

FOREIGN ANIMAL DISEASES

FOREIGN PESTS AND VECTORS OF ARTHROPOD-BORNE DISEASES

(Vector-borne Diseases and Arthropod Vectors)

In many areas of the world, particularly the tropics, arthropod-borne diseases are among the major limiting factors to the efficient production of livestock and poultry. These diseases result in debilitation, lameness, blindness, wasting, congenital defects, abortions, sterility, and death. Some exotic arthropod-borne diseases of livestock are zoonotic and affect humans as well as animals.

All of the major groups of pathogenic organisms have representatives that are transmitted by arthropod vectors and cause disease in domestic livestock or poultry. For example, over 400 arthropod-borne viruses (arboviruses) have been recognized, including the etiologic agents of such major livestock diseases as African swine fever, Akabane disease, bovine ephemeral fever, the equine encephalitides, bluetongue, and epizootic hemorrhagic fever (16). Rickettsial agents that are primarily tick-borne cause several extremely important livestock disease problems, including bovine and ovine anaplasmosis, heartwater, tick-borne fever, bovine infectious petechial fever, epizootic bovine abortion, Jembrana disease, and Q fever. Arthropod-borne bacteria cause such well-known diseases as borreliosis of cattle and horses, spirochetosis of poultry, tularemia, and Lyme disease.

Some of the most devastating of all animals diseases are caused by arthropod-borne blood protozoa, including babesiosis of cattle, sheep, goats, horses, and swine; theileriosis, the East Coast fever syndrome, and Mediterranean fever; the trypanosomiases causing illness in cattle, sheep and goats, camels, pigs, dogs, and many wild game species; as well as several arthropod-borne protozoa that cause diseases of birds. Bovine filariasis is a prime example of an exotic helminthic disease that is arthropod-borne. In fact, over half of all exotic diseases of livestock and poultry of critical concern to the United States are arthropod-borne.

The most prominent groups of arthropods that transmit etiological agents

pathogenic to livestock are those that are blood-feeding (hematophagous) and are biologically involved in transmission cycles. Ticks, tsetse flies, mosquitoes, and biting midges, for example, have leading roles in the biological transmission of agents causing significant livestock and poultry diseases. Of somewhat lesser general importance are those hematophagous arthropod groups that mechanically transmit pathogens. Horse flies, deer flies, stable flies, horn flies, and others have been incriminated in disease transmission through interrupted feeding.

There are also those arthropod groups in which the many species are not blood sucking — such as muscoid flies, beetles, or grasshoppers — but which mechanically transport pathogens or serve as intermediate hosts of helminths. Of course, examples can also be found for any variety of transmission methods and cycles within each of the major vector groups.

As a whole, ticks are the most versatile vectors, for they parasitize all vertebrate groups except fish. The tick-borne diseases that they transmit are among the most significant animal health deterrents to efficient livestock production. The methods of pathogen transmission employed by ticks are both mechanical and biological. In the case of soft ticks belonging to the family Argasidae, the ability of some individuals to survive for 3 years or more between blood meals permits them to assume the dual role of vector and reservoir, which is particularly important in the transmission of African swine fever virus (16).

Mosquitoes are notorious as proven vectors of some of the most devastating human diseases. There is little need to document the impact on human public health of malaria, yellow fever, filariasis, and several mosquito-borne diseases of arboviral etiology. Rift Valley fever and the equine encephalitides are important livestock diseases transmitted by mosquitoes. Although over 2,500 species of mosquitoes have been described worldwide in 18 genera and subgenera, those species of greatest importance as vectors of pathogenic agents are found in the genera *Aedes*, *Culex*, *Anopheles*, and *Mansonia*.

Biting midges, particularly species of the genus *Culicoides*, have been incriminated in the transmission of viral, protozoal, and filarial agents pathogenic to livestock and poultry. Owing to their small size and difficulties encountered in colonization, scientific progress on their role as animal disease vectors has been delayed. However, considering the fact that biting midges are frequently among those species of biting flies in greatest abundance that attack livestock, increased attention should be given to them as animal disease vectors.

Although tsetse flies are limited in their distribution to sub-Saharan Africa, the importance of the animal trypanosomiasis (nagana of cattle) on that continent

ranks tsetse as one of the world's major arthropod-vector groups. The very complex developmental cycle of the trypanosome within the tsetse vector is further complicated by several of other factors related to the biology of the vector, pathogen, and host. Not only are the various species of tsetse flies characterized by differences in their distribution, biology, and host preferences, but even within the same species environmental factors (especially humidity, temperature, and vegetation), densities and composition of mammalian hosts, and vector population densities affect their epidemiological role. In addition, there are wide intraspecific variations in both morphology and pathogenicity of trypanosomes. Certain parasite antigens that stimulate production of protective antibodies by the host change before the parasites are completely eliminated; new antibodies are then produced by the host, and the parasites change their antigenic constitution again to maintain themselves.

The key to the success of arthropod-borne disease transmission lies in the competence of vector efficiency (6). Whereas one vector species may be extremely efficient in the transmission of a particular pathogen, a closely related species may be totally incompetent as a vector. Even within a single vector species, individuals and populations vary dramatically in their competence to transmit a particular pathogenic agent. The expression of vector competence appears to be controlled, in part, by genetic factors involving multiple genes. For example, although the biting midge species, *Culicoides varipennis*, is incompetent to transmit bluetongue virus in the Northeastern United States, populations of the same species from the Southwest and Western States are extremely efficient vectors of the virus. Genetic crosses between families of the insect vector species showed results consistent with the theory that a single genetic locus controls insect vector competence for infection with the bluetongue virus (12, 15).

Foreign Arthropod Pests and Arthropod-Borne Disease Factors

Although the introduction and establishment of any exotic arthropod pest of livestock or poultry, or any arthropod-borne disease vector, could have devastating results to affected industries, certain foreign species are of considerably greater importance than others. On the basis of potential for introduction, establishment, and economic impact, three categories of foreign arthropod pests and arthropod-borne disease vectors have been established ([Appendix 2](#)).

