Challenges in prevention and control of food-borne zoonotic parasites in Africa

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Outline

- Introduction
  - Endemic food-borne zoonotic parasites in Africa
  - Impact of food-borne zoonotic parasites in Africa
  - Current control and prevention strategies of food-borne zoonotic parasites in Africa

- Challenges in Control and Prevention
Introduction

Food-borne zoonotic parasites—considerable attention in the last decade or two

i. Cases have gone up in humans world-wide including Africa

ii. Better diagnostic tools are now available—high prevalences

iii. Improved communication—record keeping

iv. HIV-AIDS pandemic in Sub-Saharan Africa

v. Urban farming

vi. Globalization of food supply

vii. Changes in lifestyle
# Endemic food-borne zoonotic parasites in Africa

<table>
<thead>
<tr>
<th>Parasite species</th>
<th>Source of human infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. *Taenia solium</td>
<td>i. Ingestion of cysts in raw or undercooked meat (pork)</td>
</tr>
<tr>
<td></td>
<td>ii. Ingestion of eggs from contaminated food and uncooked vegetables and fruits</td>
</tr>
<tr>
<td></td>
<td>iii. Autoinfection</td>
</tr>
<tr>
<td>2. *Taenia saginata</td>
<td>i. Ingestion of cysts in raw/undercooked meat (beef)</td>
</tr>
<tr>
<td>3. *Echinococcus granulosus</td>
<td>i. Ingestion of eggs from contaminated food, fruits and uncooked vegetables</td>
</tr>
<tr>
<td>4. *Trichinella species</td>
<td>i. Ingestion of larvae in raw/undercooked meat (variety of meat)</td>
</tr>
<tr>
<td>5. *Fasciola gigantica/hepatica</td>
<td>i. Ingestion of metacercariae in edible plants or from contaminated drinking water</td>
</tr>
<tr>
<td>6. *Toxoplasma gondii</td>
<td>i. Ingestion of sporulated oocysts from contaminated fruits and uncooked vegetables fruits</td>
</tr>
<tr>
<td></td>
<td>ii. Ingestion of cysts in meat (variety of meat)</td>
</tr>
</tbody>
</table>

*Disease caused by parasite is classified under “Neglected tropical diseases”*
Food-borne zoonotic parasites fulfill the criteria for “neglected tropical diseases”

- Constitutes some of the oldest diseases known to man
- **Common in rural agricultural communities**
- Of late in urban areas where people keep livestock and live in close contact with their animals
- **Public health importance is often ignored**
- True incidence is difficult to evaluate
- Severity of their health and socio-economic impact is often unclear
- **Limited information in most countries on the spread of these diseases**
- Poor people are more vulnerable to infection
Why we only see tip of the iceberg of food-borne zoonotic parasites in Africa

- Global Burden of Disease is assessed using DALYs (disability adjusted life-years)

- This can be calculated only when the epidemiological information of the disease is known

- In most developing countries the incidences of these neglected parasitic diseases are completely unknown

- Underestimation leads to neglect due to lack of evidence for government and donor decision makers on the importance of these diseases
## Impact of food-borne zoonotic parasites in Africa

<table>
<thead>
<tr>
<th>Parasite species</th>
<th>Economic and Social impact</th>
</tr>
</thead>
</table>
| 1. Taenia solium         | i. Quality of pork affected  
 ii. Reduced farmers’ income  
 iii. Burden of disease in humans is hampered by lack of data  
 iv. Cost of disease in humans estimated USD18-34 million in Eastern Cape Prov. S/Africa and USD13 million in southern Cameroon  
 v. Taeniosis in humans |
| 2. Taenia saginata       | i. Quality of beef is affected  
 ii. Reduced farmers’ income  
 iii. Taeniosis in humans |
| 3. Echinococcus granulosus| i. Quality of meat is affected  
 ii. Reduced farmers’ income  
 iii. Hydatidosis in humans |
| 4. Trichinella species   | i. Hamper pork and game meat export  
 ii. Most human cases go unnoticed |
| 5. Fasciola gigantica/hepatica | i. Hampers animal production  
 ii. Liver condemnations  
 iii. Human cases underestimated in Africa |
| 6. Toxoplasma gondii     | i. Abortions mainly in sheep  
 ii. Congenital infection and abortions in humans  
 iii. Detrimental effects in immuno-compromised individuals |
Major neglected zoonoses and WHO Regions

AMR
Echinococcosis
Cysticercosis
Leptospirosis
Rabies
Brucellosis
B. Tuberculosis

EUR
Brucellosis
Echinococcosis
Multilocular
Echinococcosis
Rabies

EMR
Brucellosis
Rabies

AFR
Rabies
Echinococcosis
Cysticercosis,
Brucellosis
B. Tuberculosis
Z. Trypanosomiasis

SEAR/WPR
Rabies
Echinococcosis
Trematodes
Cysticercosis
Leptospirosis
Human fascioliasis—what is known in Africa?

