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***Insights******Gained from Wildlife Research in the Context of Global Anthropogenic Change***

**Aguirre. Changing Patterns of Emerging Zoonotic Diseases in Wildlife, Domestic Animals, and Humans Linked to Biodiversity Loss and Globalization, pp. 315-318**

SUMMARY: Ecosystem disruptions due to fundamental human threats has altered infectious disease transmission patterns, toxic pollutants accumulation and invasion of alien species and pathogens. This study explores the complex interactions of emerging infectious diseases and selected emerging zoonotic diseases such as RNA viruses, Rift valley fever, trypanosomiasis, hanta virus and other vector borne diseases. Mostly the most insidious factor is climate change and its effect to the wildlife species. Their inability to adapt of many species to rapid changes potentially results in extinctions. Extinction rate is difficult to estimate however IUCN has estimated extinction rates. These massive declines are referred to as “biological annihilation” which is linked further to infectious and non-infectious agents diseases in stressed animals. One example is the Ebola virus which was a global pandemic in 2014 which almost pushed gorilla and chimps to extinction in western Africa. Yearly, we have novel viruses spilling from wildlife to humans or domestic animals in unexpected ways. One to be noted is the highly pathogenic H5N1 avian influenza which jumped from chickens straight to humans calling world attention.

Infectious diseases in human-wildlife- domestic animal interfaces are affected by multitude of environmental factors, mostly induced by humans. The impact of athropogenic change in ecosystem health and needs transdisciplinary approach to necessarily identify and address health issues at the local level. One health collaborations in research , education and intervention consider health problems and risks among species and stressors and collectively countering such stressors to restore ecosystem that protects humans and non-humans alike.

ONE HEALTH

ARTHROPOD BORNE ZOONOSES IN THE US: (Eisen and colleagues 2017; Nichols and collaborators 2017): Almost 30% of zoonotic diseases are vector borne linked to wildlife reservoir with greatest diversity of arthropod borne transmitted by ticks. Coprophagous beetles have a staggering diversity of both micro and macro parasites which impacts host fitness, wildlife density and ecosystem functioning. Future efforts should focus in the overall dynamic of disease ecology in wildlife and how parasites contributes to the ecosystem structure.

RNA VIRUSES (Carrasco-hernandez and collaborators 2017): Are diverse which includes 180 species with app 2 species discovered yearly which are described as the most important viruses in zoonotic disease transmission representing a challenge for global disease control. Viruses has rapid adaptive rates which may lead to pandemics such as HIV, SARS, Hendra, Nipa and MERS to name a few.

RIFT VALLEY FEVER (Rostal and colleagues 2017): Acute mosquito borne zoonotic disease which cause abortions and perinatal mortality. Subclinical in humans and manifests as flu-like. Vaccination remains the only effective way to protect livestock.

WILDLIFE RESERVOIR OF *Trypanosoma cruzi* in SOUTHERN US ( Hodo and Hamer 2017): Review of published reports on T. cruzi infection in wildlife species and the enzootic cycle of triatomine vectors and wildlife that increases the risk of spillover to humans. NHP and dogs which in turn may develop Chagas disease. Over 60% of the reviews identified raccoons  and striped skunks as reservoirs.

IMPACT OF GLOBAL ENVIRONEMNTAL CHANGES ON INFECTIOUS DISEASE EMERGENCE IN BRAZIL (Nava et al 2017): Extensive review and analysis to implement preventative control measure on anthropogenic and environmental drivers of emerging infectious diseases in brazil including chikungunya, dengue, yellow fever, zika, hantavirus pulmonary syndrome, leptospirosis, leishmaniasis, and Chagas disease.

SPECIES IDENTITY SUPERSEDES DILUTION EFFECT OF HANTAVIRUS PREVALENCE IN TEXAS AND MEXICO (Milholland et al 2017): The study addresses a research question if rodent assemblage differs between sylvan and disturbed sites at a given locality and if there is difference in relative abundance and numerical dominance of hantavirus reservoir species between habitat types across northern Texas to southern Mexico. Findings concluded that characteristic of assemblage structure do not adhere to current conceptions of species richness and that dilution effect is limited to site/- habitat specific characteristic.

CONCLUSION:Most of the solutions to protect biodiversity and predicting and prevention of the next zoonotic epidemic are oriented towards the developed world and less useful in low income economies. Further development of regional policies at the local level are suggested to address the issues presented.

