Relationships between temperature humidity index, mortality, milk yield and composition in Italian dairy cows

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Abstract— The aim of this short paper is to describe the activities performed by the LiveM-Task L1.2. group based at the University of Tuscia, Viterbo, Italy. Three different pluriannual databases were built to perform retrospective studies aimed at establishing the relationships between temperature humidity index (THI) and parameters of interest for dairy cow farms. The THI combines temperature and humidity in a single value and has been widely used to quantify heat stress in farm animals. The first database was built to assess the relationships between THI and mortality over a 6 yr period (2002-2007); the second one was a 7 yr database (2001-2007) which was built to establish the relationships between THI and milk yield; the last database included THI, milk somatic cell counts (MSCC), total bacterial counts (MTBC), fat and protein percentages (MF and MP%, respectively) data collected over a 7 yr period (2003-2009). The analysis of the three databases provided several equations which demonstrated and quantified an increase of mortality, reduction of milk yield and a worsening of milk quality in hot environment. Results of these analyzes authorized speculations about risks for dairy cows and their productivity in a warming planet. Furthermore, the same results are being utilized by economists also working within MACSUR at the University of Tuscia for an integrated study aimed at establishing the economic impact of climate change in the dairy sector. Combining this information with climate change regional scenarios might permit prediction of the impact of global warming and identification of adaptation measures that are appropriate for specific contexts.

Index Terms—Dairy cows, Milk yield and composition, Mortality, Temperature humidity index

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1 Introduction

Production losses in livestock enterprises are an expected outcome of the temperature increase which is part of the ongoing and predicted climate change (Gaughan et al. 2009). Among farm animal species, high yielding dairy cows are particularly prone to experience heat stress in hot environment. This consists of physiological and behavioral responses, which may lead to physiological disorders that negatively affect welfare, health, survival, reproductive and productive performances (Nardone et al. 2010; Lacetera et al., 2013). Several climatic indexes have been suggested to describe the influence of thermal environment on animal response. The THI combines temperature and humidity in a single value and has been widely used to quantify heat stress in farm animals (Bohmanova et al. 2007).

The aim of this short paper is to describe the activities performed within MACSUR by the LiveM-Task L1.2. group based at the University of Tuscia, Viterbo, Italy.

2 Materials and methods

Three different pluriannual databases were built to perform retrospective studies aimed at establishing relationships between THI and parameters of interest for dairy cows.

The first database was built to assess the relationships between THI and mortality over a 6 yr period (2002-2007) (Vitali et al. 2009). Briefly, mortality data (51,240 deaths) were extracted from the Italian Bovine Spongiform Encephalopathy database which contains records on cows older than 24 mo that died on a farm from all causes, were slaughtered in an emergency state, or were sent for normal slaughter but were sick in the preslaughter inspection. This database was integrated with THI values, which were obtained by using temperature and relative humidity data from 73 weather stations.

The second database was built in order to establish the relationships between THI and milk yield over a 7 yr period (2001-2007) (Bernabucci et al. 2014). Briefly, milk yield data were provided by the Italian Holstein Breeders Association and comprised 1,488,474 test-day records relative to 191,012 cows. This database was integrated with THI values, which were obtained by using meteorological data from 35 weather stations.

The third database was intended to study the relationships between THI, MSCC, MTBS, MF and MP% over a 7 yr period (2003-2009) (Bertocchi et al. 2014). Briefly, 508,613 milk quality data of 316,160 cows were merged with THI data relative to 40 weather stations.

In all cases, each farm where data were recorded (deaths, milk yield or composition) was assigned the THI values calculated at the closest weather station.

The relationships between THI, cow mortality, milk yield or milk quality were established by a 2-phase linear regression procedure (Nickerson et al. 1989) which detects an inflection point, if one exists, in the relationship between the independent variable (THI) and the dependent variable (mortality, milk yield or milk quality).

3 Results and discussion

The analysis of mortality data indicated that THI of 79.6 is the break point where a significant change in the slope describing the relationship between THI and the number of deaths in dairy cows occurs and that the highest risk of death for dairy cows should be expected when daily THI is above 87. A detailed description of results has already been reported elsewhere (Vitali et al. 2009).

The analysis of milk yield data pointed out that, depending on parity (1st, 2nd or 3rd calving), the THI breaking point ranged from 73 to 76. A complete description of these results has been reported in a recently published paper (Bernabucci et al., 2014).

Finally, the analysis of the milk quality database provided the following breakpoints for MSCC, MTBC, MF% and MP%: 57.5, 72.8, 50.2 and 65.2, respectively. Also in this case, results and much more are part of a recently published paper (Bertocchi et al., 2014).

The described variations of breakpoints in relation to parameters support the need for a rationalization/modulation of the adaptation strategies (i.e. cooling, diet modifications, etc.) in relation to the impacts which need to be prevented/mitigated.

Results from these studies have been and are still being utilized by economists also working within MACSUR at the University of Tuscia for integrated studies aimed at establishing the economic impact of climate change in the dairy sector. Furthermore, the same results are part of the MACSUR data utilized by researchers at the University of Sassari who are working to identify the right approach to support the adaptive responses to climate change through the combination of modeling approaches and stakeholder engagement.

4 Conclusions

Looking ahead and in the light of a possible MACSUR extension phase, further studies are encouraged to extend these analyses to additional parameters of interest for dairy cows (i.e. indicence of infectious or metabolic diseases, culling rate, reproductive efficiency, etc.) and/or to further farm animal species. Moreover, combining the information reported herein with climate change regional scenarios might permit prediction of the impact of warming in the dairy sector and the identification of adaptation measures that may be appropriate for specific geographic contexts.

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