COMBATTING PARASITES IN SWINE HERDS

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Pigs, parasites and me

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Do parasites matter?

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Production losses

- Reduced weight gain/increased feed costs
- Costs for prevention/treatment
- Treatment costs of secondary infections
- Loss of carcass/liver etc.

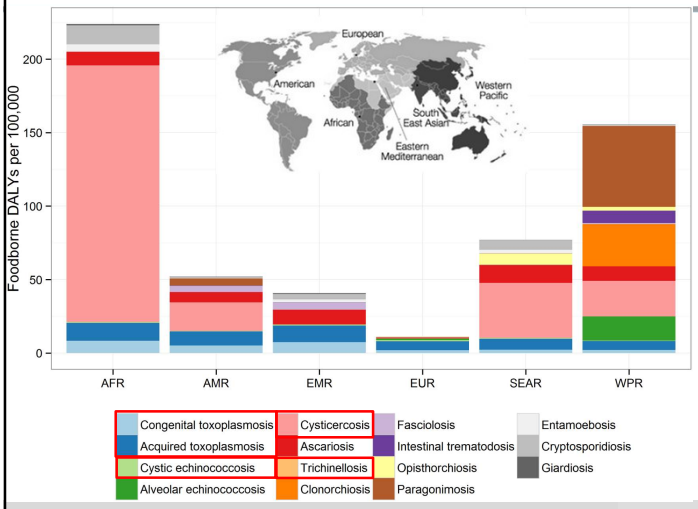
Zoonoses

- Loss of carcass etc.
- Surveillance costs

Animal health and welfare

- Reduced return
- Costs of treatment/prevention
- ?

Pigs, parasites and WHO



https://journals.plos.org/plosmedicine/article/figure?id=10.1371/journal.pmed.1001920.g002
https://www.pig333.com/articles/yangxiang-the-9-storey-farm_15384/
https://www.newscientist.com

Outline

- Pig parasites: the most important ones
- Parasites in a pig‘s life
- Current and future diagnostic options
- Issues for diagnosis and control: parasite biology and immunity against parasites
- Control options and alternatives
- A glance into the crystal ball: the future of parasitology in swine herd management

Porcine parasites

Parasite	Economic significance	Clinical significance (pig)	Zoonosis
Ectoparasites			
Sarcoptes scabiei	X	X	x
Haematopinus suis		x	
Helminths			
Cysticercus cellulosae	X (FP)		X!
Trichinella spiralis	X (FP)		X!
Trichuris suis	x	x	
Strongyloides ransomi	x	X	
Ascaris suum	X	x	(x)
Oesophagostomum spp.	x	?	
Metastrongylus spp.		x	
Protozoa			
Balantidium coli			x
Toxoplasma gondii	(x) (FP)	(x)	X!
Sarcocystis spp.	(x) (FP)		X
Eimeria spp.	(x)		
Cystoisospora suis	X	X	

Which parasites matter?

…depending on

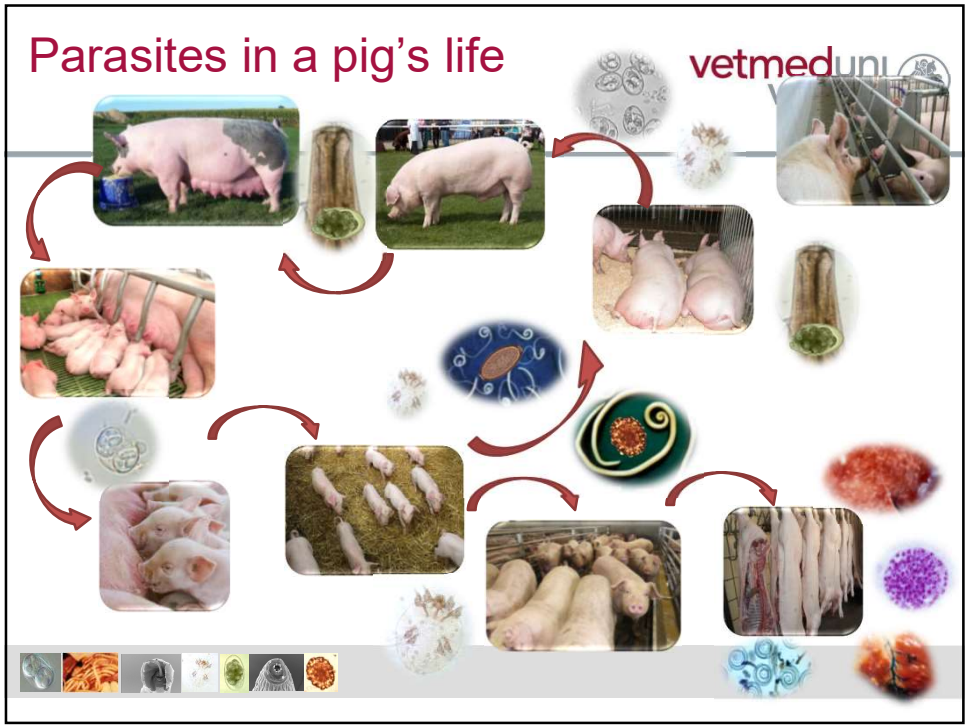
- age group (production stage)
- management form (intensive/conventional) – extensive (organic)

