Preventing human diseases by altering pathogen transmission in animal reservoirs (AKA “...taking it to the streets...”)

Charles E. Rupprecht
Viral & Rickettsial Zoonoses Branch
RATIONALE FOR TARGETING SUSPECTED RESERVOIRS:

Basic goals (prevention, control, elimination, eradication, etc.?)
Status (exotic, enzootic, epizootic, etc.?)
Species (domestic, wild, ‘pests’, ‘charismatic megafauna’, etc.?)
Disease ecology (deemed simple or complex; pathogenesis, etc.?)
Methods (practical, feasible, temporal dynamics, etc.?)
Economics (start-up costs, short term benefits, etc.?)
Infrastructure (inter-sectoral cooperation, diagnostics, etc.)
Society (culture, traditions, religious beliefs, education, community participation, etc.?)
ZOONOSIS PREVENTION & CONTROL

QUALITATIVE CONCERNS: VEHICLES* OF TRANSMISSION
*(more than 1 may apply)

Flesh
Hide
Saliva
Blood
Milk
Gametes

Vertebrate Species ABC

Hair
Feces
Urine
Offspring
ORIGINS FOR TARGETING SUSPECTED RESERVOIRS?

- Oral/Written History
- Religious or Cultural Traditions
- Legends: Mythology, Fables, Fairy Tales, Folklore
- Common Sense
- ‘Organized’ Medicine
- Modern theory
Gradual rise in the belief about “germs” and their effects in animal populations

- By the mid-to late 19th century, many professional veterinarians throughout Europe were beginning to accept the notion that epizootics were contagions caused by the spread of disease-matter (‘materies morbi’), unlike the majority of their other biomedical colleagues...

- Institution of quarantines, and destruction of obviously ill animals, could serve to impede disease spread.
Professional acceptance of killing vs. healing in large animal veterinary medicine (economy over sentimentality)

- Replacement costs often more timely, less costly than repairs
- More expedient to harvest, before animal values fell further
- Increasing sensibility of slaughter choices in reducing risks
- Appreciation of individual carcass rendering, compared to en masse disposal during large outbreaks
“Something in the air tonight…”

- Despite their historical distance from so-called “horse doctors” and “veterinary quacks”, many prominent 19th century European physicians held to the conviction that certain diseases were endemic and sporadic, relating to a generalized belief in ‘miasmas’ (‘poisoned airs’), and that overall environmental improvements would gradually prevent the generation and diffusion of such poisons in animal and human populations...
Support for ‘anti-contagionism’ and global markets

Coupled with the ideals of ‘miasmas’, many supporters of free trade viewed methods such as quarantine, exclusion, import inspection, taxes, slaughtering practices, etc. as an intrusion, nothing more than a nationalistic means of economic protectionism, rather than a prohibition against the potential introduction and exchange of animal pathogens.

Obviously, history held no monopoly on corruption or incompetence...
Zoonosis Prevention & Control

Spatio-Temporal & Resource Issues

- Quarantines
- Import/export
- Stray removal
- Garbage disposal
- Health certificates
- Spay/neuter
- Poop scoops
- Muzzling
- Confinement
- Leashes
- Vertebrate Species ABC
- Exclusion
- Food inspections
- Zoning
GROSS ENTRY RESTRICTIONS: COARSE-GRAINED

COUNTRY ABC

X

SPECIES & SOURCE ABC
SITE RESTRICTIONS: MEDIUM-GRAINED

SINK
ABC
(e.g. government, university, zoo, private, etc.)

X

SPECIES
ABC
ZOOONOSIS PREVENTION & CONTROL

UTILIZATION RESTRICTIONS: MORE FINE-GRAINED

USE ABC

X

SPECIES ABC
SELECTED EXAMPLES OF REGULATED ANIMAL USE

- FOOD
- COMPANIONSHIP
  - LABOR
  - FUR
  - EDUCATION
  - Vertebrate Species
  - ABC
  - TRANSPORTATION
  - SPORT
- RESEARCH
- ENTERTAINMENT
- RITUAL
- INDUSTRIAL PRODUCTS
COMING TO TERMS WITH LETHALITY: “FATAL DISTRACTIONS”

EUTHANASIA
SELECTED CULLING
PREDATOR CONTROL
SANCTIONED BOUNTIES

Vertebrate
Species
ABC

POPULATION REDUCTION
TEST/SLAUGHTER
OPEN SEASONS
HABITAT DESTRUCTION

‘VERMIN’ REGULATION, ALA SNAKE ROUND-UPS, SHARK HUNTING REDUX’ ‘JAWS’

INTENTIONAL EXTIRPATION
Helminth control: Prevalence of *Echinococcus granulosus* (Gemmell & Roberts, 1998)
Baylisascaris, raccoon latrines, and the great outdoors...

