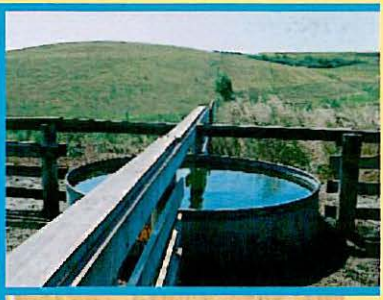
LIVESTOCK ENVIRONMENT VIII

Proceedings of the Eighth International Symposium



Iguassu Falls, Brazil
August 31 - September 4, 2008

CIGR
bea
ASABE

Livestock Environment VIII

Proceedings of the Eighth International Symposium Iguassu Falls, Brazil

August 31 – September 4, 2008

Published by

American Society of Agricultural and Biological Engineers
2950 Niles Road, St. Joseph, Michigan 49085-9659 USA
www.asabe.org

Copyright © 2008 By

American Society of Agricultural and Biological Engineers

All Rights Reserved

Library of Congress Card Number (LCCN) 2008940560
International Standard Book Number (ISBN) 1-892769-68-9

ASABE Publication 701P0408

American Society of
Agricultural and Biological Engineers

The American Society of Agricultural and Biological Engineers is not responsible for statements and opinions advanced in its meetings or printed in its publications. They represent the views of the individual to whom they are credited and are not binding on the Society as a whole.

Preface

On behalf of the entire Planning Committee, we welcome you to the Eighth International Livestock Environment Symposium (ILES VIII), held in Iguassu Falls, Brazil (*Foz de Iguazu*). This unique conference has its roots in 1974 and was initiated by the Structures and Environment Division of the American Society of Agricultural Engineers (now ASABE). Past Symposia have been held in Lincoln, Nebraska, USA; Ames, Iowa, USA; Toronto Canada; Coventry, England; Bloomington, Minnesota, USA; Louisville, Kentucky, USA; and Beijing China. The strong tradition of an *international* emphasis on livestock environment continues with this 8th ILES, both in content of these proceedings and in the manner in which the Symposium was planned and executed.

This is the first time that the ILES has been held in the southern hemisphere. It is quite appropriate that Brazil serve as the host nation. Brazil is a leading agricultural producer, ranking at the top in global poultry and livestock production. We thank the Brazilian Society of Agricultural Engineers (SBEA) for their willingness to serve as our local hosts.

In this Symposium, there were two concurrent tracks across the three-day event. One of these tracks was a fairly substantial focus on myriad aspects of agricultural air quality issues regarding quantification and mitigation of facilities emissions. The second track provided a venue for the traditionally broad subject matter of ILES, including animal responses to environment, management and tools, modeling, animal welfare, systems and techniques and thermal environment.

A unique aspect of this ILES VIII was that it was concurrently held with the SBEA annual conference and with a special conference for the World Society of Agricultural Engineering, CIGR. In total, seven specialty conferences and symposia were held at the same time and place, making this a truly international event of substantial scope.

We would like to recognize the hard work and dedicated efforts of the ILES Planning Committee: ASABE staff Ms. Jane Bruck and Ms. Sharon McKnight for all their help; Mariane Spina from Aqua Consultoria of Brazil for her great help on the program, facilities and proceedings; Professors Hongwei Xin (Iowa State University) and Tadayuki Yanagi, Jr. (Universidade Federal de Lavras) co-chairs of the Programming Committee; Professors Richard Stowell (University of Nebraska) and Eileen Wheeler (The Pennsylvania State University) co-chairs of the Proceedings Committee; Professor Ilda de Fatima Tinôco (Universidade Federal de Viçosa) as Virtual and Technical Tour Chair; Professor Jarbas Honorio de Miranda (Universidade de São Paulo – ESALQ) as the SBEA Liaison; and Professor Irenilza Nääs (retired, State University of Campinas), President of CIGR, for her many efforts to make this entire event an outstanding success.