Category A. These species have the highest potential for introduction, establishment, and economic impact. They consist of five tick species, one parasitic mite, one blowfly, and one muscoid fly. The southern cattle tick, *Boophilus microplus*, is a vector of bovine babesiosis, bovine anaplasmosis, and

benign bovine theileriosis. This tick is found in the hotter, more humid parts of the West Indies, Mexico, Central America, South America, Africa, Australia, the Orient, and Micronesia. At one time it was also established in southern Florida, in several counties in southern Texas, and is found in Puerto Rico and St. Croix, U. S. Virgin Islands. A closely related species, *B. annulatus*, the cattle tick, was once the most important external parasite of cattle in the Southern United States. It is a principal vector of bovine babesiosis and has also been incriminated in the transmission of bovine anaplasmosis, benign bovine theileriosis, and spirochetosis of cattle, sheep, goats, and horses. The cattle fever tick has been eradicated from the continental United States, but periodic introductions from Mexico continue to occur. It is also found in western and central Africa, the Mediterranean basin, and the Near East.

Another exotic tick species of great concern to this hemisphere is the tropical bont tick, *Amblyomma variegatum* (Fig. 53). A native of Africa south of the Sahara Desert, the tropical bont tick was introduced into the Caribbean island of Guadeloupe around 1830 on cattle imported from Senegal. This tick is a common vector of *Cowdria ruminantium*, which is the etiological agent of heartwater that affects cattle, sheep and goats. The bont tick is also associated with the spread of dermatophilosis and has been incriminated in the transmission of Nairobi sheep disease. An international effort is under way to eradicate the tropical bont tick from the Western Hemisphere. *A. hebraeum* (Fig. 54), the bont tick, is also of African origin and is a common vector of heartwater. The exceptionally long mouthparts enable it to produce deep-seated painful wounds that often become infected and lead to abscess formation.

The brown ear tick, *Rhipicephalus appendiculatus*, is widely distributed in the wetter areas of Africa. Although primarily a cattle tick, there are numerous secondary host species. Because the most important predilection site of this species is the inside of the earflap, it is the most important species involved in transmitting the etiological agent of East Coast fever. *Rhipicephalus appendiculatus* has also been incriminated in the transmission of bovine babesiosis, other pathogens of the East Coast fever syndrome, louping ill, Nairobi sheep disease, and Kisenly sheep disease.

Another tick species of high vector potential is the European castor bean tick, *Ixodes ricinus*. This tick is common throughout most of Europe, including the British Isles, and is found in North Africa and limited areas of Asia. It has never been established in North America, although closely related species of the genus *Ixodes* do exist in this hemisphere. The European castor bean tick is responsible for transmitting the causative agents of bovine babesiosis, bovine anaplasmosis, louping ill, and tick-borne fever of cattle, sheep, and goats. Completion of the life

cycle can require as long as 3 years.

The sheep scab mite, *Psoroptes ovis*, is recognized as an exotic arthropod pest having highest potential for introduction because it has been eradicated from the United States and could easily be reintroduced from other countries of this hemisphere. Interceptions at port of entry have been made from sheep, goats, llamas, and alpacas.

Another exotic arthropod pest of highest importance is the New World screwworm, *Cochliomyia hominivorax*. This species has been eradicated from the United States and Mexico through the classic application of the sterile male technique, and the program continues to approach its goal of eradication throughout Panama. Screwworms were introduced into Libya from South America and subsequently eradicated through an international effort utilizing the sterile male technique. Until a barrier is established in Panama, there is a persistent threat for the reintroduction of screwworms on infested mammalian hosts from areas that have not yet been eradicated.

The louse fly, *Hippobosca longipennis* (Fig. 55), which inflicts a painful bite, is an ectoparasite of all hairy animals, including livestock, dogs, cats, and wild game. The louse fly has been introduced into the United States on a shipment of cheetahs destined for zoological parks and subsequently eradicated from six states. This species has also been introduced on bat-eared foxes.

The final species in Category A is a licking fly, *Musca vitripennis*. This species has been reported as being a tenacious feeder on the facial secretions of cattle, a mechanical vector of the etiological agent of infectious keratoconjunctivitis, and a biological vector of bovine filariasis. Adults of this fly have been intercepted on several occasions in aircraft originating from the Azores, but this species has not yet become established in North America (13).

Category B. Exotic arthropod pests and arthropod-borne disease vectors in Category B merit particular concern with respect to introduction, establishment, and economic impact. So many arthropod species could be assigned to this category that they are listed by genera rather than by individual species. As before, the lead is taken by hard ticks of the genera *Amblyomma*, *Dermacentor*, *Hyalomma*, *Ixodes*, and *Rhipicephalus*, followed by soft ticks of the genera *Argas* and *Ornithodoros*. Mosquitoes of the genera *Aedes*, *Anopheles*, and *Culex* are a continual concern for introduction and establishment, as has recently occurred with the Asian tiger mosquito, *Aedes albopictus*. Muscoid flies (*Musca*) could be introduced in bedding material of animal importations. The numerous species of tsetse flies, *Glossina* spp., are listed within Category B because they are all limited

to the African continent and, in view of their biological cycle and naturally low reproductive efficiency and population density, are less likely to be a threat to introduction. However, should a tsetse species become established in a tropical or semitropical area of this hemisphere, eradication would undoubtedly be a formidable task.

Category C. Species of foreign arthropod pests and arthropod-borne disease vectors assigned to Category C are those with some potential for introduction, establishment, and economic impact. They originate from all areas of the globe and are too numerous to characterize even at the generic level. Thus, species of particular concern are found in the families Ceratopogonidae (biting midges), Simuliidae (black flies), Oestridae (bot flies), Chloropidae (eye gnats), Sarcophagidae (flesh flies), Ixodidae (hard ticks), Tabanidae (horse flies and deer flies), Culicidae (mosquitoes), Muscidae (muscid flies), and Cuterebridae (robust bot flies).

