Opportunities and challenges of new technologies for performance recording with focus on claw health and metabolism

F. Grandl[1], J. Kofler[2], M. Suntinger[3], P. Majcen[4], M. Mayerhofer[3], F. Papst[5], O. Saukh[5], M. Fallast[6], A. Turkaspa[7], F. Steininger[3], K. Linke[3], J. Duda[1], T. Wittek[2], B. Fuerst-Waltl[8], F.J. Auer[9] and C. Egger-Danner[3]

[1]LKV Bayern, Landsberger Straße 282, 80687 Munich, Germany
Corresponding Author: Florian.Grandl@lkv.bayern.de
[2]Clinic for Ruminants, University of Veterinary Medicine, Veterinaerplatz 1, 1210 Vienna, Austria
[3]ZuchtData EDV-Dienstleistungen GmbH, Dresdner Str. 89, 1200 Vienna, Austria
[4]LK Österreich, Schauflergasse 6, 1010 Vienna, Austria
[5]TU Graz, Institute of Technical Informatics, Inffeldgasse 16/I, 8010 Graz, Austria
Complexity Science Hub Vienna, Josefstädter Straße 39, 1080 Wien, Austria
[6]smaXtec, Belgiergasse 3, 8020 Graz, Austria
[7]SCR by Allflex, Hamelacha St. 18, Netanya, Israel
[8]Department of Sustainable Agricultural Systems, Division of Livestock Sciences, University of Natural Resources and Life Sciences, Gregor-Mendel-Str. 33, 1180 Vienna, Austria
[9]LKV Austria, Dresdner Straße 89, 1200, Vienna

Abstract

Breeding goals are broadening with more and more emphasis on health and efficiency related traits. New technologies are revolutionising the dairy industry. In addition to achievements in omics technologies, information and communication technologies (e.g., sensor technologies, Internet of Things, embedded machine learning) are also finding their way into modern dairy herds. Instead of punctual measurements, embedded sensors continuously record animal behavioural patterns that can imply on the animal well being and welfare. Large amounts of data generated by deployed sensor systems along with the integration of related data sources promise ultimately new insights into animal health.

Traditional data pipelines with information about animal performance recordings in combination with indicators for metabolic disturbances, such as veterinary diagnoses, feeding information, test of ketone bodies, body condition score, and mid-infrared spectra have been around for some time already. They provide more precise possibilities to predict diseases, such as ketosis, compared to the methods using fat-protein-ratio. In the context of the claw health, the information about the regular claw trimming visit, veterinary diagnoses and regular lameness scoring has been made available only partly so far. Sensor technology provides alarms and early warnings based on irregularities of normal behaviour for early detection of disorders. Advanced methods and technologies offer the possibility to combine various environmental information and genomic background to get new insights into the occurrence of or susceptibility to disorders. To explore these opportunities the biggest challenge is the integration of different data sources. In practice, monitoring data is often provided by different hardware and software products. This makes data integration more difficult due to the differences in the data exchange format of the partners involved. Moreover, the same traits may be defined differently by different products. It is therefore necessary to create structures to bring these data sources together in order to provide farmers with maximum support for herd management. Another challenge of data integration from different sources is compliance with legal data protection regulations, since this is often associated with lack of clarity in practice. Cooperation between different partners and integration of different data is a precondition for successfully applying advanced data technologies based on complex trait definitions. We summarize the steps to overcome these challenges based on our research within the project D4Dairy.

Keywords: performance recording, data integration, claw health, metabolism, advanced data technologies.

Introduction

In the recent years, dairy production has seen a lot of technological advances in different areas. On the farms, technologies for automation of work processes are increasingly implemented, particularly automatic milking and feeding systems. Furthermore, livestock sensors for the acquisition of behaviour and health data as well as environmental parameters (e.g., barn climate) become widely available. These systems are able to deliver large amounts of data from which conclusions on the animal wellbeing and welfare can be drawn.

There has also been an impressive development of lab technologies in various fields that can now be exploited for dairy farming. New laboratory diagnostic methods and analyses as well as a bunch of omics technologies can nowadays be used at high-throughput and are thus available for samples from many animals. This additional information can also provide new insights into the state of the animals, be it once (e.g., when genotyping animals) or repeatedly (e.g., when analysing milk samples from performance recording).

Digitalisation adds another dimension to the use of new technologies. Networking and integration of different data sources provide the basis for enhanced data science approaches such as Big Data analyses, image and pattern recognition. The challenge of the current situation is the existence of disconnected data silos, and a heterogeneous landscape of application programming interfaces (Egger-Danner *et al.*, 2019; Papst *et al.*, 2019). Privacy concerns is one of the main reasons for the reluctance in data sharing. Farm and animal data can be considered as a farmers' trade secret. Manufacturers of automation solutions and sensor systems, which also process (and sometimes host) their customers' farm data, generate additional insights from these data by applying proprietary algorithms. Thus, part of the data of interest is coupled with the intellectual property of companies.

