but not always with vaccination against rabies and other diseases (Alley Cat Allies, 2012c). Such programmes generate support and enthusiasm from many animal welfare advocates, yet these managed feral cat 'colonies' are not innocuous. Feral cats can cause considerable

mortality to local wildlife (Hawkins et al., 1999; Jessup, 2004; Baker et al., 2008), act as reservoirs for feline-specific diseases (Nutter et al., 2004a; Al-Kappany et al., 2011; Cohn, 2011) and transmit zoonotic diseases to humans (CDC, 1995, 2008b; Nutter et al., 2004a; McElroy et al., 2010). Additionally, claims by TNR advocates that managed colonies can reduce feral cat populations and control rodents are contradicted by research (Hawkins et al., 1999; Castillo and Clarke, 2003; Longcore et al., 2009; Gunther et al., 2011). As such, communities deciding how to manage feral cat overpopulation are torn between the competing interests of cats, wildlife and public health.

Rabies is a zoonotic disease of particular importance. The World Health Organization attributes more than 55 000 human deaths each year to rabies worldwide primarily in countries where canine rabies has not been controlled (WHO, 2005). Effective rabies control programmes in the United States limit human deaths attributed to rabies to just a few each year. However, up to 38 000 persons are estimated to receive rabies post-exposure prophylaxis (PEP) annually due to a potential exposure (Christian et al., 2009). In addition to PEP, vaccination of owned pets and removal of stray cats and dogs are also important in preventing human rabies mortality by reducing the opportunities for exposure. The interaction between cats and raccoons or other wildlife rabies reservoirs is the source of rabies infection by which cats may subsequently infect people. As a rabies vector, cats pose a disproportionate risk for potential human exposures compared with wildlife reservoir species in part because people, and especially children, are more likely to approach them. As such, potential exposures from cats of unknown vaccination history account for a substantial proportion of PEP administered annually in the United States (Hensley, 1998; Moore et al., 2000). They also pose a considerable rabies risk to persons who are exposed but fail to recognize the need for PEP, as is sometimes the case with children (CDC, 2012). Thus, comprehensive rabies control requires continued implementation of current policies for animal vaccination and removal of strays, as well as administration of PEP following potential exposures. The policies outlined in the National Association of State Public Health Veterinarians (NASPHV) Compendium of Animal Rabies Control and Prevention specifically state that all cats be up to date on rabies vaccine, a daunting challenge for any caretaker with a sizable feral cat colony (National Association of State Public Health Veterinarians, 2011).

In this review, we focus on the impact of managed feral cats from a public health perspective. Special emphasis is given to rabies virus because it is often discounted as a risk by TNVR advocates (Alley Cat Allies, 2012b). In addition, we review scientific literature regarding the efficacy of TNVR programmes to achieve rabies vaccination coverage and impact feral cat populations. Lastly, we consider other community concerns that arise when addressing managed feral cat colonies and their impact on wildlife.

Cats and the Threat of Rabies

Throughout the world, dogs are the rabies reservoir of greatest human health concern, causing 99% of human infections (WHO, 2005). In the United States, however, the canine rabies virus variants have been recently eliminated, and, as such, dogs are now a vector species for wildlife rabies instead of a reservoir. In 2010, 303 rabid cats were reported through national surveillance, compared with only 69 dogs (Blanton et al., 2011). This 4-fold difference is in sharp contrast to the pattern reported in 1946 (prior to mass vaccination of dogs), when 8384 rabid dogs were reported rabid compared with only 455 cats (Held et al., 1967). The dramatic decline in dog rabies from over 8000 cases a year to fewer than a hundred was accomplished through policies that promote mass vaccination coverage and control of strays, but adherence to these policies appears limited for cats (CDC, 2008a; National Association of State Public Health Veterinarians, 2011). Legislation reflects this disparity; canine rabies vaccination is required by 38 states, but only 30 states require cats to be vaccinated (Blanton et al., 2010). Because control tactics for cats are less emphasized, the number of reported rabies cases in cats has not declined in the same way as it has in dogs.