QUESTIONS

1. What is the fundamental human threat to biodiversity so named as “THE EVIL TRIO”?
2. What is IUCN?

ANSWERS

1. Overexploitation of species, habitat destruction, exotic species introduction
2. International Union for conservation of Nature

**Eisen et al. Tick-Borne Zoonoses in the United States: Persistent and Emerging Threats to Human Health, pp. 319-335**

Domain 1

SUMMARY: This ILAR Journal article was a review that discusses diseases transmitted by ticks, the natural history and associated pathogens of those ticks, changes in vector tick distribution of disease, and identified gaps and barriers for prevention for the tick-borne diseases.

<https://tickencounter.org/tick_identification> has excellent pictures of all stages of ticks found in the United States, as well as maps of geographic distribution

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Common Name | Scientific Name | Human Disease Agents | Geographics | Life Cycle/ Pathogen Transmission |
| Deer tick | *Ixodes scapularis* | *Borrelia burgdorferi, Borrelia mayonii*(Lyme disease) | Non-arid areas | 3-host tick |
|  |  | *Borrelia miyaamotoi*(relapsing fever spirochete) | Expanding | Human incidental host |
|  |  | *Anaplasma phagocytophilum*(Anaplasmosis) |  | White-tail deer primary host |
|  |  | *Ehrlichia muris euclairensis*(Ehrlichiosis) |  |  |
|  |  | *Babesia microti*(Babesiosis) |  |  |
|  |  | Flaviviridae virus- Powassan encephalitis virus |  |  |
|  |  |  |  |  |
| Lone Star Tick | *Ambylomma americanum* | tularemia (*Francisella tularensis*) | Woods | White-tail deer primary host |
|  |  | ehrlichiosis *(Ehrlichia chaffeensis* and *Ehrlichia ewingii)* | expanding north |  |
|  |  | Heartland virus (Family: Bunyaviridae) |  |  |
| Gulf Coast Tick | *Ambylomma maculatum* | *Rickettsia parkeri* | xeric habitats | white tailed deer, cattle, feral swine, migratory birds (attribute to expansion of tick geographic area) |
|  |  |  |  |  |
| American Dog Tick | *Dermacentor variabilis* | *Ricketsia rickettsia-*Rocky Mountain Spotted Fever (rare) | High humidity | 3-host |
|  |  | non-pathogenic spotted fever group | Widely distributed | non-nidocolous ticks |
|  |  | *+/- Fransciella tularensis* |  | feed on small mammals to larger (adults) |
|  |  |  |  |  |
| Brown Dog Tick | *Rhipicephalus sanguineus* | *Rickettsia rickettsia*RMSF | most widely distributed hard tick in US | Monotropic, domestic dog serves as principle host for all life stages |
|  |  | *R. massiliae* |  | Resistant to desiccation, peridomestic and endophilic habitats |
|  |  | *Ehrlichia canis* |  | *Rickettsia*can be transmitted to all stages of tick, as well as transovarilly to eggs |

QUESTIONS

1. All of the following are characteristics of the Ixodid tick except:

a.  Ixodid ticks are capable of transmitting protozoa, bacteria, and viruses

b.  Ixodid ticks have a soft shell

c.   Ixodid ticks take a single blood meal from vertebrate hosts in all life stages

d.  Ixodid ticks are capable of biting humans in all life stages

2. Which of the following is a characteristic of a nidocolous tick?

a.  Nidocolous ticks remain in the nest and do not openly host-seek

b.  Nidocolous ticks do not contribute to zoonotic pathogen transmission

c.  There is no seasonality to nidocolous tick behaviors

d.   Nidocolous ticks are resistant to most environmental fumigates.

