AI/ML in poultry, cattle and pig farming in post-communist Central Eastern European and South Caucasus (CEE/SC) countries

Andrzej Jarynowski
Wroclaw Medical University
Interdisciplinary Research Institute, Wrocław
E-mail address: ajarynowski@gmail.com
ORCID: https://orcid.org/0000-0003-0949-6674

Abstract: Central and Eastern European (CEE) and Southern Caucasus (SC) farms have a big potential in current times of change adopting AI-driven systems for livestock management, particularly in dairy, chickens and pigs. The democratization of AI through affordable devices (like CCTV and smartphones) presents potential for cost-effective revolution in livestock management. However, challenges persist in scaling AI-driven Precision Livestock Farming solutions, including conflict with BigTech/BigArgi holdings and balancing productivity with animal welfare. Despite few successful case studies in the region, careful management is required to address animal welfare, ethical, communication, and legal issues. Thus, I emphasise the importance of integrating AI education into veterinary curricula.

Introduction

An increasing number of farms in CEE/SC have recently implemented an advanced AI (artificial intelligence)-driven system to monitor and manage their animal health and farming operations. We include countries in the eastern part of Europe[1], which were part of the Eastern Bloc with a similar historical disconnection from global veterinary science and the same structural pattern (Jarynowski et al., 2021). The war in Ukraine, Armenia and tensions in Serbia in recent years caused the best specialists in electronics and programming to be incorporated in the military industry. Author's colleagues who were electronicians making animal sensors moved to the military sector because of the full scale war in 2022. Author himself also was mobilised to serve in the biodefense military corpus among many other MDs and DVMs. However, when the peace will come back hopefully these people will

[1] Albania, Armenia, Bosnia and Herzegovina, Bulgaria, Czech Republic, Estonia, Croatia, Georgia, Hungary, Lithuania, Latvia, Moldova, Montenegro, Poland, Romania, Slovenia, Slovakia, Republic of North Macedonia, Republic of Serbia, and Ukraine (without The Union State of Russia and Belarus which are under sanction since 2022)

return to agriculture with new skills (also with experience with use of American, Israeli high tech among others).

These systems incorporate computer vision, machine learning and deep learning techniques to optimise various aspects of production, including disease detection, environmental management and growth prediction.

Case Description - weakness and opportunities of AI driven PLF system in CEE/SC

CEE/SC countries can be involved in projects funded by EU mechanisms and are very under-represented. For example, less than 10% of the projects included in ICT (Information and Communication Technology) in AgriFood (https://ictagrifood.eu) are led by institutions from the CEE/SC region. The disproportion of R&D spending is even higher in the private sector, as most R&D centres operate from Western Europe (i.e. because the headquarters of large agribusinesses are located there (Milanovic, 2016)).

While most of the innovations in the so-called 4th industrial revolution (Ćwiklicki et al., 2022) in animal husbandry took place in the block of 1) North America-Australia/NZ-South Africa, 2) Western Europe, 3) China, new technologies open some new perspectives for CEE/SC countries (Milanovic, 2016). Most of the AI-driven PLF (precision livestock farming), developed for scientific purposes in highly research-intensive countries, may not be scalable in CEE/SC conditions. Instead, we propose to use resources and skills as they exist, and to use advances in technology and data, which moreover already exist, to optimise the system. Moreover, the similarity of the region allows novel solutions to be developed and implemented based on their social and cultural experiences, to the benefit of all.

While high-income countries with more intensive research have invested in and tested animal sensors and analogue technologies over the last five decades, progress in robotics, diagnostics and logistics is much more advanced, and competition in these areas is very high (Ćwiklicki et al., 2022). However, the proliferation of cheap dual-use devices such as CCTV and smartphones is democratising the system. Ear or other tags (Sibanda et al., 2022) that allow data transmission and actively collect information can cost 3-5 EUR, a negligible cost compared to feed in most situations. Cheap AI systems could continuously analyse video feeds and smartphone sensor data to detect signs of disease and predict growth rates, and automatically adjust environmental conditions, with almost no cost to farmers or veterinary authorities.

Practical definition of AI in veterinary medicine

Advances in computing power and modelling techniques, together with the amount of data obtained (Jarynowski, 2023) from i) disease surveillance ii) registries iii) digital traces, enable i) machine learning ii) complex system analytics iii) standard statistical tools iv) as well as computer simulation to be applied to the field of Veterinary Medicine (i.e.

