Risk Assessment and Recommendations for Participation of Piroplasmosis-Positive Horses in Field Equestrian Events for the 2010 World Equestrian Games at the Kentucky Horse Park

Prepared by:

Equine Event Piroplasmosis Evaluation Group
Veterinary Services
Animal and Plant Health Inspection Service
U.S. Department of Agriculture

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Dr. Gregory Burg, Assistant Professor, University of Kansas, Lawrence, Kansas

Mr. Rusty Ford, Equine Specialist, Kentucky Department of Agriculture

Dr. Angela James, Research Entomologist, CEAH, APHIS, USDA, Fort Collins, Colorado

Dr. Jerome Freier, Research Entomologist, CEAH, APHIS, USDA, Fort Collins, Colorado

Dr. Roxanne Mullaney, Area Veterinarian in Charge, APHIS, USDA, Albany, New York

Mr. John Nicholson, Director KHP, Lexington, Kentucky

Dr. Robert Stout, State Veterinarian, Kentucky Department of Agriculture

Dr. Peter Timoney, Research Scientist and Director, Gluck Equine Research Center, Lexington, Kentucky

Dr. Lee Townsend, Research Entomologist, University of Kentucky, Lexington, Kentucky

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Equine Event Piroplasmosis Evaluation Group Members

Chair, Dr. Freeda Isaac, Senior Staff Veterinarian, National Center for Import and Export, Veterinary Services, Riverdale, Maryland

Dr. Barbara A. Bischoff, Area Veterinarian in Charge, Frankfort, Kentucky

Dr. Timothy R. Cordes, Senior Staff Veterinarian and National Manager for Equine Programs, National Center for Animal Health Programs, Veterinary Services, Riverdale, Maryland

Dr. Joseph Corn, Wildlife Biologist, Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, Athens, Georgia

Ms. Yashika N, Forrester, Risk Analyst, Policy and Program Development, Risk Analysis Systems, Riverdale, Maryland

Dr. Glen I. Garris, Chief of Staff, Emergency Management and Diagnostics, Riverdale, Maryland

Dr. Eric Grant, Agricultural Engineer, Policy and Program Development, Risk Analysis Systems, Riverdale, Maryland

Dr. Donald P. Knowles, Research Scientist, Agricultural Research Service, Pullman, Washington

Ms. Dorothy Roe, Writer-Editor, National Animal Health Policy and Programs, Riverdale, Maryland

Dr. Glen Scoles, Research Entomologist, Agricultural Research Service, Pullman, Washington

Executive Summary

The Kentucky Horse Park's (KHP) bid to hold the 2010 World Equestrian Games (WEG) in the KHP depends on the U.S. Department of Agriculture's (USDA) approval of the participation of horses positive for piroplasmosis (a tick-borne disease) in field events. The United States has previously granted waivers to horses found positive for equine piroplasmosis (EP) to enter the United States for competitions such as the 1984 Olympics and the 1996 Summer Olympic Games. Because EP is not endemic in the United States and waivers for previous events excluded all field events, the USDA faces a unique challenge. Moreover, if the bid is granted to KHP, this would be the first time the WEG will be held in the United States or outside of Europe. Therefore, the Equine Event Piroplasmosis Evaluation Group (EEPEG) of USDA experts in piroplasmosis, tick and wildlife biology, risk analysis, international equestrian competitions, and U.S. importation requirements have carefully assessed the risk of ticks infected with piroplasmosis transmitting the disease to susceptible horses at the 2010 WEG.

For previous events, both in the United States and Australia, risk analyses examined issues associated with cross country or the marathon phase of 3-day eventing and excluded EP-positive horses from participating in events with prolonged exposure to vegetation and opportunity for tick attachment. In consideration of this request, the group has examined the occurrence of ticks in Kentucky and the results of a 2002 survey of the KHP conducted in the summer months. The survey indicated a low prevalence of American dog ticks, which are competent vectors of EP, leading the Kentucky State Veterinarian, the American Horse Council, the American Association of Equine Practitioners, and the Kentucky Thoroughbred Association to support the participation of piropositive horses in the field events, under adequate surveillance and monitoring protocols. Overall, the group agreed that the study indicates a low prevalence but recommends additional surveys during the fall months when the WEG will be held.

In addition, the group conducted a site visit to the KHP, a large park area with grounds that have been highly managed for decades making it a unique venue for such an event. The short grass found in the fields and pastures is not characteristic for most areas where horse events would typically occur, thus offering an advantage for tick control. The adjacent farms and pastures also follow the same type of landscaping, making the vegetation management for tick mitigation strategies much easier to fulfill.

The conclusion of the risk analysis was that the possibility of one or more susceptible horses becoming positive for piroplasmosis resulting from the 2010 WEG could be as low as 0.00014 percent (1 in 1,000,000 horses), or as high as 0.0088 percent (9 in 100,000 horses), but is most likely 0.00065 percent (7 in 1,000,000 horses). This broad range is attributable to many variables and tells us that the more effective the tick mitigations and controls, the lower the risk of susceptible horses becoming infected.

To effectively address the potential risk factors for tick incursions onto the KHP grounds and competition courses, the group recommended requirements for tick control including general long-term strategies, preparation of the venue for the games, tick control for horses, and security. Tick experts should work with the KHP to develop a site plan for the field events. Tick surveys should then be conducted along the proposed event courses to determine the need for additional control measures. These strategies are recommended to minimize the risk of introduction of piroplasmosis infection into the local tick population of Kentucky and decrease the risk of infection from EP-infected horses to susceptible horses.

Based on the data and information presented in this paper, the EEPEG recommends that EP-positive horses be allowed to participate in the field events of the 2010 WEG, if the WEG are awarded to the KHP, provided that tick control measures discussed in this document are fully implemented. These strategies should form the basis of an action and tick control plan that can be developed by all parties involved in the planning and execution of the WEG in Kentucky. The USDA, State of Kentucky, American Horse Council, and Fédération Equestre Internationale representatives will work cooperatively to develop and refine a tick control program that will promote the competition at the games as well as prevent piroplasmosis from being introduced into the United States.

Introduction

In September 2004, representatives of the Kentucky Horse Park (KHP) asked the U.S. Department of Agriculture (USDA) to allow horses positive to equine piroplasmosis (EP), a tick-borne disease, to compete in field events of the Sixth World Equestrian Games (WEG) in October 2010. These equine games have seven disciplines: dressage, eventing, endurance, jumping, driving, vaulting, and reining. Three of the disciplines—eventing, endurance, and driving—require field venues or courses. The KHP along with the State of Kentucky has submitted a proposal to the Fédération Equestre Internationale (FEI) to win the bid for these games. The FEI governs the sport horse federations of each country. A major concern for an equestrian event of this magnitude in the United States is that EP is not endemic in the United States as it is in European countries that have hosted the WEG in the past. Because all WEG have been held in Europe, the KHP and State of Kentucky bid for the Sixth WEG is a unique undertaking for all involved in the planning and execution of these games. USDA's approval of this request is required for Kentucky's eligibility to win the bid for the 2010 WEG.

Background

Equine Babesiosis (Piroplasmosis)

Equine piroplasmosis (EP) is a tick-borne disease. The etiologic agents of EP, *Babesia caballi* and *B. equi*, are protozoan parasites with complex life cycles that include obligate sexual stages in the guts of their tick vectors. Consequently, only ticks that are competent vectors (ticks that are capable of supporting the development of the parasite) biologically transmit these parasites. During blood feeding, infected red blood cells enter the gut of the tick where the parasites differentiate into micro and macrogametes. Fusion of gametes occurs in the lumen of the tick midgut, resulting in the formation of zygotes. The zygotes transform into the mobile ookinete stage, which then penetrates the gut wall and migrates to the salivary glands (*B. equi*) or the ovaries (*B. caballi*). In the salivary glands, *B. equi* replicates to form the infectious sporozoites, which are transmitted in the saliva when the ticks take a subsequent blood meal. In the ovaries, *B. caballi* invades the eggs and is subsequently transmitted to the offspring; larval ticks transmit sporozoites in their saliva when they take their first blood meal.

When these organisms invade and destroy red blood cells, they cause fever, anemia, icterus, hemoglobinuria, central nervous system disturbances, and sometimes death in their host. In the acute phase, some infected animals are affected less severely and may exhibit little or no clinical signs with no indications of decreased performance. Those that survive infection in the acute phase may carry the parasites for prolonged periods during which they are potential sources of infection to other horses via tick-borne transmission or mechanical transfer by biting ticks, needles, or surgical instruments. Immunogenetics of the horse, the virulence of the infecting strain, the tick burden, the tick infection rate, and the challenge dose are factors impacting disease expression and possibly transmission.

EP is endemic in many countries, but with the exception of Puerto Rico and the U.S. Virgin Islands, is not endemic in the United States. The United States has not had evidence of clinical disease since August 1961. Because the horse population within the continental United States is presumed to be entirely susceptible to infection, safeguards against the entry and dissemination of piroplasmosis continue. The United States has adopted the strategy of preventing EP-infected horses from entering based on finding anti-*B. caballi* and anti-*B. equi* antibodies in horses presented for importation. In addition, U.S. horses that are infected while residing in other countries are restricted from re-entry into the United States.

