508: Trends for Diurnal Temperature Variation and Relative Humidity and Their Impact on Milk Yield of Dairy Cattle in Tropical Climates

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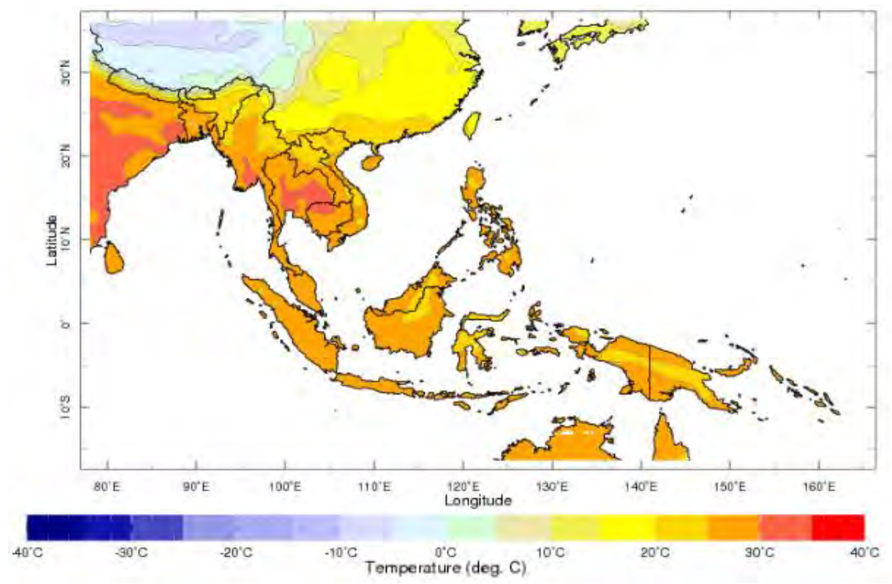
ABSTRACT

Climate change is expected to adversely affect agricultural production, in particular dairy farming. Ambient temperature and relative humidity are the main climatic factors influencing dairy production. The diurnal temperature variation in tropical regions (**DTV**; difference between daily maximum and minimum temperatures) should be considered with the relative humidity (**RH**) due to their large daily variation. The objectives of this study were to characterize the effect of **DTV** and **RH** on milk yield of dairy cattle, and their trends over time in Thailand. The dataset consisted of monthly test-day milk yields (46,444 records) from 5,080 first-lactation cows raised in 456 farms throughout Thailand. The climate data consisted of **DTV** and **RH** (76,619 daily records) collected from 2002 to 2014 by 17 stations of the Thai Meteorological Department (TMD) located near the dairy farms in this study. The mixed linear model considered herd-year-season of calving (HYS), age at first calving (AFC), days in milk (DIM), days in milk squared (DIM^2), **DTV** and **RH** as fixed effects, and animal, permanent environment and residual as random effects. All factors (HYS, DIM, DIM^2, **DTV** and **RH**) except AFC had an effect on milk yield ($P < 0.01$). **Milk yield increased as DTV increased** (b = 0.029 ± 0.007; $P < 0.01$), **whereas milk yield decreased as RH increased** (b = - 0.011 ± 0.002; $P < 0.01$). The correlation between **DTV** and **RH** was high and negative (r = -0.625; $P < 0.01$). The yearly LSM ranged from 9.30 °C (2011) to 10.29 °C (2004) for **DTV** and from 72.57 % (2004) to 75.23 % (2011) for **RH**. However, **the DTV (b = -0.005 ± 0.022; P > 0.05) and the RH (b = 0.076 ± 0.056; P > 0.05) trends from 2002 to 2014 were close to zero** and not significant. **These results confirmed the impact of climate effects (DTV and RH) on milk production of dairy cattle raised under tropical conditions, reiterating the need to account for these factors in both management and genetic selection programs.**

INTRODUCTION

Climate changes, including higher extremes (droughts, heat waves, storms and floods) have become stronger over the continental interiors of the world after the 1980s. Temperatures in tropical regions have increased by 0.1 to 0.3 °C per decade between 1951 and 2000 due to increases in green house gases (GHG; IPCC, 2007). Moreover, variation in temperatures has increased by 0.7 to 0.8 °C due to the effect of El Niño Southern Oscillation (ENSO) over the past century (Malhi and Wright, 2015). Climate anomalies in the tropics have been associated with ENSO and human activities. This increase in climate variability has negatively impacted natural resources, ecological systems, agriculture systems, and livestock production, particularly dairy farming (Thorn et al., 2009).