Post-exposure prophylaxis has been crucial to the prevention of human deaths due to rabies following contact with rabid cats, where contact is defined as an exposure that could potentially transmit rabies virus. No national reporting system exists to quantify the proportion of PEP attributable to cat exposures, but estimates indicate that 16% of PEP administration in the United States is likely due to cats and may account for the majority of PEP administration in some areas (Christian et al., 2009). Some regions experience much higher rates of PEP from cat exposures. A study of 67 counties in Pennsylvania found that 44% of PEP administration was due to cats, most of which (82%) were feral, stray or unowned (Moore et al., 2000). Similarly, New York state attributes more PEP administration to cat exposures (32%) than any other species (Eidson and Bingman, 2010). Most striking, a study in Montgomery County, Virginia, attributed 63% of PEP recommendations to stray cat exposures compared with only 8% for wild animal contact (Hensley, 1998). In this community, the high rate of PEP due to cats resulted in part from the lack of a county animal shelter facility for cats, illustrating the need for removal of feral and stray cats as a means of rabies control and PEP reduction.

The propensity to underestimate rabies risk from cats has led to multiple large-scale rabies exposures and

potentially caused a recent case of clinical rabies. In 1994, 665 persons in New Hampshire received PEP following exposures to a rabid stray kitten of unknown history, one of the largest documented mass exposure events recorded in the United States (CDC, 1995); for each person, exposure status either was sufficient for transmission or could not be determined because of the young age of those potentially exposed. Similarly, contact with a rabid stray kitten found at a South Carolina softball tournament led to 27 individuals requiring and receiving PEP in 2008 based on exposure of open wounds or mucous membranes to the kitten's saliva (CDC, 2008b). Individuals who are exposed to saliva from rabid cats in an open wound or mucous membrane and are not administered PEP are at risk of developing rabies and death. During 2011, an 8-year-old girl contracted rabies because no one was aware of an exposure; investigation showed that she had petted and been scratched by stray cats around her school weeks before developing clinical signs, but because she recalled no animal bites and none of the cats captured after her illness were rabid, and the definitive source of her infection was never identified (CDC, 2012). While this was an atypical case of human rabies with the child surviving, the vast majority of rabies victims die. Historically, exposures to rabid cats resulted in human fatalities in 1960 and 1975 (Anderson et al., 1984). In addition to these reported human cases associated with exposures to cats, more than 25 000 cats are submitted for rabies diagnosis each year in the United States to rule out potential human exposures (Blanton et al., 2011). All of these examples illustrate both the real potential for feline rabies infection and potential for transmission to humans.

Human rabies fatalities are rare in the United States thanks to the effectiveness of properly administered modern PEP, but treatment is expensive. Biologics alone cost in excess of $2000 (Shwiff et al., 2007). When mass exposure events occur, the monetary burden can be substantial; PEP for the New Hampshire mass exposure event referenced above totalled $1.1 million (CDC, 1995). Also, while comparatively safe, it should be noted that severe adverse events have been rarely reported in association with rabies PEP (CDC, 2008a).

Public Health and TNVR Programmes

The ability of TNVR programmes to achieve appropriate levels of rabies vaccination coverage in feral cat populations is doubtful. The current recommendations of the American Association of Feline Practitioners (AAFP) and the European Advisory Board on Cat Diseases (ABCD) state that kittens should be vaccinated against rabies between 12 and 16 weeks of age, boostered at a year and then again at the interval recommended by the manufacturer (Richards et al., 2006). Unfortunately, most cats in TNVR programmes will only be trapped once in their lifetimes (Richards et al., 2006). While feral cats in managed colonies live far shorter lives on average than indoor cats, many can live at least six years (Levy et al., 2003), and therefore, one vaccine dose does not necessarily offer lifetime coverage. Additionally, annual trapping rates of less than 10% (Foley et al., 2005) cannot reach a sufficient proportion of the population to establish and maintain herd immunity, even without accounting for declines in vaccine-induced immunity over time. Furthermore, the lack of consistent, verifiable documentation of vaccination for cats in TNVR programmes makes it unlikely that vaccination would change practices regarding human exposure assessment and PEP. When a stray cat involved in an exposure to a human is captured, it is recommended that the animal be confined and observed for ten days or immediately euthanized and tested for rabies (CDC, 2008a). Generally, if the animal cannot be captured, persons should begin PEP. Given the challenges mentioned above, ongoing vaccination of colony cats in a TNVR campaign would not be likely to impact these recommendations or the risk assessment process.