Currently, the competitive enzyme-linked immunosorbent assay (cELISA) is the test required for importation of horses into the United States for piroplasmosis. The previous test was the complement-fixation test (CFT). This test lacked sensitivity because the equine immunoglobulin isotype IgG(T) that develops in the chronic phase of infection does not fix complement via the classic pathway. Therefore, its past use allowed positive horses to enter the United States; this deficiency in the CFT test led to the need for development of the cELISA test. The cELISA is based on monoclonal antibodies to immunodominant surface proteins of each parasite and uses recombinant antigen produced in *Escherichia coli.*

Data indicate that EP could be transmitted in the United States through several tick species: *Dermacentor (Anocentor) nitens*, *D. albipictus*, *D. variabilis*, and *Boophilus microplus* (Stiller and Coan 1995; Stiller et al., 2002). The U.S. cattle fever tick program guards against the reestablishment of *B. microplus* north of Mexico through surveillance and acaricide application. Vector control through use of acaricides is a viable part of an EP control program, but acaricide resistance is an emerging concern. *D. nitens* is known to transmit *Babesia* species in dogs, and its ability to transmit in equines has been established. However, *D. nitens* is confined to the southern most parts of Florida and Texas thus would not be a concern for Kentucky.

Previous USDA Piroplasmosis Waivers for Major Events

For horses to permanently enter the United States, USDA requires negative tests for EP, along with equine infectious anemia, dourine, and glanders. However, on a case-by-case basis, we have waived EP requirements for horses entering temporarily for shows and competitions, under cooperative service agreements. Event sponsors assumed regulatory oversight, and the following conditions were met (Brooks):

- Horses arrived for the event on a strict schedule and left promptly.
- Local factors ensured negligible risk to indigenous horse and tick vector populations.
- Facilities were adequate for scheduled events and required regulatory oversight.
- The waiver was agreed to by local and State animal health regulatory officials.
- It was safe and feasible to apply necessary regulatory actions.
- Appropriate tick control and disease prevention measures could be performed.
- Event sponsors provided resources for special oversight needed.

In the 1984 Olympics in Los Angeles, California, an EP waiver was extended for horses participating in the stadium jumping and dressage event, but not for the 3-day eventing competition, one phase of which takes place in the field. In the 1996 Olympic Games in Atlanta, Georgia, USDA granted a similar waiver. A risk analysis concluded that although there was a very low risk for transmission of piroplasmosis from infected horses to uninfected horses during the stadium Olympic Games equestrian events, there still existed a risk of local tick populations acquiring infection from infected horses in the field events.

For the 1996 Summer Olympics equestrian competitions, USDA assessed the risk associated with permitting the participation of horses with a positive reaction to the CFT for EP (Amen and Garris). The risk of introducing the etiologic agents of EP into indigenous ticks and establishing potential sources of infection for a susceptible population of horses was assessed by estimates using existing mathematical models. Three scenarios were considered. It was assumed that *D. variabilis*, the American dog tick, which is a competent vector of EP in laboratory tests, would be actively seeking hosts during the Olympic Games. At the Olympic site in Conyers near Atlanta, estimated population densities of 1,302-3,302 ticks per hectare would be expected during July.

In scenario I, it was estimated that 5 to 9 percent of the 255 participating horses would be EP infected. For this scenario, no tick control measures were implemented. In scenario II, 1 or 2 of the 255 horses scheduled to compete were assumed to be EP-infected horses undetected by the CFT; no tick control measures were implemented. The criteria established for scenario I was repeated for scenario III; except that in scenario III, a series of mitigating measures including tick control were introduced to reduce the risk of establishment of the EP organism.

The analysis showed that *B. caballi* and *B. equi*, causative agents of EP, can become established in a local tick population. A number of factors were identified by the analysis process that significantly affected the risk associated with the introduction of horses CFT-positive for EP. It was concluded that (Amen and Garris):

- The longer a local population of ticks is exposed to CFT-positive horses, the greater the risk of establishment of the disease. Because a larger number of ticks per hectare are found in Georgia during April, May, and June than during July, introduction of CFT-positive horses during these months increases the risk of establishment of the disease.
- In the absence of serologic screening, tick control measures are effective in reducing the risk of introduction of EP into a susceptible horse population, and serologic screening combined with tick control is likely to be more successful in prevention than either measure used alone.
- Although the risks during the Olympics of interstadial (nymphal acquisition and adult transmission) transmission appeared low, the introduction of EP into the local tick-vector population, the potential for transovarial transmission in the ticks, and subsequent transmission by infected larvae to susceptible animals were major concerns.

Based on this analysis, the Georgia Department of Agriculture (GDA) and the USDA approved the participation of EP horses in stadium events such as dressage and jumping, but not in the 3-day eventing competition, one phase of which takes place in the field. The GDA and USDA developed the Piroplasmosis Control Program (Brooks). The Georgia International Horse Park (GIHP), with a 150-acre core and 1,300 acres of surrounding woods in Conyers, served as the equine venue for the 1996 Summer Olympics. Primary safeguards in the program involved the environmental management of ticks. Controls included spraying the entire GIHP core and all stable areas with an approved acaricide. Critical areas of the GIHP, including the Piroplasmosis Restricted Area (PRA), the warm-up and holding areas, and the competition areas received additional treatment before the Olympic equestrian events began.

Secondary tick controls were implemented for horses testing positive to EP by keeping them in the PRA thus significantly reducing the potential of tick exposure. This area was devoid of vegetation, and the removal of infected horses from the PRA was allowed only for warm up just before competition. Acaricide shampoos were applied to horses on a daily basis. The number of infected horses was limited to 20 to allow for effective planning and management of the control measures. Infected horses were allowed entry into the GIHP no sooner than July 1, 1996, and were required to be exported by August 7, 1996, allowing ample time for pre-competition acclimation and post-competition recovery (Brooks).

Secondary environmental safeguards targeted indirect vector controls. These safeguards included a fence around the 150-acre GIHP core to prevent the entry of wildlife and an effective rodent control program to ensure that small tick-carrying rodents would not gain access. Pets were restricted from the GIHP because dogs serve as a primary host of *D. variabilis*. All horses entering the venue were inspected for ticks prior to official entry and while in the GIHP. All hay used in the GIHP was procured from non-tick infested areas, and bedding was either of material not conducive to harboring ticks (shredded paper or fresh shavings), or was inspected visually for ticks by regulatory officials (straw). Access of personnel was limited to ensure the safeguards and reduce the possibility of attached ticks (Brooks).

Procedures were included in the program to monitor the effectiveness of the safeguards. Two sentinel horses were used as controls to monitor the status of tick infestation on the GIHP and to ensure that they remained negative for piroplasmosis. One horse was housed with EP-positive horses beginning with their arrival in the PRA. The second sentinel was stabled with the remaining non-infected horses. Environmental and wildlife tick surveillance was conducted to identify ticks discovered in adjacent areas and to ensure that ticks did not gain access to infected horses (Brooks).

2000 Olympics in Sydney, Australia

The participation of horses positive for piroplasmosis was evaluated for the 2000 Olympics in Sydney, Australia. Through various tick surveys and risk analyses, the Australian Quarantine and Inspection Service (AQIS) determined the risk of establishing EP from the temporary importing of serologically positive horses would be negligible (OIE 2003). The scientific literature conveyed that there were no known tick vectors for *B. caballi* in Australia. The two known potential tick vectors of *B. equi* in Australia are *B. microplus* and *Rhipicephalus sanguineus*, which were found in the northern and southern territories, respectively. It was determined that seropositive horses could compete in international competitions such as dressage, show jumping, eventing, and races in exhibitions but not in events that allowed prolonged exposure to vegetation and opportunity for tick attachment such as endurance rides and driving events that involve a marathon phase (AQIS 1999).

The Sydney International Equestrian Center Horsley Park (SIEC), with 80 hectares of scrubland, was selected for the Olympic equestrian event and post-arrival quarantine. Tick surveys in 1997-1999 found no tick species that might be implicated in spreading piroplasmosis. The SIEC consisted of two quarantine zones. The main quarantine zone surrounded the stables zone to include the dressage, show jumping arena, and the training tracks. The stables zone included the main stable block, overflow stables, piroplasmosis separation stables, and farriers compound. A 200 meter horse-free zone surrounded the quarantine zone (OIE 2003).

Through advance inspections, AQIS established 25 pre-export quarantine (PEQ) zones throughout Europe and the United States that were supervised by AQIS officials. Horses entered these PEQ zones for a minimum of 14 days isolation from other horses and were tested for equine infectious anemia and piroplasmosis. They were also inspected and treated for ticks (OIE 2003).

The horses arrived in Sydney in late August and departed in early October. Of the 239 horses imported into Australia for the Olympic Games, 15 tested positive for piroplasmosis. Upon arrival in Sydney, horses were quarantined for 2 weeks in the SIEC and were closely monitored. The overflow stables and the piroplasmosis separation stables had separate entrances and exits. Amenities and decontamination procedures included a checkpoint in the main stables zone where people arriving were issued protective clothing, stables access passes, and identification wristbands that were color coded to allow appropriate entry (OIE 2003).

The 15 piroplasmosis-positive horses were housed in a separate section for additional quarantine and management control throughout their stay. Twenty seronegative competitors were also housed in this section as companion animals. All horses in the piroplasmosis stables were closely observed for the presence of ticks and were sprayed with Bayticol 1:1000 on four occasions. Entry restrictions for the piroplasmosis stables remained during the competition period. The 15 seropositive horses competed in show jumping, dressage, and eventing (OIE 2003).