Traditionally high consumption of raw vegetables contaminated with metacercariae
Taenia solium taeniosis/cysticercosis in eastern and southern Africa

Pig tapeworm has two hosts: Man- Taeniosis and cysticercosis

Pigs-Cysticercosis
### Regional projections of total demand and consumption of pork (million tonnes)

<table>
<thead>
<tr>
<th>Region</th>
<th>1993</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed Region</td>
<td>38</td>
<td>41</td>
</tr>
<tr>
<td>Developing Region</td>
<td>39</td>
<td>81</td>
</tr>
</tbody>
</table>

**PORK**
Global distribution of *Taenia solium* cysticercosis/taeniosis

- **High prevalence**
- **Moderate prevalence**
- **Low prevalence (imported cases)**
- **No information available/no evidence**
Taenia solium: Effects on pig production

- Cysts greatly reduce market value

- Condemnation of pork
  - Loss of animal protein
  - Loss of income (producer)
Taenia solium: Effects on humans

Cysts in brain (Neurocysticercosis)
   a. Epilepsy
   b. Headache
   c. Death

Economic effects:
   a. Loss in man hours
   b. Reduced labour force
   c. Hospitalization cost

Social effects
   a. Epileptics-stigmatised
Possible intervention strategies for control of cysticercosis

- Properly cook pork
- Control slaughter
- Meat inspection
- Mass taeniacidal treatment
- Improve sanitation (CLTS)
- Pig confinement
- Pig treatment
- Pig vaccination
- Improve sanitation (CLTS)
## Results of prevalence studies on porcine cysticercosis conducted in ESA

<table>
<thead>
<tr>
<th>Country</th>
<th>Porcine Cysticercosis Prevalence (%)</th>
<th>No. pigs surveyed</th>
<th>Type of survey</th>
<th>Area Surveyed</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tanzania</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.04 - 4.9</td>
<td>45,794</td>
<td>P</td>
<td>Mbulu District</td>
<td>Nsengwa, 1995b</td>
</tr>
<tr>
<td></td>
<td>4.5 – 37.7</td>
<td>83</td>
<td>P</td>
<td>Northern highlands</td>
<td>Boa <em>et al.</em>, 1995</td>
</tr>
<tr>
<td></td>
<td>3.2 – 46.7</td>
<td>770</td>
<td>L</td>
<td>Mbulu District</td>
<td>Ngowi, 1999</td>
</tr>
<tr>
<td></td>
<td>0 – 26.9</td>
<td>1,789</td>
<td>L</td>
<td>Southern highlands</td>
<td>Boa, 2002</td>
</tr>
<tr>
<td><strong>Kenya</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.0 – 14.0</td>
<td>407</td>
<td>L</td>
<td>Busia &amp; South Nyanza Districts</td>
<td>Githigia <em>et al.</em>, 2002</td>
</tr>
<tr>
<td><strong>Uganda</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33.7 – 44.5</td>
<td>600</td>
<td>P</td>
<td>Moyo District</td>
<td>Anyanzo, 1999</td>
</tr>
<tr>
<td></td>
<td>0 - 33.7c</td>
<td>297</td>
<td>P</td>
<td>Central &amp; Northern Districts</td>
<td>Kisakye and Masaba, 2002</td>
</tr>
</tbody>
</table>

*aP = post-mortem, L = lingual examination, S = serological;  
*bSurvey conducted from 1985 – 1989  
*cEight foetuses from a positive slaughtered pregnant sow were all found to be infected with cyst*
## Results of prevalence studies on porcine cysticercosis conducted in ESA