Parasite management in livestock focuses on the most relevant species in each group!

"Lead parasites" in swine production

- Protozoa: *Cystoisospora suis*
- Nematoda: *Ascaris suum* (control also extends to *Trichuris suis* and *Oesophagostomum* spp.)
- Ectoparasites: *Sarcoptes scabiei* var. suis

…are still around despite intensive control efforts!


Parasites in a pig's life
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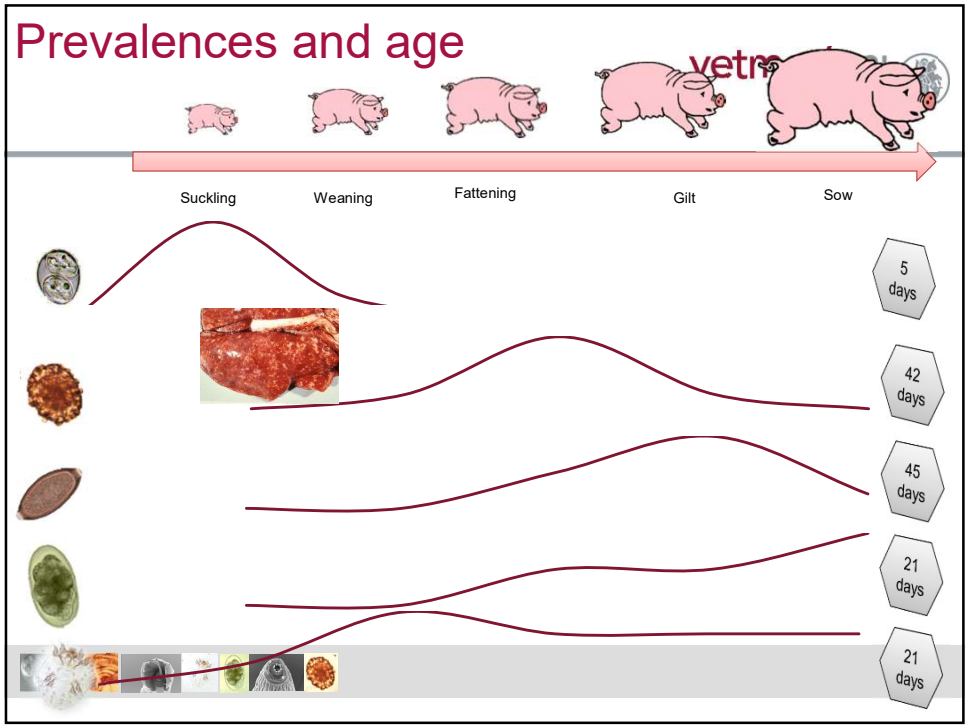
Prevalences and age
Suckling
Weaning
Fattening
Gilt
Sow
5 days
42 days
45 days
21 days
21 days

Cystoisospora suis

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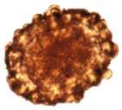
- Causative agent of porcine neonatal coccidiosis
- Direct transmission (oral uptake of oocysts) after birth
- Invasion of the small intestine (jejunum)
- Prepatency: 5 days
- Enteritis, diarrhoea, stunted growth
- Ubiquitous with high prevalences on the herd level
- Routine prophylactic treatment with toltrazuril 3.-5. day of life (20 mg/kg BW)

