Emerging Infections and the Ecotone

Cover: Emerging Zoonoses and Pathogens of Public Health Concern
Basic Science

Medical Ecology

Applied Science
Basic Sciences:

- Geology
- Ecology
- Oceanography
- Hydrology
- Biochemistry and Molecular Biology
- Physics
- Atmospheric Sciences
- Chemistry
- Remote Sensing
Applied Sciences:

- Biostatistics
- Medical Sciences
- Epidemiology
- Anthropology
- Agronomy
- Environmental Health Sciences
- Socio-Medical Sciences
- Toxicology
- Medical Geography
To learn more, log on to:

www.medicaledcology.org
An ecotone is a narrow transition zone between one ecosystem and another.
<table>
<thead>
<tr>
<th>Characteristics reportedly elevated in Ecotones</th>
<th>Ecological process effected</th>
<th>Host-Parasite (pathogen) Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>species richness &amp; density</td>
<td>High frequency of novel species contact</td>
<td>increased opportunity for pathogen host-switch, species jumping</td>
</tr>
<tr>
<td>genetic diversity</td>
<td>Intense, diversifying selection pressure</td>
<td>increased opportunity for genetic exchange, genetic novelty</td>
</tr>
<tr>
<td>productivity</td>
<td>High population density</td>
<td>opportunity for pathogen persistence</td>
</tr>
<tr>
<td>Cross - and along boundary flows of energy, materials, and organisms.</td>
<td>High dispersal and regulation of movement and flows of species, water, and materials</td>
<td>increased opportunity for pathogen spread via host or environmental media (water, air, soil/sediment)</td>
</tr>
<tr>
<td>Environmental variability and gradients; habitat heterogeneity</td>
<td>Spatial and temporal environmental variation in biotic and abiotic factors</td>
<td>more rapid microbial, parasite or pathogen adaptation</td>
</tr>
</tbody>
</table>
### CDC Master List of Emerging Infectious Diseases

<table>
<thead>
<tr>
<th>Infectious Agents</th>
<th>Natural Reservoir</th>
<th>Source</th>
<th>Ecotone involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Cholera</td>
<td>copepods/water</td>
<td>fecal contam</td>
<td>Transmission leading to endemic or epidemic disease from shellfish or marine or estuarine water</td>
</tr>
<tr>
<td>1 Hantavirus pulmonary syndrome</td>
<td>vertebrates</td>
<td>rodents</td>
<td>Transmission mainly from wild rodents encroaching into homes and farm buildings</td>
</tr>
<tr>
<td>1 Hendra virus infection</td>
<td>vertebrates</td>
<td>bats</td>
<td>Spillover from Pteros bats to horses (MacKenzie et al 2001)</td>
</tr>
<tr>
<td>1 Influenza</td>
<td>vertebrates</td>
<td>birds</td>
<td>Spillover from migratory waterfowl, domestic fowl, to pigs; migratory waterfowl</td>
</tr>
<tr>
<td>1 Lyme disease</td>
<td>vertebrates</td>
<td>tick</td>
<td>hosts and vectors proliferate in forest edges</td>
</tr>
<tr>
<td>1 Nipah virus infection</td>
<td>vertebrates</td>
<td>bats</td>
<td>Spillover from Pteros bats to pigs</td>
</tr>
<tr>
<td>1 Rabies</td>
<td>vertebrates</td>
<td>mammals</td>
<td>Spillover to dogs or direct transmission from wild mammals</td>
</tr>
<tr>
<td>1 Yellow fever</td>
<td>vertebrates</td>
<td>mammals</td>
<td>Transmission leading to endemic or epidemic disease from mosquitoes at forest edges</td>
</tr>
<tr>
<td>African trypanosomiasis</td>
<td>vertebrate</td>
<td>mammals</td>
<td>Spillover from wild ungulates to pigs</td>
</tr>
<tr>
<td>2 Campylobacteriosis</td>
<td>vertebrates/water</td>
<td>Vibrio or fecal contaminated water</td>
<td>Spreads via ground and surface water; facilitated by human alteration of natural drainage systems</td>
</tr>
<tr>
<td>2 Chagas disease</td>
<td>vertebrates</td>
<td>Reduviid bug</td>
<td>Spreads via ground and surface water; facilitated by human</td>
</tr>
</tbody>
</table>
The main animal hosts of vector-borne diseases

