

## Rabies: Its Ecology, Control, and Treatment

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### Introduction

Rabies is a disease caused by a virus in the Rhabdoviridae family that affects the central nervous system of the infected host. All mammals, including domestic and non-domestic animals and humans, can be infected with the virus. However, rabies in the United States is reported most often in raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), Eastern gray (*Urocyon cinereoargenteus*) and red (*Vulpes vulpes*) foxes, groundhogs (*Marmota monax*), and several species of bats (Figure 1). Squirrels, chipmunks, mice, rats, and rabbits rarely are affected by rabies and are not known to have transmitted rabies to humans.

Prior to 1960, the majority of reported cases of rabies occurred in domestic animals; today less than 10 % of all reported cases involve pets or livestock. Between 1980 and 1997, 34 human cases of rabies were reported in the United States. Of these, 19 cases were attributed to bats, particularly the silver-haired bat (*Lasionyctaris noctivagans*). However, in 10 cases, no definitive history of the person coming into direct contact with a bat was found. The last confirmed case of human rabies in Virginia was an individual who succumbed to a strain of raccoon rabies in February 2003. Prior to that, the last confirmed human deaths in Virginia associated with rabies were bat rabies cases in 1998 and 1953.

### Distribution of Major Terrestrial Reservoirs of Rabies in the United States

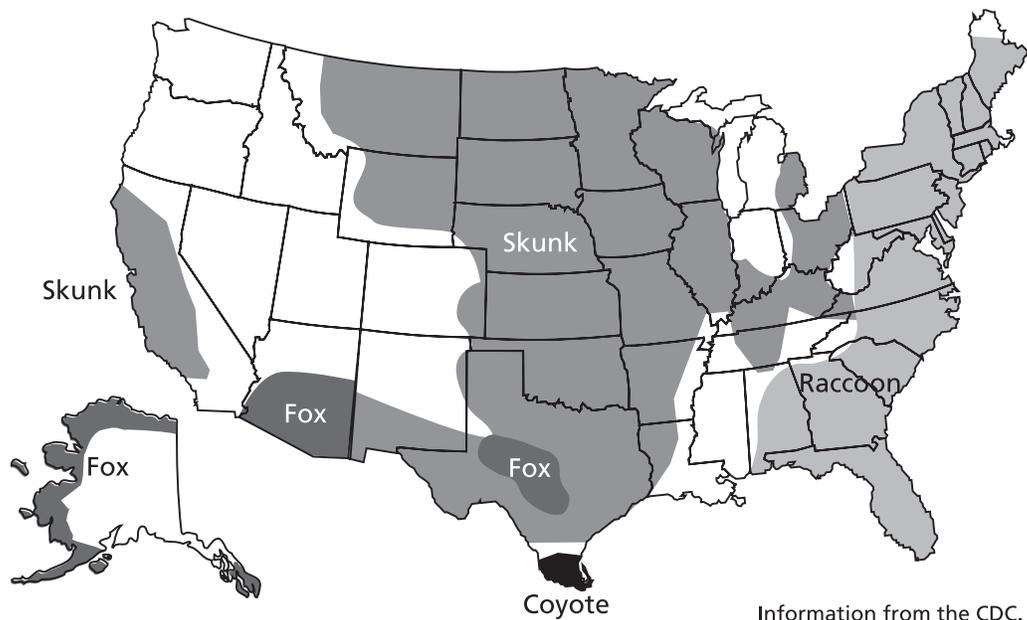


Figure 1.

Mandatory vaccination programs for domestic dogs first were implemented in the late 1940s. However, health experts credit both the development of an effective vaccine and enforcement of animal control laws during the 1950s with the dramatic decrease in rabies among domestic animals. Many states, including Virginia, now require rabies vaccinations for cats as well as dogs. Rabies vaccines also are available for use on certain livestock and ferrets.

Despite the successes in managing rabies among domestic animals, the total number of reported cases of rabies nationwide has continued to climb. In 2001, 7,437 rabid animal cases were reported in the United States, an increase of about 2 percent above the 2000 total (Figure 2). Of these cases, 93 percent involved a wild mammal.

Raccoons were identified as the primary vector species (40 percent of all reported cases), followed by skunks (33 percent), bats (18 percent), and foxes (6 percent) (Figure 3). Nationally, Pennsylvania, New York, Texas, Georgia, and Virginia tallied the highest number of confirmed cases of rabies involving domestic animals.