Ascaris suum



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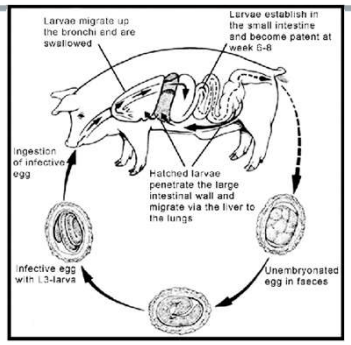
- "Large roundworm", zoonotic
- Oral infection via ingestion of larvated eggs
- Migration phase => small intestine
- "Milk spots" = inflammatory response
- Heavy infections may cause pneumonia, stunted growth, constipation
- Eggs extremely numerous, resistant, long-lived and sticky
- Worm burden and excretion highly **overdispersed**; far more pos. livers than egg shedders!

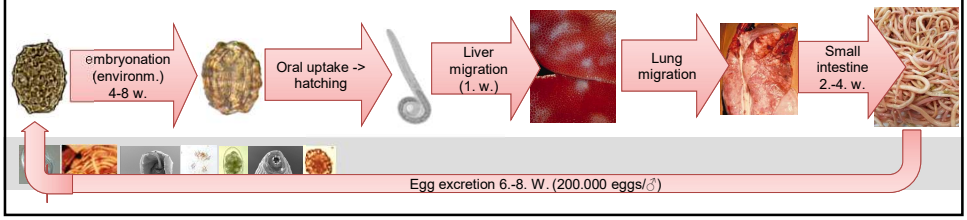
Dr. L. Schwarz, Vetmeduni Vienna

Milk Spots: when do they develop?



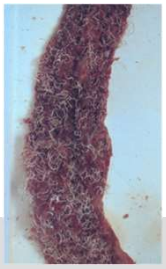
From: Nansen & Roepstorff, 1997

Milk spots develop as a conseqwuence of migrating *A. suum* larvae.
Larvae hatch from embryonated eggs upon ingestion and migrate to the liver (6-24 h pi).
This is followed by a MIGRATION PHASE in the liver incl. ecdysis L3 -> L4. Ca. 1 week p.i. the larvae continue their way to the lungs-trachea-small intestines (from 8 dpi).
Final ecdysis in small intestines (from 25. Tag pi).
Egg excretion from 6-8 week pi
Exogenous egg development at least 3 weeks (room temp: 4-8 weeks)



Trichuris suis

- "Whipworm"
- Oral infection via ingestion of larvated eggs
- Larval development in intestinal wall
- Adults buried in the mucosa of the large intestine
- Large worm burdens may cause chronic enteritis
- Long development of L1 limits infection pressure



Oesophagostomum spp.

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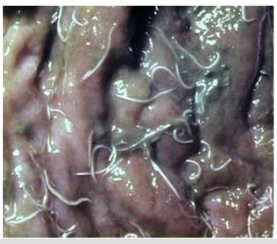
- "Nodule worm"
- Oral infection via ingestion of free-living L3
- Larval development in intestinal wall ("nodules")
- Adults attached to the mucosa of the large intestine
- Lack of immunity causes accumulation of worm burden in older animals
- Short development time (4 weeks)
- AR development described!



Fotos: A. Daugschies, Tiho Hannover/VMF Leipzig

Anthelmintics for pigs

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- Benzimidazoles:
  - Flubendazole
    - Flimabend 100 mg/g suspension (chicken, pigs)
      drinking water application (10 mg = 1 mg flubendazole /kg BW for 5 days (*Ascaris* L4 and adults; WD= 3 days)
    - Calculation for drinking water (20-200 mg/l): mg Flimabend/l water = $\frac{\text{mg Flimabend/kg BW/day x Ø BW (kg) of pig group}}{\text{Ø water (l/pig) for 4h}}$
    - Solubenol, 100 mg/kg, as above
  - Fenbendazole
    - Suspension (Panacur Aquasol, Pigfen), 200 mg/ml zum mixed in water
    - Powder, pre-mix or granulate 40 mg/g (dose: 5 mg/kg BW 1x (also against migrating stages of *A. suum*) or spread over 5-15 days (only against intrestinal stages)
- Macrocyclic lactones (see mange treatment!)
  - Ivermectin (parenteral or pre-mix)
  - Doramectin (parenteral)