Most dairy cows in Thailand are kept in open barns. Thus, environmental effects such as air temperature, relative humidity, and changes in climate have a direct impact on cow productivity. Lactating dairy cows must be in thermal equilibrium with their environment. Generally, the weather in Thailand is hot and humid with substantial differences between maximum and minimum temperatures and changes in climate conditions in recent years. These changes are thought to increase the level of heat stress on dairy cows. Stress can negatively impact cow health, maintenance, and milk production. Therefore, the objective of this research was to characterize the effects of **DTV** and **RH** on milk yield and their trends over time in a multibreed dairy cattle population in Thailand.



MATERIALS AND METHODS

Dataset, animal and management: The dataset was composed of monthly test-day milk yield from 5,080 first-lactation-cows gathered between January 2002 to December 2014. Cows were from 456 farms located in Northern (79 farms), Northeastern (226 farms), Central (61 farms) and Southern (90 farms). Cows were the progeny of 771 sires and 4,285 dams. Cows were housed in open barns and they were milked twice a day (morning between 05:00 to 7:00 am, and afternoon between 03:00 to 05:00 pm). Farmers milked their cows using a bucket-type system. Test-day milk yields from individual cows were recorded once a month until dying off. Days in milk at test-day recordings ranged from 5 d to 320 d.

Breeds represented in the multibreed population were Holstein, Jersey, Red Dane, Brahman, Red Sindhi, Sahiwal, and Thai native. The breed most prominently represented was Holstein with the average breed fraction of 89% (SD = 10%). The average age at first calving was 31 mo (SD = 6 mo).

Climate data: Climate data consisted of daily diurnal temperature variation (**DTV**; °C) and relative humidity (**RH**; %) from 17 meteorological stations of the Thai Meteorological Department (TMD) located close to each farm. These stations were identified using the global positioning system (GPS). The average distance between a farm and its closest meteorological station was 35.58 km (SD = 13.53 km). The climate dataset contained daily weather information from 2002 to 2014 (12 yr). The **DTV** were calculated as the difference between daily maximum temperature (MXT) and minimum temperature (MNT). Seasons were classified as Summer (March to June), Rainny (July to October), and Winter (November to February).

Preparation and statistic analysis: Dairy production data (test-day milk yield) were merged with climate data (**DTV** and **RH**) by matching test-date and location in SAS (SAS, 2003). All traits were statistically described (mean, standard deviation, minimum and maximum). Then, the effect of **DTV** and **RH** on milk yield was analyzed using a mixed linear model that considered herd-year-season of calving (HYS), age at first calving (AFC), days in milk (DIM), days in milk squared (DIM^2), **DTV** and **RH** as fixed effects, and animal, permanent environment and residual as uncorrelated random effects.

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RESULTS AND DISCUSSION

Factors affecting daily milk yield: The average daily milk yield was 13.99 kg/cow/day (SD = 4.83 kg/cow/day). Milk yield was higher in winter (14.53 ± 0.65 kg/cow/day) than in the summer (13.93 ± 0.63 kg/cow/day) and rainy seasons (13.91 ± 1.97 kg/cow/day).

Country means were 11.37 °C (SD = 3.02 °C) for **DTV** and 69.43 % (SD = 8.33 %) for **RH** in winter (November to February), 10.22 °C (SD = 2.82 °C) for **DTV** and 72.36 % (SD = 9.40 %) for **RH** in summer (March to June), and 8.13 °C (SD = 1.91 °C) for **DTV** and 79.79 % (SD = 6.72 %) for **RH** in the rainy season (July and September). Winter had the highest **DTV** and the lowest **RH**.

All fixed effects, except for **AFC**, influenced milk yield ($P < 0.01$; **Table 1**). As expected, milk yield decreased as DIM increased both linearly (-0.010 ± 0.001 kg/d; $P < 0.01$) and quadratically (-0.010 ± 0.001 kg/d^2; $P < 0.01$).

Milk yield increased as **DTV** increased (b = 0.029 ± 0.007 kg/°C; $P < 0.01$). High **DTV** were observed in winter, which generally had low temperatures and low humidity, and had stronger association with **MNT** (night time) than with **MXT** (day time). Thus, dairy cows may get relief from heat stress during the evening and night cooling (Nassuna-Musoke et al., 2007)

Table 1 Regression coefficients and SE of daily milk yield on age at first calving (AFC), days in milk (DIM), days in milk squared (DIM^2), diurnal temperature variation (DTV) and relative humidity (RH)

Factor	Regression coefficient ± SE	P-value
AFC (kg/mo)	**-0.011 ± 0.012**	**0.37**
DIM (kg/d)	**-0.010 ± 0.001**	**< 0.01**
DIM^2 (kg/d^2)	**-0.010 ± 0.001**	**< 0.01**
DTV (kg/°C)	**0.029 ± 0.005**	**< 0.01**
RH (kg/%)	**-0.011 ± 0.002**	**< 0.01**

Conversely, milk yield decreased as **RH** increased (b = - 0.011 ± 0.002 kg/%; $P < 0.01$). Heat exchange between a cow and her environment (conduction, convection, and radiation, evaporation) depends on the existing thermal gradient. High **RH** could reduce a cow's respiratory and surface evaporation (sweating and panting) resulting in an upsurge of rectal temperature and heat stress, and a decrease in feed intake and milk yield (Kadzere et al., 2002; West, 2003).

