Differential Diagnosis for Mycotoxicoses in Swine

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Differential Diagnosis for Mycotoxicoses in Swine, 2024

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Foreword

The aim of this document is to create awareness about the risk of mycotoxins in pigs and to present differential diagnoses.

Mycotoxins are one of many challenges pig producers have to overcome on their farms. Hence, an integrated Mycotoxin-Risk-Management is a prerequisite to keep pigs healthy and productive. We should always keep in mind that high-yielding animals in particular need optimal conditions to deliver required live-performance.

As a veterinarian, I am personally interested in the effects of mycotoxins on the immune system. Why do interventions like vaccination lead to success in one farm but not in another? Part of the explanation might be exposure to mycotoxins. Recently, a vaccination-challenge trial was published showing that exposure to deoxynivalenol can potentially lead to failure of the PRRSV-vaccination (Rückner et al., 2022).

We at dsm-firmenich Animal Nutrition and Health are proud to contribute to sustainable production of feed and food with our nutritional solutions. A proper mycotoxin risk management plan helps to optimize feed utilization and performance and save resources.

I want to express my special thanks to the authors of the first version of this booklet as well as to my co-authors of the current issue. Special thanks also to Michaela Hoessinger, who is responsible for the graphic design, and to my supportive colleagues in the Competence Center for Mycotoxin Risk Management.

This booklet is dedicated to all current and future stakeholders in swine production!
Do not hesitate to contact your local dsm-firmenich representative if you have further questions.

Dr. med.vet. Bettina Behler-Wöchtl

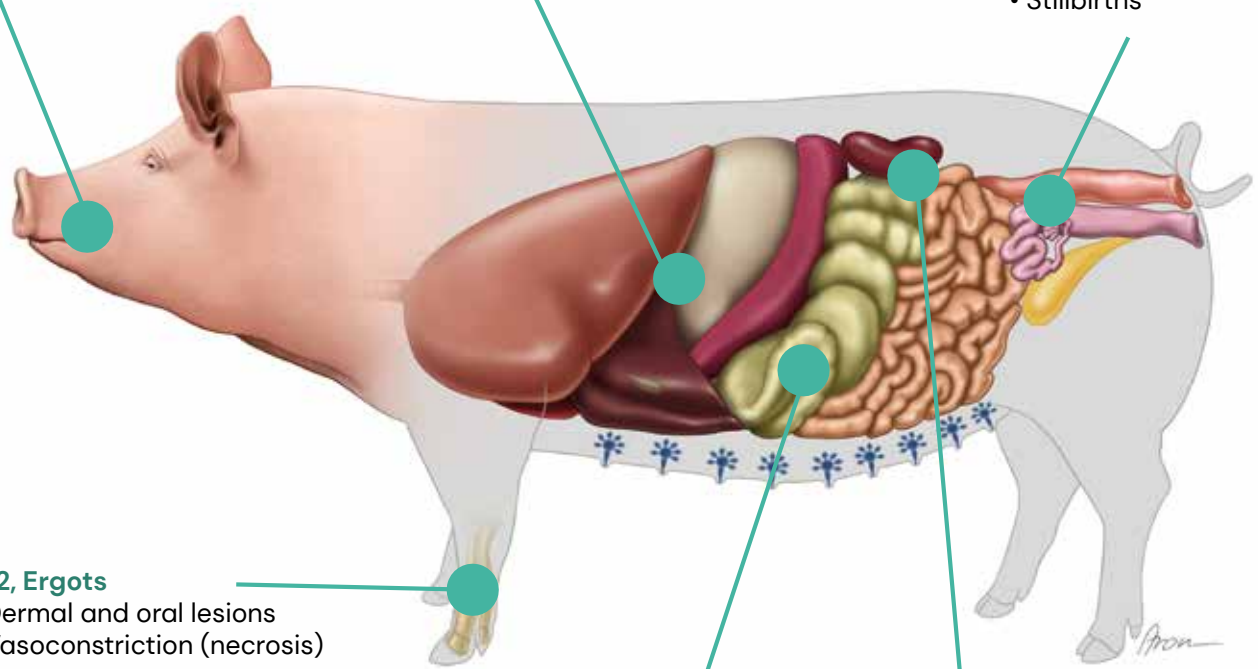
Global Product Manager
Competence Center Mycotoxin Risk Management
dsm-firmenich Animal Nutrition and Health

T-2, DON, Afla, OTA, FUM, Endotoxins
- Intestinal hemorrhages
- Damage of the kidneys
- Pale and fatty liver
- Porcine pulmonary edema (PPE)
- Increased water consumption
- Fever*

*endotoxin-associated diseases

T-2, DON, Ergots
- Decreased feed intake
- Dermal and oral lesions
- Feed refusal
- Vomiting
- Impaired growth

ZEN, T-2, DON, Ergots
- Irregular heats
- Abortion
- Pseudo pregnancy
- Low conception rates
- Ovarian cysts
- Embryonic Loss
- Tail necrosis
- Nymphomania
- Hypertrophy of the uterus
- Shrunken udder/Agalactia
- Stillbirths



T-2, Ergots
- Dermal and oral lesions
- Vasoconstriction (necrosis)

T-2, DON, Afla, OTA, FUM
- Decreased performance
- Immunosuppression
- Pancreatic necroses

Afla, T-2, OTA
- Diarrhea
- Blood in feces and urine
- Inflammation of bladder and kidneys

Meaning of abbreviations:
Afla: Aflatoxins
DON: Deoxynivalenol
FUM: Fumonisins
HT-2: HT-2 toxin
NIV: Nivalenol
T-2: T-2 toxin

Can biomarkers prove that an animal is affected by mycotoxins?

It is understandable that producers and stakeholders want reliable methods to diagnose mycotoxicosis (or sub-clinical effects like mycotoxin-induced depression of performance) in their animals.

Analysis of feed is still state of the art, with well-known limitations (*Table 1*). A good sampling procedure as well as the choice of the most suitable method (*Table 2*) are prerequisites for reliable results. Analysis of biomarkers is essential to prove the efficacy of mycotoxin-detoxifying feed additives in scientific settings. **The use as a diagnostic tool in the field is currently not practical or accepted.**

What are biomarkers?

According to the WHO (1993), the term „biomarker" is a broad term that includes almost any measurement reflecting an interaction between a biological system and an environmental agent. These interactions could be chemical, physical or biological.

Mycotoxin biomarkers:

• Exposure-based biomarkers: concentration of mycotoxins and/or metabolites in biological matrices

Example: Deoxynivalenol in serum of animals as a biomarker for deoxynivalenol exposure

• Mechanism-based biomarkers: Increase/decrease of proteins, cellular metabolites, etc.

Example: Sphinganine-to-sphingosine ratio as a biomarker for fumonisin exposure

dsm-firmenich's researchers utilize biomarker analysis

Authorities require specific biomarker-based trials to prove the efficacy of feed additives against mycotoxins in the registration process. Hence, in experimental studies, dsm-firmenich researchers regularly use biomarkers. These studies based on biomarker-approaches result in peer-reviewed papers and contribute to successful application for approval of DSM's feed additives for deactivation of mycotoxins in the European Union and USA.

What are the limitations for on-field application of mycotoxin biomarkers?

• Diverse metabolization of mycotoxins

Kinetic profiles of mycotoxins differ considerably. Hence, the timepoint when biomarker concentration in blood reaches the maximum level after last feed intake varies depending on the mycotoxin. A given timepoint of sampling after last feed intake might be ideal for one mycotoxin, but not for others. To sample animals at an exact time after last feed intake is often not feasible at a farm.

• Which biomarker in which matrix depends on mycotoxin and species

The ideal biomarker-matrix combination depends on the species and mycotoxin of interest. Fumonisins are poorly absorbed and therefore impossible to detect in blood. For many mycotoxins the metabolization pathway and time is not yet completely known and therefore, selection of suitable biomarker and matrix is impeded.

• Huge individual differences

Individual animals in a group can show marked variations in biomarker levels, even if they are exposed to the same feed lot and sampled at the same time as other animals. Many factors including sex, age or co-exposure to different mycotoxins might influence biomarker levels.

• Interpretation

So far, no correlation has been established between exposure-based biomarkers and clinical signs or severity of mycotoxicosis. Hence, there are no scientifically based reference levels available for interpretation.

Table 1: *Limitations of feed diagnostics*

- Sampling error
- Availability of samples for retrospective analysis in case of problems
- Interpretation, especially in multi-contamination scenarios
- The applicability of a tight sampling scheme very much depends on the farm and might be difficult for smallholders.

Table 2: *ELISA versus LC-based methods*

ELISA
- Fast and easy
- Inexpensive
- Raw materials only

LC-based methods (i.e. LC-MS/MS)
- Sensitive
- Suitable for various feed matrices
- Detection of masked and emerging mycotoxins possible
- More expensive
- Experienced operator and advanced lab equipment needed

dsm-firmenich offers the most advanced methods for feed analysis:

Spectrum 380®
Detects >800 different mycotoxins and metabolites:
• Frequently occurring mycotoxins
• Masked mycotoxins
• Emerging mycotoxins
• Other secondary metabolites
• Phytoestrogens
• Pesticides, veterinary drugs

The LC-MS/MS method was developed and is performed by our partners at the Center for Analytical Chemistry at IFA-Tulln, the world's leading center for mycotoxin research.

Spectrum Top® 50
Detects >50 different mycotoxins and metabolites:
• Frequently occurring mycotoxins
• Masked mycotoxins
• Emerging mycotoxins
• Other secondary metabolites

Developed and conducted by Romer Labs (Part of dsm-firmenich)

Emerging Mycotoxins

In addition to the major mycotoxins, more than 800 emerging mycotoxins and metabolites—many with as-yet unknown relevance—have been identified.
Emerging mycotoxins are currently unregulated. As the DSM World Mycotoxin Survey reveals, some of these substances occur very frequently and in high concentrations (*Figure 1*).
Trials conducted with intestinal porcine epithelial cells (IPEC-J2) revealed cytotoxicity of several emerging mycotoxins, some of which are even more cytotoxic than deoxynivalenol (DON) (Novak et al., 2019).
Apicidin > Beauvericin > DON > Enniatin B > Enniatin A > Enniatin B1 > Enniatin A1 > Aurofusarin

Emerging mycotoxins Apicidin, Aurofusarin, Beauvericin and Enniatins (Enniatin A, A1, B and B1) significantly reduce gut barrier function. Recent research also indicates that Apicidin, Aurofusarin and Beauvericin have synergistic effects with DON (Springler et al., 2016), meaning that the interaction of the mycotoxins causes greater negative effects than the sum of individual effects of the mycotoxins. Considering the high percentage of samples co-contaminated with more than one mycotoxin (*Figure 2*), this finding is of enormous relevance.

