

Bat Rabies in Indiana, 1965-1984

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Introduction

Rabies in terrestrial animals and in Central and South American vampire bats has been known for many years, but rabies in North American insectivorous bats was first discovered in 1953 in Florida. Since then, rabies has been found in at least 26 species of North American bats and in all 48 contiguous states. Information on rabies in bats from Indiana was previously summarized by Whitaker, Miller & Boyko (1969), by Whitaker & Miller (1974), and (abstract only) by Whitaker & Douglas (1979). The purpose of this paper is to present information on rabies from bats from Indiana submitted to the Indiana State Board of Health over the past 20 years. Rabies information will be summarized by species of bat, by county, by latitude, and temporally.

Although it is known that different strains of rabies occur (see below), this virus is still treated as a single disease, which might imply that it is freely transmitted between carnivores and bats. If that were so, then the distribution of bat rabies and "street" or carnivore rabies should be similar. Information is presented here on the occurrence of "street rabies" in comparison with bat rabies in an attempt to determine if the viruses tend to occur together, or if they occur independently.

Rabies apparently consists of at least three major strains, as listed below. Summaries of information can be found in Constantine (1966, 1967) and Davis, Karstad and Trainer (1981). Carnivore rabies or "street" rabies is the typical rabies strain we have long known in the U.S. It is transmitted by bite; infected animals exhibit "furious rabies" then die, usually in 3-4 weeks. Diagnosis is by negri bodies in the brain. Vampire bat rabies is a major problem in Central and South America where livestock and humans become infected. In this strain, the virus appears in the saliva about 2 weeks after infection and remains there up to three months. Infected bats may show no symptoms, they may show signs of paralysis ("dumb rabies") but recover, and some individuals die.

All bats of Indiana are insectivorous; thus it is this strain of rabies that concerns us here. Rabies in insectivorous bats is similar to that in vampires. Infected animals may show no outward symptoms, they may exhibit dumb rabies and recover, and apparently some individuals may die. Antibodies may be found in bats that have recovered. Since many bats recover from the disease, bat rabies is easily maintained. It can be transmitted to baby bats. Death may occur much later than for street rabies, up to six months after infection. The fluorescent antibody method is needed for diagnosis in bats. Even within insectivorous bats, it appears that there may be separate rabies strains "cycling" in different species of insectivorous bats. Infection rates are generally low, 1% or less in insectivorous bats taken under normal circumstances. Rates are higher in "downed" or suspect bats or sick bats such as those submitted to rabies labs. Classically rabies is transmitted by bite. However, bat rabies can also be transmitted through the air as demonstrated by Constantine (1971).

At least 5 people have died in the U.S. from insectivorous bat rabies, two after visiting a cave in Texas which contains large numbers of rabid bats. Neither was bitten; they apparently received infection via aerosol. The other three people contracted rabies by bite. Occasionally furious rabies has been observed in bats; for example, a woman in Pennsylvania was bitten without provocation by a rabid Hoary Bat. At least one person has recovered from bat rabies after the onset of symptoms, whereas none has recovered from street rabies after exhibiting symptoms.

Twelve species of bats are known from Indiana, all insect-eating species of the family Vespertilionidae. The species are:

- Eptesicus fuscus*, the Big Brown Bat
- Pipistrellus subflavus*, the Pipistrelle
- Nycticeius humeralis*, the Evening Bat
- Myotis lucifugus*, the Little Brown Myotis
- Myotis sodalis*, the Indiana Myotis
- Myotis keenii*, Keen's Myotis
- Myotis grisescens*, the Gray Myotis
- Plecotus rafinesquii*, the Big-eared Bat
- Myotis austroriparius*, the Southeastern Myotis
- Lasiurus cinereus*, the Hoary Bat
- Lasiurus borealis*, the Red Bat
- Lasionycteris noctivagans*, the Silver-haired Bat

The Big-eared Bat and Gray Myotis are very uncommon in Indiana, with but a few individuals ever being taken, and the Southeastern Myotis is uncommon and found in only a few caves. No individuals of these three species from Indiana have been examined for rabies.