The World Equestrian Games

The WEG are distinctly different from the Olympic Games. The International Olympic Committee (IOC) of the Summer Olympic Games hosts and recognizes only four equestrian disciplines (dressage, show jumping, eventing, and reining) as a small portion of the much larger games. Newly adopted IOC policy limits the total number of competition horses to approximately 240. The equine competitions are routinely held in venues that are far away from the Olympic Village. Olympic horses may be seen in the opening ceremonies at the Olympic Village. Stabling, schooling, training, and competition occur at a different location.

In contrast, the WEG are the definitive world championship for equestrianism hosted by the FEI. Historically, the WEG have been held every 4 years (alternate Summer Olympic years) in Europe with six recognized disciplines (dressage, show jumping, eventing, endurance riding/racing, vaulting, and driving). In 2002, reining was included as the seventh sport of the competition. A complex scoring system qualifies riders through specifically designated qualifying events for the WEG. For example, specific Nation's Cup and Grand Prix competitions for show jumpers are qualifying events. All events of the WEG occur at one location and have been held in Europe at the following locations:

- Stockholm, Sweden (1990)
- Den Haag, Netherlands (1994)
- Rome, Italy (1998)
- Jerez de la Frontera, Spain (2002)

The Fifth WEG in 2006 will be held in Aachen, Germany, and should include approximately 800 athletes and 900 horses. The FEI has predicted that horses competing in the Sixth WEG will not differ substantially in numbers, discipline, and country from those in the Fifth WEG.

Ticks in Kentucky and Tick Survey of the Kentucky Horse Park

A review of databases provided by the USDA, Animal and Plant Health Inspection Service's (APHIS) National Veterinary Services Laboratories (NVSL) and Centers for Epidemiology and Animal Health as well as the Southeastern Cooperative Wildlife Disease Study provided documentation of 12 species of ticks in Kentucky (*Ixodes woodi, I. texanus, I. scapularis, I. kingi, I. dentatus, I. cookei, Amblyomma maculatum, A. americanum, D. variabilis, D. albipictus, R. sanguineus, and Haemaphysalis leporispalustris*). Additional tick species (*I. angustus, I. baergi, I. banksi, I. brunneus, I. marzi,* and *I. muris*) have distributions that may include Kentucky, but confirmation of their presence was not found (Keirans and Litwak 1989). Of the tick species reported for the region, six (*I. scapularis, A. maculatum, A. americanum, D. variabilis, D. albipictus,* and *R. sanguineus*) have at least occasionally been reported from livestock and wild cervids.

The KHP was surveyed for ticks during 2002 (Townsend 2002). These surveys were conducted using tick flags and tick traps from May 28-August 16. The surveys were fairly extensive and included attempts to collect ticks in most habitats present at the site. Specimens of the American dog tick (*D. variabilis*) were collected May 31-July 17.

These results are consistent with what would be expected for this area; however, surveys were not conducted during September and October when the WEG would be held. In addition, only tick flags and tick drags were used. These are standard methods for collection of ticks, but these methods are limited in terms of what species and life stages of ticks may be collected. A comprehensive survey for ticks at this site would include tick flags, tick traps, and surveillance of wildlife.

Only two of the tick species that might be present, *D. variabilis* and *D. albipictus*, are known to be competent vectors of *B. equi* or *B. caballi* (Stiller and Coan 1995; Stiller et al., 2002). The vector competence of the other tick species present has not been evaluated for either of these parasites. However, *I. scapularis* has been shown to be a competent vector of *Babesia* species infecting rodents and deer. *R. sanguineus* and African species of *Haemaphysalis* are known to transmit *Babesia* species infecting dogs and *Theileria* species infecting sheep and cattle.

D. variabilis has been shown to transmit *B. caballi* transovarially and *B. equi* intrastadially. Larvae and nymphs of this tick feed on small mammals while adults feed on large mammals including horses, deer, and dogs (Allan 2001). In the Bluegrass Region of Kentucky, adults of *D. variabilis* are active April-August (Burg 2001).

D. albipictus has been shown to transmit *B. caballi* transovarially; its vector competence for *B. equi* is not known. This is a single-host tick that feeds primarily on cervids but may also be found on livestock including horses (Allan 2001). *D. albipictus* generally is active late fall through early spring. However, this species has been found feeding on elk in periodic surveys conducted in eastern Kentucky during January, March, April, June, July, August, October, November, and December (Corn).

Kentucky Horse Park Site Visit

A site visit to the KHP was conducted on April 21, 2005, to collect information on the events and potential uses of the KHP by horses during the 2010 WEG and to evaluate the grounds, facilities, and neighboring lands. The KHP is located in Lexington, Kentucky, on 1,200 acres. The KHP includes barns containing 1,100 permanent horse stalls, 3 outdoor stadiums, 3 outdoor show rings, 5 dressage areas, a covered arena, a planned indoor arena, 7 warm-up rings, a cross country/marathon course, 4 polo fields, a steeplechase course, a trade fair area, a museum, offices, roads, parking lots, and storage buildings. There are 200 resident horses at the park at any given time.

The KHP grounds are highly maintained and appear to be frequently mowed or grazed. Pastures where the eventing and driving course would be located have short grass. Individual trees are present but sparse. The areas around the trees and the fence lines are devoid of vegetation other than the short grass. However, a small number of wood rows, wooded areas, and ponds are present and provide limited habitat for wildlife and may be a source of ticks.

Proposed 2010 WEG stadium events such as dressage, show jumping, reining, and vaulting would take place in indoor and outdoor arenas located near the barns. The eventing and driving competitions would take place within the grounds of the KHP and follow a course outline similar to that of the annual Rolex Kentucky 3-day event. All routes of movement for horses from the barns to event locations would be separated from the public and be in fenced walkways.

Three sites adjacent to the KHP are proposed for inclusion in the 100-mile endurance course, configured as a clover leaf with five veterinary checkpoints on the grounds of the KHP. Two of the proposed sites are adjacent horse farms, and the other is a pasture owned by the University of Kentucky. Landscaping of the adjacent horse farms is similar to that of the KHP—highly managed pastures with minimal vegetation. At the time of our visit, the University of Kentucky pasture had not recently been mowed and was a mixture of grasses and forbs. The vegetation was not dense or tall, and fence lines and tree lines were relatively clean of underbrush.

The larger barns each contain 50 stalls and are surrounded by pavement. Currently, there are no plans to have turnout areas or paddocks available for the WEG horses due to the large numbers of horses that will be present. Security as required by FEI rules would be strict and would limit access of personnel to horses in the barn areas. The stalls are 10 feet by 10 feet and have concrete flooring and wooden walls. Rodent management consists of cats being kept at the barns, and rodents are not considered a problem. Raccoon traps are set as needed. Stalls typically are bedded with wood shavings or straw. Timothy hay is usually sourced from Canada or Oregon.

Risk Analysis

Under Title 9, *Code of Federal Regulations*, section 93.308, equine species entering the United States will be tested for dourine, glanders, EP, and equine infectious anemia while in post-entry quarantine. An animal testing positive for any of these diseases is not permitted to enter the United States. The United States has previously granted waivers to horses found positive for EP to enter the United States for competitions such as the 1984 Olympics in Los Angeles, California, and the 1996 Summer Olympics Games in Atlanta, Georgia. The official test for EP is the cELISA, and the official laboratory designated to perform these tests is the NVSL. If the United States allows participation in field events of horses testing positive on the cELISA for EP for the 2010 WEG, the regulatory question is: What is the likelihood that ticks infected with piroplasmosis will transmit the disease to susceptible horses at the 2010 WEG?

Among the 12 Ixodid species of ticks found in Kentucky, *D. variabilis* and *D. albipictus* are known to be competent vectors of EP. The United States does not have clinical disease of piroplasmosis and, with the exception of Puerto Rico and the U.S. Virgin Islands, is not considered to be endemic for EP. This analysis addresses the likelihood of at least one susceptible horse becoming infected with piroplasmosis at the WEG 2010 from tick to horse transmission.

Components Required for Transmission of Piroplasmosis

The traditional epidemiological triangle (Figure 1) denotes the three components required for transmission of piroplasmosis to negative horses in this analysis. In the absence of any component, transmission is not possible.

