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Climatic Characterization of Manuel Fajardo Livestock Company, and its Relation to Performance Tests in Cuban Cattle

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ABSTRACT

Background: The strategies for cattle production development should rely on information of agro-meteorological characteristics, which determines production processes. The aim was to analyze the climatic conditions at the Genetic Livestock Company, home to the largest herd of Cuban Creole cattle, and its possible relation to the outcome of performance tests.
Methods: The information available about 1 375 animals tested during the 1982-2015 period was used. The final weight was adjusted to 540 days (AFW). The mean daily gain (MDG) and weight by age (WBA) were included. The monthly records of minimum temperatures (Tmin), medium temperatures (Tmean), relative humidity (RH) % were also available for the study. The temperature-humidity index (THI) was generated as well. Monthly and yearly analysis of variance and regression equations were performed to analyze the behavior of the climatic variables per year and month, the behavior of AFW, MDG, and WBA throughout time, and their relations with the climatic variables.
Results: The general means were, 19.19 ± 0.87 ^{0}C; 24.51 ± 0.63 ^{0}C; 78.64 ± 2.66 %; 74.23 ± 0.99 for Tmin, Tmean, RH, and THI, respectively. All the variables were influenced ($P \leq 0.001$) by the start month and year of PT, and the means for the tests. 334.43 ± 39.59 kg; 494.21 ± 107.81 g/day; 610.90 ± 77.25 g/day for AFW, MDG, and WBA, respectively. All the variables were affected ($P \leq 0.001$) by the start month and year, and the THI. The most accurate regression equations with R^2 > 94% were observed between AFW-THI and WBA-THI.

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Conclusions: A clear trend was observed toward a worsening of climatic conditions and the PT indicators throughout time. They are developed under conditions of climatic alertness, and were favorable only when they were initiated in the first quarter of the year, and December.

Keywords: Cuban Creole, performance tests, climatic variables (*Source: DeCS*)

INTRODUCTION

Climate change is a global phenomenon, and one of the most significant socioeconomic issues in the international agenda. There is a renewed interest in the effect of heat stress on livestock productivity as a result of this phenomenon, since temperatures are expected to increase, along with the frequency in which extreme climatic events occur.

The strategies for agricultural development must be supported by thorough knowledge of agrometeorological features of particular areas, which is a determining factor due to the relation of the productive process with these areas (Domínguez-Hurtado, Moya-Álvarez, and Estrada-Moreno, 2010).

Studies in this direction have been more numerous and comprehensive in dairy cattle; however, studies are not so abundant in meat cattle, particularly the ones including national breeds, perhaps because they are thought to be well adapted to tropical environments, and need no studies of this kind.

Tropical environments offer advantages and disadvantages for animal production. Among the positive aspects are high occurrence of precipitations, and constant daily sun radiation, which favor forage production through most of the year. On the other hand, the disadvantages are associated to the proliferation of internal and external parasites (Jiménez *et al*., 2007); diseases (White *et al*., 2003); high contents of cell wall in forages, which favor the generation of internal heat (Sánchez, Villareal, and Soto, 2000; Arieli *et al.*, 2004); and high humidity and relative temperatures that cause heat stress, affecting the expression of the genetic potential due to compromised welfare (Kadzere *et al*., 2006).

In recent years, a series of papers have tackled this issue, but mostly in relation to dairy production, such as Hernández *et al*. (2007) in Mexican Tropical Dairy Creole, Bohlouli *et al*. (2013) in Holstein in Iran, Carabaño *et al.* (2015 a, b) in Holstein in Europe, Europa, Polsky and von Keyserlingk (2017), in a bibliographic review, Guerra Montenegro *et al*. (2018) in Panamá, and Cheruiyot *et al*. (2019) in Holstein in Australia. In small ruminants, Menéndez-Buxadera *et al*. (2012) in Murciano-Granadina and Payoya, in Spain, analyzed heat stress on dairy production on the control day, as well as temperature-humidity index, and Hammami *et al*. (2014) consider studies on heat stress as a new characteristic that should be considered in genetic breeding.

Hence, the aim of this paper was to analyze the climatic conditions at the Livestock Genetic Company holding the largest Cuban Creole cattle herds, and its possible relation with performance tests.