<table>
<thead>
<tr>
<th>Country</th>
<th>Porcine Cysticercosis Prevalence (%)</th>
<th>No. pigs surveyed</th>
<th>Type of survey</th>
<th>Area Surveyed</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zambia</td>
<td>20.6 - 56.6</td>
<td>1,316</td>
<td>S,P</td>
<td>Lusaka</td>
<td>Phiri et al., 2001</td>
</tr>
<tr>
<td></td>
<td>8.2 - 20.8</td>
<td>249</td>
<td>L,S</td>
<td>Eastern &amp; Southern Provinces</td>
<td>Phiri et al. 2002</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>0.03 - 4.3</td>
<td>1,000,000</td>
<td>P</td>
<td>National</td>
<td>Robinson, 1978</td>
</tr>
<tr>
<td></td>
<td>2.7 - 28.6</td>
<td>99,525</td>
<td>P</td>
<td>Western Region</td>
<td>Matenga et al., 2002</td>
</tr>
<tr>
<td>Mozambique</td>
<td>6.5 - 33.3</td>
<td>387</td>
<td>S</td>
<td>Tete Province</td>
<td>Afonso et al., 2001</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.5 – 25.1</td>
<td>&gt; 100,000</td>
<td>P</td>
<td>National</td>
<td>Viljoen, 1937</td>
</tr>
<tr>
<td></td>
<td>0 – 9.1</td>
<td>28,242</td>
<td>P</td>
<td>National</td>
<td>Heinz and MacNab, 1965</td>
</tr>
</tbody>
</table>

*P = post-mortem, L = lingual examination, S = serological*
Main risk factors identified

- Endemic in pig raising/pork consuming areas

- Associated with poverty
  - inadequate sanitation
  - lack of proper slaughtering facilities, meat inspection & control
  - poor pig husbandry practices

- Spread by people/pig movement
  - immigration
  - overseas domestic workers
  - international travel
  - marketing and transport of pigs
The pig population in Africa increased 284% during the 20 year period 1980–1999 - far more than any other livestock species during that time and the trend continues.
Clandestine livestock market in downtown Lusaka – more than 20% of pigs are infected with *Taenia solium*!

**ESA in general:**

- Lack of official slaughtering facilities for pigs
- Lack of official pork inspection and control
- Inadequate pork inspection guidelines
Control and Surveillance of food-borne zoonotic parasites

<table>
<thead>
<tr>
<th>Parasite species</th>
<th>Control and prevention options at farm and abattoir level</th>
</tr>
</thead>
</table>
| 1. *Taenia solium*        | i. Improvement in pig production systems  
                        | ii. Meat inspection at abattoir level  
                        | iii. Post-slaughter processing to inactivate larvae |
| 2. *Taenia saginata*      | i. Improvement in pig production systems  
                        | ii. Meat inspection at abattoir level  
                        | iii. Post-slaughter processing to inactivate larvae |
| 3. *Echinococcus granulosus* | i. Meat inspection at abattoir level  
                        | ii. Control of stray dogs and deworming of dogs |
| 4. *Trichinella species*  | i. Improvement in pig production systems  
                        | ii. Meat inspection at abattoir level  
                        | iii. Post-slaughter processing to inactivate larvae |
| 5. *Fasciola gigantica/hepatica* | i. Anthelmintic treatment of ruminants  
                        | ii. Meat inspection at abattoir level |
| 6. *Toxoplasma gondii*    | NP                                                       |
Challenges in Control and Prevention

• Collapse in veterinary infrastructure and services of most African countries

• Lack of regulations or enforcement of regulations to prevent and control some of these parasites

• Lack of reliable epidemiological data on infection in humans and animals

• The diseases do not lead to large-scale international outbreaks and hence countries are not compelled to international notification

• Lack of awareness of the diseases and no coordinated approach by health/veterinary professionals
Challenges in Control and Prevention (ctd)

- Lack of research on the epidemiology of the diseases
  - Results in lack of accurate data on the incidence, sources and transmission routes
  - Do not fulfill a risk-based approach as proposed by Codex Alimentarius to implement risk-based control programme

- Poverty (Lack of adequate sanitation in resource-poor communities, illiteracy and malnutrition)

- Under-diagnosis of diseases due to unavailable or inadequate laboratory equipment, methods and qualified staff

- Livestock rearing methods (mainly extensive, exposing animals to the parasite)
Cysticercosis Working Group in East and Southern Africa

- Tanzania
- Kenya
- Uganda
- Burundi
- Rwanda
- DR Congo
- Malawi
- Madagascar
- Mozambique
- South Africa
- Zimbabwe
- Zambia
- Angola
LET’S BREAK THE PORK TAPEWORM CYCLE

with these 6 easy steps

6. Cook meat well.
   It is better to be safe than sorry. Pork must be cooked thoroughly so that there is no pink meat and no blood running out. This will kill any tapeworm cysts and prevent infection.