Examples of Interceptions and Introductions

Historically, some of the most economically important arthropod pests of livestock found in the United States were introduced from Europe (2). There is evidence to suggest that the house fly and stable fly were introduced when the first settlers brought livestock with them from their home countries. The horn fly, a pest of cattle throughout the United States, was first discovered near Camden, New Jersey, in 1887. By 1990, it had spread to all states of the United States and all provinces in Canada. More recently, the face fly, a livestock pest and carrier of parasites, entered Nova Scotia in 1952 on cargo transported by air from England. Face flies now infest cattle in all but the southernmost states.

Examples of arthropod vectors that have been intercepted at ports of entry or that have been detected on premises and subsequently eradicated are numerous and alarming (3,8,11,17). Records on exotic arthropod pests found on animals and products have systematically been compiled for over 35 years. Since that time, over 70 species of exotic ectoparasites, primarily ixodid ticks, have been collected from a wide variety of both domestic and zoological animals at ports of entry into the United States. Many of the species intercepted are known vectors of some of the most economically important livestock diseases in the world, including bovine babesiosis, heartwater, East Coast fever, corridor disease, Nairobi sheep disease, louping ill, and tropical disease ([Table 1](#)). Other species intercepted, such as the sheep scab mite, New World screwworm, and louse flies, although not disease vectors, could become serious pests of our nation's livestock population if they were to become established in the United States. Most of the exotic pests intercepted were found on animals while in quarantine at a USDA import center.

Examination and precautionary treatment routinely provided to these animals ensure that they are free of ectoparasites before being released from quarantine. When exotic animal pests are found on animal or plant products, baggage, cargo, etc., at ports of entry other than USDA quarantine stations, treatment of the infested material is provided to eliminate the pest before further movement into commerce.

The greatest threat to the livestock industry comes from those animals that may enter the United States without being held in quarantine or undergoing a precautionary treatment before entering. Such animals are those zoological specimens not regulated by the USDA. [Table 2](#) summarizes those arthropod pests of livestock that have been introduced into the United States. In some cases, lengthy and expensive eradication programs had to be conducted to ensure that these pests did not become established. Specific examples of some of these introductions are briefly discussed below.

In 1960, the red tick, *Rhipicephalus evertsi*, was discovered at a wild animal compound in Florida (3). This was the first time that this tick had been identified in North America. It was never determined when and how the red tick was introduced into the United States; however, it was probably brought in on eland or zebra imported from Africa. The tick was found as a result of an intensive surveillance campaign by the USDA and the State of Florida during an eradication program of the southern cattle tick, *B. microplus*, in Florida. Many of the wild animals representative of the various species at the compound were inspected to determine the relative abundance of the red ticks. Systematic application of pesticide to the entire compound, lasting for 9 months, was implemented and the tick eradicated.

In 1972, the louse fly, *H. longipennis* (Fig. 55), was identified in California on cheetahs that had been imported from Africa in 1970 (7). Subsequent investigations revealed that the louse fly had also become established at zoological compounds in Georgia, Texas, and Oregon. Although primarily an ectoparasite of wild carnivores, there was concern that *H. longipennis* would become an endemic pest of pet animals, native wildlife, or livestock. As a result, treatments began at the various parks in 1972. However, because of the louse fly's adaptability and the relative ineffectiveness of the pesticides used early in the treatment program, the eradication effort was not successfully completed until 1975. The louse fly was reintroduced in 1983 when bat-eared foxes imported from Africa were found infested with this species at a zoological park in North Carolina. Systematic treatment of the foxes and the area in which they were housed was conducted and the infestation eliminated.

The New World screwworm, *C. hominivorax*, was successfully eradicated from the United States in 1966. Since that time, it has been introduced on five occasions, twice in 1987, once in 1990, and twice in 1997 (in 1988, screwworm larvae were collected from 1 of 45 Argentine polo ponies during quarantine at a USDA quarantine facility; the larvae were removed and both the wound and the quarantine facility were treated with an appropriate pesticide). The 1987 introductions occurred when screwworm larvae were collected from dogs returning to the United States from either South or Central America. In both cases, sterile screwworm flies from Mexico were released around the area where the dogs were located in the United States. In 1990, screwworm larvae were removed from a head wound of a paratrooper who had jumped from a plane into Panama, was injured, and subsequently evacuated to Ft. Sam Houston Military Hospital, San Antonio, TX. Even though climatic conditions were not conducive for establishment, surveillance activities were conducted in the area to ensure that screwworms were not present. The 1997 introductions occurred when dogs returning from Panama were found with infestations of screwworm larvae. In both instances, the infestations were discovered early enough to preclude the release of sterile screwworm flies. However, in both cases, the infested wounds were treated for screwworms, and all conveyances used to transport the dogs and the premises where the dogs were housed were cleaned and disinfected.

In 1997, the African tortoise tick, *Amblyomma marmoreum*, an experimental vector of heartwater, was discovered on the premises of a reptile breeder in central Florida (1). Surveillance data indicated that the infestation was restricted to the one premises. Appropriate actions to eradicate the tick, including treatment of the infested animals and the premises, are under way.

The recent trend towards placing zoological animals in situations that directly expose them to susceptible domestic and native wildlife greatly increases the risk of introducing exotic arthropod pests of livestock. Two introductions of hard ticks serve to emphasize this risk. The first, in 1984, occurred when the bont tick, *A. hebraeum*, a vector of heartwater, was collected from black rhinoceroses imported into the United States from South Africa (17). Some of the infested rhinoceroses were placed on a working cattle ranch in south Texas. The rhinoceroses and premises were systematically treated. After an intensive 6-month surveillance program, it was determined that this tick had not become established in the United States. In the second introduction, other vectors of heartwater, including *A. gemma*, *A. lepidum*, and *A. variegatum*, were introduced into the United States on ostriches imported from Africa in 1989 (10). Like the black rhinoceroses, some of the ostriches were placed in ecological settings favorable for the establishment of exotic ticks, whereas others were placed in situations that directly exposed them to domestic livestock. Premises with the ostriches were placed under quarantine, and the ostriches and premises systematically treated with an acaricide to

eliminate the ticks.

