Rabies in Indiana Bats

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Abstract

A total of 626 bats routinely submitted to the Indiana State Board of Health from 1965 to 1968 was examined for rabies using the fluorescent antibody test and sometimes the mouse test. Of these 42, or 6.7%, were rabid. Twenty-four of 364 big brown bats, *Eptesicus fuscus,* were rabid as were 11 of 152 red bats, *Lasiurus borealis.* Bat rabies was more common in the southern than in the northern portions of the state, and was more common in the summer and fall than at other times. There were two apparent outbreaks of rabies in Indiana in bats in 1967, one in *Eptesicus fuscus* in Jefferson County and one in *Lasiurus borealis* in Vanderburgh County. Bat rabies has been reported in a total of 17 Indiana counties. There appears to be no positive correlation in Indiana between rabies in bats and rabies in other species. A total of 133 big brown bats was collected in "normal wild" populations of *Eptesicus* in Jefferson County at the height of the 1967 rabies outbreak, but all proved negative for rabies.

Introduction

Rabies was first found in a United States bat in 1953 when a Florida Yellow bat was killed while attacking a seven-year-old boy (7). Rabies has now been reported in all of the 48 contiguous states; Rhode Island became the last on June 12, 1967 (1). The disease has now been found in at least 20 species of bats.

Some summarized incidence figures for bat species in which large numbers of bats have been examined in Florida (5, 7), Texas (6), southwestern United States (2), southern New England (3) and Illinois (4, 8) are:

	Number examined	*Number rabid*	*Percent rabid*
Lasiurus borealis	191	12	6.28
Eptesicus fuscus	177	5	2.82
Tadarida brasiliensis	963	27	2.80
Lasiurus floridanus	717	20	2.79
Lasiurus seminola	846	6	0.71
Pipistrellus subflavus	406	2	0.49
Myotis velifer	273	1	0.37
Myotis grisescens	281	1	0.36
Myotis lucifugus	984	3	0.30
Myotis austroriparius	1998	1	0.05

Illinois is the only midwestern state in which there have been extensive surveys for bat rabies. A total of 652 bats was examined (8, 4) and none were found to be rabid. Unfortunately only 12 were red bats, the species in which the highest incidence of rabies generally occurs. Of the remainder, 504 were *Myotis*, the genus which generally has the lowest incidence of rabies. Fifty-five were *Eptesicus*, 65 were *Pipistrellus*, 8 were *Plecotus* and 8 were *Lasionycteris noctivagans*.

Before the present study there were four confirmd cases of bat rabies in Indiana. A red bat, *Lasiurus borealis*, taken in Tippecanoe County, September 5, 1960, was rabid, as was a silver-haired bat, *Lasionycterius noctivagans*, taken September 12-13, 1960, in Montgomery County. Thirty-three additional bats, unidentified, taken in 1960, were not rabid. None were examined from 1961 through 1963, but in 1964, 37 unidentified bats were found to be negative for rabies. Two rabid specimens were found in 1965 among 70 unidentified bats. One of the rabid bats was from Delaware County and one from Monroe County.

The present study was initiated in 1965 to determine:

a. the distribution and incidence of rabies in Indiana bats
b. the relationship between rabies in bats and rabies in other species of mammals in Indiana
c. the relation between incidence of rabies in bats turned in by Indiana citizens to the Indiana State Board of Health and rabies in wild-taken bats.

Materials and Methods

The brains of all bats submitted to the Indiana State Board of Health were examined directly for Negri bodies and by the fluorescent antibody method. Brain material from many was injected into white mice as a further test. These bats came from throughout the state. Starting in 1966, all bats submitted to the Indiana State Board of Health were identified by the senior author.