Sarcoptes scabiei var. suis

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- „Burying mite“ / „Mange mite“ of swine, zoonotic
- Female mites bury into the skin to deposit eggs
- Larvae and nymphs emerge => transmission
- Acute => chronic: intense pruritus => severe skin alterations (ears, body, joint crooks)

Swine scab

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@HF Mathes (Afosa)
TiHo Hannover

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Control options for scabies in swine

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- Stamping out (and establishment of a mange-free herd)
- Treatment in regular intervals:
  - Acaricides: organophosphates (Phoxim), washing/spraying (REPEAT after 7 days!), WD: 2 weeks
  - Macrocyclic lactones (single application!)
    - Ivermectin 0.3 mg/kg s.c., WT: 28 days or in-feed (0.1 mg IVM/kg BW daily for 7 days)
    - Doramectin 0.3 mg/kg i.m., WD: 77 days
    - EFFECTIVE ALSO AGAINST ROUNDWORMS!!!

https://www.badische-bauern-zeitung.de/ab-unter-die-dusche

Stamping out

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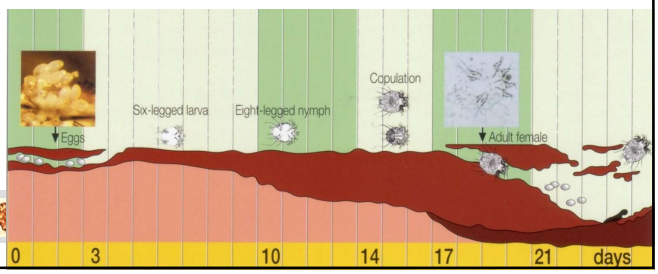
- Eradication of *Sarcoptes* from a herd/farm
- All stages are on the host
- All stages **except eggs** are susceptible to acaricides
- Treatment an re-treatment after hatching but before copulation (<14 days after 1st treatment) => kills **all** mites!
- NEEDS RELIABLE DIAGNOSTIC TOOLS TO EVALUATE STATUS!



Diagnostic issues

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	Direct diagnosis	Indirect diagnosis
Methods	Fecal examination Skin scraping Post mortem examination	Serum antibody detection (var. methods)
Specificity	High (CAVE coprophagy in pigs!)	Moderate-high
Sensitivity	Low	High
Availability	Coccidia, nematodes, mites (patent period)	*Ascaris, Sarcoptes* (prepatency, patency, post-patency)
Effort	High	Moderate

Do we need specific diagnosis?

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+ Treatment can be minimised to detectable parasites
+ Reduction of treatment costs, drug residues
+ Delay of AR
- Insensitive diagnosis may lead to false negative results and preclude treatment decisions
- Costs for diagnosis may exceed costs for treatment (and income from it is lower…)
- Endectocides cover a broad range of parasites in one treatment, anyway

New and future diagnostic tools (and their context with infection)

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- Fecal smear examination for *C. suis* using autofluorescence
- *Ascaris* serology
- Advanced serology for *Sarcoptes*

Autofluorescence for detection of *C. suis*

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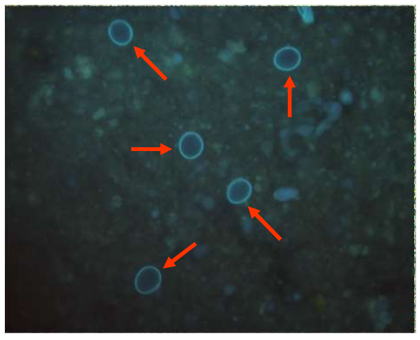
- Piglet faeces: high fat content, poor sensitivity of fecal smears/flotation
- Autofluorescence increases sensitivity
- No concentration, no labelling required



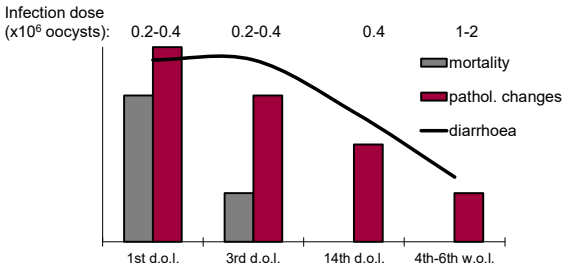
Daugschies A, Bialek R, Joachim A, Mundt HC. Autofluorescence microscopy for the detection of nematode eggs and protozoa, in particular *Isospora suis*, in swine faeces. Parasitol Res. 2001 May;87(5):409-12.