MATERIALS AND METHODS

This research was developed at the Basic Company Unit called “Cupeycito”. It is located in quadrant 88 147 04 of Comandante Manuel Fajardo Genetic and Breeding Company, in the municipality of Jiguani, province of Granma. To the north, it has boundaries with Farm No. 2, San Jose del Retiro; to the north it borders Carretera Central (National Highway); to the east, with the small town Turcios Lima; and to the west, with Cautillo River.

Most grazing area (982.3 ha) contains native pasture, accounting for 98.3%. The forage areas represent only 4.4% of the farming area, which as a result of growingly intense droughts, may be insufficient to ensure the nutritional needs of herds during the dry season, with a considerable reduction in pasture yields. Some of the limitations include poor draining, between mid to strong, which covers 38.64-44.67% of the farming area, and salinity, which represents 12.38% of the land. Only 4.31% of the area has no limitations (Benítez *et al*. (2002).

The climatic localization of the area studied classifies as type II, subtype 6, which is defined as plains and heights with relatively stable seasonal humidity, high evaporation, and high temperatures.

The information was collected from 1 534 animals that underwent their performance test in the 1982-2017 period. The database was improved by removing all the animals with incomplete records, with unreliable data; the resulting number of animals in the 1982-2015 period was1 375.

Weight was adjusted at 18 months of age (540 days), based on the formula below:

$$\mathbf{PA18} = \left(\frac{\mathbf{P18} - \mathbf{PA}}{\mathbf{IPA} - \mathbf{P18}}\right)\mathbf{X\ 175} + \mathbf{PA}$$

Where:

PA = weight recorded at 1 year

P18=weight recorded at 18 months

IPA-P18 = day interval since the date weight was recorded, until weight is recorded at 18 months.

The temperature-humidity index was made according to Ravagnolo, Mistzal, and Hoogenboom (2000).

THI = 0.81*Te + (RH/100) * (Te – 14.4) + 46.4, where Te is mean environment temperature in ^{o}C, and RH is mean relative humidity in %.

The climatic indicators where obtained from the data provided by the local weather station in Contramaestre, based on monthly recordings

Analysis of variance were performed according to the SAS GLM procedure, to analyze the influence on the climatic variables: minimum and mean temperatures (^{o}C), relative humidity (%), and the temperature-humidity index (THI) of the effect of start month and year of performance tests, using

Yijk= µ + AIi + MIj + eijk

Where:

Yijk is the climatic variable analyzed (Tmin, Tmean, RH, and THI).

µ, the common general mean for all observations.

AIi and MIj start year and month of the performance test, respectively.

eijkl is the residual effect associated to every observation, with 0 mean, and σ^2 e variance.

THI was divided into 4 classes, according to some classifications in the literature, in: < 70 normal, 70-73 acceptable, 74-76 alert, and 77 danger.

Analyses of variance were performed using the same procedure mentioned above, to analyze the time behavior in the performance tests, as well as THI on AFW, MDG, and WBA using this mathematical model:

Yijkl = µ +AIi + MIj + ITHk +eijkl

Where:

Yijkl is the analyzed character of PFA, GMD, and PPE

µ, the common general mean for all observations.

AIi and MIj start year and month of the performance test, respectively.

THI is the temperature-humidity index in previously defined classes.

eijkl is the residual effect associated to every observation, with 0 mean, and σ^2 e variance.

The Tukey's test was used to detect significant differences between the means of significant variation sources.

RESULTS AND DISCUSSION

The influence of weather variables on cattle has been studied by several authors. Accordingly, some say that solar radiation, air temperature, and wind velocity have the greatest effects on the thermal state of animal bodies (Kulicov and Rudnev, 1987). Hence, Khalifa (2003) considers that proper description of the environment is necessary (climatic indexes) to estimate the capacity of heat-regulation and adaptation.

Relative temperature and humidity have also been used to study their influence on the parameters of the lactation curve in Brown Swiss cattle, in tropical conditions (Lucena, 2014), and on milk production on control days (Contreras and Manrique, 2014), including some physiological responses to heat and humidity on different genotypes (Espinoza *et al*., 2011).

Table 1 shows the general stratigraph of the climatic variables studied.

Table 1. Climatic variables studied

Variables	Mean	± SD	VC (%)
Minimum temperature (ºC)	19.19	0.87	4.53
Mean (ºC)	24.51	0.63	2.55
Relative humidity (%)	78.64	2.66	3.38
Temperature-humidity index	74.23	0.99	1.33

The results show relatively low variation coefficients, with the greatest variations in minimum temperature and relative humidity.