Epidemiology). In the context of PLF, AI refers to the application of advanced computational techniques such as computer vision (Fernandes et al., 2020), rule-based algorithms, statistical modeling/simulation and deep learning to improve the management and monitoring of farm operations. The most important aspect of modern AI systems is the amplification of machine learning (ML) techniques (Appleby & Basran, 2022), which allows models to be trained and retrained on their own data, allowing the system to 'learn' the specifics of a given farm or region. AI systems in PLF analyse vast amounts of data from sensors, cameras and other IoT (Internet of Things) to optimise key aspects of animal production, including disease detection, environmental control and growth prediction. AI systems in veterinary medicine rely heavily on herd medical records, which need to be primarily digitised, so a simple ICT system needs to be in place on the farm. Large Language Models (LLMs) are very promising tools for optimising farm operations. LLM is a type of artificial intelligence trained on vast amounts of text data to understand and generate human-like language in response to a wide range of prompts and questions (Jarynowski, Krzowski, Maksymowicz, & Romanowska, 2024). These technologies allow farmers to make data-driven decisions that improve efficiency, animal welfare (AW) and productivity, often with reduced costs and minimal human intervention (Fang et al., 2021; Ribeiro et al., 2019). In this paper, AI for AW is mainly analysed from health, economic and ethical perspectives (De Briyne et al., 2020).

Global scene for AI in biomedical science and practice

The author's experience of attending trade fairs such as Horticultural Expo 2023, Expo 2022 and ArabHealth Dubai, Digital Heath Euro (2022, 2024), VetConress 2022, Polagra 2021, EuroMedica 2021 showed that more and more attention is being paid to the implementation of AI solutions, rather than just showing how great AI is (Jarynowski, Maksymowicz, et al., 2023; Jarynowski, 2024a)). Knowledge and progress in the efficient detection, monitoring and treatment of common diseases is still quite limited, and further advances in methods and approaches are needed. However, there is considerable interest in using AI to detect and treat rare diseases and conditions (e.g. to detect spillover or emerging pathogens). In Europe, many ideas revolve around apps and software solutions, while the actual technology development is mainly taking place in the US and China. The digitisation process and the implementation of these solutions in practice is progressing slowly, with faster adaptation in administrative areas rather than in clinical veterinary medicine (much more organisation of the vet's work in the field rather than solutions that can be applied). The cost effectiveness of these new solutions remains uncertain (there are many papers on AI drive projects in laboratory or small scale conditions, but we see very little in practice). While research papers are important, validation in the real world is crucial. Europe (including Western Europe) is lagging significantly behind not only North America and Australia, but also China. This is an extremely important notice, because CEE is an even worse situation with the most resources in high tech PLF solutions going into old EU countries, and less privileged regions mainly get money for consumption or non priority business such as ecological farming.

Case Studies of already implemented projects in the region

In the last decades the CEE/SC region was not progressing as fast as Western Europe in e-solutions, however in recent few years a speed up in AI solution in biomedicine is observed (Jarynowski, Maksymowicz, et al., 2023). Few CEE/SC start-ups are successful case studies[2]:

- Muumap (active in Serbia, Romania, Czech Republic, Poland) is a transport management system for real-time optimisation of the cold supply chain for raw milk (from collection from the farmer to delivery to the dairy station). Inexpensive sensors not only control the temperature (legal requirement in the EU), connect farmers with delivery drivers, but also plan the multi-destination route (a well-known problem in logistics) with GPS transponders (https://muumap.com/en/muumap).
- Embriovet/EMBRYOGEN (operating in Poland, Lithuania, Latvia) uses ML model to classify pigs/cattle semen of the best quality. This type of automation of biochemical biomarker scores is combined with computer vision to calculate sperm activity (https://embryogen.org).
- AgHiTech (operating in Poland, Hungary, Estonia) produces indoor sensors (air quality, temperature, humidity) and makes sense for productivity of broilers/laying hens or pigs (https://livestocksense.eu/aghitech/).
- Aidmed (active in Poland, Slovakia and Croatia) produces animal sensors and uses the data to try to predict health conditions such as colic in horses or rumination and respiratory problems and lameness in cattle (https://www.aidmed.ai).
- Vetapp (operating in Poland and Estonia) has used LLM-trained models to triage animal health problems by lay people (animal owners, farmers) in preparation for a remote or physical veterinary consultation (https://vetapp.app/en/vet).