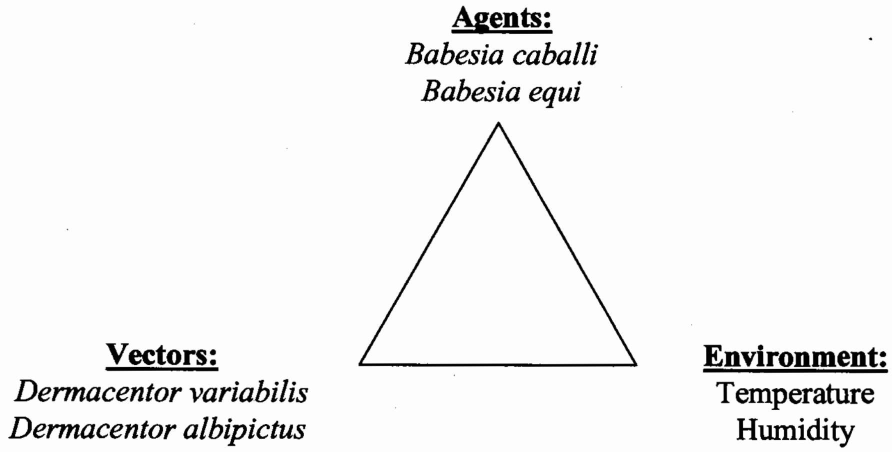

Figure 1: Epidemiological Triangle Illustrates the Components Needed to Facilitate the Spread of Piroplasmosis

Agent

Equine babesiosis (piroplasmosis) is a disease of equids in many regions of the world. The central concern is the risk and consequences of entry of these parasites through international movement of horses into the continental United States. The horse population within the continental United States is presumed to be entirely susceptible to infection. Therefore management safeguards against the entry and dissemination of piroplasmosis continue.

As discussed above under Background, EP is a tick-borne disease. The etiologic agents of EP are the protozoan parasites *B. equi* and *B. caballi*. Only ticks that are capable of supporting the development of the parasite can biologically transmit these parasites. When ticks transmit these parasites to their equine hosts, these parasites invade and destroy red blood cells causing fever, anemia, icterus, hemoglobinuria, central nervous system disturbances, and (depending on the virulence of the strain) death. In the acute phase, some infected animals are affected less severely and may exhibit little or no clinical signs. Horses that survive acute infection may carry the parasites for prolonged periods during which they are potential sources of infection to other horses via tick-borne transmission or mechanical transfer by biting insects, needles, or surgical instruments.

Environment

The environment can play a key role in transmission of the agents of equine babesiosis through its effect on tick development, survival, fecundity, host seeking activity, etc. For both *D. variabilis* and *D. albipictus*, environmental factors primarily influence portions of the life cycle that take place off of the host (i.e., host finding, molting, egg laying, etc.).

Mount and Haile (1989) have summarized the work of several different authors on the effects of environmental variables on various life stages of *D. variabilis*. The developmental temperature threshold for all tick stages is 9-10° C; below this temperature, eggs will not progress toward hatching, ticks will not molt, etc. At an optimum average pre-oviposition temperature of 25° C, each female tick will produce more than 4,500 eggs; at less optimum temperatures, fewer eggs will be laid (e.g. ≈ 1,800 at 15° C, ≈ 1,700 at 36° C). Weekly survival rates of ticks off of the host at optimum temperatures and humidity are above 90 percent for all tick life stages. On average, survival of all life stages is highest in "forest" and "ecotome" habitats and lowest in "meadow" habitats. Younger ticks (i.e., larvae and nymphs < 40 weeks, adults < 60 weeks of age) have the highest survival; older ticks have lower survival rates. Reductions in temperature and humidity result in reductions in off host tick survival; temperatures above about 25° C also reduce survival, but not to the same extent as low temperatures.

On host survival of *D. variabilis* is most affected by density (i.e., it is density dependent), which is mediated by host resistance to ticks (i.e., the more ticks there are on a host, the higher the level of anti-tick immunity; this results in reduced feeding success, leading to mortality). Host suitability is also a factor (i.e., preferred host = higher survival). Rates of host finding are also affected by temperature, with lower host finding success at lower temperatures. Humidity and photoperiod also influence host finding, but the full effects of these environmental factors on acquisition of hosts remain largely undefined.

Although its biology is similar in many respects to that of *D. variabilis* (because the two species are relatively closely related), much less is known about the effects of the environment on *D. albipictus*. However, the one-host life cycle of this species would make it less vulnerable to off host environmental factors that affect host finding of nymphs and adults, and molting of fed larva and nymphs in *D. variabilis*.

Vector

D. albipictus has a very different seasonal activity pattern than does *D. variabilis*. *D. albipictus* is called the winter tick because it primarily parasitizes its hosts during the winter months. Larval ticks begin host seeking in the fall. They parasitize primarily large animal hosts, and once they acquire a host, they remain on that host (thus the term "one-host-tick"). They feed as larvae, then nymphs, and finally as adults through the winter, not leaving the host until they are fully engorged. In the late winter or early spring, engorged females drop off and lay their eggs. The eggs hatch; then the larvae remain quiescent through the summer and complete the cycle by beginning host seeking the following fall. So, with this species, transmission has to be either transovarial (transmission by larvae that come from females fed on an infected host) or intrastadial (i.e., male acquisition, then transmission when infected males move from host to host as they seek females to mate). This requires hosts to be in contact with one another. *D. albipictus* has been shown to transmit *B. caballi* transovarially. Its vector competence for *B. equi* is not known.

In contrast, the seasonality of *D. variabilis*, a three-host tick, varies from region to region, but the larvae and nymphs will generally be host seeking in the summer through the fall. However, larvae and nymphs primarily seek small animal hosts (i.e., rodents) and are rarely seen or collected by humans. Adult ticks, the stage most frequently seen by humans, seek larger animals as hosts (i.e., predominantly dogs, although they are often found feeding on larger animals including humans, cattle, and horses). The adults of this species are active in the late spring through the early summer, with a smaller portion of the population remaining active into the late summer. Adults are rarely seen in the fall. The greatest risk of transmission by this species would be either transstadial (= interstadial, nymphal acquisition followed by adult transmission) or intrastadial (male transmission, as described above), again animal-to-animal contact if male ticks were to move from one horse to another. (Note: intrastadial transmission of *B. equi* by *D. variabilis* has been demonstrated [Stiller et al., 2002].) In summary, the following are the relevant factors for this analysis:

1) *D. albipictus* larvae are active in September and October.
2) *D. variabilis* larvae and possibly nymphs might be active in September and October, but they are only seeking small animal hosts. Adults would not be active at this time.
3) Transovarial transmission of *B. caballi* has been demonstrated for both *D. albipictus* and *D. variabilis*. The real risk may not be immediate transmission, but delayed transmission by larvae of adults that feed on infected horses. This risk could accrue to American horses months after competition horses have been exported back to their countries of origin.

The System

The scenario tree in Figure 2 represents an overview of the system being analyzed. The analysis begins with the initiating event of imported piroplasmosis-positive horses entering ports en route to the WEG 2010 games, and ends with the possibility of susceptible horses becoming infected with piroplasmosis. The nodes represented by parameters P1, P2, P3, and P4 denote critical piroplasmosis mitigation points.

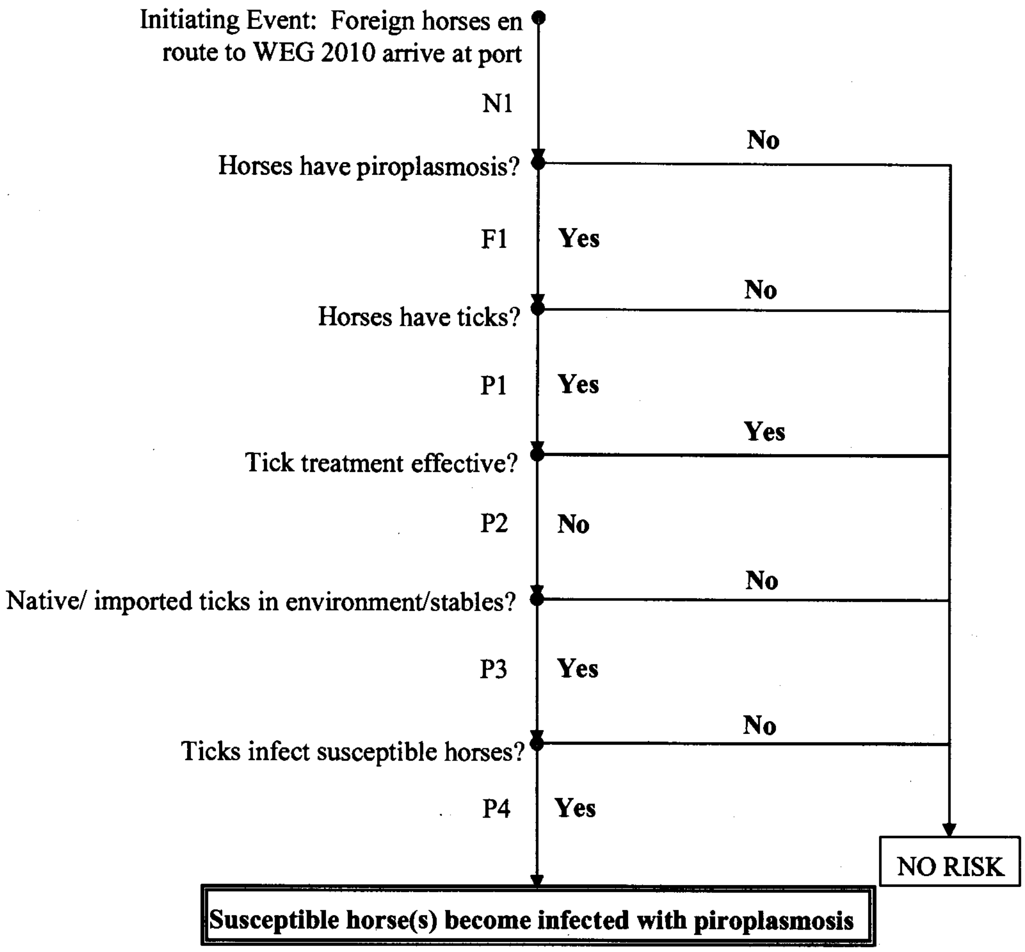

Figure 2: Scenario Tree Illustrating the Primary Events Necessary for Susceptible Horses During the 2010 WEG To Become Infected with Piroplasmosis

Model Assumptions

- Of the 12 Ixodid species of ticks in Kentucky, *D. variabilis* and *D. albipictus* are known competent vectors of piroplasmosis.
- Animals such as rodents, deer, and dogs are negligible vectors in the spread of piroplasmosis from imported horses to negative horses at the 2010 WEG.
- One tick infected with piroplasmosis, which feeds on a horse, will cause disease transmission.
- *D. variabilis* larvae and *D. albipictus* larvae and nymphs are potentially active during September and October. Therefore, all developmental stages of ticks are considered vectors.
- Transovarial transmission of *B. caballi* is possible in *D. variabilis* and *D. albipictus*.

