Investigating the emergence, prevalence, and dispersal of antibiotic resistant *E. coli* infecting wild birds in Alaska

Andrew Ramey

*US Geological Survey, Alaska Science Center, 4210 University Drive, Anchorage, Alaska 99508*
Acknowledgements

Jonas Bonnedahl  
Linnaeus University

Björn Olsen  
Uppsala University

USGS Alaska Science Center  
John Reed  
Andy Reeves  
Lee Tibbits  
Matthew Smith

Swedish National Veterinary Institute  
Stefan Börjesson
Erythromycin

D’Costa et al. 2006

D’Costa et al. 2011
genes encoding resistance to ß-lactam, tetracycline and glycopeptide antibiotics
The New York Times

The World Wakes Up to the Danger of Superbugs

By THE EDITORIAL BOARD  SEPT. 28, 2016


TIME

HEALTH DRUGS
Farm Animals Are Now Resistant to a Last-Resort Antibiotic

TIME

HEALTH DRUGS
Why Drug-Resistance Genes Are Showing Up In Smog

The Washington Post

Report: Studies reveal drug-resistant super bacteria in Rio Olympics water venues

Early Lead


Several bodies of water in Rio that will be used both as leisure spots and Olympic event sites contain antibiotic-resistant super bacteria. (AP Photo/Giulio Izquierdo, File)

USGS

science for a changing world
Furuya and Lowy 2006
High prevalence of antimicrobial-resistant genes and integrons in *Escherichia coli* isolates from Black-headed Gulls in the Czech Republic

M. Dolejska¹, A. Cizek¹ and I. Literak²

Carriage of CTX-M type extended spectrum β-lactamases (ESBLs) in gulls across Europe

Johan Stedt¹, Jonas Bonnedahl², Jorge Hernandez³, Jonas Waldenström¹, Barry J. McMahon⁴, Conny Tolf⁴, Björn Olsen³ and Mirva Drobný³*
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Multilocus Sequence Typing Confirms Wild Birds as the Source of a *Campylobacter* Outbreak Associated with the Consumption of Raw Peas
Patrick S. L. Kwan⁶, Catherine Xavier⁷, Monica Santovenia⁸, Janet Pruckler⁹, Steven Strolka⁹, Kevin Joyce⁹, Tracie Gardner,⁹ Patricia L. Fields,⁹ Joe McLaughlin,⁹ Robert V. Tauxe,⁹ Collette Fitzgerald⁹

STUDY OF THE BACTERIAL CONTENT OF RING-BILLED GULL DROPPINGS IN RELATION TO RECREATIONAL WATER QUALITY
Benoît Lévesque¹*, Pierre Brousseau², France Bernier³, Éric Dewailly¹ and Jean Joly³

THE CONTAMINATION OF A MAJOR WATER SUPPLY BY GULLS (*Larus* sp.)
A STUDY OF THE PROBLEM AND REMEDIAL ACTION TAKEN
C. Benton¹, F. Khan¹, P. Monaghan², W. N. Richards¹ and C. B. Shedden²
Evidence for intercontinental parasite exchange through molecular detection and characterization of haematozoa in northern pintails (Anas acuta) sampled throughout the North Pacific Basin

Andrew M. Ramey a,b,*, Joel A. Schmutz a, John A. Reed a, Go Fujita c, Bradley D. Scotton d, Bruce Casler e, Joseph P. Fleskes f, Kan Konishi g, Kiyoshi Uchida h, Michael J. Yabsley b,l

Dispersal of H9N2 influenza A viruses between East Asia and North America by wild birds

Andrew M. Ramey a,*, Andrew B. Reeves a, Sarah A. Sonsthagen a, Joshua L. TeSlaa b, Sean Nashold b, Tyrone Donnelly a, Bruce Casler c, Jeffrey S. Hall b

Genetic diversity and mutation of avian paramyxovirus serotype 1 (Newcastle disease virus) in wild birds and evidence for intercontinental spread

Andrew M. Ramey · Andrew B. Reeves · Haruko Ogawa · Hon S. Ip · Kunitoshi Imai · Vuong Nghia Bui · Emi Yamaguchi · Nikita Y. Silko · Claudio L. Afonso
Comparison of Extended-Spectrum β-Lactamase (ESBL) CTX-M Genotypes in Franklin Gulls from Canada and Chile

