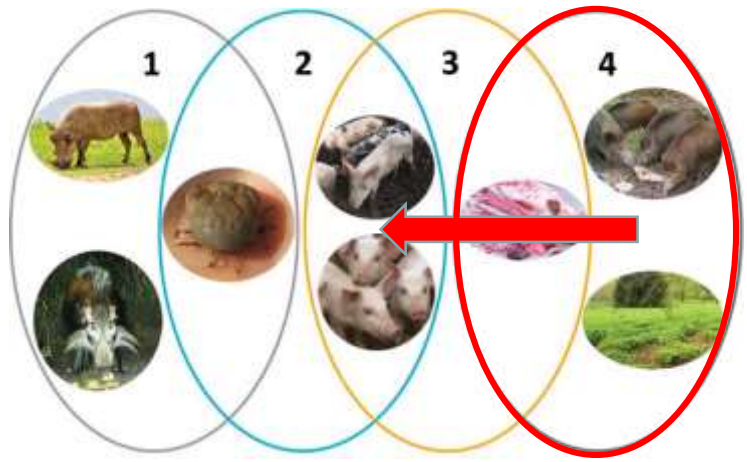
The role of the „wild boar-habitat cycle“ for ASF transmission to domestic pigs

https://www.google.de/search?q=wildschwein+kontakt+hausschwein&rlz=1C1GCEA_enDE801DE801&source=lnms&tbm=isch&sa=X&ved=0ahUKEwil1d_j-e7bAhUECpoKHRc-AksQ_AUICigB&biw=1280&bih=882#imgrc=UJnSChnXHzuFNM:

The epidemiologic cycles of ASF and main transmission agents

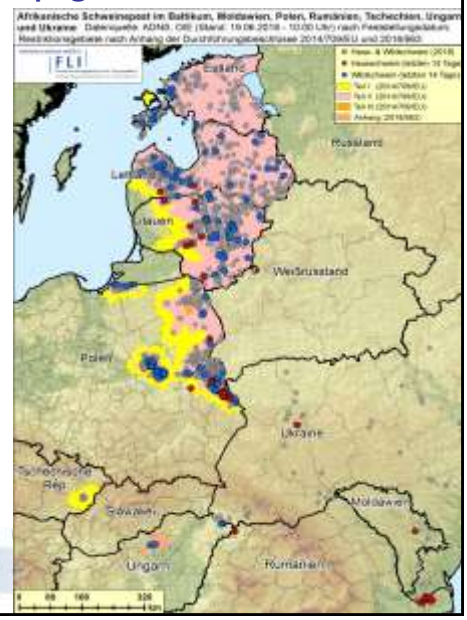


Chenais et al., Emerg Infect Dis. 2018 Apr;24(4):810-812.

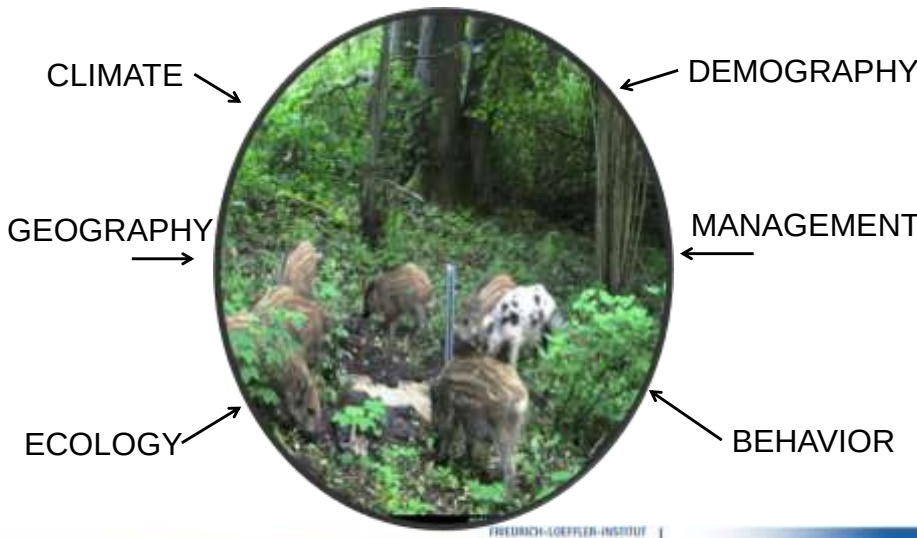
Localisation of ASF cases in wild boar and domestic pigs