Disease

Arboviruses:
- dengue
- haemorrhagic dengue
- yellow fever
- encephalitis

Dracunculiasis

Filariasis:
- Bancroftian
- Brugian
- Loiasis
- onchocerciasis

Leishmaniasis:
- cutaneous
- visceral

Malaria
- Schistosomiasis

- mansoni
- hematobium
- japonicum

African trypanosomiasis
- Rhodesian
- Gambian

hosts:
- pigs
- birds
- rodents
- monkeys
- large herbivores
- carnivores
- human is principle host
Associations between vectors, diseases and water

Disease
Arboviruses:
- dengue
- haemorrhagic dengue
- yellow fever
- encephalitis

Dracunculiasis
Filarisis:
- Bancroftian
- Brugian
- Loiasis
- onchocerciasis

Leishmaniasis:
- cutaneous
- visceral

Malaria
Schistosomiasis
African trypanosomiasis

The vector's relationship with water
- Breeds in water
- Breeds in wet ground
- Breeds in damp ground
- Lives near water
- Found in drinking water
- Entire life cycle in water
- Lives elsewhere
The principle diseases in relation to the principle habitats of the vectors

<table>
<thead>
<tr>
<th>Disease</th>
<th>Arboviruses:</th>
<th>dracunculiasis</th>
<th>filariasis:</th>
<th>leishmaniasis:</th>
<th>malaria</th>
<th>schistosomiasis</th>
<th>african trypanosomiasis</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>dengue</td>
<td></td>
<td>bancroftian</td>
<td>cutaneous</td>
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<td></td>
<td>haemorrhagic dengue</td>
<td></td>
<td>brugian</td>
<td>visceral</td>
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<td></td>
<td>yellow fever</td>
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<td>loiasis</td>
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<td></td>
<td>encephalitis</td>
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<td>onchocerciasis</td>
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<td>arid and semi-arid lands</td>
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<td>rain forests</td>
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<td></td>
<td>riverain vegetation</td>
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<td>savanna woodlands</td>
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<td></td>
<td>irrigation ditches and canals</td>
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<td></td>
<td>lakes and ponds</td>
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<td></td>
<td>wetland rice cultivation</td>
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<td></td>
<td>rivers and streams</td>
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<td></td>
<td>human settlements</td>
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<td></td>
<td>coastal plains</td>
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</tbody>
</table>
Environmental disturbance leads to emergence or establishment of infectious agents

Urbanization: (encroachment into natural systems)
- Cholera
- Rabies
- Lyme Disease
- Arboviruses - Yellow Fever, Dengue Fever
- Ebola, Lassa, Hanta
- Plague
- African Sleeping Sickness
Cholera
Cholera
Then and Now

John Snow
Rita Colwell
Distribution Of Estuaries
El Niño Increases Diarrheal Disease Incidence by 200 Percent

The El Niño phenomenon--the warming of the equatorial Pacific ocean that occurs every two to seven years--has been linked to outbreaks of dengue, malaria, and cholera. Now, researchers from the Johns Hopkins School of Public Health, A.B. Prisma, and the Instituto Nacional de Salud in Lima, Peru, have found that the 1997-1998 El Niño season increased hospitalizations for diarrheal disease by 200 percent, according to a study published in the February 5th issue of *The Lancet*. The results are cause for concern, said the researchers, since diarrhea already causes one billion episodes and three million deaths annually in children under five worldwide.
Trophic Relationships Of The Mangrove Estuary

From: E. Odum *Fundamentals Of Ecology*
Ecology of Cholera Epidemics

Throw net fishing for crustacea after the monsoons in Bay of Bengal

Fecal contamination of freshwater and human activities

Filter-feeding crustacea

Copepod

Numbers increase during monsoons due to phytoplankton blooms

Cholera bacteria
**Vibrio cholerae** and its relatives are marine microbes, fully integrated into their respective food webs.

Environmental conditions favoring growth of vibrio:

1. **Low salt**
2. **High Nutrient Load**
3. **20°C**
4. **Triggers phytoplankton bloom**
5. **Followed by zooplankton bloom**
6. **Followed by a cholera outbreak**
Monsoons

1. lower the salinity of the estuary
2. bring nutrients to the estuary
3. raise the ambient water temperature of the estuary
World Distribution of Rabies

*Rabies in this manual is defined as a disease caused by Lyssaviruses belonging to serotype/genotype 1.*
Rabies vectors and carriers
Fruit Bats

Did you know?
30% of all mammalian species are bats

Vampire Bat

rabies virus

Nipah virus
Hematophagous (vampire) bats are proliferating because of forest devastation in the state of Maranhão, northeastern Brazil. 20 cases of fatal rabies have been clinically documented. The population in the area is protecting their houses with wire nets to prevent bat bites.

