Anthrax

C. D. STEIN AND G. B. VAN NESS

ANTHRAX, or splenic fever, is an acute, infectious, febrile disease that has a rapidly fatal course. Sometimes it is referred to as charbon and milzbrand in animals, and as a malignant pustule and the woolsorter's disease in people.

Anthrax is one of the oldest and most destructive diseases of livestock. Outbreaks that took many animal and human lives are recorded by many medieval and modern writers. The disease has been associated closely with early discoveries that lead to the development of the modern sciences of bacteriology and immunology. It was the first infectious disease of animals in which the causative agent was definitely demonstrated to be a specific micro-organism and the first disease against which a bacterial vaccine was found to be an effective and practical means of prophylaxis.

The specific cause of anthrax is *Bacillus anthracis*, a Gram-positive, nonmotile, spore-forming, rectangular-shaped bacterium of relatively large size. The growing bacilli are usually arranged in chain formation in animal tissue or cultures, but they may occur singly or in pairs. When properly stained, the bacilli in blood and tissue smears of animals dead of the disease usually reveal a distinct capsule.

The organisms are highly virulent. When they gain access to the animal body, they multiply rapidly, invade the blood stream, and produce a rapidly fatal blood infection (septicemia). In the presence of oxygen, sufficient moisture, and a favorable temperature, the bacilli develop spores of remarkable tenacity. It is generally believed that spores do not form in the unopened carcass, but sporulation occurs readily when organisms are discharged from the body of an infected animal or when the carcass is opened for autopsy.

Anthrax spores are highly resistant to heat, low temperatures, chemical disinfectants, and prolonged drying. They may retain their viability for many years in the soil, in water, on hides, and on any contaminated objects held in storage.

On some marshy or bottom land or in soils that contain decomposed vegetable or animal matter, the organisms survive for long periods. In anthrax districts where the soil is known to be seriously infected, the disease may occur in epizootic form among livestock on pasture, especially during late summer and early fall, when grazing is closer because of scanty pasturage and when flies are numerous. Anthrax tends to be seasonal, but sporadic outbreaks may occur anywhere at any time.

ANTHRAX OCCURS in all parts of the world. Districts where repeated anthrax outbreaks occur exist in southern Europe, parts of Africa, Australia, Asia, and North and South America.

Large recognized areas of infection exist in South Dakota, Nebraska, Arkansas, Mississippi, Louisiana, Texas, and California, and small areas exist in a number of other States. Anthrax has been recognized as a disease of livestock in the United States for more than 60 years. There were 3,447 outbreaks in 39 States, with losses of 17,604 head of livestock, between 1945 and 1955.

Anthrax is spread from one country to another mainly through infected animals and the interchange of infected objects closely associated with animal life, such as hides, hair, wool, bonemeal, meat scraps, fertilizer, and forage.

When anthrax is once established in an area, it may spread to adjoining localities and even to distant points by contamination of soil, drinking water, and pasture plants with discharges of diseased animals; by dogs, cats, coyotes, and other carnivora that have fed on infected carcasses; by carrion-eating birds, especially buzzards; by flies and possibly other types of insects; by streams contaminated with surface drainage from anthrax-infected soil and tannery wastes; and by mixed feeds containing contaminated bonemeal, meat scraps, and other animal proteins.

All animals are susceptible to anthrax in some degree. Cattle, horses, sheep, and goats are most commonly affected. Man and swine possess a greater natural resistance to the disease. Dogs, cats, and wild animals of prey, as well as birds, frogs, and toads may become infected under certain conditions. Mice, guinea pigs, and rabbits, which are commonly used in the laboratory diagnosis of anthrax, are highly susceptible, but rats have considerable resistance.

Infection in cattle, horses, mules, sheep, and goats is usually the result of grazing on infected pastureland. Infection may also be caused by contaminated fodder or artificial feedstuffs, such as bonemeal, blood meal, oilcake, and tankage; by drinking from contaminated pools; or by the bites of contaminated flies. Swine, dogs, cats, mink, and wild animals held in captivity usually acquire the infection from consumption of infected meat. Widespread outbreaks in herds of swine in the Midwest in 1952 were traced to mixed feeds containing contaminated bonemeal.