Sampling for *C. suis*: when and how?

- Faecal examination > 5 days of age, most animal start to excrete around 8-12 days of age with diarrhoea
- On farm level: repeated sampling 2nd-4th week of life in weekly intervals improves detection
- In a herd: „endemic stability“, parasite prevailance
- Excretion/intestinal stages in older pigs (> 3 weeks) => clinical relevance?

Age resistance to *C. suis*

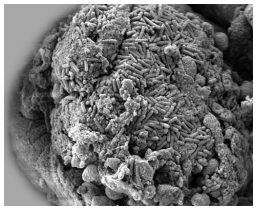
- Susceptibility of piglets strongly decreases with age
- Piglets > 3 weeks resistant to infection (irrespective of previous infections, i.e. immunity!)



(Stuart et al., 1982)

Age resistance to *C. suis*

- Reasons:
  - Poorly developed intestinal cellular immune system in suckling piglets?
  - Increased epithelial cell turnover in older animals?
  - Microbiome?

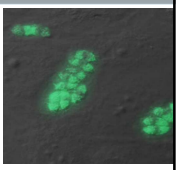


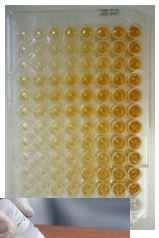
What about immunity?

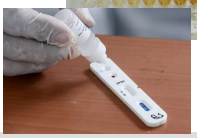
- Cellular and humoral responses to infection detectable in mature animals
- IgA in colostrum/milk/sow serum/piglet serum: correlation with protection against experimental infection in suckling piglets
- Colostrum generally important!
- Alternative control strategies?

C. suis: do indirect detection techniques make sense?

- Serology for Ab detection (IFAT): colostral transfer of maternal Ab disguise piglet Ab; acute infection precedes Ab production!
- Herd status monitoring: *C. suis* practically ubiquitous!
- Detection of coproantigen: unavailable! „Make a wish“: Fast strip test for diarrheal pathogens in piglets!





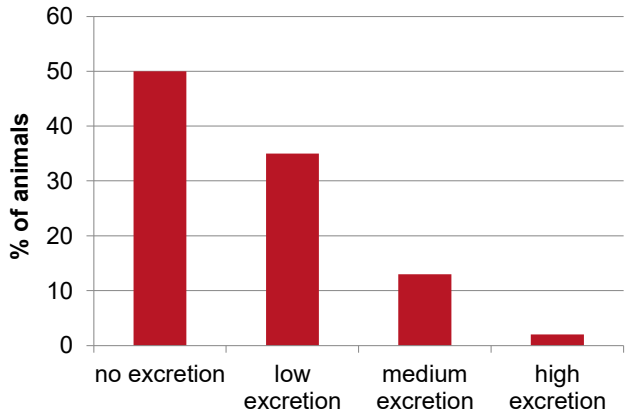


https://de.wikipedia.org/wiki/Enzyme-linked_Immunosorbent_Assay
www. middleeastmonitor.com: A coronavirus (COVID-19) rapid test kit [Anton Raharjo - Anadolu Agency]

New and future diagnostic tools (and their context with infection)

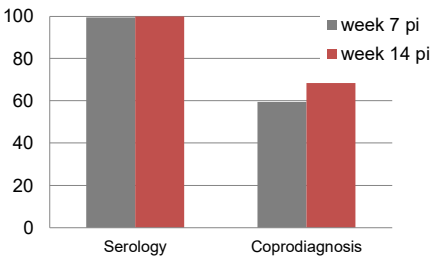
- Fecal smear examination for *C. suis* using autofluorescence
- *Ascaris* serology
- Advanced serology for *Sarcoptes*

Overdispersion of *Ascaris* shedders



Ascaris serology

- Antigen: *Ascaris* haemoglobin molecule; high sensitivity (99.5%) and specificity (100%)
- Commercialised as SERASCA® ELISA
- Detection of antibodies not very long before egg shedding



