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Introduction

Although bats are known to host a variety of microbial organisms, disease transmission to man is rare. Parasites of bats are not significant to human health (1, see also 2,3), and even the danger of rabies "has been vastly exaggerated" (2). Media coverage involving bats is often sensational and grossly inaccurate (2,4, for examples see 5). Careless reporting stimulates increased notice of sick bats (6-8) and elicits intense public demands for destruction of all bats (2). Subsequent poisoning increases the number of sick bats encountered by people (6,7,9-12), thereby creating "a self-perpetuating cycle of hysteria" (6). Serious hazards to man and the environment are sometimes created when pest control companies exploit these intense but unnecessary public fears (2,13).

Our purpose is to provide an up-to-date review of research involving the relationship of bats to public health, placing risks in perspective, and offering advice on prevention and solution of problems. Emphasis will focus on the involvement of bats in the epidemiology of histoplasmosis and rabies, since these are the only diseases associated with bats that are believed to be of consequence to public health.

Histoplasmosis

Histoplasmosis is a fungus that prefers soils enriched by bird or bat droppings (2,14). Human infection is common, sometimes as high as 80% of the population, in wide areas of the Americas, Europe, Africa, and the Far East (15). In the United States almost 90% of all reported cases in man come from the Ohio and Mississippi River drainages, extending eastward into Virginia and Maryland (14). It is probably endemic in 31 states (16). Although especially virulent forms may occur in some caves

in Latin America (12,17) and Puerto Rico (18), elsewhere infections are usually asymptomatic, or may appear as benign respiratory illness (12). Histoplasmosis survival in hot, dry attics is uncommon (19) and the few people exposed in such places seldom become seriously ill (2). No other noteworthy risks from human exposure to bat droppings are known (2,12).

Histoplasmosis infection occurs primarily through inhalation of airborne spores in dust. Therefore, in places where histoplasmosis is a concern, people should avoid dust inhalation. If removal of bat guano is necessary, use of a properly fitted respirator (capable of filtering particles as small as 2 microns in diameter) will greatly reduce exposure (2).

Rabies

Geographic Distribution and Infection Rates

Rabies infection in bats is rare in Asia, Africa, and Europe (20-22). A total of only two cases of transmission from bats to man is suspected for Asia (23) and Africa (20,21), while in India alone other animals cause an estimated 15,000 human rabies deaths annually (24). European bats are practically rabies free and are not considered important as disease vectors (24-26). Rabies is unknown from Australia (27). Reporting from Latin America is incomplete, but despite widespread vampire populations there, human mortality from bat-transmitted rabies still appears to be relatively low (22). The United States reported a total of nine cases of human rabies from bats in more than 30 years (2), and only a single case is known from Canada (28,29).

Infection rates in bats outside the New World are far too low to be calculated. Even in North America they are very low, usually less than one half of one percent in seemingly normal bats (7,8,11,22,30-32). Incidence in sick, dead, or suspect bats submitted for testing ranges about 3-10% (11,33,34-36). Figures indicating higher rates in wild populations often result from a variety of sampling biases, including small samples and mixing of suspect and apparently normal bats (2,8,31,32,37). Rabies outbreaks in bats other than vampires "either do not occur or must be rare" (38, see also 11).

Transmission to Humans

Healthy bats do not attack people (2), and attacks by the few that become rabid "are exceedingly rare" (6, see also 8,11,20,30,31,38,39). Frequent public reports of bat attacks result from a variety of errors (see Evaluation and Treatment of Human Exposure and 40). Most human exposures to infected bats result from careless handling of partially paralyzed, grounded individuals (2,11,30, see also 39). The public health significance of bat rabies lies in the number of persons vaccinated each year following exposure to potentially rabid bats (8). "A large number, probably most, of these treatments are unnecessary, resulting from

misidentification of the animal involved, exaggeration of the extent of exposure, and, most frequently, mishandling of the bat involved, making laboratory examination impossible" (41, see also 42).

Although two cases may have resulted from aerosol exposure to millions of bats in a unique cave environment (32), the fact that thousands of people explore bat caves each year without harm demonstrates that aerosol transmission is exceedingly rare. Such transmission "is *not* a public health hazard with house bats" (2, see also 33).