STOP ITINERANT PROCYONID DEFECATION TODAY!
ANTHRAX

Ingested (grazing/browsing/drinking)
inhaled sometimes? (spore-laden dust)
Fly-bite sometimes?

Pulmonary (spore-laden dust)

Gastrointestinal (infected meat, contaminated water/vegetables?)

Cutaneous (via lesion. From handling infected meat/contaminated materials. Fly bite sometimes?)

If hygiene poor

TURNBULL, 1998

HERBIVORE
Germination & multiplication in lymphatics & spleen. Vegetative forms released in massive numbers into the blood in final hours of life

SPORES
Sporulate on exposure to O₂

VEGETATIVE FORMS
(shed at death in haemorrhagic exudate from nose, mouth or anus or in spilt blood)
BOVINE BRUCELLOSIS

(1) Define area of action

(2) Is Brucellosis present? What type?

YES

(4) Define unit of action

NO

(3) Protect area

Surveillance

* Replacement animals

(5) Is surveillance available?

YES

(7) Prevalence / unit in area?

NO

* Systematic vaccination

< 1%

1-5%

>5%

(8) Test and slaughter

* Combined

Surveillance

Replacement animals

until 1%

5-10 years

until < 5%

PLOMMET et al., 1998
ZOONOSIS PREVENTION & CONTROL

Cat Scratch Disease

- Source/breed/temperament
- Selection of older cats
- Claw trimming
- Bite/scratch behavior modification
- Flea control
- Vaccination??
Total Feral Cat Colony Management For a Potpourri of Problems

- Restricted additional members
- Resource control
- Vaccination
- Drug treatment
- Spay/Neuter
- Surgery
- Euthanasia
Zoonosis Prevention & Control

Rodents & HFRS viruses

- Rodenticides
- Household exclusion
- Habitat modification
- Refuse removal
- Predator promotion
- Pathogen introduction
Defining the problem: the Filovirus reservoir(s)?

WHO
WHAT
WHERE
WHEN
HOW

---------------------------------- WHY?
Examining the issues: possible zoonosis ‘wannabes’

- Borna disease is a condition of horses and other vertebrates caused by a negative-stranded RNA virus
- Touted as an emerging zoonosis in human affective disorders
- Objective interpretations of serology and PCR data appear related in part to cross-reactivity and contamination
- Any implied methodology to target reservoirs for specific control would be impractical when information in toto suggests alternative explanations...
Xenotransplantation issues

- Rather than focus solely on a short laundry list of known pathogens to screen, proper and rigorous health promotion at the captive animal population level (closed herd, flock, school, etc.) is perhaps the better route...
QUINTESSENTIAL RABIES CONTROL IN ANIMALS

- Quarantine/Restricted Entry
- Population Reduction
- Movement Restriction
- Habitat Modification
- Parenteral Vaccination
- Oral Immunization
This illustration from Daniel’s Rural Sports (1807) details operation for removal of “worm” (lyssa) from the tongue, thought for centuries to prevent rabies. At top, lines indicate site of incision. At center, mucous membrane is reflected and lyssa dissected away. At bottom is extracted “worm.”

BAER et al., 199
10 February 1831.

A BILL
To prevent the spreading of Canine Madness.

Note.—The Words printed in Italics are proposed to be inserted in the Committee.