An animal trial conducted in weaning piglets for 14 days resulted in:

- Significant reduction of weight gain when emerging mycotoxins Enniatin B/B1 were fed together with DON
- Significant increase of liver lesions when animals were exposed to DON alone, Enniatin B/B1 alone or in combination
- Reduction in the number and the diversity of taxa (groups of microorganisms) in the young piglets—which might lead to a higher susceptibility to diseases and a decreased immune system—in the presence of emerging mycotoxins

(Novak et al., 2021)

Metabolite	Prevalence	Average	Maximum
cyclo(L-Pro-L-Tyr)	82%	741	34910
Tryptophol	78%	474	53620
Aurofusarin	74%	670	319920
Moniliformin	72%	90	7066
Culmorin	71%	626	157114
Beauvericin	69%	27	1610
Deoxynivalenol	67%	536	34861
Enniatin B	67%	55	7519
cyclo(L-Pro-L-Val)	67%	1434	30360
Enniatin B1	67%	49	5507
Brevianamid F	65%	89	3026
15-Hydroxyculmorin	63%	433	23576
Zearalenone	63%	90	11192
Equisetin	62%	47	6120
Emodin	59%	88	134460
Infectopyron	57%	1939	181067
Enniatin A1	56%	21	2063
Rugulusovin	54%	82	2310
Asperglaucide	53%	123	22566
Tenuazonic acid	46%	267	27301
Fumonisin B1	46%	738	111253
Nivalenol	45%	127	11232
DON-3-glucoside	44%	86	4516
3-Nitropropionic acid	44%	30	8427
Asperphenamate	44%	83	18713
Altersetin	42%	69	6607
Bikaverin	40%	57	2694

Figure 1: Swine feed (2014-2022; n=890)
Positive Samples [%] for metabolites present in more than 50% of samples (orange bars indicate regulated or guideline mycotoxins; red bar indicates a masked mycotoxin). Cut off for all metabolites 1 ppb (except for aflatoxins 0.5 ppb). Average of positives and Maximum are presented in ppb.

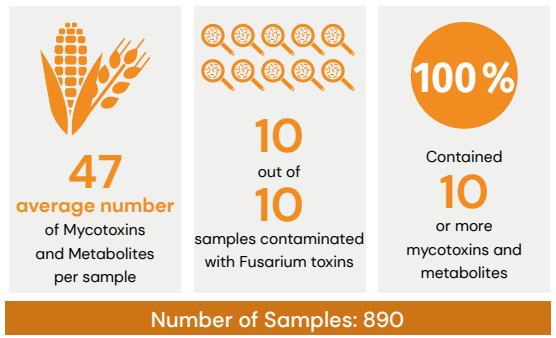


Figure 2: Multiple mycotoxin occurrence in swine feed analyzed with Spectrum 380® (2014 - 2022; dsm-firmenich World Mycotoxin Survey)

Reduced Feed Intake

Adequate feed intake is necessary for pigs to grow. Among mycotoxins, deoxynivalenol is most cited for adversely affecting feed intake. Vomiting and complete refusal of feed due to DON can occur. From the same group (trichothecenes), T-2 toxin also has a negative effect on feed intake.

The feed itself can have a detrimental effect on feed intake and therefore for growth. Feed palatability, feed texture (e.g., mash vs. pellet, granulometry) and feed ingredient quality all influence consumption. The energy density of the feed has an inverse correlation with feed intake.

In case of nutrient excess or deficiency, pigs try to address the problem and decrease or increase feed intake respectively. Use nutrient guidelines (e.g., dsm-firmenich's OVN® Guidelines, or those from genetic companies or the NRC) to define optimum levels.

Water offered in adequate quantity and quality (preferably drinking water quality) is essential for feed intake. Especially in lactating sows, water needs to be provided in a high flow rate. Control flow rate by measuring how much water flows out of a nipple within a minute. Be aware that water pressure can vary within stable depending on positioning of nipples.
If microbiological contamination of water is suspected, control not only water from the well but also in the system, as contamination can occur for example in the pipes (biofilm formation).
High water pressure and flow rate could hinder piglets from drinking. Observe animals to see if they are comfortable when drinking.

When pigs are too hot, they become stressed and consume less feed. The same can be said when temperatures are too low. Ventilation also affects feed intake. Insufficient ventilation can cause a buildup of emissions, and excessive ventilation may lead to a drop in temperature. In both cases, feed intake is affected.

High pen densities, inadequate feeder space or an insufficient number of drinkers all reduce feed consumption. Uneven groups could indicate lack of adequate resources.

Lame animals are lying for long periods of time and have problems reaching resources like feed and water.

Fever leads to anorexia, thus all kind of pathogens causing feverish disease can reduce feed intake. We listed some examples.

Mycotoxins

Problem	Checklist	Corrective action
Trichothecenes • Reduction or refusal of feed intake caused by direct neuronal depression of hypothalamic appetite nucleus • Oral/dermal irritation • Digestive disorders with ulceration and vomiting, and visceral bleeding • Negative effect on integrity of intestine	• Test for trichothecenes (e.g., DON, nivalenol, T-2, HT-2): ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Fumonisins • Decreased feed consumption • Negative effect on feed digestibility • Negative effect on integrity of intestine • Hepatosis with icterus • Diarrhea	• Test for fumonisins: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Ergot alkaloids • Agalactia in sows, therefore in suckling piglets: » Reduced growth » Starvation • Feed refusal in fattener pigs	• Check for sclerotia in raw material • Test for ergot alkaloids in raw materials and finished feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®

Uneven group

Nutrition

Problem	Checklist	Corrective action
Feed palatability • Feed palatability has a direct effect on feed intake	• Ingredients with bitter taste • Anti-nutritional factors • Physical form of feed (e.g., pellet vs. mash)	• Reduce inclusion of ingredients with bitter taste or anti-nutritional factors • Mask taste with flavors and organic acids • Use ingredients with sweet, sour or salty taste • Check amino acid ratio especially that of tryptophan to other large neutral amino acids (leucine, isoleucine, valine, tyrosine and phenylalanine) - see tryptophan below
Water • Water intake determines feed consumption	• Water flow • Pigs per drinker • Water quality	• Depending on age; 0.75 L/min (suckling piglets), Min. 2.5 L/min for a sow, up to 4 L/min in lactating sows grower and fattener pigs: 0.6 – 1.8 L/min (depending on age) • 1 drinker per 10 pigs • Sanitization of water (e.g., chlorination)
Fat quality • Peroxidation of lipids is one common and frequently undesirable chemical change that may impact flavor, aroma and nutritional quality.	• Measuring free fatty acids level or peroxide level • Oxygen bomb test	• Review fat source and type • Deliver fresh feed; do not store feed for long periods
High proportion of small particles in feed • Potentially leads to gastric ulcers: » Decreased feed intake and growth rate » Paleness, black-colored feces	• Control particle size distribution by sieve analysis	• Adapt particle size distribution: » < 20% particles < 0.2 mm » 15 – 20% particles > 1 mm (Kamphues, 2007)
Energy content • Energy content has a negative effect on feed intake • Pigs adjust feed intake to the energy	• Check feed labels	• Adjust energy content to genetic recommendations in each phase of production. • Review lysine energy ratio for fatteners
Tryptophan • Tryptophan regulates serotonin secretion in the brain with an effect on feed intake.	• When the ratio of tryptophan to other amino acids (especially large neutral amino acids) is low, feed intake is reduced	• Optimize essential amino acids ratio according to phase • Supply synthetic tryptophan when necessary
Nutrient deficiencies • Sodium • Zinc • Pantothenic acid (Vit B5) • Thiamine (B1)	• Check feed labels • Check feed formulas • Feed lab analysis	• Target: » Sodium: 0.2 – 0.25% » Zinc: 75 – 150 ppm » Pantothenic acid: 10 – 20 ppm » Thiamine: 1 ppm
Nutritional excess • Due to miscalculation/defective mixtures » Manganese » Zinc	• Check feed labels • Check feed formulas • Feed lab analysis	• Negative effects can be expected, if » Manganese: >2,000 ppm » Zinc: >3,000 ppm

Housing, management and other factors

Problem	Checklist	Corrective action
High environmental temperature, heat stress Pigs are especially sensitive to heat due to lack of sweat glands. Lactating sows are in special risk due to metabolism. • Lower milk production • Respiratory rate increases • Pulse rate increases • Heavy panting • Reduced feed intake	• Check temperature in barn	• Cooling, e.g., by evaporation of water • Cool collapsed sows with cold water
Ulcera Ulcera in the gastrointestinal tract cause pain and lead to feed refusal.	• Control for pale (anemic) pigs, black-colored feces • Initiate diagnostics with veterinarian (pathomorphological examination) • Check for predisposing factors: » Wrong particle size distribution in feed (see Nutrition section) » Mycotoxins (A-Trichothecenes) » Stress (overcrowding, mixing of groups, limited access to feed or water)	• Adapt diet • Eliminate stressors • Mycofix®

Wasting weaner pig
Photo courtesy of University of Veterinary Medicine Vienna.
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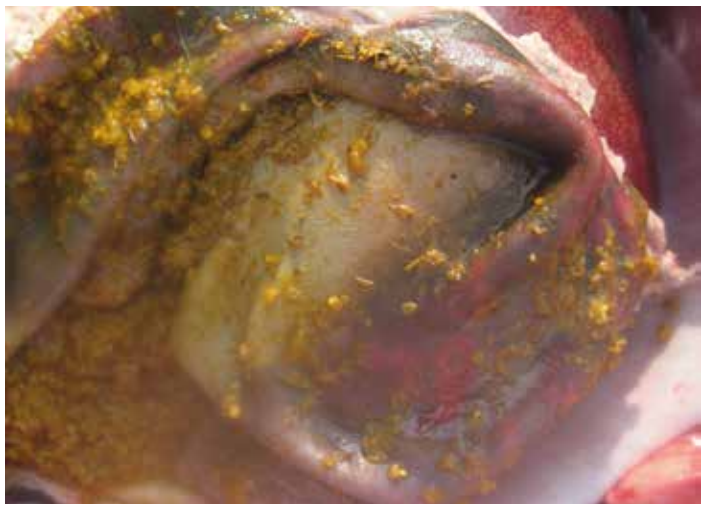


Stomach ulceration

Feces indicative for swine dysentery. Reduced feed intake can also occur in affected pigs.