- ASF disease dynamics have proven to be complex and difficult to control
- ASF prevalence remains <5%
- a pattern of local persistence
- slower than expected dynamic spatial spread is evident, estimated at an average of 1–2 km/month

(EFSA, 2017)



The wild boar habitat cycle



FRIEDRICH-LOEFFLER-INSTITUT
since 1910
FLI
Bundesforschungsinstitut für Tiergesundheit
Federal Research Institute for Animal Health

Means of transmission within the wild boar habitat cycle?

- Direct transmission between infected and susceptible wild boar
- Indirect transmission through carcasses in the habitat
- Indirect transmission through other potential vectors?
- Indirect transmission through the environment?

Direct transmission between infected and susceptible wild boar
What do we need to know?

- EXCRETION: Virus excretion by urine/saliva low -> low dose
- Contacts within one group of animals high -> possibly higher dose
- Transmission between groups?
  - Rather low (Iglesias et al., 2015; Pietschmann et al., 2015)

Level of excretion

TABLE 1:

Quantification of African swine fever virus (ASFV) in blood, secretions and excretions of infected domestic pigs with currently circulating strains in Caucasus, Ea

Sample type	ASFV strain	Inoculation	Maximum of virus titres detected	References
Blood	Lithuania LT14/1490 isolated from wild boar	Intramuscular 10 HAD_{50}/ml	$10^{6.8}$ to $10^{8.7}$ HAD_{50}/ml at 4 dpi	Gallardo and others 2015a
		Contact	$10^{6.4}$ to $10^{8.7}$ HAD_{50}/ml at 14 dpi	
	Georgia 2007/1 isolated from domestic pig	Intramuscular 10^2 HAD_{50}/ml	10^8 to 10^8 HAD_{50}/ml from 5 dpi	Guinat and others 2016
		Contact	10^8 to 10^8 HAD_{50}/ml from 10 dpi	
	Russia Kashino 14/13 isolated from wild boar	Intranasal 5×10^2 HAD_{50}/ml	$10^{7.2}$ HAD_{50}/ml at 7 dpi	Vlasova and others 2015
		Intranasal 10 HAD_{50}/ml	$10^{6.2}$ to $10^{7.2}$ HAD_{50}/ml from 7 dpi	
		Contact	$10^{6.2}$ to 10^{7} HAD_{50}/ml from 12 dpi	
	Russia Bryansk+ 08/13 isolated from domestic pig	Intranasal 5×10^2 HAD_{50}/ml	$10^{6.2}$ to $10^{7.2}$ HAD_{50}/ml from 9 dpi	Vlasova and others 2015
		Intranasal 10 HAD_{50}/ml	$10^{6.2}$ to 10^{7} HAD_{50}/ml from 7 dpi	
		Contact	10^{7} HAD_{50}/ml at 15 dpi	
	Russia K 08/13 isolated from wild boar	Intramuscular 5×10^2 HAD_{50}/ml	$10^{6.2}$ to 10^{7} HAD_{50}/ml from 7 dpi	Vlasova and others 2015
		Intramuscular 10 HAD_{50}/ml	$10^{6.2}$ to 10^{7} HAD_{50}/ml from 9 dpi	
Nasal fluid	Georgia 2007/1 isolated from domestic pig	Intramuscular 10^2 HAD_{50}/ml	Intermittent detection, 10^{2} to 10^{4} HAD_{50}/ml from 4 dpi	Guinat and others 2016
		Contact	Intermittent detection, 10 to 10^{2} HAD_{50}/ml from 7 dpi	
Rectal fluid	Georgia 2007/1 isolated from domestic pig	Intramuscular 10^2 HAD_{50}/ml	Intermittent detection, 10 to 10^{2} HAD_{50}/ml from 5 dpi	Guinat and others 2016
		Contact	Intermittent detection, 10 to 10^{2} HAD_{50}/ml from 12 dpi	