Vlaminck J, Nejsum P, Vangroenweghe F, Thamsborg SM, Vercruysse J, Geldhof P Evaluation of a serodiagnostic test using *Ascaris suum* haemoglobin for the detection of roundworm infections in pig populations. Vet Parasitol. 2012;189(2-4):267-73.
http://www.serasca.com/en/Home

Advanced *Sarcoptes* serology

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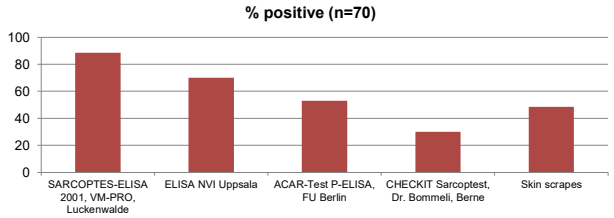
- Current tests based on whole antigen of *S. scabiei* (var. suis or vulpis): substantial variations!



- Single antigens: e.g. apolipoprotein (>90% sensitivity from 8-16 weeks p.i.), paramyosin

Mattsson JG, Ljunggren EL, Bergström K. Paramyosin from the parasitic mite *Sarcoptes scabiei*: cDNA cloning and heterologous expression. Parasitology. 2001 May;122(Pt 5):555-62.

Löwenstein M, Kahlbacher H, Peschke R. On the substantial variation in serological responses in pigs to *Sarcoptes scabiei* var. suis using different commercially available indirect enzyme-linked immunosorbent assays. Parasitol Res. 2004 Sep;94(1):24-30.

Rampton M, Walton SF, Holt DC, Pasay C, Kelly A, Currie BJ, McCarthy JS, Mounsey KE. Antibody responses to *Sarcoptes scabiei* apolipoprotein in a porcine model: relevance to immunodiagnosis of recent infection. PLoS One.2013 Jun 6;8(6):e65354.

Challenges in *Sarcoptes* serology

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- Slow development of antibodies
- Cross-reactivity with free-living mite antigens
- Virus-induced suppression (PCV2!) of Ab production
- Production of autoantigens in infected pigs
- Persistence of antibodies after treatment

Zalunardo M, Cargill CF, Sandeman RM. Identification of auto-antigens in skin scrapings from scabies-infected pigs. Int J Parasitol. 2006 Sep;36(10-11):1133-41.

Hejduk G, Hofstätter K, Löwenstein M, Peschke R, Miller I, Joachim A. Characterisation of Sarcoptes scabiei antigens. Parasitol Res. 2011 Feb;108(2):309-15.

Casais R, Goyena E, Martínez-Carrasco C, Ruiz de Ybáñez R, Alonso de Vega F, Ramis G, Prieto JM, Berriatua E. Variable performance of a human derived *Sarcoptes scabiei* recombinant antigen ELISA in swine mange diagnosis. Vet Parasitol. 2013 Oct 18;197(1-2):397-403.

Immunity against *Sarcoptes*

- Allergic type Th2 (IL-4, -13) and Th17 (IL-17, -23) responses contribute to the clinical picture ("crusted scabies")

=> Strong immunopathology!

- Development of immunity takes months, not sterile (sows as reservoirs!)

Mounsey KE, Murray HC, Bielefeldt-Ohmann H, Pasay C, Holt DC, Currie BJ, Walton SF, McCarthy JS. Prospective study in a porcine model of *Sarcoptes scabiei* indicates the association of Th2 and Th17 pathways with the clinical severity of scabies. PLoS Negl Trop Dis. 2015 ;9(3):e0003498.

Treatment classics

- Standard parasite control using antiparasitic drugs applied at certain times in the production phase irrespective of status, previous treatments etc.
- Examples:
  - Piglets receive toltrazuril at 3 days of age (together with iron, vaccine…)
  - Weaners/growers receive anthelminthics when moved to a fattening unit
  - Sows receive an endectocide before birth

Are these treatments justified – effective – cost efficient? What are the alternatives?