THE SYMPTOMS OF ANTHRAX vary according to the species of animals and the acuteness of the attack. The average period of incubation—that is, the period of time elapsing between exposure to infection and the appearance of the first symptoms—under natural conditions is not known definitely, but experimental evidence indicates it may vary from 24 hours to 5 days or much longer.

The disease may occur in a peracute, acute, subacute, or chronic form.

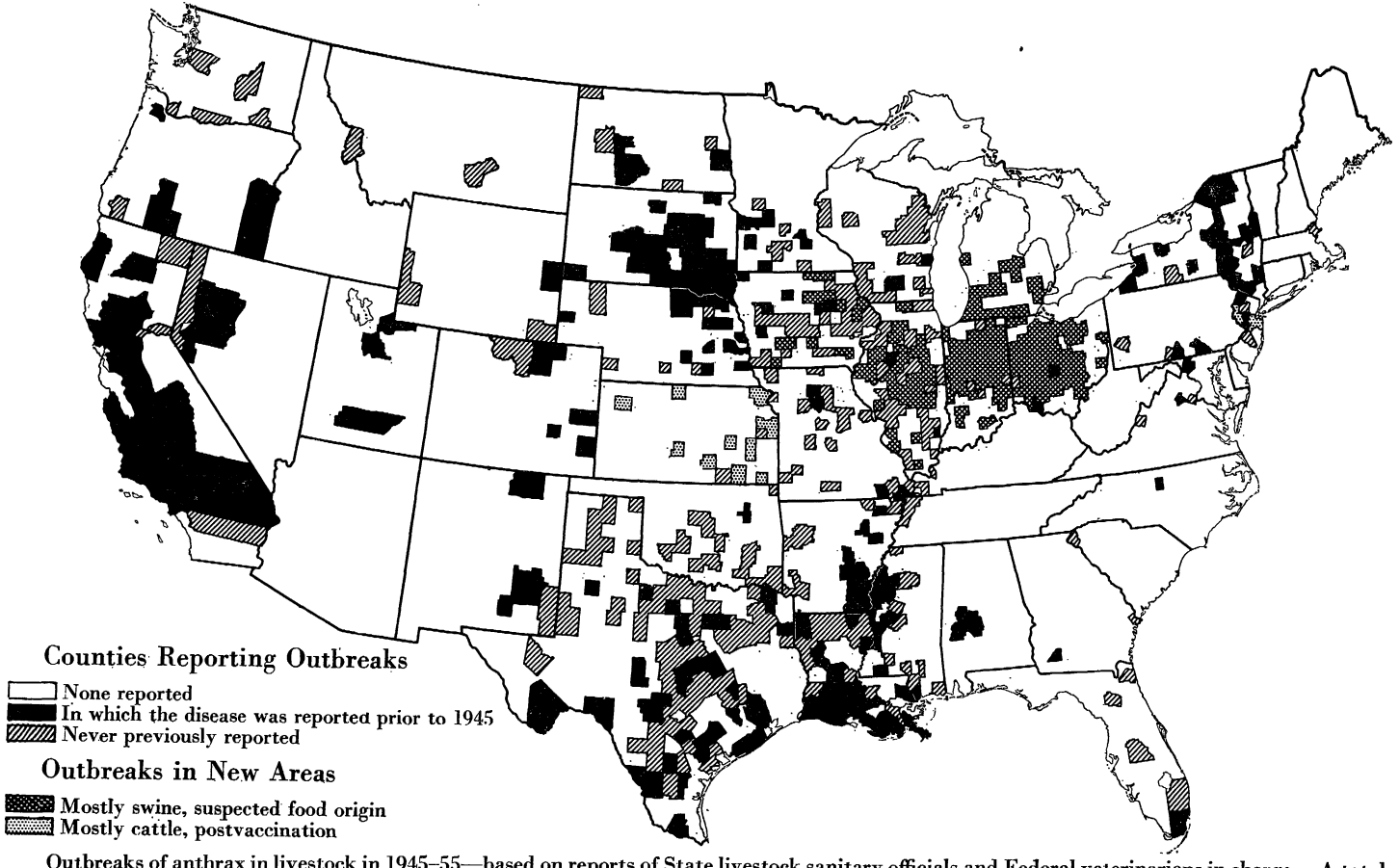
The peracute form, most common in cattle, sheep, and goats, occurs at the beginning of an outbreak and is characterized by its sudden onset and rapidly fatal course. Victims present a picture of cerebral apoplexy—sudden staggering, difficult breathing, trembling, collapse, a few convulsive movements, and death. Death may occur without any noticeable illness.