During 2002, 591 confirmed cases were documented in Virginia, including 317 raccoons, 147 skunks, 46 domestic animals, and a number of other wild mammals. Among domestic animals (8 percent of all reported cases), rabies in cats accounted for 59 percent of these cases, which is similar to the trend nationwide (Figure 4). No instances of human rabies were reported in Virginia in 2002.

## Rabies in Wild Animals

Although rabies has been present in Virginia since the 1750s, a significant increase in the incidence of raccoon rabies occurred during the early 1970s. This spike may be related to several hunt clubs bringing infected raccoons into the commonwealth. Apparently raccoons that were harboring the disease, but not yet showing visible symptoms, were captured in Florida and released in Virginia in an effort to restock local raccoon populations. Since that time, raccoon rabies has spread northward and eastward and now is well established throughout the East and as far north as New England and Canada. Periodic outbreaks of rabies occur among raccoons when their populations swell regionally and the number of infected animals within them increases over a period of years. Then, as

**Cases of Animal Rabies, 1955-2001**

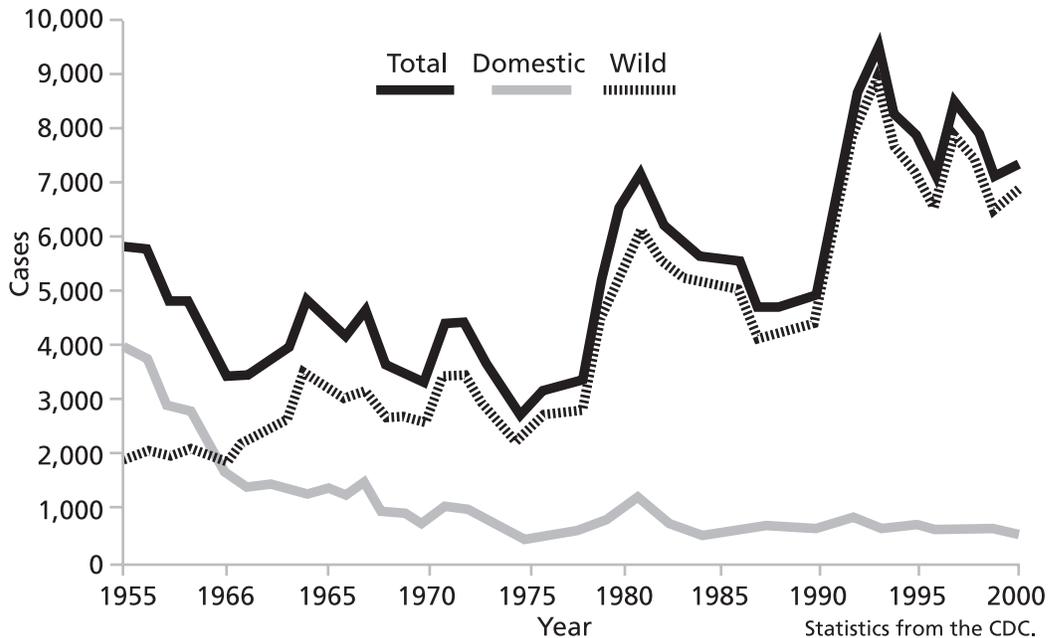


Figure 2.

