The raccoon dog as reservoir and vector for *Trichinella* in Germany?

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Trichinellosis cases in Germany

**Imported outbreaks**
- 2007 from Romania (3 cases, domestic pig)
- 2007 from Poland (3 cases, domestic pig)
- 2015 from Serbia (8 cases, domestic pig)

**Autochthonous outbreaks**
- 2006 in MWP (16 cases, domestic pig)
- 2013 in Saxony (14 cases, wild boar)
Trichinella clustering in Germany

Approx. 90% of all Trichinella findings in Germany in three most eastern federal states
Comparison of *Trichinella* prevalence in wild boar in Germany and Mecklenburg-Western Pomerania

![Graph showing prevalence of Trichinella in wild boar over years 2004 to 2017]
Raccoon dogs – a recent invasive species

- 1928-1955 > 9000 animals released in European part of Russia
- Presence confirmed in Eastern Germany in 1960’s
- In 1994/95 approx 200 animals recorded

- Distinct migratory behaviour due to
  - High number of puppies (6-9)
  - Early dispersal of juveniles of both sexes
  - Acceptance of diverse habitats

- Omnivorous animals with distinct scavenging behaviour (up to 35% carrion feeding; highly dependent on habitat)

- Well known Trichinella reservoir in Finland and Estonia

Source: http://www.heimische-tiere.de/Marderhund.jpg

Questions

- How far has and how fast is the raccoon dog migrating through Germany?
- Does the raccoon dog feed on carrion in the study region?
- What is the *Trichinella* prevalence and larval burden in raccoon dogs in comparison to wild boar and foxes in Germany?
- Can the raccoon dog carry the parasite into the sylvatic cycle, i.e. can we see a (south) westward spread of *Trichinella* in the sylvatic cycle over time?
Raccoon dog migration in Germany

Raccoon dog hunting bag, Germany (2000-2016)

www.jagdverband.de
How far has the raccoon dog migrated?

Minimum viable population (MVP) is the smallest population size of a species that can survive in the wild – determined by population viability analysis (Vortex10.2.16).

<table>
<thead>
<tr>
<th>Variablen</th>
<th>Scenario settings</th>
<th>Mortality rates</th>
<th>Carrying capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>nr. of iterations</td>
<td>90% probability that the population survives for 100 years</td>
<td></td>
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<tr>
<td>nr. of years</td>
<td></td>
<td></td>
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<tr>
<td>days per year</td>
<td></td>
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<tr>
<td>extinction definition</td>
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<tr>
<td>age of first offspring (female)</td>
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<tr>
<td>maximum age of reproduction</td>
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<tr>
<td>age of first offspring (male)</td>
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<td></td>
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<tr>
<td>maximum age of reproduction</td>
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<tr>
<td>maximum lifespan</td>
<td></td>
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<td></td>
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<tr>
<td>maximum number of brood per year</td>
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<tr>
<td>maximum number of progeny per brood</td>
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<tr>
<td>sex ratio at birth -- % male</td>
<td></td>
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<tr>
<td>% adults females breeding</td>
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</table>

Minimum viable population (MVP) is the smallest population size of a species that can survive in the wild – determined by population viability analysis (Vortex10.2.16).

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Raccoon dog migration in Germany

Maps showing the distribution of raccoon dogs in Germany from 2000 to 2015, with different shades indicating the population density.

Legende:
- 0: None
- 1-119
- 120-300
- 301-500
- 501-700
- 701-1000
- 1001-2000
- 2001-4000

Source: Mayer-Scholl et al., NRL Meeting, Rome, 24.-25.5.2018

BfR
Determining speed of raccoon dog migration

- four measuring points at Eastern border determined
- each year mean distance between these points and furthest districts with stable population determined
- Yearly mean difference in geographic spread calculated
Raccoon dog migration in Germany

Mean migratory speed of 8 km/year in past 15 years
Feeding habits of the raccoon dog
What is the *Trichinella* prevalence and larval burden in raccoon dogs in comparison to wild boar and foxes?

