Diagnosis of porcine cysticercosis

Marshall Lightowlers
University of Melbourne
Why do we want to diagnose porcine cysticercosis?

- Epidemiology – to reveal areas of full *T. solium* transmission
- Monitor the outcomes of *T. solium* interventions
Porcine cysticercosis - case definition:

- Presence of *T. solium* cysticerci having potential to cause human taeniasis
Porcine cysticercosis is definitively diagnosed by identifying cysticerci in pig tissues.
Serology has been used commonly for diagnosis of porcine cysticercosis

ELISA          Many

cAg HP10       Correa et al. Acta Leid 57:293, 1989

cAg B158/B60   Nguekam et al. Vet Parasitol 111:323, 2003

Publications have cited high sensitivities and specificities for serology, however many have been based on comparisons with commercially-reared non-infected control pigs, or relied on mathematical predictions
Serology for diagnosis of *T. solium* infection in naturally infected pigs

- In studies involving field-reared pigs comparing serology and full necropsy, all serological tests have poor specificity
- Many pigs that have no cysts at necropsy are serologically positive (Ab or Ag)
- If serology were used to monitor the outcomes of *T. solium* interventions, all of these false-positive reactions would be interpreted as control failures
Limitations of current diagnostic procedures for the diagnosis of *Taenia solium* cysticercosis in rural pigs

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42 field-reared pigs subjected to full necropsy

24 found to have no cysts

- 13/24 (54%) false +ve Ag ELISA (HP10)
- 9/22 (40%) false +ve EITB
Peru Tumbes trial (2005 necropsy data; A. Gonzales, February 2015)

- 326 field-reared pigs, full post mortems
  - 171 EITB +ve
  - 40 had cysts (18 viable, 22 non-viable)
  - 76.6% false +ve rate by EITB
Validity of the Enzyme-linked Immunoelectrotransfer Blot (EITB) for naturally acquired porcine cysticercosis

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107 field-reared pigs fully necropsied

18/107 pigs had *T. solium* cysts

- 89/107 EITB +ve
- 64/107 EITB +ve but with no cysts

59.8% false positives
Complexities in using sentinel pigs to study *Taenia solium* transmission dynamics under field conditions

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\textsuperscript{b} Institute of Health and Society, Université catholique de Louvain, Clos Chapelle-aux-Champs 30, 1200 Brussels, Belgium
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\textsuperscript{e} National Zoonoses and Food Hygiene Research Centre, Chagol, Kathmandu, Nepal
\textsuperscript{f} Department of Internal Medicine, B.P. Koirala Institute of Health Sciences, Dharan, Nepal
\textsuperscript{g} Department of Biomedical Sciences, Institute of Tropical Medicine, Nationalestraat 155, 2000 Antwerp, Belgium
14/17 positive at some time
14/17 positive at some time

32/200 individual bleeds +ve
14/17 positive at some time

32/200 individual bleeds +ve

No *T. solium* cysts at necropsy in any animal (whole carcase)
14/17 positive at some time

32/200 individual bleeds +ve

No *T. solium* cysts at necropsy in any animal (whole carcase)

16% false positive
Many pigs that have no cysts at necropsy are serologically positive. Why?
Many pigs that have no cysts at necropsy are serologically positive. Why?

• Exposure to $T.\ solium$ that does not result in cyst development
Many pigs that have no cysts at necropsy are serologically positive. Why?

- Exposure to *T. solium* that does not result in cyst development
- Infection with *Taenia hydatigena* (AgELISA)
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- Exposure to *T. saginata* that does not result in cyst development
- Exposure to dog *Taenia* sp eggs that does not result in cyst development
Many pigs that have no cysts at necropsy are serologically positive. Why?

- Exposure to *T. solium* that does not result in cyst development
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- Exposure to *T. hydatigena* that does not result in cyst development (AgELISA)
- Infection with *T. saginata*
- Exposure to *T. saginata* that does not result in cyst development
- Exposure to dog *Taenia* sp eggs that does not result in cyst development
- Sparganosis
Serology for diagnosis of *T. solium* infection in pigs

• There is a major lack of data about the specificity of all serological methods used for diagnosis of *T. solium* infection in pigs.