5. Check meat is safe.
   Check meat carefully to make sure there are no cysts. Meat with cysts should not be eaten or sold.

4. Stop pigs from roaming.
   Keep your pigs in a pen or tied to a stake, so that they can’t eat human faeces containing pork eggs.

3. Go to the clinic.
   If you think you have tapeworm, go to the clinic and get treatment as soon as possible.

2. Wash your hands.
   Tapeworm eggs are too small to see and spread easily. So wash your hands well with soap and clean water after using the toilet and before touching food.

1. Always use a toilet.
   Use a toilet to stop worm eggs infecting pigs and other people.
Workshop for OIE National Focal Points for Animal Production Food Safety
Hammamet, Tunisia (4-6 April 2011)

TOOLS FOR DETECTION AND SURVEILLANCE OF SELECTED FOOD-BORNE ZOONOTICS PARASITES
Effective detection/diagnostic tools for zoonotic parasites are essential for ensuring food safety.

The diagnostic methods should be reliable (sensitive, specific and inexpensive).

Traditional parasitological tools (accessible to most labs in developing countries, inexpensive, sensitivity +/-, specificity +, tedious as surveillance tools).

Molecular tools (not readily accessible to most labs in developing countries, expensive to run, sensitivity ++, specificity ++, easy to run and require little material).

Serological tools (commercial kits available for some parasites, sensitivity +, specificity +/-, easy to run and very useful as surveillance tool).
Trichinellosis

- All *Trichinella* species are presumed infective to man and a large variety of mammals

- Average incidence of the disease in humans worldwide is about 10,000 cases/year

- Mortality rate of about 0.2% (mostly in Europe and what about Africa?)

- Infection is underreported in many African countries due to lack of appropriate detection tests and knowledge of the disease on the part of physicians (Pozio, 2007).

- Direct life cycle (no exogenous stage)

- Broad host spectrum

- All species morphologically indistinguishable

  - Two clades
    i. Encapsulated species
    ii. Non capsulated species
Encapsulated (red) and non-encapsulated (green) species and genotypes of *Trichinella* based on the variation in mitochondrial LSU and COI DNA (on the left) and SSU rDNA (on the right) (Zarlenga et al. 2006).
Geographical distribution of *Trichinella* genotypes
Sylvatic cycle in Africa
(*Trichinella zimbawensis*)

- Nile crocodile ++
- Varan (monitor lizard) ++
- Lion ++
- Warthog??
- Bush pig??
- Domestic pig ++
- Monkeys ++

Domestic cycle of *Trichinella spiralis*

![Domestic cycle diagram]

Fig. 176. *Trichinella spiralis*. Twenty days for larvae to be infective. Larvae to adult in 4 days.
<table>
<thead>
<tr>
<th>Animal code</th>
<th>SFB</th>
<th>SMB</th>
<th>BFB</th>
<th>BFM</th>
<th>SFM</th>
<th>SMM</th>
<th>BMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infective dose/kg</td>
<td>16</td>
<td>16</td>
<td>7</td>
<td>25</td>
<td>24</td>
<td>24 500</td>
<td>17 600</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>400</td>
<td>300</td>
<td>000</td>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clinical signs and symptoms</td>
<td>Day of the first manifestation pi</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fever</td>
<td>9</td>
<td>11</td>
<td>16</td>
<td>14</td>
<td>13</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>19</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Depression</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Periorbital edema</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Muscular pain</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Alopecia</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Blindness</td>
<td>38</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Death</td>
<td>49 dpi</td>
<td>50 dpi</td>
<td>no</td>
<td>30 dpi</td>
<td>no</td>
<td>36 dpi</td>
<td>no</td>
</tr>
</tbody>
</table>

Table 1. Clinical manifestations of baboons and monkeys infected with *Trichinella zimbabwensis*
Post-slaughter detection of Trichinella

Samples for Diagnosis of *Trichinella*

a. The detection of *Trichinella* larvae is mainly targeted to post-mortem inspection of pigs and wild animals which are consumed by humans.