Many bats came from a small number of counties. In two counties, Jefferson and Vanderburgh, there were widely publicized bat rabies scares in 1967; these are the counties from which we have examined the largest numbers of specimens. Three other counties from which large numbers of bats have been examined are Marion, Johnson, and St. Joseph, all of which have yielded rabid bats. Bat rabies in Vanderburgh County was chiefly in red bats, *Lasiurus borealis*, while in Jefferson County it was primarily in big brown bats, *Eptesicus fuscus*. Efforts were made to obtain large numbers of bats from "normal wild colonies" of *Eptesicus* in Jefferson County on July 21, 1967, at the peak of the outbreak. A total of 97 bats was collected that day by the senior author and Robert Kerr, the Jefferson County Sanitarian. Later samples by Mr. Kerr increased the total of bats from the "wild" populations to 133.

Information on rabies in species other than bats was acquired from the files of the Indiana State Board of Health. This information was compared with the bat rabies information.

A total of 759 bats was examined during this study, 626 of them submitted to the Indiana State Board of Health by citizens, physicians, veterinarians, and law or health officials for routine rabies examination, and 133 from the Jefferson County "wild sample."

Species of bats infected

Two of the species collected in small numbers, *Pipistrellus subflavus* and *Lasiurus cinereus*, had the highest incidence of rabies of any of the bats taken during this study (Table 1), but this may be chance. Only 16 individuals of each species were taken.

TABLE 1. *Rabies in bats collected by citizens of Indiana, summarized by species, 1965-1968.*

	No. examined	*No. rabid*	*% rabid*
Eptesicus fuscus	364	24	6.6
Lasiurus borealis	152	11	7.2
Myotis lucifugus (incl. 2 probably this species)	50	1	2.0
Myotis sodalis	12	0	0
M. keeni	4	0	0
Lasionycteris noctivagans	3	0	0
Nycticeius humeralis	9	0	0
Pipistrellus subflavus	16	2	12.5
Lasiurus cinereus	16	4	25.0
	626	42	6.7

The two most common bats of Indiana appear to be *Lasiurus borealis*, the red bat, and *Eptesicus fuscus*, the big brown bat. *Lasiurus borealis* is a solitary species, but is quite common, especially in southern Indiana. This species would appear to be the most commonly infected of the United States bats that have been studied. In Indiana, 7.2% of the red bats submitted by citizens to the State Board of Health were rabid (Table 1). *Eptesicus fuscus* is most often directly associated with human beings, often forming large colonies in barns, houses and other buildings. For this reason, and since large numbers of *Eptesicus* have not been examined for rabies, data on this species are particularly desirable. The rate of rabies infection in *Eptesicus*, 6.6%, was slightly lower than in red bats.

In Indiana, the major cave bats are species of *Myotis*, of which 66 specimens were examined, one (1.5%) being rabid.

Overall, 42 of 626, or 6.7% of the bats submitted to the Indiana State Board of Health were rabid.

Geographic distribution of bat rabies in Indiana

During the present study (Table 2), rabies was found in bats from fourteen counties: Daviess, Dearborn, Fayette, Gibson, Greene, Hendricks, Jefferson, Jennings, Johnson, LaPorte, Marion, Monroe, St. Joseph, and Vanderburgh, bringing to 17 the total number of counties from which rabid bats have been taken (including Delaware, Montgomery, and Tippecanoe, counties in which bat rabies was found before the initiation of this study).

TABLE 2. *Rabies in bats collected by citizens of Indiana, summarized by county, 1965-1968.*

	No. examined	*No. rabid*	*% rabid*
Allen	13	0	0
Bartholomew	6	0	0
Boone	4	0	0
Brown	2	0	0
Cass	2	0	0
Clark	3	0	0
Clinton	2	0	0
Daviess	1	1	100.0
Dearborn	6	1	16.7
Decatur	1	0	0
*Delaware	5	0	0
Elkhart	3	0	0
Fayette	1	1	100.0
Floyd	1	0	0
Fountain	2	0	0
Franklin	1	0	0
Fulton	2	0	0
Gibson	4	1	25.0
Greene	4	2	50.0
Hamilton	1	0	0
Hancock	4	0	0
Hendricks	8	2	25.0
Henry	4	0	0
Howard	6	0	0
Huntington	1	0	0
Jackson	8	0	0
Jefferson	132	13	9.9
Jennings	2	1	50.0
Johnson	51	3	5.9
Knox	2	0	0
Kosciusko	3	0	0
LaGrange	3	0	0
Lake	11	0	0
Laporte	2	1	50.0
Lawrence	8	0	0