Many other potential zoonotic and cat-specific diseases are harboured in feral cat populations in addition to rabies. Among these are bartonellosis, toxoplasmosis, plague, endo- and ectoparasites, feline immunodeficiency virus (FIV), feline leukaemia virus (FeLV) and rickettsial diseases (Nutter et al., 2004b; McElroy et al., 2010; Al-Kappany et al., 2011; Little, 2011). The feline immunosuppressive diseases (i.e. FIV and FeLV) are especially important because they may predispose infected cats to developing additional viral, bacterial or parasitic diseases that can be passed to humans or owned cats (Al-Kappany et al., 2011). Many of these diseases are prevalent at higher levels in feral cats compared with the owned pet population because outdoor access poses the greatest risk of infection (Little, 2011). Group feeding of cats by colony caretakers puts cats at greater risk for contracting diseases whose transmission is augmented by increased animal density and contact rates among cats. Feline respiratory disease complex (FRDC), a group of pathogens that lead to high morbidity in shelters, catteries and colony feeding sites, is one such example (Cohn, 2011); however, other diseases are likely to be facilitated as well.

Group feeding also increases risk of contracting rabies and other wildlife diseases by enabling greater contact along the interface between cat colonies and wildlife reservoirs. A TNVR study in Florida reported that a feral cat feeding site attracted raccoons and opossums (Levy et al., 2003), and studies with rabies oral vaccine baits have shown cats sharing sites with these species as well as gray foxes (Olson et al., 2000) (Fig. 1). Feeding sites that attract raccoons, skunks and foxes are particularly dangerous because these species are rabies reservoirs in the United States (CDC,

Fig. 1. Potential interaction between a cat and raccoon. (Credit: Alan Hopkins).

2008a). Cross-species contact also allows feral cat populations to spread diseases to wildlife. In one study, about a third of raccoons and opossums sharing habitats with feral cats showed evidence of past infection with *Toxoplasma gondii*, a deadly zoonosis that requires felids to complete its life cycle (Fredebaugh et al., 2011).

Effectiveness of TNVR Programmes

Other disease risks notwithstanding, maintaining adequate rabies vaccination coverage in feral cat populations is impractical, if not impossible. Therefore, these populations must be reduced and eliminated to manage the public health risk of rabies transmission. Traditional animal control policies have stressed stray animal control and removal since the 1940s (Held et al., 1967; Anderson et al., 1984), and such policies were a major factor in the decline of canine rabies in the United States. In contrast, less emphasis on control and removal of stray cats is likely the cause of increased numbers of rabid cats compared with dogs (CDC, 2008a). Trap–neuter–vaccinate–return programmes claim to reduce stray cat populations over time, but evidence indicates that current implementations are unlikely to achieve declines in populations (Longcore et al., 2009). A study of 103 local colonies in Rome, Italy, found that while half of the colonies reported population decreases, virtually the same number were stable or showed increases (Natoli et al., 2006) in spite of an active sterilization campaign and the adoption of most of the kittens being born in colonies. A Tel Aviv, Israel study similarly showed that two colony populations continued to grow even at 73–75% sterilization, mostly due to immigration from surrounding cat populations (Gunther et al., 2011). Likewise, managed cat colonies in two Florida parks increased in size despite TNR programmes (Castillo and Clarke, 2003). These failures can be attributed in part to inadequate levels of sterilization. One model estimates that the per cent sterilization needed to reduce feral cat populations is between 71% and 94%, levels that are rarely reached in real-world scenarios (Foley et al., 2005). Similarly, another study concluded that 90% sterilization is necessary to reduce feral cat populations (Jones and Downs, 2011).

Evidence from other model-based analyses of TNR programmes showed that while TNVR may be useful if broadly implemented in closed populations when no animals can immigrate into colonies (e.g. island settings), it is ineffective in open populations that more closely resemble most cat colonies in the United States (Schmidt et al., 2009). Facing these challenges, many TNVR programmes only show positive results at temporarily reducing cat numbers when heavily subsidized by adoptions and assisted by colony cat emigration to other areas (Levy et al., 2003). Moreover, while emigrants do technically reduce the number of cats living in a particular colony, they should not be interpreted as reducing the overall feral cat population. Thus, unless sterilization is nearly universal and unneutered cats are prevented from immigrating, colony populations do not decrease and eventually disappear with time and may increase in response to supplemental feeding.