• Until more data are available, serology has limited value

• For accurate diagnosis, there is no current option other than necropsy
Diagnosis of porcine cysticercosis by necropsy

How much of the carcase meat needs to be dissected?

• Dissection of the heart, tongue and masticatory muscles identified 80% of naturally infected animals; 100% with >50 cysts (Lightowlers et al. *Int J Parasitol* 45:815, 2015)
Research needs in relation to pig serology

- New/improved tests where positive serology correlates with the presence of cysticerci

- Greater use of sera from field-reared pigs with known cyst burdens in the evaluation of serological tests
Updating the WHO *Taenia solium* distribution map

Meritxell Donadeu
University of Melbourne
Fig. 4.16.1 Countries and areas at risk of cysticercosis, 2012
What is the primary purpose of the map?
What is the primary purpose of the map?

- To highlight regions where full transmission occurs and where intervention measures are warranted
What is the primary purpose of the map?

• To highlight regions where full transmission occurs and where intervention measures are warranted

• A different map could highlight the burden of cysticercosis, highlighting many countries where full transmission occurs as well as some countries where migration leads to imported cases and occasional local (limited) transmission.
Methodology

- Peer reviewed publications (PubMed search)
- Grey literature research (Internet research engines) in English, Spanish, Portuguese, French, Italian
- Number of pigs in the country: (FAOSTAT 2013 & OIE)
- Notifications to the OIE of pig & human cases (OIE data by country and disease 2005-2014)
- Human Development Index and Inequality-adjusted Human Development index produced by the UN, 2013
- Access to sanitation: Data from WHO/UNICEF 2013, used for the Water and Sanitation score
- Geography and religion: for some countries with limited information, the local geography and predominant religion was also taken into account.
- Type of pig production: for some countries with very limited information,
Categories

- **Endemic (E):** There is reasonable evidence of full cycle of the disease transmission.

- **Suspected endemic (SE):** There is limited information or evidence but there are good reasons to believe that the disease is endemic eg a relatively large number of pigs are exposed to the known risk factors.

- **Few pigs with risk factors (FPRF):** There is limited information, and there are very few pigs exposed to the known risk factors.

- **Not endemic (NE):** No full disease transmission cycle present.

- **No Data (ND):** or extremely limited information available.