TABLE 2. *Rabies in bats collected by citizens of Indiana, summarized by county, 1965-1968.*—(Continued)

	No. examined	*No. rabid*	*% rabid*
Madison	7	0	0
*Marion	69	3	4.3
Marshall	3	0	0
Miami	2	0	0
Monroe	16	1	6.3
*Montgomery	9	0	0
Morgan	5	0	0
Noble	1	0	0
Pike	1	0	0
Posey	4	0	0
Putnam	2	0	0
Randolph	1	0	0
Ripley	2	0	0
Rush	6	0	0
St. Joseph	47	2	4.3
Scott	3	0	0
Spencer	2	0	0
Steuben	1	0	0
Sullivan	4	0	0
Switzerland	1	0	0
*Tippecanoe	10	0	0
Vanderburgh	95	10	10.5
Vigo	7	0	0
Wabash	1	0	0
Warren	1	0	0
Wayne	15	0	0
Wells	1	0	0
White	1	0	0
	626	42	6.7

* Bat rabies found before initiation of present study.

During this study, most of the rabid bats were from southern Indiana. The state was divided roughly into thirds, from north to south. Three of 97, or 3.0% of the bats from the northern third of the state were rabid, 9 of 221, or 4.1% from the central third, and 30 of 308 or 9.7%, from the southern third of the state were rabid. This difference was significant (Chi-square = 9.68**, 2 df). However, the two major bat rabies counties, Jefferson and Vanderburgh, are in the southern third. Excluding information from those two counties, seven of 81 bats, or 8.6%, were rabid from the southern third of the state, thus still constituting a greater percentage infection than in the north or central counties, but this difference was not significant (Chi-square = 3.10, 1 df).

Time of year of infection

Rabies infections in bats were summarized by time of year of occurrence (Table 3). Most rabid bats were taken in the summer, but these were also the months in which most of the bats were taken. Of 429 bats taken in the summer (June-August), 32, or, 7.5% were rabid, while in

TABLE 3. *Time of year of rabies infection of bats caught by Indiana citizens.*
(No. rabid per year is in parentheses.)

	1966	*1967*	*1968*	*Total*	*Total Rabid*	*%*
January	0	7	4	11	0	0
February	4	2	2	8	0	0
March	1	6	9	16	0	0
April	6 (1)	5	15	26	1	3.8
May	14	13	15 (2)	42	2	4.8
June	12 (2)	30 (3)	32	74	5	6.8
July	10 (1)	80 (12)	60 (3)	150	16	10.7
August	42 (2)	12 (7)	39 (2)	205	11	5.4
September	11 (3)	40 (1)	7	58	5	8.6
October	4 (1)	5 (1)		9	2	22.2
November	5	8		13	0	0
December	6	8		14	0	0
	115 (10)	328 (24)	183 (8)	626	42	6.7
%	8.6%	7.3%	4.4%			

the fall (September to November) 7 of 80, or 8.8% were rabid, in the winter (December to February), 0 of 33, and in the spring (March to May), 3 of 84, or 3.6% were rabid. Thus, bat rabies in Indiana has been occurring in the summer and fall.

Change in rate of occurrence of disease through years of study

The overall rate of infection in 1966 was 8.6% (10 of 135 infected); in 1967 it was 7.3% (24 of 328), and in 1968 it was 4.4% or 8 of 183. Thus it would not appear that the disease has been increasing in Indiana bats over the past three years. These data would suggest a decrease over the period, but the observed difference was not significant (Chi-square = 2.33, 2 df).

Marion, Johnson, St. Joseph, Vanderburgh, and Jefferson Counties

Five counties were studied intensively (Table 4). There were rabies "outbreaks" in 1967 in big brown bats in Jefferson County and in red bats in Vanderburgh County. Both outbreaks were publicized, hence

numerous bats were submitted to health authorities, and we have rather large citizen samples from these counties. Also we have a rather large citizen sample from Marion, Johnson, and St. Joseph Counties. These are counties in which rabies is present but in which there was no major publicity.