Results and Discussion

A total of 3564 individuals of the other nine species of bats from Indiana was examined for rabies between 1965 and 1984, with at least 15 individuals being examined per species (Table 1). The 1965 data are excluded from most tables since bats were not identified to species. No rabid individuals have been found in Indiana from three of the remaining species, the Evening Bat, Keen's Myotis, and the Indiana Myotis. The Evening Bat lives in houses; Keen's and the Indiana Myotis winter in caves and summer in trees or woodlands. The Silver-haired Bat is solitary and migratory, passing through our state in spring and fall.

Rabies has been found in the remaining six species of bats from the state (Table 1). Overall, 156 of the 3564 bats examined, or 4.4%, were rabid. Listed by order of decreasing infection rate they are the Hoary Bat (18.6% rate), the Pipistrelle (17.4), the Red Bat (8.8), the Big Brown Bat (2.6), the Silver-haired Bat (2.3), and the Little Brown Myotis (0.5).

The two most abundant species of bats of Indiana are the Big Brown Bat, *Eptesicus fuscus*, and the Red Bat, *Lasiurus borealis*. These are also the two species in which the largest numbers of rabid bats have been taken. The Big Brown Bat lives in colonies in buildings, whereas the Red Bat is solitary and lives in trees. The Big Brown Bat hibernates in small numbers near cave entrances and in buildings. The Red Bat migrates south for the winter. The third most abundant species of bat in Indiana is the Little Brown Myotis. It hibernates in caves, but lives in colonies in buildings in summer. The species of *Myotis* are seldom rabid. Only one Silver-haired Bat, *Lasionycteris noctivagans*, was rabid, of 43 examined.

TABLE 1. Bats from Indiana examined for rabies, 1965-1984.

	No. Examined	No. Rabid	% Rabid
<i>Eptesicus fuscus</i>			
Big Brown Bat	2336	60	2.6
<i>Lasiurus borealis</i>			
Red Bat	756	66	8.7
<i>Myotis lucifugus</i>			
Little Brown Myotis	193	1	0.5
<i>Lasiurus cinereus</i>			
Hoary Bat	101	18	17.8
<i>Pipistrellus subflavus</i>			
Eastern Pipistrelle	46	8	17.4
<i>Myotis sodalis</i>			
Indiana Myotis	46	0	0
<i>Lasionycteris noctivagans</i>			
Silver-haired Bat	43	1	2.3
<i>Nycticeius humeralis</i>			
Evening Bat	28	0	0
<i>Myotis keenii</i>			
Keen's Myotis	15	0	0
	3564	154	4.3

The two remaining species are less common, but have the highest incidences of rabies of any of the Indiana species of bats. The Pipistrelle in summer is a colonial bat living in buildings, but in winter it hibernates individually in caves. The Hoary Bat is also solitary. It lives in trees and migrates south for the winter. Thus the six species of bats found with rabies differ considerably in habits.

This raises the question of how rabies is transmitted between bat species. Several of the species live close to each other in caves in winter. They are primarily the Little Brown Myotis, which forms colonies, and the Big Brown Bat and Pipistrelle, which generally hang alone in caves. These same species form summer colonies in buildings. However, they form separate clusters, and usually in separate buildings. The three have very different infection rates: the Pipistrelle has a high rate, the Big Brown Bat has a relatively high rate, and the Little Brown Myotis has a low rate.

The Hoary and Red Bats hang alone in trees in summer, thus one might expect them to have low rates of infection. However, they have high infection rates. (The Silver-haired Bat, also solitary, appears to have a low rate in the east, but has a high infection rate in the western U.S.). These species migrate but little is known concerning their winter whereabouts.

Overall, the behavior patterns of the various bat species of Indiana do not seem to enhance the possibilities of rabies transmission between them, especially in the species with the highest infection rates.

Geographical Occurrence of Bat Rabies in Indiana

Bat rabies has been found in 42 of the 92 (45.7%) Indiana counties (Table 2), but probably will eventually be taken in every county. Bat rabies is here reported for the first time in the following counties: Allen, Benton, Brown, Clinton, Elkhart, Grant, Hamilton, Kosciusko, Lawrence, Owen, Posey, Vigo and Warrick (marked with asterisk in Table 2).