Dr. Luciano Goldani
Infectious Diseases Unit
Universidade Federal do Rio Grande do Sul
Brazil
Control of rabies by oral bait-vaccine

3.1 Rabies Situation and Rabies Control in the Czech Republic 2000 – 2002

by O. Matouš1 and J. Vlásák2
1State Veterinary Institute, Liberec 30, CZ
2State Veterinary Administration, Prague, CZ

1. Oral vaccination of foxes

The field trial of oral immunization of foxes was started in the Czech Republic in spring 1989. The first application of the oral rabies vaccine (SAD B19-Tübingen) was carried out in the districts Klášter, Domazlice and Tachov adjacent to the German border in spring 1999. During the course of the next campaigns the treated area was extended covering 44 districts in autumn 1992. In the autumn 1993 the whole territory of the Czech Republic, with exception of rabies free districts bordering Germany, was included.

Since 1992 only the Czech made vaccine LYSOVLPEN manufactured by BIOVETA fromnice with the SAD B19 vaccine virus strain has been used in the Czech Republic.

The “Bavarian model” was applied during all vaccination campaigns. Voluntary hunters distributed the vaccine baits by hand in their hunting preserves. The strategy of two vaccination campaigns per year, one in spring and one in autumn, was applied. From 1996 aerial distribution of the vaccine baits was selectively used on a restricted territory (4 – 6 districts). In the last years, the aerial vaccination was extended to 50% of the treated territory (28 districts) in 2002. (See Map). More than nineteen million of vaccine baits were used from 1989 till the autumn 2002.
Thanks, Louie!
Yellow Fever

Distribution of Yellow Fever

“A man, a plan, a canal. Panama”

Walter Reed
Aedes aegypti
the yellow fever mosquito
Copyright © 1995 Leonard E. Munstermann
Panama Canal: 
The Early days
Canopy Transmission
By Haemogogus sp.
Ecology of Transmission
Of Yellow Fever

Ecotone

YF transmission patterns

Jungle mosquitoes

Monkeys

Humans in transition (emergence) zone

Humans in City

Aedes aegypti
Occupations at High Risk

Rubber

Coffee

Sugar cane

Insurgent
Lassa fever
Lyme Disease

Willy Burgdorfer

Ixodes scapularis

Borrelia burgdorferi
Lyme Disease Maintenance: Urbanization and De-forestation
Westchester County, NY
African Trypanosomiasis
East African Savanna
Riverine Tsetse and agriculture
Civil Unrest and War - 2005

Liberia
Côte-d’Ivoire
Sudan
Ethiopia
Nigeria
Sierra Leone
Guinea
Ghana
Burundi
Burkina Faso
Cameroon
Gambia
Rwanda
Swaziland
Mauritania
Zambia
Central African Republic
Namibia
Democratic Republic of Congo

Cases - 400,000/yr
Deaths - 60,000/yr

Refugees
Leishmaniasis

12 million people infected
350 million people at risk

Visceral
Cutaneous / Mucocutaneous
The principle diseases in relation to the principle habitats of the vectors:

**Disease**
- Arboviruses:
  - dengue
  - haemorrhagic dengue
  - yellow fever
  - encephalitis
  - Bancroftian
  - Brugian
  - Loiasis
  - onchocerciasis
- Leishmaniasis:
  - cutaneous
  - visceral
- Malaria
- Schistosomiasis
- African trypanosomiasis

Habitats:
- arid and semi-arid lands
- rain forests
- riverain vegetation
- savanna woodlands
- irrigation ditches and canals
- lakes and ponds
- wetland rice cultivation
- rivers and streams
- human settlements
- coastal plains
Rodent Holes and Sandfly Habitat
Reservoir Hosts
Encroachment and Vector-borne Diseases
Occupations at Risk

Rubber

Coffee

Sugar cane
Malaria

PLASMODIUM FALCIPARUM
Some Important Vectors

Anopheles gambia

Anopheles dirus

Anopheles balabacensis
Oasis habitat
Marsh habitat
Irrigation Canal Habitat
Swampland Habitat
Rice Paddy Habitat
What’s Next?
Without an ecological perspective on infectious disease transmission, it's anyone’s guess!