b. Detection usually achieved through routine meat inspection

c. Sensitivity of existing methods is dependent on the muscle selected for sampling, sample size and quality assurance measures employed

d. Predilection sites for *Trichinella*
   - *Pigs* (diaphragm pillars, tongue and masseter muscles)
   - *Wild boars* (forearm muscle, diaphragm pillars)
   - *Crocodiles* (tail and extremeties)
   - *unknown for the species* (tongue)
<table>
<thead>
<tr>
<th>Techniques</th>
<th>Tools</th>
<th>Advantages/Disadvantages</th>
</tr>
</thead>
</table>
| 1. Observation of muscle larva | i. Trichinoscopy and microscope            | i. Ideal for field situations  
ii. Laborious and time consuming for individual carcasses  
iii. Low sensitivity  
iv. Not recommended for use in food and game animals intended for human consumption |
| 2. Artificial digestion of muscle | i. Magnetic Stirrer method (Gold standard)  
ii. Stomacher method  
- Pooled samples  
- Individual samples | i. Need for retesting individual samples if the pooled sample is positive  
ii. Need for laboratory and equipment  
iii. Ideal for large samples |
| 3. Serological techniques      | i. ELISA                                   | i. Unsuitable for the purposes of meat inspection  
ii. Useful for surveillance and epidemiological studies in animal populations  
iii. False negatives during early stages of infection  
iv. Techniques not tested in wild animals |
Geographical distribution of *T. zimbabwensis*

- Zimbabwe (commercially reared crocodiles, wild crocodiles, varans)
- South Africa (commercially reared crocodiles, wild crocodiles, lions)
- Mozambique (wild crocodiles)
- Ethiopia (wild crocodiles)
### Serological detection of trichinellosis (Gajahdah et al., 2009)

<table>
<thead>
<tr>
<th>Method</th>
<th>Antigen</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELISA</td>
<td>Crude</td>
<td>99% (pigs, humans)</td>
<td>60% (humans)</td>
</tr>
<tr>
<td>ELISA</td>
<td>Excretory/Secretory</td>
<td>98% (pigs, horses) 99% (humans)</td>
<td>98% (pigs)</td>
</tr>
<tr>
<td>ELISA</td>
<td>Beta tyvelose</td>
<td>&lt;98% (pigs) &lt;98% (horses)</td>
<td>&gt;99% (pigs)</td>
</tr>
<tr>
<td>Western Blot</td>
<td>Crude antigen</td>
<td>98% (humans)</td>
<td>98% (humans)</td>
</tr>
<tr>
<td>Western Blot</td>
<td>ES antigen</td>
<td>Not available</td>
<td>98% (horses)</td>
</tr>
</tbody>
</table>
Porcine cysticercosis

- Detection of porcine cysticercosis cases is vital for preventing human infections as well as for monitoring interventions programmes.

- Detection methods are available for live animals as well as inspection of carcass at slaughter.
<table>
<thead>
<tr>
<th>Techniques</th>
<th>Tools</th>
<th>Advantages /Disadvantages</th>
</tr>
</thead>
</table>
| 1. Lingual examination  | i. Visual inspection and palpation for cysts on the ventral surface of tongue | i. Inexpensive and quick method for farmers and pig traders  
ii. Specificity is very high  
iii. Useful for rapid assessment of sites and determination of “hot spots”  
iv. Sensitivity depends on the intensity of infection  
v. May underestimate prevalence of infection |
| 2. Pig carcass inspection | i. Slaughter houses, equipment and official meat inspection guidelines | i. Sensitivity is low in pigs with low intensity of infection  
ii. Underestimates the true prevalence  
iii. Useful for validating other diagnostic methods if conducted properly |
| 3. Serological techniques | i. ELISA reader, plates and chemical reagents | i. Useful for surveillance and epidemiological studies in animal populations  
ii. Cross-infection with *Taenia hydatigena* |
Larval *Taenia solium* cysts on pig’s tongue
Toxoplasmosis in livestock

• Very few countries implement active surveillance programmes for toxoplasmosis

• Main challenge is the epidemiological versatility and complexity of *T. gondii*

• Practice of extensive farming of livestock adds a challenge for the detection of the parasite

• Unavailability of resources and technology in Africa limits the relevance of a single global control strategy
Life cycle of *Toxoplasma gondii*

- **Fecal Stage:** Sporulation of the oocyst
  - The oocyst undergoes meiosis, producing an octet of infectious environmentally resistant sporozoites.