The CEE/SC region is focused on milk production for internal consumption for cultural and historical reasons, so dairy production should be a priority for digitalisation (Lardy et al., 2023). The secondary sectors of pigs (Edwards, 2021) and laying hens/broilers (Gržinić et al., 2023) may need technological modernisation. As the major inhibitors of pig and poultry production in the regions are infectious diseases, mainly ASF (Jarynowski, Czekaj, Semenov, & Belik, 2024) and HPAI (Jarynowski, Romanowska, Maksymowicz, et al., 2024), AI support systems for biosecurity management are highly valued. However, to the author's knowledge, all attempts such as the use of drones for predicting wild boar habitat (e.g. in the Czech Republic and Poland (Szczepaniak et al., 2023)) or apps for identifying wild boar carcasses (e.g. in Serbia) or smart fences (e.g. in Estonia) have failed.

Multidimensional analysis of AI livestock system in CEE/SC

While these systems can greatly improve production efficiency and reduce dependence on international corporations and Western technology, several concerns have arisen.

[2] This is a subjective list of solutions, that author had opportunity to learn and test himself

Animal Welfare

The ability of the AI system to detect early signs of disease through behavioural analysis and sound monitoring could lead to faster treatment or culling and reduced suffering. There is growing concern in EU Member States about the welfare of farm animals, including a proposal to phase out and eventually ban the use of cages in the EU. AI-based monitoring can provide some support in measuring AW in the interim period. Some parts of the AW assessment protocol (e.g. welfare quality scoring (Lardy et al., 2023)) can be automated. Automated environmental control based on AI algorithms can provide optimal conditions for the comfort and health of chickens (Bryden et al., 2021)/pigs (Oczak et al., 2023)/cows (Lavrova et al., 2023) by controlling lighting, ventilation or humidifiers.

There is a risk of reduced human supervision and potential neglect of aspects of welfare that can't be easily quantified by current AI systems (Neethirajan, 2017). Such a scenario has been observed in human medicine in low-resource settings, where disadvantaged patient populations (e.g. homeless people in India) are limited to using app symptom checkers with automated prescription systems. There's a risk of over-reliance on technology, potentially leading to reduced human observation and interaction with animals (Gawlik-Kobylińska, 2022). The system's focus on production efficiency may not fully take into account all aspects of AW, such as the ability to express natural behaviours (the priority of optimised function by developers from CEE/SC may be more focused on productivity than on welfare, in contrast to Western European solutions).

Ethics

The use of AI to maximise production efficiency raises questions about the balance between productivity and allowing animals to live more natural lives (Maksymowicz, 2024). On one hand, there is potential for AI to reduce overall animal suffering through improved health management However, there are ethical considerations regarding the extent to which technology should be used to control and manipulate the environment and behaviour of animals, the conflict of anthropometric and biocentric paradigms (Jarynowski, Maksymowicz, Meletis, & Kostoulas, 2024).

The lack of regulatory oversight in veterinary medicine (in contrast to human medicine where such concepts are discussed) is a cause for concern, potentially affecting the reliability and ethical standing of AI (Cohen & Gordon, 2022). The shift (Bushuyev et al., 2023) from the VUCA to the BANI model (COVID-19, wars in Europe and the Middle East, adaptation to climate change, disease X) of technological development in AI creates an opportunity for countries that do not have the headquarters of big companies (BigTech, BigPharma and Big Agroholdings). The economic and technological disparities between the extremely rich countries, medium speed trap countries such as CEE/SC) created these inequalities and have maintained them in the VUCA model (Maksymowicz, 2024). In the BANI model, however, these chains can be renegotiated. However, It's important not to rely only on global solutions from BigTech coming mainly from the USA (Zybertowicz & Piekutowski, 2022). Meta has

played a major role in the development of YOLO (the most popular algorithm for recognising animals and their movements) and its applications. Google has also made significant contributions via the Cloud Vision API: Google's offering of pre-trained systems. Also all big LLMs have been controlled from the USA (Gemini- Google, LLama- Meta, ChatGPT - Open.ai, Cualde - Anthropic).

