

SZENT ISTVÁN EGYETEM
GÖDÖLLŐ

SWINE HERD HEALTH MANAGEMENT

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1 Background and objectives

Porcine Respiratory Disease Complex (PRDC) affects pigs and is a result of a combination of different infectious agents, environmental and management conditions, causing significant production losses (average daily weight gain, feed conversion rate). It results in increased mortality, culling rate and medication costs, making it one of the most important health concerns with high economic losses for swine producers. The severity of clinical signs in a given farm greatly depends on the type of infectious agents involved and the environmental and management conditions.

Non-infectious causes, primarily management and environmental conditions contribute to the development of respiratory diseases by facilitating the spread of pathogens. Unfavourable housing conditions may also cause stress which can negatively affect the defence mechanisms of the respiratory tract. Swine production has become more intensive in the past 30 years, with large herd sizes on most farms, which emphasizes the importance of proper ventilation and hygiene. Overcrowding and inadequate ventilation may lead to an increased amount of CO₂, ammonia, humidity and dust in the buildings, which negatively affects respiratory tract defences. Inappropriate temperatures (chilling or overheating) can have the same consequences. Operating with continuous pig flow can be considered a severe management mistake: without an all-in/all-out system in place younger pigs can mix with older pigs, which maintains the infection within the herd or can cause severe, acute respiratory disease outbreaks.

PRDC generally affects 30 to 70% of the animals in a herd, with mortality between 4 to 6% depending on the severity of secondary infections. Clinical signs are generally seen at 14 to 20 weeks of age, manifesting in a significant decrease in performance and severe respiratory symptoms – depending on the type of concurrent infections. Clinical signs are not characteristic: fever, lethargy, anorexia, nasal discharge, coughing, dyspnoea and pale skin or cyanosis of the skin, especially of ear-tips. Therefore diagnosis is based on clinical signs, history and pathological and laboratory findings. Respiratory disease not responding to antibiotic treatment and the presence of pathological lung lesions are indicative of PRDC.

PRDC prevention is hindered by the fact that the pigs are exposed to the pathogens at different time points during production. Vaccination plays an important role in preventing PRDC, but its success is greatly affected by the immune status of the pigs, environmental conditions and management practices. This means that farms should have tailor-made vaccination protocols that are updated regularly according to the animal health status and the economic situation on the swine market. PRDC causes losses at many

levels: it greatly impairs feed conversion rate and decreases average daily weight gain, while increasing mortality in growers and finishers.

In this thesis I will answer the following questions:

1. How is the animal health aspect of PRDC managed on the investigated grower/finisher farms, what type of data are used and which procedures are in place?
2. How do farm managers and veterinarians perceive the risk factors and the pathogens of PRDC?
3. Which are the critical points of PRDC management according to farm managers and veterinarians?
4. Which competencies and attitudes are swine farm managers expected to have?

2 Material and method

2.1 Material

92 Hungarian large scale pig farms were surveyed between March 2010 and February 2018 (**Table 1**) with the primary method of evaluating 136 questionnaire surveys and data acquired from farm databases to assess environmental, management, housing and production characteristics as well as the respiratory health status (including PRDC vaccination protocols) of the pig farms by conducting interviews with the farm managers and veterinarians, using the questionnaire from the ResPig Farm Audit Tool™ (MSD AH). 41 of the 92 large scale pig farms were assessed multiple times to monitor the effect of changes they implemented to their PRDC control program.

Table 1: Annual number of PRDC surveys on farms between 2010 and 2018

Year	Number of farm surveys (pcs)	Newly surveyed farms (pcs)	Number of sows on the new surveys	Number of nursery piglets in the new surveys	Number of fatteners in new surveys
2010	2	2	2,950	12,265	25,144
2011	43	39	47,240	196,409	402,639
2012	30	23	32,010	133,088	272,830
2013	23	12	1,730	7,193	14,745
2014	22	7	22,670	94,255	193,223
2015	2	1	6,700	27,857	57,106
2016	11	5	8,900	37,003	75,857
2017	1	1	1,230	5,114	10,484
2018	2	2	8,550	35,548	72,874
Total	136	92	131,980	548,732	1,124,901

The majority of the surveyed farms used modern hybrid lines: 59 out of the 92 farms used the hybrid lines of international pig breeding companies. We surveyed a total of 92 farms but show data for 85 farm managers only, because in a number of cases the same person was in charge of 2 farms. Most of the farm managers are above the age of 50 (38%) and are men (81%). The oldest farm manager was 75 years old and 20% of farm managers did not undergo relevant specialist training. 92% of veterinarians were men and over 41% of them belonged to the above 50 age group. The oldest veterinarian was 77 years old.

A large proportion of swine farms are farrow-to-finish operations with all production phases located at one site. Other operations are split up into production phases: these multi-site farms operate the farrowing, often the nursery and the fattening phases on different farms. Almost 80% of the surveyed farms work in 1, 3 or 4-week batch systems, using it to separate the animals into age groups. Depending on the farrowing system and the capacity of the farms, various lactation lengths were observed. 55% of the surveyed farms provided not more than an average of 24 days for the piglets with the sow before they were weaned. The surveyed farms kept the weaned piglets in the nursery for 5 to 7 weeks. This means an average of 3 weeks of suckling and 7 weeks in the nursery, making the average pig transferred to the fattening unit 10 weeks old.

After starting the PRDC management survey in 2010 by filling in the questionnaires, visiting farms and talking to professionals, we determined a further objective in 2013: we needed to get information and assess the conduct of responsible persons to get insight into successful PRDC control. Farm managers achieve predetermined control and management practices on a farm through managing and organizing workflow and farm employees. So we asked 101 professionals (among them 37 veterinarians and 39 agricultural engineers) on 75 pig farms in the Czech Republic, Slovakia and Hungary between February and May 2014 on their opinion on critical management factors affecting PRDC control and the competencies and attitudes a swine farm manager should possess.

2.2 Method

For each farm three topics – general, disease and economy – were surveyed, the questionnaires were filled in during the interviews. Acquired data were uploaded into a software that used a 3-point scale to evaluate each parameter of the farm. The questions were answered and results evaluated together with the management of the farm following a thorough farm visit and the identification of problems.

The farm assessment questionnaire had two main modules: one for general information and one for assessing disease status.

We addressed the following issues in the **general survey**:

1. Pig farming environment (low farming density; biosecurity; quarantine; buying animals; all-in/all-out; separating age groups; hygiene equipment; implementing rules regarding employees and visitors);
2. Management (owner expectations; human resources; feed quality; feeding system; water system; good veterinary practice; storage and administration of vaccines; data processing);
3. Housing (temperature, ventilation; heating; population density; isolation of sick animals);

4. Production parameters (uniformity, average daily gain – ADG; feed conversion ratio – FCR; mortality and culling; veterinary costs);
5. Lung health status (prevalence of infectious respiratory diseases; course of disease in the previous 6 months; clinical signs; results of pathological examinations);
6. Results of slaughterhouse checks (scoring) – respiratory tract and liver).

When assessing **the disease status**, we checked if the farm is:

1. performing laboratory diagnostics (serology, histopathology) with regard to PRDC-pathogens (PRRSV, *Mycoplasma hyopneumoniae* (Mhyo), *Actinobacillus pleuropneumoniae* (APP), swine influenza (SIV), *Haemophilus parasuis* (HPS), Aujeszky's disease, PCV2, atrophic rhinitis (AR)),
2. vaccinating – against which pathogens and at which age.

The software uses data from the survey to calculate how each general parameter contributes to the risk of PRDC and the importance and severity of each respiratory disease on the given farm. The score calculated by the software is a result of all answers related to the given parameter. The answers are weighted according to the importance of the issue.

The software calculated scores on a scale of 0 to 3, with evaluation based on the following categories:

- 0.0–0.5: no or negligible risk/importance;
- 0.6–1.5: moderate risk/importance;
- 1.6–2.5: major (significant) risk/importance;
- 2.6–3.0: severe risk/importance.

An economic simulation model was also used to assess the farms. We collected the price and cost data that are most significant for fattening operations, e.g. carcass price, weaned piglet price, weighted post-weaning feed costs. Based on these we could estimate the effects different vaccination protocols would have on production, their cost and the revenue generated – as well as the return on investment.

Some of the surveyed farms have multiple production units on the same site, such as nurseries and either a single fattening unit or two stage grower/finisher units. This meant we assessed a parameter for the combination of these during the farm visits or – mainly during follow-ups – as a total for the farm (all production units combined). For the purpose of this thesis we merged the scores of individually assessed production units and the scores of those assessed as a total in some of our assessments into a “Total” category. We created a **PRDC Index** for the evaluation of the severity and the importance of the respiratory disease complex in a given production unit, which shows how management affects the manifestation of PRDC on the given farm. It is evaluated on a scale of 0 (no or negligible risk/importance) to 3 (severe risk/importance). In the “Results” section **Noncompliance ratio %** shows the

ratio of factors with scores between 1 and 3 (non-compliant) to factors that scored 0 (compliant) during the assessment of a given parameter. Farm managers who participated in the survey on responsible management practices determining the success of PRDC control received a list with 30 aspects of PRDC control and they had to choose the ones they considered most important. These aspects were investigated in detail on previously selected farms. During the interviews we compared the statements of the group of veterinarians (26 Hungarian, 10 Czech, 1 Slovak, a total of 37 veterinarians) with the group of farm managers (32 Hungarian, 6 Czech, 1 Slovak, a total of 39 agricultural engineers) regarding the evaluated aspects (predisposing and risk factors of PRDC, PRDC management on farm). Predisposing factors of PRDC were rated by farm managers and veterinarians on a scale of 0 to 3 with 0 being excellent and 3 being bad/immediate intervention needed.

The following general aspects were assessed:

- **Farming environment** (FE) includes farm isolation (FI), biosecurity (BS), quarantine practices (QP), all-in/all-out procedures (AIAO), hygiene level (HL).
- **Management** (M) includes owner's attitude (OA), staff qualification and morale (HR), feed quality (F), water supply (WS), daily veterinary practices (GVP), and collection and management of data (DM).
- **Housing** (H) issues are ventilation, cooling and heating (V), stocking density (SD), separation of sick animals (SSA), while **production technical parameters** (PTP) are disposal rate (DR), average daily gain (ADG), feed conversion ratio (FCR), uniformity (U), and animal health costs (HC).
- With regards to **lung health status** (LHS) clinical signs (CS), pathological signs (PS), recent disease outbreaks (RO) were assessed, while further aspects of **other diseases** (OD), and **slaughterhouse checks** (SHC) were evaluated such as lesions in the lungs (LL), pleura (PL), pericardium (PC), peritoneum (PT), joints (Art), liver (MS), skin (SL) and nasal cavities (ND).