dpi Day post infection, HAD_{50}/ml 50 per cent haemadsorbing doses per ml

Guinat et al., 2016

Tenacity

Material	duration	method	Reference
Feces (4°-6C)	160 days	Bioassay (i.m.)	Kovalenko 1972
Feces (4°C-RT)	3 months	Virus isolation (low titres)	Blome and Dietze, 2011 (FAO report)
Feces (4°C)	8 days	Virus isolation	Davies et al., 2015
Feces (37°C)	3-4 days	Virus isolation	Davies et al., 2015
Urine (4°C)	15 days	Virus isolation (low titres)	Davies et al., 2015
Urine (21 °C)	5 days	Virus isolation (low titres)	Davies et al., 2015
Urine (37°C)	2-3 days	Virus isolation (low titres)	Davies et al., 2015
Urine (4°-6C)	60 days	Bioassay (i.m.)	Kovalenko 1972

We assume that

HIGH
- within a group (within stable) permanent contact
- oral uptake of a high virus dose (>1000 HAU)
- parenteral transmission

Probability of Infection (PoI)

LOW
- between groups (open system…e.g. forest)
- low virus dose (<100 HAU)
- oral transmission

Indirect transmission through carcasses in the habitat

What do we need to know?

1.) Tenacity: How long are carcasses infectious ?

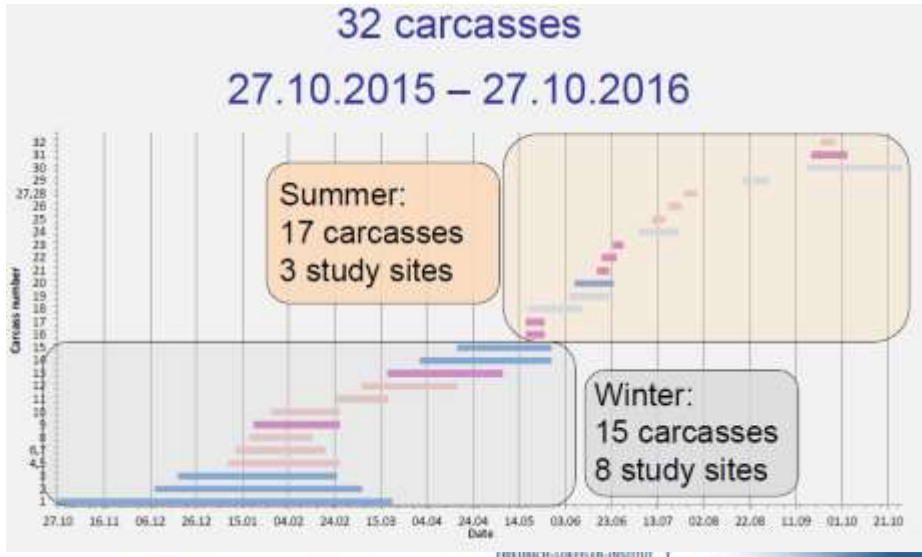
2.) Availability: How long is the process of natural decomposition of a wild boar until they „disappear“? What happens with the left-overs (bones)?

3.) Contact: Do wild boar eat their dead fellows / what do they do when they find a dead fellow?

Tenacity

Material	duration	method	Reference
Blood	140 days in the dark	Bioassay	Montgomery et al., 1921
Blood	> 6 years at 4-6°C	Bioassay (i.m.)	Kovalenko et al., 1972
Blood	> 90 days	Virus isolation (high titres)	Blome and Dietze, 2011
Spleen	240 days (6-8°C)	Bioassay (i.m.)	Kovalenko et al., 1972
Spleen	>90 days	Virus isolation (high titres)	Blome and Dietze, 2011
Muscle	155 days (6-8°C)	Bioassay (i.m.)	Kovalenko et al., 1972
Muscle	183 days		McKercher, 1987
Muscle	90 days	Virus isolation (low titre)	Blome and Dietze, 2011
Fat	123 days	Virus isolation	McKercher, 1987

Carcass experiment



Probst et al., 2017 (see handout)

Example of natural decomposition of a wild boar carcass in summer in the forest (with access to scavenger animals) A, B= Day 1, flies lay eggs in little carcass holes
C = Day 6, massive larvae invasion
D = Day 9, process almost finalized. Only small islet of larvae activity; bones almost spread.