3. Which of the following is the most commonly reported vector-borne disease in the United States?

a.  Rocky Mountain Spotted Fever

b.  Ehrlichiosis

c.  Lyme Disease

d.   Powassan encephalitis

4. Which of the following is the most widely distributed hard tick species in the continental United States?

a.  *Dermacentor variabilis*

b.  *Ixodes scapularis*

c.   *Rhipicephalus sanguineus*

d.  *Ambylomma americanum*

ANSWERS

1. b. Argasidae (*Ornithodoros* spp) are soft-shelled ticks

2. a

3. c

4. c

**Nichols et al. Coprophagous Insects and the Ecology of Infectious Diseases of Wildlife, pp. 336-342**

Domain 3: Research

Tertiary Species: Invertebrates

SUMMARY: Parasites influence wildlife population density, community structure, and ecosystem function through their impacts on individual host fitness. Dung beetles interact with large numbers of wildlife parasites. These authors reviewed the potential impacts of coprophagous dung beetles on the transmission of wildlife parasites, and how dung beetle-parasite interactions influence the dynamics and patterns of infection in natural systems. Dung beetles can have suppressive effects (i.e., negative implication on survival and transmission of parasites) by direct mechanical interference damaging and killing the parasite eggs through feeding and nesting activities. They can also have indirect suppressive effects through alteration of the abiotic conditions in fecal pats such as aeration, desiccation, microclimate changes and burial activities. On the other hand, dung beetles can have maintenance effects (i.e., positive implications for parasite survival and transmission) either through direct biological facilitation acting as intermediate hosts or transport facilitation of parasite eggs or larvae on beetle exoskeletons or within their gastrointestinal systems.  Wildlife decline and extinction may introduce contact between coprophagous beetles and novel wildlife feces and associated parasites. At wildlife-domestic animal interface, dung beetles may show a high potential for linking coupled domestic and sylvatic transmission systems.

QUESTIONS

1. Which of the following parasites has been associated with esophageal sarcomas in dogs?

a. *Ditestolepsis diaphana*

b. *Ascaris suum*

c. *Trichostrongylus colubriformis*

d. *Spirocerca lupi*

2. Which of the following is known as the large roundworm of pigs that commonly produces “milk spots” in the liver?

a. *Ostertagia ostertagi*

b. *Ascaris suum*

c. *Trichuris suis*

d. *Oesophagostomum dentatum*

ANSWERS

1. d

2. b

**Carrasco-Hernandez et al. Are RNA Viruses Candidate Agents for the Next Global Pandemic? A Review, pp. 343-358**

Domain 1: Management of Spontaneously and Experimentally Induced Diseases (K. 7: Epidemiology)

SUMMARY: RNA viruses are important zoonotic agents and primary etiological agents of human emerging pathogens. These include HIV, Lassa fever, Ebola, avian influenzas, Middle East respiratory syndrome, SARS, Influenza A, Chikungunya, and Zika. RNA viruses show greater mutation rates and substitution rates than DNA viruses, giving them remarkable capabilities to adapt to new environments and selective pressures they encounter. One manner of supporting mutation is that the majority of RNA viral replicases lack proofreading activity. The presence of multiple proofreading pathways in DNA polymerases diminishes the burden of random mutations, preserving the genetic identity of the species.

Approaches to controlling RNA viruses include diversification and evolution of pharmaceutical measures as well as surveillance of host populations and reservoirs. Strategies such as multidrug therapies, RNA silencing (using siRNA complementary to specific RNA sequences to form double-stranded RNA and induce degradation of original messenger RNA), and manipulation of codon base pairs in vaccines are used to combat RNA viruses. Field surveys of domestic and wildlife RNA viruses, known or suspected reservoirs, and their routes of zoonotic transmission are other methods aimed at controlling RNA viruses. These field surveillances incorporate host species evolution, phylogeny of viruses, molecular techniques to identify novel viruses, and predictive modeling of vector/reservoir abundance.

Examples of historical zoonotic outbreaks of RNA viruses include Influenza A outbreaks in humans from wild waterfowl, Chikungunya transmitted to humans by varying *Aedes* mosquitos based on which species fostered viral survival, and spread of SARS being perpetuated via increasing international wildlife trade and activities in wildlife markets.

RNA viruses jump species more often than DNA viruses. It is likely that most instances of viral emergence have their roots in ecological perturbation. Therefore, quantitative models that account for localization of human disturbance should help predict future interspecies transmission events. Aside from interspecies transmission, studies have determined that viruses that induce low host mortality, establish long-term chronic infections, and that are nonsegmented, nonenveloped, and not transmitted by vectors were more likely to be transmissible between humans.

In general, risk assessment of potential zoonotic viral threats requires the combination of genetic, phenotypic, and epidemiological information of viruses along with the ecology of reservoirs/vectors and human activities affecting ecosystems. Unfortunately, disease control is ultimately limited by economic and social constraints so the design of pharmaceuticals and surveying techniques must cope with the feasibility of their implementation at the population level.