Use of new technologies for performance recording

The challenge for performance recording organisations and data processing centres is to integrate the variety of new data sources in the traditional data processing used to generate information and decision support for the farmers and broaden the data basis for breeding value estimation. This is particularly relevant in the field of novel phenotypes, where traditional data recording schemes are limited. In this paper, we discuss such approaches for the trait complexes metabolic status and claw health in dairy cows.

Metabolic status

So far, milk constituents (fat and protein content, fat-to-protein ratio, milk urea) have been the main information source from routine milk recording for the metabolic status of dairy cows. Additionally, some recording schemes for diagnoses exist, but these catch primarily only severe clinical cases. However, metabolic disorders often occur subclinically. Due to the economic impact, the earliest possible detection of subclinical signs is of great importance (Egger-Danner *et al.*, 2015). A promising approach to get insights into complex traits is the use of milk mid-infrared spectra, which are readily available from the analysis of routine milk recording samples (Gengler *et al.*, 2016). There are several authors who have shown the potential usefulness of spectral information for the assessment of the metabolic status of dairy cows (e.g., Grelet *et al.*, 2016, Luke *et al.*, 2019), and there already exist live applications of early warning services for farmers. Other diagnostic methods (e.g., ketone tests for use in milk or urine) that could be used in a routine monitoring program have also some potential for a large-scale recording of the metabolic state. However, their drawback is the labour intensiveness and the need to record the result before it can be further (electronically) processed. Sensor units that continuously collect potentially auxiliary trait data for the trait complex of metabolic disorders are also available. Most frequently, the deployed systems record eating and rumination behaviour, but also automatic body condition scoring and automatic weighing systems are commercially available. However, all these sensor systems provide rather unspecific health alerts and leave the necessary situation analysis to farmers and veterinarians. To further automate the performance analysis and bring precision diagnostic to the next level, e.g., to differentiate the metabolic status more precisely, integration of different information sources is of ultimate importance.

Claw health

For claw health, no traditional information pipeline exists in performance recording apart from the information from linear scoring of conformation traits and the reasons for culling. Similar to metabolic disorders, veterinary diagnoses mostly exist for very severe cases only. Additional information on claw health could greatly improve breeding for claw health (Linde *et al.*, 2010) and would be beneficial in advisory tools to improve housing conditions and prevention of claw disorders. Thus, the electronic documentation of claw health at the time of trimming is a very powerful approach to collect valuable data, if the data is integrated in the routine performance recording system (Kofler, 2013). Data integration with computerised documentation and analysis programs could also be beneficial for the claw trimmers through work reduction (e.g., automatically updated animal lists). Information from lameness scoring is a valuable auxiliary trait for improvement of claw health by management and genetics (Heringstad and Egger-Danner *et al.*, 2018; Koeck *et al.*, 2019). The detection of claw health problems through lameness or locomotion scoring is especially interesting, if the detection can be automated. Using modern data analytic tools, the lameness detection from camera image data seems to be possible (Abdul Jabber *et al.*, 2017). Other sensor technologies (e.g., accelerometers) also show great potential to serve as auxiliary information for claw health (Alsaood *et al.*, 2019).

Additional aspects for the use of novel data sources for metabolic status and claw health

When introducing novel data sources to the new trait complexes discussed above, a few aspects should be considered. With regards to the health status, it becomes more and more relevant to also record the application of preventive measures (e.g., administration of propylene glycol), since such measures can greatly influence the result when algorithms are built on routine data. As mentioned above, sensor-based management systems often provide unspecific alarms. It has to be verified that combining such information sources indeed increases the predictive ability of the trait of interest or show a significant correlation to the target trait. Some of the novel data sources require additional sampling, thus routine farm visit schemes and milk tests might need to be redesigned. For the development of algorithms that combine novel data sources, comprehensive research data sets are needed in order to ensure high quality of predictions. Both for development and for routine use, the optimisation of data availability is crucial. Active involvement and cooperation of partner organisations around the dairy industry is essential. Projects that put emphasis on the improved interoperability and data exchange between systems, such as the COMET-project D4Dairy (www.d4dairy.com) help to provide access to various commercial and open data in a privacy-preserving way and to generate additional value for the farmers through integration and joint analysis of this data (Egger-Danner *et al.*, 2019).

What does this mean for performance recording in 2030?

The challenge for performance recording organisations in the future will be to adapt the way what and how to record data on dairy farms. There will be a need to record a wide variety of (auxiliary) traits using new recording technologies. Existing data and technologies permanently installed at the farms will need to be integrated into performance recording. Performance recording schemes will have to be aligned with the different abilities of data provision of farms and farmers. Depending on the breeding programs, data provisioning could emerge as a new business model for the farms, where precise phenotyping is needed.