Treatment issues

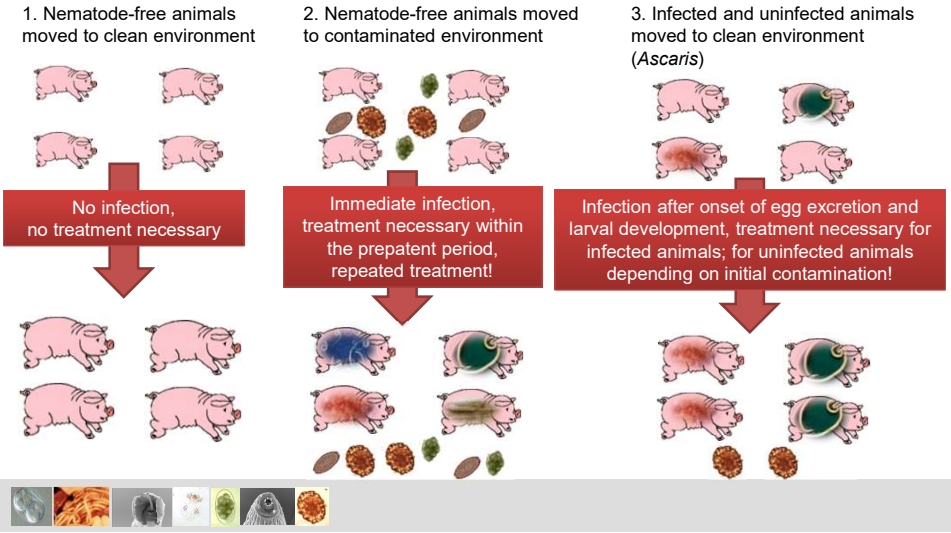
Purposes of treatment:

- Prevention of disease
  (but can disease be foreseen?)
- Prevention of economic losses
  (treatment costs must not exceed these losses)
- Prevention of environmental contamination and spread
  (parasite biology must be accounted for; diagnosis complicated)

Coccidiosis control in piglets revisited

- Toltrazuril (20 mg/kg 3.-5. day of life p.o.): in prepatency, highly effective
- Treatment „failures“ in cases of initially high infection pressure with both *C. suis* and (toxigenic) clostridia
- Treatment 1st day of life effective („off-label“!)
- Hygiene standards must be sufficient to have sustained control over *C. suis* (dry floors/pens, disinfection…)
- Routine treatment in intervals („refugia“)??
- NO elimination possible!!!

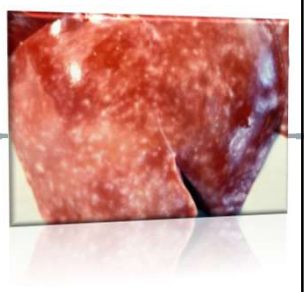
Infection dynamics of swine nematodes



Anthelminthic treatment of growers

- Application of in-feed/in-water anthelminthis
- When did/will infection take place?
- Which nematode species are involved?
  => When is egg excretion expected?
- Treatment too early: not economic
- Treatment too late: contamination with eggs, continuing reinfection!

Ascaris and the milk spot issue



- Migrating larvae induce milk spots temporaily
- More pronounced after reinfection

Factors affecting the prevalence of milk spot livers:

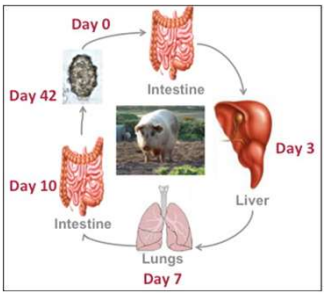
- Early infection of growers
- Larvated egg contamination in the environment of the finishers
- Ineffective treatment

Stamping out of *A. suum*?

- Intensive measures (continuing treatment, very high hygiene standards, quarantine….) can lead to elimination of *A. suum*
- Cons:
  - High costs of stamping out and maintenance of status
  - Easy reintroduction (resistant eggs!)
  - Surveillance difficult
  - Benefit unclear
  - Production of fully susceptible animals with high egg shedding after infection
- Future alternative: vaccination?