Transmission to Wildlife

Although early studies appeared to implicate bats as asymptomatic carriers of rabies (43-51), similar but relatively harmless viruses, such as Rio Bravo virus (52), likely were misidentified as rabies (11,32,53). Current research does not support a carrier state for bats. Moreno and Baer (54) and Bell (55) found no evidence that bats survive rabies better than other animals and concluded that a carrier state did not exist (see also 33). Constantine (11) also concluded that "bats are not carriers of rabies," noting that, "they either survive exposure to the virus without spreading it or they succumb like other mammals." The World Health Organization's Expert Committee on Rabies concurs (22).

But because bats once were hypothesized to be important carriers and reservoirs of rabies, many studies explored possible routes of transmission to wildlife. Results were varied. Although laboratory mice were infected by bites in several studies (55-58), in another, white mice, monkeys, and guinea pigs were bitten repeatedly by rabid bats without harm (59). In several other studies, a variety of carnivores (including dogs and cats) were bitten hundreds of times on the lips and noses by rabid bats, but rarely contracted rabies (60-63). The World Health Organization's Expert Committee on Rabies found no evidence of natural bite transmission from insectivorous bats to carnivores and noted that experimental transmission by bite had proven extremely difficult (22).

Other possible routes include ingestion and aerosol transmission. Studies in which rabid laboratory mice were fed to carnivores demonstrated that transmission by ingestion is possible (64-67). However, monkeys ate rabid bats without harm (59), and Winkler (68) once fed 40-45 clinically rabid bats to each of eight foxes without the foxes becoming infected. Conceivably, epizootics may begin under optimum conditions by ingestion of rabid bats (69). But Constantine et al. (60) found no rabid animals among predators at the entrance to Carlsbad Caverns, despite apparently optimum conditions, and Malaga-Alba (50) reported that a wide variety of carnivores in Mexico enter bat caves during major rabies die-offs of vampire bats and eat dying bats without getting sick. Constantine (70) demonstrated aerosol transmission to carnivores in certain unique bat caves of the Southwest, but noted that his test animals

were subjected to abnormal conditions of stress and exposure not encountered in the wild (see also 8,22,33). He concluded that "an independent rabies virus cycle exists in bats" that is tangential to cycles in other wildlife (30, see also 22).

Several studies have attempted to show a relationship between bats and rabies in other animals. Obviously, if bats actually served as reservoirs for the disease, then incidence in wildlife should be highest in areas of bat concentration. Although some authors have postulated such associations (71-74), actual field studies strongly contradict such a conclusion. In addition to the convincing observations of Constantine et al. (30,60) and Malaga-Alba (50), a ten year study in Georgia found a negative relationship between rabies in bats versus other wildlife and concluded that no epidemiological evidence existed to suggest transmission of rabies from bats to wildlife (37). A similar study in Indiana reported that "significantly more rabid animals were found in those counties not reporting bat rabies than in those counties with bat rabies" (35). Other studies from the United States (55), Canada (75, see also 29), and Europe (24), indicate that rabies outbreaks in wildlife are independent of the disease in bats (33).

In conclusion, available studies indicate that bats are not true carriers or important reservoirs of rabies for terrestrial wildlife.

Prevention of Human Exposure

Since even rabid bats rarely attack people (2,11,20,30,31,38,39), most human exposure can be eliminated by educating people not to handle bats and by excluding bats from human living quarters. This should be done "without creating undue alarm or failing to recognize the important ecological role of bats in the control of insects" (76).

In most cases bats can be excluded from human living quarters by simply covering chimneys with half-inch hardware cloth, adding draft guards beneath doors leading to attics, and using screens on appropriate windows, doors, and ventilation systems. Decisions to additionally exclude bats from outer areas, such as attics, eaves, or behind chimneys, should take into account that bats are beneficial (2,8,12) and should be left to the discretion of the informed home owner.