The **perception** of farm managers regarding specific **diseases** such as PRRSV, Mhyo, APP, SIV, HPS, AR (=PM+BB) and PCV2 was also surveyed.

We also interviewed **101** professionals (63 veterinarians and 38 farm managers) from 63 Hungarian, 11 Czech and 1 Slovak pig farm and asked their opinion on the critical farm factors affecting PRDC. The 101 respondents had to choose the 10 most important factors for PRDC prevention and control from a list of 30 for a) establishing a **new farm** (if they could build a new farm) and b) operating **their own farm** successfully. By this we were able to compare theoretical and practical aspects. The respondents also had to **evaluate the importance** of **critical PRDC management conditions** (c) on their farm on a scale of 1 to 100.

In the **last module of the survey** we assessed the attitude and values pig farm managers are expected to possess. Veterinarians and farm managers had to

choose from a list of competencies a) the 10 most and b) the 10 least important personal traits a Central-European pig farm manager is expected to have. The factors were awarded scores on a scale of 0 to 3. The scores were grouped according to the type of manager (veterinarian/farm manager) and topics (average scores of veterinarians and farm managers), then we calculated overall scores for general factors, diseases and derived parameters.

3 Results and discussion

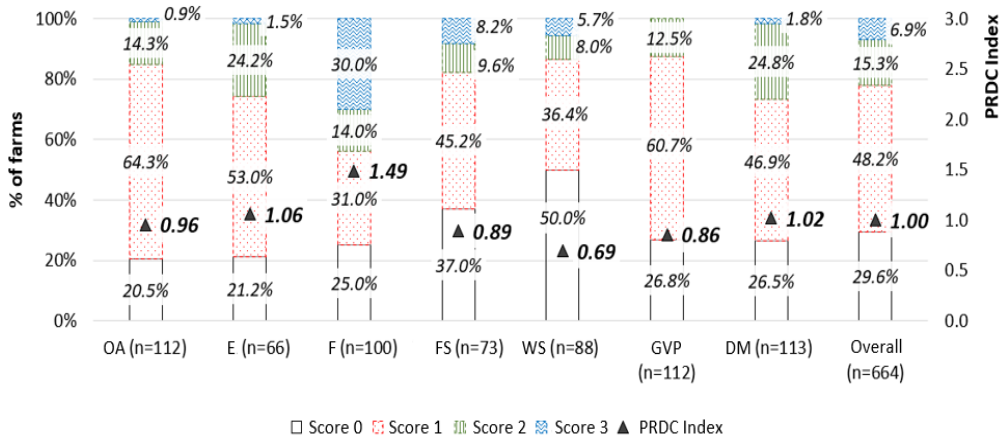
PRDC Index (PI) data show that environmental factors on average fall into the moderate risk (0.5-1.5) category, except for farm location/isolation (stocking density) which is considered to be an important risk (0.36–1.55) factor. Summarizing the results, it is clear that besides farm location/isolation, most farms have issues with quarantine, all-in/all-out and internal biosecurity.

Results of the survey show that Hungarian pig farms are often located in areas where farm density is high (PI=1.55). Among the weaknesses of our farms we can list inappropriate quarantine practices (PI=1.49) and shortcomings in the fields of AIAO (PI=1.25) and external (PI=1.05) as well as internal (PI=1.13) biosecurity. Three-quarters of our farms have obvious problems with quarantine and 30% of farms have practically no quarantine measures in place. This is one of the major risks for Hungarian farms, especially considering infectious diseases with great economic impact (African swine fever, PRRS). Replacement gilts are produced on site in 1/3 of the farms, others **purchase gilts** to replace breeding animals, under the above mentioned quarantine conditions, with 13.5% of transactions carrying pronounced risks. 52 farms buy gilts from one (the same) source, 5 from two (the same two) sources, while 2 farms buy from more, continuously varying sources. **AIAO** results indicate that of the 212 surveyed production units (production units being the nursery, grower and finisher units within the farms) the rules complied with AIAO rules in only 70 cases. The most unfavourable results come from farms that split the fattening phase into grower and finisher phases: only 18% of these farms are compliant with AIAO. The reason for this is the prolificacy of the sows, inappropriate farm management and the absence of individualised batch management systems.

Most of the problems occurring in the grower and finisher units could be solved by selling weaned piglets, but only a few farms do this. Another possible solution would be to improve production parameters – by improving animal health management – and decrease time to slaughter (better ADG, shorter fattening period to reach the same slaughter weight). **Separation of animals according to age groups** has two levels: the first is how well the age groups are separated from each other (weaned piglets, growers and finishers), the second is the age of pigs in a given unit. Separation by age shows results similar to AIAO: separation was adequate in 38% of the cases, with the grower units showing the worst results (73% not adequate), nursery units being second worst with almost 60% of them not providing adequate separation by age. Hungarian farms lag behind substantially in terms of **internal biosecurity**: only 22.5% of production units (67 units) scored 0 (adequate) in this regard. 75% of units in the nursery and the fattening phase and 96% of grower farms had shortcomings. When assessing the PRDC risk of farm **management**

factors such as owners' attitude, employees' qualification, daily workflow, feeding (quality of feed and feeding system), water supply, veterinary practices and data management, it is clear that management factors fall into a moderate risk category (0.69–1.49) (**Figure 1**).

Figure 1: Results of farm management assessments displayed as % of farms



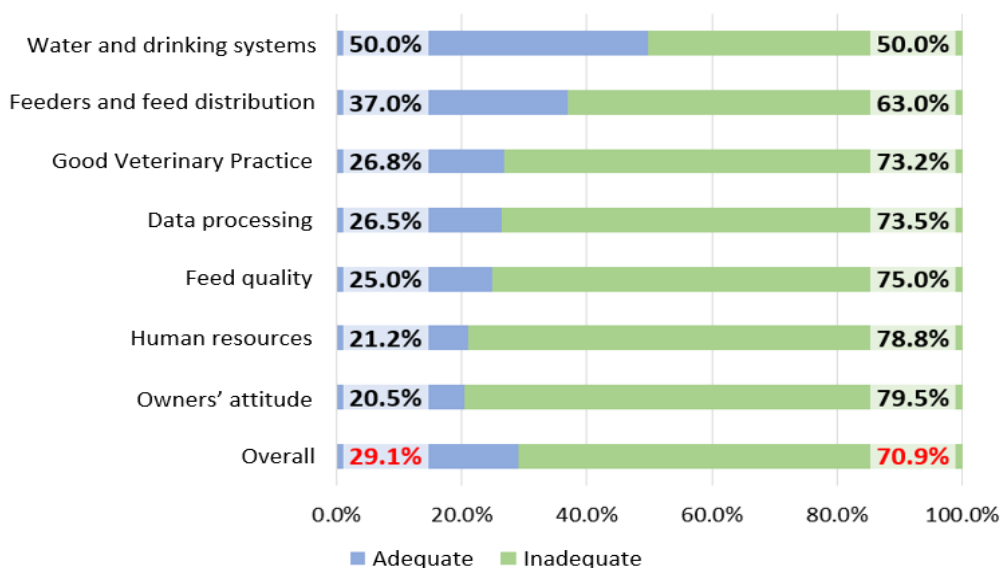
Note: Owner's attitude (OA), Employees (E), Feed quality (F), Feeding system (FS), Drinking water and water system (WS), Good Veterinary Practice (GVP), Data management (DM)

Results show that only 1 in 5 farms has adequate workforces and 20% of owners think animal health management is an important part of operating a pork production business. Only 21 to 25% of tasks are performed duly in the different the production phases, **employees'** work morale obviously needs to be improved. Again, nursery units were ranked first (best) in work morale. Although problems with feed safety (mycotoxin) and **feed quality** vary every year, the total PRDC Index for the nursery, grower and finisher phases was lower than 1. However, when looking at the total index of farms – including all production units, PI reaches a moderate value that is close to the significant category (1.49). Even though billions of HUF have been spent on modernizing farms in the past few years, 60% of Hungarian farms still lack adequate **feeding and feed distribution technologies**. These technological shortcomings may account for a significant increase in FCR and a loss of ADG. We put special emphasis on assessing **drinking water and the water systems**, evaluating operation and hygiene of the systems as well as water quality and safety. Water supply had proven to be insufficient in 50% of the production units evaluated (water quality/quantity, drinker quality/quantity/position).

When evaluating **Good Veterinary Practices**, we didn't find any severe problems (score 3), but we did find issues in 73% of the production units: 68 units had a score 1, 14 units a score 2 and 30 units had proven to be appropriate. Daily animal health practices is a part of management practices that can be improved by implementing trainings and systems, thus achieving clear improvements in the efficacy of pork production.

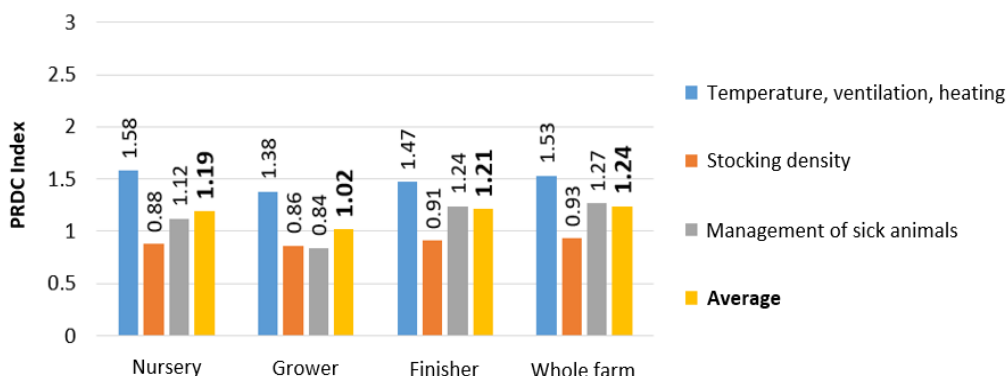
We also analysed the level of **data management** – data collection and processing – in the farms. 73% of the farms didn't have appropriate data collection and processing in place, a score 0 was awarded in 30 cases, a score 1 in 50 cases, a score 2 in 28 cases and a score 3 in 2 cases. In summary of the evaluation of farm management factors on Hungarian farms, we can conclude that there is a potential for improvement and growth in this regard, with 70% of them reaching scores of 1 to 3, meaning they are inadequate (**Figure 2**).