Pathogens – bacteria and viruses targeting the gastrointestinal tract

Problem	Checklist	Corrective action
Porcine coronviruses (including PED) Depending on immune status all age groups may be effected, classically the younger- the more severe • Diarrhea • Vomiting • Dehydration	• Initiate diagnostics with veterinarian (e.g., PCR)	• Vaccination (availability depending on region) • Electrolytes • Provide optimal surroundings (warmth) • Hygiene, disinfection
Swine dysentery: *Brachyspira hyodysenteriae, Brachyspira pilosicoli* and others • Growers and fatteners • Yellow to gray (cement-like) feces • Anorexia • Blood and slime in feces • Depressed growth	• Initiate diagnostics with veterinarian, e.g., » PCR » Cultivation (difficult)	• Increase digestibility • Use of organic acids • Phytogenics and/or prebiotics • Antibiotics • Hygiene (disinfection), control of vermin and rodents • Ban other animals (e.g., pets and birds) from stable • Increase inner biosecurity • Replace lowly fermentable fiber by highly fermentable fiber
Porcine proliferative enteritis: *Lawsonia intracellularis* • Growers and fatteners, wide range of clinical presentation • Growth depression • Diarrhea • Bloody diarrhea in acute form	• Initiate diagnostics with veterinarian (e.g., PCR)	• Vaccination • Increase digestibility • Use of organic acids • Phytogenics and/or prebiotics • Antibiotics • Hygiene (disinfection), control of vermin and rodents • Ban other animals (e.g., pets and birds) from stable
Salmonellosis • Variable, all age groups • Watery feces containing fibrin, necrotic and/or blood impurities • Lethargy • Fever	• Initiate diagnostics with veterinarian (e.g., cultivation)	• Vaccination • Antibiotics • Acidifiers • Hygiene (disinfection), • Control of vermin and rodents • Ban other animals (e.g., pets and birds) from stable • Biosecurity
Enterotoxic *Escherichia coli* (ETEC) • Mostly suckling piglets and weaners effected • Diarrhea	• Initiate diagnostics with veterinarian, e.g., » Cultivation of bacteria followed by PCR to check for genes encoding fimbriae and toxins	• Vaccination • Hygiene/biosecurity • Acidifiers • Antibiotics

Pathogens – not exclusively targeting gastrointestinal tract

Problem	Checklist	Corrective action
Porcine reproductive and respiratory syndrome-virus (PRRSV) PRRSV is responsible for reproductive and respiratory syndrome, which is associated with a wide spectrum of symptoms, including: • Depression • Fever • Anorexia	• Check for further symptoms like respiratory symptoms in weaners, growers and fatteners or reproductive symptoms in sows (e.g., late abortions) • Initiate diagnostics with veterinarian, e.g., » PCR » Serology	• Biosecurity • Vaccination • Eradication
Swine Influenza (SIV) SIV is typically associated with: • High fever • Lethargy • Rejection of feed	• Check for: high morbidity within herd, sudden onset, extreme drop of feed intake • Initiate diagnostics with veterinarian, e.g., » PCR » Serology: paired sera to control for seroconversion	• Vaccination • Anti-inflammatory drugs • Antibiotics to avoid secondary infection
Classical swine fever and African swine fever (CSF/ASF) CSF/ASF can be responsible for an extremely wide range of symptoms, including: • Fever • Anorexia • Depression • Diarrhea • Constipation • Wasting	• Check for further clinical signs indicative for CSF/ASF • Is farm located in a region at risk? » Any risk factors for introduction of disease known (e.g., introduction of animals of unknown disease status to herd, contact to wild boars, visitors/employees with potential contact to infected swine)?	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities
Foot and mouth disease • Fever • Depression/dullness • Lethargy • Vesicles around coronets dominate in swine and result in lameness	• Is farm located in a region at risk? • Any risk factors for introduction of disease known (e.g., introduction of animals of unknown disease status to herd, contact to wild boars, visitors/employees with potential contact to infected swine)?	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities

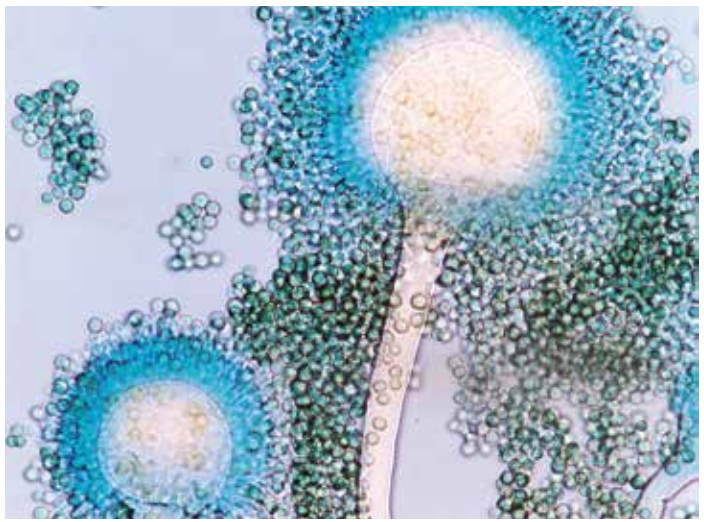
Immune Modulation

Evaluation of the status of the immune system is tricky. Typically, changes of immunological parameters due to an intervention can only be interpreted as an immunomodulation, as the ultimate consequence of the change in the highly complicated immune system is not clear. Applicability of measurement of antibodies to control effectiveness of vaccination or to evaluate herds' disease status is not applicable for all pathogens and vaccines. Some methods to evaluate immunity are only available for scientific approaches and not for routine diagnostics.

Different factors can lead to a permanent or temporary reduction in immune response. Once immunosuppression occurs, pigs are susceptible to secondary infections associated with severe economic losses and welfare issues. Immune suppression may also be the reason for inadequate response to vaccination and reactivation of chronic disease.

Several mycotoxins are known to have immunosuppressive or immune-modulating effects. These effects may already appear at contamination levels that do not cause overt disease. Additive and synergistic effects in case of co-occurrence of mycotoxins may also challenge the immune system.

We have listed some immune-suppressing agents below. In the case of mycotoxins, we strongly focus on in vivo findings, as these are of highest relevance for farmers and veterinarians.



Aspergillus flavus is a producer of aflatoxins, which modulate the immune system.

Mycotoxins

Problem	Checklist	Corrective action
Aflatoxin B_1 Aflatoxins impair innate and acquired immune systems. In animal trials, aflatoxins lead to: • Reduction of production of pro-inflammatory cytokines • Increase of anti-inflammatory cytokines • Delay and decrease of proliferation of antigen-specific cells following exposure to a model-antigen	• Test for aflatoxins in feed: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Trichothecenes (e.g., deoxynivalenol) DON modulates the immune system in a dose-dependent way. Intake of DON has been shown to: • Reduce production of specific antibodies after PRRSV-Infection and vaccination • Enhance clinical and pathological signs of PRRSV-Infection, possibly due to pro-inflammatory cytokines • Reduce number of cells reacting with IFN_γ-production on re-stimulation with PRRSV-vaccine-antigen in blood of PRRSV-vaccinated animals (weakened cellular immune response) • Up-regulate substances related to inflammation and oxidative stress • Vaccination failure due to DON was also shown in a vaccination-challenge trial • In PEDV infected porcine cells, DON inhibits Interferon-expression, indicating a supression of antiviral immune response	• Test for trichothecenes (e.g., DON, nivalenol, T-2, HT-2): ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Ochratoxin A • Depression of phagocytosis • OTA has been shown to promote salmonellosis • Exposing pigs to OTA and vaccinating them against *Salmonella* Choleraesuis resulted in: » Weakened and delayed humoral immune response (antibodies) » Delayed cellular immune response • Exposure to OTA promotes PCV2 replication in pigs	• Test for OTA: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Fumonisins Fumonisins were shown to: • Increase coughing and lung lesions in *Pasteurella multocida*-infected pigs • Increase lung damage after PRRSV infection • Increase lung damage after *M. hyopneumoniae* infection • The effects may be at least partly due to immunesuppression (Inhibition of lymphocyte´s proliferation) • Due to fumonisins, antigen specific response was decreased after vaccination with: » OVA (model antigen) » *Mycoplasma agalactiae* (model antigen, only in male piglets) » Pseudorabies-virus (reduced antibody-response)	• Test for fumonisins: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Zearalenone • Reduced antibody levels following vaccination against classical swine fever • Affects immune parameters in the gastrointestinal tract of gilts	• Test for ZEN and ZEN-metabolites: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®

Nutrition

Problem	Checklist	Corrective action
Nutrient deficiencies • Immune system uses a wide range of macro and micro nutrients.	• Follow nutrient recommendations	• Review feed formulation • Check feed labels • Analyze feed
Feed anti-nutritional factors • Anti-nutritional factors act as antigens. • In order to maintain feed intake, pigs increase their tolerance to them by suppressing their immune system.	• Check feed ingredient digestibility especially in piglets • Inclusion rates of potential anti-nutritional factors in raw materials	• Review feed formulation • Check raw material quality
Omega-3 fatty acids • The ratio of omega-6 to omega-3 fatty acids affects an inflammatory response. The higher the ratio, the higher the response.	• A ratio of 5:1 is suggested to maintain optimal growth	• Check formulation and fat source quality
Vitamin deficiencies • Vitamins have a variety of roles in immune system functionality	• B-complex vitamins, Vit E and selenium, Vit A	• Adequate supplementation of vitamins
Zinc deficiency • Zinc Is involved in over 70 enzymatic reactions	• Zinc supplementation	• 75-150 ppm

Pathogens

Problem	Checklist	Corrective action
Porcine Circovirus Type 2 (PCV2) • The virus replicates in lymphatic cells. This results in a lack of blood cells (generalized lymphocyte depletion) and immunosuppression. Affected animals are more susceptible to different diseases.	• Check for enlarged lympnodes (e.g., *Lnn. inguinales*) • Initiate diagnostics with veterinarian	• Vaccination
Porcine reproductive and respiratory syndrome virus (PRRSV) • PRRSV replicates in lymphatic cells, including alveolar macrophages. This makes the virus an important predisposing factor for other diseases.	• Check for further symptoms like respiratory symptoms in weaners, growers and fatteners or reproductive symptoms in sows (e.g., late abortions) • Initiate diagnostics with veterinarian	• Biosecurity • Vaccination • Eradication
Mycoplasma hyopneumoniae • Destroys ciliated respiratory epithelium, which is an important nonspecific defense system. *M. hyopneumoniae* therefore predisposes swine to other respiratory diseases.	• Check for coughing activity especially after activity • Initiate diagnostics with veterinarian • Check lungs of pigs in slaughterhouse for typical lesions	• Vaccination
Actinobacillus pleuropneumoniae • Toxins impair function of macrophages and neutrophils	• Initiate diagnostics with veterinarian • Check lungs of pigs in slaughterhouse for typical lesions	• Biosecurity • Vaccination
African Swine Fever • Main cells of replication are monocytes, macrophages and granulocytes **Classical Swine Fever** • Leads to leucopenia	• Check for further clinical signs indicative for CSF/ASF • Is farm located in a region at risk? • Any risk factors for introduction of disease known (e.g., introduction of animals of unknown disease status to herd, contact to wild boars, visitors/employees with potential contact with infected swine)?	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities
***Salmonella* Choleraesuis, *Salmonella* Typhimurium** • Alteration of porcine neutrophil function	• Initiate diagnostics with veterinarian (e.g., cultivation)	• Vaccination • Antibiotics • Acidifiers (e.g., products from VivoVitall™ or Biotronic® lines) • Hygiene (disinfection), • Control of vermin and rodents • Ban other animals (e.g., pets and birds) from stable

Lung of a pig diagnosed with PRRSV and *Mycoplasma hyopneumoniae*

Others

Problem	Checklist	Corrective action
Antibiotics: tetracyclines, penicillins, sulphametazine, streptomycin, chloramphenicol (prohibited in EU) • Depression of immune system in cases of prolonged treatment and overdosing	• Check for proper use	• Proper use of antibiotics
Impairment of gut health • Gut health is highly relevant for systemic immunity.	• Support gut health and integrity especially in early life	Prophylactic measures: • Phytogenics • Endotoxin binders • Acids • Blood plasma • Pre- and probiotics
Stress • Stress can result in immunosuppression.	Check for: • Inadequate housing • Overcrowding • Fights for feed, place, water • Heat stress	• Improve surroundings if any shortcomes are obvious, especially in critical periods such as post-weaning

Vomiting

Vomiting–ejection of stomach contents from the mouth–should not be confused with regurgitation. In cases of regurgitation, the feed did not yet reach the stomach, therefore it always occurs immediately after feed intake. In contrast, vomiting can occur also hours after last intake of feed.