Principles of Exclusion and Eradication

Historically, arthropod pests and their associated diseases have migrated with humanity and their animals. When travel was slow and difficult, and trading in animals and animal products was limited, pests of livestock moved slowly. Moreover, many of these pests were excluded from many parts of the world by natural environmental barriers such as mountains, oceans, deserts, rivers, and unfavorable climates (9). These barriers served to limit the distribution of both the pests and their hosts. Today, however, because of the volume and rapidity of international commerce, these natural barriers are not nearly effective in limiting the distribution of pests as in the past. As a result, strategies have been developed to prevent pests from entering the United States on animals, animal products, or other articles of commerce. Guidelines for eradication of arthropod pests and their associated diseases have also been formulated.

Effective strategies for exclusion or eradication of livestock pests must be based upon detailed knowledge of the pest's biology, host preference, and susceptibility to pesticides. In addition, those factors that limit the pest's distribution and methodologies for its surveillance must also be known. For exclusion efforts to be most effective, knowledge of the avenues by which the pests might enter the United States and become established is also needed. For example, a knowledge of the host preference(s) of ectoparasites such as ticks, helps alert animal health officials in determining the potential for introduction, whereas knowledge that some species of ticks have preferred attachment sites on the host helps focus the attention of the inspector during an examination of animals for ectoparasites.

International cooperation also plays an important role in the exclusion of many pests of livestock. For example, in some situations, inspection of certain animals (including zoo animals) destined for export to the United States and certification that they are free of ectoparasites are two of the requirements that must be met prior to export. In other situations, it may be a requirement of the exporting country to certify that the animals have been treated for ectoparasites within a specified time prior to export. Cooperation of neighboring countries with mutual interests can also play a role in the exclusion or eradication of certain livestock pests. The joint effort by the United States and Mexico in eradicating the New World screwworm from Mexico and Central America is a recent example of such cooperation.

Regulating the import of certain animals, particularly domestic livestock, is the principal means by which livestock pests and their associated diseases are

prevented from entering the United States. Livestock and certain zoological animals are required to remain in quarantine before entering into commerce in the United States. During quarantine, which is usually for a 30-day period, the animals are carefully examined for ectoparasites. The ears, flanks, escutcheon, and other less accessible areas of the host's body as well as the more obvious sites of attachment are carefully examined. With horses and other equines, particular attention is given to the careful examination of the nasal diverticula (false nostrils). If an ectoparasite is found, the animals are treated with an appropriate pesticide. An additional treatment is provided if warranted. Animals are not released from quarantine until they are free of ectoparasites.

When nonregulated animals, particularly zoological specimens, enter the United States without being held in quarantine or given a precautionary treatment with a pesticide before entering, the risk of introducing an arthropod pest of livestock is greatly increased. The risk is minimized for those zoological specimens destined for well-established and well-run zoos or zoological parks or gardens where animals are thoroughly examined and treated, if necessary, for ectoparasites. However, in situations where nonregulated zoological specimens are imported by private individuals and are subsequently sold or traded to others, many of the animals end up being exposed to domestic livestock or native wildlife. The deleteriousness of this practice is exacerbated by the ignorance of the animal owners who are not aware of the potential danger that these animals present to our Nation's livestock industry. When an arthropod pest of livestock is identified from these animals, States cooperate with Federal animal health officials to eradicate the pest. The first action taken by State animal health authorities is to quarantine the premises where the animals are located to prevent further spread of the pest. If the arthropod pest is a known or potential vector of a foreign animal disease, infested animals are observed for clinical signs of the disease. Tracebacks, conducted by Federal authorities, are made of other animals that may have come into contact with the infested animals since their entry into the United States. In some situations, because of the extensive movements of the infested animals from the time they enter the United States and the time the pest is found, tracebacks may become extremely complex and time consuming. If, through the traceback procedure, other premises are found with infested animals, these too are quarantined. Surveillance activities are undertaken on the infested premises and, if appropriate, on adjacent premises as well. Once the extent of infestation is determined, the infested animals and the premises where they are located are systematically treated with pesticides known to be effective against the pest on and off the host. Surveillance activities are continued throughout the quarantine and treatment procedures to ensure the pest is eradicated.

To date, introductions of exotic arthropod pests of livestock have been relatively localized or have involved pests whose spread has primarily been related to the

movement of their hosts (e.g., ticks and louse flies). As a result, activities to eradicate these pests have been relatively inexpensive and of short duration. However, if broad-area introductions were to be made, or if highly mobile pests such as mosquitoes or flies were to be introduced into the United States, eradication could be exceedingly costly and lengthy. In addition, because of increasing environmental concerns, eradication activities involving the widespread use of pesticides may not be sociologically acceptable and may therefore not be feasible.

Summary

Several economically important arthropod pests of livestock in the United States have been introduced. For the most part, these introductions occurred during the time when livestock entered the country without restriction. Now, however, extensive efforts are made to preclude the introduction of exotic arthropod pests of livestock and poultry and arthropod-borne disease vectors. Regulating the import of live animals, particularly domestic livestock, is the principal means by which arthropod pests are prevented from entering the United States. These animals are required to remain in quarantine until it can be determined that they are free of pests and disease.

The greatest risk of introducing pests of livestock and poultry comes from the importation of nonregulated animals — particularly zoological specimens. Such animals can enter the United States without being held in quarantine to ensure that they are free of exotic pests and diseases. When an arthropod pest of livestock or an arthropod-borne disease vector is identified from these animals, State and Federal animal health officials cooperate to eradicate the pest. Depending on the circumstances, these eradication efforts may be expensive and time consuming.