Figure 2: Summary of the evaluation of pig farm management factors



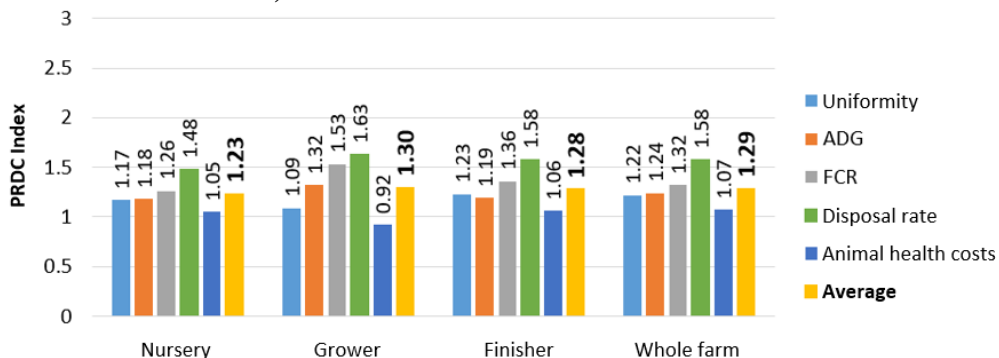
When evaluating housing of the animals, we can say these factors carry on average a moderate risk, but the ones affecting climate/ventilation carry a significant risk (0.93–1.53). We can also conclude that for the nursery (PI=1.19) and the fattening units (PI=1.21) all general factors carry a higher risk for respiratory diseases. In the nursery phase negative effects of major ventilation problems are counteracted by lower stocking density and not so bad management of sick animals, so situation was the worst in fattening units (**Figure 3**).

Figure 3: PRDC Index of housing conditions in production units (n = in the nursery units 48/40/51, in the grower units 16/14/19, in the finisher units 49/46/66, for the whole farm 57/54/73)



We performed a high number of on-farm measurements during the assessment of temperature/ventilation/heating and results show that on average 4 out of 5 Hungarian farms lack an adequate, all-year-round system for controlling these factors – with the worst conditions observed during the nursery phase: 92% of the units had shortcomings! Problems with overcrowding were seen mainly because of the spread of hyper-prolific breeds (e.g. Danbred, Topigs, Nucleus, Hypor) and fattening to larger slaughter weights. There is some level of overstocking in 60% of the production phases in Hungarian pork production. Sick animals can be separated from healthy pigs with various methods: they are either placed into a separate room or a separate pen/box. Our investigations showed that 3 farms had a euthanasia (humane killing) protocol in place for animals that could not be treated successfully or effectively. 12 farms had a quick and effective system in place for removing sick animals. According to our investigations, treating sick animals is a weakness of Hungarian pork production: an average of 81% of production phases fail at applying good treatment practices. The biggest problems are seen in the fattening and nursery units. Rooms that open from each other – even if there is a hospital pen allocated – and weaknesses in internal biosecurity, as well as the practice that handling of sick and healthy animals is not separated neither in time or space, all contribute to the spread of PRDC and PRDC-associated secondary pathogens within the farms and do not prevent disease transmission at all. Within the category of **production technical parameters** we evaluated uniformity within groups, average daily gain, feed conversion rate, disposal rate (mortality, culling, selling of culled animals and their bodyweight) and animal health costs on the farms (**Figure 4**). Result indicate that production parameters on average fell into the moderate risk category (0.92–1.06), with losses categorized as significant risks.

Figure 4: PRDC Indices for the main production parameters according to production units (n = in the nursery units 63/60/57/54/58, in the grower units 23/19/17/19/25, in the finishing units 71/68/64/62/66, for the whole farm 77/75/71/69/73)



Uniformity of a pig herd implies that pigs within a group display the same body weight, body condition and size. When assessing uniformity, we took into account the level of uniformity at the beginning of a phase. There are a number of reasons why a high rate of fattening herds lack uniformity. As hyper-prolific breeds are becoming more widespread, cross-fostering (including split suckling) should be used in a tailor-made manner to improve uniformity of suckling piglets. Appropriate feeding, housing and a higher animal health status all contribute to the uniformity of herds. Although a longer nursery period and an added grower phase improve uniformity by providing better conditions, 4 out of 5 farms still experience significant problems in this regard.

We evaluated **average daily gain** by comparing results of a given production unit in the past 6 months with documented production parameters of the given genetics. Average daily weight gains on the evaluated farms does not reach expected levels by far: 93% of farms need to improve this parameter. This is the reason why farms overstock animals and fail at AIAO, in other words: make their batch systems collapse. **Feed conversion rate** was appropriate in only 4% of the 209 evaluated production units! While feed cost is the major component in the cost of pork production, FCR is poor on an average Hungarian pig farm.

We evaluated disposal rate (mortality, culling, and emergency slaughter) by comparing farm production data to reference data (MFSE; NÉBIH). Only 6% of the assessed production units had acceptable losses. In case of **animal health costs** we evaluated it as cost per slaughter pig and took into account any losses and additional costs caused by disease (outbreaks). Costs were acceptable from both professional and economical aspects in only 15% of the

farms with costs being generally higher than optimal in the grower and finisher units.

To assess the **prevalence of respiratory disease outbreaks** we determined the number of respiratory outbreaks on the farm during the previous 6 months. Two-thirds of the examined farms experienced respiratory disease outbreaks of varying severity during this time period. A quarter of the farms struggle with respiratory symptoms continuously, with almost 30% of the farms experiencing multiple outbreaks. Disease occurs mainly in the nursery and fattening units. **Figures 5 and 6** summarize the occurrence of **clinical signs** on the farms such as coughing, sneezing, conjunctivitis, abdominal breathing, swollen joints, nosebleed or blood-tinged discharge from the nose (or mouth). We examined the animals closely for the occurrence and the extent of swollen lymph nodes, decreased feed intake, cyanosis (blue/purple discoloration) and paleness of the skin. Respiratory diseases are a major cause of mortality in almost 60% of the farms. Mortality is observed mainly in the grower, and to a lesser extent in the nursery phase. Severe, significant losses (score 3) occur in 10 to 11% of the cases, with occasionally even higher rates in nurseries.

Slaughterhouse checks revealed that only 16% of farms achieved good uniformity. **Meat quality inspections** showed compliance with genetics, slaughter weight and housing conditions in only one-quarter of the herds. Data regarding the **rejection of whole carcasses, parts of carcasses and organs** shows that only 27% of the herds are not effected by rejections of whole or part of the carcasses. Slaughterhouse checks confirmed the results and interpretation of on-farm pathological examinations. 80% of lungs displayed lesions. It is important to note that 1/4 of the lungs was free from scar tissue and 1/3 of them of interstitial pneumonia. Pleuritis occurred in 75 to 80% of the cases. Pericarditis was also common, observed in 2/3 of the herds. 55% of slaughter pig batches were affected by “milk spots”, lesions indicative of parasites in the liver.

To evaluate the **pathological aspects of respiratory diseases** we took into account recorded information as well as observations of veterinarians and veterinary technicians on respiratory diseases, in most cases performing on-site necropsies with their help. To assess the importance of **other diseases**, we investigated if they are present on the farm and determined their prevalence. We **did not** find any other, non-respiratory disease in only 7 to 12% of the production units. According to our investigations gastrointestinal diseases are most common in the nursery and grower phases, but GI disease (e.g. swine dysentery, ileitis/colitis) is present in the finishing phase also.

Figure 5: Assessment of respiratory clinical signs I.

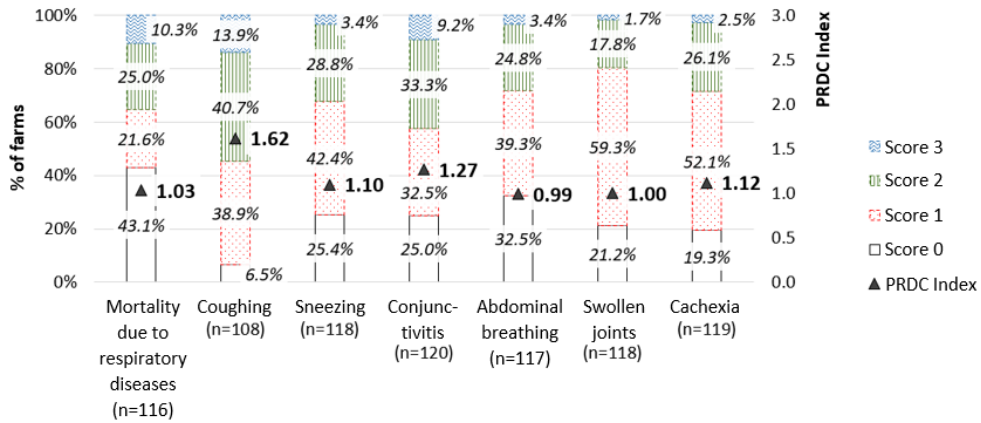
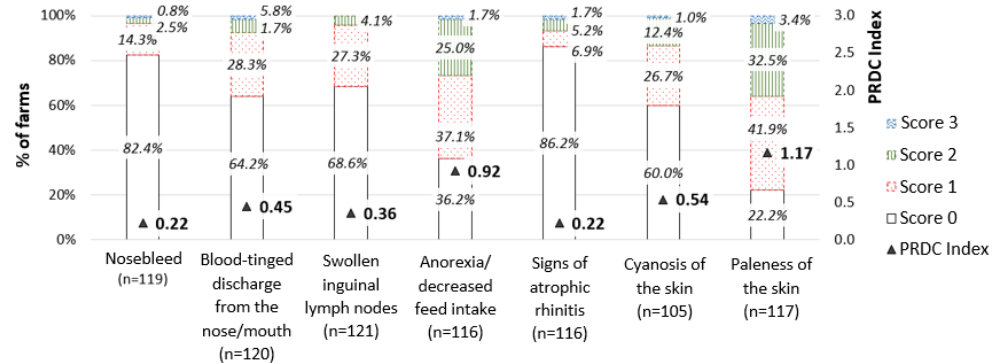
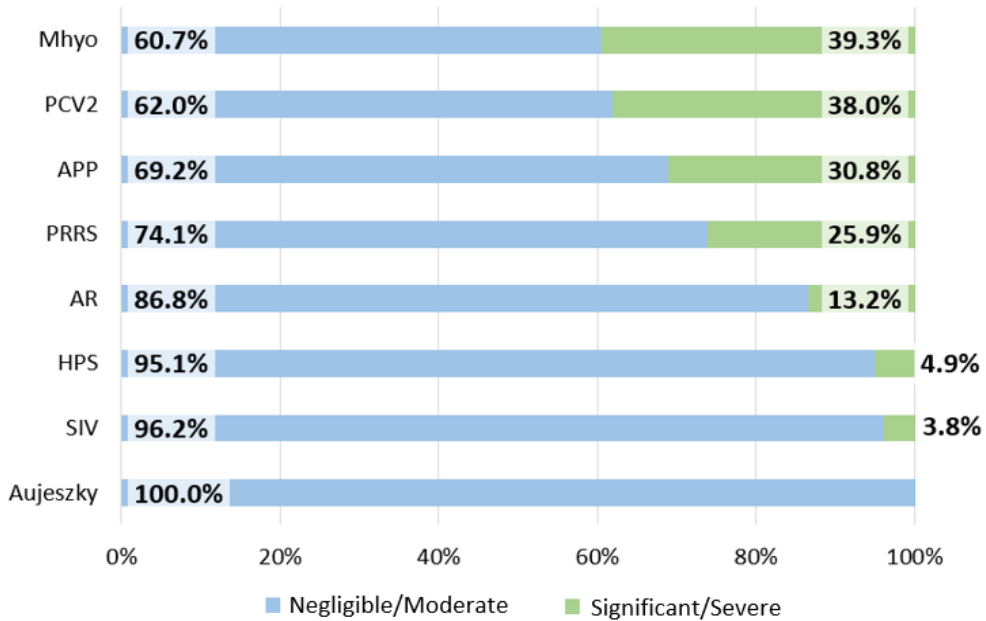


Figure 6: Assessment of respiratory clinical signs II.



