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An evaluation of bat rabies prevention in the United States, based on an analysis from Pennsylvania

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Fear of bats as vectors of rabies is pervasive as a primary cause of their needless destruction, especially in the United States. Nevertheless, transmission from bats to humans is so rare that only 27 of 50 states have reported a single case since record keeping began in the 1940s, and fewer than 0.78 persons/year have been infected. We here analyze human rabies exposure records from the Pennsylvania Department of Health to document relative risks in one representative state. Rabies exposure from bats to humans was no more frequent than from dogs and significantly less than from cats. Yet, of these three, only bats are listed as high-risk vectors. Furthermore, we found that 85.4% of rabies diagnosed from bats was confined to just one of the state's 11 species. These findings suggest that disproportionate emphasis on bats, combined with lumping all bat species into a single risk category, is counterproductive to public health interests, in addition to needlessly prejudicing the public against these highly beneficial, but declining animals.

Key words: Chiroptera, rabies, *Lyssavirus*, Rhabdoviridae, public health, Commonwealth of Pennsylvania, infectious disease

Introduction

Insectivorous bats are primary predators of night flying insects that have enormous ecological and economic impact (Whitaker, 1993; Arita and Ortega, 1998; McCracken and Westbrook, 2002). Nevertheless, bats are often feared and exterminated as a result of exaggerated public health warnings associating them with rabies, a disease that is typically transmitted by the bite of an infected animal and leads to fatal encephalitis or encephalomyelitis (Brass, 1994; Constantine, 1988). Rabies typically manifests itself in either a furious or a paralytic phase. In the former, the victim becomes aggressive, attacking and biting other animals that it encounters. In the latter, a loss of muscle control leads to paralysis and death, typically without aggression. Dogs and cats often experience the furious phase, while bats typically become paralyzed.

Worldwide, there are between 35,000 to 50,000 human rabies deaths annually, and the vast majority result from dog bites (World Health Organization, 1996). In the United States, laws require that all domestic dogs be vaccinated for rabies, greatly reducing transmission to humans (Brass, 1994; Cockrum, 1997). Cat vaccination laws are less consistent from state to state and are often un-enforced.

Approximately 46 species of bats occur in the United States (Simmons, In press), with rabies detected in at least 38 (Constantine, 1988). Less than five percent of suspect bats submitted to state health departments test positive (e.g., Childs *et al*., 1994). Sampling of wild populations indicates rabies infection in less than 0.5% (Brass, 1994; Constantine, 1988; King *et al*., 1990).

Though rabies is widespread in United States wildlife, it is rarely transmitted to humans. In the period from 1951 through 2000, no cases were transmitted from raccoons or foxes, only one case from skunks (CDC, 1983*a*), and 38 from bats (Sulkin and Greve, 1954; Irons *et al*., 1957; Gottlieb, 1959; CDC, 1959, 1979, 1983*b*, 1984, 1991*a*, 1991*b*, 1993, 1994*a*, 1994*b*, 1995*a*, 1995*b*, 1996*a*, 1996*b*, 1997*b*, 1997*c*, 1998*b*, 1999*b*, 2000; Humphrey *et al*., 1960; Kent and Finegold, 1960; Hattwick *et al*., 1972; Brass, 1994). Nevertheless, the Centers for Disease Control (CDC), and most states, list all these groups as high risk vectors while none include either domestic dogs or cats in this category. Furthermore, the entire order Chiroptera is considered high-risk, with little effort made to identify species tested, despite the fact that most species have not transmitted the disease to humans. Our purpose is to compare rabies incidence versus human exposure and transmission rates to document relative risks in a manner that enables public health officials to more clearly educate the public with less harm to conservation efforts.