QUESTIONS

1. True or False: DNA viruses mutate more rapidly than RNA viruses.

2.  True or False: DNA polymerases have multiple proofreading pathways.

3.  RNA viruses include:

a. Lassa fever

b.  Influenza A

c.  Zika virus

d.  Human immunodeficiency virus

e.  All of the above

f.   a, b, and c only

4. Chikungunya is transmitted to humans by:

a.  Ctenocephalides spp.

b.  Sarcoptes spp.

c.  Aedes spp.

d. Psoroptes spp.

e.   Polyplax spp.

ANSWERS

1.  False

2.  True

3.  e

4.   c

**Rostal et al. Rift Valley Fever: Does Wildlife Play a Role?, pp. 359-370**

SUMMARY: Rift Valley fever virus (RVFV) is a vector-borne zoonosis that primarily causes febrile illness and abortions in domestic ruminants but can affect wildlife and humans as well. It causes sporadic epizootics and epidemics with multi-year inter-epidemic periods. RVFV has primarily been found in Africa, however in the last 15 years there have been documented cases in the Arabian Peninsula. There are multiple species of mosquitos that can serve as vectors to transmit RVFV, including Aedes spp and Culex spp. Floodwater Aedes species are hypothesized to transmit the virus transovarially. The eggs are desiccation resistant and survive on top of the soil until flooding occurs, at which time the infected mosquitos hatch and initiate infection in wildlife or domestic ruminants. Other mosquito species are then capable of transmitting the virus horizontally, which leads to amplification and spread of the virus. The role of wildlife in the viral ecology is undescribed; although there are anecdotal reports of clinical signs of Rift Valley fever in wildlife, it is still unclear if wildlife serves as a vertebrate reservoir host. The World Organization for Animal Health (OIE) determines trade standards for terrestrial animals and permits the use of the following assays for detection of RVFV: virus culture, agar gel immunodiffusion, real-time PCR, histopathology with immunostaining, and virus neutralization assays. Several ELISAs have been described in the literature but they require validation by species and are not considered prescribed tests for international trade. Virus neutralization tests are the gold standard but are very costly and require BSL-3 facilities to work with the live virus.

A systematic review of the literature was used to investigate RVFV in free-ranging wildlife. Despite a significant amount of testing, only 31 animals from 14 species have been reported as testing positive for RVFV in the peer-reviewed literature. The animals include!
buffalo, springbok, waterbuck, giraffe, and three species of bats. In order to be considered a reservoir, a host species should demonstrate minimal clinical signs and/or mortality associated with a high and long-lasting viremia, range overlap enzootic regions, detection of the virus in free-ranging members of the species, and relatively high seroprevalence levels across populations. Experimental infection of wildlife has been limited to rodents, primates, and other traditional lab animal species, with an occasional study on buffalo, bats, and birds. Thus far there is no evidence to implicate a specific wildlife reservoir host for RVFV. There is evidence of low-level circulation of RVFV, with animals testing seropositive in the absence of a known outbreak. This supports the theory that RVFV may depend on a reservoir system that involves low-level cycling among wildlife and domestic ruminants that may suddenly increase to an epizootic when sufficient vectors are present.

QUESTIONS

1. Which organization determines reporting requirements for internationally important diseases?

a. United States Department of Agriculture (USDA)

b. Centers for Disease Control and Surveillance (CDC)

c. World Health Organization (WHO)

d. World Organization for Animal Health (OIE)

2. Which invertebrate species is a vector of Rift Valley Fever virus?

a. Aedes spp

b. Glossina spp

c. Tunga spp

d. Ixodes spp

3. Which group of tests is considered the gold standard for diagnosing RVFV?

a. ELISA

b. Virus neutralization

c. PCR

d. Histopathology

4. For a species to be considered a reservoir for a viral disease, which of the following is true:

a. Low levels of the virus over long periods of time

b. High morbidity and mortality

c. Low seroprevalence across populations

d. Range overlap with enzootic regions

ANSWERS

1. d

2. a

3. b

4. d

**Mulcahy. The Animal Welfare Act and the Conduct and Publishing of Wildlife Research in the United States, pp. 371-378**

Domain 5

SUMMARY:  Publications almost always have an “Instructions to Authors” for helping would be authors know how to prepare their manuscript for publication in a specific journal.  The instructions given to the authors vary from journal to journal as to how they require that the author report that work with animals be reported.  Specifically, whether they are required to report if the project received the “blessing” of the Animal Care and Use Committee.