Automated ML-trained systems may be more likely to administer antibiotics due to their growth-promoting side effects, which may induce AMR (antimicrobial resistance), a major public health concern (Jarynowski, Romanowska, et al., 2023; Maksymowicz, 2023). The introduction of AI systems could lead to the creation of well-paid jobs in the province for well-trained farmers, but could also lead to the displacement of small, less-trained traditional farms in the agricultural sector, raising ethical questions about the impact on rural communities. (Jarynowski, 2024b).

The artificial intelligence models underpinning chatbots could potentially assist in planning an attack with a biological weapon (Jarynowski, Krzowski, Maksymowicz, & Romanowska, 2024) against animals. The CEE/SC region is unstable due to geopolitical conditions (Bartosiak, 2019).

Communication

AI-enhanced systems are in line with the EU's Green Deal and Smarter Europe projects (Gailhofer et al., 2021). This fact can be used for marketing.

Clear communication protocols need to be established when the AI system detects potential health problems or anomalies (Romanowska, 2024b), especially in terms of veterinary public health. AI driven solutions come with uncertainty (Gailhofer et al., 2021). I.e. AI could detect import of ASF to disease-free regions. Until laboratory confirmation of the cases some procedures within Veterinary Authorities and Farmers must be prepared in advance. Transparency in communicating how AI is used in production practices to consumers and regulators is critical to maintaining trust (Romanowska, 2024a).

The development of proprietary AI systems may lead to conflicts (Milanovic, 2016) between large international companies offering such solutions (mainly based in Western Europe and North America) and new companies in the CEE/SC regions.

Interdisciplinary communication between AI developers, animal scientists and farmer’s workers is essential for continuous improvement of the system. There's a need for effective training programmes (mainly by increasing mathematical and statistical literacy in the population) to help farmers and vets interpret and act on the complex data generated by AI systems. The new generation of veterinary students in CEE/SC needs to take courses in Digital Veterinary Medicine (Meletis et al., 2024), and AI solutions should be integrated into other practical and theoretical courses. The author's experience in teaching such courses emphasises the need for practical sessions on the use of LLMs, such as ChatGPT, in the veterinary curriculum (Jarynowski, Romanowska, & Belik, 2024).

LLMs (Gradon, 2024) can be used by Western or Kremlin (Jarynowski, Krzowski, et al., 2023) organisations to polarise CEE/SC using bionegations or animal related issues (such as CO2 emission or human-like animal rights (Jarynowski et al., 2019)). It's very important to fight food (animal products) misinformation (Chowdhury et al., 2023) in the regions as it can be generated by generative language models (Jarynowski, Krzowski, Maksymowicz, & Romanowska, 2024).

Law

The use of AI in animal production raises questions about liability in the event of system failure or incorrect decisions made by the AI (Dudek et al., 2023). The software may experience a glitch or bug in its code thus generating or insufficient training data of algorithms (Lichosik et al., 2023). There may be a need for regulation of the use of AI in animal production (Cohen & Gordon, 2022) (as there is none at all, while in other areas of life many countries in the EU have introduced some internal legislation to protect consumers from harm, such as loss of privacy), particularly in relation to AI standards. Data privacy and security issues need to be addressed, especially with regard to the collection and storage of sensitive production data (Jarynowski, Romanowska, Maksymowicz, et al., 2024). However, it cannot stop data exchange. Intellectual property rights related to AI algorithms and ML models in agriculture need to be clarified. Especially in the context of domination of BigTech and BigAgri in terms of best layers or patent officers, they can hire against.

EU CEE/SC countries are in a stricter legal situation, as they are directly subject to EU legislation and must comply with any AI or AW legislation. Non-EU CEE/SC countries can still choose which part of the legislation is suitable for their farming system. Such a regulation should not stifle AI initiatives in agriculture. There is a risk that some overly strict measures could be imposed in the EU. This could create opportunities for non-EU CEE/SC countries to host some controversial initiatives and generate income and human welfare in the Caucasus or Western Balkans.

Discussion

These technologies offer numerous benefits, including improved animal health monitoring, optimised environmental conditions and increased production efficiency. In global value and commodity chains (Milanovic, 2016), agriculture in the CEE/SC region should evolving faster than very high-income countries to close the gap, and its own AI solution in PLF can contribute to this.