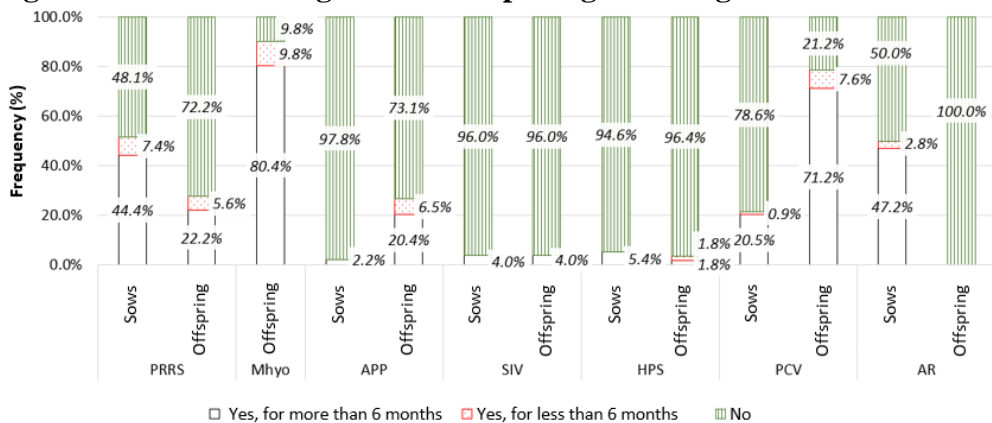
Pathogens contributing to **PRDC** on the farms. During the assessment of the farms we systematically performed so called comparative studies to determine the severity of a disease caused by a specific pathogen in terms of clinical picture, pathological lesions and slaughter house checks – under the particular conditions of production. We checked these data multiple times, even for the same production unit and results are summarized in **Figure 7**. Our investigations show that even in the face of years or even decades of vaccination, PRRS is present in a significant or severe form in a quarter of the production units. Even more surprisingly Mhyo and PCV2 also cause significant/moderate problems in almost 40% of the production units. Severe/significant problems with APP were apparent in 30% of the units.

Figure 7: Severity of disease caused by PRDC pathogens



We also investigated if a **vaccination** program was in place against PRDC pathogens in any of the production units (breeders and offspring) (**Figure 8**).

Figure 8: Vaccination against PRDC pathogens on a given farm



52% of farms affected by PRRS vaccinated sows, 28% even vaccinated piglets (this study contains data from the period before the PRRS eradication program was implemented). 90% of fatteners were vaccinated against Mhyo, while 2% of farms vaccinated sows and 27% vaccinated piglets against APP. Level of immunization against HPS and SIV is low, with 4 to 5% of farms vaccinating sows or piglets. 21% of farms vaccinate sows against PCV2 and 79% vaccinate offspring. 50% of farms affected by AR vaccinate sows regularly.

3.1 Economic analysis of farms based on production parameters

I performed economic analysis in 332 cases during the study. For each farm I used prices and costs (purchase price, feed costs) and production (ADG, FCR, etc.) and animal health parameters relevant for the given time period. Clinical and economic manifestations of PRDC depend on which contributing management factors and pathogens – viruses, bacteria and migrating nematode larvae – (PRDC factors) are present at the same time. The consequences affect production in multiple ways. The number of slaughter pigs sold is one of the most important measurable production parameters, which is directly affected by mortality, culling, average daily gain and feed conversion rate. Cost of production or price of a weaned piglet and feed cost during the fattening phase are the biggest variable costs in pork production. Weight and price of slaughter pigs are the basis of income in the fattening unit. Average daily gain has a direct effect on the length of the fattener phase (number of fattening cycles) and as a consequence on the number of slaughter pigs sold in a given time period.

For this thesis I created a **model** adapted to **Hungarian conditions** to measure the effect various PRDC pathogens have on **pork production**. Calculations were based on a model farrow-to-finish farm with 1,000 sows, a farrowing index of 2.35; 14 live born per litter and 12 weaned piglets per litter. Piglets are weaned with 7 kg bodyweight on the 28th day of lactation and are sold at the age of 170 days, weighing 105 kg. This means that total average daily gain for the post-weaning period – nursery and fattening – can be calculated by dividing 98 kg by 142 days, which gives a result of 695 g per day. Feed conversion rate in the post-weaning phase is 2.85 kg/kg, with mortality and culling rates at 5% for this period. For the calculations I assumed production costs to be 75 HUF/kg and a market pig price of 350 HUF. I assumed the farm to be moderately affected by PCV2, Mhyo and APP; I calculated with a moderate rate of overcrowding and moderate shortcomings in terms of isolating sick animals (PRDC Index = 1.55).

During the calculations I did not account for any other costs, or assumed they were constant. To **calculate the cost of producing a weaned piglet** I took into account only sow feed costs (daily feed intake of the sow and the number of days on feed multiplied by the unit price of feed), the average cost of gilt replacement and three lactations (assuming an annual sow disposal rate of 35%). To calculate the cost of fattening I used the price (production cost) of a weaned piglet, the cost of feed used to produce a weight gain of 98 kg and the losses due to mortality. To calculate the cost of mortality I used the following parameters: price of a weaned piglet, the feed consumption of an average 71 days in fattening and mortality rates. I did not take into account loss of future

earnings from fattening. To calculate **profit** I deducted the cost of nursery pigs and feed costs during the fattening phase from revenues.

Known PRDC factors affect the number pigs marketed (e.g. through mortality, culling), feed conversion rate and daily gain in different ways. **Table 2** summarizes the effects of the most important pathogens and management factors on production parameters based on literature data. The number of pigs marketed is affected by: the number of piglets born, mortality during fattening and culling. Some pathogens and management factors may have a direct (indicated with “Yes”) or an indirect (indicated with “No”) effect on the number of animals. Some factors have no effect on the number pigs sold (indicated with “No”). When the total of the points awarded for these three production parameters (yes=1; partially=0.5; no=0) was at least 1.5, I indicated it as a “Yes” (1 point) in the table, meaning it has an effect on the number of pigs sold. The effects of the various infectious and non-infectious PRDC factors on feed conversion and daily gain were also evaluated by the same scoring method of: yes=1; partially=0.5; no=0.

Table 2: Summary of the effects of various PRDC factors on a scale of three possible answers

Effect of PRDC factors on major production parameters	PCV2	Mhyo	APP	PRRS	HPS	SIV	AR	Overstocking	Ventilation	Separating age groups	AIAO
Number of pigs marketed	I	N	I	I	R	R	N	I	R	R	R
Number of piglets born	I	N	N	I	N	N	N	N	N	N	N
Mortality	R	N	I	I	R	R	N	I	R	R	R
Culling	I	R	R	I	R	N	N	R	R	R	R
ADG	I	I	R	I	R	I	R	I	I	R	I
FCR	I	I	R	I	R	R	R	I	R	R	I
Total score	3	2	2	3	1.5	2	1	3	2	1.5	2.5

Note: I = yes, N = no, R = partially

A qualification of factors with yes/partially/no makes it possible to compare them with each other, and total scores show that the main factors influencing production parameters are PCV2, PRRS and overcrowding.

I prepared a calculation model to assess the effect of PRDC on production parameters based on the above described scoring system and PRDC Indices calculated during farm assessments, taking into account data from literature regarding the effect of these factors on ADG, FCR and the number of pigs marketed. Four categories were established in the model based on PRDC Indices, indicating if the given factor is not present or has a moderate, significant or severe effect. Every factor that achieved a “Yes” for the effect on the number of pigs marketed was taken into account as +1%, +2% or +3% in disposal rates (change in the number of fatteners), according to the level of impact. Similarly, factors that qualified as “Partially” influencing the number of pigs sold were accounted as +0.5%, +1% és +1.5% in disposal rates and factors with “No” as 0% disposal. For factors affecting ADG, “Yes” answers were calculated as -25 g, -50 g and -70 g in ADG, taking “Partially” answers into account as -12.5 g, -25 g és -37.5 g in ADG. In a similar way the model uses +0.1; +0.2 and +0.3 kg/kg for “Yes” and +0.05; +0.1 and +0.15 kg/kg for “Partially” answers with regard to FCR (**Table 3**).

Table 3: Modelling the effects of PRDC on production

Effect of PRDC factors on major production parameters	PCV2	Mhyo	APP	PRRS	HPS	SIV	AR	Overstocking	Ventilation	Separating age groups	AIAO
PRDC Index 0.6 to 1.5 – MODERATE											
Change in the number of pigs marketed (%)	1	0	1	1	0.5	0.5	0	1	0.5	0.5	1
Decrease in ADG (g/day)	25	25	12.5	25	12.5	25	12.5	25	25	12.5	25
Increase in FCR (kg/kg)	0.1	0.1	0.05	0.1	0.05	0.05	0.05	0.1	0.05	0.05	0.1
PRDC Index 1.6 to 2.5 – SIGNIFICANT											
Change in the number of pigs marketed (%)	2	0	2	2	1	1	0	2	1	1	1
Decrease in ADG (g/day)	50	50	25	50	25	50	25	50	50	25	50
Increase in FCR (kg/kg)	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.2
PRDC Index 2.6 to 3 – SEVERE											
Change in the number of pigs marketed (%)	3	0	3	3	1.5	1.5	0	3	1.5	1.5	2
Decrease in ADG (g/day)	75	75	37.5	75	37.5	75	37.5	75	75	37.5	75
Increase in FCR (kg/kg)	0.3	0.3	0.15	0.3	0.15	0.15	0.15	0.3	0.15	0.15	0.3

The economic losses caused by PRDC on a farm can be estimated based on the data in Table 3. When compared to a farm not affected by PRDC (PRDC Index = 0 to 0.5), production parameters evaluated based on the PRDC Index (number of fatteners sold, ADG, FCR) will be predictably worse, and the volume of economic losses can also be calculated.

