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The effect of heat waves on dairy cow mortality

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ABSTRACT

This study investigated the mortality of dairy cows during heat waves. Mortality data (46,610 cases) referred to dairy cows older than 24 mo that died on a farm from all causes from May 1 to September 30 during a 6-yr period (2002–2007). Weather data were obtained from 12 weather stations located in different areas of Italy. Heat waves were defined for each weather station as a period of at least 3 consecutive days, from May 1 to September 30 (2002–2007), when the daily maximum temperature exceeded the 90th percentile of the reference distribution (1971–2000). Summer days were classified as days in heat wave (HW) or not in heat wave (nHW). Days in HW were numbered to evaluate the relationship between mortality and length of the wave. Finally, the first 3 nHW days after the end of a heat wave were also considered to account for potential prolonged effects. The mortality risk was evaluated using a case-crossover design. A conditional logistic regression model was used to calculate odds ratio and 95% confidence interval for mortality recorded in HW compared with that recorded in nHW days pooled and stratified by duration of exposure, age of cows, and month of occurrence. Dairy cows mortality was greater during HW compared with nHW days. Furthermore, compared with nHW days, the risk of mortality continued to be higher during the 3 d after the end of HW. Mortality increased with the length of the HW. Considering deaths stratified by age, cows up to 28 mo were not affected by HW, whereas all the other age categories of older cows (29–60, 61–96, and >96 mo) showed a greater mortality when exposed to HW. The risk of death during HW was higher in early summer months. In particular, the highest risk of mortality was observed during June HW. Present results strongly support the implementation of adaptation strategies which may limit heat stress-related impairment of animal welfare and economic losses in dairy cow farm during HW.
Key words: heat wave, dairy cow, mortality, welfare, global warming

INTRODUCTION

The effect of weather on livestock health is a topic of increasing concern, especially in light of the future scenarios on climate change. Climatologists forecast that earth's temperature will rise over coming decades and that the frequency of heat waves, a prolonged period of excessively hot weather, will increase in terms of frequency, intensity, and length (Beniston et al., 2007).

Climate scenarios for the temperature-humidity index (**THI**), an index that combines the simultaneous effect of temperature and humidity and that has been widely used to assess the degree of heat stress in livestock, were recently described for the Mediterranean area (Segnalini et al., 2013). For the coming decades, the study forecasted an increase of THI during summer months, which will likely cause thermal discomfort in livestock species with consequences on animal welfare, performance, health, and survival. In a previous study, we highlighted a greater frequency of deaths during summer months and indicated that approximately 80 and 70 THI were maximum and minimum, respectively, above which the number of deaths in dairy farms starts to increase significantly (Vitali et al., 2009).

The effect of heat waves on human mortality has been studied in depth (Ostro et al., 2009; Schifano et al., 2009; Li et al., 2011); conversely, this topic has been poorly investigated in livestock species. To the best of our knowledge, one study reported an increase in cattle deaths as consequence of a week-long heat wave in the mid-central United States during July 1995 (Hahn, 1999), and recently a French study analyzed the effect of heat waves which occurred during 2003 and 2006 on cattle mortality (Morignat et al., 2014). Hahn (1999) reported that the exposure to heat wave resulted in death losses as high as 5 to 10%, whereas the French study (Morignat et al., 2014) indicated that

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the increase of mortality during the heat waves was between 12 and 24%. Our retrospective study investigated the effect of heat waves on dairy cows mortality during a 6-yr period.

MATERIALS AND METHODS

Weather Data

Temperature and relative humidity data from 1971 to 2007 were obtained from 12 weather stations located in 12 Italian provinces. The provinces were selected on the basis of a weather station present in the area in operation at least since 1970 as well as having a significant number of dairy cows. Basic quality-control procedures of weather data were carried out by following the guidelines provided by the World Meteorological Organization (Zahumenský, 2004). The control procedures performed were relative to completeness, extremes values, variability, and internal and spatial consistencies. The missing and incorrect values of temperature and relative humidity in the whole series were estimated on the closest point of a regular grid (30 × 30 km). Daily values of each point were calculated starting from data recorded in the Italian weather stations network as reported by Perini et al. (2004). For each station, about the 5.4% of the data were replaced. Finally, for each station, time series data only referred to years 2002 to 2007 when THI was calculated. Calculation of THI was carried out by using the Kelly and Bond (1971) formula.

A heat wave is generally defined as a prolonged period of excessively hot weather. The lack of an official definition of heat wave is based on average weather conditions in the area and on normal seasonal temperatures (Robinson, 2001; Beniston et al., 2007; Russo et al., 2014). In our study a heat wave was defined as a period of at least 3 consecutive days when the daily maximum temperature exceeded the 90th percentile of the reference distribution (1971–2000; Russo et al., 2014). Therefore, heat waves were identified and characterized from May 1 to September 30 during the years 2002 to 2007. The percentile thresholds were determined empirically from the observed stations series in the climate period 1971 to 2000. The values of percentile were calculated from 5-d periods centered on each calendar day to account for the mean annual cycle. A total sample of 150 values (30 yr × 5 d) for each day of the year was generated. This approach ensured that extreme temperature events, in terms of crossings of percentile thresholds, can occur with equal probability throughout the year (Klein Tank and Konnen, 2003). The analysis of weather data were performed by the R Core Team (2014) software.

The days from May 1 to September 30 (2002–2007) were classified as days in heat wave (**HW**) or not in heat wave (**nHW**). The length of exposure to heat was considered and the days within each HW were counted. The exposure to HW was categorized as short (1 to 3 HW days), medium (4 to 6 HW days), long (7 to 10 HW days), and very long (>11 HW days).

Prolonged effects following exposure to heat is an important health topic, and no evidences of the excess in mortality following heat waves in livestock species exists. In humans, Basu and Samet (2002) reviewed the lag times with the strongest association of heat with mortality range from the same day to 3 d following an HW. In light of this, we also investigated potential prolonged effects and the 3 nHW days following the end of HW, categorized as first (**nHWst**), second (**nHWnd**), and third (**nHWrd**).

Cow Data

Mortality data referred to 46,610 counts (deaths) recorded in the 12 provinces selected from May 1 to September 30 during a 6-yr period (2002–2007; Table 1). Data were extracted from the Bovine Spongiform Encephalopathy databases available at the Italian Reference Centre for Animal Encephalopathies (Turin, Italy) and at the National Reference Centre for Animal Welfare (Istituto Zooprofilattico Sperimentale Lombardia ed Emilia Romagna, Brescia, Italy) as previously described (Vitali et al., 2009). Briefly, databases contained records of cows older than 24 mo that died on a farm from all causes, were slaughtered in an emergency, or were sent for normal slaughter but were found to be sick in the preslaughter inspection. The latter 2 categories accounted for approximately 2% of total deaths. For each death reported, the databases provided cow identification number (official ear tag), date of death, the identification number of the farm where the cow was before death, and the province where the farm was located. In general, it can be assumed that farms where the deaths were recorded were homogeneous for the production system adopted (intensive), and for stall design and management (total confinement freestall housing with no time at pasture, TMR as a feeding practice, and year-round calving patterns).

Age of cows were calculated and mortality counts were stratified by classes of age (expressed in months). The classes of age were ≤28, 29 to 60, 61 to 96, and ≥97 mo and were chosen according to those reported for cow consistency from Italian National Bovine Registry (BDN, 2010). In Table 1, statistics on the deaths and consistencies of cows stratified by age are reported. Table 1 also reports productive and reproductive statistics of dairy cows population involved in the study