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TABLE 1. Exotic arthropod pests of livestock intercepted at U. S. ports of entry¹

Year	Arthropod species	Animal or product	Suspected or confirmed disease relationship(s) ²
1958	<i>Rhipicephalus pulchellus</i>	Giraffe	NSD
1960	<i>Rhipicephalus evertsi</i>	Zebra	ECF, BB
	<i>R. pulchellus</i>	Zebra	NSD

1961	<i>Dermacentor reticulatus</i>	Oryx	BB
	<i>Rhipicephalus evertsi</i>	Oryx, zebra	ECF, BB
	<i>R. e. mimeticus</i>	Zebra, oryx,	ECF
	<i>R. pulchellus</i>	hartebeest Zebra	NSD
1965	<i>Boophilus decoloratus</i>	Giraffe, hartebeest	BB
	<i>Rhipicephalus evertsi</i>	Eland	ECF, BB
1966	<i>Hyalomma marginatus</i>	Equine	TD
	<i>Rhipicephalus</i>	Zebra	ECF, BB, CD, LI
	<i>appendiculatus</i>	Equine	BB, NSD
	<i>R. bursa</i>	Zebra, antelope	ECF, BB
	<i>R. e. evertsi</i>	Giraffe, zebra, eland	ECF
	<i>R. e. mimeticus</i>	Zebra	NSD
	<i>R. pulchellus</i>		
1967	<i>Rhipicephalus e. evertsi</i>	Zebra	ECF, BB
	<i>R. pulchellus</i>	Zebra	NSD, BB
1968	<i>R. e. evertsi</i>	Zebra	ECF
1969	<i>Amblyomma gemma</i>	Zebra	HW, NSD
	<i>Haemaphysalis longicornis</i>	Equine	BBT
	<i>Hyalomma detritum</i>	Equine	TD
	<i>Rhipicephalus e. evertsi</i>	Zebra	ECF, BB
	<i>R. pulchellus</i>	Zebra	NSD
1970	<i>Amblyomma gemma</i>	Zebra	HW, NSD
	<i>Rhipicephalus evertsi</i>	Zebra	ECF, BB
	<i>R. pulchellus</i>	Zebra	NSD
1971	<i>Rhipicephalus evertsi</i>	Zebra	ECF, BB
	<i>R. e. mimeticus</i>	Zebra	ECF
	<i>R. pulchellus</i>	Zebra	NSD

1972	<i>Rhipicephalus pulchellus</i>	Zebra	NSD
	<i>R. e. mimeticus</i>	Zebra	ECF
	<i>R. evertsi</i>	Zebra	ECF, BB
1973	<i>Boophilus decoloratus</i>	Zebra	BB
	<i>Ixodes ricinus</i>	Donkey	BB, LI
	<i>Rhipicephalus appendiculat</i>	Zebra	ECF, BB, CD, LI
	<i>R. evertsi</i>	Zebra	ECF, BB
	<i>R. pulchellus</i>	Zebra	NSD
1974	<i>Boophilus decoloratus</i>	Zebra	BB
	<i>Rhipicephalus e. evertsi</i>	Gnu, zebra	ECF, BB
	<i>R. e. mimeticus</i>	Gnu	ECF
	<i>R. pulchellus</i>	Zebra	NSD
1975	<i>Rhipicephalus evertsi</i>	Zebra	ECF, BB
1976	<i>Boophilus decoloratus</i>	Zebra	BB
	<i>Rhipicephalus evertsi</i>	Zebra	ECF, BB
1981	<i>Hyalomma margintaum</i>	Cork ³	TD
1982	<i>Haemaphysalis longicornis</i>	Horse	BBT
	<i>Musca vitripennis</i>	Military cargo ⁴	BP
1983	<i>Rhipicephalus compositus</i>	Plant material ⁵	ECF
	<i>R. e. evertsi</i>	Zebra	ECF, BB
	<i>R. e. mimeticus</i>	Zebra	ECF
1984	<i>Hyalomma excavatum</i>	Baggage ⁶	TD
	<i>Rhipicephalus kochi</i>	Cut flowers ⁵	ECF

985	<i>Musca vitripennis</i> <i>Rhipicephalus capensis</i>	Military cargo ⁴ Cut flowers ⁵	BP ECF
1986	<i>Musca vitripennis</i> <i>Hippobosca equine</i>	Military cargo ⁴ Horse	BP NP
1988	<i>Haemaphysalis longicornis</i> <i>Ixodes ricinus</i> <i>Cochliomyia hominivorax</i>	Horse Horse Horse	BBT BB, LI M
1989	<i>Amblyomma gemma</i> <i>A. lepidum</i> <i>A. sparsum</i> <i>A. variegatum</i> <i>Haemaphysalis punctata</i> <i>Hyalomma marginatum</i> <i>rufipes</i> <i>H. truncatum</i> <i>Ixodes ricinus</i>	Ostrich Ostrich Tortoise, rhinoceros Ostrich Ostrich Ostrich, rhinoceros Ostrich Horse	HW, NSD HW HW HW, NSD, BBT, DT BB, BBT TD BB, SS BB, LI
1990	<i>Rhipicephalus e. evertisi</i>	Horse	ECF, BB
1992	<i>Haemaphysalis longicornis</i>	Horse	BBT
1993	<i>Amblyomma variegatum</i>	Cattle	HW, NSD, BBT, DT
1994	<i>Amblyomma hebraeum</i> <i>A. marmoreum</i> <i>A. sparsum</i> <i>A. variegatum</i>	Giraffe Leopard tortoise Monitor lizard Horse, sheep	HW HW HW HW, NSD, BBT, DT
1995	<i>Haemaphysalis longicornis</i> <i>Ixodes ricinus</i> <i>Amblyomma marmoreum</i>	Horse Leopard tortoise	BBT BB, LI HW

1996	<i>Amblyomma marmoreum</i>	Leopard tortoise	HW
1997	<i>Amblyomma marmoreum</i>	Bell's hingeback tortoise	HW
	<i>A. variegatum</i>	Leopard tortoise	
	<i>Haemaphysalis longicornis</i>	Karoo Cape tortoise	HW, NSD, BBT, DT
		Savanna monitor lizard	BBT
		Horse	

¹ Unless otherwise indicated, all collections were from USDA quarantine facilities.

² Abbreviations:

BB=bovine babesiosis

BBT=benign bovine theleriosis

CD=Corridor disease

DT=dermatophilosis

ECF=East Coast fever

HW=heartwater

LI=louping ill

M=myiasis

ND=nuisance pest

NSD=Nairobi sheep disease

SS=sweating sickness

TD=Tropical disease.