**Rabies in Wild Animals, 1955-2001**

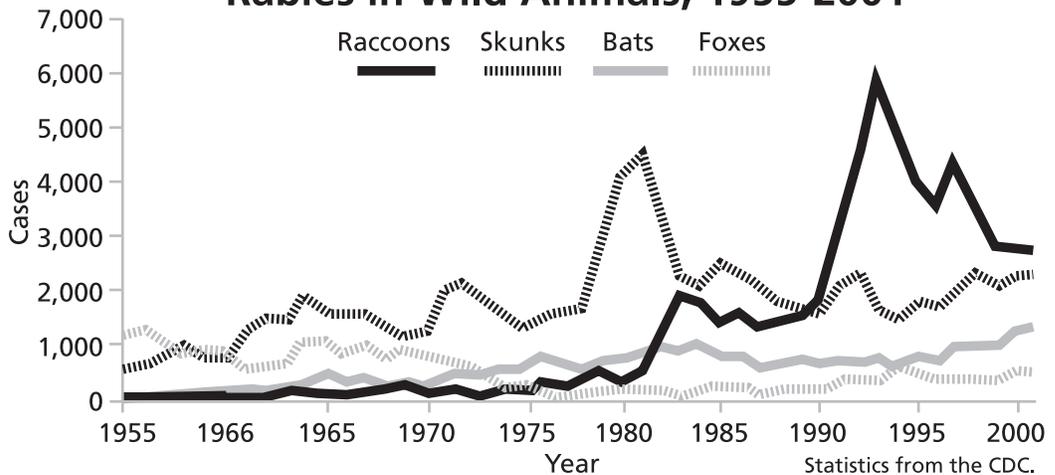


Figure 3.

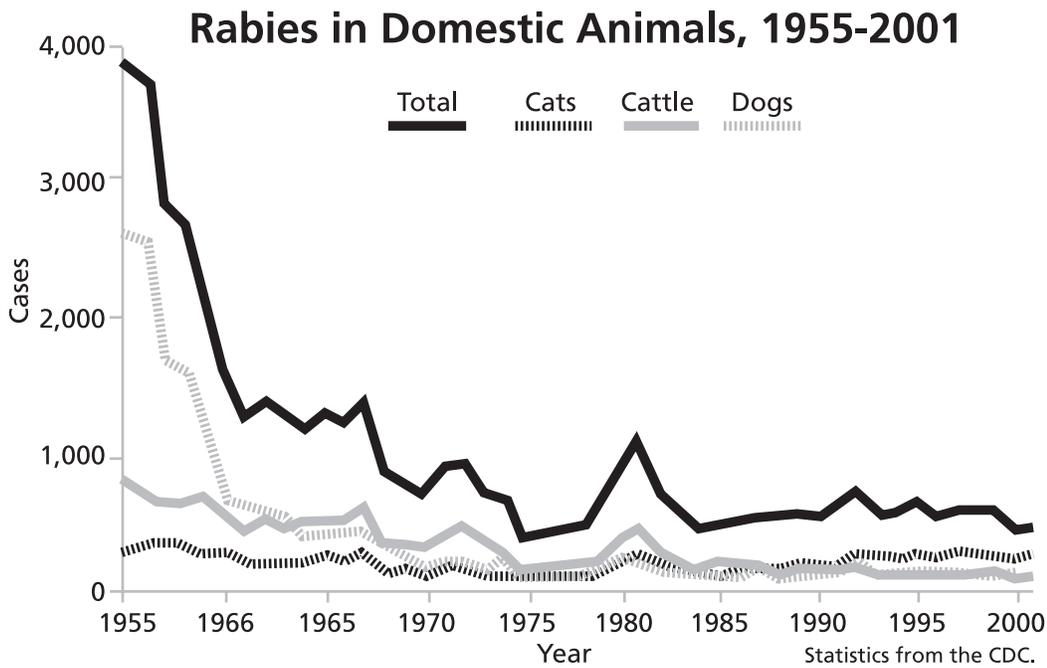


Figure 4.

mortality increases due to rabies, the number of surviving raccoons regionally is lowered and the overall incidence of the disease declines. However, it never will disappear completely. Although the total number of confirmed cases of rabies has fluctuated or declined slightly in recent years, regional or localized areas can become hot spots for the disease on a cyclic basis.

The occurrence of rabies in bats is a growing concern, even though its incidence is relatively low. According to researchers, less than 1 percent of the bat population is rabid. Also, the presence of an infected individual within a bat colony does not necessarily mean that the entire colony has a greater incidence for rabies than any other colony. Infected individuals die rather quickly (usually within days of showing symptoms) and thus the opportunity to spread infection is limited.

However, despite this low incidence, bats deserve special attention. Nearly all of the recent confirmed cases of human rabies in the United States involved bats. Therefore, you should treat any encounter with a bat with caution and not place yourself in jeopardy of exposure. Bats that are encountered during the day or in places where you would not normally expect to find them, or that appear to be having difficulty flying should be treated as suspicious and should not be approached or handled. One difficulty with bats is the uncertainty that can arise about possible exposure when you are awakened by one in your bedroom or find one in the room of an unattended child or an infirm, bedridden, or elderly person. Because the teeth of a bat are so small, it often is nearly impossible to detect whether

a bite has occurred. In cases of suspected or potential exposure, health officials suggest that you contact your local department of health office and receive guidance on what precautions to take. In many cases, the department may recommend that the bat, when it has been captured or restrained, be submitted for testing. Therefore, do not discard or destroy a suspicious bat found under these circumstances.