Mathematical Model

The following section describes each basic model parameter (Figure 3) along with dependent variables, dimensional analysis, and various probabilistic outputs.

MODEL PARAMETERS

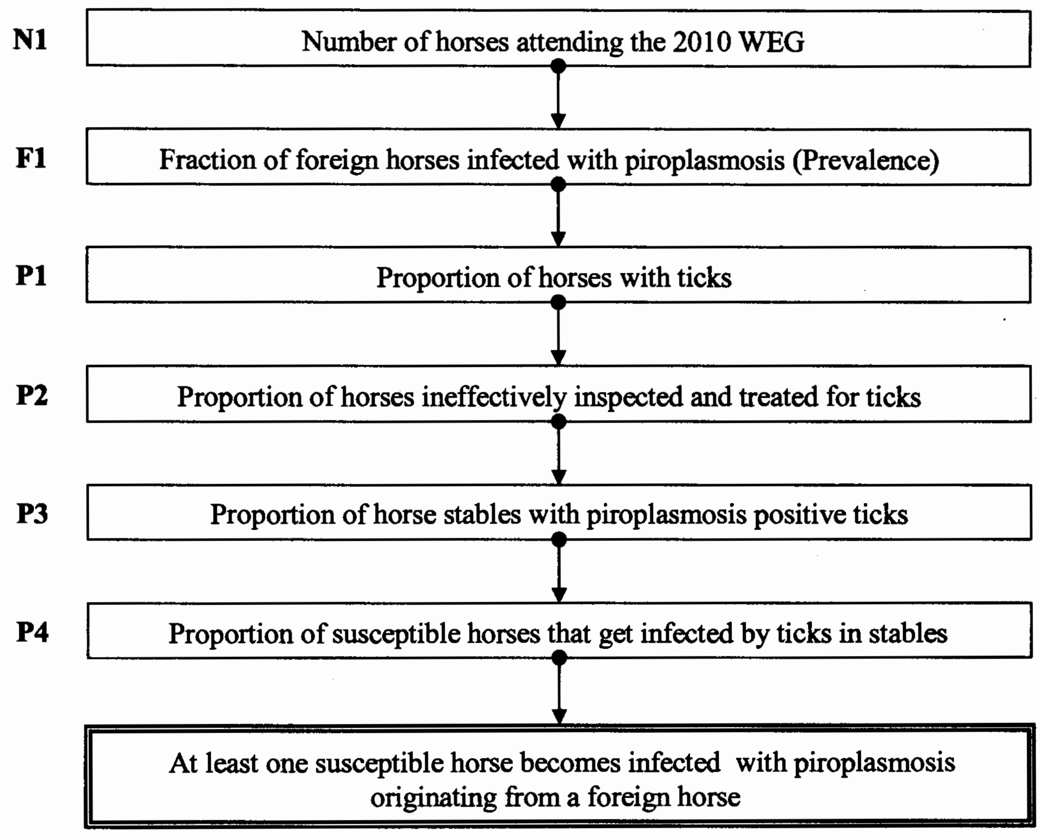

Figure 3: Mathematical Relationship of Model Parameters

Node 1: *N1-* **Number of horses attending the 2010 WEG**

The exact number of horses expected at the 2010 WEG is unknown; however, this number, *N*, can be extrapolated from previous WEG records. Figure 4 shows the historical athlete attendance at the 1990, 1994, and 2002 WEG, as well as the projected attendance, *N*, for the 2010 WEG.

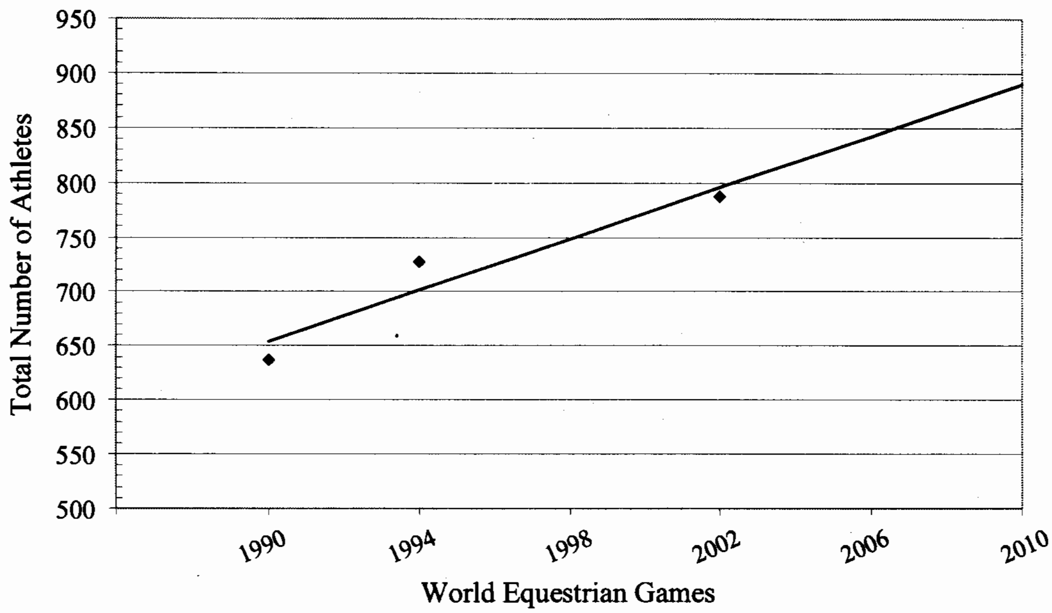

Figure 4: Total Athletes Attending the WEG

$$N1=890 \qquad (1)$$

N1, is the total number of athletes attending the 2010 WEG.

Node 2: *F1-* **Fraction of imported horses infected with piroplasmosis**

The precise number of horses expected at the 2010 WEG with piroplasmosis (disease prevalence) is unknown. The uncertainty surrounding the anticipated number of piroplasmosis-positive horses at the 2010 WEG is conveyed through a *triangular distribution, F1*, which has three components: the minimum *(min)* possible value, the most likely *(ml)* value, and the maximum *(max)* possible value. This distribution indicates that the anticipated prevalence of piroplasmosis among 2010 WEG horses falls between the *min* value and the *max* value, but is most likely closer to the *ml* value.

$$F1= TRIANG\ (min,\ ml,\ max)$$

The minimum *(min)* possible value:
The *min* value represents the lowest expected prevalence of piroplasmosis among 2010 WEG horses. WEG are historically held in countries endemic with piroplasmosis. As a result, the piroplasmosis status of the horses was deemed irrelevant, and data regarding disease prevalence at these games are not available. However, prevalence data from international equestrian events held outside Europe exist. For the 1996 Olympic Games in Atlanta, Georgia, EP horses were restricted to participate in stadium events only and a limit of 20 EP horses was placed for attendance at the games resulting in disease prevalence of $min=3/240$, among participating athletes.

The most likely *(ml)* value:
For the 2000 Olympic Games in Sydney, Australia, there was no limit placed on the number of EP horses that could participate in the games, and EP horses participated in stadium and field events. The disease prevalence at these games was $ml=15/240$, among participating athletes, a 5 percent increase in disease prevalence over the 1996 Olympic Games in Atlanta. With a similar policy toward piroplasmosis-positive horses, a comparable disease frequency is expected at the 2010 WEG.

The maximum *(max)* possible value:
The highest disease prevalence anticipated at the 2010 WEG is represented by the *max* parameter. Participation of piroplasmosis-positive horses will extend to all events. As a result, a similar 5 percent increase in disease prevalence observed at the 2000 Olympic Games in Sydney, Australia, is expected. This equates to approximately 100 of 890 ($min=100/890$) horses at the 2010 WEG testing positive for piroplasmosis.

$$F1 = TRIANG\ (3/240,\ 15/240,\ 100/890)$$
$$F1 = TRIANG\ (0.0125,\ 0.0625,\ 0.1125) \qquad \textbf{(2)}$$

The Use of Expert Judgment for Nodes 3-6

Decisionmakers historically used expert information to inform critical decision making processes that significantly impact life and death, as well as financial, legal, and social issues. Expert judgment is used in scientific analyses to supplement insufficient empirical data. For the numbers used in Nodes 3-6, equine experts were asked to make estimates based on experience in order to furnish data that could be used for these variables.

