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RABIES IN RODENTS AND LAGOMORPHS IN THE UNITED STATES, 1971–1984: INCREASED CASES IN THE WOODCHUCK (*MARMOTA MONAX*) IN MID-ATLANTIC STATES

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ABSTRACT: A review of surveillance data on animal rabies from the Centers for Disease Control revealed 104 cases of rabies in rodents and lagomorphs for 1971 through 1984 in the United States; 80% of these were reported between 1980 and 1984. Woodchucks (*Marmota monax*) accounted for 64% of the cases. Most of the cases of rabies in woodchucks were associated with an epizootic of rabies in raccoons (*Procyon lotor*) in the mid-Atlantic states. In rabies endemic areas, humans exposed to woodchucks should receive rabies postexposure prophylaxis if the animal is not available for testing. The decision to administer postexposure prophylaxis to humans exposed to other rodents and lagomorphs should take into consideration the epidemiology of rabies in the exposing species.

INTRODUCTION

Rodents and lagomorphs have not been considered previously as important reservoirs or vectors of rabies, nor have exposures from these animals ever been demonstrated to cause rabies in humans in the United States. A report in 1972 concluded that rodent contacts resulted in misuse of public health resources because of unnecessary rabies testing and antirabies treatment (Winkler, 1972). Nevertheless, there is still considerable concern about rabies in rodents and lagomorphs. This concern is evidenced by the fact that 8,895 rodents were examined for rabies in 1984, and in part validated by the isolated cases of rodents with rabies that have been confirmed and reported (Dowda et al., 1981; Dowda and Disalvo, 1984). However, the public health importance of these cases is not clear.

To reassess the public health importance of rabies in rodents and lagomorphs, we examined surveillance data on animal rabies from the Centers for Disease Control (CDC) for the 14-yr period from 1971 to 1984. We identified the woodchuck as a new rodent reservoir of rabies with implications for ongoing surveillance and postexposure prophylaxis.

MATERIALS AND METHODS

This investigation deals with members of the order Rodentia (rats, mice, muskrats, hamsters, gophers, squirrels, woodchucks, and beavers) and members of the closely related order Lagomorpha (rabbits, hares, and pikas). The number of rodents and lagomorphs confirmed as rabid and the total number of rodents and lagomorphs examined for rabies were obtained from monthly animal rabies surveillance information reported by the State Departments of Health to CDC. If necessary, State Departments of Health were contacted to obtain information sufficient for speciation of individual animals. All states used either fluorescent antibody testing or mouse inoculation to diagnose rabies. In some cases, the diagnosis of rabies in a rodent was confirmed and the virus characterized antigenically at the CDC Rabies Laboratory by monoclonal antibody techniques (Smith et al., 1984b). A panel of 23 monoclonal antibodies specific for rabies virus nucleocapsid was produced and characterized (Smith et al., 1984a). The indirect, immunofluorescent antibody-staining procedure was used for detection of nucleocapsid antigen, in which acetone-fixed cell monolayers or touch impressions of brain material were treated with hybridoma antibodies for 30 min at 37 C, washed to remove unbound antibody, and restained with fluorescein-conjugated goat

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TABLE 1. Reported number of rabid rodents and lagomorphs by species and 3-yr periods, United States, 1971–1984.

Animal	Period					Total
	1971–1973	1974–1976	1977–1979	1980–1982	1983–1984[a]	
Woodchuck (*Marmota monax*)	5	1	4	21	36	67
Gray squirrel (*Sciurus carolinensis*)	0	0	0	1	5	6
Fox squirrel (*Sciurus niger*)	1	0	0	0	0	1
Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*)	0	0	0	1	0	1
Muskrat (*Ondatra zibethicus*)	0	2	0	5	0	7
Old World rabbit (*Oryctolagus cuniculus*)	0	0	0	2	2	4
Eastern cottontail rabbit (*Sylvilagus floridanus*)	0	0	1	1	1	3
Southern flying squirrel (*Glaucomys volans*)	1	0	2	0	1	4
Common house rat (*Rattus* sp.)	0	0	0	1	2	3
Eastern wood rat (*Neotoma floridana*)	0	0	0	1	0	1
Guinea pig (*Cavia porcellus*)	2[b]	0	0	0	0	2
Eastern chipmunk (*Tamias striatus*)	0	1	0	0	1	2
Beaver (*Castor canadensis*)	0	0	0	0	2	2
White mouse (*Mus musculus*)	0	1[c]	0	0	0	1
Total	9	5	7	33	50	104
Mean/year	3.0	1.7	2.3	11.0	25.0	7.4

[a] Data for 2-yr period only.
[b] Pet domestic animals developed rabies after being vaccinated with modified live rabies vaccine.
[c] Found loose in rabies vaccine production laboratory.

antibody to mouse IgG (Tago, Burlingame, California 94010, USA). Slides were examined at a magnification of 200–400× with a standard universal microscope with vertical illumination (Carl Zeiss, New York). The light source was an XBO-150-W xenon bulb with KP490 and LP510 filters.