Regarding the mean temperature of the air (24.51ºC), Kulicov and Rudnev (1987) considered that it can be favorable to both tropical breeds, though the main cattle breeds used in Cuba are new breed crossings, or breeds that are more or less adapted to the Cuban conditions, with an important Bos taurus component; the Cuban Creole breed is within that group. Suárez *et al*. (2012) said that the production of meat from European cattle breeds is reduced when they are under the effects of constant temperature, approximately 25 °C. The effects gradually become more severe, with temperature values between 29 °C and 32 °C. In Zebu cattle under the conditions of the Sinu Valley, in Colombia, these effects become harder in temperatures above 32 °C.

The minimum temperature was lower than the one reported by Suárez Tronco *et al*., (2018) in several cattle raising companies in the country; the mean temperature was similar, but relative humidity was higher, with a similar THI.

A THI of 74.23 falls within mean stress (Armstrong, 1994; De Rensis, García-Ispierto, and López-Gatius (2015), but punctual values should be considered cautiously, due to variations that take place during the year in tropical conditions. Classifications and definitions differ among researchers. Armstrong (1994) considered that THI < 71 is within the comfort zone for dairy cows; 72-79 causes mean stress; 80-90 moderate stress; and > 90 causes severe heat stress. De Rensis *et al*. (2015) considered that THI < 68 is outside the danger zone; mean signs of stress are observed between 68-74 and ≥ 75 cause a drastic reduction of productive performance, and assure that THI is the main determinant of decisions in management. The previous results mainly apply to temperate and non-tropical areas in dairy cattle.

Table 2 summarizes the results of the analyses of variance of the 4 climatic variables.

Table 2. Overall results for the climatic variable studied

Variation sources	LG	Tmin	Tmean	RH	THI
		Significance			
Year start	33	***	***	***	***
Month start	11	***	***	***	***
R^2 (%)		84.40	86.98	66.03	88.36

Tmin=minimum temperature; Tmean=mean temperature; RH=relative humidity; THI=temperature-humidity index. * (P≤ 0.001) R^2 =determination coefficient.**

The starting year and month of the performance test were highly significant (P≤ 0.001) for all the climatic variables; the determination coefficients were relatively high, except RH, mostly due to the fact that the variations of such indicators depend on the two factors analyzed, and was more accurate in the case of THI, which is a complex index.

Kulicov and Rudnev (1987) noted that in tropical cattle, air temperatures between 16-24 ºC are ideal, and 24-27 ºC are favorable; the latter including the mean temperature.

Figure 1 shows a time tendency of increasing temperature in the location, and the linear regression equations produced a 0.05 ºC/year and 0.02 ºC/year in the minimum and mean temperatures, respectively (Table 3).

In dairy cattle from Panama, comfort and stress zones were identified, depending on the temperature. Besides, some antagonism was observed between heat tolerance and accumulated milk production (Guerra Montenegro *et al*. 2018).

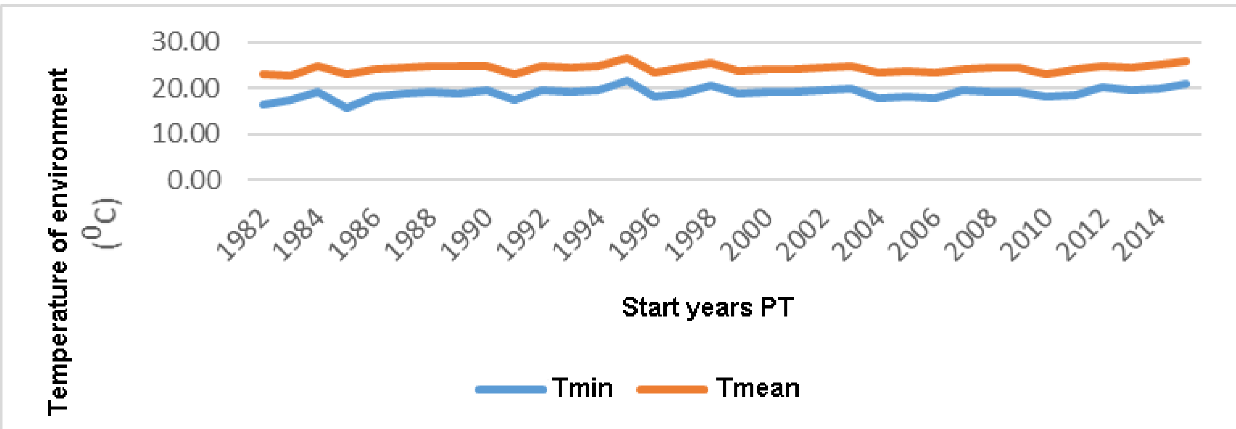

Figure 1. Time variations of mean and minimum temperatures at Manuel Fajardo Livestock Breeding Company