Jefferson County is in southeastern Indiana. In 1967, 11 of 93 bats, or 11.8% were found to be rabid. In 1968, 2 of 36, or 5.5% were rabid. All but one of the rabid bats from this county were big brown bats, and all were from the city of Madison. None of the 16 red bats, *Lasiurus borealis*, taken there were rabid.

In Vanderburgh County, seven of the ten rabid bats were red bats, *Lasiurus borealis*, but only thirteen big brown bats, *Eptesicus*, were

TABLE 4. *Rabies in bats in Vanderburgh, Jefferson, Marion, Johnson, and St. Joseph Counties.*

	Vanderburgh			*Jefferson*			*Marion, Johnson, St. Joseph*		
	No.	*Rabid*	*%*	*No.*	*Rabid*	*%*	*No.*	*Rabid*	*%*
L. borealis	61	7	11.5	16	0	0	27	2	7.4
L. cinereus	9	1	11.1	0	0	0	4	1	25.0
E. fuscus	13	1	7.7	102	12	11.8	96	4	4.2
Other	12	1	8.3	14	1	7.1	33	1	3.0
	95	10	10.5	132	13	9.8	160	8	5.0
1966	2	0	0	3	0	0	42	4	9.5
1967	67	9	13.4	93	11	11.8	69	2	2.9
1968	26	1	3.8	36	2	5.6	49	2	4.1
	95	10	10.5	132	13	9.8	169	8	5.0
January	0	0	0	0	0	0	4	0	0
February	0	0	0	0	0	0	1	0	0
March	1	0	0	3	0	0	6	0	0
April	1	0	0	1	0	0	9	0	0
May	3	0	0	4	0	0	13	1	7.7
June	6	0	0	18	1	5.6	15	1	6.7
July	34	4	11.8	59	10	16.9	25	1	4.0
August	43	5	11.6	34	2	5.9	55	3	5.5
September	7	1	14.3	14	0	0	20	2	10.0
October	0	0	0	1	0	0	3	0	0
November	0	0	0	0	0	0	6	0	0
December	0	0	0	0	0	0	3	0	0
	95	10	10.5	132	13	9.8	160	8	5.0

taken, of which one was rabid. The total number of bats examined from Vanderburgh County was 95.

Thus the bat rabies situation was much different in Jefferson and Vanderburgh Counties, with red bats being the main species infected in Vanderburgh County, and big brown bats being the main species infected in Jefferson County. Hopefully more red bats from Jefferson County and more big brown bats from Vanderburgh County will be taken in the future.

Marion, Johnson, and St. Joseph Counties were counties in which bat rabies has been found, but where this fact apparently was not widely publicized, thus there was no major effort by citizens to turn in bats. However, large numbers of bats were submitted from these counties, and data from them, taken collectively, was considered as a control, for comparison with data from the two counties with publicized rabies. In the three counties, eight of 160 bats, or 5.00% were rabid, as compared to 23 of 227 (10.1%) in Jefferson and Vanderburgh Counties. This difference was not significant (Chi-square = 3.35, 1 df).

Relation between Rabies in the "Citizen Sample" and the "Wild Sample"

It was hypothesized that if the bats were being found by the citizens because they were "sick" from rabies, then the incidence of rabies should be higher in the citizen sample than in the wild simple. On the other hand, if the bats were not affected by the virus, then rabies should occur in the wild sample and the citizen sample at about the same rate. (In this latter case, they could be acting as carriers of rabies in that they harbor the virus, yet do not get the disease themselves, as has been suggested. If this were the case then bats might constitute a natural source of infection from which other species might contract the disease.)