ASF in Wild boar habitat

If wild boar eat infected carcasses, the Pot must be very hight


How do wild boar behave towards
wild boar carcasses?
Probst et al., 2017 see your handout


Wild boar were more interested in the soil underneath and in vicinity of the carcasses
Probst et al., 2017; Masiulis et al., in press
SEISSIGER Wildkamera
M
13/07/2016 07:28:48
015°C P5

Probst et al., 2017 see your handout

Probst et al., 2017 see your handout

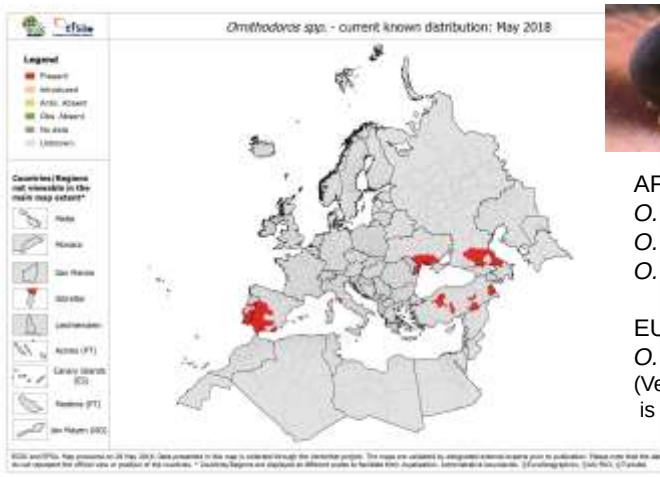
Indirect transmission through potential arthropod vectors (mechanical or virus reservoir?)
What do we need to know?

1.) Invasive vectors: Ticks, biting flies, mosquitoes, lice

2.) Maggots:
- Do wild boar take them up from carcasses?
- Are they infectious (Forth et al., 2017 - handout)

3.) other scavenging species:
- Fox, wolf, birds, others?

Ornithodorus as competent vector

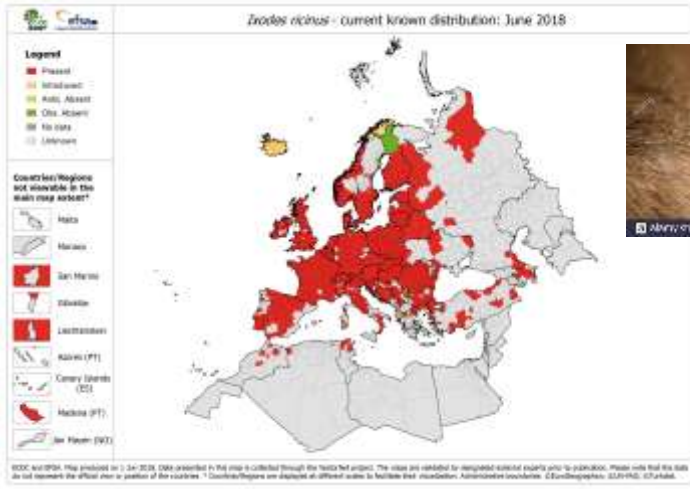


AFRICA
O. Moubata
O. Savignyi
O. Porcinus

EUROPE:
O. Erraticus
(Vector competency is lower)

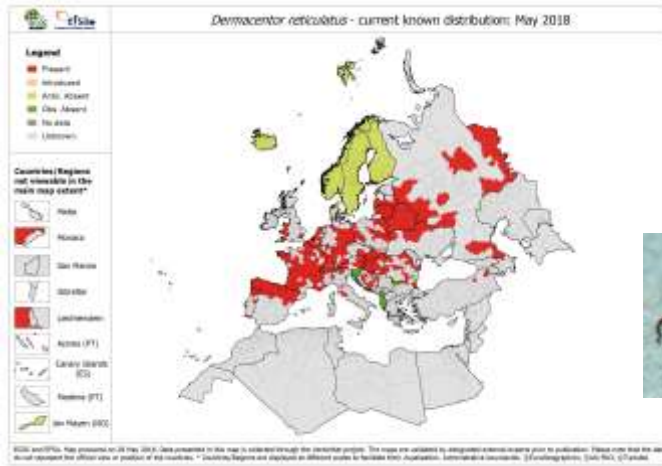
https://ecdc.europa.eu/en/disease-vectors/surveillance-and-disease-data/tick-maps