TABLE 2. Rabies in bats collected by citizens of Indiana, summarized by county, 1965-1984. (*First rabies occurrence for county after 1977)

County	No. Examined	No. Rabid	% Rabid
Adams	19	0	0
*Allen	184	1	0.5
Bartholomew	25	0	0
*Benton	4	1	25.0
Blackford	3	0	0
Boone	11	0	0
*Brown	9	1	11.1
Carroll	2	0	0
Cass	34	0	0
Clark	16	1	6.3
Clay	13	0	0
*Clinton	9	1	11.1
Crawford	0	0	0
Daviess	35	1	2.9
Dearborn	13	1	7.7
Decatur	9	0	0
DeKalb	8	1	12.5
Delaware	41	3	7.3
Dubois	10	0	0
*Elkhart	109	5	4.6
Fayette	5	1	20.0
Floyd	9	1	11.1
Fountain	12	0	0
Franklin	6	0	0
Fulton	15	1	6.7
Gibson	18	2	11.1
*Grant	38	1	2.6
Greene	31	2	6.5
*Hamilton	20	1	5.0
Hancock	14	0	0
Harrison	15	0	0
Hendricks	28	4	14.3
Henry	39	1	2.6
Howard	28	0	0
Huntington	16	0	0
Jackson	32	2	6.25
Jasper	12	0	0
Jay	8	0	0
Jefferson	235	14	5.9
Jennings	17	2	11.8
Johnson	127	3	2.4
Knox	21	0	0
*Kosciusko	58	2	3.4
LaGrange	7	0	0
Lake	126	4	3.2
LaPorte	59	3	5.1
*Lawrence	73	1	0
Madison	52	4	7.7
Marion	330	5	1.5
Marshall	24	0	0
Martin	8	3	37.5
Miami	14	0	0
Monroe	66	3	4.5
Montgomery	70	2	2.9
Morgan	20	0	0
Newton	6	0	0
Noble	13	0	0
Ohio	0	0	0
Orange	4	0	0

TABLE 2.—Continued

*Owen	7	1	14.3
Parke	11	0	0
Perry	6	0	0
Pike	4	0	0
Porter	49	1	2.0
*Posey	16	2	12.5
Pulaski	6	0	0
Putnam	10	0	0
Randolph	16	0	0
Ripley	6	0	0
Rush	12	0	0
Saint Joseph	186	4	2.2
Scott	11	0	0
Shelby	6	0	0
Spencer	14	0	0
Starke	6	0	0
Steuben	14	0	0
Sullivan	9	0	0
Switzerland	4	0	0
Tippecanoe	116	2	1.7
Tipton	0	0	0
Union	5	0	0
Vanderburgh	532	47	8.8
Vermillion	3	0	0
*Vigo	83	2	2.4
Wabash	19	1	5.3
Warren	3	0	0
*Warrick	97	13	13.4
Washington	8	0	0
Wayne	48	0	0
Wells	7	0	0
White	19	3	15.8
Whitley	1	0	0
	3564	154	4.3

Rabies in bats has been found in all parts of the state (Figure 1). Counties from which larger samples of bats were taken, but in which bat rabies has not yet been found, are Wayne (48 bats), Cass (34), and Howard (28). The largest numbers of rabid bats have been taken in Vanderburgh (47), Jefferson (14), Warrick (13), Marion (5), and Elkhart (5) counties. Only 14 bats had been submitted from Warrick County through 1980, but in 1981 and 1982 bat rabies was publicized there, and 69 bats were submitted, indicating the effect publicity has on returns.

We examined bat rabies data from the northern, central and southern part of Indiana. In 30 northern Indiana counties, 28 of 1086 bats were rabid (2.6%), in 30 central Indiana counties, 30 of 1118 (2.7%), and in 33 southern Indiana counties, 96 of 1360 (7.1%). However, rabid bats were not uniformly distributed over southern Indiana. Of the 95 rabid bats from southern Indiana, 47 were from Vanderburgh County, 14 were from Jefferson County, and 13 were from Warrick County, of 532, 236, and 97 bats examined. Over the rest of southern Indiana, 22 of 495 (4.4%) were infected. This difference is significant (chi-square = 38.16, 1 df). Rabies is more common in bats in southern than northern and central Indiana.