RESULTS

A total of 104 cases of rabid rodents and lagomorphs was reported from 1971 through 1984. Improved diagnostic techniques are thought to have caused a downward trend in the number of reported cases which began in the early 1960's (Winkler, 1972). This trend continued through the 1970's, but reversed in the late 1970's (Table 1). Reported cases increased steadily through 1984. Eighty-three (80%) of the 104 cases were reported between 1980 and 1984.

Table 1 shows the number of reported rabid rodents and lagomorphs by species. The woodchuck accounted for 67 (64%) of the 104 cases. Four gray squirrels (*Sciurus carolinensis*) were reported rabid in 1984, the largest number of this species reported rabid in a single year since the early 1960's. No pocket gophers (Geo-

TABLE 2. States reporting rodents and lagomorphs with rabies by 3-yr period and species, United States, 1971–1984.

State[a]	Period					Total
	1971–1973	1974–1976	1977–1979	1980–1982	1983–1984[b]	
Alabama	—	A[c]	B	—	—	2
California	C	—	—	—	—	1
Delaware	—	—	—	—	2D	2
Illinois	2D	—	—	—	—	2
Indiana	2E	—	—	—	D	3
Iowa	D	D, F	—	3D, F, G	—	8
Kansas	—	H	—	—	—	1
Maryland	B	—	—	2D	18D, 2I, 2J, K, L	27
Minnesota	—	F	D	D, G	D	5
Missouri	—	—	—	K	—	1
Montana	—	—	—	2F	—	2
North Dakota	—	—	2D	F	—	3
Ohio	—	—	—	2D	—	2
Pennsylvania	—	—	—	2D	6D, 3J, 2G, B	14
South Carolina	—	—	G	F, I, J	M	5
South Dakota	—	—	—	—	D	1
Tennessee	2D	—	—	—	—	2
Texas	—	—	B	L, N	L	4
Virginia	—	—	D	7D	7D	15
West Virginia	—	—	—	D	—	1
Wisconsin	—	—	—	3D	—	3
Total	9	5	7	33	50	104

[a] Other states and the District of Columbia reported no cases for years listed.

[b] Data for 2-yr period only.

[c] Legend symbol (indicates one case unless otherwise noted): A = eastern chipmunk (*Tamias striatus*); B = southern flying squirrel (*Glaucomys volans*); C = fox squirrel (*Sciurus niger*); D = woodchuck (*Marmota monax*); E = pet domestic guinea pigs (*Cavia porcellus*) vaccinated with modified live rabies vaccine; F = muskrat (*Ondatra zibethicus*); G = Old World rabbit, domestic (*Oryctolagus cuniculus*); H = white mouse (*Mus musculus*) found in rabies vaccine production laboratory; I = beaver (*Castor canadensis*); J = gray squirrel (*Sciurus carolinensis*); K = eastern cottontail rabbit (*Sylvilagus floridanus*); L = common house rat (*Rattus* sp.); M = eastern wood rat (*Neotoma floridana*); N = thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*).

myidae) or hamsters (*Mesocriticetus auratus*) were reported rabid.

Cases were reported from 21 states (Table 2). Fifty-six (54%) of these came from Maryland, Pennsylvania, and Virginia. Of these 56 cases, 55 (98%) have been reported since 1980. These cases were associated temporally and geographically with an expanding epizootic of rabies in raccoons in the mid-Atlantic states.

The relationship between rabies in raccoons and rodents was further supported by monoclonal antibody analysis of rabies virus isolates from four rodents (three woodchucks and an eastern chipmunk, *Tamias striatus*) in the mid-Atlantic states. The monoclonal antibody nucleocapsid (MAB-NC) pattern of the rabies virus isolates from rodents was identical to that of 29 rabies virus isolates from raccoons collected from animals involved in the mid-Atlantic outbreak. The ability of an endemic species to transmit rabies to rodents is not limited to the mid-Atlantic outbreak. A rabies virus isolate from a woodchuck in Minnesota matched the MAB-NC pattern found in a midwestern epizootic in skunks. Analysis of isolates of rabies virus from three rodents in areas where epizootics of rabies have occurred in Texas revealed two isolates indistinguishable from that associated with striped skunks (*Mephitis me-*

phitis) and one identical to that found in Mexican freetail bats (*Tadarida brasiliensis mexicana*) in Texas.