Table of Contents

Monitoring & Modeling Systems

Monitoring Systems – Animal Activity

Monitoring Systems – Data Acquisition & Transfer

Strategies to Minimize Effects of Hot Climate Conditions on Livestock in Portugal: A Regional Approach

J. C. Barbosa[1], V. F. da Crus[2], and J. S. Silva[3]

[1] Instituto Politécnico de Bragança. Bragança, Portugal, bb@ipb.pt

[2] Universidade de Évora. Núcleo da Mitra, Évora, Portugal

[3] Ministério da Agricultura, DRAP-Norte. São Torcato, Portugal

Abstract. *In Portugal, animal production is of major significance, both economically and socially. Livestock are especially important to those regions in which agriculture is the main economic activity. Situated in Southwestern Europe, Portugal has a Mediterranean climate with hot and dry summer. Livestock farmers have to deal with high temperatures and with their effects on animal production. In most cases, breeders are not prepared to handle animals under high temperatures; they lack facilities and/or knowledge about this problem. We have begun work with the aim of developing strategies to monitor and prevent harm to animals (housed or raised outdoors) during the summer months. We need to identify the Portuguese regions most seriously affected by this problem, as well as where and for how long high temperatures occur most frequently. Both individual days with very high temperatures and heat waves are becoming more and more common in Portugal. The past four summers have been among the hottest ever registered. Since 2003, eight heat waves have occurred. We chose two locations in Portugal's Northeast to carry out a preliminary study in order to evaluate the occurrence of hot climate conditions in recent years; to develop methods of obtaining that data; and to learn how climatic factors (mainly temperature) evolve over the course of the summer. We can conclude that in this region livestock are commonly exposed to high temperatures for long periods. It is necessary to develop strategies to protect animals from the effects of such conditions.*

Keywords. *Hot climate, Heat waves, Animal husbandry*

Introduction

Portugal is located in Southwestern Europe (37° to 42° N and 9.5° to 6.5° W). Although it has a large Atlantic coast, its climate is mainly Mediterranean. In general, winters are cold and wet; and summers are hot and dry. In terms of temperatures, winter is cold, mainly in the North and especially in northeastern regions; summer is hot, particularly in Alentejo (South) and northeastern regions. Rainfall occurs mainly in winter and summers tend to be dry. In littoral areas, the climate is milder and the rain is more frequent.

With a surface of 92 391 km^2, Portugal is a small country. However, it is marked by a great diversity of climate from region to region, which has an effect on agricultural activity and also on the animal production in each region. In addition to other factors, these climatic conditions have a major influence on the geographical distribution of domestic animal species.

Animal production (mainly meat and milk) represents 32% of the Portuguese Agriculture Product (MADRP, 2007). In the above context, animal production has a great importance, both economically and socially. In some regions, livestock are of quite central significance, especially in those areas in which agriculture is the main economic activity, such as inland, and near the frontier with Spain.

In addition to other disadvantages due to local or regional constraints, livestock farmers in inland regions have to deal with high temperatures in summer. Moreover, in these regions, periods of several consecutive days with very high temperatures, or even heat waves, are becoming more and more frequent. In fact, in recent years, temperatures in summer have tended to be higher. These adverse climate conditions can affect livestock and animal production and may bring about serious problems or harm to animals and as well as losses to the farmer.

It is recognized that high temperatures, associated with dry air, or even wet air, have several effects on animals. Heat stress decreases voluntary feed intake (Fuquay, 1997; Nienaber et al, 2004); disturbs animal activity and interactive social behavior (Frazzi et al, 1998; Hahn, 1989); retards animal growth (Cruz et al, 2000); affects carcass composition and meat quality (Nienaber et al, 1987); and decreases milk production while lessening milk quality (West et al, 2003; Perissinotto et al, 2005). Adult animals are prepared to face adverse climate conditions, although within limits. High temperatures combined with a lack of the necessary equipment to air condition inside buildings, or deficient regulation in indoor climatization of animal housing, may cause losses in animal production. Livestock in extensive systems, or raised outdoors, can be

affected by high temperatures associated with humidity, as well as by the absence of shade, airflow or wind. The risk increases when these conditions persist for several consecutive days (Nienaber et al, 2004).

In several regions of Portugal, the buildings for livestock are not suitable for animal housing under high temperatures and they lack appropriate equipment to control indoor environmental conditions. Livestock in extensive systems, especially in inland regions, remain exposed for long periods to high temperature conditions; and, in these regions, most of the breeders have difficulty dealing with these climatic factors. Bearing this in mind, we intend to study the situation in different regions to help breeders tackle the problem.

