Biological safety
Course
Zoonoses in the Arctic

History and epidemic of zoonoses in Svalbard

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Eva Fuglei
Norwegian Polar Institute

Photo: Jørn Dybdahl
Arctic fox is the main vector for zoonosis in the Arctic

- The tapeworm the *Echinococcus multilocularis*
- The rabies virus
- *Toxoplasma gondii*
The cestode *Echinococcus multilocularis*, found over large areas in the northern hemisphere, in Norway only found in Svalbard. Humans can also be infected.

Arctic foxes are the determinant host of the tapeworm *EM* and the sibling vole the intermediate host. Dogs can also be determinant hosts.

Henttonen et al. 2001; Fuglei et al. 2007; Stien et al. 2010
Echinococcus multilocularis
”Museparasitten” or ”revens dvergbendelorm”

- It has no English name
- It has a Latin name: Echinococcus multilocularis (E. multilocularis)
- It is a tapeworm (Latin: Cestoda, Norwegian: bendelmark)

- Bentelmarkene

- It is a big group of parasitic animals
- Adult worms develop in the intestines of vertebrates
- Do not have a mouth or intestines, but absorb nutrients through the body surface.
- It has a larval stage that is a parasite in another species than the adult stage
  - ”complex lifecycle”
The larvae stadium can survive and grow in several mammals, also humans, but small mammals are the most important group, specifically sibling voles and lemmings.

- Adult individuals lives and produces eggs in the intestines of foxes (arctic fox, redfox etc.), dogs, and sometimes in cats.
  
  A natural english name would be: “a small fox-tapeworm”

- The larvae stadium can survive and grow in several mammals, also humans, but small mammals are the most important group, specifically sibling voles and lemmings.

- It create cysts that grows over time, most often in the liver.

*Echinococcus multilocularis*
Both a vole parasite and a fox paracite
Life cycle of *Echinococcus multilocularis*

- Adult cestode in intestine of fox or dog
  - Eggs in vegetation eaten by voles
  - Eggs washed into vegetation
  - Eggs hatch and larval stage develop in liver
    - Vole with larvae eaten by fox or dog
  - Eggs in fox faeces
  - Eggs eaten by humans
Smitte til mennesker

- Skjer når vi får i oss eggene til *E. multilocularis*
  - Fingre i munnen etter kontakt med
    - reve eller hunde-møkk med egg
    - vegetasjon med egg på
  - Muligheten for smitte via mat er liten men kan skje hvis
    - sopp eller bær med egg spises
    - vann med egg drikkes

Smitte forebygges først og fremst ved *vask av hender*,
og koking av mat og vann.
Hunder holdes smittefri ved behandling med ”ormekur”

**Smitter ikke** fra mus til mennesker

- Musene er ikke farlige
- Hunder kan bli smittefarlige hvis de får lov til å spise mus
Global distribution of *E. multilocularis*

- *E. multilocularis* is found in Svalbard, but also in many other locations.
- It is a health concern in some places in the northern hemisphere, such as in Central Europe/Alps: 210 patients in 1991-2000.

Eckert *et al.* 2000
The distribution of *E. multilocularis* in Svalbard

The parasite was discovered for the first time in 1999

- Adult cestode develop in intestine of the arctic fox
- The larval stage develop in the sibling vole (*Microtus levis*)
Sibling vole (*Microtus levis*)

A small introduced rodent species with restricted spatial distribution.

Photo: N. Yoccoz, E. Fuglei
A recently introduced species to Svalbard

Probably introduced to Svalbard between 1920 and 1960

The distribution area of the sibling vole
Sibling vole distribution area in Svalbard:
The Isfjord area, between Barentsburg and Longyearbyen
Fuglebjella, Isfjorden

16 years live-trapping (capture re-capture) series
Ims, Yoccoz, Stien, Fuglei

- Extreme inter-annual variance
«Rain-on-snow» events drives the dynamics of resident vertebrates with highly contrasting life histories

Reindeer fecundity, sibling vole population abundance, and 'rain-on-snow' in perfect correlation.

Stien et al. 2012
Autopsy of sibling vole from Fuglefjella (trapped in Litle Bjørndalen).
The liver is almost completely capsuled by cysts of the parasite.

EM cysts in the liver

The eggs are spread through faeces from foxes or dogs.
The sibling voles are very local - Grumant/Fuglefylla. The arctic fox are using large areas and can spread the eggs over huge areas.