**Study design**

- sampling number: 1560 raccoon dogs (obtained from the rabies monitoring) from 14 counties and 4 cities in Brandenburg (29,479 km²) between 2008-2016
- muscle samples (30-50 g) from:
  - diaphragm pillar
  - forearm muscle
  - masseter
- samples were stored at -20°C prior examination

**Methods**

- **artificial digestion** (magnetic stirrer method) with 60 min sedimentation time
- **multiplex-PCR** (Pozio and La Rosa, 2003) for species identification
- **PCR-RFLP** (Mayer-Scholl et al., 2014) for verification of *T. nativa*
Prevalence study in Brandenburg 2008-2016

**Trichinella prevalence in raccoon dogs in Brandenburg**

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</tr>
</thead>
<tbody>
<tr>
<td>No raccoon dogs</td>
<td>34</td>
<td>76</td>
<td>59</td>
<td>-</td>
<td>-</td>
<td>12</td>
<td>263</td>
<td>173</td>
<td>152</td>
<td>237</td>
<td>296</td>
<td>116</td>
<td>142</td>
<td>93</td>
<td>88</td>
<td>1560</td>
<td>173</td>
</tr>
<tr>
<td>positive prevalence [%]</td>
<td>0,00</td>
<td>2,63</td>
<td>1,69</td>
<td>-</td>
<td>-</td>
<td>0,00</td>
<td>0,76</td>
<td>1,16</td>
<td>0,66</td>
<td>2,95</td>
<td>2,36</td>
<td>3,45</td>
<td>2,11</td>
<td>5,38</td>
<td>3,41</td>
<td>2,2 %</td>
<td></td>
</tr>
</tbody>
</table>

Significant trend of increased Trichinella prevalence over time ($p = 0,006$; Cochran-Armitage test for trend)
What is the *Trichinella* prevalence and larval burden in raccoon dogs in comparison to wild boar and foxes?

<table>
<thead>
<tr>
<th>Species</th>
<th>Region</th>
<th>Year</th>
<th>n</th>
<th>Prevalence</th>
<th>T. species</th>
<th>Lpg range (median)</th>
</tr>
</thead>
<tbody>
<tr>
<td>raccoon dog</td>
<td>Brandenburg</td>
<td>2008-2016</td>
<td>1560</td>
<td>2.2%</td>
<td>90% <em>T. spiralis</em> 3% <em>T. pseudospiralis, britovi, spp.</em></td>
<td>0.5-235 (14)</td>
</tr>
<tr>
<td></td>
<td>MWP</td>
<td>2011</td>
<td>117</td>
<td>4%</td>
<td>-</td>
<td>0.06 - 65</td>
</tr>
<tr>
<td>fox</td>
<td>9 federal states</td>
<td>2011</td>
<td>3154</td>
<td>0.3%</td>
<td>51% <em>T. spiralis</em> 30% <em>T. britovi mixed infections</em></td>
<td>0.35-8 (1.4)</td>
</tr>
<tr>
<td>wild boar</td>
<td>Germany</td>
<td>2002-2016</td>
<td>&gt; 4.000.000</td>
<td>0.003%</td>
<td><em>T. spiralis</em> – 75% <em>T. pseudospiralis</em> – 16% <em>T. britovi</em> – 4% mixed./spp– 5%</td>
<td>2-922 (19)</td>
</tr>
</tbody>
</table>
Can we see a spread of *Trichinella* in the sylvatic cycle?

*Trichinella* positive raccoon dogs in Brandenburg

*Trichinella* positive wild boar in Mecklenburg-Western Pomerania
Discussion/ Outlook

- The raccoon dog is the most important *Trichinella* reservoir in Eastern Germany (prevalence, larval burden)

- Trend of an increasing *Trichinella* prevalence in raccoon dogs in Brandenburg

- Indication of spread of *Trichinella* infected wild boar in MWP

- Is the *Trichinella* cycle self-maintained in the raccoon dog population and/or can raccoon dogs carry the parasites into the sylvatic cycle?
  - influence of hunter behaviour?
  - do wild boar/ raccoon dogs feed on raccoon dog carcasses?

- Problems associated with study design:
  - Conservative estimation of spread of raccoon dogs, as results based on hunting bag, not population densities
  - Differences in hunting practices in federal states not considered
Acknowledgements

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Thank you for your attention!