Node 3: P1- Proportion of horses with ticks

Horses attending the WEG may host ticks from a number of sources. First, ticks on horses could result from oversight during inspections and treatments (*AS*) at both the incoming port and the game site. Second, horses can become infested with native ticks while on the field or in stables during endurance events (*EE*). Third, horses may acquire ticks from bedding (*BD*).

Let:

- (*AS*)- Proportion of horses arriving at game site with ticks (1 in 100).
- (*EE*)- Proportion of horses infected with ticks from endurance event or exercising (1 in 1,000).
- (*BD*)- Proportion of horses infected with ticks from bedding (1 in 100).

$$P1 = AS + EE + BD$$
$$P1 = 0.01 + 0.001 + 0.01 = 0.021 \qquad (3)$$

<u>Node 4: P2- Proportion of horses ineffectively inspected and treated for ticks</u>

The effectiveness of the inspection and treatment regimes for ticks is primarily dependent upon two factors. First, the examiner needs specific level of skills and experience. It is widely recognized that experts, like the USDA Tick Riders (APHIS, Veterinary Services, port inspectors along the Mexican border) and FEI equestrian team veterinarians, have a proven record in finding adult ticks when examining horses for tick infestation. This level of expertise would not be expected of the average equine practitioner (Cordes, personal communication, 2005). The second factor is the effectiveness of the treatment regimes in killing and repelling ticks. Treatment of stables and event areas with an approved acaricide would decrease the adult tick population by about 80 percent (Haile et al., 1990).

Let *SV* be the skill of FEI equestrian team veterinarians and Tick Riders in performing tick inspections. *SV* is expressed by a *uniform distribution, Uniform (min, max)*, which has two components: the minimum *(min)* possible value and the maximum *(max)* possible value. Experts assigned values of 90-99 percent for the effectiveness of team veterinarians and Tick Riders in finding ticks, *Uniform (0.90, 0.99)*.

Let:

- *1-SV* represent any deficiencies in the performance of tick inspections by team veterinarians.
- *ET* be the effectiveness of the treatment regimes (acaricides, etc.) in killing and repelling ticks.
- *1-ET* represent any ineffectiveness of treatment regimes in killing and repelling ticks. .

Horses are ineffectively inspected and treated for adult ticks *(P2)*, if there are deficiencies in the inspection process *(1-SV)* and the treatment *(1-ET)*:

$$P2 = (1-SV) \cdot (1-ET)$$
$$P2 = [1-RiskUniform\ (0.9,\ 0.99)] \cdot (1-0.80)$$
$$P2 = RiskUniform(0.002,\ 0.02) \qquad (4)$$

The value of *P2* indicates with 90 percent probability between *2 in 1,000* and *2 in 100* horses are likely to be ineffectively inspected and treated for ticks.

Node 5: P3- Proportion of susceptible horses that acquire piroplasmosis-infected ticks from imported horses

Susceptible horses at WEG can come into contact with piroplasmosis-infected ticks from imported horses under several scenarios. Below are descriptions of the scenarios and respective expert judgments on the probability/possibility of their occurrence.

Scenario A: During endurance event
Native or imported ticks on EP horses fall onto the grass outside the Game Park during the field events. Adult ticks survive, mate, and successfully produce second generation ticks. According to the 2002 Atlanta, Georgia, Equine Piroplasmosis Risk Assessment, it was estimated that from 0.063 to 2.87 first-generation infected ticks and from 4.9 to 22.2 second-generation infected ticks would result from 10 hours of exposure, and that 8.9 to 48.9 first-generation and 83 to 379 second-generation infected ticks would result from a 1-week exposure of the horses to a tick-infested environment. With an increase in the number of first-generation infected ticks, there is a corresponding increase in second-generation infected ticks surviving.

Let *P3a* be the probability of horses acquiring tick(s) as a result of field events:

$$P3a = 3 \text{ in } 10{,}000 = 0.0003 \qquad \textbf{(5a)}$$

Scenario B: Bedding from infected stables
Infected imported and established native ticks on bedding from piroplasmosis horses are improperly disposed. Adult ticks survive, mate, and successfully produce second generation ticks.

Let *P3b* be the likelihood of tick-infested bedding being improperly disposed and surviving tick(s) produce second generation ticks:

$$P3b = 1 \text{ in } 1{,}000 \qquad \textbf{(5b)}$$

Scenario C: Tick migration from designated infected stables to negative stables
Infected ticks from the positive stables of imported horses migrate to negative stables. The likelihood of this occurring is dependent upon the configuration of stables and barns.

Let *P3c* be the probability of ticks migrating from designated piroplasmosis stables to piroplasmosis-free stables:

$$P3c = 1 \text{ in } 1{,}000 \qquad \textbf{(5c)}$$

Let *P3* be the likelihood that *Scenario A (P3a), Scenario B (P3b), or Scenario C (P3c)* would occur:

$$P3 = P3a + P3b + P3c$$
$$P3 = 0.0003 + 0.001 + 0.001$$
$$P3 = 0.0023 \qquad \textbf{(5)}$$

Node 6: P4- Proportion of susceptible horses that get infected by piroplasmosis-infected ticks

The proportion of susceptible horses that become infected with piroplasmosis at the 2010 WEG is dependent upon both the number of ticks required to infect a horse and the number of ticks likely to move from infected to uninfected stalls:

$$P4 = 100\% \qquad \textbf{(6)}$$

P4 represents the probability that a piroplasmosis-infected tick will transmit the disease to the horse(s) it feeds on.

Dimensional Analysis

	DESCRIPTION	UNITS
N1	Total number of horses attending the 2010 WEG	Horses
F1	Fraction of imported horses infected with piroplasmosis (Prevalence)	Positive Imported Horses ----------------------------------- Imported Horses
P1	Proportion of horses with ticks	Positive Imported Horses ----------------------------------- Positive Imported Horses
P2	Proportion of horses ineffectively inspected and treated for ticks	Positive Imported Horses ----------------------------------- Positive Imported Horses
P3	Proportion of susceptible horse stables infected with piroplasmosis-positive ticks	Infected Susceptible Stables ----------------------------------- Positive Imported Horses
P4	Proportion of susceptible horses that get infected by ticks in stables	Positive Susceptible Horses ----------------------------------- Infected Susceptible Stables
P5	Percentage of susceptible horses among the 2010 WEG athletes	Susceptible Horses ----------------------------------- Horses

Table 1: Dimensional Analysis

Probabilistic Outputs

Given that piroplasmosis-positive horses (*F1*) entering the United States for the 2010 WEG have ticks or acquire native ticks (*P1*) and are ineffectively treated (*P2*), and ticks feeding on these infected horses become positive and established in the environment or stables (*P3*), which subsequently infect susceptible horses (*P4*):

Let *L1* be the probability that a susceptible horse attending the 2010 WEG, selected at random and tested, would be positive for piroplasmosis:

$$L1 = F1 \bullet P1 \bullet P2 \bullet P3 \bullet P4$$
$$L1 = Triang(0.0125, 0.0625, 0.1125) \bullet 0.021 \bullet Uniform(0.002, 0.02) \bullet 0.0023 \bullet 1$$
$$L1 = Triang(1.7E\text{-}09, 7.8E\text{-}09, 1.1E\text{-}07) \qquad (7)$$

Where: $1.7E\text{-}09 = 1.7 \times 10^{-09} = 0.0000000017$
$7.8E\text{-}09 = 7.8 \times 10^{-09} = 0.0000000078$
$1.1E\text{-}07 = 1.1 \times 10^{-07} = 0.00000011$

The result of equation *L1* is a triangular distribution:

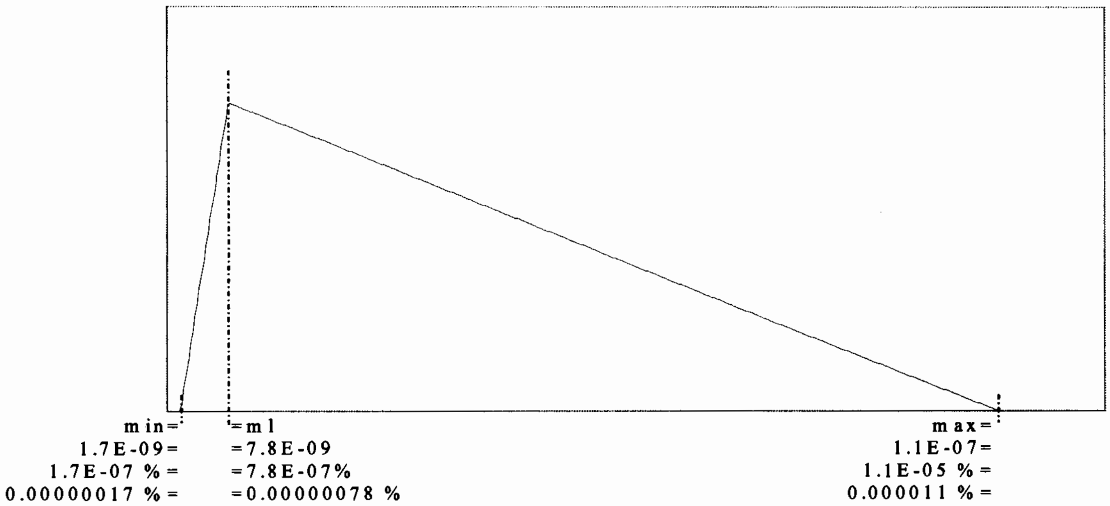

Figure 5: Resulting Triangular Distribution for *L1*

This implies the likelihood of a susceptible horse being positive for piroplasmosis following random selection and testing ranges from 0.00000017 percent (min) to 0.000011 percent (max), but is most likely 0.00000078 percent (ml).

