Animal (2016), **10:9**, pp 1482–1483
doi:10.1017/S1751731116001142

animal

Editorial: Precision livestock farming: a 'per animal' approach using advanced monitoring technologies

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Precision livestock farming (PLF) can be defined as real-time monitoring technologies aimed at managing the smallest manageable production unit's temporal variability, known as 'the per animal approach'. The first massive application of PLF, years before the term PLF was coined in 2004 (Berckmans, 2004), was the individual electronic milk metre for cows. The first milk metres became commercially available in the 1970s (Peles, 1978) and early 1980s (Brayer, 1982), followed by commercialised behaviour-based oestrus detection and later still, rumination tags and an online real-time milk analyser (Schmilovitch *et al*., 2007). In this special issue on PLF, Steensels *et al.* (2016) make use of these milk and behaviour parameters to detect post-calving diseases. Further accuracy to predict individual cows' feed intake is reached by employing different sensors (Pahl *et al*., 2016) and by adding feeding behaviour to a feed-intake model (Halachmi *et al*., 2016).

The milking robot is a classical PLF application: the smallest manageable production unit in this case is one single quarter of an udder. Simulation-optimisation based on animal behaviour was developed for robotic milking farms at the beginning of this century (Halachmi, 2004). In this PLF issue, John *et al.* (2016) review the utilisation of robots after a farm was designed and a robot operated. They also review the robot milking–pasture combination. Continuing with dairy in this issue, Salau *et al.* (2016) develop a Kinect-based system, and Kinect is applied by Van Hertem *et al.* (2016) for automatic lameness detection. Another approach for automatic lameness detection, gait behaviour and ground reaction forces, is proposed by van Nuffel *et al.* (2016). IR-thermography-based monitoring of body temperature of calves (Hoffmann *et al*., 2016) and gene expression of calves undergoing gradual weaning (Johnston *et al*., 2016) are presented in this special issue.

In meat production, one of the first PLF applications was related to individual feed distribution in a group housing (Marcon *et al*., 2015). In this special issue, we see monitoring of drinking behaviour of individual pigs housed in a group using radio frequency identification (Maselyne *et al*., 2016). We also see the development of automatic surveillance of animal behaviour and welfare using image analysis and machine-learned segmentation technique (Nilsson *et al*., 2015).

Broiler chickens are usually fast-growing, bred intensively with up to 40 000 conspecifics. The farmers' challenge is to reach high final BW in a short time while maintaining an efficient feed-conversion rate. Therefore, one of the first PLF applications in broilers was to automatically monitor the animals' weight (Fontana *et al*., 2015). Another application in this issue offers vocalisation sound pattern identification in young broiler chickens (Fontana *et al*., 2016).

Beyond these achievements, the integration of PLF into scientific communities is moving forward: the EAAP (European Federation of Animal Science), with its annual meeting in Copenhagen in August 2014 was, to the best of our knowledge, the first animal science federation to host an international symposium on PLF. The EAAP facilitated 'cross-disciplinary' discussions focussing on interpretations of sensed animal responses and the associated management actions. Several livestock sectors participated in the discussions: (1) providers of animal-sensing technology such as start-up companies and sensor developers, (2) mature industries such as retailers, animal feed suppliers, farm equipment providers, farm designers and veterinarians, covering the animal and human food chains, and (3) animal geneticists, nutritionists, health experts, zoologists, biologists, environmental scientists, i.e. animal-focussed scientists and the farmer organisations that usually attend EAAP annual meetings. The 'questions and answers' debates inscribed during this joint session's discussions are presented in a book (Halachmi, 2015), and the selection of full-length papers are presented in this special issue of Animal. This special issue covers the next generation applications. Its content provides evidence of the initial integration of PLF into the community of animal scientists, with a widening and deepening of research, development and evaluation of underlying concepts of PLF for a vast and diverse world of livestock production. Potential applications include individual animal food intake, automatic early detection of ill-ness or stress and monitoring of animal welfare. The prospects for further developments are manifest.

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