In conclusion, although AI has great potential to improve poultry, egg, milk, beef and pork production (as well as all by-products) (Jarynowski, 2024b), its implementation needs to be carefully managed to address AW, ethical, communication and legal challenges. Future

research should focus on a systematic review of the holistic implementation of AI systems in the CEE/SC region.

Acknowledgement. Author thanks for CEEPUS scholarship to attend VetNEST SUMMER SCHOOL Animal Welfare Ethics and Law and Communication skills as he is grateful for fantastic lectures/workshops and inspiring discussions.

References

Appleby, R. B., & Basran, P. S. (2022). Artificial intelligence in veterinary medicine. *Journal of the American Veterinary Medical Association*, *260*(8), 819–824. https://doi.org/10.2460/javma.22.03.0093

Bartosiak, J. (2019). *Przeszłość jest prologiem*. Zona Zero.

Bryden, W. L., Li, X., Ruhnke, I., Zhang, D., & Shini, S. (2021). Nutrition, feeding and laying hen welfare. *Animal Production Science*, *61*(10), 893–914. https://doi.org/10.1071/AN20396

Bushuyev, S., Piliuhina, K., & Chetin, E. (2023). TRANSFORMATION OF VALUES OF THE HIGH TECHNOLOGY PROJECTS FROM A VUCA TO A BANI ENVIRONMENT MODEL. *Innovative Technologies and Scientific Solutions for Industries*, *2 (24)*, 191–199. https://doi.org/10.30837/ITSSI.2023.24.191

Chowdhury, A., Kabir, K. H., Abdulai, A.-R., & Alam, M. F. (2023). Systematic Review of Misinformation in Social and Online Media for the Development of an Analytical Framework for Agri-Food Sector. *Sustainability*, *15*(6), 4753. https://doi.org/10.3390/su15064753

Cohen, E. B., & Gordon, I. K. (2022). First, do no harm. Ethical and legal issues of artificial intelligence and machine learning in veterinary radiology and radiation oncology. *Veterinary Radiology & Ultrasound*, *63*(S1), 840–850. https://doi.org/10.1111/vru.13171

Ćwiklicki, M., Duplaga, M., & Klich, J. (Eds.). (2022). *The digital transformation of healthcare: Health 4.0*. Routledge.

De Briyne, N., Vidović, J., Morton, D. B., & Magalhães-Sant'Ana, M. (2020). Evolution of the

Teaching of Animal Welfare Science, Ethics and Law in European Veterinary Schools (2012–2019). *Animals*, *10*(7), 1238. https://doi.org/10.3390/ani10071238

Dudek, A., Dąbek, A., Zborowska, I., & Lichosik, J. (2023). Integrating artificial intelligence in forensic science. *E-Methodology*, *10*(10), 13–31.

Edwards, S. (Ed.). (2021). *Understanding the behaviour and improving the welfare of pigs*. Burleigh Dodds Science Publishing Limited.

Fang, C., Zhang, T., Zheng, H., Huang, J., & Cuan, K. (2021). Pose estimation and behavior classification of broiler chickens based on deep neural networks. *Computers and Electronics in Agriculture*, *180*, 105863.

Fernandes, A. F. A., Dórea, J. R. R., Fitzgerald, R., Herring, W., & Rosa, G. J. M. (2020). A novel automated system to acquire biometric and morphological measurements and predict body weight of pigs via 3D computer vision. *Journal of Animal Science*, *98*(3), skaa021.

Gailhofer, P., Herold, A., & Schemmel, J. P. (2021). *The role of artificial intelligence in the European green deal*. European Parliament.

Gawlik-Kobylińska, M. (2022). Current Issues in Combating Chemical, Biological, Radiological, and Nuclear Threats to Empower Sustainability: A Systematic Review. *Applied Sciences*, *12*(16), 8315. https://doi.org/10.3390/app12168315

Gradon, K. T. (2024). Generative artificial intelligence and medical disinformation. *BMJ*, q579. https://doi.org/10.1136/bmj.q579

Gržinić, G., Piotrowicz-Cieślak, A., Klimkowicz-Pawlas, A., Górny, R. L., Ławniczek-Wałczyk, A., Piechowicz, L., Olkowska, E., Potrykus, M., Tankiewicz, M., Krupka, M., Siebielec, G., & Wolska, L. (2023). Intensive poultry farming: A review of the impact on the environment and human health. *Science of The Total Environment*, *858*, 160014. https://doi.org/10.1016/j.scitotenv.2022.160014

Jarynowski, A. (2023). *ML/AI w zwalczaniu chorób zakaźnych i kontroli zakażeń*. Konferencja PulmoRehab, Głuchołazy.