Relative humidity underwent a slight decrease, and THI increased slightly (0.02 units/year), as shown in figure 2, though the determination coefficient was very low. It is expected that climatic change makes a more hostile environment to livestock raising.

Table 3. Regression equations obtained

Variables	Equation	Type	R^2 (%)
AFW-year	$Y= 0.2685X^2 – 12.506X + 450.78$	Polynomial	52.41
Tmin-year	$Y= 0.0505X + 18.113$	Linear	17.44
Tmean-year	$Y= 0.0183X + 24.065$	Linear	4.74
RH-year	$Y= -0.07744 + 80.058$	Linear	11.42
THI-year	$Y= 0.0204X +73.68$	Linear	2.19
MDG-year	$Y= 0.5632X^2 – 25.731X + 728.9$	Polynomial	37.07
WBS-year	$Y= 0.5601X^2 +27.259X + 874.46$	Polynomial	59.73
AFW-THI	$Y= -8.4508X + 359.6$	Linear	95.68
MDG-THI	$Y= -17.325X + 546.18$	Linear	94.85
WBA-THI	$Y= -22.724X + 679.95$	Linear	89.00

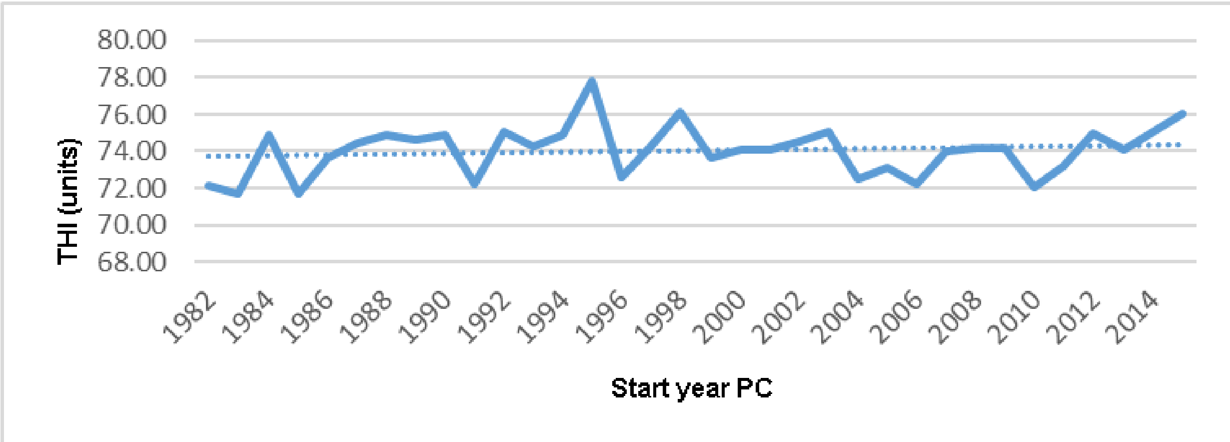

Figure 2. Time variations of the temperature-humidity index

Although all the regression equations were obtained in the climatic variables studied (Table 3), figure 3 only shows the one related to monthly THI, which fits a polynomic regression with a high determination coefficient (89.11%). A more favorable performance was observed in the coolest months, reaching 77.71 in August, which is not appropriate for animals, regardless of the fact that the cattle type used was Cuban Creole. Hernández *et al*. (2007) found that the climate in the Mexican tropical region showed great stability during the period studied, as well as clear seasonality between the dry and rainy seasons, with variable THI between the seasons, as shown in figure 3.

Table 4 shows the general statigraphs to evaluate performance tests, where the final weight is the main criterion for male selection, so far.

For 11 months, a relatively low variability (9.27%) was observed, with also low weight gains (494 g/day). The relative reduced variability of the fit final weight in the test (11.84%) was affected by data fitting to make them more comparable.