Time of Year of Infection

Rabies records in bats from Indiana have been broken down by month (Table 3).



FIGURE 1. Numbers of rabid bats taken in counties of Indiana (1966-1984).

There are few cases from November through March. They then increase through spring and summer peaking in September and October. The number of rabid bats was greatest in August, but the greatest percentages were in September and October.

TABLE 3. Bats from Indiana tested for rabies, 1965-1984.

	No. Examined	No. Rabid	% Rabid
January	115	1	0.87
February	93	0	0.00
March	96	1	1.04
April	193	4	2.07
May	240	7	2.92
June	372	12	3.23
July	642	29	4.52
August	1047	52	4.97
September	429	32	7.46
October	141	12	8.51
November	85	2	2.35
December	111	2	1.80
	3564	154	4.32

Bat Rabies Occurrence by Year

There is a good deal of variation in bat rabies on a yearly basis in Indiana (Table 4). These values are, of course, greatly influenced by "outbreaks" in individual counties in some years. The periods 1966-67, 1970, and 1981 had larger numbers and percentages of rabies cases, whereas 1971-1974 and 1976-1980 were relatively low.

Jefferson, Vanderburgh, and Warrick Counties

Jefferson, Vanderburgh, and Warrick Counties have had a high occurrence of rabies. From 1966 through 1984, of 156 bats positive for rabies submitted to the Indiana State Board of Health, 47 or about one-third were from Vanderburgh County

TABLE 4. Bats from Indiana examined for rabies, 1965-1984, summarized by year.

	No. Examined	No. Rabid	% Rabid
(1965)*	(70)	(2)	(2.8)
1966	114	10	8.8
1967	329	24	7.3
1968	220	9	4.1
1969	129	3	2.3
1970	229	16	7.0
1971	132	2	1.5
1972	162	3	1.9
1973	138	3	2.2
1974	152	2	1.3
1975	129	6	4.7
1976	136	4	2.9
1977	98	3	3.1
1978	215	4	1.9
1979	155	6	3.9
1980	224	7	3.1
1981	312	27	8.7
1982	251	10	4.0
1983	229	7	3.1
1984	210	8	3.8
	3564	154	4.3

*Not included in most tables, or in total figures, because not identified to species.

(Evansville area), 14 or 9.0% were from Jefferson County (Madison), and 13 or 8.3% were from Warrick County. Thus just under half the rabid bats submitted came from these counties. Greater numbers of bats have been submitted from these counties than from most others, 537 coming from Vanderburgh County (8.8% infection rate), 224 from Jefferson County (6.3%), and 93 from Warrick County (14.0%). Samples from these counties were large at least partly because of publicized bat rabies "outbreaks" in some years (Table 5), particularly 1967 in Jefferson and Vanderburgh Counties; 1970, 1980-81 in Vanderburgh County; and 1981-83 in Warrick County. Note the increased numbers of bats submitted during these periods.

Jefferson County

In Jefferson County 13 of 14 cases of bat rabies (Table 5) involved the Big Brown Bat (the other bat was a Pipistrelle). This period included the only outbreak in that county. The outbreak was real. Eleven of 93 bats (11.8%) submitted for rabies analysis that year were rabid as compared to 3 of 140 or 2.1% in the other years combined. Two of the additional rabid bats were in the next year (1968) whereas the last case was in 1977. It is interesting that none of the Red Bats (total of 29) submitted from

TABLE 5. Bats tested for rabies from Jefferson and Vanderburgh Counties, 1966-1984.