## Control of Rabies in Animals

Attempts to control rabies in wild animals are recent and only in the early stages of development. However, preliminary trial use of oral rabies vaccines has proven effective in foxes in Europe and Ontario, Canada, and in coyotes in Texas. The U.S. Department of Agriculture now is in its third year of testing to see if a barrier of vaccinated raccoons can be established from the Great Lakes south to the Gulf Coast as a means to prevent the westward spread of the disease. An oral vaccine (*RABORAL V-GR*) is hidden in a bait that is attractive to raccoons and distributed to raccoons by dropping baits from aircraft or by hand placement. Thus far, a barrier has been established from Ohio through West Virginia and currently is being extended through Virginia and Tennessee. According to health officials, the barrier appears to be working so far. The next phase of this project will be to extend the barrier further south, but also back toward the East in an effort to eliminate rabies in raccoons where it already has become established.

Previous attempts to control rabies in wildlife included depopulation within an affected area through trapping, hunting, or the distribution of toxic baits. For the most part, these attempts have not been successful and rarely can be justified economically. In addition, the potential to harm or kill non-target animals is high, particularly where indiscriminate poisons are placed randomly in the environment.

Thus, the focus of most rabies control programs in the United States likely will continue to emphasize vacci-

nation of domestic animals, increase the awareness of and knowledge about the disease among our citizens, and expand experimental efforts to create barriers in the field against wild animal infections using oral-vaccine baiting programs.

## Transmission and Pathogenesis of Rabies

The rabies virus can be transmitted to a new host only through an open wound or, less likely, through the mouth, the eyes, or the mucous membranes of the nose. Because the virus is present in the saliva and brain material of infected individuals, most transmission events occur through bite wounds. Although respiratory transmission has been reported in very rare circumstances in laboratory accidents and in a particular bat cave in Texas, it is not considered a risk under routine conditions. The amount of time between exposure and the display of visible symptoms is called the incubation period. It can vary from as little as a few days to many years in rare cases. However, in most cases, incubation occurs within one to three months. During this time, the animal or the person is not capable of transmitting the disease.

Once an individual is infected with the rabies virus, it replicates within the cytoplasm of muscle cells and can pass from cell to cell. Eventually, it reaches nerve receptors and enters the nervous system. The virus passes along the nerve network, traveling to the central nervous system, where it concentrates in the brain and upper spinal cord. As the disease progresses, the virus continues to multiply and spreads back through the peripheral nervous system to the salivary glands. Although the virus is known to exist in other parts of the body (e.g., the skin and intestines), it is found in amounts too small to play a role in transmission.

The length of the incubation period will vary and depends on several factors, including the amount of the virus transmitted and the location on the body where exposure occurred. Not all animals or humans exposed to the virus contract the disease. However, once symptoms become evident, the disease usually is fatal.

Symptoms in animals and humans can be similar, but usually are highly variable and numerous. In humans, initial symptoms typically appear within 30 to 60 days following exposure and can include pain and itching at the site of the virus' entrance into the body, restlessness, headache, fever, nausea, sore throat, and loss of appetite. Increased production of saliva, muscle stiffness, sensitivity to light or loud sounds, irrational excitement, or convulsions occurs as the infection progresses. Other

symptoms may develop later, such as anxiety, confusion, agitation, delirium, and the display of abnormal behavior. Symptoms of rabies in animals can include an evident change in behavior, loss of appetite, fever, change in phonation (e.g., the sound of a dog's bark), greater excitement, aggression, paralysis (especially in the lower jaw), and increased salivation.

Although three distinct phases of the disease often are described, they are not always observed. Each phase has a different set of outward, or visible, symptoms. The first ("prodromal") phase occurs early during the illness. At this stage, the virus is replicating and begins to pass through the nervous system. Behavioral changes, often in the form of a reversal of normal patterns, usually begin to show in this phase. For example, if an animal usually is shy, it may become more aggressive following infection, whereas a more aggressive animal under normal conditions may become more timid. In wild animals particularly, those that normally would be expected to be active during the day (diurnal) become active at night, and nocturnal animals, such as raccoons and bats, are observed moving about more than expected during the day.

