



Porcine Epidemic Diarrhea (PED)

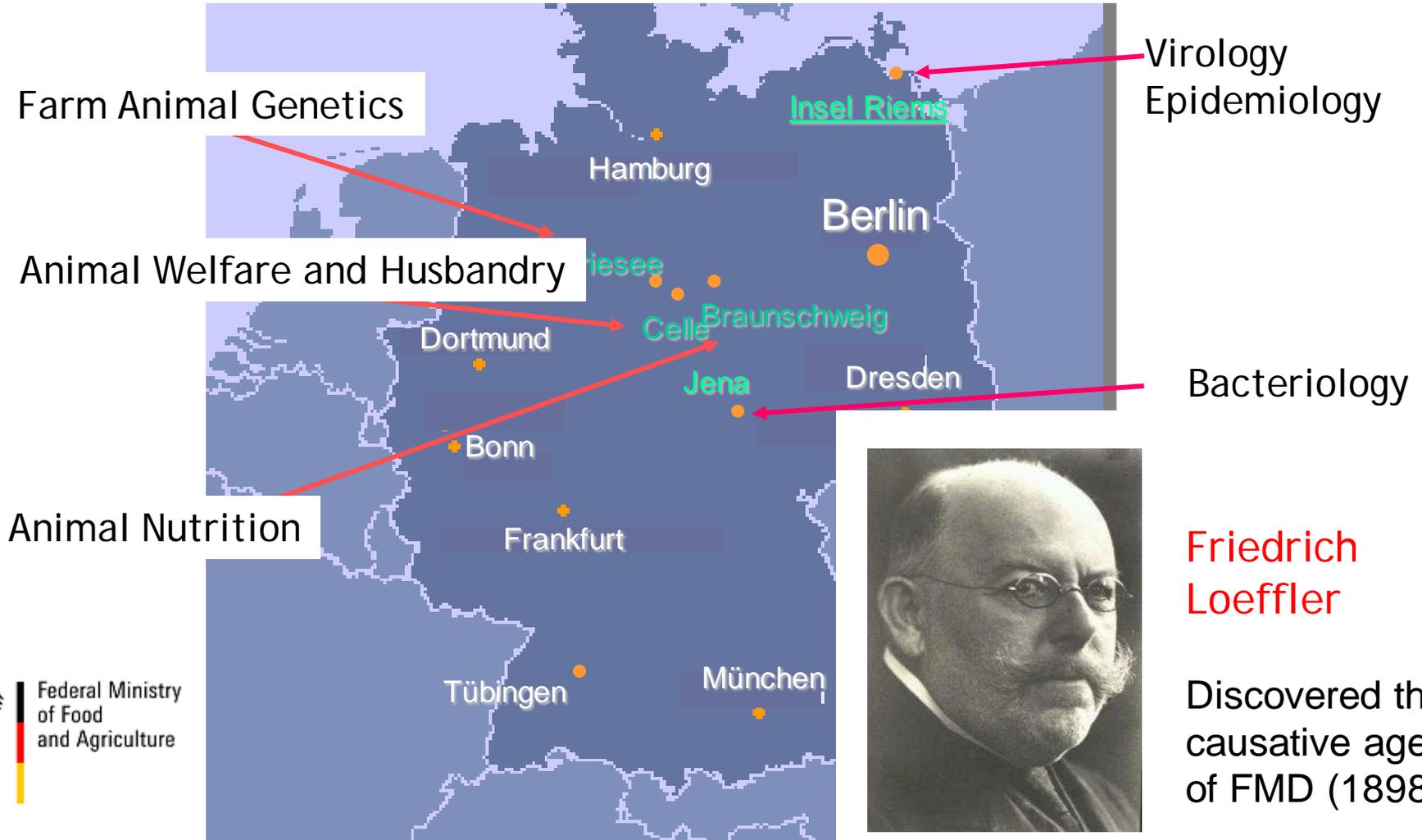
The German Perspective

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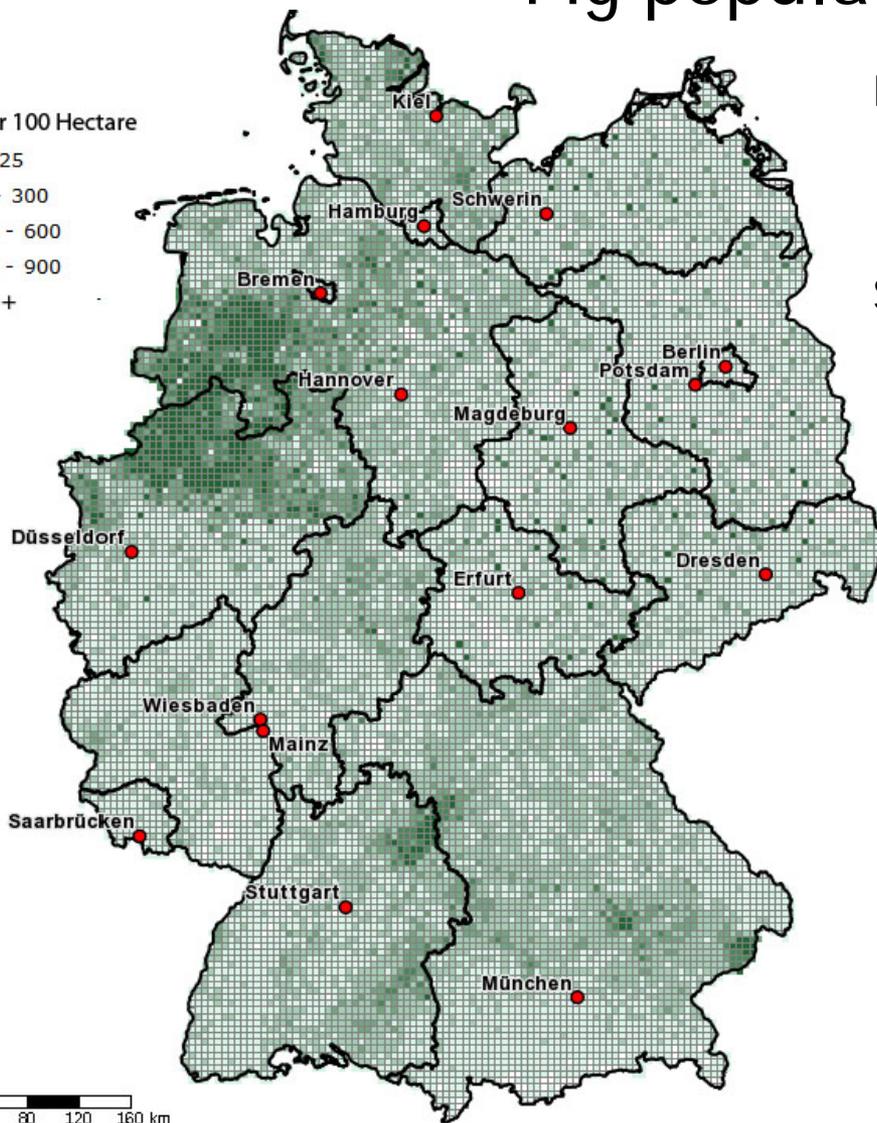
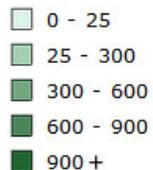
Friedrich
Loeffler

Discovered the
causative agent
of FMD (1898)



Pig population in Germany

Pigs per 100 Hectare



Pig population: **28 Millions**
(incl. 2 Mio breeding sows and 9 Mio piglets)

Slaughtered pigs per year: **60 Millions**

Pig holdings: **50 000**

Herd size	% (2010)
1 - 49	41,7
50 - 99	7,9
100 - 399	18,5
400 - 999	17,4
≥1000	14,6



Laboratory Diagnosis of PED in Germany

Electron microscopy may provide a hint what to look for

PED used to be diagnosed by IF in intestinal cryosections of freshly diseased piglets

Conjugate no longer available at the FLI

Now, **RT- qPCR** is the most important diagnostic method

Minnesota N + S; Multiplex Kim mod.

Sequencing

Serology is possible by **IIF**, using PEDV infected cell monolayers

ELISA being validated, specificity issues



RT-qPCR Minnesota S

PED_S_Forward-1910	PEDV S gene (Spike)	111 nt	ACG TCC CTT TAC TTT CAA TTC ACA
PED_S_Probe-1939, FAM-BHQ			TGA GTT GAT TAC TGG CAC GCC TAA ACC AC
PED_S_Reverse-2021			TAT ACT TGG TAC ACA CAT CCA GAG TCA

RT-qPCR Minnesota N

PED_N_Forward-941	PEDV unglycosylated RNA binding nucleocapsid (N)	87 nt	GAA TTC CCA AGG GCG AAA AT
PED_N_probe-963, FAM-BHQ			CGT AGC AGC TTG CTT CGG ACC CA
PED_N_Reverse-1028			TTT TCG ACA AAT TCC GCA TCT

RT-qPCR Multiplex Kim mod.