	Jefferson County					Vanderburgh County					
	All bats	Big Brown Bats	Red Bats	Pipi-strelles	Other bats	All bats	Big Brown Bats	Red Bats	Hoary Bats	Pipi-strelles	Other bats
1966 No.	3	3				2		1	1		
No. rabid	0	0				0		0	0		
% Rabid											
1967 No.	93	69	14	2	8	67	9	43	3	2	10
No. rabid	11	10	0	1	0	9	1	6	1	1	0
% Rabid	11.8	14.5		50.0	0	13.4	11.1	14.0	33.3	50.0	
1968 No.	43	36	3	1	3	32	6	19	5		2
No. rabid	2	2	0	0	0	1	0	1	0		0
% Rabid	4.6	5.6				3.1		5.3			
1969 No.	13	12	1			13	2	8	3		
No. rabid	0	0	0			0	0	0	0		
% Rabid											
1970 No.	11	7	4			116	24	71	6	3	12
No. rabid	0	0	0			14	2	10	2	0	0
% Rabid						12.1	8.3	14.1	33.3		
1971 No.	16	15	1			18	2	16			
No. rabid	0	0	0			0	0	0			
1972 No.	13	12			1	28		23	4	1	
No. rabid	0	0			0	2		1	0	1	
% Rabid						7.1		4.3		100	
1973 No.	10	9			1	7	4	2			1
No. rabid	0	0			0	0	0				0
% Rabid											
1974 No.	7	7				11		8	2	1	
No. rabid	0	0				1		0	1	0	
% Rabid						9.1			50.0		
1975 No.	4	4				9	1	6	1	1	
No. rabid	0	0				1	0	1	0	0	
% Rabid						11.1		16.7			
1976 No.	8	4	4			18	5	7	5	1	
No. rabid	0	0	0			1	0	1	0	0	
% Rabid						5.5		14.3			

TABLE 5.—Continued

	Jefferson County					Vanderburgh County					
	All bats	Big Brown Bats	Red Bats	Pipi-strelles	Other bats	All bats	Big Brown Bats	Red Bats	Hoary Bats	Pipi-strelles	Other bats
1977 No.	3	3				0		0			
No. rabid	1	1									
% Rabid	33.3	33.3									
1978 No.	3	3				4	1	2	1		
No. rabid	0	0				1	0	1	0		
% Rabid						25.0		50.0			
1979 No.	4	2	2			8	3	4	1		
No. rabid	0	0	0			1	0	0	1		
% Rabid						12.5					
1980 No.	0	1				24	3	18	2		1
No. rabid						4	0	3	1		0
% Rabid						16.7		16.7	50.0		
1981 No.	1	1				88	17	56	3	5	7
No. rabid	0	0				11	0	10	0	1	0
% Rabid						12.5		17.9		20.0	
1982 No.	0	0				51	16	30	2	1	2
No. rabid						0	0	0	0	0	0
% Rabid											
1983 No.	3	3				21	4	7	2	4	4
No. rabid	0	0				1	0	0	1	0	0
% Rabid						0.21			50.0		
1984 No.	0	0				15	9	6			
No. rabid						0	0	0			
% Rabid											
Total No.	235	191	29	3	13	532	106	328	40	19	39
No. rabid	14	13	0	1	0	47	3	34	7	3	0
% Rabid	6.0	6.8		33.3	0	8.8	2.8	10.2	17.5	14.3	0

Jefferson County, including 14 from 1967, were rabid, since Red Bats were the principal infected species in Vanderburgh County.

Vanderburgh County

In Vanderburgh County (Table 5), 47 of 532 bats submitted were rabid (8.8%). The biggest number was of Red Bats (34 of 328 taken, or 10.2%), followed by 7 of 40 Hoary Bats (17.5%). Only 3 of 106 Big Brown Bats were rabid (2.8%). The remaining three individuals were Pipistrelles.

Rabies was found in Vanderburgh County in 11 years of the study. There were high rates of infection in four different years: 9 of 67 (13.4%) in 1967, 14 of 114 (12.3%) in 1970, 4 of 17 (16.7%) in 1980, and 11 of 88 (12.5%) in 1981. In this county rabies was primarily in the Red Bat by sheer numbers (33 of 44 rabid bats, or 75%), but other species were also infected, and two of them at higher rates, the Hoary Bat (7 of 40, 17.5%) and the Pipistrelle (2 of 19, 10.5%).

It is interesting that a low percentage of Big Brown Bats (3 of 107 or 2.8%) taken from Vanderburgh County were rabid. However, during the four outbreak years, 3 of 55 or 5.5% of the Big Brown Bats were infected, versus 29 of 188 (15.4%) red bats those same years. These data indicate little relation between rabies in Big Brown and Red Bats.