- Some countries got a combined classification ND/FPRF. That was used for countries with extremely limited information, but there were very few pigs (if any) that could be exposed to the risk factors.
<table>
<thead>
<tr>
<th>Continent</th>
<th>Country / Territory</th>
<th>Capital</th>
<th>T solium</th>
<th>Like</th>
<th># Pigs 2011</th>
<th>HDI</th>
<th>IHD lr</th>
<th>Sanit</th>
<th>% Sar</th>
<th>Criteria &amp; comments</th>
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<tbody>
<tr>
<td>Africa</td>
<td>Algeria</td>
<td>Algiers</td>
<td>ND</td>
<td>FPRF</td>
<td>5,000</td>
<td>0.717</td>
<td></td>
<td></td>
<td>60.39</td>
<td>55.14 No publications. Never occurred.</td>
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<tr>
<td>Africa</td>
<td>Angola</td>
<td>Luanda</td>
<td>Endemic</td>
<td></td>
<td>2,603,365</td>
<td>0.526</td>
<td>0.295</td>
<td>16.12</td>
<td>58.69</td>
<td>Large pig population and risk of ASF. Ceballos et al. 2006.</td>
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<tr>
<td>Africa</td>
<td>Benin</td>
<td>Porto Novo, Cotonou</td>
<td>Endemic</td>
<td></td>
<td>414,000</td>
<td>0.476</td>
<td>0.311</td>
<td>0.02</td>
<td>14.17</td>
<td>Ref 58-61 in Braae paper. Relative risk of ASF.</td>
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<tr>
<td>Africa</td>
<td>Botswana</td>
<td>Gaborone</td>
<td>ND</td>
<td>FPRF</td>
<td>FAO 13,500; OIE 3,300</td>
<td>0.683</td>
<td>0.422</td>
<td>19.15</td>
<td>64.04</td>
<td>No publications. Reported high risk of ASF.</td>
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<tr>
<td>Africa</td>
<td>Burkina Faso</td>
<td>Ouagadougou</td>
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<td></td>
<td>2,345,188</td>
<td>0.388</td>
<td>0.252</td>
<td>1.04</td>
<td>18.02</td>
<td>Refs 62-69 in Braae paper.</td>
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<td>Burundi</td>
<td>Bujumbura</td>
<td>Endemic</td>
<td></td>
<td>388,242</td>
<td>0.389</td>
<td>0.257</td>
<td>11.96</td>
<td>50.05</td>
<td>Refs 70-73 Braae paper.</td>
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<td>Cameroon</td>
<td>Yaounde</td>
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<td></td>
<td>1,750,000</td>
<td>0.504</td>
<td>0.339</td>
<td>11.00</td>
<td>47.80</td>
<td>Refs 74-87 Braae paper.</td>
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<tr>
<td>Africa</td>
<td>Cabo Verde</td>
<td>Praia</td>
<td>Endemic</td>
<td></td>
<td>84,559</td>
<td>0.636</td>
<td>0.511</td>
<td>18.70</td>
<td>63.29</td>
<td>Various human reports from major cause epilepsy.</td>
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<td>Africa</td>
<td>Central African Republic</td>
<td>Bangui</td>
<td>Endemic</td>
<td></td>
<td>1,000,000</td>
<td>0.343</td>
<td>0.203</td>
<td>5.76</td>
<td>33.79</td>
<td>Druet-Cabacan 1999. Large pig population.</td>
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<td>Africa</td>
<td>Chad</td>
<td>N’Djamena</td>
<td>Endemic</td>
<td></td>
<td>33,000</td>
<td>0.372</td>
<td>0.232</td>
<td>0.00</td>
<td>11.73</td>
<td>Mopate 2003 &amp; 2010. Asa 2011.</td>
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<tr>
<td>Africa</td>
<td>Comoros</td>
<td>Moroni</td>
<td>ND</td>
<td></td>
<td></td>
<td>0.488</td>
<td></td>
<td></td>
<td>6.30</td>
<td>NA No publications and no pig</td>
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<tr>
<td>Africa</td>
<td>Congo</td>
<td>Brazzaville</td>
<td>Endemic</td>
<td></td>
<td>95,000</td>
<td>0.564</td>
<td>0.391</td>
<td>0.97</td>
<td>17.78</td>
<td>No publications. Disease reported.</td>
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<tr>
<td>Africa</td>
<td>Côte d’Ivoire</td>
<td>Yamoussoukro, Abidjan</td>
<td>Endemic</td>
<td></td>
<td>362,693</td>
<td>0.452</td>
<td>0.279</td>
<td>2.69</td>
<td>23.93</td>
<td>Local surveillance 2013.</td>
</tr>
<tr>