Vomiting caused by high levels of mycotoxins contaminating the feed

Mycotoxins

Problem	Checklist	Corrective action
Trichothecenes *Fusarium*-produced trichothecenes negatively impact the organism. Some impacts are: • Vomiting • Feed refusal • Reduced weight gain	• Test for trichothecenes (e.g., DON, nivalenol, T-2, HT-2, DAS): ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Ergot alkaloids • Vomiting has been described as a symptom in cases of acute intoxication	• Check for sclerotia in raw material • Test for ergot alkaloids in raw materials and finished feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®

Sclerotia are resting stages of fungi, in this case of *Claviceps* spp.

Nutrition and feed

Problem	Checklist	Corrective action
Deficiencies of vitamins • Riboflavin • B6 (pyridoxine) • Thiamine • Niacin	• Check vitamin supplementation in final feed	• Follow vitamin nutrition recommendations for swine
Selenium and Vit E • Intramuscular injection in piglets	• Check dosage	• Review product quality
Toxic doses of trace elements • Iron • Copper • Zinc • Iodine • Selenium (>20 ppm)	• Check supplementation	• Implement feed quality control system
Heavy metal contamination • Mercury • Arsenic • Lead	• Check raw material quality and certificates	• Implement feed quality control system
Salt poisoning (NaCl) • Salt poisoning occurs when feeding high concentrations of salt together with restricted water access	• Check water access • Check salt concentration in feed	Ensure water access: • Min. 2.5 L/min for a sow, up to 4 L/min in lactating sows, grower and fattener pigs: 0.6 – 1.8 L/min (depending on age) • In pens at least 1 drinker per 10 pigs • Reduce salt intake
Intoxication (not necessarily feed borne)		
Pesticides and insecticides • Residues in grains	• Analyze grain for residues (Spectrum 380®)	• Implement feed quality control system
Rat poison • Depending on type of rodenticide	• Check trap placement	• Do not place rat traps above pig pens
Cyanamid • Used for control of flies and *Brachyspira* spp. • Toxic for pigs; pigs like to lick the substance; it is lethal in the worst cases • Symptoms include vomiting and diarrhea	• Control proper use	• Strictly follow instruction from supplier • Use cyanamid only in empty stables • All rests of substance need to be carefully removed

Pathogens and parasites

Problem	Checklist	Corrective action
Transmissible gastroenteritis (TGE), porcine epidemic diarrhea (PED) caused by porcine coronaviruses Depending on immune status all age groups may be affected, classically the younger, the more severe: • Watery diarrhea • Vomiting • Dehydration	• Initiate diagnostics with veterinarian e.g., » PCR » Histology	• Vaccination (availability depending on region) • Electrolytes • Provide optimal surroundings (warmth) • Hygiene, disinfection
Vomiting and wasting disease (hemagglutinating encephalomyelitis) caused by a hemagglutinating coronavirus Virus targets central nervous system leading to: • Vomiting • Anorexia • Dehydration • Motor disorders • Depression • Stunted growth	• Initiate diagnostics with veterinarian (e.g., PCR)	• No effective treatment • Build herd immunity • Biosecurity and hygiene measures
Aujeszky's disease (AD) Symptoms of AD vary, depending on age • Vomiting • Neurological signs • Respiratory signs • Reproductive failure (e.g., abortion, mumies, stillbirth, etc.) • Fever	Check for further clinical signs indicative for AD: • Is farm located in a region at risk? • Any risk factors for introduction of disease known (especially direct or indirect contact to wild boars?) • Other species than swine (e.g., cats and dogs) nearly always die due to AD	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities
Classical and African swine fever (CSF/ASF) CSF/ASF can be responsible for an extremely wide range of symptoms, including: • Vomiting • Anorexia • Depression • Diarrhea • Constipation	Check for further clinical signs indicative for CSF/ASF: • Is farm located in a region at risk? • Any risk factors for introduction of disease known (e.g., introduction of animals of unknown disease status to herd, contact to wild boars, visitors/employees with potential contact to infected swine)?	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities
Ascaris suum • In heavily infested pigs, vomiting can occur when small intestine is blocked by worms	• Whitish worms in droppings (in cases of high worm burden) • Milk spot lesions of liver tissue • Worm eggs in feces (flotation)	• Anthelmintics (e.g., avermectins, benzimidazole carbamates, imidazothiazoles, organophosphates, tetrahydropyridinamines, piperazine salts)

Others

Problem	Checklist	Corrective action
Gastric ulcers In case of gastric ulcers following symptoms can occur: • Vomiting • Anemia • Black feces • Lethargy • Weakness • Signs of pain (e.g., increased respiratory rate, teeth grinding) • Anorexia	• Control particle size distribution by sieve analysis • Pelleting (may contribute to ulcers) • Check corn and wheat content • Check for stress factors (promote ulcers)	• According to checklist • Adapt particle size distribution: » < 20 % particles < 0.2 mm » 15–20 % particles > 1 mm (Kamphues, 2007)
Atresia ani Congenital absence of anus leads to: • Abdominal distension • Vomiting • Death	• Absence of anal opening • Possible genetic transmission	• Surgery • Euthanasia
Rectal stricture Aquired rectal stricture can be the result of: • Salmonella infection • Rectal prolapse • Vit D overdosing	• Check for abdominal distension • Palpation of the distal gastrointestinal tract	• Euthanasia • Prevention according to predisposing events
Foreign body • Foreign bodies may cause obstruction of stomach or proximal parts of intestine	• For prevention check feed and environment • Sometimes present in plastic (packing) materials of bakery byproducts	• Avoid accessibility of foreign bodies
Procaine penicillin • May lead to vomiting and fever. Most animals recover completely.		

Atresia ani

Rectal Prolapse

Rectal prolapses occur frequently in pigs compared to other domestic animals. In individual herds, the determination of causes is often difficult. The increase of abdominal pressure and/or the weakening of the supportive pelvic diaphragm ultimately leads to this condition.

Often, this condition occurs in young pigs between six and 16 weeks. Also sows, especially around parturition, are affected. Around parturition, connective tissue is relaxed and softened due to the hormones estrogen and relaxin. Due to its estrogenic effects, ZEN can cause the same condition. The enhanced weight of the reproductive tract and constipation, which requires more physical effort for defacation, leads to increased abdominal pressure and can therefore contribute to the condition. Nutritional factors like high feed intake and nutrient density, excess dietary lysine and diets with high starch content from one cereal source result in high amounts of undigested feed in the large intestine.

The undigested feed quickly ferments, produces gases and sticky feces with a subsequent increase in abdominal pressure.
It is highly likely that prolapsed tissue gets bitten by pen mates. This leads to wounds, bleeding, anemia, cicatrization and, in the worst cases, death due to stricture of intestine if no intervention is undertaken. Remove the pigs from the pen to avoid further injury and cannibalistic behavior from pen mates. Surgical intervention, although infrequently performed, often leads to total recovery.

Rectal prolapse

Mycotoxins and phytoestrogens

Problem	Checklist	Corrective action
Zearalenone • Estrogenic effect of zearalenone (ZEN) leads to softening of connective tissue	• Test for ZEN and ZEN-metabolites: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Phytoestrogens • Similar to ZEN, phytoestrogens simulate effects of estrogen and lead to similar clinical presentation. • Phytoestrogens are often found in legumes like soy and clover. • Synergistic effects with ZEN in some parameters	• Test feed for phytoestrogens: » Spectrum 380®	• No specific counteraction available. Reduce contaminated compound.

Nutrition

Problem	Checklist	Corrective action
Constipation • Sows around farrowing often suffer from constipation; the rectum may be pushed outwards by defecation effort	• Water shortage • Dietary fiber content • Anion cation balance between gestation and lactation feed	• Drinker flow min. 2.5 L/min for a sow, up to 4 L/min in lactating sows, provide additional water in trough of farrowing grate • Drinker flow for grower and fattener pigs: 0.6-1.8 L/min (depending on age) • At least 1 drinker/10 pig • Review fiber content and difference between lactation and gestation feeds in terms of anion cation balance
Abnormal fermentation • Undigested feed in the large intestine produces gases and increases pressure	• High feed intake • High nutrient density • Excess of dietary lysine • Low intestinal digestibility • Abrupt dietary transition	• Control feed intake • Decrease nutrient density • Review lysine energy ratio • Increase intestinal digestibility of feed • Avoid abrupt changes in ration

Pathogens and parasites

Problem	Checklist	Corrective action
Whipworm *(Trichuris)* • This parasite mainly infests the cecum, in severe cases also the colon. It potentially causes mucohemorrhagic diarrhea. In humans, *Trichuris* is an important reason for rectal prolapse.	• Identify worm eggs in feces (fecal flotation), necropsy findings	• Anthelmintic therapy • Hygiene
Pathogens of respiratory tract causing coughing • Coughing increases abdominal pressure	• Apply diagnostics with veterinarian	• According to etiology
Pathogens of gastrointestinal tract • Diarrhea and inflammation may contribute to rectal prolapse • For example: *Salmonella* spp., *Brachyspira* spp., *Lawsonia intracellularis*	• Apply diagnostics with veterinarian	• According to etiology
Feverish disease • Fever may lead to constipation and therefore difficulties in defacation.	• Apply diagnostics with veterinarian	• According to etiology • Provide sufficient water • NSAID

Slippery floor may lead to falls and temporary increase in abdominal pressure

Rectal prolapse

Rectal prolapse

Housing, management and other factors

Problem	Checklist	Corrective action
Water shortage • Water shortage leads to constipation and coprostasis	• Control for adequate drinker flow and water pressure according to animals' age and size.	Drinker flow sows: • At least 2.5 L/min, up to 4 L/min in lactating sows • Provide additional water in through of farrowing grate Drinker flow grower and fattener pigs: • 0.6–1.8 L/Min • At least 1 drinker/10 pigs
Piling and overstepping • If pen is overcrowded or if pigs pile up to warm themselves, abdominal pressure might be enhanced in animals by pressure from outside.	• Verifiy room temperature • Check stocking density	• Adapt heating • Adapt stocking density
Floor design • Deficiency in floor design may lead to falls and temporary increase in abdominal pressure. • In sows crated on sloped floors, pressure on anal sphincter may be persistently enhanced, leading to prolapse.	• Ensure floors are not too slippery and minimize slope	• Adapt floor
Damage of nerves • Tail biting or removal of more than 2/3 of the tail might damage nerve supplying of anal spincter.	• Check length of tail	• Adapt tail-docking regime • Counteract tail biting
Antibiotics • Lincomycin and tylosin have been reported to cause prolapses in the first weeks of usage.		• Avoid usage of these antibiotics in herds with high prevalence of prolapses
Genetics/inherited predisposition • Genetics may have an impact due to overconsumption of feed.	• Avoid genetic predisposition to overconsumption	• Discuss with genetic companies, change genetics in cases of severe problems • If prolapses occur in offspring of certain boars, avoid usage of respective boar/semen
Tenesmus related • Conditions related to tenesmus favor prolapses (excess salt in diet, inflammation and/or injury of urogenital tract and rectum, e.g., due to mating)	• Apply diagnostics with veterinarian	• According to etiology
Age and parity • Gradual weakening of pelvic diaphragm in older sows	• Control age structure of the herd	• Adjust replacement rate

Ear/Tail/Skin Necrosis

Necrosis of the skin, ear or tail commonly occurs in swine production, and represents an animal welfare issue that may, in severe cases, lead to culling or condemnation of carcasses in the abattoir.

