The Journal of Infectious Diseases

MAJOR ARTICLE

Seoul Virus Infection and Spread in United States Home-Based Ratteries: Rat and Human Testing Results From a Multistate Outbreak Investigation

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Journal Club

Fecha (Ene 25, 2023)

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7.759

Journal Impact Factor ™ (2021)

Introduction

Seoul virus (SEOV), an Old World Orthohantavirus.

Infected rats shed virus in urine, saliva, and feces for periods from 1 month to >4 months.

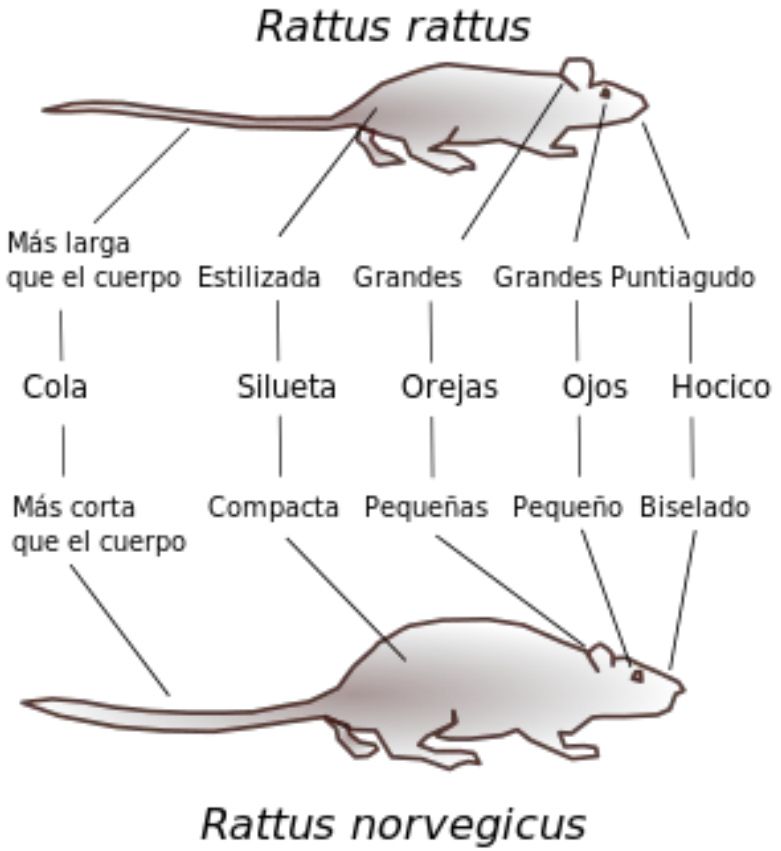
There is no known clinical disease exhibited by rats infected with SEOV

Humans can become infected with SEOV through:

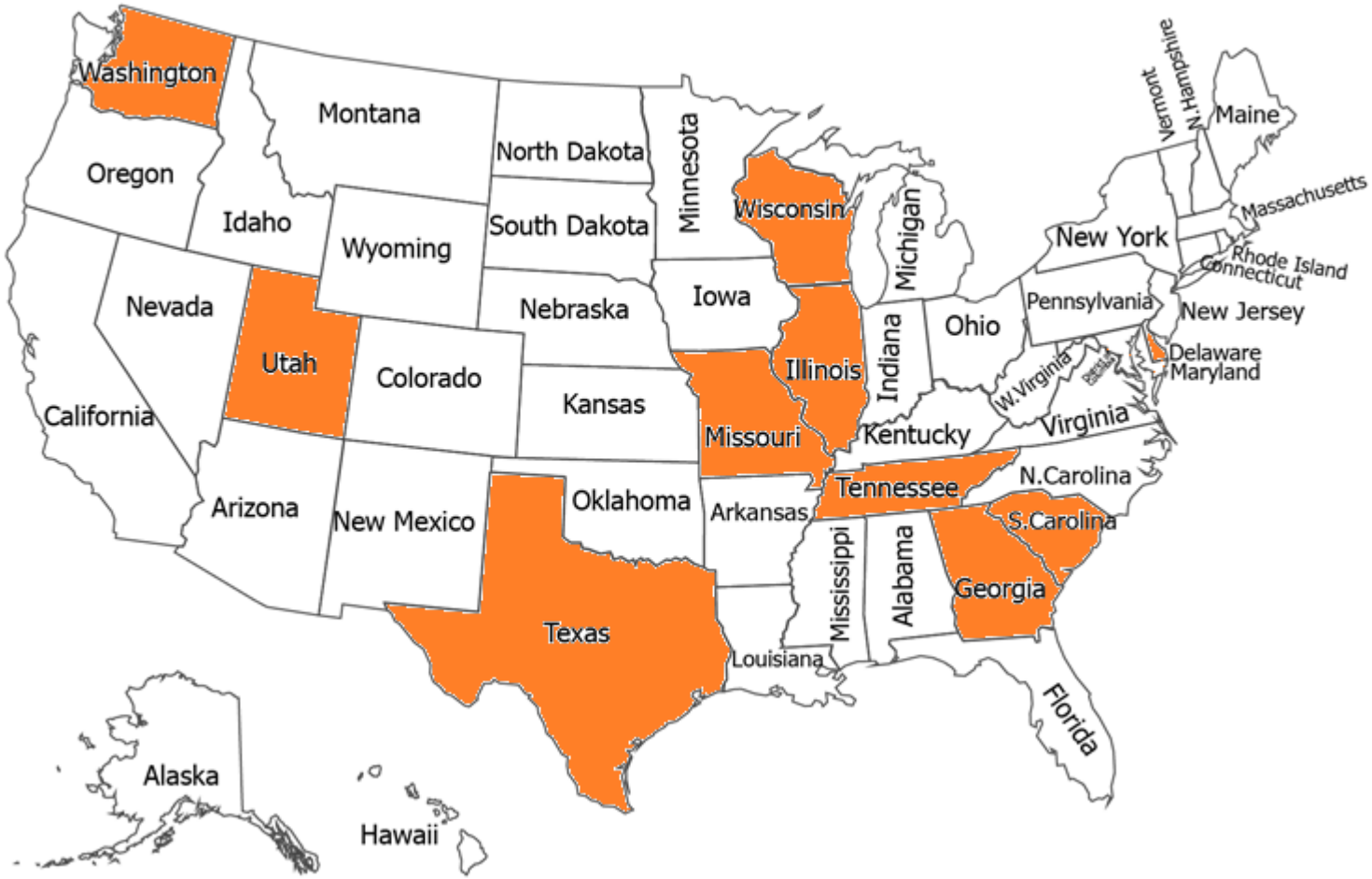
- *Aerosol exposure to virus:* shed in rodent urine, saliva, or feces.
- *Via direct inoculation:* rodent bites or scratches or contact with mucous membranes.