L2 expresses the likelihood of at least one susceptible horse attending the 2010 WEG becoming infected with piroplasmosis.

Let:

- *(1-L1)* be the a susceptible horse attending the 2010 WEG, selected at random and tested, that would **not** be positive for piroplasmosis.
- *P5* be the percentage of susceptible horses at the WEG. Assuming similar disease prevalence (15/240) as that of the 2000 Olympic Games in Sydney, Australia, the percentage of susceptible horses expected is P5 *(P5=1-15/240=0.94).*
- *(N1•P5)* be the total number of susceptible horses.
- $(1\text{-}L1)^{N1 \cdot P5}$ be the likelihood of at least one susceptible horse attending the 2010 WEG, **not** becoming infected with piroplasmosis.

$$L2=1-(1-L1)^{N1 \cdot P5}$$
$$L2=1-(1-[Triang(1.7E\text{-}09,\ 7.8E\text{-}09,\ 1.1E\text{-}07)])^{890 \cdot 0.94}$$
$$L2=Triang(1.4E\text{-}06,\ 6.5E\text{-}06,\ 8.8E\text{-}05) \qquad \textbf{(8)}$$

The result of equation *L2* is a triangular distribution:

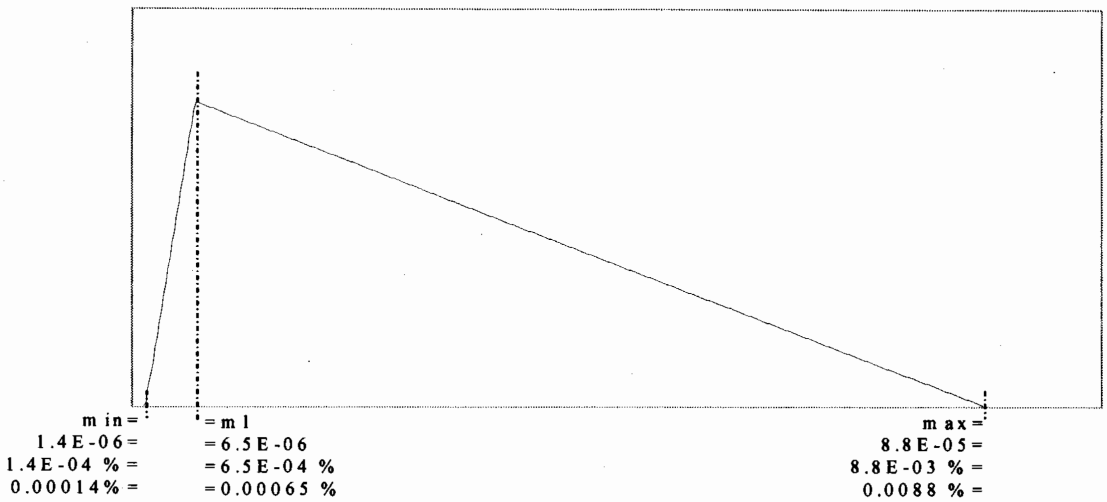

Figure 6: Resulting Triangular Distribution for *L2*

The resulting distribution *L2* shows that the likelihood of at least one susceptible horse becoming positive for piroplasmosis resulting from the 2010 WEG ranges from 0.00014 percent (min) to 0.0088 percent (max), but is most likely 0.00065 percent (ml).

Conclusions

The transmission of piroplasmosis from infected to susceptible horses as a result of the 2010 WEG requires the presence of three essential components—the piroplasmosis agents (*B. caballi* and *B. equi*), appropriate vectors, and suitable environment. Piroplasmosis-positive horses (*F1*) will attend the 2010 WEG and could come into contact with the appropriate vectors (*P1 and P3*), *D. variabilis and D. albipictus*. In addition, it is possible that the temperature and humidity in Kentucky during September and October could facilitate the transmission of the disease.

The analysis considered the factors contributing to all components. Figure 2 illustrates the factors in an overview of our system. In order for susceptible horse(s) to become infected with piroplasmosis, positive horses (*F1*) entering the United States for the 2010 WEG must have ticks or acquire native ticks (*P1*) and be ineffectively treated and inspected (*P2*), and ticks feeding on these infected horses must become established in the environment or stables (*P3*) and then infect susceptible horses (*P4*). These factors are combined and expressed in equations (7) for *L1* and (8) for *L2*.

L1 represents the probability that a susceptible horse attending the 2010 WEG, selected at random and tested, would be positive for piroplasmosis. The resulting triangular distribution of *L1* shows that a susceptible horse being positive for piroplasmosis following random selection and testing could be as low as 0.00000017 percent (2 in 1,000,000,000 horses) or as high as 0.000011 percent (1 in 10,000,000 horses), but is most likely 0.00000078 percent (8 in 1,000,000,000 horses). *L1* is a function of *F1, P1, P2, P3*, and *P4*.

L2 represents the likelihood of at least one susceptible horse attending the 2010 WEG becoming infected with piroplasmosis. The resulting triangular distribution of equation *L2* shows that the likelihood of at least one susceptible horse becoming positive for piroplasmosis resulting from the 2010 WEG could be as low as 0.00014 percent (1 in 1,000,000 horses) or as high as 0.0088 percent (9 in 100,000 horses), but is most likely 0.00065 percent (7 in 1,000,000 horses). The wide range of possible values for *L2* is impacted by both the inherent uncertainty of model input values as well as the efficacy of mitigations. The likelihood of susceptible horses becoming infected with piroplasmosis, *L2*, moves toward the low extreme with increased mitigations efficacy.

The results of L1 and L2 show a low likelihood of disease transmission. The biggest contributors to overall risk are the prevalence of piroplasmosis in the imported horses and the effectiveness of inspection and tick control measures. Resources appropriated to either or both contributors would reduce the overall risk.

			VALUES			
Parameter	**Description**	**Distribution**	**Min**	**ML**	**MAX**	**Output**
N1	Total number of horses attending the 2010 WEG	Point Data		890		890
F1	Fraction of imported horses infected with piroplasmosis (Prevalence)	TRIANGLE	0.0125	0.0625	0.1125	0.043498
P1	Proportion of horses with ticks	Point Data		0.021		0.021
P2	Proportion of horses ineffectively inspected and treated for ticks	Uniform	0.002		0.02	0.01112
P3	Proportion of susceptible horse stables infected with piroplasmosis-positive ticks	Point Data		0.0023		0.0023
P4	Proportion of susceptible horses that get infected by ticks in stables			1		1
P5	Percentage of susceptible horses			0.94		0.94

Table 2: Values for Parameters

Recommendation for Control of EP-Positive Horses and Tick Mitigation Strategies

Based on the scientific information available for babesiosis in horses and the biology of ticks, specific strategies would need to be followed if the KHP wins the bid for the 2010 WEG and EP-positive horses are permitted to participate in field events. These strategies are recommended to minimize the risk of introduction of piroplasmosis infection into the local tick population of Kentucky and decrease risk of infection from EP-infected horses to susceptible horses. These strategies include some of the controls used in the Atlanta and Sydney models (discussed above) and new considerations for this specific event and venue. If the WEG for 2010 are awarded to the State of Kentucky, the USDA, State of Kentucky, American Horse Council, and FEI representatives will work cooperatively to develop and refine a tick control program that will promote the competition at the games as well as prevent piroplasmosis from being introduced into the United States.

As noted earlier in this document, there have been 12 species of Ixodid ticks documented in Kentucky with 6 of these species found on livestock and wild cervids. Two of these tick species, *D. variables and D. albipictus,* are known to be competent vectors for equine babesiosis. In the tick survey conducted by Thompson in 2002, *D. variabilis* was identified between May 31 and July 17, which is consistent with the known activity period for this tick species. However, since no survey was performed during September and October when the WEG would be held, we do not know the prevalence of *D. albipictus* nor can we confirm that *D. variabilis* is not active during this time period at the KHP. The Thompson survey also did not include collections of ticks from deer, rodents, or horses, which would have provided a more accurate analysis of the tick population in the KHP. In the absence of such data, the Equine Event Piroplasmosis Evaluation Group (EEPEG) will proceed under the conservative assumption that ticks are potentially present in the area with a low prevalence and that through active tick mitigation strategies, we can minimize the risk of transmission of piroplasmosis from EP-positive horses to susceptible horses and the local tick population.

The WEG offer unique challenges compared to the challenges of the Atlanta Olympic Games in 1996 and the Sydney Olympics in 2000. The WEG is strictly an equine event with seven disciplines versus three events in the Olympics. With an estimated 900 horses participating in the WEG, there will be a greater number of horses than were at the Olympics, which had an estimated 240 horses participating. These factors offer challenges in maintaining security and implementing effective tick control strategies on such a large scale. Our recommendations are based on the assumptions that EP-positive horses would potentially compete in all seven disciplines, the number of EP horses allowed entry into the KHP would be unlimited, and all EP-positive horses would be promptly exported from the United States upon completion of the WEG.