Feral Cats and Wildlife

Exotic feral cats can have profound ecological effects on native species. As an obligate predator, this invasive species often preys on native wildlife. A study comparing an area with supplemental feral cat feeding to one without it found that the area with feeding had reduced abundance of native rodent and bird populations, illustrating that supplemental feeding attracts cats without substantially decreasing their hunting behaviour (Hawkins et al., 1999). When the quantitative effects of cat predation have been estimated, results are striking. One study in the United Kingdom observed sites where the estimated number of birds killed was greater than the number fledged for multiple passerine species (Baker et al., 2008). Despite their ability to affect native bird and mammal populations, cats do not appear to significantly decrease populations of synanthropic pest species. Feeding sites do not show decreased populations of house mice, as access to a constant food source may increase their populations (Hawkins et al., 1999). The difference in the effects of cats on native fauna compared with exotic rodents may be due to their coevolution with foreign pest species, which made pests better adapted to evasion of cats (Jessup, 2004). In addition to the risks posed by feral

cats to biodiversity and ecosystems, several wildlife veterinarians and scientists question the logic of prioritizing feral cat welfare over the welfare of native prey animals (Jessup, 2004).

Discussion

Rabies remains an important cause of human mortality throughout the world, but the effectiveness of control programmes in the United States may subdue the collective memory of the significance of rabies. Despite the presence of enzootic rabies in nearly every state, only a few human deaths are reported each year in the United States. This accomplishment is entirely the result of practical, effective public health policy and education in tandem with appropriate animal vaccines and vaccination schedules, use of PEP and stray animal management.

Unfortunately, most current applications of TNVR programmes do not provide effective rabies vaccination coverage or cat population control. Current NASPHV rabies recommendations stipulate that all cats, dogs and ferrets be current on rabies vaccinations. Within feral cat colonies, even those with TNVR programmes, compliance with national vaccination recommendations or laws that uphold them are likely to be impractical. Although most caretakers provide food for colonies, adequate domestic animal care also requires prevention of disease and unmitigated breeding. Feeding of feral cat colonies sustains their populations, and it likely subjects them to increased disease transmission by increasing cat densities and contact rates at feeding sites (Hawkins et al., 1999; Jessup, 2004; Cohn, 2011). Trap–neuter–vaccinate–return does not adequately meet feral cat population control needs that public health and animal welfare necessitate.

Feral cat population control should be conducted with the input of all invested stakeholders such that an effective and ethically acceptable method for controlling feral cats and their associated potential public health concerns can be achieved. One recent study, which modelled costs and benefits for TNVR as compared to trap and euthanize programmes, found that in all scenarios, trap and euthanize programmes were less expensive to conduct and had a higher economic benefit (Lohr et al., 2012). However, that study found that the relative difference in benefits between both programmes was reduced as the abandonment rate of cats in the community increased.

Domestic cats are an important part of American culture and provide companionship for millions of people. As such, it is important for public health institutions to take a science-based stance for effective and humane management of feral cat populations. While TNVR programmes may be a component in controlling small populations of cats (particularly in closed population settings), it should not be endorsed as an effective approach by itself or as a method for mitigating health concerns related to feral cat colonies. Any stance should include objectives that are shown to reduce the disease burden on both the feral and owned populations of cats and to lessen the risk of zoonotic diseases, including rabies, to humans. Most importantly, any programme focused on reducing feral cat populations should include components to reduce abandonment rates of cats. It is critical to educate cat owners on responsible pet ownership including the importance of maintaining a regular vaccination schedule, keeping records of these vaccinations for their cats, restricting their cats from roaming freely and spaying and neutering to prevent unwanted kittens that will be abandoned rather than adopted to responsible homes. Furthermore, state and local governments will need to enact or enforce existing animal control laws to uphold these public health recommendations. In particular, requirements for rabies vaccination, requirements or incentives to spay or neuter and prohibitions against free-roaming should be applied to cats as they are generally applied to dogs; they reflect standards of ownership that are appropriate for all domestic companion animals. By following these steps, feral cat populations and associated zoonotic diseases such as rabies can be better controlled. However, continued research to establish best practices for developing and effectively implementing comprehensive cat population control programmes is warranted.

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