The following example demonstrates the economic effects of various levels of PRDC on a farm in comparison to the Hungarian reference farm described above. In this example (Example “A”) the farm is affected significantly by PCV2, moderately by Mhyo and severely by APP, with no PRRS, HPS, SIV and AR present. It qualified as having moderate problems with overstocking, significant problems with ventilation and separation of age groups and severe problems with AIAO. **Table 4** shows that PRDC load in example “A” increased production costs, the number of fatteners dead, decreased annual revenues from market pigs – by more than 400 million HUF and decreased profit by a total of almost 119 million HUF.

Cost-benefit analysis should be performed before deciding **if it is worth vaccinating** against a disease(s) present on a given farm. I performed cost-benefit analysis based on the economic models described in my thesis and the SPCs of vaccines against PRDC pathogens available on the Hungarian market. I assumed that by implementing vaccination and achieving immunity within the herd, the measured PRDC index will improve to at least moderate from significant or severe, and to “not present” from being categorized as moderate before the vaccination. To account for this improvement, I calculated with an increase in the number of pigs marketed and an improvement in ADG and FCR. To calculate the cost of vaccination I took into account vaccine cost per dose and the number of vaccinations per pig, e.g. the vaccine against APP has to be administered twice per pig, while the cost of AR vaccination of sows has to be divided by the number of piglets weaned per sow.

Table 4: Example „A”– Estimation of PRDC losses on a farm with significant PCV2, moderate Mhyo and severe APP infections (PRDC index = 2.05)

Production parameter	Reference	Example „A”
Number of sows (pcs)	1,000	1,000
Number of litters per sow per year (litter)	2.35	2.35
Weaned piglets / litter (pcs)	12	12
Number of weaned piglets per year (pcs/farm)	28,200	28,200
Post-weaning mortality (%)	5	14.5
ADG (g/day)	695	407.5
FCR (kg/kg)	2.85	3.9
Pigs marketed (pcs/year)	26,790	15,721
Cost per pig marketed (HUF/fattener)	30,512	34,341
Fattener mortality (pcs/year)	1,410	4,089
Farm revenues (HUF/year)	984,532,500	578,470,453
Cost of mortality (HUF/year)	28,358,029	57,812,125
Feed cost during fattening (HUF/year)	817,416,480	540,561,681
Farm gross margin (HUF/year)	138,757,991	19,903,353
Difference in gross margin (HUF/year)		-118,854,638

I calculated the benefit/cost ratio for implementing a vaccination protocol in the case of the farm that was most severely affected by PRDC according to our investigations (Example “C”). The first calculation included vaccination against PCV2 only (Table 5). The implementation of a PCV2 vaccination protocol would mean lower production costs, improved weight gain and decreased mortality, resulting in a higher number of pigs marketed. Although the farm is still achieving negative gross margin, it has increased by 63 million HUF. Profit of vaccination is estimated to be 57 million HUF, yielding a very high benefit/cost ratio of 10.65.

Table 5: Return on investment for PCV2 vaccination on a pig farm severely affected by PRDC (Example „C”, PRDC index = 2.75)

ITEM	Before vaccination	After vaccination
Pigs marketed (pcs)	15,934	16,919
ADG (g/day)	282.5	332.5
FCR (kg/kg)	4.4	4.3
Profit (HUF/farm)	-72,079,847	-8,995,648
Cost of PCV2 vaccine (HUF/fattener)		350
Cost of PCV2 vaccination (HUF/farm)		5,921,591
Gross margin over vaccination costs (HUF/farm)		-14,917,239
Profit of vaccination (HUF/farm)		57,162,608
B/C (benefit/cost ratio of vaccination)		10.65

When implementing PCV+Mhyo+APP vaccination on farm “C”, the farm with the highest PRDC Index, all production parameters improved after vaccination, but B/C was 3.21 – lower than for vaccination against PCV2 only. Another calculation was performed to model the use of every relevant vaccine (PCV, Mhyo, APP, PRRS and AR) on the farm. The use of the full vaccine range yielded the highest number of pigs marketed on this farm severely affected by PRDC. Production cost and mortality rates improve; and gross margin will also be positive: 16.5 million HUF. Profit of vaccination is the highest in this case: 88.5 million HUF, with a benefit:cost ratio of 3.1. Analysis shows that implementing vaccination can improve profitability of the farm but the high number of management issues still mean that revenues remain 200

million HUF lower than for the reference farm. For this farm I performed a separate calculation to determine the effect of vaccination against the two PRDC pathogens that caused the most severe problems (PRRS and AR). Results show that combined vaccination against PRRS and AR yield the best results in gross margin over vaccination cost (20.2 million HUF) and second-best results in B/C (9.17), meaning that this vaccination programme provides the largest economic benefit for the farm.

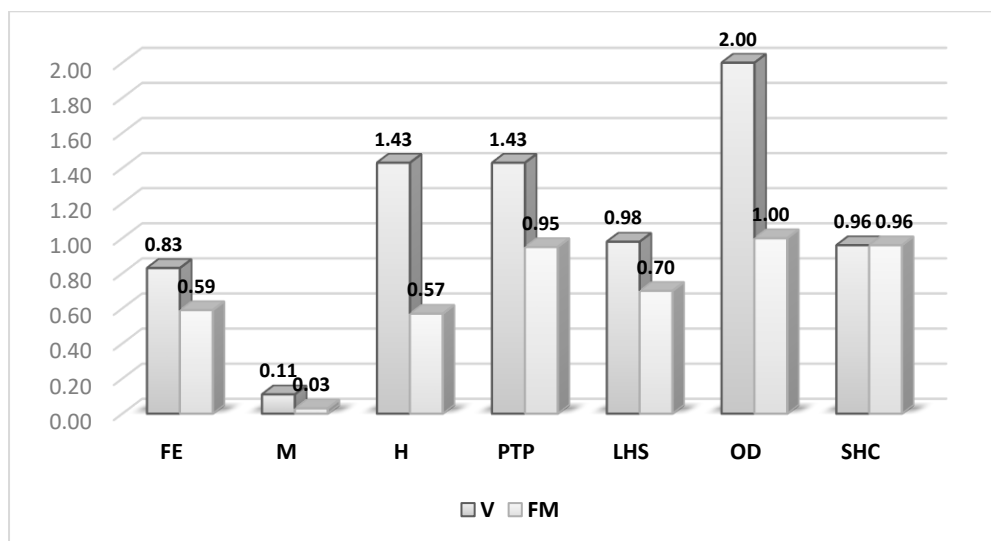
When I evaluated the vaccination protocols on the farms, results indicated that vaccination – even if used according to indications – did not yield the expected increase in profit because of shortcomings in vaccine administration (e.g. age, dose, MDAs, method of administration) and other management issues (e.g. housing). Because of this, I used economic analysis to show how the implemented vaccination programmes/combination of vaccines could increase revenues in a given production unit. For example in 2013 on one of the farms I recommended to quit vaccination altogether, because it was unnecessary and we could increase revenues by 1,111 HUF per market pig. When looking at the farms in total, my calculations show that vaccination against PCV2 would yield the most economic benefit, even if used by itself; followed by APP, Mhyo and PRRS. When vaccinating against two pathogens, immunization against PCV+APP resulted in the highest increase in revenues, followed by PCV+Mhyo and Mhyo+APP. For the combinations of three pathogens, PCV+Mhyo+APP promised best improvement in revenues.

In conclusion we can state that vaccines and vaccine protocols used on farms were capable of significantly decreasing losses due to infectious diseases, but did not realize the expected profits following implementation. The surveyed farms still lagged behind significantly in almost all production parameters, with the number of market pigs per year being the most important parameter. This could be improved by improving mortality rates and ADG.

3.2 The importance of PRDC pathogens and predisposing factors and management practices and values according to farm managers and veterinarians in Central-Europe

Figure 9 summarizes that veterinarians were stricter (identifying more non-compliance) during the evaluation of predisposing factors than farm managers for all factors – farming environment, management, housing, production technical parameters, lung health status and other diseases – except for slaughterhouse checks. Farm managers identified and evaluated only 62% of existing non-compliant general conditions compared to veterinarians. Regarding disease, 81% of farm managers' results coincided with veterinarians' but farm managers failed to recognize clinical signs of atrophic rhinitis.

Figure 9: The importance of general risk factors for PRDC according to veterinarians and farm managers

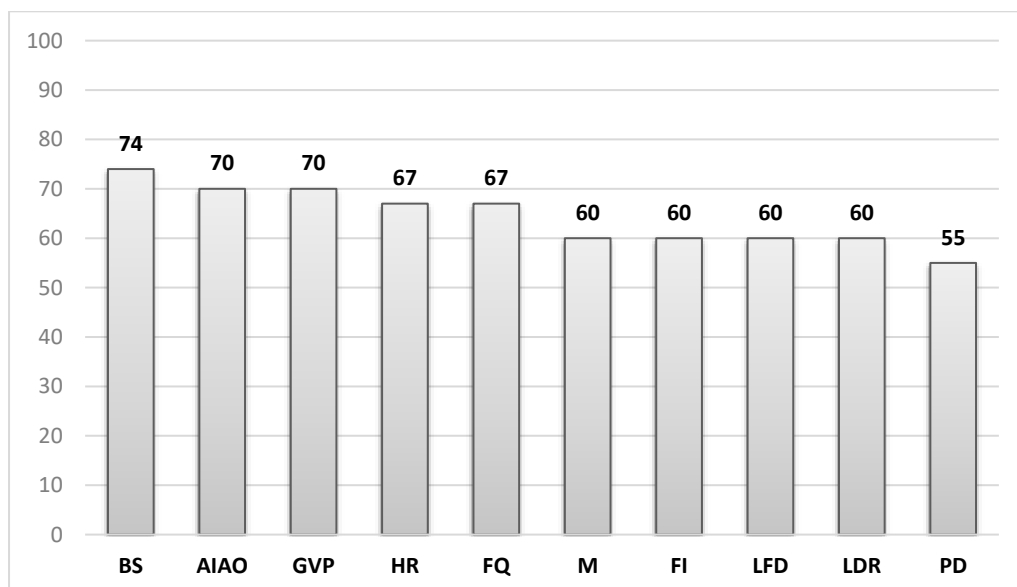


Note: FE - farming environment; M – management; H – housing; PTP - production technical parameters; LHS - lung health status; OD - other diseases; SHC - slaughterhouse check

Veterinarians considered farming environment, management, housing, production technical parameters, lung health status and other diseases to be the most important PRDC risk factors, although we would have expected farm managers to evaluate general factors more strictly. Their opinions were more similar regarding the importance of PRDC pathogens, although farm managers did not identify atrophic rhinitis at all. Based on these results we can conclude that farm managers in Central-Europe should perform external audits of their farms more frequently to avoid becoming “blind” to problems and to gain better understanding of the predisposing factors and the multifactorial nature of PRDC. Results also point out that both farm managers and veterinarians need regular trainings in internal biosecurity (animal hygiene) and management. Farm managers should receive in-depth training regarding disease symptoms and it would be beneficial to implement a training and coaching system based on regular farm assessments prevent production losses arising from “operational blindness”. The evaluation method used in this thesis could be a good tool for such audits.