Materials and Methods

For our comparisons, we chose records for rabies testing from the Pennsylvania Department of Health, a state of approximately average size and rabies risk, and examined records from 1992 through 2000 for the primary mammalian groups they monitor (raccoons, skunks, foxes, bats, cats, and dogs). These years were selected because 1992 is the first year for which both incidence and rates of human exposure per incident were recorded. In some cases, species identification was not available. All raccoons in Pennsylvania are *Procyon lotor*, whereas skunks may have included both *Spilogale putorius* and *Mephitis mephitis*. Foxes may be *Vulpes vulpes* or *Urocyon cinereoargenteus*. Bats may have included any of the 11 species that are known to occur in the state (Merritt, 1987). Cats were *Felis sylvestris* (domestic cat), and dogs were *Canis lupus familiaris* (domestic dog). Species classification as used above follows Wilson and Reeder (In press).

Human exposure was defined as any event that led to possible exposure to rabies via an animal vector that tested positive. These included being bitten, handling a rabid animal where no bite occurred, or simply being in proximity to an animal that tested positive. Statistical analyses were performed on both the number of vector cases that occurred and the on the number of human exposures which resulted. Data were analyzed using MiniTab 10.5 Power Xtra 1995 (Minitab Inc., State College, PA, USA), and a two-way ANOVA (species versus year) was used to examine the number of cases of rabies per mammal group per year. Pair-wise comparisons were subsequently analyzed using Tukey's test. A similar analysis, of the number of cases of rabies that resulted in human exposure was also performed for each of the six mammal groups for each year.

We additionally obtained species identification data on tested bats, courtesy of the Pennsylvania Department of Agriculture State Veterinary Diagnostic Laboratory. This is one of four facilities that tests for rabies on animals submitted to the Pennsylvania Health Department, and it is the only laboratory in the state that provides species identification for suspected rabies vectors. We analyzed their data for the same 1992–2000 period.

Results

Significant differences were found among mammal groups but not among years with regard to the number of cases of rabies reported for any purported vector (Tables 1 and 2). Raccoons had the highest incidence of rabies of any group ($\bar{x}$ = 227.5 cases/year). Skunks had the second highest incidence ($\bar{x}$ = 83.2 cases/year). Foxes, cats, and dogs were not statistically distinguishable, in cases/year, from bats. Dogs were the only group ($\bar{x}$ = 2.1 cases/year) with a lower incidence of rabies than that exhibited by bats.

TABLE 1. Significance levels from two-way ANOVA that evaluated the effects of six mammal groups and year on the number of rabies cases (n = 3,323) and the number of human exposure cases (n = 704) that occurred in the Commonwealth of Pennsylvania between 1992 and 2000

Factor	Cases of rabies	Human exposure
Groups	$P < 0.001$	$P < 0.001$
Year	ns	ns
Groups by year	ns	ns

Raccoons were significantly higher in human exposure cases compared to the other vector groups (Table 2), averaging 35.2 human exposures per year or 15.4% of cases that resulted in exposure of a human. With the exception of raccoons, cats and skunks contributed significantly more human exposures than the other groups. Cats averaged 24.8 human exposures, or 86.4% of rabies cases in this vector group. The remaining mammal groups (foxes, dogs, and bats) were statistically indistinguishable, in terms of cases that resulted in human exposure.

Only 48 (3.9%) of the 1,224 bats tested by the Pennsylvania Department of Agriculture State Veterinary Diagnostic laboratory, were positive for rabies. The largest sample, 839 of 1,224, was for *Eptesicus fuscus*. Of the 839 *E. fuscus* suspected of having rabies, only 41 (4.9%) tested positive. For all other species of suspiciously behaving bats combined, only seven additional individuals tested positive for rabies over the same nine-year period (0.57%).

DISCUSSION

Our finding that bats tested positive for rabies less frequently than almost all other mammals, and that human exposure rates were similar for both dogs and bats, calls into question why bats are so disproportionately emphasized in public health warnings. De-emphasis of domestic cats as high risk vectors is especially surprising, given that they cause more human exposures than either dogs or bats. Veterinary diagnostic laboratory records show that only 3.9% of bats, suspected of having rabies, actually tested positive and that most positives were from a single species, the big brown bat (*E. fuscus*), which was responsible for 41 of the 48 rabies cases in bats. As a group, suspect bats of the other 10 species combined had a positive rate of only 0.57%. These data suggest that it is inappropriate to lump all 11 species into a single group.