Ticks in Europe: Ixodes



https://ecdc.europa.eu/en/disease-vectors/surveillance-and-disease-data/tick-maps

Ticks in Europe: Dermacentor



https://ecdc.europa.eu/en/disease-vectors/surveillance-and-disease-data/tick-maps

Investigation in ticks and other blood sucking arthropods

- Investigation in ticks in Estonia – no ASFV detection
- Investigation in Cullicoides – no ASFV detection

please contact L. Zani, J. Forth, A. Viltrop or S. Blome for more information

- Role of Biting flies: *Stomoxys* found to be short distance mechanical vector, Mellor et al., 1987; Oelsen et al., 2018. Role of Tabanids?
- Role of lice (mechanical vector ? Anecdotally ASFV active up to 20 days (Botija and Badiola 1966)
- Flies collected on ASF-affected farms in Lithuania tested negative for ASFV (EC 2014 b)

Indirect transmission through the environment

What do we need to know?

1.) Bones: How long are bones (bone marrow) infectious ?

Material	duration	method	Reference
Bone marrow	94 days	Virus isolation	McKercher, 1987
Bone marrow	188 days (6-8°C)	Bioassay (i.m.)	Kovalenko et al., 1972

2.) Soil: What is the role of soil?

Experiments are running at the FLI (Dr. Carolina Probst carolina.probst@fli.de)

Tenacity

Material	duration	method	Reference
Blood on wooden plank under soil	81 days	Bioassay (i.m.)	Kovalenko 1972
ASF-Blood on wooden plank on soil	192 days	Bioassay (i.m.)	
ASF-Blood on clay brick under soil	112 days	Bioassay (i.m.)	
ASF-Blood contaminated sand	81 days	Bioassay (i.m.)	
ASF-Blood contaminated soil	112 days	Bioassay (i.m.)	
ASF-Blood contaminated water 1:100	176 days	Bioassay (i.m.)	
ASF-Blood contaminated water 1:1000	<17 days	Bioassay (i.m.)	

But: No virus isolation possible from soil beneath positive carcasses and viral genome load very low (PCR) (Nurmoja and Zani et al., 2018)

Transmission to domestic pigs

Table 1: Number of outbreaks in domestic pigs and cases in wild boar notified to the Animal Disease Notification System from 24 January 2014 until 16 September 2016

Country	Outbreaks in domestic pigs[a]	Cases in wild boar [b]
Estonia	24	2,249
Latvia	44	2,068
Lithuania	37	534
Poland	20	188

(a): An outbreak of African swine fever in domestic pigs refers to one or more cases of ASF detected in a pig holding.
(b): A case of African swine fever in wild boar refers to any wild boar or wild boar carcass in which clinical symptoms or post-mortem lesions attributed to ASF have been officially confirmed, or in which the presence of the disease has been officially confirmed as the result of a laboratory examination carried out in accordance with the diagnostic manual.

Abrahantes et al., 2017 (EFSA)

Transmission to domestic pigs
What do we need to know?

- Direct contact (infected wild boar to susceptible domestic pig)
- Indirect contact
  - Infected wild boar products (uncooked meat), feeding uncooked swill (hunting?)
  - Contaminated fomites (?): surfaces of vehicles, equipment or animal worker clothing -> unknown impact
  - Biosecurity (hunter / farm)
  - Contaminated bedding material, fresh grass, seeds (EC 2014a)
  - Specific feed
  - Blood sucking arthropods?
- Social attitudes and economic considerations (Vergne et al., 2016)
  - lack of disease awareness
  - reputation

Direct contact

- Susceptible pigs housed in direct contact with infected wild boar became infected after 6-12 days (Gabriel et al., 2011; Pietschmann et al., 2015
- Even when susceptible pigs were separated from the infectious wild boars in an adjacent pen without direct contact, the transmission occurred after 21 days