Often, the condition co-occurs with biting behavior and the initial problem is frequently not clear. Moderate and possibly unnoticed biting behavior might facilitate entrance of bacteria, which secondarily causes inflammation and ultimately necrosis. Otherwise, biting may follow inflammation, as animals suffering from pruritus accept the manipulation of the affected body part.

Below are common causes of necrosis of pigs´ skin, tail and ears.

Pigs with severe injuries due to biting behaviour
Photo courtesy of University of Veterinary Medicine Vienna. Used with permission.

Mycotoxins/endotoxins

Problem	Checklist	Corrective action
Trichothecenes (especially A-Trichothecenes) • Dermotoxicity leads to oral and dermal lesions, including necrosis. The most toxic compound regarding dermotoxicity is T-2 toxin, which has been reported to cause ear and tail necrosis.	• Test for trichothecenes (f.e. T-2, HT-2, DON, nivalenol): ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Ergot alkaloids • Vasoconstriction due to ergot alkaloids results in ischemia and dry gangrene, typically at the ears, tail and feet.	• Check for sclerotia in raw material • Test for ergot alkaloids in raw materials and finished feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Endotoxins (lipopolysaccharides) • Endotoxins are released when gram-negative bacteria are lysed.Heat stress increases permeability of gut for endotoxins. • Endotoxins cause microvascular abnormalities and intravascular coagulation, which may lead to the development of necrosis in the ear, tail and hooves. • Massive endotoxin stress triggered by highly energy-dense diets in weaners promotes caudophagy.	Check for stressors, which increase amount of released endotoxins: • Heat stress • High fat diets • Dysbiosis • Pathogens • Antibiotic treatment (e.g., cephalosporin) • Constipation	• Control gut micro flora: » Check feed formulation » Mycofix® » Prevent heat stress

Top ear necrosis

Top ear necrosis

Nutrition – Ear necrosis

Problem	Checklist	Corrective action
Lysine levels • Inadequate dietary lysine levels contribute to ear necrosis	• Formulation • Raw material digestibility	• Adjust lysine levels to feed consumption • Check amino acids ratio • Check lysine: energy ratio
Zinc, niacin, pantothenic acid (Vit B_5) • Deficiencies are reported to result in dermatitis and ear necrosis	• Check inclusion levels • Product quality	• Zinc: 75–150 ppm • Niacin: 15–32 ppm • Vit B_5: 10–20 ppm
Non-satiety and lack of nutrients • Results in ear biting	• Check salt inclusion • Check formulation • Check feed consumption	• 0.3% salt in final feed • Consult a nutritionist • Adjust nutrient density to feed consumption • Review raw material quality
Impaired oxygen transport in body • Lack of oxygen may cause top ear necrosis	• Addition of hemoglobin powder (1–2%) • Control of B-Vitamins such as B_{12} • Niacin and folic acid	• Check labels and formulation of the feed

Nutrition – Tail necrosis

Problem	Checklist	Corrective action
Group B vitamins • Deficiencies cause dermatitis and may result in tail necrosis	• Review inclusion rates • Review product quality	• Nutrient recommendations, Vit B_5 10–20 ppm
Zinc • Deficiencies cause dermatitis and may result in tail necrosis	• Review inclusion rates • Review product quality	• 75–150 ppm
Non-satiety and lack of nutrients • Results in tail biting	• Check salt inclusion • Check formulation • Check feed consumption	• 0.3% salt in final feed • Consult a nutritionist • Adjust nutrient density to feed consumption • Review raw material quality

Pathogens & parasites

Problem	Checklist	Corrective action
***Fusobacterium necrophorum*, spirochetes** • Injuries of the facial skin mainly due to fighting for teats in suckling piglets provides entry for pathogens and may lead to necrotic alterations. • Spirochetes have been identified in oral cavities of piglets and in respective wounds.	• Typical location of necrotic skin (cheeks) • Check for predisposing factors: » Agalactia » Misproportion number of piglets: count of functional teats	• Shortening of canine teeth • Cross fostering • Provide additional milk source
Mycoplasma suis • The blood parasite *Mycoplasma suis* leads to red blood cell agglutination, which is believed to cause ear tip/ear rim necrosis.	• PCR (EDTA) • Red blood count (MCH, MCV) • Blood smear (Giemsa stain, acridine orange stain)	• As the pathogen is distributed via blood: » Control blood-sucking insects like *Haematopinus suis* » Apply hygiene measures in surgery (castration), injections, etc. • Antibiotics (tetracyclines)
***Staphylococcus hyicus*, spirochetes and porcine circovirus 2** • These pathogens are causes of ear tip/ear rim necrosis. Even very small injuries due to ear-in-mouth interaction can serve as entrance for pathogens and may be a predisposing factor for ear necrosis.	• Initiate diagnostics with veterinarian	• Treatment and metaphylaxis depending on identified pathogens
Septicaemia (*E. coli, Salmonella* Choleraesuis, *Streptococcus suis*) • Septicaemia can cause discoloration (erythema, cyanosis, necrosis, bleeding)	• Initiate diagnostics with veterinarian • Blood culture • Post-mortem examination (sampling for culturing of bacteria needs to be performed immediately after death)	• Depending on etiology: » Hygiene » Improvement of zootechnical procedures » Vaccination
Classical and African swine fever (CSF/ASF) CSF/ASF can be responsible for an extremely wide range of symptoms, including: • Discoloration of skin • Skin bleeding • Skin necrosis (ASF)	Check for further clinical signs indicative for CSF/ASF: • Is farm located in a region at risk? • Any risk factors for introduction of disease known (e.g., introduction of animals of unknown disease status to herd, contact to wild boars, visitors/employees with potential contact to infected swine)?	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities
Porcine dermatitis and nephropathy syndrome (PDNS; etiology unclear, PCV2 is discussed as cause) • Dermatitis characterized by confluent hemorrhages and necrosis. Typically starts at perineum; high lethality	• Initiate diagnostics with veterinarian (pathohistology)	• Vaccination

Others

Problem	Checklist	Corrective action
Trauma due to biting (tail, ear, flank) • Biting is a common condition in swine production with a very complex etiology. Injuries can even lead to dead. Bacteria can enter the wounds. In case of tail biting, abscesses in the spine are a common complication. • Practical evidence suggests trichothecenes as predisposing factor for biting behavior. • Classically, ear biting results in wounds at the base of the ears.	Check for triggers, for example • Bad housing conditions • Stressors • Lack of occupation • Drafts • Uncomfortable temperatures • Mixing of animal groups • Trichothecenes • Non-satiety and lack of nutrients	• Closely monitor your animals • Separate and treat injured pigs • Identify and resolve triggers
Swine inflammation and necrosis syndrome (SINS) • Inflammation and necrosis of different body parts including ears, tail, teats, claws and navel also occur without any action from other pigs or other mechanical irritations in different age groups, including newborns. Mycotoxins (DON) and endotoxins contribute to etiology.	• Histopathology: vascular-associated inflammation but intact epidermis • Occurence in newborn • Different body parts in individual animals affected • Genetics plays a role	• Mycofix® • Avoid constipation of sow by ensuring water supply and fiber intake • Improve housing conditions • Supply high-quality water to all age groups • Use sows with intact claws, skin and teats • Check with genetic company

Tail necrosis in a suckling piglet
Photo courtesy of University of Veterinary Medicine Vienna. Used with permission.

Conjunctivitis

Conjunctivitis is the inflammation of conjunctiva, a thin membrane that covers the eyeball and lines the insides of the eyelid. When inflammation occurs, the blood vessels in the membrane become enlarged, making the eye look red.

In some cases of conjunctivitis, the nictitating membrane (third eyelid) in the inner corner of the eye may protrude. Enforced lacrimation may lead to dirty appearance (disposition of dust) or discoloration of hair there.

Dusty environment can irritate conjunctivae

Profound conjunctivitis

Mild conjunctivitis

Mycotoxins

Problem	Checklist	Corrective action
Trichothecenes • Conjunctivitis has been observed in cases of chronic poisoning with trichothecenes.	• Test for trichothecenes (e.g., DON, nivalenol, T-2, HT-2): ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®

Nutrition

Problem	Checklist	Corrective action
Dusty feed • Dust in air irritates conjunctiva (e.g., due to low energy diets, which do not contain oil). • Mold spores in the air cause allergic conjunctivitis.	• Control particle size distribution using sieve analysis • Control feeding procedure (application of feed)	• Adapt particle size distribution • Add oils to feed to bind dust • Cooling systems based on evaporation of water also lead to dust binding

Pathogens

Problem	Checklist	Corrective action
Chlamydia suis • Conjunctivitis and keratoconjunctivitis • Chlamydia infection is often inapparent, but can potentially manifest in reproductive, respiratory and locomotory tract.	• Check for mechanical vectors: birds, flies, mice/rats • Initiate diagnostics with veterinarian, include boars in diagnostics (e.g., PCR, serology)	• Biosecurity (especially avoid mechanical vectors) • Identify and remove carrier boars • Implement artificial insemination • Antibiotics (tetracyclines)
Porcine reproductive and respiratory syndrome- virus (PRRSV) • PRRSV is responsible for reproductive and respiratory syndrome. Conjunctivitis and prolapse of nictitating membrane (third eyelid) can be indicative for PRRS, especially in weaned piglets.	• Check for further respiratory symptoms and/or reproductive failure like cases of abortion in late gestation • Initiate diagnostics with veterinarian (e.g., PCR, serology)	• Biosecurity • Vaccination • Eradication
Swine Influenza (SIV) • SIV is typically associated with high fever and lethargy and high a proportion of animals are affected. Abortion could occur due to high fever.	• Check for: high morbidity within herd, sudden onset drop of feed intake • Initiate diagnostics with veterinarian (e.g., PCR, serology)	• Vaccination • Anti-inflammatory drugs • Antibiotics to avoid secondary infection
Mycoplasma hyorhinis • Conjunctivitis • Serositis and subsequent accumulation of fluid or inflammation products in different body cavities • Bad performance	• Initiate diagnostics with veterinarian e.g., » Cultivation » PCR	• Antimicrobial therapy • Herd-specific vaccine
Classical swine fever/African swine fever (CSF/ASF) • Conjunctivitis • Wide range of possible further symptoms including high fever and hemorrhages	Check for further clinical signs indicative for CSF/ASF: • Is farm located in a region at risk? • Any risk factors for introduction of disease known (introduction of animals of unknown disease status to herd, contact with wild boars, visitors/employees with potential contact with infected swine)?	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities