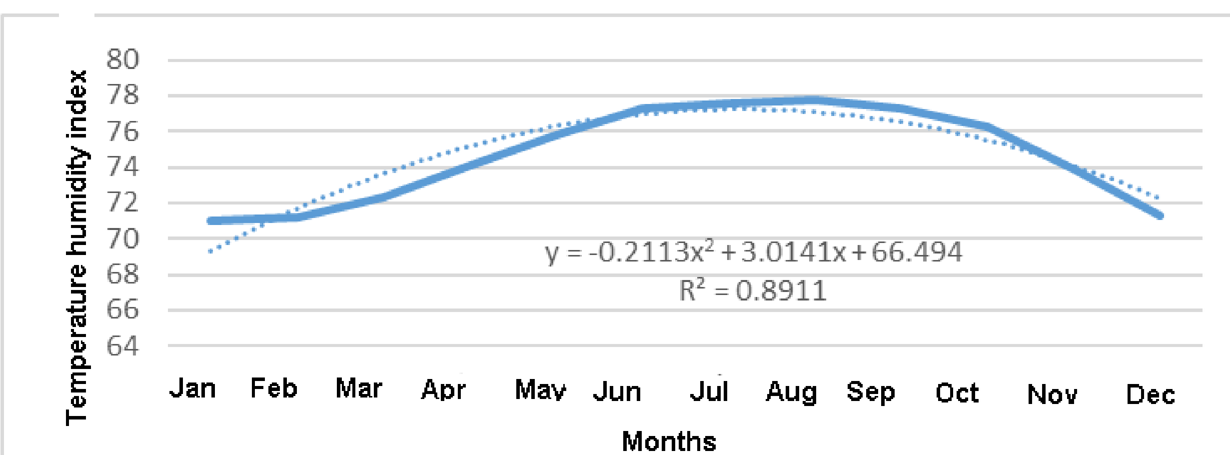

Figure 3. Monthly THI variation

Table 4. Statigraphs of gain and weight measurements evaluated in performance tests

Variables	N	Mean	± SD	VC (%)
Final weight fit (kg)	1 395	334.43	39.59	11.84
Mean daily gain (g/day)	1 395	494.21	107.81	21.81
Weight by age (g/day)	1 395	610.90	77.25	12.64
Test duration (days)	1 395	322.89	29.93	9.27

Table 5 shows the summarized results of the analyses of variance, in which the climatic conditions of year and month of the beginning of the performance test, and THI significance, were significant. The most accurate model, according to the determination coefficients was WBA.

Table 5. Results of analyses of variance in the performance tests

Variation sources	LG	AFW	MDG	WBA
		Significance		
Year start	33	***	***	***
Month start	11	***	***	***
THI	3	**	**	**
R^2 (%)		65.24	59.83	69.49

Figure 4 shows the decreasing trend of final weight in the performance test, which may be somehow influenced by a worsening in the climatic conditions, but also by other problems associated to the tests. The best regression equation fit was polynomial, with a 52.41% determination coefficient (Table 3). Arias, Mader, and Escobar (2008) mentioned that studies developed in the west of Canada, using data collected for seven years, during the winter, by Christison and Milligan (1974), indicated that the climatic variables, in general, and the average temperature, particularly, mainly affected daily weight gain, and the quantity of megacalories required for every kilogram of weight gained.

Similarly, figure 5 shows the evolution of mean daily gain and the weight by age, in the performance tests, logically, two parallel lines with a decreasing trend, which concords with AFW reduction in the test. The best fit regression equations were the polynomials (See Table 3).