We can also expect an increasing demand of new services for the performance recording organisations. Performance recording schemes need to be adapted to variable intervals and to daily/hourly/every second data flows. Decision (support) systems for farm management based on different sources of data will play a greater role as a service to the farmers. Performance recording results will have to be made available for further automation of farm work processes (e.g., milk lab results for the calibration of inline measurement systems). With regards to the still existing privacy concerns, it will be crucial that the performance recording organisations make the routine data exchange and data use along the dairy supply chain transparent and are trusted in the context of data sharing between the parties involved.

Acknowledgement

This work was conducted within the COMET-Project D4Dairy (Digitalisation, Data integration, Detection and Decision support in Dairying). That is supported by BMVIT, BMDW and the provinces of Lower Austria and Vienna in the framework of COMET-Compentence Centers for Excellent Technologies. The COMET program is handled by the FFG.

List of references

Abdul Jabbar, K., M.F.Hansen, M.L. Smith and L.N. Smith, 2017. Early and non-intrusive lameness detection in dairy cows using 3-dimensional video. Biosyst. Eng. 153: 63-69.

Alsaaod, M., M. Fadul and A. Steiner, 2019. Automatic lameness detection in cattle. Vet. J. 246: 35-44.

Egger-Danner, C., B. Fuerst-Waltl, P. Klimek, O. Saukh, T. Wittek and D4Dairy-Consortium, 2019. Internet of Cows – Opportunities and Challenges for Improving Health, Welfare and Efficiency in Dairying. *https://www.icar.org/Documents/Prague-2019/Presentations/ICAR-2019-Egger-Danner-invited-talk-20190617.pdf*

Egger-Danner, C., J.B. Cole, J.E. Pryce, N. Gengler, B. Heringstad, A. Bradley and K.F. Stock, 2015. Invited review: Overview of new traits and phenotyping strategies in dairy cattle with a focus on functional traits. Animal 9(2): 191-207.

Gengler, N., H. Soyeurt, F. Dehareng, C. Bastin, F. Colinet, H. Hammami, M.-L. Vanrobays, A. Lainé, S. Vanderick, C. Grelet, A. Vanlierde, E. Froidmont and P. Dardenne, 2016. Capitalizing on fine milk composition for breeding and management of dairy cows. J. Dairy Sci. 99(5): 4071-4079.

Grelet, C., C. Bastin, M. Gelé, J.B. Davière, M. Johan, A. Werner, R. Reding, J.A. Fernandez Pierna, F.G. Colinet, P. Dardenne, N. Gengler, H. Soyeurt and F. Dehareng, 2016. Development of Fourier transform mid-infrared calibrations to predict acetone, â hydroxybutyrate, and citrate contents in bovine milk through a European dairy network. J. Dairy Sci. 99(6): 4816-4825.

Heringstad, B., C. Egger-Danner, N. Charfeddine, J.E. Pryce, K.F. Stock, J. Kofler, A.M. Sogstad, M. Holzhauer, A. Fiedler, K. Müller, P. Nielsen, G. Thomas, N. Gengler, G. de Jong, C. Ødegård, F. Malchiodi, F. Miglior, M. Alsaaod and J.B. Cole, 2018. Invited review: Genetics and claw health: opportunities to enhance claw health by genetic selection. J. Dairy Sci. 101(6): 4801-4821.

Köck, A., B. Fuerst-Waltl, J. Kofler, J. Burgstaller, F. Steininger, C. Fuerst and C. Egger-Danner, 2019. Short communication: Use of lameness scoring to genetically improve claw health in Austrian Fleckvieh, Brown Swiss, and Holstein cattle. J. Dairy Sci. 102(2): 1397-1401.

Kofler, J., 2013. Computerised claw trimming database programs as the basis for monitoring hoof health in dairy herds. Vet. J. 198(2): 358-361.

Linde, C., G. de Jong, D.P.C. Koenen and H. Eding, 2010. Claw health index for Dutch dairy cattle based on claw trimming and conformation data. J. Dairy Sci. 93:4883-4891.

Luke, T.D.W., S. Rochfort, W.J. Wales, V. Bonfatti, L. Marett and J.E. Pryce, 2019. Metabolic profiling of early-lactation dairy cows using milk mid-infrared spectra. J. Dairy Sci. 102(2): 1747-1760.

Papst, F., O. Saukh, K. Römer, F. Grandl, F. Steininger, M. Mayerhofer, J. Duda and C. Egger-Danner, 2019. Embracing Opportunities of Livestock Big Data Integration with Privacy Constraints. In: Proceedings of International Conference on the Internet of Things (IoT'19). Bilbao, Spain 4 pp.