For comparison with the citizen sample, 133 bats were collected from seven colonies during the height of the 1967 rabies outbreak in Jefferson County (97 in six colonies in the city of Madison, some in the same buildings from which rabid bats had originated, and 36 bats from a locality 15 miles southwest of Madison.) None of these bats was rabid. The above hypothesis was not supported. However, it is possible that rabies is found only in certain colonies, and that the wrong colonies were sampled. The possibility that bats leave the colonies when they become rabid, and that they are more likely to come into contact with humans, when rabid, seems a probable explanation of the data at this time.

Hopefully, future laboratory studies can be undertaken to determine whether individual bats become sick or die when they contract the disease, and if so, how long this takes.

Relation of Rabies in Bats to Rabies in Other Species in Indiana

If there is a relationship between rabies in bats and rabies in other species of mammals as has been suggested, then it would seem that there should be a positive association between areas with bat rabies and

those with rabies in other species. If there is no such relationship, then it would seem that incidence of rabies in other species would be about the same in counties with bat rabies and counties without bat rabies.

Since the greatest number of cases of bat rabies occurred in 1967, and since the Indiana State Board of Health has summarized information concerning rabies in all species in 1967, data from that year were examined for relationship between bat rabies and rabies in other species.

In the six counties with bat rabies in 1967, a total of 949 individuals other than bats were examined. Five of these, or 0.5% were found to be rabid. From all other counties, a total of 2369 individuals was examined, of which 58, or 2.45% were rabid.

This would lead one to believe that, in Indiana, there is no positive correlation between rabies in bats and rabies in other species. In fact, one could draw the reverse conclusion, that there is a negative correlation between bat rabies and rabies in other species, since significantly more rabid animals were found in other species in those counties not reporting bat rabies than in those with bat rabies in 1967 (Chi-square = 13.18, 1 df). Unfortunately, the counties in which numbers of bats have been examined are not always the same counties in which adequate numbers of other species have been examined.

Information from some of the critical counties is as follows: in Jefferson County rabies was not found in the 27 other mammals examined in 1967; in Vanderburgh County, three of 193 other mammals examined were rabid (1.55%). In Marion County, in which 3 of 67 bats over the past three years have proved rabid, no rabies cases were reported in 537 mammals examined in 1967. Other than Vanderburgh, the major rabies counties for other species in 1967 were Daviess, Knox, Lake, and Shelby, each having at least three rabid animals other than bats in 1967. Thus, it would be instructive to examine large numbers of bats from these counties, but a total of only five was received in 1967.

Twelve of 168 bats (7.1%) were rabid from the 44 counties with rabies in other species in 1967, while in the counties not reporting rabies in other species, 22 of 160 bats (13.8%) were rabid, but this difference was not significant (Chi-square = 3.44, 1 df).

As a further test, the data from the counties adjoining the two major bat rabies counties, Jefferson and Vanderburgh, were summarized and compared to the data from the remainder of southern Indiana. In Vanderburgh, Posey, Gibson, Pike, and Warrick Counties, 243 individuals other than bats were examined, of which 3 or 1.23% were rabid. In Jefferson, Scott, Clark, Jennings, Ripley, Dearborn, Ohio, and Switzerland Counties, a total of 188 individuals of other species were taken, of which 8, or 4.2% were rabid. In the remaining southern Indiana counties, 379 individuals other than bats were examined, of which 24, or 6.3% were rabid, thus again indicating lack of association or even negative association between bat rabies and rabies in other species.

Although important data are lacking, one can only conclude that there is no positive correlation between bat rabies and rabies in other species in Indiana.

Thanks to Mr. Robert Kerr, the Jefferson County Sanitarian, we have relatively complete information concerning the status of many of the Jefferson County bats when collected. Of 109 bats collected 17, or 15.6% were dead when taken. Among the 96 non-rabid bats, 14 or 14.6% were dead, while among the 13 rabid bats, 3 or 23% were dead.

It is recognized that there are certain problems inherent in data of the kind that have been collected during this study. For example, in the comparison between bat rabies and rabies in other species, most of the bats were from cities, while many of the specimens of wild species may be from rural areas, but there is no way to check this. We have no actual or relative information concerning the size of the bat populations in the various counties. Data of this sort would be very valuable. Most important, none of the data were collected in a truly random fashion.

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