Pathogens

Problem	Checklist	Corrective action
Aujeszky´s disease (AD) • Keratoconjunctivitis • Up to 100% mortality in suckling piglets, severe neurological disorder mainly in young piglets	Check for further clinical signs indicative for AD: • Is farm located in a region at risk? • Any risk factors for introduction of disease known (introduction of animals of unknown disease status to herd, contact with wild boars, visitors/employees with potential contact with infected swine)?	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities
Progressive atrophic rhinitis (PAR) • Intensified lacrimation occurs in chronic cases, as the flow of tears is blocked by deformation. Area beyond medial canthus of eye looks dirty or discolored due to continuous tear flow -> differential diagnosis to conjunctivitis	• Check for further clinical signs indicative for PAR (e.g., nosebleeding, deformation of noses) • Initiate diagnostics with veterinarian (detection of dermonecrotic toxin is mandatory) • Other species than swine (e.g., cats and dogs) nearly always die due to AD	• Biosecurity • Vaccination • Antibiotics

Housing, management and other factors

Problem	Checklist	Corrective action
Gases • Gases known for irritation: • Ammonia (NH_3) • Hydrogen sulfide (H_2S)	• Check for bad or pungent odors • Check if you develop headache, irritation of conjunctivae, irritation of respiratory system (coughing) and reinforced lacrimation in stable. Be aware that pigs are exposed to the gases continuously. • Use gas sensors to control for gases. Concentration of carbon dioxide (CO_2) is indicative for effectiveness of ventilation and should be <1,500 ppm.	• Adapt ventilation • Achieve target concentrations
Relative humidity • Low humidity harms the conjunctivae and makes them more susceptible to infection.	• Check relative humidity with hygrometer (relative humidity should be between 50 – 80 %)	• Cooling systems based on evaporation of water also lead to dust binding and enhance relative humidity.
Dust • Meal diets, bedding and/our employment materials can be a source of dust (e.g., hay, straw) and/or mycotoxins. • Mold spores in dust can cause allergic conjunctivitis. • Usage of straw does not work in all conditions.	• Control for dust due to bedding and/our employment materials	• Choose alternative materials and/or ways of distribution. • Remove material if not compatible with housing system.
Residues of irritating disinfectants • Residues of disinfectants may irritate conjunctivae.	• Check disinfection regime	• Adapt disinfection regime. Extend time between application of disinfectant and introduction of animals to stable or make sure to ventilate stable well.

Jaundice (Icterus)

Jaundice or icterus is the yellowing discoloration of white connective tissue in the body, skin or eye sclera. It is the result of a high bilirubin (yellow pigment) concentration in the blood. Bilirubin is the end product of heme metabolism, which occurs when erythrocytes (red blood cells) are destroyed, for example due to physiological aging of the cells. Bilirubin gets conjugated to glucuronic acid in the liver and excreted via bile into the small intestine.

Jaundice occurs in cases of:
• Massive blood lysis (overburdening of the system)
• Liver dysfunction (conjugation process does not work or only insufficiently works)
• Obstruction to biliary drainage (bilirubin gets reabsorbed to blood)

Jaundice of the liver is used as an indicator of meat safety. Liver discoloration contributes to carcass disposals. High occurrence of jaundice may jeopardize market reputation and can result in high economical loses.

The liver is the major organ for detoxification. Thus, any exposure to mycotoxins poses a challenge to this organ.

Pig with severe icterus
Photo courtesy of University of Veterinary Medicine Vienna. Used with permission.

Mycotoxins

Problem	Checklist	Corrective action
Aflatoxins Aflatoxins target organs like liver, kidney and the immune system. Hepatotoxicity (chronic–acute) leads to: • Changes in liver parameters (e.g., AST, ALT, GGT, AP) • Jaundice: eye sclera, liver, fat • Hemorrhages • Diarrhea • Reduced protein synthesis (also impacting immune system) • Loss of performance • Necrosis and hemorrhage in liver (acute) • Liverfibrosis and bile duct proliferation (chronic)	• Test for aflatoxins: ELISA for raw material, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Fumonisins Fumonisins target several organs like the liver, pancreas and the immune system. Hepatotoxicity leads to: • Changes in liver parameters (e.g., AST, GGT, bilirubin, cholesterol) • Hepatosis • Necrosis of the liver • Bile retention • Jaundice • Loss of performance	• Test for fumonisins: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Ochratoxin A (OTA) • Ochratoxins are best known for there nephrotoxic effect. In high dosages, the liver might be damaged as well. • Signs of kidney damage will dominate the clinical presentation	• Test for OTA: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®

Sow liver with jaundice from aflatoxin intoxication

Jaundice of sclera and conjunctivae

Nutrition and feed

Problem	Checklist	Corrective action
Excess copper • Copper excess can cause hemolytic anemia and jaundice. • Deficiencies of zinc and iron have a synergistic effect.	• Copper inclusion • Zinc inclusion	• Adjust inclusion rates in production phase • Consult a nutritionist
Intoxication with heavy metals • Different heavy metals can cause hemolytic anemia.	• Check for accidential intoxication	• According to agent
Vitamin E and selenium • Deficiency of Vit E and/or selenium results in jaundice.	• Vit E and selenium inclusion	• Adjust inclusion rates in production phase • Consult a nutritionist

Intoxication

Problem	Checklist	Corrective action
Cyanamid • Used for control of flies and *Brachyspira* spp. • Toxic for pigs; pigs like to lick the substance. • Damages liver and causes icterus, lethal in worst cases • Symptoms include vomiting and diarrhea	• Control proper use	• Strictly follow instruction from supplier • Use cyanamid only in empty stables • All rests of the substance need to be carefully removed

Liver displaying multiple milkspots caused by migration of larvae of *Ascaris suum*
Photo courtesy of University of Veterinary Medicine Vienna. Used with permission.

Pathogens & parasites

Problem	Checklist	Corrective action
***Leptospira* spp.** • *Leptospira* may cause a huge range of clinical conditions (including reproductive issues, fever, anorexia) depending on age of animal and respective serovar. • Icterus is most likely in pregnant sows and young piglets. • In aborted piglets or weak born piglets, damage of liver might occur.	• Apply diagnostics with veterinarian » Pathomorphological examination of aborted piglets » Serology (microscopic agglutination test) » PCR	• Biosecurity (hygiene) • Avoid humid surfaces (reservoir for *Leptospira*) • Deratization, avoid contact to other species (e.g., dogs) • Antibiotics (tetracyclines) • Vaccination
Mycoplasma suis • *Mycoplasma suis* are in close contact with the red blood cells, which get destroyed subsequently • Excess of bilirubin due to blood lysis leads to icterus.	• Apply diagnostics with veterinarian » PCR (EDTA) » Red blood count (MCH, MCV) » Blood smear (Giemsa stain, acridine orange stain)	As the pathogen is distributed via blood: • Control blood-sucking insects like *Haematopinus suis* • Apply hygiene-measures in surgery (castration), injections etc. • Antibiotics (tetracyclines)
Porcine circovirus 2 (PCV2) Several diseases are associated with PCV2 including PMWS (post weaning multisystemic wasting syndrome): • Piglets waste after weaning (in classical cases) • Icterus occurs occasionally	• Check for enlarged lympnodes (e.g., *Lnn. inguinales*) • Initiate diagnostics with veterinarian • Diagnosis of PMWS requires: » Clinical presentation (enlargement of lymph nodes, wasting) » Pathological changes (morphological and histological) » Quantification of virus particles (e.g., PCR)	• Vaccination
***Salmonella* Choleraesuis** *Salmonella* Choleraesuis is distributed via blood and targets multiple organs including: • Liver (necrotic alterations) • Gallbladder (thickening of the wall) • Icterus may occur.	• Initiate diagnostics with veterinarian (e.g., cultivation of bacteria from feces or intestine, in case of septicemia from lung, liver, spleen; serology) • Biosecurity	• Vaccination • Antibiotics • Acidifiers (e.g., products from VivoVitall™ or Biotronic® lines) • Hygiene (disinfection), • Control of vermins and rodents • Ban other animals (pets and birds) from stable
***Ascaris suum* (large white worm)** Migration of larvae leads to destruction of liver tissue: • Milk spots in liver tissue • Pancreatic duct obstruction • Cholangitis	• Whitish worms in droppings (in cases of high worm burden) • Milk spot lesions in liver tissue • Worm eggs in feces (flotation)	• Anthelmintics (e.g., avermectins, benzimidazole carbamates, imidazothiazoles, organophosphates, tetrahydropyridinamines, piperazine salts) • Hygiene, all-in/all-out

Reproductive Failure

Many factors, including mycotoxins, can lead to impairment of reproductive performance. Abortion is defined as the premature expulsion of dead or non-viable fetuses. It occurs from day 35 – 110 of gestation, after bone development has started and fetuses cannot be absorbed anymore. Stillbirth (the birth of fully developed but death piglets) and abortion can be considered as the „worst-case scenarios" of reproductive outcomes.

Not only abortions but all presentations of reduced reproductive performance compromise economical success of farms:

- Prolonged weaning to estrus interval: leads to more unproductive days
- Enhanced return to estrus rate: Sows are coming in heat again although they were mated/inseminated. This might be due to non-successful fertilization or early embryonic death. Early embryonic death (before 35 days of gestation) does not result in expulsion of embryos.
- Reduced number of piglets born alive
- Enhanced number of death or weak born piglets
- Reduced weight of piglets
- Reduced number of weaned piglets
- Anestrus: Sow does not come into heat
- Constant estrus: Sow appears to be constantly in heat, but mating/insemination is not successful.

We listed some potential causes of abortion and reproductive failure. A proper mycotoxin risk management strategy is necessary for a healthy and productive herd.