Actual Situation in Portugal

Hot Climate Conditions

The map in Figure 1 shows the spatial distribution, for each region, of the average values for daily Maximum Air Temperature in summer 2006 (along the months of June, July and August).

In this map we can identify the regions where high temperatures more frequently occur: Alentejo, (in the South) and the inland Northeast. Generally, the periods of high temperatures are combined with dry air, that is, low relative humidity values. Considering the values at 15:00 h in inland areas, we found that, in general, the relative humidity is under 50%.

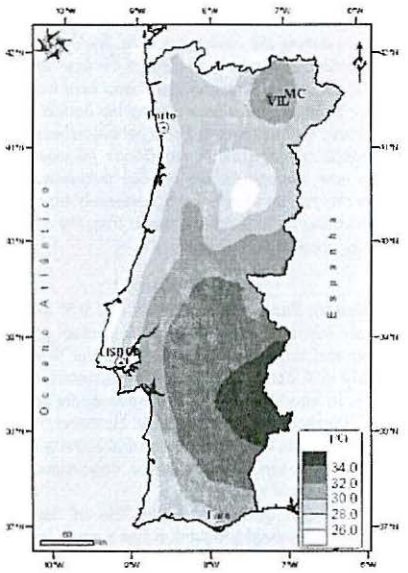


Figure 1. Distribution of maximum air temperature (°C) in summer 2006 (source: IM, 2006).

Significantly high temperatures have become more frequent. According to IM (Instituto de Meteorologia) in recent years, the average of the Mean Air Temperature in summer (June, July, August) has tended to be above the average of the reference period (1961-1990). This period refers to the years between 1961 and 1990, according to the Climatological Standard Normals (WMO, 1983). In fact, in reference to the five hottest summers since 1931, we have:

- Summer 2005 (anomaly in mean air temperature: + 2.38°C)
- Summer 1949 (anomaly in mean air temperature: + 1.98°C)
- Summer 2004 (anomaly in mean air temperature: + 1.92°C)
- Summer 2003 (anomaly in mean air temperature: + 1.91°C)
- Summer 2006 (anomaly in mean air temperature: + 1.80°C)

Four summers from recent years are among the hottest summers since 1931.

Another consequence of this trend is the regular occurrence of heat waves. The World Meteorological Organization considers that a heat wave occurs whenever there are, at least, six consecutive days with a maximum temperature of five degrees over the average for the reference period. According to the Heat

Wave Duration Index, since 2003 eight heat waves have occurred in Portugal. They are as follows: in 2003, from 29 July to 14 August; in 2005, from 30 May to 11 June, during eleven days, with temperatures over 40ºC in some places; and again in 2005 from 15 to 23 June with temperatures over 40ºC degrees, in several regions. Maps in Figure 2 show the regions that were most affected by these heat waves revealing large areas predominantly in the inland regions

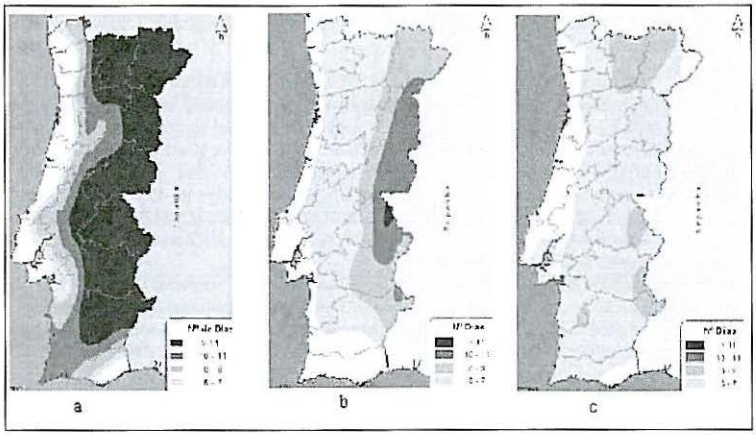


Figure 2. Duration (days) of heat waves in July 2003 (a); May (b) and June (c) 2005 (source: IM, 2007).

In summer 2006, again, we had five heat waves in the period from May to September (Figure 3). In summer 2006, again, we had five heat waves in the period from May to September (Figure 3). These five heat waves affected different regions for several days. On 7 July a heat wave began that had the greatest territorial extension ever registered.