In the acute and subacute forms, most common in cattle, horses, and sheep, there is first a rise in body temperature and a period of excitement, followed by depression, stupor, spasm, respiratory or cardiac distress, staggering convulsion, and death. During the course of the disease, the body temperature may reach 107° F. Rumination ceases, the milk secretion of milking cows is materially reduced, and pregnant animals may abort. Bloody discharges may emanate from the natural body openings. Swellings may appear in different parts of the body.

Horses may show fever, chills, severe colic, loss of appetite, extreme depression, muscular weakness, a bloody diarrhea, and swellings in the region of the neck, sternum, lower abdomen, and external genitals. The acute form usually terminates in death in a day or two. The subacute form may result in death in 3 to 5 days or longer—or recovery.

A cutaneous, or localized, form of anthrax characterized by swellings in various parts of the body may occur in cattle and horses when anthrax organisms lodge in wounds or abrasions of the skin. This form of the disease may occur following bites by infected flies or in highly susceptible animals following vaccination.

Chronic anthrax, with local lesions confined to the tongue and throat, occurs mostly in swine but is observed occasionally in cattle, horses, and dogs.



Outbreaks of anthrax in livestock in 1945–55—based on reports of State livestock sanitary officials and Federal veterinarians in charge. A total of 3,447 outbreaks in 714 counties in 39 States was reported.

The symptoms of anthrax in swine are marked swellings of throat and tongue. Often a blood-stained, frothy discharge comes from the mouth.

Some swine may die of acute anthrax without having shown any previous signs of illness. Others in a herd may have a high temperature, loss of appetite, depression, and rapidly progressing swelling about the throat, which sometimes causes death by suffocation. A comparatively large percentage may develop the disease in a mild and chronic form and may make a gradual recovery; some of them, when presented for slaughter as normal animals, however, on the postmortem examination may show some evidence of chronic anthrax infection in the cervical lymph glands and tonsils.

In animals dead of anthrax there is usually an oozing of blood from the nostrils and anus, rapid decomposition, and marked bloating. The blood fails to clot readily and is darker than normal. Rigor mortis (stiffening of the muscles) is frequently absent or incomplete. Hemorrhages beneath the skin are common. Clear or blood-tinged gelatinous exudates are found at the site of swellings. The spleen is usually greatly enlarged. The splenic pulp is soft or semifluid in consistency and dark red to black. The liver, kidneys, and lymph glands are usually congested and enlarged.

ANTHRAX IN MAN is acquired by skinning, butchering, or making postmortem examinations of infected carcasses (agricultural anthrax), or by handling contaminated hides, wool, hair, or other material (industrial anthrax).

In man the disease may occur as a cutaneous, pulmonary, or intestinal infection.

The cutaneous form, which is most prevalent, occurs as a primary, localized infection of the skin, usually on exposed parts, such as the hands, arms, neck, and face. The lesion first appears as a small pimple, which rapidly develops into a large vesicle with a black, necrotic center, commonly referred to as malignant pustule. A fatal blood infection may result if the condition becomes generalized.

The pulmonary form (known as woolsorter's disease) affects principally the lungs and is due to inhalation of spores during processing of hair and wool. This form usually ends in death.

In countries where people eat the flesh of animals dead of disease, an intestinal form of anthrax sometimes follows the consumption of contaminated meat.

Prompt diagnosis and early treatment are of utmost importance in combating the disease in man. While specific antiserum, arsenicals, and sulfa drugs have given excellent results in treatment of anthrax in man during the past 20 years, the trend in recent years appears to be toward penicillin, which has been found to be highly effective. More recently some of the newer antibiotics, such as Aureomycin and Terramycin, have proved to be extremely effective in the treatment of a limited number of cases.

The United States Public Health Reports, covering the 10 years from 1945 through 1954, show a total of 483 anthrax cases in man, most of which were of industrial origin. Human anthrax in the United States is not a common disease, but it cannot be considered rare.