The 101 respondents considered the 10 management factors shown in **Figure 10** to be the most important when **establishing a new farm** (results presented as a percentage of respondents).

Figure 3: The 10 most important PRDC management factors to consider when establishing a new farm (%)

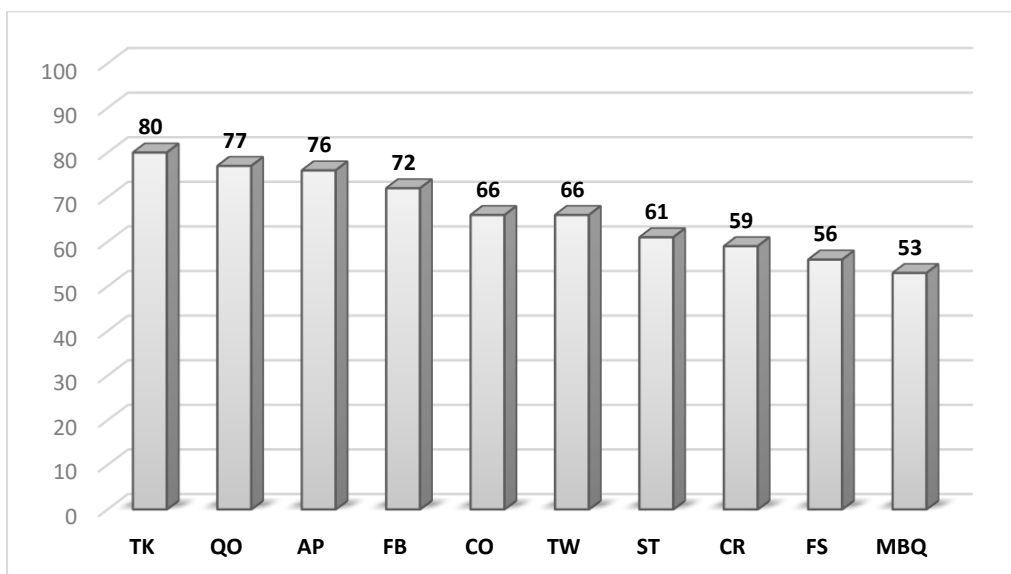


Note: Biosecurity, BS; All-In-All-Out, AIAO; Good Vet Practice, GVP; Human Resources, HR; Feed Quality, FQ; Management, M; Farm Isolation, FI; Low Farm Density, LFD; Low Disposal Rate, LDR and Population Density, PD.

Biosecurity, AIAO, Good Veterinary Practice, human resources, low farm density, feed quality and management were named in the survey. Feed safety (mycotoxins), internal biosecurity (animal hygiene) and owners' attitude were also identified by respondents as being critical management factors. Only low disposal rate (culling and mortality) had been chosen from the group of production parameters, FCR, ADG, output and data management were not considered to be that important. Our survey revealed that farm management is not efficient, which means that unsolved problems arising persistently from daily operations (not adequate AIAO, biosecurity, internal biosecurity, and feed safety – mycotoxins) have the most damaging effect on the PRDC situation in pig farms in Central-Europe.

Figure 11 displays the **10** leadership competencies respondents considered to be the **most important (a)** in Central-European pig farms according to respondents.

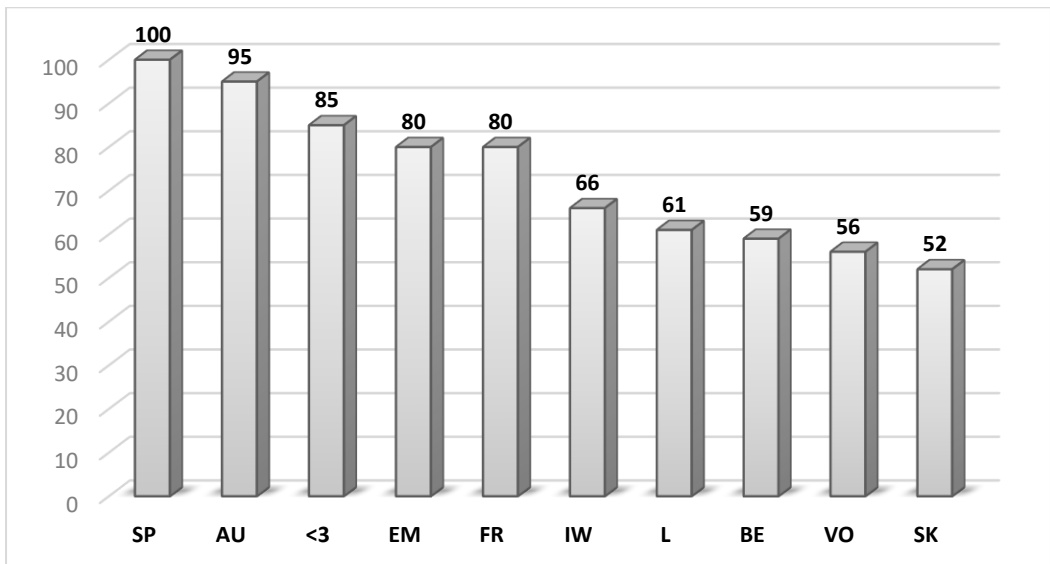
Figure 41: The 10 most important leadership competencies of pig farm managers (shown as a % of answers)



Note: Technical knowledge, TK; Quality orientation, QO; Accuracy, punctuality, AP; Feed-back, FB; Cooperation, CO; Teamwork, TW; Strategic thinking, ST; Creativity, CR; Financial security, FS and – mind and body qualities, MBQ.

Figure 12 demonstrates the **10 least important (b)** leadership competencies in Central-European pig farms according to respondents. Based on the results we can conclude that managers generally avoid changes and competition, strive to achieve stability and are not willing to take risks. This might be the reason why pig farms are slow to react to changes, whether in the field of nutrition (mycotoxins), genetics (genetic improvement or improvement in production provided by new hybrids), technology (new trends in reproduction), daily operations (changes in cross fostering methods) or biosecurity (PRRS eradication). Since pig farms operate under continuously changing conditions, our investigation underlines the importance of appropriate training regarding management for both farm managers and veterinarians.

Figure 5: The 10 least important leadership competencies of pig farm managers (shown as a % of answers)



Note: Spirituality, SP; Autonomy, AU; Love, <3; Empathy, EM; Friendship, FR; Individual work, IW; Loyalty, L; Belief, BE; Value orientation, VO and Self-knowledge, SK.

4 New and novel scientific results

- 1) I presented the type and proportion of genetics used in Hungarian farms, farrowing systems, farming environment, biosecurity measures and level of employee working standards. The majority, 65% of farms use hybrids of international breeding companies (Topigs, Danbred Hypor), while some use Hungarian genetics (FSE and mangalica). Generally (90%) production is either continuous or organized in 1-week batches. Location and external/internal biosecurity of the farms are the most vulnerable points of the sector. The weakest point being the lack of quarantine measures: 3 out of 4 farms do not have appropriate quarantine conditions for incoming animals. Staff are not appropriate for competitive pork production – neither in numbers, in education levels or working standards – except for staff working in the farrowing units. Only 20% of staff comply with working standards in the everyday tasks.
- 2) I evaluated housing and management of pigs as well as production parameters and concluded that lack of AIAO procedures, inappropriate stocking density, handling of sick animals in a way that does not prevent the spread of infections are the major cause of economic losses beside environmental factors (ventilation, heating, cooling). On many farms the feeder and drinker systems are not capable of providing enough feed and water for the animals to reach their full genetic potential, resulting in a loss of profit. 80% of the surveyed farms do not have adequate heating, cooling and ventilation systems to provide appropriate environmental conditions all year round. 92% of current systems cannot provide appropriate environmental conditions. On farms affected by porcine respiratory disease complex (PRDC) suboptimal use of capacity, low daily gains, high feed conversion rates and significant disposal rates result in economic losses.
- 3) While studying lung health status as well as the clinical, pathological and slaughterhouse manifestations of PRDC and the occurrence of other concurrent diseases relevant to PRDC in Hungary, I concluded that recording of clinical data and pathological findings is incomplete and not systematic on many farms. Most clinical signs raise suspicions of a disease, confirm the presence of the pathogens and manifestations commonly correlate with losses caused by the pathogens. The main PRDC pathogens on Hungarian farms are PCV2, *Mycoplasma hyopneumoniae* and *Actinobacillus pleuropneumoniae*. *Escherichia coli* and *Streptococcus suis* are common non-respiratory diseases with relevance to PRDC, their control also requires intensive management strategies. Infectious respiratory disease outbreaks occur regularly – multiple times per year – in 30% of the surveyed farms. Coughing, conjunctivitis and wasting the

most characteristic clinical signs. I found out that farms vaccinate most against PCV2 and *Mycoplasma hyopneumoniae*, while *Haemophilus parasuis* and swine influenza virus tend to be the least important pathogens in vaccination programs. PRRS eradication is the biggest challenge for affected farms. Cost-benefit analyses revealed that B/C ratio for various types of vaccination programs against PRDC pathogens ranged between 3.08 and 10.65.

- 4) I surveyed the opinion of decision makers (farm managers and veterinarians) on the importance of PRDC pathogens and risk factors; and which management factors they consider to be important when establishing a new farm or continuing operations on an existing farm. My investigations revealed that farm managers tend to be less good in recognizing and evaluating predisposing factors of PRDC. I concluded that farm managers' do not have adequate knowledge regarding the symptoms of respiratory disease and this results in a lack of implementing appropriate measures. Result showed that almost 3 out of 4 respondents considered appropriate biosecurity to be the most important management factor when building a new farm, while currently lack of AIAO and appropriate staff are the most important problems on their existing farms. I found that inadequate stocking density and biosecurity are the most important factors hindering development on existing farms. This study point out that systematic audits/benchmarking should be implemented to avoid operational blindness of farm managers.
- 5) I specifically included the gender, age and level of education for farm managers and demonstrated which leadership competencies and attitudes are considered to be important by pig farm managers. I observed that decision makers in Hungarian pig production are men, older than 40 years of age among who many (20%) have no vocational training and the ratio of managers with a university degree is very low. My investigations demonstrated that technical knowledge and quality orientation are the most important competencies for farm managers, while value orientation and self-knowledge are not considered to be important at all in Hungary.