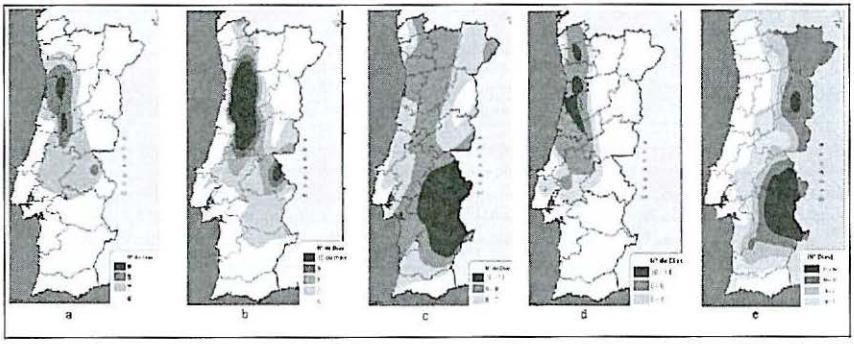


Figure 3. Duration (days) of heat waves in 2006: May (a), June (b), July (c), 2 August (d) and 27 August (e) (source: IM, 2006).

From 27 August to 9 September marked the longest heat wave ever registered, with a duration of 14 days in some places. In the maps from Figure 3 we can see a new feature in territorial distribution: there were heat waves that affected littoral regions instead of the inland areas.

High temperatures are more and more common, and this frequency can cause problems in animal housing or even in livestock raised outdoors.

Animal Production

Livestock and poultry are found all over Portugal, but they have different predominance from region to region. Pig production is more common in the littoral Center and in Alentejo, in the South. Poultry predominates in the center and littoral North. Beef cattle is more common in Alentejo (extensive systems) and in the littoral North (intensive systems), whereas dairy cattle can mainly be found in the littoral North

and the Azores Islands. Sheep and goat farming is more common in the inland regions of the center and North.

Looking at the maps in preceding Figures, it is obvious that the regions with a higher risk of high temperatures or extended heat waves (especially Alentejo, in the South, and the inland regions) are the regions in which animal production is very significant. For example, considering the number of animals by region, we can estimate that 77% of sheep and 54% of goats, in Portugal, are located in regions with a significant risk of heat waves or occasional high temperatures. Thus it is important to inform breeders about the risk of such conditions.

Hot Climate Conditions: A Regional Approach

We have begun work with the aim of developing strategies to monitor and prevent harm to housed animals due to hot climate conditions in Portugal. However, apart from regular meteorological data, the information available about other aspects of this problem is scarce. We need more detailed information about high temperature occurrence; regions that have been affected (and may be affected) and the importance of their animal husbandry; the level of the farmers' knowledge to deal with the situation; and data on the losses caused by these adverse climatic conditions. Moreover, institutions and associations (breeders, producers, public services) are recognizing the problem and are becoming concerned about the way in which farmers will deal with the situation.

We chose two locations (Macedo de Cavaleiros and Vilariça) in the Northeast of Portugal to carry out a preliminary study in order to evaluate the occurrence of hot climate conditions in recent years; to develop ways of obtaining the necessary information; and to get to know how climatic factors (mainly temperatures) evolve over the course of the summer. Macedo de Cavaleiros (MC) and Vilariça (VIL) are located in Trás-os-Montes, a region in which high temperatures occur frequently (see previous Figure 1).

Data were collected by weather stations from Instituto Politécnico de Bragança located in MC (lat 41° 32' N long 6° 57' W) and VIL (lat 41° 13' N long 7° 06' W) and were registered every ten minutes. We selected data about temperature, relative humidity and wind speed, between 1 May and 30 September, over the last three years.

In this region, livestock production consists mainly of sheep and goat farms that produce milk for cheese-making, generally in extensive systems and very few with permanently housed animals. There are, also, some beef cattle farmed in extensive systems and there are a few swine, rabbit and poultry farms.

Temperature

Preliminary data about temperatures show that hot climatic conditions are frequent on summer days in this region. In general, temperatures in VIL are higher than temperatures in MC, and the highest temperatures were registered in VIL, as we can see in Table 1.

Table 1. Highest temperatures registered during years 2005 to 2007.