Jonas Bonnedahl1,2,*, Johan Stedt1, Jonas Waldenström1, Lovisa Svensson1, Mirva Drobní3, Björn Olsen3
<table>
<thead>
<tr>
<th>country</th>
<th>% of <em>E. coli</em></th>
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</thead>
<tbody>
<tr>
<td>Spain</td>
<td>75%</td>
</tr>
<tr>
<td>France</td>
<td>47%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>38%</td>
</tr>
<tr>
<td>Chile</td>
<td>30%</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>29%</td>
</tr>
<tr>
<td>England</td>
<td>27%</td>
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<tr>
<td>Sweden</td>
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</tr>
<tr>
<td>Latvia</td>
<td>17%</td>
</tr>
<tr>
<td>Portugal</td>
<td>13%</td>
</tr>
<tr>
<td>Ireland</td>
<td>5%</td>
</tr>
<tr>
<td>Poland</td>
<td>1%</td>
</tr>
<tr>
<td>Denmark</td>
<td>0%</td>
</tr>
</tbody>
</table>

Dissemination of Multidrug-Resistant Bacteria into the Arctic

Maria Sjölund,*† Jonas Bonnedahl,† Jorge Hernandez,‡ Stina Bengtsson,* Gunilla Cederbrant,* Jarone Pinhassi,‡ Gunnar Kahlmeter,*§ and Björn Olsen‡§

We show that Escherichia coli isolates originating from Arctic birds carry antimicrobial drug resistance determinants. This finding implies that dissemination of drug-resistant bacteria is worldwide. Resistance genes can be found even in a region where no selection pressure for resistance development exists.

We show that *Escherichia coli* is disseminated among Arctic birds and even in a region where no threat from resistant bacteria is worldwide. This finding implies that dissemination of resistant bacteria is worldwide, even in a region where no threat from resistant bacteria is worldwide.
Dissemination of Multidrug-Resistant Bacteria into the Arctic Environment

Maria Sjölund,†
Jorge Hernández...
Gunilla Cederbrann
Gunnar Kahlmeter

We show that Escherichia coli and Klebsiella pneumoniae in Arctic birds carry antimicrobial resistance. This finding implies that the dissemination of resistant bacteria is worldwide, even in a region where no similar development exists.

<table>
<thead>
<tr>
<th>Location</th>
<th>Isolates ($n =$)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenai Peninsula (urban)</td>
<td>55</td>
<td>4</td>
<td>14</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Middleton Island (remote)</td>
<td>60</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Atterby et al. 2016*
### **Number of compounds E. coli resistant to:**

<table>
<thead>
<tr>
<th>Location</th>
<th>Isolates (n =)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>7</th>
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<td>0</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

30/55 = 55%

5/60 = 8%

***significant Kenai Peninsula vs Middleton Island, P value <0.0001, two-tailed Fisher’s exact test***

Atterby et al. 2016
<table>
<thead>
<tr>
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</tr>
<tr>
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<td>2</td>
<td>1</td>
<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

12/55 = 22%

1/60 = 2%

***significant Kenai Peninsula vs Middleton Island, P value <0.001, two-tailed Fisher’s exact test

Atterby et al. 2016
12/55 = 22%
1/60 = 2%

***significant Kenai Peninsula vs Middleton Island, P value <0.001, two-tailed Fisher’s exact test

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<tbody>
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<td>Kenai Peninsula (urban)</td>
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<td>Middleton Island (remote)</td>
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12/55 = 22%
1/60 = 2%

***significant Kenai Peninsula vs Middleton Island, P value <0.001, two-tailed Fisher’s exact test
\[ \frac{2}{55} = 22\% \]

\[ \frac{1}{60} = 2\% \]

***significant Kenai Peninsula vs Middleton Island, P value <0.001, two-tailed Fisher’s exact test**

Atterby et al. 2016
Pilot project on ABR bacteria dispersal by migratory birds
• sample at two remote areas: outer Yukon-Kuskokwim Delta and Middleton Island
• compare prevalence of ABR *E. coli* in species:
  1. that use anthropogenically influenced habitats in winter and remote areas in summer
  2. that inhabit remote areas year round
Potential outcomes:

1. higher prevalence of antibiotic resistant *E. coli* in species that winter in anthropogenically influenced habitats as compared to sympatric species that inhabit remote areas of North America year-round

2. equally low prevalence of antibiotic resistant *E. coli* in species with contrasting life histories

3. equally high prevalence of antibiotic resistant bacteria in species with contrasting life histories
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GWFG  low = low

SPEI
Potential outcomes:

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GWFG  
SPEI  
high = high
Results: Outer Yukon-Kuskokwim Delta...
Results: Outer Yukon-Kuskokwim Delta...