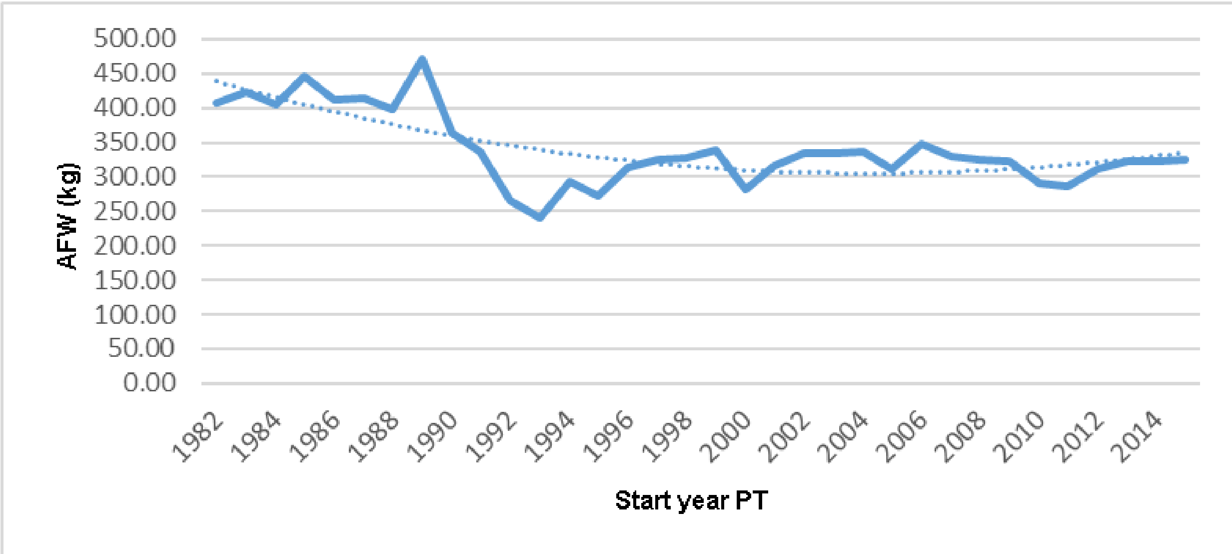

Figure 4. Year variation of AFW

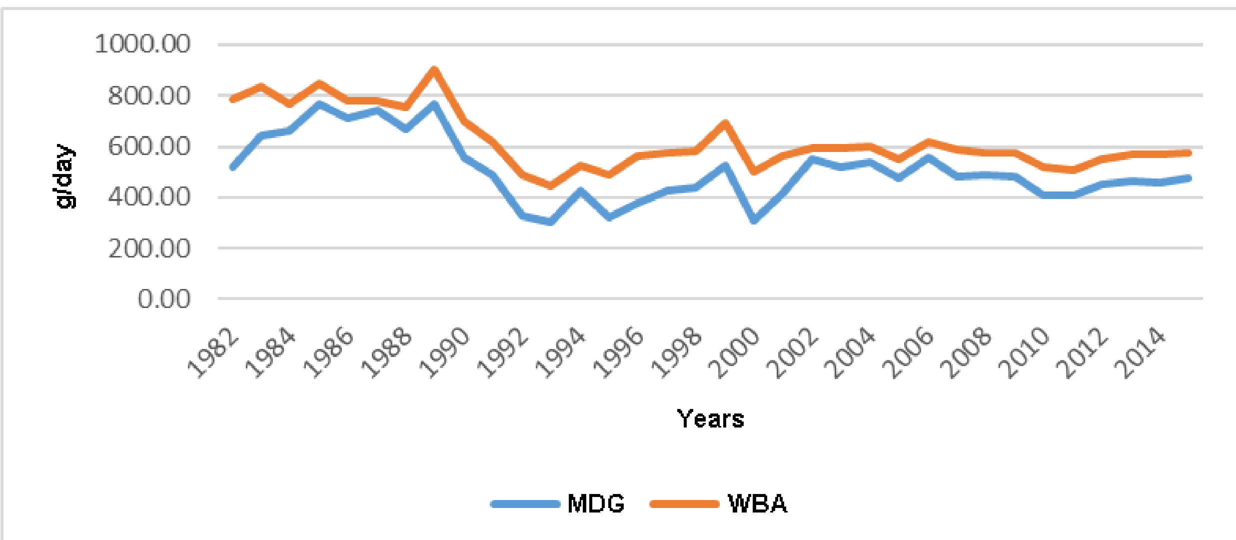

Figure 5. Year MDG and WBA variations

Figure 6 shows an important result, since a decreasing tendency was observed in AFW, during the test, depending on the start year of the test, which somehow supports the results shown in figure 4. The regression equation was more accurate (See Table 3), indicating a reduction in 8.45 kg of weight per every increase in the THI type. The MDG and WBA equations (Table 3) showed a similar behavior, and 3 had high determination coefficients.

