and ruminants are the major contributors (65–77% of the global livestock emissions). Farmers will need to adopt practices to low the environmental impact, such as manure management, efficient use of feed and high animal welfare. The LATTE DIGITALE (Milk production in Lombardy region towards digital and precision livestock farming) project aims to demonstrate that the digital technologies have positive effects on the farm efficiency and the environment by improving the performances and the welfare of dairy cattle. Precision livestock farming (PLF) may help to reach the goals because a farmer can monitor in real-time a wide series of parameters regarding animals and farm. He could then be able to early detect the outbreak of health issues by taking precocious actions, to verify the accuracy and the distribution of the diet, to simplify the reproductive management and to supervise the energy consumption of the farm. This may let the animal welfare and production and the efficient utilization of resources improve, thus avoiding economic losses. The PLF technologies monitor various aspects, for example food composition (NIR) and distribution (rail-guided feed wagons, feeding distributor wagons), animal welfare (videocameras, accelerometers, microphones, neck collars) rumination rate (neck collars), behaviour (automatic milking and feeding systems, videocameras), oestrus (neck collars, accelerometers), energy consumption, environment conditions and management. The project is coordinated by CREA and involves three innovative dairy farms in the Lombardy region. Three LCA analyses of the farms are carried out before, during and after the introduction of a variety of new PLF technologies. Primary data are collected by giving the farmers a questionnaire, while secondary data are obtained by databases and literature sources. All the data are then processed with CAP'2ER® in order to quantify the potential improvement of the global warming, the acidification and the eutrophication processes and the energy consumption. The estimated carbon footprints (kg CO_2-eq/kg FPCM) of these farms in the first evaluation were 0.75, 0.74 and 0.83.

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Monitoring calf body temperature by infrared thermography: preliminary assessment of environmental effects

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Pyrexia is one of most important non-specific symptoms of disease in animals. Among cattle, calves are very susceptible to get sick, with often a high mortality rate. Traditionally, calf body temperature is measured using rectal thermometers. Besides being time consuming, this can be very stressful for animals. Recent techniques based on thermal imaging allow to estimate the body core temperature by measuring the surface temperature of different parts of the calf body. This study investigated the possibility to use thermal imaging of the calf eye to predict core body temperature and to diagnose pyrexia.

A total of 602 thermal images of the left eye were acquired on 113 female Holstein calves (0–90 days of age; mean 29 ± 20 days) with FLIR C2 thermal camera over a period of 1 year. At the same time, rectal temperatures (RECT) of the calves were measured using a digital thermometer. Thermal camera emissivity, eye-camera distance and insertion depth of rectal thermometer were 0.95, 50 cm and 8.0 cm, respectively. Environmental temperature (ET) and relative humidity in calves' pens were measured with HOBO sensors. Image analysis was performed using the FLIR TOOL software, while statistical analysis was conducted using the Matlab Statistics and Machine Learning Toolbox. For thermal images, the maximum temperature point (EYET) was selected in the area of interest (the eye plus a 2 cm area all around it).

Over the study period, ET showed minimum and maximum values of 0.3 °C and 32.5 °C, respectively, and mean RECT was 39.4 ± 0.6 °C. In newborn calves (up to 15 days, $n = 172$), RECT showed moderate correlation ($r = 0.6$) with the last 6-hr average ET. Mean EYET was 36.2 ± 1.5 °C and the correlation with RECT was 0.50. The EYET and RECT ratio varied in the range 0.74–1.0 and was highly correlated with ET ($r = 0.79$). The best equation obtained through a stepwise regression includes, as parameters, EYET, calf age and ET, and can predict RECT with an RMSE of 0.45 and R^2 of 0.38; this equation shows, with a cut-off of 39.5 °C, a sensibility of 56%, 81% of specificity and 67% of precision.

The preliminary results show that thermal imaging eye temperature associated with environmental parameters is a promising technique for no-contact, rapid detection of pyrexia in calves. Further analysis will be devoted to improve the accuracy of the model by investigating the influence of additional environmental parameters.

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A bibliometric analysis in precision livestock farming

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The interest through the precision livestock farming (PLF), a concept discussed for the first time in a conference held in 2001,

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