Immunity against *A. suum*

- Liver: short-lived immunity
- Lungs: local response, antibody production in LN
- => 50% of the larvae do not finish migration
- Intestines: hypersensitivity reaction, expulsion of L4 (90%) => strong intestinal immunity against incoming L3 („pre-hepatic barrier“)
- Strong immunity after several weeks of repeated exposure



Dr. Peter Geldhof, Uni Ghent
http://www.vetparasitology.ugent.be/

Endectocide application in sows

- Macrocyclic lactones (ivermectin, doramecin) highly effective against nematodes and mange mites, long lasting, different application options (in-feed, injection)
- Regular treatment of sows should prevent transmission of parasites to offspring (directly or via environmental contamination)
- „One for all“ treatment scheme effective?

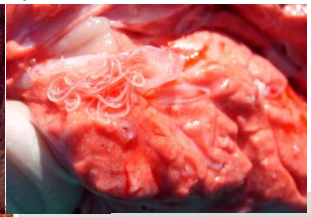
Endectocide application in sows

- *Sarcoptes scabiei*: stamping out vs. treatment (development of resistance)?
- *Ascaris suum*: Treatment of sow vs. piglet/weaner?
- *Oesophagostomum* spp.: development of resistance?
- *Strongyloides ransomi*: strongly suppressed by ML!

Alternative management – alternative parasites?

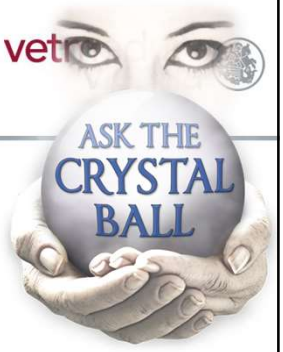
http://www.freerangepigsireland.com/pet_pigs

- „Green“ pig production favours certain parasites with low prevalence in conventional management
- *Hyostrongylus rubidus*, *Fasciola hepatica*, *Metastrongylus*, *Macracanthorhynchus hirudinaceus*: „outdoor parasites“
- Re-emergence?
- Inclusion in diagnostic panel!
- Evaluation of treatment options!



http://farmacologiamca.blogspot.com/2016/05/hyostrongylus-rubidus_15.html
http://servacal.blogspot.com/2014/05/metastrongylus-spp-en-porcino-iberico.html
https://quizlet.com/187651838/acanthocephala-and-platyhelminthes-flash-cards/

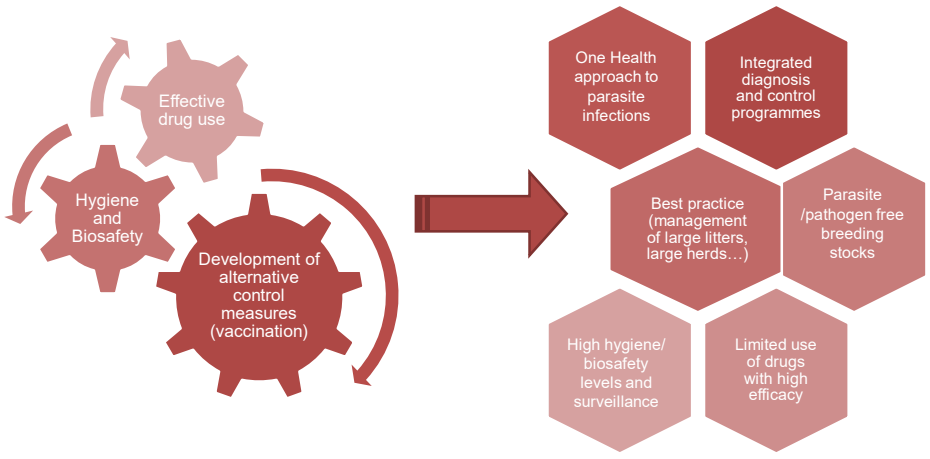
The future?



- „Taylor-made“,
  integrated control programmes
- Reduction of use of antiparasitics,
  routine surveillance of efficacy
- ~~Development of new drug classes~~
- Development of AR in pig parasites?
- Alternative control measures (vaccines, plant derived products?)
- Improved diagnostics in combination with biosecurity
  => sustainable parasite (nematode, mite)-free herds

https://www.cleanpng.com/png-crystal-ball-psychic-reading-spell-crystal-healing-1364625/download-png.html

Present and future



Thank you for your attention!

vetmeduni vienna

https://regenerationinternational.org/2016/05/10/strange-farmfellows-pigs-and-chickens-regenerate-the-land-in-bela-bela-south-africa/