5 Conclusions and recommendations

PRDC represents a major challenge for both veterinarians and producers because it is a multifactorial disease and management issues play an important role in its pathogenesis. This implies that an appropriate vaccination program is only one component in preventing severe clinical signs of respiratory disease, it is recommended to observe the following management rules also:

- implementation of strict biosecurity measures, use at least 60 days of quarantine, limit entry of visitors;
- „all-in/all-out” strategy within a room, thorough cleaning and disinfection between batches, at least 3 days downtime;
- implementing internal biosecurity measures (separate equipment and personnel for each age group, disinfectant at the door of each room and building);
- avoid mixing animals that were born more than 1 week apart, avoid overcrowding and unnecessary movement of animals, isolate sick animals in a separate room and handle them separately;
- provide appropriate ambient temperature all year round, avoid high temperature fluctuations in the buildings (± 2 °C);
- provide appropriate ventilation all year round, strive for a relative humidity of 70%, keep ammonia levels below 50 ppm and carbon-dioxide levels below 1500 ppm;
- reduce the level of nematode infestation by regular deworming;
- monitor, survey the farm regularly to determine environmental, housing, management, production and respiratory health issues;
- monitor PRDC with regular serological testing and slaughterhouse checks.

The quality of animal health practices is a decisive factor determining the biosecurity of the farm, greatly influencing productivity and profitability. Since the relationship between management strategies in pig farms and animal health practices has been proven to be significant, the costs of PRDC control are proven to return manifold if the farm managers are committed to improve the animal health status of the farm.

In this thesis I described the animal health aspects PRDC management of pig production operations in detail, I analysed and evaluated farm management and available data with the help of a scoring system. In some farms management-related data are available (monitoring of critical factors influencing PRDC) but there are management errors and daily organization has shortcomings (farm surveys).

Our investigations revealed (study of critical PRDC factors) that farm managers fail to identify a number of management factors (mainly predisposing factors for PRDC such as environment, management, housing, production parameters, respiratory and other diseases) that lead to the manifestation or the aggravation of PRDC, while also failing at recognizing symptoms of specific diseases.

Results of our study show that veterinarians consider the following factors to be most important regarding PRDC management (in order of decreasing importance): other – non-respiratory – diseases on the farm, monitoring productivity with slaughterhouse checks, monitoring production parameters, continuous monitoring of lung health status and environment (including farm isolation, internal and external biosecurity, purchase of animals, separation of animals according to age and AIAO). Farm managers ranked the following 5 factors as most important (in order of decreasing importance): other – non-respiratory – diseases on the farm, monitoring production parameters, housing conditions (ventilation, heating, cooling, stocking density, isolation and treatment of sick animals and uniformity), continuous monitoring of lung health status and monitoring productivity with slaughterhouse checks. Both groups of respondents ranked other, non-respiratory diseases as the most important, and neither ranked good veterinary practices among the 5 most important factors. Veterinarians did not include housing (including isolation of sick animals), while farm managers did not include farming environment (AIAO and internal/external biosecurity).

Result demonstrated that respondents consider creative, quality team work based on technical knowledge to be the most important for pig farm managers. They also mentioned strategic thinking and striving for financial security. Meanwhile performance orientation, lifelong learning, innovation, risk taking and competitiveness did not make it into the list of the 10 most important competencies. Surprisingly self-knowledge, value orientation and loyalty were ranked to be among the 10 least important competencies. Based on the results we can conclude that managers generally avoid changes and competition, strive for stability and do not take risks. This might be the reason why pig farms are slow to react to changes in nutrition, genetics, technology, daily operations or biosecurity. Since pig farms operate under continuously changing conditions, it has to be stated that either managers lack such knowledge or they are not making use of their knowledge.

Our results indicate that both farm managers and veterinarians need regular trainings in the fields of internal biosecurity (animal hygiene) and management. It is also obvious that farm managers should receive in-depth training regarding disease symptoms and a training and coaching system based on regular farm assessments is needed to prevent production losses.

Our surveys revealed that farm management is not efficient, which means that unsolved problems arising persistently from daily operations (not adequate AIAO, internal biosecurity, feed safety) have the most damaging effect on the PRDC situation in pig farms in Central-Europe. As pig farms operate in a continuously changing environment, our results point out that it would be important for both farm managers and veterinarians to receive education regarding change management also.

6 Author's publications relevant to this thesis

I. Scientific journals (foreign language publications)

1. **BÚZA, L., ÓZSVÁRI, L.** (2019): Comparative study on risk and critical management factors for PRDC from the Central-European vets' and farm managers'. *SEA - Practical application of Science*, 7. (21) 221-227.
2. **BÚZA, L., ÓZSVÁRI, L.** (2019): The job characteristics Leaders need on Central-European Livestock Farms with special regard to management skills. *Journal of Central-European Green Innovation*, 7. (2) 33-44. DOI: 10.33038/JCEGI.2018.6.4.13

II. Oral presentation at a scientific conference published in proceedings (foreign language)

1. **BÚZA L., MAKKAI I., MÁTÉ P., ÓZSVÁRI L.** (2019): Why did the farrowing rate decrease in a Hungarian sow farm? – a field study. 11th European Symposium of Porcine Health Management, 22-24 May 2019, Utrecht, The Netherlands, Abstract book, 348.
2. **TÓTH Cs., BÚZA L., ÓZSVÁRI L.** (2019): Installation of a digital biosecurity system on Hungarian swine farms. 11th European Symposium of Porcine Health Management, 22-24 May 2019, Utrecht, The Netherlands, Abstract book, 243.
3. **SIPOS R., BÚZA L., ÓZSVÁRI L.** (2019): Survey on major production parameters, PRDC status and vaccination protocols on pig fattening farms. 11th European Symposium of Porcine Health Management, 22-24 May 2019, Utrecht, The Netherlands, Abstract book, 246.
4. **MÁTÉ P., MAKKAI I., BÚZA L., ÓZSVÁRI L.** (2019): Microclimatic measurements as a tool for PRDC management – a field study. 11th European Symposium of Porcine Health Management, 22-24 May 2019, Utrecht, The Netherlands, Abstract book, 242.
5. **MÁTÉ P., MAKKAI I., BÚZA L., ÓZSVÁRI L.** (2019): Transabdominal ultrasound examination of the ovaries of culled sows to detect the reason of the culling – a field study. 11th European Symposium of Porcine Health Management, 22-24 May 2019, Utrecht, The Netherlands, Abstract book, 349.
6. **MAKKAI I., MÁTÉ P., BÚZA L., ÓZSVÁRI L.** (2019): Transabdominal ultrasound examination of sows to improve the reproduction – a field study. 11th European Symposium of Porcine Health Management, 22-24 May 2019, Utrecht, The Netherlands, Abstract book, 47 & 86.

7. HUDÁK L., **BÚZA L.**, ÓZSVÁRI L. (2019): Environmental conditions on Hungarian pig farms. 11th European Symposium of Porcine Health Management, 22-24 May 2019, Utrecht, The Netherlands, Abstract book, 244.
8. **BÚZA L.**, ÓZSVÁRI L. (2016): The job characteristics leaders need on Central-European swine farms with special regard to management skills. 8th European Symposium of Porcine Health Management and 24th International Pig Veterinary Congress. Dublin, Ireland, 7-10 June, 2016. Proceedings, pp. 308.
9. **BÚZA L.**, ÓZSVÁRI L. (2016): Critical success factors of PRDC management in Central-Europe. 8th European Symposium of Porcine Health Management and 24th International Pig Veterinary Congress. Dublin, Ireland, 7-10 June, 2016. Proceedings, pp. 303.
10. **BÚZA L.**, ÓZSVÁRI L. (2016): Comparative study on risk factors and management of PRDC from the Central European vets' and farm managers' point of view. 8th European Symposium of Porcine Health Management and 24th International Pig Veterinary Congress. Dublin, Ireland, 7-10 June, 2016. Proceedings, pp. 315.
11. ÓZSVÁRI L., **BÚZA L.** (2015): The risk factors, prevalence and prophylaxis of BRDC in Hungarian large-scale cattle herds. European Buiatrics Forum 2015, Rome, Italy, 14-16. October, 2015. Proceedings, pp. 203.
12. ÓZSVÁRI L., **BÚZA L.** (2015): Prevalence and Severity of and Vaccination against PRDC in Hungarian Swine herds between 2011 and 2014. 7th International Symposium on Emerging and Re-emerging Pig Diseases 2015, Kyoto, Japan, 21-24. June, 2015. Proceedings, pp. 247.
13. **BÚZA L.**, ÓZSVÁRI L. (2015): Change in Monthly Slaughterhouse Lung-scoring due to Mycoplasma hyopneumoniae Outbreak and Subsequent Vaccination in a Swine Herd Between 2012 and 2014. 7th International Symposium on Emerging and Re-emerging Pig Diseases 2015, Kyoto, Japan, 21-24. June, 2015. Proceedings, p. 248.
14. ÓZSVÁRI L., **BÚZA L.** (2015): The change in the production parameters in swine herds vaccinating against PRDC between 2011-2014. 7th European Symposium of Porcine Health Management. Nantes, France, 22-24 April, 2015. Proceedings, pp. 205.
15. SÜTH M., **BÚZA L.** (2010): Budapest Charta on the sustainable food chain. World Meat Hygiene and Inspection Congress 2010, Budapest, 17-21 August, 2010. Proceedings, pp. I-IV.
16. **BÚZA L.** (2010): Trichinellosis. World Meat Hygiene and Inspection Congress 2010, Budapest, 17-21 August, 2010. Proceedings, pp. 76.

III. Research Report (foreign language)

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IV. Scholarly book, book chapter (foreign language)

1. **BÚZA L.** editor (2010): Proceedings of the 1st Sustainable Food Chain World Summit and its central event the 10th jubilee World Meat Hygiene and Meat Inspection Congress: Budapest, 17-22 August 2010.; [publ. ... European Food Chain Parliament] (2010) Budapest.