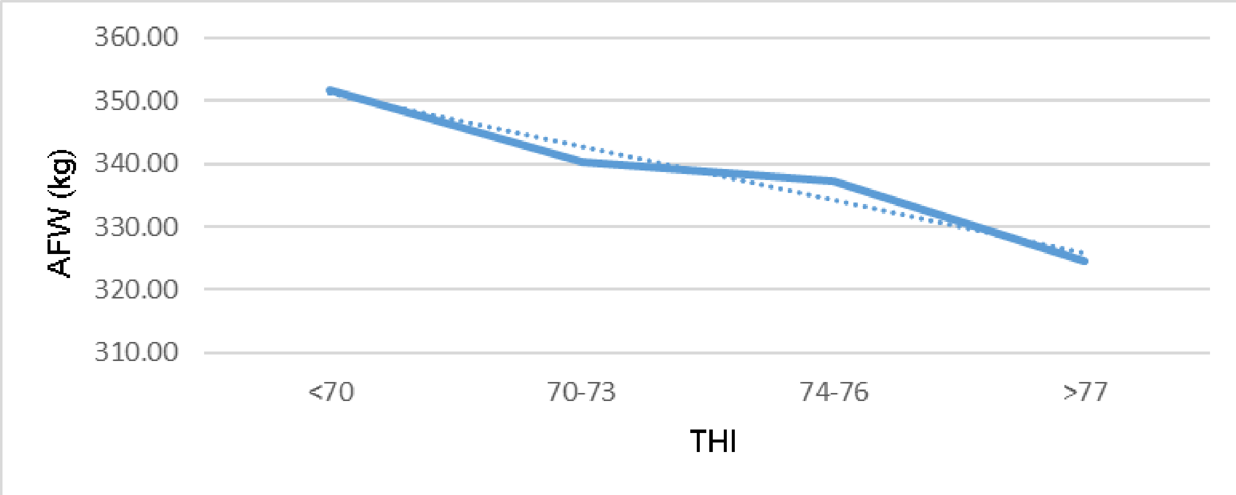

Figure 5. THI-dependent AFW performance

Hernández *et al*. (2007) demonstrated that the Dairy Tropical Creole cows in the tropical conditions of Mexico are not part of a homogeneous group due to stress. This allowed them to establish selection criteria for future programs including this breed, which may also be the case of the Cuban Creole cattle.

Carabaño *et al*. (2015a) concluded that in the dairy cattle from several European countries, a moderate stress is considered at 72 THI or higher, whereas Mellado *et al*. (2013) in the north of Mexico (arid environment) said that a 70-95 THI increase is associated to a decrease in the conception rate between 47% and 26%, and Ouarfli and Chehma (2018) studied the relationship between the variations of the temperature humidity index and the rate of success at first insemination in two breeds of dairy cows: Holstein and Montbeliarde, on 112 dairy farms in the northern Algerian Sahara, since 2010-2016. The results revealed that THI values higher than 80 led to a considerable drop of efficiency of insemination in the first service, to less than 50%, with negative correlations (-0.73 and -0.65) in Holstein and Montbeliarde, respectively. The analysis of monthly THI values observed in the animals from this Saharan regions, under heat stress between April and October, showed THI values way above the critical value of 72, with a negative impact on the productive and reproductive performance of dairy cattle in tropical and subtropical climates.

According to studies developed by Benítez *et al*. (1998), in the lower basin of Cauto River, in the province of Tunas, the climatic conditions are generally adverse through most of the year, and for several hours a day, hindering the implementation of cattle systems, using dairy or beef breeds, and the temperature humidity indexes were extreme throughout the year. A similar adverse situation was described by Valdés *et al*. (2003) in the results achieved in Siboney breed, in the Cauto Valley, which showed that permanence under stressing climatic conditions (temperature and relative humidity) through most of the year was a non-determining factor, but it had a marked influence on proper reproductive performance of the breeds in this region.

Farming demands efficient management of natural resources, including the climate, and the implementation of strategies that allow for adapting the negative animals for production.

CONCLUSIONS

There is a clear tendency to a slight worsening of the climatic conditions in time, which coincides with the prediction for climate change.

The indicators of performance tests have deteriorated through time.

The performance tests are mostly run under alertness conditions, with favorable results only in the first quarter of the year and in December.

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AUTHOR CONTRIBUTION

Conception and design of research: MAST, MRC, YCD, YLC, data analysis and interpretation: MAST, MRC, YCD, MCGR, MSMG; redaction of the manuscript: MAST, YCD.

CONFLICT OF INTERESTS

The authors declare no conflict of interests.