Location	Highest temperature registered (°C)	Date
VIL	43	7 August 2005
VIL	41	17 July 2006
VIL	42	Several days (Jul, Aug, Sep) 2007
MC	38	7 August 2005
MC	36	17 July 2006
MC	36	4 August 2007

The longest hot period occurred in VIL from 27 June to 14 August 2006 (49 consecutive days) when the daily maximum temperature was always over 30°C (including six days over 40°C and seven days when the daily minimum temperature was over 22°C). From 1 June to 31 August over half of these days registered a daily maximum temperature above 29 °C.

Figure 4 shows the evolution in temperature and relative humidity, in VIL, from 27 August to 9 September 2006. The last days in this period coincide with a heat wave (see previous Figure 3).

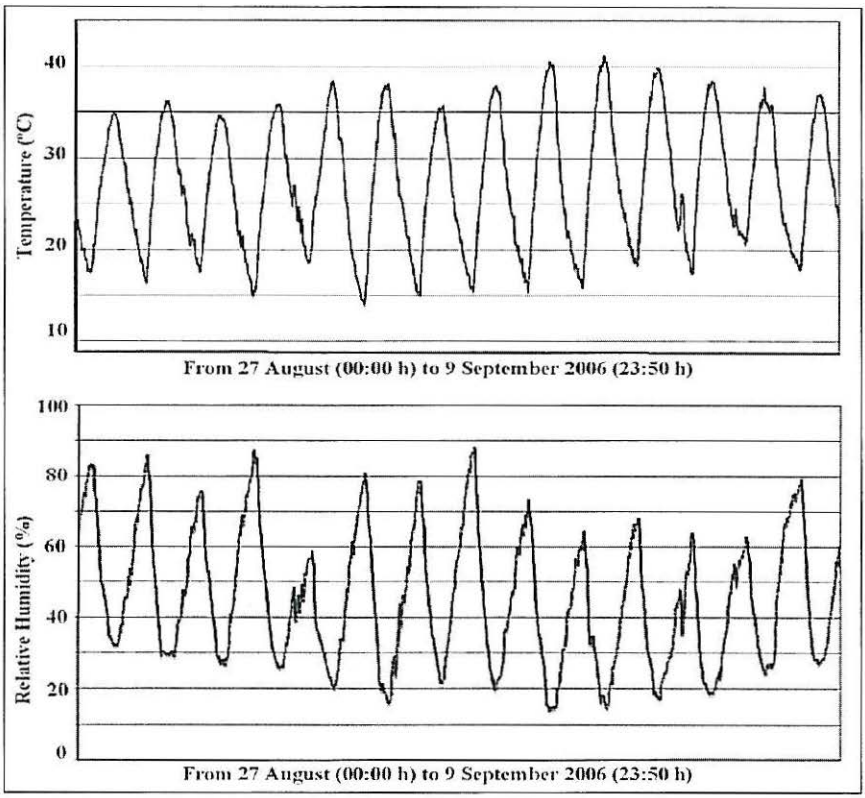


Figure 4. Temperature and relative humidity, in Vilariça. Values are registered every ten minutes.

Relative Humidity

In Portugal, generally, periods of high temperatures are combined with dry air, that is, low relative humidity values; and that was what happened in the region studied. Both MC and VIL had several days with the maximum value for relative humidity under 70% (during the night) and several days with values under 20% (coincident with the hours of high temperatures). This relationship is clear in the chart from Figure 4.

Wind Speed

Generally, air speed is very slow. Considering data from wind speed during the summers of the last two years, at VIL, the average is 1.136 m/s and the highest speed reached 4.94 m/s. Per hour, 57% of the time the air velocity is under 1.0 m/s.

Conclusion

In recent years, several heat waves have occurred in Portugal. In addition, very high temperatures have also been registered on occasion. Inland regions, such as those we studied in the Northeast, are experiencing adverse hot climatic conditions more and more frequently. This presents a new challenge to livestock farmers.

In the region we studied, livestock have been exposed to high temperatures for long periods, and it has becomes clear that it is necessary to promote strategies to prevent animals from experiencing the harmful effects of hot climatic conditions.