Stillborn piglet

Mycotoxins and phytoestrogens

Problem	Checklist	Corrective action
Zearalenone (ZEN) • ZEN binds to estrogenic receptors and simulates effects of estrogen. This is especially crucial in prepubertal pigs, as the endocrine system is still premature. • In female pigs, ZEN-exposure has been shown to lead to: » Enlargement of internal and external reproductive tract » Disturbance of follicle development » Delay of first estrus » Prolongation of weaning-to-estrus interval » Infertility » Constant estrus » Pseudopregnancy » Juvenile hyperestrogenism of offspring » Decreased litter weight and reduced litter size » Increased embryonic mortality » Weakness and malformations that result in increased mortality in first days of life • Male pigs´reproductive performance may suffer due to: » Reduced libido » Reduced testosterone level in plasma » Atrophy of testes	• Test for ZEN and ZEN-metabolites: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Trichothecenes Trichothecenes alone may directly and indirectly impair reproductive performance, for example due to: • Negative influence on maturation of oocytes • Inhibitory effect on granulosa cell proliferation • Digestive disorders and loss of nutrients • Feed refusal/decreased feed intake • Impaired immune response to pathogens and vaccination • The combination of DON and ZEN has additive and synergistic effects on a variety of parameters relevant for reproduction.	• Test for trichothecenes (e.g., DON, nivalenol, T-2, HT-2): ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Phytoestrogens • Similar to ZEN, phytoestrogens simulate effects of estrogen and lead to similar clinical presentation. Phytoestrogens are often found in legumes like soy and clover. • Synergistic effects with ZEN in some parameters.	• Test feed for phytoestrogens: Spectrum 380®	• No specific counteraction available. Reduce contaminated compound.

Mycotoxins and phytoestrogens

Problem	Checklist	Corrective action
Ergot alkaloids • Abortion • Shortened or prolonged gestation • Stillbirths • Reduced birth weight of piglets • Agalactia, starvation of piglets	• Check for sclerotia in raw material • Test for ergot alkaloids in raw materials and finished feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Aflatoxins • Indirect effect on reproduction due to reduced protein synthesis • Lower productivity and immune function	• Test for aflatoxins: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Beauvericin • The exposure of cumulus-oocyte complexes from gilts with emerging mycotoxins *in vitro* impaired maturation and increased degradation, indicating a negative effect on fertility. Cumulus-oocyte complexes are oocytes surrounded by specialized cells as they occur around ovulation.	• Test feed for beauvericin (Spectrum 380®, Spectrum Top® 50)	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Others Indirect impairment of reproduction for example by, • Impaired gut integrity • Impaired liver health (protein synthesis) • Immunomodulation	• Apply diagnostic methods covering a huge range of mycotoxins (Top®50, Spectrum 380®)	• Prevent mold growth • Purchase clean raw materials • Mycofix®

Phytoestrogens can frequently be found in legumes like soy and can impair reproductive performance.

Nutrition

Problem	Checklist	Corrective action
Energy • Low temperature in the gestation barn increases energy demand for maintenance which reduces its availability for reproduction. In extreme cases, abortion might occur.	• Review housing conditions • Adjust feeding curve to housing conditions and body condition of sow.	• Implement sow feeding curves based on genetics, production and housing
Body condition • A low body score after lactation or a high body score after overfeeding during gestation could result in non-infectious infertility problems.	• Perform body condition scoring (1: emaciated – 5: obese) • Perform backfat measurement	• Adjust feeding management to achieve optimal condition • BCS: should be 3-4 at farrowing and should not be less than 2.5 at weaning • Backfat based on recommendation for respective genetics and method of measurement
Water • Lack of water in early gestation and low water quality (yeasts, microorganisms) have been identified as reasons for abortion.	• Water flow and availability per sow • Improve water quality	• Minimum water flow from drinker 2.5 l/min in early gestation • Use acidification products in water (e.g., VivoVitall™ or Biotronic® products)
Vitamin A • Deficiency causes congenital anomalies and possibly abortions.	• Vit A inclusion in final feed	• 12 MIU per kg of final feed
Vitamin B_{12} • The link is not fully understood, however, there are reports that abortion occurs in sows fed Vit B_{12}-deficient diets.	• Vit B_{12} inclusion in final feed	• 25 ppb per kg of final feed

Emaciated sow (body condition score 1)
Photo courtesy of University of Veterinary Medicine Vienna.
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Pathogens & parasites

Problem	Checklist	Corrective action
Porcine reproductive and respiratory syndrome – Virus (PRRSV) PRRSV is responsible for reproductive and respiratory syndrome, which is associated with a wide spectrum of symptoms, including: • Late-term abortion • Still birth • Weak piglets • Return to estrus	• Check for further symptoms like respiratory symptoms in weaners, growers and fatteners. • Initiate diagnostics with veterinarian (e.g., PCR, serology)	• Biosecurity • Vaccination • Eradication
Porcine parvovirus • Porcine parvovirus causes SMEDI: still birth, mumification, embryonic death, infertility	• Check if vaccination scheme was followed properly. Vaccination against porcine parvovirus should be considered standard • Initiate diagnostics with veterinarian: PCR (fetuses)	• Vaccination
Porcine Circovirus 2 (PCV2) Several diseases are associated with PCV2 including PCV2 reproductive disease: • Return to estrus • SMEDI: still birth, mumification, embryonic death, infertility • Abortion (controversial)	• Initiate diagnostics with veterinarian: PCR/ISH/IHC of fetal heart tissue in case of abortion	• Vaccination (in case of reproductive disease, sows and/or gilts)
***Leptospira* spp.** • *Leptospira interrogans* is considered the most important species in swine. High diversity within the species (about 200 serovars), highly dependent of region. Clinical presentation depends on serovar. • Abortion • Stillbirths • Mummification • Weak premature piglets • Enhanced mortality in young neonates • Infertility	• Epidemiology might be indicative: rodent infestation, damp surfaces • Initiate diagnostics with veterinarian (e.g., PCR from fetal kidney or liver, maternal genital tract and kidney; serology)	• Avoid contact with potential carriers (e.g., rats, mice, dogs, cattle, wild boars, etc.) • Avoid damp surfaces, where *Leptospira* can survive • Antimicrobial therapy • Vaccination • In some regions, legal actions are required
Listeria monocytogenes Common colonizer of the pig´s intestine. Seldomly causes clinical presentations like septicaemia, nervous signs and reproductive failure: • Abortion • Stillbirths • Weak piglets	• In case of silage feeding, check for quality, as poor-quality silage has been reported to be a source of *Listeria* spp. Higher prevalence of carriers found in herds with liquid feeding. • Check for immunosuppressive agents like DON.	• Ensure good feed quality (especially when feeding silage and/or liquid feed) • Apply MRM • Antimicrobial therapy

Pathogens & parasites

Problem	Checklist	Corrective action
***Chlamydia* spp.** Next to other clinical presentations (enteritis, pneumonia, pericarditis, conjunctivitis, etc.), fertility may be affected: • Abortus, mainly at end of gestation • Metritis and vulvovaginitis associated with discharge • Return to estrus • Weak piglets, preterm delivery • Orchitis, epididymitis and reduced fertility of boars	• Initiate diagnostics with veterinarian, for example: » Serology (paired samples) » PCR (fetal liver and kidney)	• Antimicrobial therapy (tetracyclines) • Artificial insemination
Mycoplasma suis Fertility problems due to this parasite of the blood have been reported, but are controversial: • Abortion • Anestrus • Delayed estrus • Early embryonic death	• Initiate diagnostics with veterinarian, for example: » PCR (EDTA) » Red blood count (MCH, MCV) » Blood smear (Giemsa stain, acridine orange stain) • Interpretation of the results is often difficult	• As the pathogen is distributed via blood: » Control blood-sucking insects like *Haematopinus suis* » Apply hygiene measures in surgery (castration), injections etc. » Antibiotics (tetracyclines)
Classical swine fever / African swine fever (CSF/ASF) Classical and African swine fever can be responsible for an extremely wide range of symptoms, including: • Stillbirths • Mummification • Congenital malformation	• Check for further clinical signs indicative for CSF/ASF • Is farm located in a region at risk? • Any risk factors for introduction of disease known (introduction of animals of unknown disease status to herd, contact to wild boars, visitors/employees with potential contact to Infected swine)?	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities
Aujeszky's disease (AD) • Symptoms of Aujeszky´s disease vary, depending on age. • Weak births • Stillbirths • Mummifications • Small litters • SMEDI-syndrome (controversial)	• Check for further clinical signs indicative for AD: • Is farm located in a region at risk? • Any risk factors for introduction of disease known (especially direct or indirect contact to wild boars)? • Other species than swine (e.g., cats and dogs) nearly always die due to AD	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities
Systemic disease: • *Actinobacillus* spp. • *Erysipelothrix rhusiopathiae* • *Lawsonia intracellularis* • Foot and mouth disease • Influenza A • *Salmonella* spp. • *Streptococcus* spp. • Infectious diseases which do not directly target the reproductive tract may lead to fertility problems, including abortion, for example by inducing high fever.	• Initiate diagnostics with veterinarian. • Respective pathogens cannot be isolated from reproductive tract or aborted fetuses	• Depending on pathogen • In case of fever apply anti-febrile medication • If a notifiable disease is suspected, take actions according to legal requirements in your region

Housing, management and other factors

Problem	Checklist	Corrective action
High environmental temperature • Heat stress negatively affects embryo development, especially in early gestation.	• Check temperature in barn	• Adapt ventilation • Cooling, e.g., by evaporation of water • If possible, keep temperature under 25 °C
Big temperature fluctuations and drafts • Swine are sensitive to high fluctuations	• Check for drafts and temperature fluctuations	• Avoid temperature fluctuations • Avoid drafts
Carbon monoxide • CO concentration exceeding 100 ppm leads to stillbirths • When CO exceeds 250 ppm, clinical symptoms occur in sows	• Check for sources of CO (for example, malfunctioning heaters)	• Keep CO concentrations <100 ppm
Stress • Stress (for example, due to fights, poor housing conditions) may induce abortion.	• Check for stressors in the stable, regularly observe your animals, check space per sow in group housing	• Identify and avoid stressors • Especially 2-21 days post mating (before embryos are safely implanted), stress should be avoided. Therefore, no regrouping should be performed in this period.
Inadequate light level and duration • Wild boars are seasonal breeders, regulated by photoperiodic information. Due to this evolutionary adjustment, farrowing at winter season is avoided. Also, in modern breeds there is still a seasonal influence, resulting in a reduction of fertility in late summer/autumn (northern hemisphere). Irregular return to estrus is typical.	• Check light intensity with a lux meter: 150 lux at the height of sow´s head should be achieved for 10 – 12 hours in mating rooms.	• Implement artificial light program. • Install artificial light in mating rooms at a height that is accessible for cleaning and produces 250 lux at the height of a sow´s head.
Poor insemination management and hygiene • Bad sperm quality and suboptimal insemination procedures hinder successful fertilization	• Check boars´ health if applicable • Control semen quality and storage • Check insemination procedure, especially regarding time of insemination, hygiene and stimulation of sow	• Replace poor performing boars • Implement artificial insemination • Optimize semen storage • Use boars for stimulation of sows

Mixing during gestation can lead to aggression/ear-biting in sows causing stress.

SMEDI syndrome – still birth, mummification, embryonic death, infertility
Photo courtesy of University of Veterinary Medicine Vienna.
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Artificial light providing 250 lux at the height of the sows head

Sudden Death

In cases of sudden death, the farmer might not have noticed any symptoms at all or only shortly before the death of the animal. Fever is indicative for involvement of an infectious agent.

For diagnostics it is important to initiate necropsy of the deceased animals as soon as possible, as this might already help to reveal etiology. Some analyses should only be performed if samples were collected from very fresh carcasses (for example, cultivation of bacteria).