Jarynowski, A. (2024a). *Introduction to telemonitoring and e-health*. E-methodology,

Wroclaw. http://e-methodology-conference.eu/2024/schedule/

Jarynowski, A. (2024b). Protesty rolników a hodowla zwierząt jako koło zamachowe dobrobytu na prowincji w obliczu kryzysu. *Nowa Konfederacja*. https://nowakonfederacja.pl/nadchodzi-szosta-fala-pandemii-covid-19-jak-sobie-z-nia-radzic/

Jarynowski, A., Buda, A., PŁATEK, D., & Belik, V. (2019). African Swine Fever Awareness in the Internet Media in Poland–exploratory review. *E-Methodology*, *6*(6), 100–115.

Jarynowski, A., Czekaj, Ł., Semenov, A., & Belik, V. (2024). Multiplex Network Approach for Modeling the Spread of African Swine Fever in Poland. In M. H. Hà, X. Zhu, & M. T. Thai (Eds.), *Computational Data and Social Networks* (Vol. 14479, pp. 349–360). Springer Nature Singapore. https://doi.org/10.1007/978-981-97-0669-3_32

Jarynowski, A., Krzowski, Ł., & Maksymowicz, S. (2023). *Biological mis(dis)-information in the Internet as a possible Kremlin warfare* (Version v3). IBI. https://doi.org/10.5281/ZENODO.7932530

Jarynowski, A., Krzowski, Ł., Maksymowicz, S., & Romanowska, M. (2024). *Assessing Large Language Models in the Context of Bioterrorism: An Epidemiological Perspective with Experimental Insights*. War Science Academy, Warsaw. https://www.slideshare.net/slideshow/assessing-large-language-models-in-the-context-of-bioterrorism-an-epidemiological-perspective-with-experimental-insights/269599413

Jarynowski, A., Maksymowicz, S., Meletis, E., & Kostoulas, P. (2024). *Zdrowie zwierząt w trakcie wodnych katastrof ekologicznych w mediach z perspektywy sanitarno-weterynaryjnej: Tesalia 2023 oraz Odra 2022 – wstępna analiza*. preprint. http://interdisciplinary-research.eu/wp-content/uploads/2024/01/praktyki_zwierzeta_post.pdf

Jarynowski, A., Maksymowicz, S., & Ślósarz, L. (2023). The future of AI in medicine and education—10th anniversary of E-methodology community. *E-Methodology*, *10*(10), 6–12.

Jarynowski, A., Romanowska, M., & Belik, V. (2023). *Nasłuchiwanie nowych mediów w celu monitorowania stosowania środków przeciwdrobnoustrojowych i ich percepcji*. IPF, Olsztyn. http://interdisciplinary-research.eu/wp-content/uploads/2023/11/antybiotyki_same.pdf

Jarynowski, A., Romanowska, M., & Belik, V. (2024). *Utilizing AI tools in Teaching ONE health (tutorial hands on)*. classes with students, WrocMed,.

Jarynowski, A., Romanowska, M., Maksymowicz, S., & Belik, V. (2024). One Health Multimodal surveillance in time of change: Lessons NOT learnt from case study of A/H5N1 spillover to mammals in Gdańsk metropolitan area. *One Health Journal*, *2*(III), 45–61. https://doi.org/10.31073/onehealthjournal2024-III-06

Jarynowski, A., Semenov, A., Wójta-Kempa, M., & Belik, V. (2021). Social Cohesion During the Stay-at-Home Phase of the First Wave of the COVID-19 Pandemic on Polish-Speaking Twitter. In D. Mohaisen & R. Jin (Eds.), *Computational Data and Social Networks* (Vol. 13116, pp. 361–370). Springer International Publishing. https://doi.org/10.1007/978-3-030-91434-9_31