In those instances when bats are an actual nuisance and must be excluded, the only safe, permanent solution is to seal entrance holes after nightly or seasonal departure of the bats (2,10,11,33,76-80). Exclusion should not occur when flightless young would be trapped inside (usually June and July in the U.S.). Since sealing holes and cracks may result in greater thermal efficiency, energy conservation tax credits are available from IRS (2). Ultrasonic repellents are of questionable value (81,82), may irritate nearby humans (12), and are potentially dangerous (83). Poisons increase risk of human exposure and will be discussed later (see Hazards of Mismanagement). A manual (2) entitled *House Bat Management* (US Fish & Wildlife Service Resource Publication No. 143) provides many

valuable details of exclusion techniques and can be ordered from the US Government Printing Office, Washington, D.C. 20402.

Because dogs and cats continue to be the reason for giving the majority of antirabies treatments (84,85), it is important that they be immunized regardless of local presence of bats.

Evaluation and Treatment of Human Exposure

Since bat attacks are exceedingly rare (6), and since fear prompts many mistaken reports of bat attacks, physicians should carefully screen all alleged attacks. During routine investigations for Public Health and Parks Departments in Milwaukee, Wisconsin and elsewhere, Tuttle (unpublished obs.) found several instances in which bats were blamed for attacks by nesting screech owls. Many reported attacks resulted from panicked people scratching themselves while attempting to "escape" a bat that merely flew past, and some resulted from misidentified insect bites. Several elderly women and others became paranoid from hearing strange sounds at night and the next morning interpreted unidentified marks on their extremities as proof of having been attacked in their sleep. None of more than 25 suspect cases investigated proved valid. People actually bitten usually see the bat at the time. Bites, if visible, usually appear as one or more puncture wounds about 0.5-1.5 mm in diameter, typically 3-10 mm apart.

Casual contact, such as mere touching of a rabid animal, does not constitute an exposure unless scratches, abrasions, open wounds, or mucous membranes are contaminated with potentially infectious material such as saliva or brain tissue (85). Pre-exposure immunization is recommended for researchers and other high risk people (11,85). Human diploid cell rabies vaccine is preferred for its effectiveness and lack of adverse reactions (85,86).

A recent survey of physicians revealed that frequent misunderstanding of proper post-exposure treatment placed patients at unnecessarily high risk of rabies infection (87). The Center for Disease Control has published detailed post-exposure procedures (85), which include: (1) thoroughly wash wound, (2) safely capture animal for testing, (3) promptly seek medical treatment (commonly including vaccination for tetanus, antibacterial measures, prompt administration of rabies immune globulin for immediate passive immunity, plus human diploid cell vaccine for slower but longer lasting active immunity). For further details call the nearest state health department or the Center for Disease Control in Atlanta, Georgia.

Hazards of Mismanagement

Poisoning of bats is strongly contraindicated. Extermination of bats with DDT, Chlorophacinone (Rozol), or other toxic chemicals serves to increase rather than decrease hazards to public health (2,4,10,11, 13, 33, 76, 81, 88). Poisons used in bat control may seriously threaten humans as

well (2,13) and cause sickened bats to scatter and fall to the ground, where they die slowly and may be picked up by inquisitive children or pets (4,6,7,11,33,76). Recently a single application of a toxicant resulted in a 700% increase in human contact with bats (9). Furthermore, Trimarchi (7) hypothesized that physiological stress imposed by sub-lethal levels of pesticide toxicity might increase bat susceptibility to viral infections such as rabies. Such increased hazards of pesticide application are long-term (6,7,11,12), sometimes persisting up to six years (80). Additional deleterious effects of pesticide use against bats involve environmental contamination (13,80) and needless destruction of bats, whose value to medicine, research, and insect control have long been acknowledged (2,8,12,18,48,52,79,89-95).

“Those who do the most to keep the public afraid of bats are usually those who profit from their destruction” (53). Killing bats is lucrative in generating repeat business for the pest control industry (13,53), because in the absence of physical exclusion dead bats eventually are replaced (10,12,33,76,96). “A need exists to educate the public toward a climate that recognizes the inescapability of, and desirability of coexistence of man and bats” (7). Visual and printed media which sensationalize dangers associated with bats are counterproductive. Only persistent misinformation and fear preclude safe, non-destructive solutions to legitimate problems.

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