Usually, cases of sudden death in a herd are only the tip of the iceberg and other animals will be affected, showing milder symptoms and poor performance. For diagnostics of infectious diseases at the herd level, sampling of acutely diseased animals is often advisable. If a bacterial agent is suspected to cause the problems, collect samples before application of antibiotics.

In recent years, an increase in cases of sudden death, especially in Danish and Dutch sow herds, has been reported. Often, this problem occurs in the farrowing house in the first five days *post partum* or in the week before weaning. Torsion of liver lobes (without rotation of other organs) was diagnosed in many of these cases and represents a new condition.

Many diseases typically occur in certain age groups, which we indicated in the section 'Pathogens'.

Lethal case of septicemia in a pig

Mycotoxins

Problem	Checklist	Corrective action
Fumonisins • Consumption of high doses of fumonisins results in porcine pulmonary edema (PPE). The fatal condition is due to acute left-side heart failure.	• Test for fumonisins in feed: ELISA for raw materials, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®
Aflatoxins • Consumption of high doses of aflatoxins causes acute liver disease characterized by hemorrhage and necrosis and can be lethal.	• Test for aflatoxins: ELISA for raw material, HPLC for feed • Origin of raw materials from known sites of contamination	• Prevent mold growth • Purchase clean raw materials • Mycofix®

Nutrition

Problem	Checklist	Corrective action
Mulberry heart disease due to deficiency of selenium and/or Vit E • Deficiency of Vit E and/or selenium results in degeneration of muscle cells.	• Initiate diagnostics with veterinarian • (Pathomorphological and histological examination, serum Vit E analysis, CK, AST)	• Check Vit E and selenium inclusion in feed

Pig short of breath

Ascaris suum found in the intestine of a pig
Photo courtesy of University of Veterinary Medicine Vienna. Used with permission.

Pathogens

Problem	Checklist	Corrective action
***Clostridium (C.) perfringens* type C** • *C. perfringens* type C is a typical pathogen causing diarrhea in young suckling piglets. • Due to toxins, cases of sudden death can occur.	• Check for occurrence of foamy, stinking, watery and/or bloody diarrhea in respective litter. • Initiate diagnostics with veterinarian (cultivation of bacteria from feces or small intestine followed by determination of toxovar)	• Vaccination of sows • Antibiotics
Streptococcus (S.) suis • *S. suis* causes disease in all age groups with often suckling piglets and weaners are affected. • Septicemia can lead to death. Other frequently occurring presentations of *S. suis* infection are arthritis, meningitis, endocarditis, abscesses.	• Check for further signs of *S. suis* – infection in herd • Initiate diagnostics with veterinarian (e.g., cultivation of *S. suis* from organs of recently deceased animals or blood culture)	• Hygiene (disinfection, all-in/all-out) • Antibiotics • Vaccination (depending on age of diseased animals)
Shigatoxin-producing *E. coli* (STEC), edema disease • Edema disease is a frequent problem in weaner piglets. STEC produces toxins, which target the capillaries and make them leaky. • Neurological symptoms are typical as well as cases of sudden death. Typically, edema disease occurs after weaning, when piglets compensate for reduced eating in the first days. Abrupt diet change also promotes edema disease.	• Check for pigs with neurological signs, visible edema (e.g., eyelids) and typical strident screaming. • Initiate diagnostics with veterinarian (cultivation of bacteria followed by PCR targeting specific genes)	• Vaccination • Antibiotics • Acidifiers (e.g., products from VivoVitall™ or Biotronic® lines) • Disinfection
***Salmonella* Choleraesuis** • Septicemia is often lethal	• Initiate diagnostics with veterinarian (e.g., cultivation of bacteria from feces or intestine, in case of septicemia from lung, liver, spleen; serology)	• Vaccination • Antibiotics • Acidifiers (e.g., products from VivoVitall™ or Biotronic® lines) • Biosecurity: » Hygiene (disinfection) » Control of vermin and rodents » Ban other animals (e.g., pets and birds) from stable » All-in/all-out
***Glaesserela parasuis* (GPS)** • Especially in immunologically naive herds, infection with GPS can cause septicemia and sudden death.	• Check for other symptoms of GPS-infection in the herd (e.g., polyserositis) • Initiate diagnostics with veterinarian (e.g., PCR, cultivation of bacteria from effected tissues)	• Vaccination • Antibiotics
Classical swine fever/African swine fever (CSF/ASF) Cases of sudden death are possible. • Often, acute symptoms occur such as: » Fever » Feed refusal » Hemorrhages	Check for further clinical signs indicative for CSF/ASF • Is farm located in a region at risk? • Any risk factors for introduction of disease known (introduction of animals of unknown disease status to herd, contact to wild boars, visitors/employees with potential contact to infected swine)?	• Actions according to legal requirements in your region • Inform veterinarian and/or authorities

Pathogens

Problem	Checklist	Corrective action
Erysophelothrix rhusiopathiae Occurs mainly in unvaccinated animals (pigs > 6 month) • Different courses of disease are possible, » Sudden death (peracute) » Acute, feverish disease with typical skin alterations » Chronic disease (endocarditis, polyarthritis)	• Initiate diagnostics with veterinarian (in case of peracute disease necropsy, cultivation of bacteria from blood) • Check vaccination status	• Vaccination of sows and pigs that are intended for long production life • In acute disease penicillin and antipyretic medication
***Actinobacillus pleuropneumoniae* (APP)** Course of disease might be chronic, acute or peracute (sudden death) depending on the immunological status of the herd • Acute form: » High fever » Feed refusal » Dyspnea, coughing » Abortion due to fever • Chronic form: » Dyspnea, coughing » Reduced feed intake » Wasting	• Initiate diagnostics with veterinarian (e.g., necropsy, pathohistology, PCR of lung tissue, APX IV-ELISA) • Bloody foam coming out of the nostrils upon death or in acutely diseased piglets is a strong indication for APP.	• Vaccination • Antibiotics • Antiphlogistic treatments • Check temperature in barn • Check for drafts
Proliferative hemorrhagic enteropathy (PHE) caused by *Lawsonia intracellularis* • Outcome of *Lawsonia intracellularis* infection depends on respective age group and immunological status. • In immunologically naive fatteners, young sows and boars, cases of peracute death may occur due to hypovolemic shock.	• Check for animals with bloody diarrhea. • Initiate diagnostics with veterinarian (e.g., necropsy, PCR from faeces or ileum)	• Biosecurity: » Hygiene (disinfection) » Control of vermin and rodents » Ban other animals (e.g., pets and birds) from stable • Vaccination • Antibiotics
Swine dysentery (e.g., *Brachyspira hydodysenteriae*) Dysentery is a disease in grower-finisher pigs: • Bloody/mucoid diarrhea • Peracute death possible	• Check for animals with bloody diarrhea. • Initiate diagnostics with veterinarian (e.g., necropsy, PCR from feces or colon)	• Biosecurity: » Hygiene (disinfection) » Control of vermin and rodents » Ban other animals (e.g., pets and birds) from stable • Antibiotics
Ascaris suum • In extreme cases of worm infestation, ileus (obstruction of intestine) and death might occur. Cases of death in the herd need to be considered as the tip of the iceberg.	• Initiate diagnostics with veterinarian: » Necropsy • At herd level: » Whitish worms in droppings (in cases of high worm burden) » Milk spot lesions in liver tissue » Worm eggs in feces (flotation)	• Anthelmintics • Hygiene, all-in/all-out

Housing, management and other factors

Problem	Checklist	Corrective action
Torsions of gastrointestinal tract, possibly caused by gas-producing *Clostridia* spp. and yeasts • Due to gas formation, inflation of stomach and small intestines occurs followed by torsion of parts of the gastrointestinal tract. The liver and spleen might be involved. Death is due to hypovolemic shock (blood is sequestered in gastro-intestinal tract). • Occurrence mainly in growing and fattening pigs fed with liquid feed, but also in sows. • Over-feeding and irritation of gastric mucosa might promote the condition. Feeding behavior (greedy, aggressive in fast-growing pigs) is also genetically determined.	• Initiate diagnostics with veterinarian (necropsy)	• Feed hygiene • Use organic acids and phytogenics • Feed 2 – 3 times a day or ad libitum • Reduce stress, especially around feeding time • Keep a strict feeding regime (including weekends and bank holidays)
Liver torsion • Liver torsion is a new presentation diagnosed in sows after farrowing/ before weaning and might be promoted by a dilated stomach (damage of liver ligaments). Torsion results in infarction, ruptures and fatal abdominal bleeding. • Etiology might be similar to other torsions and irritation of the gastric mucosa and/or gastric ulcers.	• Initiate diagnostics with veterinarian (necropsy) • Check for factors promoting gastric irritation/ulcers and formation of gas.	• Feed hygiene • Use organic acids and phytogenics • Feed 2-3 times a day or *ad libitum* • Reduce stress, especially around feeding time • Keep a strict feeding regime (including weekends and bank holidays) • Adapt particle size distribution
Disruption of ulcers and/or internal bleeding Gastric ulcers may be lethal due to: • Destruction of a blood vessel resulting in internal bleeding and death • Rupture of the stomach followed by peritonitis	• Initiate diagnostics with veterinarian (necropsy) • Control particle size distribution by sieve analysis • Pelleting (may contribute to ulcers) • Check corn and wheat content • Check for stress factors (promote ulcers)	• Adapt particle size distribution: » < 20 % particles < 0.2 mm » 15 – 20 % particles > 1 mm (Kamphues, 2007) • Avoid stressors
Porcine stress syndrome (PSS) • This genetically transmitted myopathy is triggered by stress and can, in the worst cases, lead to heart failure and death..	• Initiate diagnostics with veterinarian (pathomorphological examination)	• Change genetics (use only boars negative for respective gene)
Suffocation • Ventilation failure followed by lack of oxygen	• Anamnesis	• Emerging power system
Gas poisoning • Carbonmonoxide (CO): inefficient combustion of fuel due to faulty heaters • H_2S, HCN: released when liquid manure is manipulated	• Check heater	• Always ensure fresh air supply • Do not move/pump manure with animals in the pens

Intoxication

Problem	Checklist	Corrective action
Cyanamid • Used for control of flies and *Brachyspira* spp. • Toxic for pigs, pigs like to lick the substance; it is lethal in the worst cases	• Control proper use	• Strictly follow instructions from supplier • Use cyanamid only in empty stables • All rests of substance need to be carefully removed
Selenium Intoxication might occur, because of: • Overdosing (injection) • Mismixing feed Neurological symptoms and lameness typically occur at herd level. Selenium intoxication is lethal in the worst cases.	• Control mixing procedure	• Implement feed quality control system
Salt poisoning (NaCl) • Salt poisoning occurs when feeding high concentrations of salt together with restricted water access. Typically, neurological symptoms occur at herd level.	• Check water access • Check salt concentration in feed	• Drinker flow: » Min. 2.5 L/min for a sow, up to 4 L/min in lactating sows • Grower and fattener pigs: » 0.6-1.8 L/min (in dependence of age) » At least 1 drinker/10 pigs

All pigs need to have unlimited access to water.