There is often a question as to whether “field studies” require ACUC approval.  The AWA and AWAR exempt “field studies” so long as the study does not harm or alter the behavior of the animal.  Therefore, an observational study would likely not require ACUC approval, but capturing an animal for a blood sample would.

The author of this study examined his personal database of 17,000 wildlife articles.  From this he selected 106 journals to examine their stance of ACUC approval for wildlife studies.  The author categorized the journals as being either USA centric or the rest of the world centric.  These were further subdivided into one of three domains (Disease, Ecology, and General).  In general (based on the instruction to the authors) it was found that disease-oriented journals originating in the United States and those produced by professional societies and government agencies have a higher explicit requirement for ACUC review than do disease-oriented journals produced outside the United States or those produced commercially.   Furthermore, General related journals outside the USA had more explicit instructions for ACUC approval than generally-oriented journals produced in the United States or those produced by professional societies and government agencies.  Ecology related journals whether inside or outside the USA had low rates of requiring ACUC approval.

QUESTIONS

1. What agency has had delegated to it from the Secretary of Agriculture the enforcement of the AWA and its regulations?

a.   OLAW

b. USDA

c.   CDC

d.  WWF

2.  What amendment to the AWA excluded purpose bred mammals from the genera *Mus* and *Rattus*?

a. Transportation and Handling Act, 1972

b.   Animal Protection Act, 1988

c.   Food Safety Act, 1998

d. Farm Security and Rural Investment Act, 2002

3.  Which of the following studies would most likely not require Animal Care and Use Committee approval?

a.  Study evaluating the immune status of NYC sewer rats.  Rats are captured, bleed, and quickly released.

b.   Behavioral study involving small island foxes in which predatory hawk noises are played over a speaker to determine their reaction to protecting their cubs.

c.  Capture and release of sea otters.  During capture a radio device is implanted into the abdomen of the otter and then it is released.  The otters’ movement will be tracked remotely from a distance that will not be perceived in any way by the animals.

d.  Drought has caused bears in Yellowstone to consume more meat.  Researchers want to collect bear scot for protein analysis.

ANSWERS

1.  b

2. d

3.  d

**Hodo and Hamer. Toward an Ecological Framework for Assessing Reservoirs of Vector-Borne Pathogens: Wildlife Reservoirs of *Trypanosoma cruzi* across the Southern United States, pp. 379-392**

Domain: 1 Management of Spontaneous and Experimentally Induced Diseases and Conditions. K3. Parasitology

SUMMARY: This article aims to provide a framework to identify candidate wildlife reservoirs of *Trypanosoma cruzi* in the southern United States by reviewing current literature. This is important because *T. cruzi* is the agent of Chagas disease, a zoonotic vector-borne protozoan that has a complex, multi-host transmission system.

Background on *T. cruzi*

The arthropod vector for *T. cruzi*are triatomines (aka kissing bugs) of the family Reduviidae. There are 11 species of kissing bugs in the United States. The triatomines acquire the trypomastigote stage of *T. cruzi* during blood feeding on an infected host, and the parasite then replicates as epimastigotes in the triatomine bug’s gastrointestinal system. Infective *T. cruzi*metacyclic trypomastigotes are then passed in the feces of the bug, which infect a mammalian host via stercorarian or ingestion routes. Stercorarian transmission involves the triatomine bug defecating onto the host during a blood meal, and the infected feces is then rubbed into the bite wound, broken skin, or mucous membranes afterwards.

Candidate species for wildlife reservoirs of *T. cruzi*

In the literature, there are at least 26 wildlife species that have been shown to have anti-*T. cruzi*antibodies or parasite infections. From there, an infectiousness index was calculated based on reports that utilized measures of parasitemia in candidate reservoir host species.  An aggregate overall prevalence and an aggregate infectiousness indexwas calculated for each wildlife host species for comparative purposes.

Results

The authors identified three knowledge gaps during the course of their review that need to be filled before reservoir potential can be more comprehensively evaluated. Four wildlife species, raccoons, opossums, woodrats, and skunks rose to the top in importance as reservoirs of *T. cruzi* in the United States. The three knowledge gaps are: 1) Measuring host infectiousness and infection dynamics, 2) measuring vector-host contact, and 3) determining epidemiological relevance of *T. cruzi*strains in enzootic transmission.