- **Enteroepithelial Stage** (in Felidae species):
  - Sexual reproduction
  - Sex structures: micro- and macrogamocytes fuse and form oocyst

- **Asexual Reproduction and Resting Stages** (in all hosts):
  - Mitotic division and encystation
  - Sporozoites differentiate into rapidly dividing tachyzoites (acute infection)
  - Tachyzoites transform into slowly dividing bradyzoites (chronic infection)
  - Bradyzoites form tissue cysts

- **Transmission to Fetuses** (tachyzoites)
  - Ingestion of feces containing sporozoites
  - Transmission to fetuses

- **Meat Consumption** (tissue cysts)
  - Meat consumption

- **Cat Litter Boxes, Soil** (oocysts)
  - Cat litter boxes, soil (oocysts)

http://www.metapathogen.com/IMG/Tgo-lc.png
Methods for detection of *T. gondii*

Many methods are available but the reliability is unclear

a. Serological tests
b. Parasite isolation and identification
c. Polymerase chain reaction (PCR)

Use of properly validated assays in laboratories operating as part of a recognised quality assurance system is essential
Wildlife products in Africa: what are the zoonotic parasites to look for?
Introduction

Factors to consider

- Role of wildlife as potential source of zoonotic parasites to human and domestic animals
- Growth rate of the global human population (demand for food)
- Expanding appetite for resources of all types
- Dissolution of many ecological barriers important in the natural control of parasitic zoonoses
- Human intrusions into many wildlife habitats and the reverse
- Shift in the interface between wildlife and people from often sporadic and fragile environments to more permanent and substantial opportunities for parasite transmission
- Change of life-style and eating habits
Wildlife Products likely to be source of infection

- **Bush meat**-(illegal and unsustainable trade in wildlife for meat and income)
- **Wild meat**- (legal and sustainable trade in wildlife for meat and income)
- **Game meat**-(legal and sustainable trade of farmed or ranched wildlife for meat and income)

Cultural traditions for food preparation that do not affect parasite viability lead to transmission of parasites
Some statistics of bushmeat trade African countries

• More than 30 million poor rural and urban people in sub-saharan Africa are dependent on bushmeat as food, role in rituals or for trade

• In Central Africa, over 1 million metric tons of bushmeat is eaten each year — the equivalent of almost 4 million cattle

• Illegal trade in game meat runs into millions of USD every year
Reptiles and other wildlife are often captured for food or trade.
Some zoonotic parasites of wildlife origin acquired by parasite flow through consumption of infected meat/tissue

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Wildlife host</th>
<th>Route(s) of human infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Trichinella</em> spp.</td>
<td>Carnivorous and omnivorous mammals, birds and reptiles</td>
<td>Infective larvae in meat which is raw or undercooked</td>
</tr>
<tr>
<td>2. <em>Toxoplasma gondii</em></td>
<td>Mammals and birds</td>
<td>Bradyzoites or tachyzoites in intermediate hosts</td>
</tr>
<tr>
<td>3. <em>Angiostrongylus cantonensis</em></td>
<td>Rodents</td>
<td>Infective larvae in gastropod intermediate hosts, snails, slugs, fish, crab or crayfish paratenic hosts, or on vegetables</td>
</tr>
</tbody>
</table>

Are these the only zoonotic parasites from wildlife?
Zoonotic parasites web comprising multiple possible routes of parasite flow (Polley, 2005)
Crocodile Farming in sub-saharan Africa
Croc tails meat ready for marketing
Trichinella zimbabwensis-infected crocodile farms in Zimbabwe

Fig. 1. Map of Zimbabwe showing the crocodile (Crocodilus niloticus) farms and their relative position (black area) in Africa. (▲), Farms with no history of Trichinella-positive crocodiles; (●), farms which had Trichinella-positive crocodiles in 1995 but not in 2002; (■), farms with Trichinella-positive crocodiles in 2002; (○), towns and cities.
The rat lung-worm *Angiostrongylus cantonensis* first report in South Africa (Archer et al 2011)
Challenges in detecting zoonotic parasites in wildlife products

- Difficulties in accessing wildlife products for inspection (informal channels)
- Lack of information regarding the host and geographic distributions of the hosts and the zoonotic parasites.
- Lack of validation of some of the diagnostic tests used for these infections in wildlife, particularly those based on serology.
- Lack of national or regional monitoring/surveillance for wildlife zoonotic parasites in Africa
Thank you for your attention