WHEREAS many of His Majesty's Subjects have suffered from the disease occasioned by the bite of Dogs in a rabid state, and in such cases death hath ensued; And whereas in cases where parties suffer from the bite of Dogs no summary compensation can be had by them for the same, and it is expedient to provide such summary compensation: And whereas mischief to other Animals in which His Majesty's subjects have a property, hath also often ensued from the bite of Dogs: And whereas no summary compensation for such mischief can be had by the owners of such Animals; and it is therefore expedient at all times, when Canine Madness is known to be prevalent, to prevent Dogs from going at large, and to empower Justices of the Peace and others to seize the owners, and if necessary, to cause any Dogs to be destroyed, and also and at all times to make summary compensation to the parties injured by the bite of Dogs, or to the owners of Animals so injured; BE IT therefore Enacted, by the King's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the Authority of the same, THAT from and after the passing of this Act, it shall be lawful for any Justice of the Peace, or Chief Magistrate, on information or suspicion of the existence of Canine Madness, to issue a public Notice, requiring all Dogs within any parish, wapentake, division, city, borough, liberty, township, market town, franchise, hamlet, titling, precinct and chapelry, mentioned in such notice, to be kept confined during the time therein stated.

England Muzzling Law, 1831.

BAER et al., 1996
FLEMING, 1872
VACINE SEU CÃO
CONTRA RAIVA
Monthly incidence of animal rabies, Houston–Harris County, Texas, January 1953 to October 1955 (Tierkel, 1956).
SELECTED EXAMPLES OF CANINE RABIES ELIMINATION

- United Kingdom, 1922
- Malaysia, 1955
- Japan, 1956
- Taiwan, 1961
- Portugal, 1961
- Uruguay, 1983
Thailand

Rabies PET

- about 2.6 mill dogs annually vaccinated
- annual costs US$ 6.5 mill

Rabies death
# Vampire Bat Population Reduction: Anti-coagulant Use

<table>
<thead>
<tr>
<th>Method</th>
<th>Place</th>
<th>Bite Reduction</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systemic</td>
<td>Mexico (ir)</td>
<td>90-98%</td>
<td>Thompson et al. 1972</td>
</tr>
<tr>
<td>Tx. Cattle</td>
<td>Mexico (im)</td>
<td>88-97%</td>
<td>Flores-Crespo et al. 1979</td>
</tr>
<tr>
<td>Topical</td>
<td>Mexico</td>
<td>81-95%</td>
<td>Flores-Crespo et al. 1991</td>
</tr>
<tr>
<td>Tx. Bites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topical</td>
<td>Mexico</td>
<td>96%</td>
<td>Flores-Crespo et al. 1991</td>
</tr>
<tr>
<td>Tx. Bats</td>
<td>Brazil</td>
<td>91-100%</td>
<td>Kverno et al. 1976</td>
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A MODEL OF VAMPIRE BAT CONTROL (Massad et al. 2001)
A MODEL OF VAMPIRE BAT CONTROL (Massad et al. 2001)

![Graph showing the relationship between the proportion of intervention and rabies prevalence, comparing Bat Control and Vaccination.]
Common Bat Entry Points

Under eaves
Under loose shingles
Down chimney
Openings around chimney
Through vents
Through open, unscreened windows
Under or through open doors
**POPULATION REDUCTION: Alberta, Canada 1952-56 (strychnine baits)**

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Number Poisoned</th>
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<tbody>
<tr>
<td>Fox</td>
<td>55,889</td>
</tr>
<tr>
<td>Coyote</td>
<td>53,364</td>
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<tr>
<td>Lynx</td>
<td>10,044</td>
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<tr>
<td>Wolf</td>
<td>5,461</td>
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<tr>
<td>Bear</td>
<td>4,130</td>
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<tr>
<td>Skunk</td>
<td>664</td>
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<tr>
<td>Cougar</td>
<td>69</td>
</tr>
<tr>
<td>Fisher</td>
<td>18</td>
</tr>
<tr>
<td>Fisher</td>
<td>18</td>
</tr>
<tr>
<td>Badger</td>
<td>4</td>
</tr>
<tr>
<td>Wolverine</td>
<td>1</td>
</tr>
</tbody>
</table>

Ballantyne, 1958
A FOCUS ON THE RESERVOIR(S) OR A QUESTION OF BALANCE?

- Dairy/beef & bovine tuberculosis?
- Small ruminants & brucellosis?
- Poultry practices & influenza?
- Cannibalistic hoofed stock and TSEs?
- Modern swine production & Nipah?
- Etc.