<td>Africa</td>
<td>Djibouti</td>
<td>Djibouti</td>
<td>No</td>
<td></td>
<td></td>
<td>0.467</td>
<td>0.306</td>
<td>17.56</td>
<td>61.33</td>
<td>No publications. No data from Red Book 2015.</td>
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<td>Africa</td>
<td>Democratic Republic of the Congo</td>
<td>Kinshasa</td>
<td>Endemic</td>
<td></td>
<td>1,050,000</td>
<td>0.338</td>
<td>0.211</td>
<td>4.76</td>
<td>30.72</td>
<td>Kanobana 2011, Charrbot 15.</td>
</tr>
<tr>
<td>Africa</td>
<td>Egypt</td>
<td>Cairo</td>
<td>ND</td>
<td>FPRF</td>
<td>10,600</td>
<td>0.682</td>
<td>0.518</td>
<td>59.59</td>
<td>94.95</td>
<td>No recent data. Publication</td>
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<td>Africa</td>
<td>Equatorial Guinea</td>
<td>Malabo</td>
<td>RF</td>
<td></td>
<td>6,700</td>
<td>0.556</td>
<td></td>
<td></td>
<td>44.18</td>
<td>NA Diaz Menendez 2012. Neurology.</td>
</tr>
<tr>
<td>Africa</td>
<td>Eritrea</td>
<td>Asmara</td>
<td>ND</td>
<td>FPRF</td>
<td>5,000*</td>
<td>0.381</td>
<td></td>
<td></td>
<td>0.00</td>
<td>NA No publications. &gt;50% population.</td>
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<td>Africa</td>
<td>Ethiopia</td>
<td>Addis Ababa</td>
<td>ND</td>
<td>FPRF</td>
<td>FAO 33,000; OIE 3,300</td>
<td>0.435</td>
<td>0.307</td>
<td>1.78</td>
<td>20.71</td>
<td>No publications. Never occurred.</td>
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<td>Africa</td>
<td>Gabon</td>
<td>Libreville</td>
<td>Endemic</td>
<td></td>
<td>225,000</td>
<td>0.674</td>
<td>0.512</td>
<td>5.46</td>
<td>32.89</td>
<td>Only one ref, but large number of pigs.</td>
</tr>
<tr>
<td>Africa</td>
<td>Gambia</td>
<td>Banjul</td>
<td>Endemic</td>
<td></td>
<td>4,873</td>
<td>0.441</td>
<td></td>
<td></td>
<td>21.47</td>
<td>Only one ref, but risk factor.</td>
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<td>Africa</td>
<td>Ghana</td>
<td>Accra</td>
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<td>638,000</td>
<td>0.573</td>
<td>0.394</td>
<td>0.00</td>
<td>13.46</td>
<td>Refs 94-95 in Braae paper.</td>
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<tr>
<td>Africa</td>
<td>Guinea</td>
<td>Conakry</td>
<td>RF</td>
<td></td>
<td>104,000</td>
<td>0.392</td>
<td>0.243</td>
<td>1.16</td>
<td>18.48</td>
<td>Gyorkos 1996. Tenaïs et al.</td>
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<td>Africa</td>
<td>Guinea-Bissau</td>
<td>Bissau</td>
<td>Yes</td>
<td></td>
<td>46,000</td>
<td>0.396</td>
<td>0.239</td>
<td>1.32</td>
<td>19.04</td>
<td>Valadas 2015. Imported cases.</td>
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<td>Africa</td>
<td>Kenya</td>
<td>Nairobi</td>
<td>Yes</td>
<td></td>
<td>432,979</td>
<td>0.535</td>
<td>0.360</td>
<td>4.33</td>
<td>29.38</td>
<td>Refs 30, 95, 98-101 Braae.</td>
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<td>Lesotho</td>
<td>Maseru</td>
<td>RF</td>
<td></td>
<td>81,000</td>
<td>0.486</td>
<td>0.313</td>
<td>3.39</td>
<td>26.31</td>
<td>Very close to Eastern Cape i.</td>
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<tr>
<td>Africa</td>
<td>Liberia</td>
<td>Monrovia</td>
<td>RF</td>
<td></td>
<td>292,000</td>
<td>0.412</td>
<td>0.273</td>
<td>1.08</td>
<td>18.20</td>
<td>Relative large pig population.</td>
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<td>Africa</td>
<td>Libya</td>
<td>Tripoli</td>
<td>No</td>
<td></td>
<td></td>
<td>0.784</td>
<td></td>
<td></td>
<td>66.59</td>
<td>No publications and no pig</td>
</tr>
</tbody>
</table>
Next steps:
42 field-reared pigs subjected to full necropsy

18 found to have *T. solium* cysts
• 8/18 (44%) +ve Ag ELISA (HP10)
• 10/18 (55%) +ve Ab ELISA
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24 found to have no cysts
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• 6/24 (25%) false +ve Ab ELISA
• 9/22 (40%) false +ve EITB