TGENF	TGEV N	120 nt	GCAGGTAAGGTGATGTGACAA
TGENR			ACATTCAGCCAGTTGTGGGTAA
TGE-TEX			TGGCACTGCTGGGATTGGCAACGA
PEDNF	PEDV N	198 nt	CGCAAAGACTGAACCCACTAATTT
PEDNR			TTGCCTCTGTTGTTACTTGGAGAT
PED-FAM			TGTTGCCATTGCCACGACTCCTGC

Pan-Corona Lelli 2013

IZS-CoV forward	Pan RdRp	180 nt	CDCAYGARTTYTGYTCNCARC
IZS-CoV reverse			RHGRTANGCRTCWATDGC
Corona 1 forward	RdRp	760 nt (440 for seq.)	GGTTGGGACTATCCTAAGTGTGA
Corona 2 reverse			CCATCATCAGATAGAATCATCATA
Corona 1 forward degenerated			GGNTGGGAYTAYCCNAARTGYGA

Sequencing N Li 2013

Li-PEDV-N-F	PEDV N	1380 nt	TGCGGTTCTCACAGATAGTG
Li-PEDV-N-R			AAGTCGCTAGAAAAACACTCAGTAAT

Sequencing S partial Li 2012

Li-PEDV-Sp-F	PEDV S gene (Spike)	420 nt	GCAACTCAAGTGTCTCAG
Li-PEDV-Sp-R			GAGTCATAAAAAGAAACGTCCG



PEDV was confirmed in a pig herd in Germany in 2014

Farm with 1400 fattening pigs, diarrhea for about a week, 20 pigs died

PEDV Isolates (PK15 + Vero cells) were sequenced (full length)

Comparative analyses of full-length sequences revealed that the recent German isolates can **clearly be distinguished from the highly virulent PEDV** strains from the US but show high similarity with the new "mild" US strain OH851 found in 2014.

Similar strains may have already been circulating in Europe for some time.



What can we do with PEDV sequence data?

Molecular epidemiology, e.g. “tracing back” ?

No comprehensive strain collection of recent years and decades!

Determine the “Pathotype” ???

Determinants of virulence unknown!

How reliable and standardized are field data?

More research needed!



PED in Europe

PED enzootic in the European pig population since 1970s

Severity of clinical disease depended on immune-status of herd
mostly moderate, but in non-immune, fully susceptible populations
80% mortality in neonatal piglets

Since 1980's outbreaks less frequent, virus persisted in the pig population

Serological prevalence usually low
localized pockets of infection

Last documented evidence of PED:
Italy, 2005 - 2006, affecting pigs of all age groups
Germany, 2014

PED is not notifiable in the EU



History and occurrence of disease

- England 1971
- Belgium 1977
- Germany 1980
- Japan 1982
- China 1984 (presumably present there since 1973)
- Switzerland 1987
- South Korea 1992
- Thailand 2007
- Vietnam 2009
- 2010 onwards: high morbidity and mortality in China, US, Japan, ...



Prevalence in Europe

Year	Country	Sero-Prevalance	Reference
1979-1981	Germany	26 %	Prager & Witte, 1983
1980	Germany	19.6 %	Hess et al., 1980
1987	Switzerland	1.6 %	Hofmann & Wyler, 1987
1992/1993	Spain	29.6 %	Carvajal et al., 1995
1996	Hungary	5.5 %	Nagy et al., 1996
1996	Belgium	1.4 %	In Review of Martelli et al. 2008
2004	The Czech Republic	12.3 %	Rodak et al., 2004
2013	Great Britain	10 %	SDEC, UMN, 2014

(within herd 70%)

- No active surveillance anymore



First occurrence of PED in USA (spring 2013)

- High mortality in suckling pigs
- Clinical signs in adult and fattening pigs
- **Four farms not connected to each other!**
- **Rapid spread despite high biosecurity!**
- => import restrictions (Japan, China, Mexico, France)



Open Questions:

Did the virus enter naive populations ?

Can this explain the severe clinical signs ??

Can changes in viral properties explain the re-occurrence? Probably yes - but lack of data!

More research needed!



Import of live pigs

- In 2013: 167 live pigs from US to UK; no other countries imported live pigs
- In 2014: so far no live pigs imported
- July 10th, 2014: regulation for import: (EU 750/2014)
 - Pigs held ≥ 40 days in a holding with no PED + PCR test
- Regulation in place for vesicular stomatitis
 - Pre-export quarantine for 30 days



Import of live pigs

- => Entry risk is estimated as **low**
(with low uncertainty)



Risk assessment -SDPP

- Source of serum ?
- From apparently healthy animals (ante-mortem inspection) at abattoir - no lab test
- One contaminated batch may infect many farms
- Experimental evidence that viruses can survive spray drying

Excretion of PEDV after SDPP feeding has been shown (Pasick et al., 2014)

- There is no QM-System in place that ensures inactivation of viruses (Temperature may be specified - but not incubation time, no or insufficient process controls...)