Tenacity of meat products

Material	duration	method	Reference
Pork products*	16 days (22-27°C)	Virus isolation (low titre)	Kolbasov et al., 2011
	84 days 4-6°C)	Virus isolation (low titre)	Kolbasov et al., 2011
	118 days (-18 to -20°C)	Virus isolation (low titre)	Kolbasov et al., 2011
Heated ham	<5 days	Virus isolation negative (5 d)	Mc Kercher 1978
Salami/peperoni sausage	<30 days	Virus isolation negative (30 d)	Mc Kercher 1978
Iberian Ham	112	Virus isolation	Mebus et al. 1993
Serrano ham	140	Virus isolation	Mebus et al. 1997
Salami	18 days	Bio assay (oral)	Petrini et al. 2019
Pork belly	60 days	Bio assay (oral)	Petrini et al. 2019
Loin	83 days	Bioassay (oral)	Petrini et al. 2019

*corned pork, pork fat, cured pork fat, smoked pork fat

Hunted boar can be positive

Table 10: Apparent Virus (PCR) prevalence in wild boar in the Baltic countries and Poland, January 2014 to August 2016 (percentage; source: DCF)

Country	2014		2015		2016	
	Wild boar found dead	Wild boar hunted	Wild boar found dead	Wild boar hunted	Wild boar found dead	Wild boar hunted
Estonia	29.8*	1.01*	71.41	3.8	85.7	3.0
Latvia	53.2	0.68	73.08	1.8	78.2	2.1
Lithuania	23.8	0.11	27.3	0.97	59.9	0.13
Poland	1.4***	0.04**	1.42***	0.1**	0.5***	0.0**

n/a: data are not available.
*: Samples from a period the infection was not detected in a country are included.
**: Most of the samples tested originate from affected administrative units (see Figure 3A).
***: A large proportion of samples tested originate from unaffected administrative units (see Figure 3B).

Abrahantes et al., 2017 (EFSA)