QUESTIONS

1. What are the two methods of transmission from an infected triatomine bug to a mammalian host?

a.  Ingestion and inhalation of infective trypomastigotes

b.   Ingestion and stercorarian routes

c.   Ingestion and direct contact with mammalian wildlife reservoir hosts

d.  Inhalation and stercorarian routes

e.   Inhalation and direct contact with mammalian wildlife reservoir hosts

2. Which of the following, according to this article, is not an important potential wildlife reservoir species for *T. cruzi* in the United States?

a.   Skunk

b.   Woodrat

c.   Opossum

d.   Bobcat

e.   Raccoon

ANSWERS

1. b

2. d

**Nava et al. The Impact of Global Environmental Changes on Infectious Disease Emergence with a Focus on Risks for Brazil, pp. 393-400**

SUMMARY: Environmental changes have a huge impact on the emergence and reemergence of certain infectious diseases, mostly in countries with high biodiversity and serious unresolved environmental, social, and economic issues.

Brazil diseases of present public health importance are Chikungunya, dengue fever, yellow fever, Zika, hantavirus pulmonary syndrome, leptospirosis, leishmaniasis, and Chagas disease. An extensive literature review revealed a relationship between infectious disease outbreaks and climate change events (El Nim, La Nina, heatwaves, droughts, floods, increased temperature, higher rainfall, others).

QUESTIONS

1. Which are key drivers of environmental changes affecting the emergence and spillover of infectious diseases between wild animals, domestic animals, and humans globally.

a. El Nino

b. Drought

c. Floods

d. Bushmeat consumption

e. a, b, c only

f. All above

2. Reason(s) why Brazil is a hot spot of emerging infectious diseases?

a. Advance of the agriculture frontier into the rainforest

b. Hydroelectric dams

c. Poverty in Guinea drives people to expand their range of activities

d. Pet trade

e. All the above

3. It is widely accepted that human modifications to the environment are the main cause or drivers for global environmental changes state that global environmental changes, planet Earth has entered a new geological epoch termed the \_\_\_\_\_\_\_\_\_\_\_\_\_.

4. Several studies have decided local climate change, distribution of important ecosystems and ecosystem services, large scale deforestation, and urbanization as drivers of a wide range of life-threatening infectious diseases, including all but

a. Hantavirus pulmonary syndrome

b. Dengue fever

c. Yellow fever

d. Malaria

e. All the above

5. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is indispensable in preventing disease emergence by identifying areas of before they become a treat to human and animal health.

6. T/F. To avoid or control outbreeds, integrated surveillance systems and effective outreach programs are essential.

7. T/F. Due to strong global and local influence on emergence of infectious diseases, a more holistic approach is necessary to mitigate or control them in low-income nations.

ANSWERS

1. f

2. e

3. Anthropocene

4. e

5. Active surveillance

6. T

7. T

**Milholland et al. Species Identity Supersedes the Dilution Effect Concerning Hantavirus Prevalence at Sites across Texas and México, pp. 401-412**

**Domain 3:** Research

**SUMMARY:** This study investigated the prevalence of Hantavirus antibodies, between JAN 2011 and JAN 2016 at 20 sites across Texas and Mexico. Items evaluated included Hantavirus seroprevalence, species composition, and assemblage structure between sylvan and disturbed habitats. Authors initially hypothesized seeing a greater species richness higher in sylvan habitats vs disturbed areas, but was not supported with data. This suggest that assemblage structure characteristics, do not adhere to current conceptions of species richness negatively influencing prevalence with a dilution effect. Authors found 313 (out of 2406) small mammals + for Abs against hantaviruses. Authors were able to make real-world inferences into the efficacy of dilution effect theory.



**QUESTIONS**

1.  Which of the following species is known to carry Hantavirus in the US?

a. Sigmodon hispidus

b.  Peromyscus maniculatus

c.  Oryzomys palustris

d.   Peromyscus leucopus

e.  All of the above

2.  Regarding the first reported Hantavirus case in the US, what does “four corners” reference?

**ANSWERS**

1. e

2.   In May 1993, an outbreak of an unexplained pulmonary illness occurred in the southwestern United States, in an area shared by Arizona, New Mexico, Colorado and Utah known as “The Four Corners”.