Warrick County

Only fourteen bats were submitted from Warrick County through 1980. The first rabid bats were submitted from there in 1981 when 7 of 40 bats (17.5%) were rabid. Included were 1 of 5 Big Brown Bats and 6 of 23 Red Bats. None of 3 Little Brown Bats, 2 Hoary Bats, or 1 Pipistrelle were rabid. In 1982, 4 of 29 bats (13.8%) were rabid, 2 of 9 Big Brown Bats (22.2%) and 2 of 12 Red Bats (16.7%). None of 7 Little Brown Bats or one Evening Bat (*Nycticeius humeralis*) was infected. In 1983 10 bats were submitted: 4 Big Brown Bats, *Eptesicus fuscus* (none were rabid); 1 of two Red Bats, *Lasiurus borealis*, was rabid; the single Silver-haired Bat, *Lasionycteris noctivagans*, was rabid; and neither the one Hoary Bat nor the one Pipistrelle was infected. In 1984, only 4 bats were submitted. All were *Eptesicus*, and all were negative.

The following bats from Warrick County were examined for rabies during the 3 years of the outbreak (1981-83).

	No.	No. rabid	% rabid
Red Bats	43	9	20.9
Big Brown Bats	18	3	16.7
Silver-Haired Bats	1	1	100.0
Little Brown Bats	11	0	0
Evening Bats	1	0	0
Hoary Bats	3	0	0
Pipistrelles	2	0	0
Total	79	13	16.5

Warrick County is adjacent to Vanderburgh County so might be expected to be similar in bat rabies occurrence to that county. It differs, of course, in that no cases were reported before 1981. However, this may have simply been that rabies occurred but no bats happened to be submitted. The red bat was the primary species involved in both counties. It is interesting that 3 Big Brown Bats from Warrick County were rabid, as none of 37 Big Brown Bats from Vanderburgh County taken in 1981 through 1983 were rabid. Also the outbreak in Vanderburgh County occurred in 1980 and 1981 (15 of 112 bats rabid, 13.4%) whereas none of 51 bats submitted in 1982 from that county and only 1 of 21 submitted in 1983 were rabid. Thus even in adjacent counties, the course of the outbreak differed considerably.

A large number of bats have been submitted in certain counties but total cases of rabies have been low. For example, a total of 329 bats has been submitted from Marion County, but only 5 (1.8%) were rabid. Corresponding figures for some other counties were Allen (186, 1, 0.5%), Johnson (127, 3, 2.4%), Lake (126, 4, 3.2%), St. Joseph (187, 4, 2.1%), and Tippecanoe County (116, 2, 1.7%). These figures show that it is not simply a matter of failure of submission that accounts for rabies not being found.

Rabies in Non-bat Hosts from Indiana, 1965-1984

Data on rabies in hosts from Indiana other than bats are presented in Table 6. One needs to be mindful that all data presented here concern "suspect" animals, i.e., animals suspected of having rabies. They do not constitute a random sample of the general population of skunks, bats, foxes or other species. Also, since skunks and foxes display recognizable symptoms, i.e., they generally get "furious" rabies, the number of cases, rather than the percentage, may be more important for any one year or locality. (This is not true for bats, since bats generally do not display symptoms.)

TABLE 6. Hosts from Indiana examined for rabies, 1965-1984.

	No. Examined	No. Rabid	% Rabid
Cow, <i>Bos taurus</i>	779	56	7.2
Cat, <i>Felis catus</i>	15166	31	0.2
Dog, <i>Canis familiaris</i>	14428	63	0.4
Fox	996	49	4.9
Goat, <i>Capra</i>	4	1	25.0
Groundhog, <i>Marmota monax</i>	98	2	2.0
Guinea pig, <i>Cavia porcellus</i>	36	2	5.6
Hamster, <i>Cricetus cricetus</i>	255	1	0.4
Horse, <i>Equus caballus</i>	143	11	7.7
Opossum, <i>Didelphis virginiana</i>	70	1	1.4
Raccoon, <i>Procyon lotor</i>	582	3	0.5
Rat, <i>Rattus norvegicus</i>	149	1	0.7
Sheep, <i>Ovis aries</i>	7	1	14.3
Skunk, <i>Mephitis mephitis</i>	1733	731	42.2
Squirrel	164	1	0.6
Swine, <i>Sus scrofa</i>	16	4	25.0

The greatest number and percentage of cases of rabies in Indiana currently is in skunks, followed by horses, cows, foxes, and bats. Cases in dogs, cats, foxes and cows have decreased considerably in the last several years. More information is given below for the various groups.