Mitigation actions can involve evaporative cooling systems (sprinkling; fogging; or pad-and-fan system). Taking into account the values of temperature, relative humidity and wind speed and, especially, the ways in which temperature and relative humidity fluctuate in summer, we may assume that these cooling systems can effectively minimize the impact of hot climatic conditions. As we saw, the local climate in

summer is hot and dry, and the combination of these conditions contributes to the efficiency of evaporative cooling systems.

But we are aware that farmers (especially breeders of beef cattle, sheep and goats in Portuguese inland regions) lack knowledge about these techniques and equipment. Moreover, extensive farming systems, which are characteristic of some Portuguese inland regions, present some particular issues. In these cases, farmers raise local breeds (sheep, goats and beef cattle) in extensive systems or outdoors. In extensive systems, it is important to provide shade to livestock, since the use of evaporative cooling systems can be difficult or even unsuitable.

To carry out mitigation actions in Portuguese inland regions it is advisable to collect more information, especially concerning extensive farming systems; and to assess farmers' ability to assume new procedures. For that purpose, we intend to proceed with the studies about climatic conditions in different regions and to develop a set of strategies to help breeders tackle this problem.

References

Cruz, V.M.F., J. Le Dividich, and M. Cancela D'Abreu. 2000. Efeito das altas temperaturas nas performances de suínos em fase de crescimento e engorda. O caso do Alentejo. Options Mediterranénnes, Serie A, nº 41 pp: 313-318.

Frazzi, E., L. Calamari, F. Calegari, and L. Stefanini. 1998. Behavior of dairy cows in response to different barn cooling systems. In: International Dairy Housing Conference, 4. St. Louis, Missouri, 1998. St. Louis: ASAE, pp: 387-394.

Fuquay, J. W. 1997. Heat stress and it effects animal production. *Livestock Environment*, 2: 1133-1137.

Hahn, G.L. 1989. Body temperature rhythms in farm animals - A review and reassessment relative to environmental influences. *Biometeorology*. Supplement to International Journal of Biometeorology. pp. 271-283.

IM (Instituto de Meteorologia). 2007. Climatologia: o clima. Instituto de Meteorologia, Lisboa, Portugal. Available at: http://www.meteo.pt/pt/clima/clima.jsp (acessed Sep 2007)

IM (Instituto de Meteorologia). 2006. Informação Climática. Verão 2006. Instituto de Meteorologia, Lisboa, Portugal.

MADRP (Ministério da Agricultura, do Desenvolvimento Rural e das Pescas). 2007. Plano Estratégico Nacional – Plano de Desenvolvimento Rural 2007-2013. Available at: http://www.gppaa.min-agricultura.pt/drural2007-2013/doc/PEN_set06.pdf (acessed Jan 2007)

Nienaber, J.A., and G. L. Hahn. 2004. Engineering and management practices to ameliorate livestock heat stress. In: *Proceedings, International Symposium of the CIGR. New Trends in Farm Buildings*, Lecture 6, 1-18. May 2-6, 2004, Évora, Portugal. CD-Rom.

Nienaber, J.A., G. L. Hahn, and J. T. Yen. 1987. Thermal environment effects on growing-finishing swine. Part II – Carcass composition an organ weights. *Trans. ASAE* 30: 1776-1779.

Perissinotto, M., V. M. Fitas da Cruz, E. Lucas, and D. J. Moura. 2005. Potencial de utilização do arrefecimento evaporativo na bovinocultura leiteira durante períodos de stress térmico no Alentejo. Actas do XV Congresso de Zootecnia, I Congresso Ibero-Americano de Zootecnia, Vila Real, pp: 529-532 (artigo aceite para publicação na Revista Portuguesa de Zootecnia).

West, J. W., B. G. Mullinix, and J. K. Bernard. 2003. Effects of Hot, Humid Weather on Milk Temperature, Dry Matter Intake, and Milk Yield of Lactating Dairy Cows. *Journal Dairy Science*. Vol. 86: 232-242.

WMO (World Meteorological Organization). 1983. Climatological Standard Normals - Averages of climatological data computed for the following consecutive periods of 30 years: 1 January 1901 to 31 December 1930, 1 January 1931 to 31 December 1960, etc" (WMO No. 100 – 1983).

2950 Niles Road, St. Joseph, MI 49085-9659, USA
269.429.0300 fax 269.429.3852 hq@asabe.org www.asabe.org