³ Collected at Baltimore, MD.

⁴ Two interceptions in 1982; all interceptions of *M. vitripennis* made at McGuire Air Force Base, NJ.

⁵ Collected at JFK airport.

⁶ Collected at Dover, DE.

Table 2. Exotic arthropod pests of livestock detected on premises

Year	Arthropod species	Animal	Locality disease collected	Suspected or confirmed relationship(s) ¹
1960	<i>Rhipicephalus evertsi</i>	Zebra	Florida	ECF, BB
1961	<i>Rhipicephalus evertsi</i>	Zebra	New York	ECF, BB
1962	<i>Amblyomma hebraeum</i>	Rhinoceros	New York	HW
1963	<i>Amblyomma hebraeum</i>	Rhinoceros	New York Oklahoma	HW
1965	<i>Amblyomma gemma</i>	Rhinoceros	Michigan	HW, NSD
	<i>A. tholloni</i>	Elephant	Texas	HW
	<i>A. variegatum</i>	Rhinoceros	Michigan	HW, NSD, BBT,
	<i>Rhipicephalus pulchellus</i>	Rhinoceros	Michigan	DT
	<i>R. simus simus</i>	Rhinoceros	Michigan	NSD ECF
1966	<i>Amblyomma hebraeum</i>	Elephant	Florida	HW
		Rhinoceros	California	
		Rhinoceros	Texas	
1969	<i>Amblyomma sparsum</i>	Boa constrictor	Washington	HW
1970	<i>Amblyomma hebraeum</i>	Rhinoceros	Texas	HW
1971	<i>Amblyomma sparsum</i>	Tortoise	Oregon	HW
1972	<i>Hippobosca longipennis</i>	Cheetah	California	NP
			Texas	
			Oregon	
			Georgia	

1973	<i>Amblyomma hebraeum</i>	Rhinoceros	Virginia	HW
1974	<i>Amblyomma gemma</i>	Rhinoceros	North Carolina	HW, NSD
	<i>A. tholloni</i>	Elephant	Tennessee	HW
	<i>A. variegatum</i>	Rhinoceros	North Carolina	HW, NSD, BBT, DT
	<i>Hyalomma truncatum</i>	Rhinoceros	North Carolina	NSD
	<i>Rhipicephalus pulchellus</i>			
1977	<i>Boophilus microplus</i>	Sloth	New York	BB
1979	<i>Amblyomma variegatum</i>	Kudu	Colorado	HW, NSD, BBT, DT
1980	<i>Amblyomma variegatum</i>	Eland	Colorado	HW, NSD, BBT, DT
1983	<i>Hippobosca longipennis</i>	Bat-eared foxes	North Carolina	NP
1984	<i>Amblyomma hebraeum</i>	Rhinoceros	Texas	HW
1987	<i>Cochliomyia hominivorax</i>	Dog Dog	Colorado Florida Louisiana	M
1989	<i>Amblyomma gemma</i>	Ostrich	Texas	HW, NSD
	<i>A. lepidum</i>	Ostrich	Texas	HW
	<i>A. sparsum</i>	Tortoise	California	HW
	<i>A. variegatum</i>	Ostrich	Texas	HW, NSD, BBT, DT
	<i>Haemaphysalis punctata</i>	Ostrich Pig Ostrich	California Florida Texas	BB
	<i>Hyalomma albiparmatum</i>	Ostrich	Texas	TD
	<i>H. marginatum rufipes</i>	Ostrich Horse	California Indiana California	TD
				BB, LI
	<i>Ixodes ricinus</i>			

1990	<i>Ornithodoros moubata</i>	Tortoise Man	Florida Texas	ASF M
	<i>Cochliomyia hominivorax</i>			
1991	<i>Amblyomma sparsum</i>	Tortoise Leopard	South Carolina Florida	HW HW
	<i>Amblyomma marmoreum</i>	tortoise Dog	Utah Texas	M
	<i>Cochkiomyia hominivorax</i>	Dog		

¹ Abbreviations:

ASF=African swine fever

BB=bovine babesiosis

BBT=benign bovine theileriosis

DT=dermatophilosis

ECF=East Coast fever

HW=heartwater

LI=louping ill

M=myiasis

NP=nuisance pest

NSD=Nairobi sheep disease

TD=tropical disease

APPENDIX 2

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PREPARATION AND SUBMISSION OF SPECIMENS FOR LABORATORY EXAMINATION

Confronting a Suspicious Foreign Animal Disease Case

The capability of a laboratory to confirm the diagnosis of a suspected exotic animal disease is directly related to the types, amounts, and conditions of the specimens submitted. The field diagnostician must select, aseptically procure, and properly preserve specimens for the isolation or demonstration of a causative agent. In addition, an adequate number of specimens must be taken from the appropriate tissues, at the proper stage of the disease, to maximize the chances of isolating the pathogen. The herd or flock owner, private practitioner, and diagnostic laboratory comprise a front-line defense and will, most likely, be confronted with the initial case of an exotic disease. It is vitally important that these people contact the State Veterinarian or Federal Veterinarian in Charge (FVIC) as soon as possible if a foreign animal disease (FAD) is suspected. The State or Federal official will, in turn, assign the suspicious case to a FAD diagnostician for immediate investigation.

A cadre of trained FAD diagnosticians exists throughout the country. These diagnosticians are on call at all times and are trained to investigate suspicious cases of exotic diseases of livestock and poultry. The FAD diagnostician is responsible for collecting and couriering specimens to a reference laboratory such as the National Veterinary Services Laboratories on Plum Island in New York or in Ames, Iowa, for a laboratory assessment.

Speed and efficiency in detecting, reporting, and diagnosing a newly introduced livestock or poultry disease are essential in preventing the disease from becoming widespread in the United States.

When the existence of a FAD is suspected, no animal or specimen should be removed from the premises of origin unless in the custody of an officially designated FAD diagnostician. Animals should not be moved from the premise until a diagnosis is obtained.