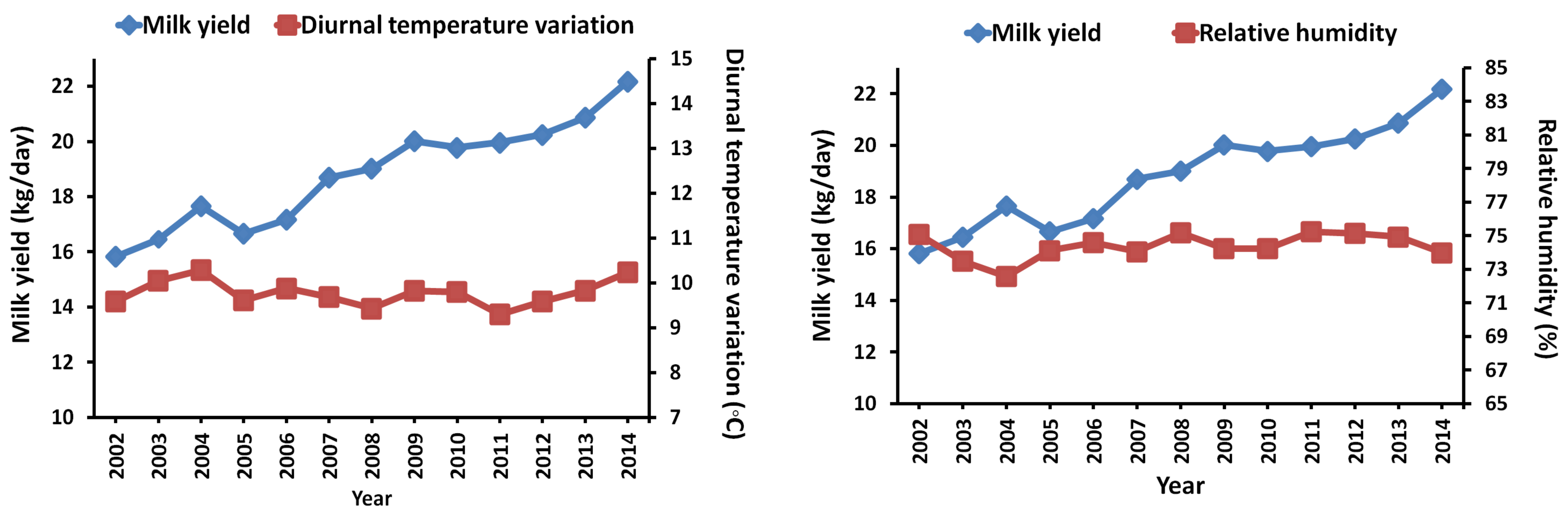

Fig. 1 Trends for Daily Milk Yield, Diurnal Temperature Variation, and Relative Humidity from 2002 to 2014

Table 2 Regression coefficients and SE of diurnal temperature variation (DTV), relative humidity (RH) and daily milk yield on year from 2002 to 2014

Trait	Regression coefficient ± SE	P-value
DTV (°C/yr)	**-0.005 ± 0.022**	**0.82**
RH (%/yr)	**0.076 ± 0.056**	**0.20**
Milk yield (kg/yr)	**0.478 ± 0.038**	**<0.01**

Trends for DTV, RH and milk yield: Yearly LSM ranged from 9.30 °C (2011) to 10.29 °C (2005) for **DTV**, and from 72.57 % (2005) to 75.23 % (2011) for **RH**. Trends for **DTV** (b = -0.005 ± 0.022 **°C/yr**; $P > 0.05$) and **RH** (b = 0.076 ± 0.056 %/yr; $P > 0.05$; **Table 2**) from 2002 to 2014 were near zero and not significant. However, the positive trend for milk yield (b = 0.478 ± 0.038 kg/yr; $P < 0.01$) indicated a positive impact of the Thai genetic improvement programs on this multibreed dairy population. This upward milk yield trend may also indicate an increase in adaptability of dairy cows to hotter and more humid environmental conditions during the years of the study. *These results highlighted the importance of **DTV** and **RH** for milk production in dairy cattle under tropical environmental conditions, and the need to account for these factors in genetic selection and management programs.*

FINAL REMARKS

- Milk yield **increased** as **DTV increased**
- Milk yield **decreased** as **RH increased**
- **Trends** for **DTV** and **RH** from 2002 to 2014 were **near zero**
- Suitable management and care changes are needed to reduce stress in dairy cows due to progressively hot and humid environmental conditions in Thailand

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