In the second ("furious") phase, the animal becomes extremely irritable and aggressive, often lunging at or biting anything that moves near it. In fact, the word *rabies* is derived from the Latin term for *rage* or *fury*. Additionally, infected animals may produce excessive amounts of saliva during this stage, from which the expression "foaming at the mouth" is derived. However, not all infected animals outwardly display the "furious" stage and may not show any aggression at all.

The final ("dumb") stage is manifest by the onset of paralysis, most often in the lower jaw and extremities. Hence, this stage also is known as the "paralytic" phase. Individuals eventually lose the ability to chew and swallow, walk normally, right themselves when they fall, maintain a standing position, or, in the case of bats, maintain flight. The term *hydrophobia*, which many people call this disease instead of rabies, comes not from an animal's fear of water, but from its inability to drink or swallow water and hence its avoidance of water. Death usually follows the development of these "dumb" symptoms.

The outward display of rabies symptoms is extremely variable among species and individuals. As some clinicians say, "The only true symptoms typical to rabies are those that are atypical." To further complicate the situation, there are other diseases, such as distemper, that can produce symptoms similar to those of rabies.

Thus, the only definitive way to diagnose and separate these diseases is to conduct appropriate laboratory tests.

## Treating and Reporting Rabies

If you have gotten saliva or brain material from any mammal into a fresh, open wound or on a mucous membrane, then you may have been exposed to the rabies virus. You should wash the wound site thoroughly with soap and lots of water and then apply standard first-aid treatment to the wound. With serious bite wounds for which you may need stitches, seek medical treatment at your local hospital. You then should notify your family physician immediately about your possible exposure to rabies and provide full details on the episode and the disposition of the suspect animal. If your doctor believes postexposure treatment is warranted, guidelines established by the U.S. Public Health Service will be followed.

Where possible, try to capture and restrain the offending animal with a sturdy container until animal control officers can come to retrieve it. Do not attempt to pick up or physically hold the suspect animal. If you are unable to restrain the animal and find it necessary to kill the animal, be sure not to damage its head—the brain must be intact for health officials to properly test for rabies (Figure 5). **Remember** ... all animal bite incidents involving humans must be reported to your local department of health office.

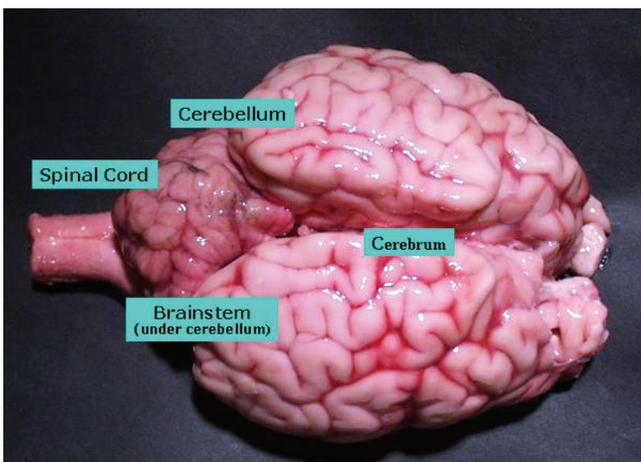


Figure 5.

For humans, postexposure treatment is used to prevent rabies. When someone is suspected of having come into contact with the virus, postexposure prophylaxis should begin as soon as possible following the exposure. If the affected person has not received any type of rabies vaccine prior to this exposure, he or she will be given human rabies immune globulin (HRIG) and a rabies vaccine. HRIG is administered only once, on the

first day (day 0) of treatment, with the injections occurring primarily at and around the site of the wound. The vaccine is given in the muscle of the upper arm on days 0, 3, 7, 14, and 28. Currently, two vaccines are available for use, including purified chick embryo cell vaccine (PCEC, e.g., *RabAvert*<sup>™</sup>), and human diploid cell vaccine (HDCV, e.g., *Immovax*). Each is effective in promoting immunity by inducing an active immune response in the treated individual. For persons who previously received a vaccine, either pre- or postexposure, only two doses of vaccine are administered for postexposure treatment. A typical postexposure treatment can cost at least \$1,200, so confirmation of whether the suspect animal was rabid can make a big difference and save that individual considerable expense. The objective of this treatment approach is to have the person's immune system develop antibodies and associated proteins that help fight the disease. It is extremely important that individuals exposed to rabies receive treatment immediately because, once outward symptoms of the disease develop in an individual, rabies normally is 100 percent fatal.