V. Academic book, book chapter (foreign language)

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VI. Other Journals (foreign language)

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VII. Scientific journals (article published in Hungarian)

1. **BÚZA L., VÁGÓ, L., ÓZSVÁRI, L.** (2017): The production impact of alteration of fostering as element of PRRS eradication program - Case study (in Hungarian with English abstract: A dajkásítási eljárások módosításának — mint a PRRS mentesítés egyik elemének — termelési tapasztalatai. Esettanulmány.) Magy. Állatorv. Lapja, 139. 525-535. **IF: 0.185**
2. **BÚZA L., POGÁCSÁS, I., ÓZSVÁRI L.** (2017): Production impact of 3 weeks batch management as an element of the PRRS eradication program. Case study (in Hungarian with English abstract: A 3 hetes csoportos fiasztatási rendszernek – mint a PRRS mentesítés egyik elemének – termelési tapasztalatai. Esettanulmány.) Magy. Állatorv. Lapja, 139. 643-653. **IF: 0.185**
3. **SÁRKÖZI R., BÚZA L., MAKRAI L., FODOR L.** (2016): Experiences of respiratory disease caused by *Actinobacillus pleuropneumoniae* serotype 16 in a Hungarian swine herd (in Hungarian with English abstract: Az *Actinobacillus pleuropneumoniae* 16-os szerotípusa által okozott légzőszervi megbetegedés tapasztalatai egy sertéstelepen.) Magy. Állatorv. Lapja, 138. 713-720. **IF: 0.185**
4. **ÓZSVÁRI L. – BÚZA L.** (2015): Comparative study on technology level, major production parameters and management of porcine respiratory disease complex (PRDC) in fattening pig herds (in Hungarian with English abstract: Sertéshizlaló telepek technológiai színvonalának, főbb termelési mutatóinak és légzőszervi tünetegyüttese (PRDC) menedzsmentjének összehasonlító vizsgálata.) Magyar Állatorvosok Lapja, 137. (2) 79-92. **IF: 0.185**

VIII. Oral presentation at a scientific conference published in proceedings (Hungarian)

1. **BÚZA, L., GRÓF, I.** (2015): AMEN – úgy legyen: a haszonállat üzletág holisztikus ügyfél együttműködési rendszere. Minőség-innováció 2015. Európai Minőségügyi Szervezet Magyar Nemzeti Bizottság (EOQ MNB), Budapest kiadványa. <http://www.eoq.hu/mm/mm161b.pdf> (eCollection: 2018.08.19.)

II. Research Report (Hungarian)

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III. Scholarly book, book chapter (Hungarian)

1. **AMBRUS, Á.** szerk. (2010): Élelmiszerbiztonság megítélési módszerei I. - IV. rész 2. fejezet: **ORBÁN, P., KŐRÖSI, G., BÚZA, L.:** Húsok trichinella vizsgálata. Edison House Holding Zrt. Budapest 1047-1075. p. ISBN 978-963-88947-0-0
2. **BABINSZKY, L.** szerk. (2019): Innovatív Takarmányozás - 32. fejezet: **BÚZA, L.:** A takarmányozás jogi és etikai szabályozása. Akadémia Kiadó, Budapest

IV. Academic book, book chapter (Hungarian)

1. **BÚZA, L.** szerk. (2014): ResPig telepi PRDC – sertések légzőszervi betegség komplexe - audit kézikönyv. - Intervet Hungária Kft., kiadványa, Budapest. www.respig.hu
2. **BÚZA, L.** (2009): Az Élelmiszerlánc terrorizmus elleni küzdelme, az Élelmiszerlánc, mint Kritikus Infrastruktúra. Mezőgazdasági Szakigazgatási Hivatal Központ Élelmiszer- és Takarmánybiztonsági Igazgatóság önálló kiadványa Budapest. <http://docplayer.hu/1763351-Az-elelmiszerlanc-terrorizmus-elleni-kuzdelme-a-fogyasztok-vedelmeben.html> (eCollection: 2018.08.19.)
3. **BÚZA, L.** szerk. (2008): Mikotoxinok előfordulása a takarmányokban. Mezőgazdasági Szakigazgatási Hivatal Központ Élelmiszer- és Takarmánybiztonsági Igazgatóság önálló kiadványa, Budapest.
4. **BÚZA, L.** szerk. (2008): A húsban előforduló trichinella hatósági vizsgálata és összefüggései. I. rész: **KŐRÖSI, G., BÚZA, L., ORBÁN, P.:** Házasított patás állatok, lött-és tenyésztett vadak húsának hatósági állatorvos által végzett vizsgálatához szükséges különleges vizsgálati eljárások a napi húsvizsgálati gyakorlatban. MgSzH Központ - MÉBiH közös önálló kiadványa, Miskolc, 2008. február 11-14.
5. **BÚZA, L.** szerk. (2008): A húsban előforduló trichinella hatósági vizsgálata és összefüggései. II. rész: **ORBÁN, P., KŐRÖSI, G., BÚZA, L.:** A húsban előforduló trichinella hatósági vizsgálatára

vonatkozó különleges vizsgálati eljárások - Magyarország Trichinella készenléti terve. MgSzH Központ - MÉBiH közös önálló kiadványa, Miskolc, 2008. február 11-14.

6. **BÚZA, L.** szerk. (2008): A húsban előforduló trichinella hatósági vizsgálata és összefüggései. III. rész: BÚZA, L., ORBÁN, P., KÖRÖSI, G.: Zoonózisok, parazitozoonózisok. MgSzH Központ - MÉBiH közös önálló kiadványa, Miskolc, 2008. február 11-14.

V. Other Journals (Hungarian)

1. ÓZSVÁRI L., BÚZA L. (2015): Sertés hizláló telepek menedzsment és technológiai színvonalának, valamint főbb termelési mutatóinak a légzőszervi betegségek (PRDC) kockázata szempontjából történő összehasonlító vizsgálata. 2011 és 2014 között. A Sertés 20. (2) 28-35. pp.
2. KUNSÁGI, Z., SITKEI, A., ÁCSNÉ KOVACSICS, L., BÚZA, L. (2009): Az aflatoxinok kimutatásához alkalmazott származékképzési módszerek. MTA Állatorvos-Tudományi Bizottsága és a Szent István Egyetem Állatorvos-Tudományi Doktori Iskola, Akadémiai Beszámolók 2009. évi 36. füzet
3. TÖLGYESI, Á., ÁCSNÉ KOVACSICS, L., BÚZA, L. (2009): Antibiotikum szermaradványok megerősítő mérése. MTA Állatorvos-Tudományi Bizottsága és a Szent István Egyetem Állatorvos-Tudományi Doktori Iskola, Akadémiai Beszámolók 2009. évi 36. füzet
4. ÁCSNÉ KOVACSICS, L., TÖLGYESI, Á., BÚZA, L. (2009): Antibiotikum szermaradványok megerősítő mérése. Hungalimentaria, Budapest. <http://hungalimentaria.hu/Default.aspx?tabid=202> (eCollection: 2018.08.19.)
5. FODOR, P., HALMÁGYI, T., BÚZA, L., BÁNÁTI, D., JÓZWIAK, Á., SZIGETI, T. (2009): A laboratóriumi eredmény-szolgáltatással kapcsolatos bizonytalanság statisztikai jellemzőinek értelmezése a döntéshozói gyakorlatban. Hungalimentaria, Budapest. <http://hungalimentaria.hu/Default.aspx?tabid=127> (eCollection: 2018.08.19.)
6. BÚZA, L., MARTHNÉ SCHILL, J., MURÁNSZKY, G., KERESZTÚRI, J. (2009): Melamin az élelmiszerláncban. Hungalimentaria, Budapest. <http://hungalimentaria.hu/Default.aspx?tabid=230> (eCollection: 2018.08.19.)
7. BÚZA, L., MARTHNÉ SCHILL, J., MURÁNSZKY, G., KERESZTÚRI, J. (2009): Melamin és a „fehérje hamisítás” összefüggései. MTA Állatorvos-Tudományi Bizottsága és a Szent

- István Egyetem Állatorvos-Tudományi Doktori Iskola, Akadémiai Beszámolók 2009. évi 36. füzet
8. **KUNSÁGI, Z., SITKEI, A., ÁCSNÉ KOVACSICS, L., BÚZA, L.** (2009): Az aflatoxinok kimutatásához alkalmazott származékképzési módszerek. *Hungalimentaria*, Budapest. <http://hungalimentaria.hu/Default.aspx?tabid=240> (eCollection: 2018.08.19.)
 9. **BÚZA, L., ÁCSNÉ KOVACSICS, L., SCHILL, J., JÓZWIAK, Á., LOVÁSZ, CS., DOMÁNY, G., KERESZTÚRI, J., MURÁNSZKY, G.** (2008): Guar-gumi PCP és dioxin szennyezettség összefüggéseinek analitikai nyomonkövetése. MTA Állatorvos-Tudományi Bizottsága és a Szent István Egyetem Állatorvos-Tudományi Doktori Iskola, Akadémiai Beszámolók 2008. évi 35. füzet
 10. **ÁCSNÉ KOVACSICS, L., DOMÁNY, G., BÚZA, L.** (2008): Guar-gumi dioxin szennyezettségének vizsgálati aspektusa. MTA Állatorvos-Tudományi Bizottsága és a Szent István Egyetem Állatorvos-Tudományi Doktori Iskola, Akadémiai Beszámolók 2008. évi 35. füzet
 11. **ÁCSNÉ KOVACSICS, L., KUNSÁGI, Z., BÚZA, L.** (2008): Deoxynivalenol (DON) ELISA és HPLC/DAD módszer összehasonlítása. MTA Állatorvos-Tudományi Bizottsága és a Szent István Egyetem Állatorvos-Tudományi Doktori Iskola, Akadémiai Beszámolók 2008. évi 35. füzet
 12. **BÚZA, L., JOZWIAK, Á.** (2008): A Trichinellózisról I. MTA Állatorvos-Tudományi Bizottsága és a Szent István Egyetem Állatorvos-Tudományi Doktori Iskola, Akadémiai Beszámolók 2008. évi 35. füzet
 13. **BÚZA, L., GYETVAI, B., ÁCSNÉ KOVACSICS, L., SCHILL, J., HOLLÓ-SZABÓ, P., ORAVECZ, M., RADÁCSY, K., SCHNUR, P., ZOLTAI, A., CZEGLÉDI, B., NAGY, A., JÓZWIAK, Á.** (2008): Válságkezelés és bioterrorizmus - tennivalók a guar-gumi ügy tapasztalatai alapján. MTA Állatorvos-Tudományi Bizottsága és a Szent István Egyetem Állatorvos-Tudományi Doktori Iskola, Akadémiai Beszámolók 2008. évi 35. füzet
 14. **BÚZA, L., MARTHNÉ SCHILL, J.** (2007): A takarmányok előállításának, forgalmazásának és felhasználásnak ellenőrzései az élelmiszerláncban. MTA Állatorvos-Tudományi Bizottsága és a Szent István Egyetem Állatorvos-Tudományi Doktori Iskola, Akadémiai Beszámolók 2007. évi 34. füzet
 15. **BÚZA, L., ÉVA, G., JÁNOSI, SZ., JOZWIAK, Á., KÖRÖSI, G., MAJOROS, T., NAGY, B., ORBÁN, P., PÁLFALVI, A., VASS, P.** (2007): *Mycobacterium bovis* lehetséges szerepe az élelmiszerláncban,

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16. ÁCSNÉ KOVACSICS, L., **BÚZA, L.**, DOMÁNY, G. (2007): Guar-gumi dioxin szennyezettségének néhány vizsgálati aspektusa. Hungalimentaria, Budapest.
<http://www.hungalimentaria.hu/Default.aspx?tabid=255> (eCollection: 2018.08.19.)