General Long-Term Strategies

- Conduct an initial, thorough tick and wildlife survey of the KHP and surrounding farms and fields during the time period when horses would be projected to arrive at the venue, possibly September and October. This will establish a baseline for prevalence of ticks prior to instituting any control measures.

- Identify all areas of stabling, training, and competition so that tick control strategies can be applied to the specific areas.
- Before the course routes are established, define a tick control protocol for the endurance courses including size of the course and buffer areas and required vegetation management.
- Two years before the WEG, but after the tick control protocol has been established and implemented, conduct surveys at the KHP during September and October to determine if ticks are present at the facility. This would include surveys on the endurance course. If ticks are found on the course with established control measures, additional control measures can be implemented. Additional surveys should be conducted 1 year before the games if necessary.
- To inhibit tick movement, fence off wooded areas in the KHP to prevent wildlife from carrying ticks into the park and use additional barriers such as wood chips.
- To limit the habitat for wildlife, mow and trim areas around wood rows and pond that have denser vegetation throughout the KHP and adjacent farms and pastures where the endurance course will be located.
- Use baited traps and other mechanical rodent control programs in the KHP to include the stable area, visitor center, and storage barns. The rodent control methods will be consistent with what is safe and effective for horse barns.
- Continue to maintain the pastures as short grass areas as is predominate throughout the KHP as well as on adjacent farms and pastures.

Preparation of Venue for the Games

- Prohibit public traffic on all walkways for horses.
- Prohibit pets in the KHP for a time period prior to and during the games to prevent new ticks from becoming established.
- Institute tick control on resident horses and all horses entering the KHP for a time period before and during the games in order to prevent new ticks from becoming established.
- Keep stadium, training rings, and areas around the import quarantine barn and EP-positive horse barn free of vegetation.
- Treat with an approved acaricide all stable and competition areas, including the eventing, driving, and endurance courses.
- Mow and treat with acaricide all courses for field events, including trails on adjacent farms and pastures. Continuously maintain these areas before and during the competitions.
- For the endurance course, maintain emergency areas that are mowed and treated with acaricide in case EP-positive horses are injured and require assistance.
- Treat dirt or grass training areas and other competition areas.
- Ensure any bedding, hay, or straw used in the stables is tick free.
- Thoroughly clean and repair all horse stables and all hay, straw, and feed storage areas to decrease the possibility of rodent infestations.

Tick Controls for Horses

- Upon entry into the KHP, inspect and treat all horses with an approved acaricide.
- Ensure all horses use secured walkways.
- House EP-positive horses in a special quarantine barn with the option of having companion horses housed with them in the barn.

- Check EP-positive horses and all horses stabled in the same barn daily for ticks and treat with an approved acaricide per label instructions.
- Ensure EP-positive horses train and compete in field areas under strict supervision of USDA and Kentucky Department of Agriculture personnel.
- Limit the movements of EP-positive horses within the park to training and competitions.
- After EP-positive horses use the 3-day event, endurance, or driving course for training or competition, thoroughly check the horses for ticks.

Security

- Identify seropositive horses.
- Before entry into the United States, identify the EP status of a horse and issue a special entry permit with an EP wavier for EP-positive horses.
- Any horses testing positive for EP (not previously identified), dourine, glanders, or equine infectious anemia during the quarantine period upon importation into the United States will be subject to the standard import testing restrictions and may be denied entry.
- Export EP-positive horses out of the United States within 10 days of the end of the WEG.
- Follow import procedures as required by applicable regulations and USDA policy.
- Apply strict control on access of personnel to all horses. Restrict access to EP horses to personnel who have been specifically authorized access based on need.
- Implement personal biosecurity measures to minimize introduction of ticks into the KHP.
- Enforce strict control on entry into the private quarantine barn until the end of the quarantine period.
- Ensure strict control on activities in the EP-positive barn for the duration of the event.
- Inspect and treat all equipment and tack accompanying imported horses for ticks.

To effectively address the potential risk factors for tick incursions onto the KHP grounds and competition courses, the EEPEG recommends that tick experts work with the KHP to develop a model for the 3-day event, driving, and endurance courses. This would include width of the course, width of a buffer area, and length of grass on the course and in the buffer area, vegetation management, and possible acaricide treatment. Once the courses are designed, surveys would need to be conducted during September and October to see if the design and tick control measures are working. Surveys should be conducted during September and October at least 2 years before the WEG so that if ticks are found, additional control measures can be implemented and additional surveys conducted 1 year before the WEG.

Conclusions and Recommendations

The request from the KHP to allow the participation of EP-positive horses in field events in the 2010 WEG has presented USDA with a unique and challenging opportunity. Unlike the EP waivers granted for the 1984 Los Angeles Olympics and the 1996 Atlanta Olympics, this waiver would include field events such as 3-day eventing, driving, and endurance. Considering the large number of horses, riders, and equipment that would participate, the size and scope of the WEG will provide an incredible challenge and opportunity for the KHP. Management and oversight of quarantines and EP-positive horses will provide equally great challenges for State and Federal regulatory officials.

The EEPEG conducted a thorough analysis of the tick data available for Kentucky, the scientific literature, a site visit of the KHP, and a risk analysis to effectively assess the risk of transmission of EP to susceptible horses and the local tick population if EP-positive horses were allowed to participate in the WEG. The EEPEG has provided recommendations to best protect susceptible horses and local tick populations from becoming infected with piroplasmosis and to promote the spirit and nature of the WEG. To effectively do this, the EEPEG sought answers to two main questions: (1) are competent tick vectors for EP present in Kentucky at the potential site for the WEG; and (2) if so, are adequate tick mitigation strategies available that could be instituted to decrease the risk of EP becoming established to negligible numbers.

1. Are there competent tick vectors for EP in Kentucky at the KHP?

Of the 12 species of Ixodid ticks identified in Kentucky from the available data, two species (*D. variabilis and D. albipictus*) are known to be competent vectors for EP and are found in Kentucky where the KHP is located. In a survey conducted by Townsend in 2002, *D. variabilis* was found to be established on the KHP grounds during the summer months. In surveys conducted by Burg over multiple years, adults of *D. variabilis* were collected annually from April-August. The EEPEG recommends that tick surveys be performed during September and October within the KHP and on adjacent premises via drag sampling and mammal trapping to effectively assess the prevalence of larvae, nymphs, and adults of *D. variabilis.* Until such information is available, we will proceed with the assumption that there is potential for some tick activity.

D. albpictus is known to be active in eastern Kentucky during the fall when the proposed WEG would be held. *D. albipictus* is a one-host tick; therefore, if an EP-positive horse were to be infested with *D. albipictus*, the tick, absent any tick treatments, would complete its life cycle on the given horse.

The EEPEG has concluded from a review of what limited scientific literature is available for Kentucky that although ticks are potentially present on the grounds of the KHP during September and October, these tick populations would be low in number. With appropriate tick control and mitigations, a low number can be managed.

2. Could there be adequate tick mitigation strategies that could be instituted to decrease the risk of EP infection becoming established to negligible numbers?

Given the presence of the above ticks in Kentucky, tick mitigations will be necessary for all EP-positive horses and potentially for all horses at the KHP if the KHP is awarded the 2010 WEG.

The KHP's well-established pastures provide an ideal situation for the successful application of vegetation management to reduce tick populations. The grounds and adjacent property of the KHP are dominated by short grass with occasional trees and little to no underbrush. The KHP is markedly different from the International Horse Park near Atlanta in that there is no abundant, established tick population on the grounds of the KHP (Amen and Garris; Townsend 2002). The situation at the KHP also is different from the situation in Sydney. It was clearly established through historical data and multiple tick surveys that no competent tick vectors for EP existed in the area of the Sydney Olympic Games; therefore, the risk of transmission from positive horses already was minimal. However, even with this minimal risk, AQIS established a separate quarantine for EP-positive horses and instituted security and tick treatments that were more strenuous than those for the general horse population.

The conclusion of the risk analysis was that the possibility of one or more susceptible horses becoming infected by the agents of piroplasmosis could be as low as 0.00014 percent (1 in 1,000,000 horses) or as high as 0.0088 percent (9 in 100,000 horses), but is most likely 0.00065 percent (7 in 1,000,000 horses). This broad range is attributable to many variables and tells us that the more effective the tick mitigations and controls, the lower the risk of susceptible horses becoming infected.

As discussed above, additional surveys of the KHP and surrounding farms and pastures are needed during September and October to accurately assess the prevalence and activity of *D. variables and D. albipictus.* Once a baseline survey is conducted, additional surveys of the grounds and course can be conducted to assess the success of the tick control program after it has been implemented. The EEPEG strongly recommends that tick experts work with the KHP to design the field courses and include strategies to minimize the presence of ticks at the KHP, including on the competition courses. Clear strategies can be employed in the initial planning stages during the development of the competition courses that could potentially save efforts during the actual events.

Overall Recommendation

Based on the data and information presented in this paper, the EEPEG recommends that EP-positive horses be allowed to participate in the field events of the 2010 WEG if the WEG are awarded to the KHP provided that tick control measures discussed in this document are fully implemented. These strategies should form the basis of an action and tick control plan that can be developed by all parties involved in the planning and execution of the WEG in Kentucky.

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