Cats and Dogs

Large numbers of cats and dogs have been examined, but infection rates are low. The greatest numbers of cases of rabies in cats and dogs were in the years 1965-1971 (Table 7), with 48 of 63 cases (76.2%) or 6.9/year in dogs, and 28 of 31 (90.3%)

TABLE 7. Rabies in Indiana in Foxes, Cows, Dogs, and Cats, 1965-1984.

Year	Foxes			Cows			Dogs			Cats		
	No. Examined	No. Rabid	% Rabid									
1965	55	8	14.5	40	11	27.5	691	11	1.6	702	7	1.0
1966	87	10	11.5	59	10	16.9	794	15	1.9	871	8	0.9
1967	80	6	7.5	41	8	19.5	809	9	1.1	946	5	0.5
1968	74	4	5.4	40	4	10.0	790	8	1.0	819	6	0.7
1969	81	4	4.9	43	1	2.3	727	2	0.3	882	1	0.1
1970	78	1	1.3	21	0	0	721	1	0.1	780	0	0
1971	68	3	4.4	38	1	2.6	736	2	0.3	892	1	0.1
1972	82	8	9.8	47	4	8.5	779	0	0	823	0	0
1973	71	3	4.2	54	1	1.9	786	3	0.4	914	0	0
1974	48	0	0	40	0	0	716	1	0.1	751	0	0
1975	37	1	2.7	28	0	0	700	1	0.1	698	0	0
1976	32	0	0	22	0	0	710	1	0.1	796	0	0
1977	22	1	4.5	20	0	0	739	0	0	603	0	0
1978	18	0	0	19	0	0	786	0	0	755	0	0
1979	24	0	0	49	4	8.2	713	1	0.1	654	0	0
1980	29	0	0	37	4	10.8	696	3	0.4	669	0	0
1981	28	0	0	41	2	4.9	647	2	0.3	682	0	0
1982	25	0	0	39	1	2.6	696	2	0.3	691	1	0.1
1983	32	0	0	49	3	6.1	619	0	0	589	0	0
1984	25	0	0	52	2	3.8	573	1	0.2	642	2	0.3

or 4 per year in cats. The average in the 13 years after 1971 were 1.1 in dogs and 0.2 in cats. These reductions would appear directly attributable to the rabies inoculation program.

Rabies in Foxes

Rabies in foxes has greatly decreased in the 20 years included by these data. Forty-seven of 49 rabid foxes were submitted between 1965 and 1973 (Table 7). It appears that the rabies inoculation program in dogs and cats has also tended to reduce fox rabies. This might indicate that the dog, cat, and fox strains are the same, and that foxes might generally be infected by dogs or cats.

Rabies in Skunks as Compared with Rabies in Bats

A total of 1733 skunks was examined over the 20 year period, with 731 (42.2%) being positive (Table 8). Bat and skunk rabies were compared on a yearly basis. If

TABLE 8. Yearly infection of bat and skunk rabies in Indiana.

Year	Bats			Skunks		
	No. Examined	No. Rabid	% Rabid	No. Examined	No. Rabid	% Rabid
1965	70	2	2.9	52	37	71.2
1966	115	10	8.7	83	59	71.1**
1967	328	24	3.0	57	32	56.1
1968	220	9	4.1	126	56	44.4**
1969	129	3	2.3	76	43	56.6
1970	229	16	7.0	29	11	37.9
1971	132	2	1.5	116	66	56.9**
1972	162	3	1.9	140	69	49.3**
1973	138	4	2.9	112	45	40.2
1974	153	2	1.3	53	12	22.6
1975	137	6	4.4	24	2	8.3
1976	138	5	3.6	54	18	33.3
1977	99	3	3.0	24	8	33.3
1978	215	4	1.9	29	9	31.0
1979	155	6	3.9	116	55	47.4**
1980	224	8	3.6	129	62	48.1**
1981	312	27	8.7	187	61	32.6**
1982	252	10	4.0	177	59	33.3**
1983	229	7	3.1	94	17	18.1
1984	210	8	3.8	55	10	18.2
	3647	159	4.4	1733	731	42.2

** 50 or more rabid

rabies is often transmitted between bats and skunks, there should be relatively good correlation between the two. In 8 of the 20 years at least 50 rabid skunks were submitted to the rabies lab, 1966, 1968, 1971, 1972, and 1979 through 1982. Conversely, low numbers of rabid skunks, twelve or less, were taken in the years 1970, 1974, 1975, 1977, 1978 and 1984.