Biosecurity during hunting

Biosecurity during hunting / collection of samples

Fotos: Thomas Patzelt

Biosecurity during hunting / collection of samples

Fotos: Thomas Patzelt

Biosecurity during hunting / collection of samples

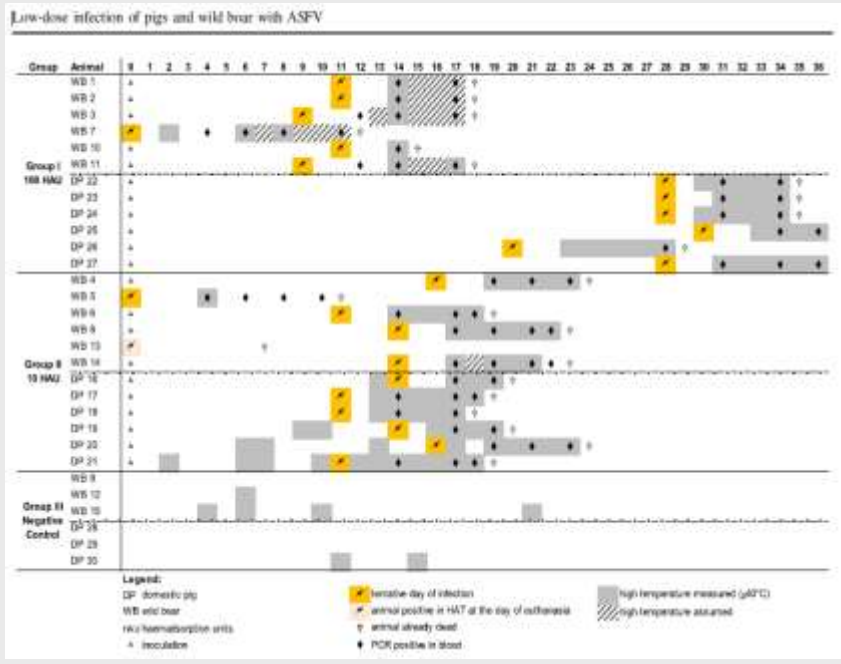
Fotos: Thomas Patzelt

Biosecurity during collection of samples from carcasses

Fotos: Thomas Patzelt

References

- Blome S, Gabriel C, Beer M. Pathogenesis of African swine fever in domestic pigs and European wild boar. Virus Res. 2013;173:122–30. 10.1016/j.virusres.2012.10.026
- Chenais E, Ståhl K, Guberti V, Depner K. Wild boar habitat and epidemiologic cycle of African swine fever epizootic in Central and Eastern Europe. Emerg Infect Dis. 2018 Apr [date cited]. https://doi.org/10.3201/eid2404.172127
- Davies K, Goatley LC, Guinat C, Netherton CL, Gubbins S, Dixon LK, Reis AL. Survival of African Swine Fever Virus in Excretions from Pigs Experimentally Infected with the Georgia 2007/1 Isolate. Transbound Emerg Dis. 2017 Apr; 64(2):425-431.
- European Food Safety Authority (EFSA). Cortiñas Abrahantes J, Gogin A, Richardson J, Gervelmeyer A. Epidemiological analyses on African swine fever in the Baltic countries and Poland. EFSA J. 2017;15:4732.
- European Food Safety Authority. Evaluation of possible mitigation measures to prevent introduction and spread of African swine fever virus through wild boar. EFSA J. 2014;12:3616.
- Forth J, Ahmendt J, Blome S, Depner K, Kampen H. Evaluation of blowfly larvae (Diptera: Calliphoridae) as possible reservoirs and mechanical vectors of African swine fever virus. TBED 2017 (65-1) 210-213
- Guinat C, Gogin A, Blome S, Keil G, Pollin R, Pfeiffer DU, Dixon L. Transmission routes of African swine fever virus to domestic pigs: current knowledge and future research directions. Vet Rec. 2016 Mar 12;178(11):262-7. doi: 10.1136/vr.103593
- Mellor PS, Kitching RP, Wilkinson PJ. Mechanical transmission of capripox virus and African swine fever virus by Stomoxys calcitrans. Res Vet Sci. 1987 Jul;43(1):109-12.
- Nurmoja I, Schulz K, Staubach C, Sauter-Louis C, Depner K, Conraths FJ, et al. Development of African swine fever epidemic among wild boar in Estonia - two different areas in the epidemiological focus. Sci Rep. 2017;7:12562.
- Olesen AS, Lohse L, Hansen MF, Boklund A, Halasa T, Belsham GJ, Rasmussen TB, Bøtner A, Bødker R (2018) Infection of pigs with African swine fever virus via ingestion of stable flies (Stomoxys calcitrans). Transbound Emerg Dis. 2018 Jun 7. doi: 10.1111/tbed.12918. [Epub ahead of print]
- Petrini S, Feliziani F, Casciari C, Giammarioli M, Torresi C, De Mia GM. Survival of African swine fever virus (ASFV) in various traditional Italian dry-cured meat products. Prev Vet Med 162 (2019) 126-130.
- Probst C, Globig A, Knoll B, Conraths FJ, Depner K. Behaviour of free ranging wild boar towards their dead fellows: potential implications for the transmission of African swine fever. R Soc Open Sci. 2017;4:170054. 10.1098/rsos.170054
- Vergne T., Guinat C., Petkova P., Gogin A., Kolbasov D., Blome S., et al (2014) Attitudes and beliefs of pig farmers and wild boar hunters towards reporting of African swine fever in Bulgaria, Germany and the western Part of the Russian Federation. Transboundary and Emerging Diseases doi: 10.1111/tbed.12254
- IGLESIAS I., MUÑOZ M. J., MONTES F., PEREZ A., GOGIN A., KOLBASOV D., DE LA TORRE A. (2015) Reproductive ratio for the local spread of African swine fever in wild boars in the Russian Federation. Transboundary and Emerging Diseases doi: 10.1111/tbed.12337



Pietschmann et al., 2015

Field data from Latvia 2014

(Oļševskis et al., 2015)

In contact pigs on farms (32 outbreaks 2014)	Pigs sick/ dead	Tested/ PCR pos
585	63/38	147/**69**

69 / 585 ~ 0,12
(~12%)

ASF CSF FMD

	ASF	CSF	FMD
Contagiousness	+	++	+++
Virus survival	+++	+	+
Case fatality	+++ (few survivors)	++	+
Initial mortality	+	+++	+
Transmission ways	Direct contact (Blood)	Droplet	Droplet
Protective immunity	+	+++	++
Exposer time	+++ (weeks)	+ (days)	+ (days)