Specimen Preparation

The following general suggestions are presented as a guide for preparing diagnostic specimens for submission to a diagnostic laboratory. Developmental studies on new diagnostic procedures are in progress for certain diseases; therefore, it is wise to contact the diagnostic laboratory (see address at end of the appendix) in addition to the State Veterinarian or Federal Veterinarian for information on special handling that may be necessary.

An initial incursion of an exotic disease will, in most cases, only be confirmed in a reference laboratory through the isolation and identification of the etiologic agent. Thus, specimens to be submitted for agent identification should be collected as aseptically and completely as possible.

Disease investigation and specimen collection must be done thoroughly and properly to avoid a return visit and a need to repeat specimen collection and submission, which would only delay the laboratory diagnosis.

Pre necropsy Procedures

1. Obtain and record a complete herd history. Information should be submitted on proper forms (VS 12-27 or APHIS Form 8004) when possible; the following information should be included:

- (a) Name and address of owner.
- (b) Name, address, and phone number of submitter.
- (c) A description of animal: breed, sex, peculiarities, etc.
- (d) Suspected disease or examinations requested, or both.
- (e) Number of animals showing signs and their ages.

(f) Number of animals dead.

(g) Vaccines administered to the animal(s) from which specimens were collected-especially important when examinations for antibodies will be conducted.

(h) Dates of the first losses and of subsequent losses.

(i) The disease signs and their duration.

(j) Ration fed.

(k) The condition of the animal.

(l) A description of the spread of the infection, if in a flock or herd. A diagram of the area is often useful.

(m) Treatment, if any.

(n) Type of housing.

(o) Accessory information; the type of preservative used for specimens.

(p) An epidemiological assessment, including recent movements into and out of the flock or herd.

(q) Any exposures of the affected poultry or livestock to persons having traveled abroad or foreign visitors.

2. Be objective and approach the investigation without a preconceived diagnosis.

3. Be alert to safety hazards in handling livestock and consider zoonotic potentials. As an example, the possibility of rabies as a differential diagnosis should be considered where appropriate.

4. Ensure that prelabeled specimen containers and tubes are available for collection and are scrupulously clean and sterile. The label must include proper identification of the animal and type of specimen.
5. Examine and collect specimens from live animals or poultry in various stages of clinical disease. Serum, vesicular fluid or tissue, or both, swabs of exudates or lesions, or both, can be secured from live animals. Serum from apparently healthy exposed animals or poultry can also be helpful. Animals sampled should be permanently identified because it is possible that convalescent serums or samples will be taken in the future for comparative purposes.
6. Blood smears should be prepared on clean glass slides. A thin blood film should be made, rapidly dried, and fixed in absolute methanol for 5 minutes. Slides having a frosted end should be used and should be identified using a lead pencil.

Unstained films should be protected from dust, insects, and abrasion and should not be refrigerated.

Obtaining Specimens at Necropsy

1. Necropsy and collect specimens from animals that have died and have undergone minimal putrefaction.
2. If it is possible to select several live animals for necropsy, try to select animals in various stages of clinical disease.
3. Be aware of any safety or biological hazards that necropsy might impose on you and the owner. Availability of a proper and safe disposal site should be considered before beginning necropsies.
4. Do not conduct necropsies while wearing street clothes. Wear rubber boots, gloves, overalls, etc., that can be disinfected or that are disposable. A mask and goggles may be used at the discretion of the diagnostician.
5. Prelabeled specimen containers will help ensure that recommended specimens will be collected.
 - (a) Use a label that cannot be easily destroyed. For instance, surgical tape should go entirely around the vial so that it will not be dislodged by moisture.
 - (b) Writing should be with pencil or ink that will not smudge or blur when wet.

(c) Use plastic screw-capped containers instead of glass containers where practical.

(d) Tape the lids of containers. Tape should be wound around the cap in the same direction as the screw-cap is applied.

(e) Use disposable equipment such as cardboard trays, disposable syringes, etc.

6. Have a systematic plan for the necropsy and know what specimens are to be collected before starting the procedure. Be certain to include all lesions for laboratory examination. Body fluids and contents of cysts, abscesses, or skin lesions can be collected using a sterile swab. If an animal is presented for euthanasia, collect all blood samples before euthanizing. If the animal or bird is presented dead, collect blood from the heart. Make blood smears as previously discussed. Ectoparasites should be noted and collected, if pertinent.

The collection of specimens based on species rather than a specific disease will be most useful in providing a diagnosis. The specimens listed in the [Table of Specimen Collection](#) are the minimum recommended and are not intended to replace the field diagnostician's judgment concerning the collection of additional specimens. In addition to the listed specimens, samples of all lesions should be collected for histologic examination. Toxicology-related problems have not been given consideration in these recommendations.

7. Fluid from any enlarged joints should be aspirated aseptically.

8. Any excess body cavity fluids should be collected aseptically via a syringe.

Other Considerations in Specimen Collection

1. Two sets of tissues are to be collected.

a. Fresh tissue for microbiological examination: Any tissue that is to be preserved in a refrigerated or frozen state should be placed in a separate container.

b. Preserved tissue for histological examination: The recommended preservative is 10 percent neutral buffered formalin. All tissues can be placed in one container, but allow no more than 1 volume of tissue to 10 volumes of formalin. Tissues from organs should be cut perpendicularly to the surface to expose their anatomic structure. The specimen should include affected and surrounding normal tissue. To provide adequate fixation, tissues except for the brain, should be sliced no more than 3 to 6 mm thick. Any lymph nodes collected should be incised.

Specimens should not be folded or bent by the container in which they are fixed. Only wide-mouthed containers should be used in this procedure.

2. The initial piece of each organ or lesion should be collected aseptically for microbiology. Tissues for formalin fixation can be collected during the necropsy.

3. Swabs should be sent in appropriate transport medium (e.g., Tris-buffered typtose broth). The laboratory can assist in the procedure for obtaining this media.