Lardy, R., Botreau, R., De Boyer Des Roches, A., Van Eerdenburg, F. J. C. M., De Graaf, S., Haskell, M. J., Kirchner, M. K., Mounier, L., Kjosevski, M., Tuyttens, F. A. M., & Veissier, I. (2023). Improvement of the Welfare Quality scoring model for dairy cows to fit experts' opinion. *Animal*, *17*(11), 101018. https://doi.org/10.1016/j.animal.2023.101018

Lavrova, A. I., Choucair, A., Palmini, A., Stock, K. F., Kammer, M., Querengässer, F., Doherr, M. G., Müller, K. E., & Belik, V. (2023). Leveraging Accelerometer Data for Lameness Detection in Dairy Cows: A Longitudinal Study of Six Farms in Germany. *Animals*, *13*(23), 3681. https://doi.org/10.3390/ani13233681

Lichosik, J., Dąbek, A., Dudek, A., & Zborowska, I. (2023). The impact of widely used algorithms of large language models on information retrieval and the associated potential risks. *E-Methodology*, *10*(10).

Maksymowicz, S. (2023). *Zielony Ordokonserwatyzm*. Nowa Konfederacja.

https://nowakonfederacja.pl/wp-content/uploads/2023/12/Raport_Zielony_ordokonserwatyzm.pdf

Maksymowicz, S. (2024). Choroba X może wywołać kryzys większy niż COVID-19. Podatność już wytworzyliśmy. *Nowa Konfederacja*. Choroba X może wywołać kryzys większy niż COVID-19. Podatność już wytworzyliśmy

Meletis, E., Jarynowski, A., Maksymowicz, S., Kostoulas, P., & Belik, V. (2024). Animal Health Discourse during Ecological Crises in the Media—Lessons Learnt from the Flood in Thessaly from the One Health Perspective. *Veterinary Sciences*, *11*(4), 140. https://doi.org/10.3390/vetsci11040140

Milanovic, B. (2016). *Global Inequality: A New Approach for the Age of Globalization*. Cambridge/Harvard University Press.

Neethirajan, S. (2017). Recent advances in wearable sensors for animal health management. *Sensing and Bio-Sensing Research*, *12*, 15–29.

Oczak, M., Maschat, K., & Baumgartner, J. (2023). Implementation of Computer-Vision-Based Farrowing Prediction in Pens with Temporary Sow Confinement. *Veterinary Sciences*, *10*(2), 109. https://doi.org/10.3390/vetsci10020109

Ribeiro, R., Casanova, D., Teixeira, M., Wirth, A., Gomes, H., Borges, A., & Enembreck, F. (2019). Generating action plans for poultry management using artificial neural networks. *Computers and Electronics in Agriculture*, *161*, 131–140.

Romanowska, M. (2024a). *The Anti-Vaccination Infodemic in Poland, Insights from Primary Healthcare Centers*. Africa Training Institute, Kenya.

Romanowska, M. (2024b). Wprowadzenie zarządzania infodemią do wspierania oceny ryzyka zgromadzeń w przypadku imprez masowych. *WHO MG All Hazards*. https://einfodemic.substack.com/p/wprowadzenie-zarzadzania-infodemia

Sibanda, T. Z., Belik, V., Jarynowski, A., Welch, M., Boshoff, J., Schneider, D., Ruhnke, I., & edited by P. A. Robinson & K. M. McIntyre and the SVEPM Executive Committee. (2022). *Understanding time series of RFID sensor data for predicting mortality in*

laying hens (pp. 197–207). SVEPM. http://interdisciplinary-research.eu/wp-content/uploads/2022/03/SVEPM_Proceedings_jarynowski_hens.pdf

Szczepaniak, P., Kalinowski, P., Ułanowicz, L., & Sibilski, K. (2023). Zastosowanie aerofotogrametrii w podczerwieni do śledzenia dzików w ich naturalnym środowisku oraz identyfikacji osobników zarażonych afrykańskim pomorem świń. Cz. II–badania systemu ASFochrona. *XX Konferencja „Mechanika w Lotnictwie (ML-XX)”*.

Zybertowicz, A., & Piekutowski, J. (2022). *Cyber kontra real: Cywilizacja w techno-pułapce* (S. Maksymowicz, Ed.). Wydawnictwo Nowa Konfederacja.