Variants of the SDPP Hypothesis

A. Unknown Asian source

- => initial input into US pigs not detected
- => SDPP from US pigs contaminated
- => spray dried, distributed and fed

B. Import of SDPP from Asia

- => => spray dried, distributed and fed

How did it spread further? **More research needed!**



Risk assessment - Import of SDPP

- If PEDV is contained in SDPP
⇒ Risk is **high**
(with moderate uncertainty)



PED as an example of getting hit by the “Unknown Unknown...”

Feed components, straw, vehicles, containers, ...
are a plausible sources for FADs and may have lead to the
introduction of FMDV (Japan 2000, Japan 2011, South
Korea...)! Evidence for “near misses” in the past...

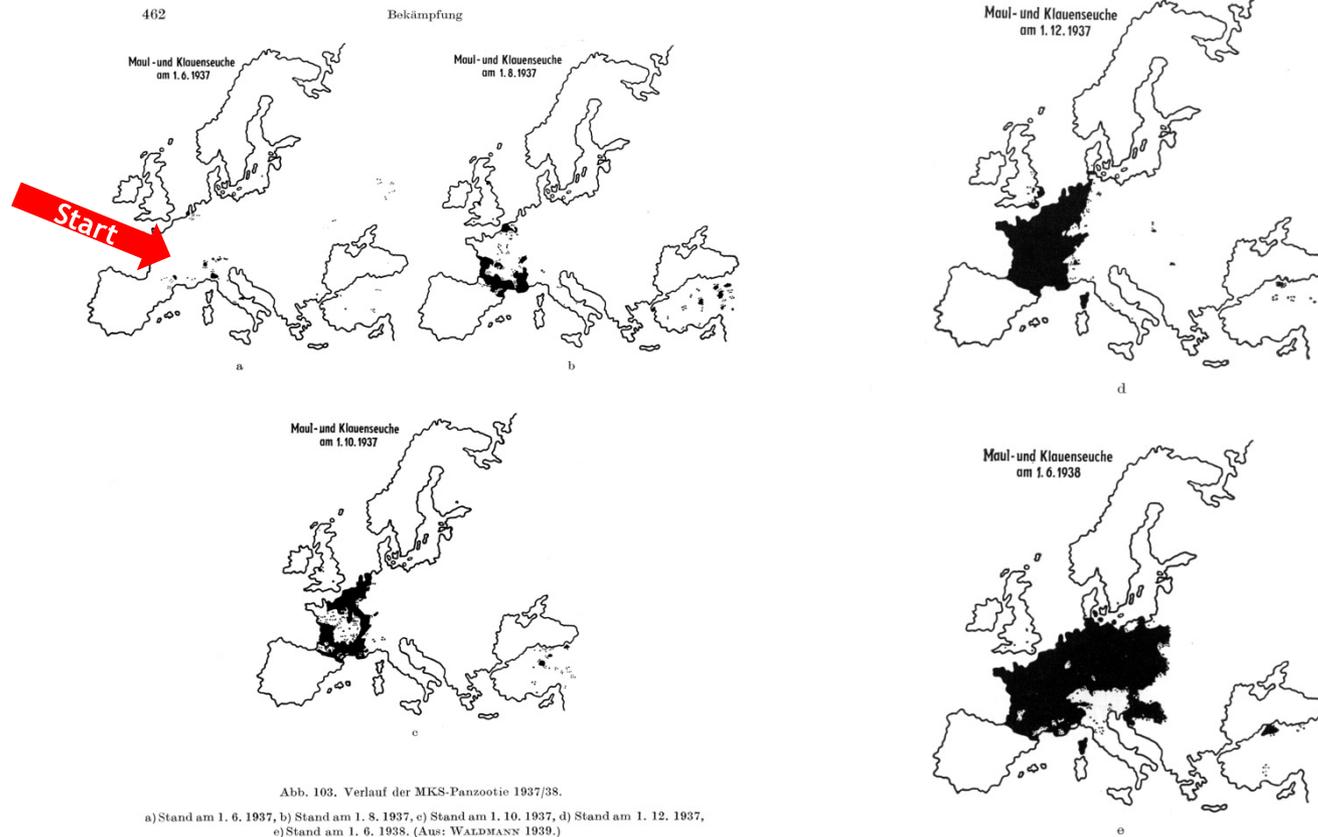
Swill feeding

Visitors and farm workers

Fetal calf serum and medicinal products



PED is a wake-up call!



FMD 1937  1938



Thank you very much for
your interest and
attention.