Cause in humans hemorrhagic fever with renal syndrome (HFRS)

Mortality: 2%



Introduction



SEOV cases were reported in patients with occupational exposure to wild rats.
In 2017, the US public health community investigated a multistate outbreak of SEOV in pet rats.

Materials and Methods

Human and rat anti-SEOV IgG and human IgM enzyme-linked immunosorbent assay (ELISA) at CDC's Viral Special Pathogens diagnostic laboratory.

Ribonucleic acid was extracted from blood and lung tissue.

A pan-hantavirus L segment-nested RT-PCR assay was performed on extracted RNA. Sequences obtained used to make specific, real-time RT-PCR.

The SEOV genomes were deposited into GenBank (MK360773-98)

Statistical Analysis were made using Microsoft Excel.

Results

209 blood specimens from 176 individuals were received for SEOV testing from December 2016 to May 2017.

Overall, 1947 rat specimens were tested by the CDC, which included 1377 blood specimen from 91 rats facilities.

Table 1. Reported Symptoms by 7 Case-Patients With Laboratory-Confirmed Recent SEOV Infection (IgM Detected)

Symptom	Cases Reporting (%)	Symptom	Cases Reporting (%)	Symptom	Cases Reporting (%)
Muscle aches	6 (86)	Joint pain	3 (43)	Hematuria	1 (14)
Headache	6 (86)	Chills	3 (43)	Ocular hyperemia	1 (14)
Fever	5 (71)	Diarrhea	3 (43)	Blurred vision	1 (14)
Decreased appetite	4 (57)	Sore throat	2 (29)	Back pain	1 (14)
Nausea	4 (57)	Dizziness	2 (29)	Chest pain	1 (14)
Abdominal pain	3 (43)	Shortness of breath	2 (29)	Sweating	1 (14)
Cough	3 (43)	Weight loss	2 (29)	Drowsiness	1 (14)

Abbreviations: IgM, immunoglobulin M; SEOV, Seoul virus.

Results

Table 3. Comparison of SEOV blood IgG ELISA and Carcass RT-PCR Results Performed in Parallel on 547 Rats

Test Result	RT-PCR-Positive Lung Tissue	RT-PCR-Negative Lung Tissue	Total
IgG-positive blood	128 (23%)	36 (7%)	164 (30%)
IgG-negative blood	31 (6%)	352 (64%)	383 (70%)
Total	159 (29%)	388 (71%)	547

Abbreviations: ELISA, enzyme-linked immunosorbent assay; IgG, immunoglobulin G; RT-PCR, reverse-transcription polymerase chain reaction; SEOV, Seoul virus.

Table 4. Comparison of SEOV Blood and Carcass RT-PCR Results Performed in Parallel on 41 Rats

Test Result	RT-PCR-Positive Lung Tissue	RT-PCR-Negative Lung Tissue	Total
RT-PCR-positive blood	12 (29%)	0	12 (29%)
RT-PCR-negative blood	16 (39%)	13 (31%)	29 (71%)
Total	28 (68%)	13 (31%)	41

Abbreviations: RT-PCR, reverse-transcription polymerase chain reaction; SEOV, Seoul virus.