Rodents continued to account for a disproportionate number of animal examinations. In 1984, rodents represented 10.1% of 87,870 animals examined for rabies in the United States, but only 29 (0.5%) of the 5,547 positive animals; excluding woodchucks, only nine (0.16%) of the positive animals were rodents and lagomorphs. The policy of states as regards testing of rodents and lagomorphs appears to vary widely. In 1984, eight states tested over 400 rodents each, and nine states tested less than 10 rodents each.

DISCUSSION

The recognition of rabies in woodchucks justifies inclusion of this rodent in the epidemiology of rabies. Rabies in other rodents remains uncommon, but does occur. The increase in rodent rabies, especially that in woodchucks, appears to be associated with the rabies epizootics, but this does not fully account for the recent trends. False positive fluorescent antibody test results may have accounted for some reported cases, but many cases have been confirmed by additional methods (Dowda et al., 1981; Dowda and Disalvo, 1984; Smith et al., 1984b; CDC, unpubl. data). False positives would not be expected to be more common in woodchucks than other rodents. It has been reported that the rabies virus strain from raccoons is highly invasive for gray squirrels (Winkler et al., 1972), but the same strain has been endemic in raccoons in the southeastern states since 1955, and few rabid rodents have been reported from those states (Prather et al., 1975). Woodchucks may have become involved in the mid-Atlantic epizootic by virtue of their competition with raccoons for den sites in areas of intense rabies activity. The urban nature of the mid-Atlantic outbreak may also have resulted in increased human contact with rabid rodents and increased submission of these rodents for testing. The greater number of cases in larger rodents might be attributable to their ability to survive the bite of raccoons, skunks and other common rabies vectors.

The association of rabid woodchucks with the epizootics in the mid-Atlantic and the Midwest justifies continued surveillance and examination of woodchucks in these areas. Other rodents in rabies endemic areas should be examined if a human exposure occurs in circumstances of an unusual or unprovoked attack or a bite by an animal that appears ill. Rodents outside of rabies endemic areas can be assumed generally not to be rabid, but testing may be indicated occasionally.

The above suggestions can also serve to avoid unnecessary postexposure treatments. When humans are bitten by woodchucks in rabies epizootic areas, prophylaxis should be considered if the animals are not available for testing. Postexposure prophylaxis is rarely indicated in the case of bites by other rodents, but State and local health departments should continue to individually evaluate cases of bites by aggressive or ill-appearing rodents anywhere in the United States.

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BOOK REVIEW . . .

Monogenea and Turbellaria. Mary Beverley-Burton. *In* Guide to the Parasites of Fishes of Canada, Part 1, L. Margolis and Z. Kabata (eds.). Canadian Special Publication of Fisheries and Aquatic Sciences No. 74, Department of Supply and Services, Canadian Government Publishing Centre, Ottawa, Ontario K1A 0S9, Canada. 1984. Pp. 5–209. $11.95 Canadian (in Canada), $14.95 Canadian (outside Canada).

This book is a must for anyone working with North American Monogenea. The title includes Turbellaria, but only two species of Turbellaria are considered. Covered are keys, diagnoses, descriptive and morphometric data and records of all of the 183 species of Monogenea and Turbellaria of fishes in Canada. All of the genera and most of the species are illustrated. There is a host-Monogenea parasite list and the appendix has among other things a listing of order, family and genus of Turbellaria and Monogenea, consideration of evolution within the Monogenea and a diagnosis of copulatory complex or "penis" types which was the basis for separation of several genera.

The taxonomy and systematics of Monogenea are very dynamic. Every group of organisms has its "lumpers" and "splitters" and the Monogenea seems to have more than its share of both. The author would have to be considered a splitter since she has resurrected all of Mueller's old genera that had been synonymized into *Urocleidus* and *Cleidodiscus* and proposed several new genera. These changes resulted from years of detailed study by the author and her coworkers.

Considering the magnitude of this work, it seems to be remarkably free of inaccuracies. It would have been good for the author to have examined fresh material of *Fundulotrema prolongis* (*Gyrodactylus prolongis*) instead of following Hargis' description since the true nature of the "anteriorly directed flange" cannot be seen in the holotype specimen.

Overall, the book is outstanding. The editors of the series "Guide to the Parasites of Fishes of Canada" are to be congratulated on Part 1 of the series.

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