Pre-exposure vaccination is strongly recommended for individuals who may be at highest risk of exposure to the virus. Examples of people who should consider pre-exposure vaccination include veterinarians, animal handlers and care givers, animal control officers, and laboratory technicians who have frequent contact with rabies suspect animals as well as field biologists who often handle nondomestic vector species. In a pre-exposure prophylaxis protocol, only the rabies vaccine is administered in three doses over a 28-day period. The same vaccines used in postexposure treatment are used here.

As noted above, all instances of suspected rabies exposure, whether from wild or domestic animals, should be reported to the local department of health. As a part of your report, you should explain fully or describe the nature of the injury that you received, when and where the event happened, the animal (species) involved, and how that animal was acting prior to the exposure event. Other authorities may need to be alerted, such as your local animal control officer, police department, or game warden (note: wardens rarely become involved in rabies situations unless it involves larger wild animals). They may be able to assist with the capture of the suspect animal so that it can be tested for the presence of rabies, which should be done if at all possible.

If you own pets and find them injured or suspect they have come into contact with a rabid animal, notify your veterinarian and local health department as soon as possible. Make sure that your pets are kept current

on rabies vaccinations. Depending on the vaccine used, pets can be vaccinated as early as eight weeks of age, but most vaccines are licensed for use beginning at three months of age. State law requires all dogs and cats to be vaccinated by a currently licensed veterinarian by the time the animal reaches four months of age. A second vaccination should be administered within a year, followed by a booster shot every one or three years, depending on the vaccine used. Today, vaccines are available for dogs, cats, ferrets, and several live-stock groups. However, not all animals maintained as pets may have a suitable vaccine available to protect them (and thus the members of your family who have frequent contact with that animal). For example, there is some question as to whether vaccines currently available provide protection against rabies for the wolf-dog hybrids that some people own.

Contact information for the various reporting authorities can be found in your local telephone directory in the government, or “blue,” section. Under your county or city listing, you should find information on how to reach your local department of health office as well as a reference for reaching the animal control office. Your local game warden can be reached through your local sheriff’s department communications office (be sure to use the non-emergency number, not the 911 system).

Please remember that it is important for wild animals to remain wild. Never attempt to care for or take in a wild animal as a pet—to do so is illegal, unless you have received a special permit to do so from the Virginia Department of Game and Inland Fisheries and/or the U.S. Fish and Wildlife Service. Do not attempt to handle or closely approach any wild animal or any domestic animal that is not known to you. If an animal displaying unusual or aggressive behavior confronts you, retreat from the area and notify an animal control officer. Rabies is a deadly disease, one that is not treatable once visible symptoms appear. Thus, be safe when in the field, keep your pet’s vaccination up-to-date, and don’t place yourself in jeopardy by trying to handle wild animals ... leave that to the experts.

## Recommended Readings

Baer, G. M. (ed.). 1991. The natural history of rabies. Second Edition. CRC Press, Boca Raton, Fla.

Virginia Department of Health. 2000. Rabies Control Guidelines. Office of Epidemiology, Virginia Department of Health, Richmond, Va.

## Sources of Additional Information on Rabies

### Virginia Contacts:

Virginia Department of Health (VDH)  
Office of Epidemiology  
Richmond, Va.  
(804) 864-8141  
<http://www.vdh.state.va.us/epi/rabies.htm>

### National Contacts:

Centers for Disease Control (CDC)  
(800) 311-3435  
<http://www.cdc.gov/ncidod/dvrd/rabies>

National Institutes of Health (NIH)  
(301) 496-5717  
<http://www.niaid.nih.gov/factsheets/rabies.htm>

### For information about Virginia wildlife in general:

Virginia Department of Game and Inland Fisheries  
4010 West Broad Street  
Richmond, VA 23230-1104  
(804) 367-1000  
<http://www.dgif.state.va.us>

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