DIAGNOSIS is based on history, clinical symptoms, and laboratory examination. Only the last is conclusive.

Anthrax should be suspected when animals die suddenly on or near premises where the disease has appeared previously.

Diagnosis based on clinical symptoms may be difficult, especially when the disease occurs in a new area. Peracute anthrax may be confused with other conditions that produce sudden death, such as lightning stroke, sunstroke, lead poisoning, and other acute, fatal maladies.

Less acute cases may be mistaken for malignant edema, hemorrhagic sep-

ticemia, the tick fever, anaplasmosis, blackleg, and sweetclover poisoning in cattle; and for purpura hemorrhagica, acute swamp fever, and colic in horses; and for malignant edema and acute hog colera in swine.

A tentative diagnosis based on clinical symptoms should always be confirmed by a laboratory examination.

When anthrax is suspected, it is not advisable to make a postmortem examination, because opening or skinning the carcass may result in spreading the disease and transmitting the infection to the operator. If a postmortem examination is necessary, the operator should use rubber gloves, rubber boots, and effective disinfectants to avoid infecting himself and the premises.

Specimens for laboratory examination should be obtained a short time following death, since specimens from carcasses showing evidence of decomposition are unsuitable for laboratory examination.

Good specimens for sending to the laboratory for examination are blood smears on clean glass slides and sterile cotton swabs, gauze, or blotting paper saturated with a sample of blood collected aseptically from a superficial blood vessel and allowed to air-dry. Specimens should be placed in clean containers labeled "suspected anthrax" and sent to the laboratory in a sealed metal mailing tube. When anthrax in swine is suspected, specimens of the cervical lymph nodes packed in borax should be submitted for examination, because anthrax organisms rarely occur in the blood stream of swine.

Laboratory examination for anthrax includes, first, a microscopic examination of blood smears properly stained for the presence of encapsulated bacilli having the characteristics of *B. anthracis;* second, culture tests on solid media for characteristic anthrax colonies showing no hemolysis; and, third, regardless of whether the microscopic and cultural tests are negative or positive, inoculation tests on guinea pigs or mice. If the injected material contains virulent anthrax organisms, the laboratory animal dies usually within 72 hours, and shows characteristic lesions of anthrax.

ANNUAL VACCINATION of livestock in anthrax districts well in advance of the anthrax season is the most effective method of prevention. Vaccination of exposed animals in an infected herd will reduce losses and help control the outbreak.

Vaccination is not completely effective, however, and an occasional loss from anthrax in a vaccinated herd does not constitute grounds for questioning the value of the vaccine that was used nor does it justify hasty revaccination of the herd.

The immunizing agents used in the United States in 1956 for vaccinating animals against anthrax were of two types—sterile products (anthrax antiserum and anthrax bacterin) and the living-spore vaccines, which consist of suspensions of living anthrax spores of different degrees of attenuation suspended in a solution of normal saline in combination with glycerine. Spore vaccines are designated as being of No. 1, No. 2, No. 3, or No. 4 strength, according to their degree of virulence.

Anthrax antiserum is of value as a preventive and as a therapeutic agent. It produces rapid immunity of short duration. Anthrax bacterin produces an active immunity of low degree but of longer duration than anthrax antiserum. Long experience, however, has shown that living-spore vaccines produce a higher degree of immunity than do bacterins.

Satisfactory results have been obtained with spore vaccines given subcutaneously by the single-, double-, or triple-injection method, but in known anthrax areas exceptionally good results are obtained with single-injection, intradermal spore vaccine of selected virulence, which produces a rapid, durable immunity with little or no reaction and is especially useful for immunizing exposed animals in an infected herd. In this method of vacci-

nation, the spore vaccine is injected directly into the skin (intracutaneously) and not under the skin (subcutaneously), the usual method used in other forms of vaccination.

A new type of spore vaccine of low virulence, prepared from an uncapsulated variant strain of *B. anthracis* and developed at the Onderstepoort Veterinary Research Laboratory, Pretoria, Union of South Africa, has been used with excellent results in South Africa, England, India, and in other countries. A spore vaccine of this type is produced and distributed in the United States.

The simultaneous administration of antianthrax serum and spore vaccine (No. 2, 3, or 4) is likewise an effective method of immunization and is the method preferred by many veterinarians for vaccinating exposed animals during an actual outbreak.