In the United States, there were only 38 human rabies deaths reported as being of bat origin between 1951 and 2000 (Sulkin and Greve, 1954; Irons *et al*., 1957; CDC, 1959, 1979, 1983*b*, 1984, 1991*a*, 1991*b*, 1993, 1994*a*, 1994*b*, 1995*a*, 1995*b*, 1996*a*, 1996*b*, 1997*b*, 1997*c*, 1998*b*, 1999*b*, 2000; Gottlieb, 1959; Humphrey *et al*., 1960; Kent and Finegold, 1960; Hattwick *et al*., 1972; Brass, 1994), including only one from Pennsylvania in 1984 (CDC, 1984). This is a death rate of just 0.78 persons/year, 0.02 persons/year for Pennsylvania. Due to advances in rabies diagnosis, reported human cases have increased in recent years (CDC, 1999*a*). The Centers for Disease Control reports that only 2 of 24 cases between 1990 and 2000 had a definite bite history (CDC, 2000), however diagnoses were mostly post mortem or of seriously neurologically impaired individuals, precluding verification of definite bite histories. A majority of these individuals had

TABLE 2. Tukey's pair-wise comparisons showing the six mammal groups for rabies cases and human exposure cases in the Commonwealth of Pennsylvania. Groups that were statistically indistinguishable from each other are connected with an unbroken line

Infected mammals					
Raccoons	Skunks	Cats	Foxes	Dogs	Bats
Human exposure					
Raccoons	Cats	Skunks	Foxes	Dogs	Bats

probable bite histories that were reported by family or friends, so are not indicative of undetected bites (Tuttle, 2000). Nevertheless, such reports have been interpreted widely as evidence that the majority of rabies transmission from bats to humans is from undetected bites (Connecticut Department of Public Health, 1995; CDC, 1998*a*; Massachusetts Department of Public Health, 1998; Dzyak and Burman, 1999).

A combination of the undetected bite hypothesis and reports that most human rabies cases in the United States are transmitted by bats, have led to sensational media headlines that disproportionately inflate the public's perceived risk, reducing tolerance of bats as beneficial allies (Tuttle, 2000).

To put human mortality risks from bat-transmitted rabies in perspective, we compared a 1980–2000 rate of 1.2 persons/year against other sources. Lightning strike kills about 90 individuals in the United States per year (Curran *et al*., 1997). Approximately 15 to 25 people die annually in the United States due to dog attacks (Sacks *et al*., 1996; CDC, 1997*a*), and 200 from accidents involving deer (Jones, 1999). After considerable research, we were unable to locate a published death rate that was as low as that from bat-transmitted rabies. The U. S. Consumer Product Safety Commission (1995) recorded 37 deaths in the United States between 1978 and 1995 due to rocking or tilting of vending machines, resulting in them toppling on people. This is a death rate of 2.2 individuals/year.

Focusing disproportionate emphasis on mortality risks associated with bat-transmitted rabies is harmful to environmental health, as well as counterproductive to public health. A study conducted by the Oregon Health Division found bat exposure to humans to be common, although bat-associated rabies is extremely rare. This study also concluded that, for Oregon to follow the U.S. Centers for Disease Control vaccination guidelines for prevention of bat-transmitted rabies (currently followed by most U.S. states), could cost $180,000,000 to prevent a single case. It estimated that just one person per 75 years would die of bat rabies even if bats were not singled out for special emphasis (P. R. Cieslak, E. E. Debess, W. E. Keene, D. W. Fleming, in litt.). Disproportionate expenditures to protect humans from wildlife rabies are based more on fear than on actual risk and are difficult to justify (Bruggemann, 1992; Tuttle, 2000).

We agree with bat researchers assembled at the 29th North American Symposium on Bat Research who concluded that bats rarely bite humans unless handled, that bites are normally detected, that transmission is rare, and that no one should handle bats who has not been vaccinated against rabies (Griffiths, 2000). Although rabies transmission from either wildlife or domestic animals in the United States is now rare, our analysis suggests that both the public and bats would benefit from a more generalized approach to rabies prevention wherein people are simply warned to avoid handling any unfamiliar animal and to seek immediate medical evaluation for any animal bite.

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