Results

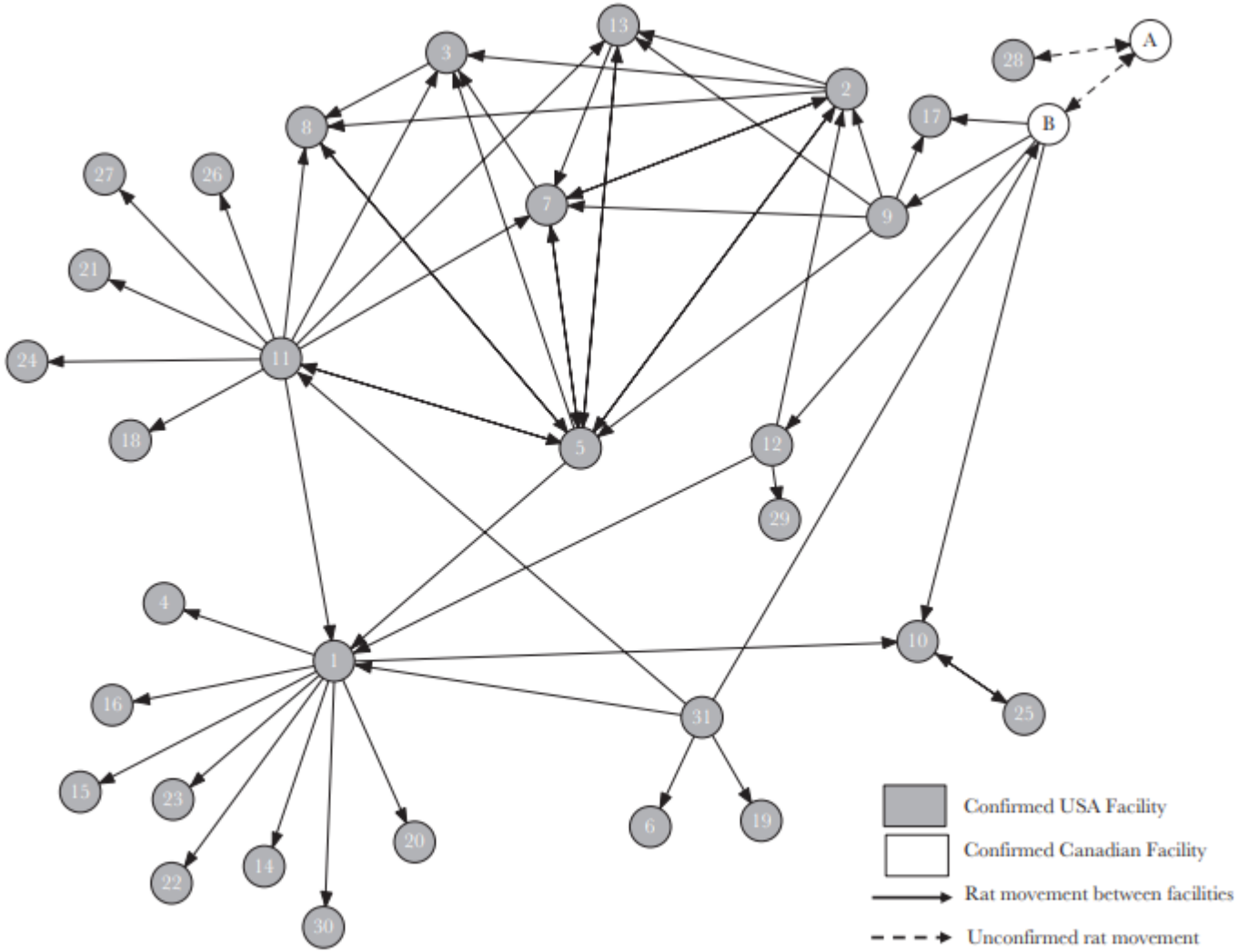


Figure 3. Transmission chain of Seoul virus-infected rats between confirmed facilities.

Discussion

2017 US SEOV outbreak investigation identified 31 facilities with infected rats or people, and 17 people with evidence of recent infection.

SEOV was described in wild Norway rats in the United State it was not reported previously in pets rats.

The relatively mild clinical course of illness in these patients stands in contrast to most New World hantavirus infections, where intubation and treatment for hypotension are a frequent feature.

Recommendations

Rattery owners can reduce the risk of SEOV infection in both their animals and in people by observing biosecurity measures that will reduce infection transmission between animals.

4-week quarantine

serological testing of new animals before commingling with the animals in the colony

cohorting animal groups, regular cleaning and disinfection of enclosures, and recordkeeping of animal acquisitions.