The more important rabies years for bats were 1966, 1967, 1970, 1981, and 1982. Thus there were three years, 1966, 1981, and 1982, which were important years for both bats and skunks; two years, 1967 and 1970, which were important for bats but not for skunks; five which were important for skunks but not for bats (1968, 1971, 1972, 1979 and 1980); and the remaining 10 years which were not particularly impor-

tant for either. Conversely, low bat rabies years (5 or less cases) were 1965, 1969, 1971-1974, 1977, and 1978. Thus there is little direct relationship in specific years between skunk and bat rabies. Unlike rabies in dogs, cats and foxes, rabies has not declined in bats or skunks over this period.

Rabies in Cows and Horses

The incidence in horses and cows was 7.7 and 7.2% (Tables 6, 7) respectively. Other than skunks and foxes, other species either were examined in low numbers or the incidence was very low. Temporal distribution of rabies in cows is more complicated than that of foxes. There is a distinct decrease in rabies in cows over the 20 years (Table 7), with 40 of the 56 cases (82%) in the first 9 years of the study period, averaging 6.2 cases per year. There were then no cases for the next five years, but relatively low numbers from 1979 to 1985, totalling 16, or 2.6/year. Possibly the inoculation program controlled street rabies in cows, but the recent cases might be primarily bat or skunk strains.

Reservoir for Carnivore Rabies

The origin and/or reservoir for carnivore rabies has long remained a mystery. If animals contracting rabies die in a short period of time, then how does the disease continue to exist? Since bats may recover from the disease, they would seem a possible reservoir for carnivore rabies. The differences exhibited between rabies in carnivores and rabies in bats would seem to argue against this, although of course the same virus might simply react differently in the different hosts. It seems more likely, as mentioned above, that the virus is different, and perhaps differs even between bat hosts. Data from Michigan suggest no relation between bat and carnivore rabies on the basis of differing yearly infestation rates. If bats were acting as the reservoir for carnivorous rabies, there should be correlations between bat and carnivore rabies. They should occur at the same time and place. We need more information on this, but neither Whitaker, Miller and Boyko (1969) nor the present authors found correlation between distribution of rabies in bats and rabies in carnivores in Indiana. Likewise bat rabies showed no positive correlation with carnivore rabies in Michigan, Georgia or New York.

D.G. Constantine and also H.B. Johnson suggest there might be a non-lethal strain which would maintain the virus in carnivore populations. The strain in skunks seems to most closely resemble bat rabies. Skunk rabies often involves a longer incubation period and lowered pathogenicity. Could bat and skunk rabies be the same?

Danger and Control of Bats and Rabies

Bat rabies is not a serious problem, mainly because rabid bats seldom have "furious" rabies. If they do become sick they generally have "dumb rabies" showing listlessness and paralysis, although they may bite when handled (whether rabid or not). Bat rabies can, of course, be transmitted via air. However, still, moist atmosphere, along with a population of rabid bats, apparently is needed for this to occur, and this sort of situation is not common. Bats found in caves of Indiana are seldom rabid, but we have been in Big Brown Bat colonies in buildings in Madison, Indiana, in summer where we felt this method of transmission was possible. However, all bats obtained from those colonies were negative for rabies.

The main cautions to Indiana citizens concerning bat rabies are to avoid handling or being bitten by bats and to avoid exposure to large bat colonies in closed areas where air is still and moist.

Bat control may be attained by using hardware cloth screening over places where bats enter. Use of pesticides for bat control is a waste of money. We collected live

bats in attics in Madison in 1967 where pesticides had been used at considerable expense just two weeks earlier.

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