EM prevalence in arctic fox faeces
Grumant: 20-60%
Bjørndalen (2-6 km): 0
Nordenskiöld Land (6-40 km): 0
Distant (Ny-Ålesund, Hornsund, 110-130 km): 0
EM prevalence from carcasses of arctic foxes decrease with increasing distance from the vole population in Grumant. But foxes trapped on Austfjordnes were infected.

Stien et al. 2010

<table>
<thead>
<tr>
<th>Distance Range</th>
<th>EM Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10 km</td>
<td>36%</td>
</tr>
<tr>
<td>11-20 km</td>
<td>20%</td>
</tr>
<tr>
<td>21-40 km</td>
<td>0%</td>
</tr>
<tr>
<td>41-70 km</td>
<td>0%</td>
</tr>
<tr>
<td>&gt;70 km</td>
<td>8%</td>
</tr>
</tbody>
</table>
Arctic fox migration is the source for spreading of diseases

Pulses of arctic fox immigration to Svalbard driven by lemming cycles in the Russian Arctic

Henttonen et al. 2001, Mørk et al. 2011, Noren et al. 2011
To sum up
Grumant is the hot-spot and high risk area for human infection of *Echinococcus multilocularis*.

- High densities of arctic foxes because of the bird cliffs (positive faeces)
- Core area for the sibling voles – can reach very high densities

Risk management:
- Minimize the use of Grumant for recreational, teaching/research and tourist purposes
- Possibility for the voles to colonize new areas is highly dependent on the vegetation. The vegetation respond slowly to climate warming
Virus: Rabies
Arctic foxes major vector of rabies virus in the Arctic region (Greenland, Canada, Alaska, Russia, Svalbard).

First rabies outbreak in Svalbard in 1981

Prevalence in Svalbard: 1996-2004 - 0.3%

Second outbreak in Svalbard in 2011

Incubation period in arctic foxes: from 8 days to 6 months. After onset of symptoms foxes die after one or two days.
Arctic fox with rabies attacking a polar dog at Hopen, Svalbard, January 2011
### Summary of rabies in Svalbard

<table>
<thead>
<tr>
<th>Year</th>
<th>Arctic fox</th>
<th>Svalbard reindeer</th>
<th>Ringed seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>13</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>1981</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1987</td>
<td>2</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>1990</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>1 (trapped at Austfjordnes)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>1 (found dead LYB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>4 (Hopen, LYB, Hornsund)</td>
<td>10 (LYB/Hornsund)</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>1 (LYB January)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Arctic fox migration is the source for spreading of diseases

Pulses of arctic fox immigration to Svalbard driven by lemming cycles in the Russian Arctic

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To sum up
Rabies:
- Probably not enzootic in Svalbard, because the density of arctic foxes is too low.
- Outbreaks are dependent on reintroductions by arctic foxes migrating over the sea ice from the Russian arctic or Greenland.

Risk management:
- Due to climate warming and reducing sea ice, the probability for new outbreaks (new introductions) decreases with decreasing sea ice.
One celled parasite: 
*Toxoplasma gondii* is a protozoan of the family *Sarcocystidae*, with a worldwide distribution.

Can infect all warm-blooded animals, but felids as cats are the only known definitive host

Found to be a disease factor and possible mortality factor in arctic foxes in Svalbard. Showed to be the cause of death in young arctic foxes, but also in adults. 
Prevalence in arctic foxes: 43%.
Prevalence in barnacle goose: 7%
Possible source of infection in arctic foxes is through arctic breeding geese, but also from the marine ecosystem.

Sørensen et al. 2005; Prestvold et al. 2007; Stacey et al. 2016

Photo: J. Madsen
Prevalence of Toxoplasma gondii in the marine ecosystem

Bearded seals: 67%
Polar bears: 46%
Ringed seals: 19%
Walruses: 6%

Prevalence of Toxoplasma gondii in polar bears has doubled in the past decade.
Can be caused by an increase in number or survivorship of oocysts being transported via the North Atlantic Current to Svalbard from the south

Prestrud et al. 2007, Jensen et al. 2010
To sum up

- *Toxoplasma gondii* prevalence in arctic foxes, but also in polar bears and seals are surprisingly high in Svalbard. It appear to be increasing in the marine ecosystem.

- Difficult to explain, but there are several hypothesis.
  - increasing arctic breeding geese populations
  - increase in number or survivorship of oocysts being transported via the North Atlantic Current to Svalbard
Thank you!!