No evidence for antibiotic resistant *E. coli* phenotypes
Results: Middleton Island...

BLKI

GWGU
Results: Middleton Island...

BLKI

No evidence for ABR

E. coli phenotypes

GWGU
Results: Middleton Island...

BLKI

No evidence for ABR E. coli phenotypes

GWGU

- 2/89 ABR E. coli strains in random sample
- 12 ABR strains among 65 samples tested using selective screen
Antimicrobial Resistance in Generic *Escherichia coli* Isolates from Wild Small Mammals Living in Swine Farm, Residential, Landfill, and Natural Environments in Southern Ontario, Canada

Samantha E. Allen,¹ Patrick Boerlin,¹ Nicol Janecko,² John S. Lumsden,¹ Ian K. Barker,¹ David L. Pearl,² Richard J. Reid-Smith,²,³ and Claire Jardine¹*

Department of Pathobiology¹ and Department of Population Medicine,² Ontario Veterinary College, University of Guelph, Guelph, Ontario, Canada, and Laboratory for Foodborne Zoonoses, Public Health Agency of Canada, Guelph, Ontario, Canada³

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Antibiotic-Resistant Bacteria in Wild Primates: Increased Prevalence in Baboons Feeding on Human Refuse

ROSALIND M. ROLLAND,¹ GLENN HAUSFATER,²+ BONNIE MARSHALL,¹ AND STUART B. LEVY¹,³*

Departments of Molecular Biology and Microbiology¹ and Medicine,³ Schools of Medicine and of Veterinary Medicine, Tufts University, Boston, Massachusetts 02111, and Section of Neurobiology and Behavior, Division of Biological Sciences, Cornell University, Ithaca, New York 14853²
Ongoing/future work:

Local scale – research questions

1. How does prevalence of ABR *E. coli* in gulls at the mouths of the Kenai and Kasilof rivers compare to sites at the Soldotna landfill and the Upper Kenai River?

2. Is there evidence that ABR *E. coli* are dispersed by gulls between the Soldotna landfill and areas where people participate in personal-use fisheries?

3. Is there evidence for a seasonal peak in prevalence of ABR *E. coli* in gulls in the Kenai and Kasilof river watersheds and how does that relate in space/time with personal-use fisheries?
Ongoing/future work:

Local scale – research activities

- Mark 15 gulls with satellite transmitters at Soldotna landfill
- Sample gull feces at Upper Kenai River, Lower Kenai River, Lower Kasilof River, and Soldotna landfill during summer
- Sample exterior and interior surfaces of fish harvested in personal-use fisheries
Ongoing/future work:

Preliminary satellite transmitter data (n = 7)
Ongoing/future work:

Regional scale – research questions

1. What is the relationship between the population of local human communities and the prevalence of ABR *E. coli* in spatially proximate populations of large gulls in Alaska?
2. Is there evidence for dispersal of ABR *E. coli* among gull populations within Alaska?
Ongoing/future work:
Regional scale – research activities

- Sample gull feces at Adak, Anchorage, Bethel, Cold Bay, Nome, Soldotna, Unalaska, and Utqiaġvik in June and August of 2016/2017
- Phenotypically/genetically characterize resultant *E. coli* isolates
- Instrument large gulls at each location with satellite transmitters
Ongoing/future work:

Intercontinental scale – research questions

1. Do large gulls make migratory movements between East Asia and Alaska that could facilitate inter-hemispheric dispersal of ABR *E. coli* and other infectious agents?

2. Is there genetic evidence for inter-hemispheric dispersal of ABR *E. coli* in large gull populations sampled in Alaska and East Asia?
Ongoing/future work:

Intercontinental scale – research activities

- Sample gull feces at locations in Japan and South Korea in June and August of 2017
- Phenotypically/genetically characterize resultant *E. coli* isolates
- Apply satellite transmitters to large gulls at locations throughout Alaska
Questions?