4. Materials submitted for possible virus isolation should be obtained from animals that died and have minimal putrefaction and from animals in the early, acute, febrile phase of illness. A reliable overnight delivery service should be used (the laboratory can recommend a service that has been effective in providing this service). Specimens shipped for virology and bacteriology should be shipped refrigerated. If at all possible, the use of dry ice should be avoided because the CO₂ will produce acid conditions that will inactivate many viruses. If there is no way to get the specimens to the laboratory within 48 hours, dry ice must be used. In this case, the specimens must be completely sealed so that there is no contact of the gas emitted by the dry ice with the specimens.

Postnecropsy Considerations

1. Clean and decontaminate instruments.

2. Clean and disinfect all work surfaces and dispose of, or clean and disinfect, personal effects.

3. Record necropsy findings.

4. Dispose of carcasses and body parts so as to avoid exposure of other animals and contamination of environment.

Considerations for Shipping Diagnostic Specimens

Regulations require that diagnostic specimens transported in interstate traffic must be packaged and labeled properly. Improper packaging and labeling of diagnostic specimens and other hazardous materials can result in unnecessary exposure to postal, shipping, and laboratory personnel.

1. The specimens must be in securely closed, watertight primary enclosures such as a screw-cap container or sealed vial. Be certain that exterior surfaces of the primary containers are decontaminated before shipment.
2. Each primary container should be wrapped in sufficient dry absorbent cotton or paper towels to absorb the material in case of breakage. Ideally, the wrapped container should be placed in sealed plastic bags.
3. Pint-, quart-, or half- gallon-sized paint cans should be used as secondary containers. These cans should have friction-type lids and be watertight when hammered closed. The primary container should be padded with more cotton or paper to prevent jarring. A tertiary container, such as a larger-sized version of the secondary container, should be considered if a zoonotic or highly infectious FAD is suspected.
4. The sealed secondary or tertiary container should be placed in a shipping container and again packed with material such as paper. The shipping container should be an insulated box with a lid that can be taped shut. A corrugated shipping box, affixed with the proper labels and shipper's certification, is the final enclosure and contains all other containers.
5. If specimens can be in transit for less than 48 hours, ice packs may be used for cold storage. Frozen "foam ice," "blue ice" picnic packs, or water frozen in sealed containers may be used. Wet ice, even when wrapped in plastic bags, should be avoided to eliminate the possibility of leakage.
6. Dry ice is the only suitable refrigerant to keep specimens frozen. Shippers must be aware of dry ice restrictions imposed by certain airlines and plan accordingly.
7. Regular mail or airmail shipment should not be used when a FAD is suspected. Courier service is the appropriate method of shipment. If FMD is considered as a possible diagnosis, a responsible individual should handcarry the specimen to the reference laboratory.

8. It is not desirable to have the submission form, with the history and other information, within the container. It is preferable to enclose the submission form between the shipping container and the cover of the outside corrugated box.
9. The shipper is responsible for notifying the intended recipient of all information relative to transportation arrangements in order to expedite package pickup and delivery to the laboratory.
10. Care must be taken to ensure that a FAD-suspicious package is only opened within the confines of a biosecure facility.

Reference Laboratory Contacts

1. Foreign Animal Disease Diagnostic Laboratory, P.O. Box 848, Greenport, LI, NY 11944-0848, Phone: (516) 323-2500, Ext. 256.
2. National Veterinary Services Laboratories, P.O. Box 844, Ames, IA 50010, Phone: (515) 239-8266.

L.M. Siegfried, D.V.M., USDA, APHIS, VS. Area Veterinarian in Charge. 2301 N. Cameron St. Rm. #412, Harrisburg, PA 17110

TABLE OF SPECIMEN COLLECTION

SPECIES	TISSUES FOR MICROBIOLOGICAL AND HISTOLOGICAL EXAMINATION	BLOOD SAMPLES	OTHER
Bovine	Skin and nasal swabs, prescapular lymph node (LN), body cavity fluids, joint fluid, liver, kidney, mesenteric LN, lung, heart, tracheal swab, 3" tied-off section of small intestine and ileum (affected area if present), 1/2 brain, any specific lesion	Serum, 20 ml Whole blood, 20 ml (hepanized), 6 Blood smears - air dried, fix in methanol	External parasites (alcohol)

Porcine	Skin swab, fluid from any affected joint, body cavity fluid, spleen, liver, kidney, gastrohepatic and mesenteric LN, lung, tonsil, 3" tied off section of small intestine and colon, 1/2 brain, and any specific lesion	Serum, 10 ml Whole blood, 20 ml (hepanized), 6 blood smears - air dry, fix in methanol	External parasites (alcohol)
Equine	Prescapular LN, mandibular LN, body cavity fluids, spleen, liver, kidney, mesenteric LN, 1/2 brain and any specific lesion. Swabs if contagious equine metritis suspected. Mares - cervical, urethral, clitoral Stallions - penile, sheath, urethral fossa, urethra	Serum, 20 ml Whole blood 20 ml (hepanized), 6 blood smears air dry, fixed in methanol	External parasites (alcohol)
Ovine	Skin and nasal swab, prescapular LN, mammary tissue, body cavity fluids, spleen, liver, kidney, mesenteric LN, lung, mediastinal LN, tracheal and bronchial swabs, 1/2 brain and any specific lesion	Serum, 10 ml Whole blood 10 ml (hepanized), 6 blood smears air dry and fix in methanol	External parasites (alcohol)
Avian	Tracheal and Nasal swabs, liver, spleen, liver, lung, trachea, bone marrow, heart, ovary, brain, intestine, and any specific lesion	Serum, 2 ml, Hepanized terminal blood	External parasites (alcohol)

Vesicular	Vesicular fluid (all that is obtainable), vesicular lesion epithelium, flaps of epithelial tissue, esophageal-pharyngeal fluid (10 ml before dilution with Tris Buffered Tryptose Broth). In addition, if dead—prescapular LN, adrenal, kidney, thyroid, heart, tonsil, mandibular LN	Serum, 10 m
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BACK



Fig. 53. Vectors - Male tropical bont tick, *Amblyomma varigatum*.

BACK



Fig. 54. Vectors - A heavy infestation of the bont tick (*Amblyomma variegatum*) on the dewlap of a cow.

BACK



Fig. 55. Vectors - Adult louse fly, *Hippobosca longipennis*.