The use of spore vaccines requires considerable discretion, and immunization should be carried out in accordance with recommendations of the livestock sanitary officials.

In administering and handling spore vaccines, the recommendations of the manufacturer should be followed carefully. Ordinarily it is inadvisable to use anthrax spore vaccines on premises where the disease has not existed previously unless danger from exposure is imminent. When spore vaccines are used, due care should be taken by the operator to prevent contamination of the surroundings and infecting himself.

Vaccination in anthrax areas with the proper type of immunizing agent usually affords protection for a season—but not more than a year—and should be repeated annually. In some endemic areas that have a long anthrax season, a booster dose of vaccine is administered 4 to 6 months after the date of the first vaccination.

TREATMENT OF ANTHRAX CASES showing advanced symptoms is of little value, but animals showing temperature reactions and other early symptoms may recover under prompt treatment.

For many years antianthrax serum was most commonly used for the treatment of anthrax in animals. In recent years, however, penicillin and other antibiotics, such as Terramycin, which have proved to be effective in the treatment of the disease in animals, are being used widely instead of specific antiserum.

Although the Department of Agriculture has conducted no experiments to determine the merits of antibiotics, such as penicillin and Terramycin, in the treatment of anthrax, clinical reports from veterinarians in the field indicate that these preparations may have considerable therapeutic value if properly administered during the early stages of the disease. Treatment of affected animals with any of the above-mentioned preparations should be under veterinary supervision.

THE FOLLOWING CONTROL MEASURES will assist in checking the disease and preventing its spread: (1) A strict quarantine of the infected premises, rigidly enforced to prevent the movement of livestock from or into the infected area; (2) prompt disposal of dead animals by complete cremation or deep burial under a layer of quicklime; (3) destruction of manure, bedding, and other contaminated material by burning; (4) isolation of visibly sick animals and immediate treatment with antianthrax serum, penicillin, or Terramycin; (5) vaccination of the apparently well but exposed animals with the immunizing agents recommended by the livestock sanitary officials; (6) change of pastures if practicable; (7) cleaning and disinfecting with a 5-percent lye solution of contaminated stables and sterilization of all milking equipment if the outbreak occurs in a dairy herd; (8) control of flies and maintenance of good sanitation; (9) due precaution to prevent spreading the infection through rats, dogs, cats, swine, chickens, buzzards, and crows feeding on the carcasses of animals dead of anthrax, or by skinning the carcass or removing it to a rendering plant.

Federal and State responsibilities in connection with the anthrax problem are carried out as follows: Actual handling of outbreaks of anthrax in each State is performed by the State livestock sanitary officials. The Department of Agriculture furnishes the diagnosticians, technical assistance, and advice when requested by State officials and carries on research on the disease.

Federal regulations to prevent the introduction of anthrax infection into the United States through importation of certain animal products are also enforced.

The regulations governing the importation of bonemeal for use in animal feeds or fertilizer are enforced by the Department of Agriculture. Regulations pertaining to the admission of hair and bristles intended for use in manufacturing shaving brushes are enforced by the United States Public Health Service.

From standpoints of economics and public health, anthrax is a serious disease against which every means of suppression needs to be exerted. The problem of control is a common cause to which every livestock owner should contribute. All persons concerned should cooperate to the fullest extent with the local veterinarian and the livestock sanitary and the public health officials who are charged with the responsibility of controlling the disease.

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Malignant Edema

C. D. STEIN

MALIGNANT edema is a wound infection that usually is quickly fatal. It is marked by painful gangrenous swellings and severely toxic symptoms.

It is caused by a spore-forming, rod-shaped germ, *Clostridium septicum*. The organism resembles the germ that causes blackleg; both grow only in the absence of oxygen. Therefore the infection usually enters the body through wounds caused by puncture or laceration. The infection develops in the injured tissue.

The germs are widely scattered in the top layers of soil. Animals kept in dusty, unsanitary surroundings may get the disease following hypodermic injections, surgical operations, parturition, and accidental wounds.

Horses, cattle, and sheep are most susceptible. Swine, dogs, and cats are rarely affected.

In horses, which are most susceptible, the infection frequently follows punctures caused by nails, splinters, and such. In sheep, it may follow