Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias

Ciba

ISSN: 2007 - 9990

Evaluación del comportamiento bioclimático de la vivienda residencial en zona suburbana-rural para determinar la acumulación de temperatura

Evaluation of the bioclimatic behavior of residential housing in a suburban-rural zone to determine temperature accumulation

Avaliação do comportamento bioclimático da viva residencial em uma área suburbano-rural para determinação da acumulação da temperatura

Carlos Alberto Fuentes Pérez
Universidad Autónoma de Tamaulipas, México
cfuentes@docentes.uat.edu.mx
http://orcid.org/0000-0001-9525-4326

Resumen

En la **introducción** se aclararon varios aspectos que caracterizan la vivienda residencial suburbana-rural en el municipio de Juárez, Nuevo León, y que se relacionaron con la arquitectura bioclimática-ambiental. El estudio estableció la valoración de las soluciones constructivas y su adaptación térmica local, mientras que el análisis de los aspectos bioclimáticos implicó el comportamiento térmico de oscilaciones variables de temperatura. El **objetivo** principal de este trabajo residió en caracterizar la temperatura del aire que osciló en dos espacios estratégicos de la vivienda residencial estudio de caso, que fueron el pasillo central en planta baja y la galería en planta alta, así como determinar la diferencia + térmica acumulada al interior en 2017. El **método** se empleó con base en el comportamiento bioclimático que fue el hilo conductor de la investigación, por medio de los factores que influyen en la comodidad variable de temperatura al exterior e interior de la vivienda residencial estudio de caso, por la tendencia del microclima y sus variaciones térmicas en el municipio de Juárez, Nuevo León. Los **resultados** residieron en gráficos bioclimáticos, con su discusión cuantitativa en tablas, que determinaron las oscilaciones de temperatura para comprender si la vivienda residencial se adaptó al clima local por medio de la diferencia + de temperatura acumulada durante el mes y día típico crítico de agosto. Las **conclusiones** explican los resultados cuantitativos y los hallazgos que avanzan en la comprensión del tema de la vivienda residencial bioclimática.

Palabras clave: comodidad variable, comportamiento bioclimático, residencia suburbana.

Abstract

In the **introduction**, several aspects that characterize suburban-rural residential housing was clarified in the municipality of Juárez, Nuevo León, and related to bioclimatic-environmental architecture. The study established the assessment of constructive solutions and their local thermal adaptation, while the analysis of the bioclimatic aspects involved the thermal behavior of variable temperature oscillations. The main **objective** of this work was to characterize the air temperature that oscillated in two strategic spaces of the residential housing case study: the central corridor on the ground floor and the gallery on the top floor, as well as to determine the thermal difference + accumulated to the interior in 2017. The **method** was used based on the bioclimatic behavior that was the guiding thread of the research, by means of the factors that influence the variable temperature comfort to the exterior and interior of the residential housing case study, by the trend of the microclimate and its thermal variations in the municipality of Juárez, Nuevo León. The **results** are in bioclimatic graphs with their quantitative discussion in tables, which determined the temperature oscillations, in order to understand whether the residential housing was adapted to the local climate by means of the cumulative temperature + difference during the typical critical day and month of August. The **conclusions** explain the quantitative results and the findings that advanced in the understanding of the topic of bioclimatic residential housing.

Keywords: variable comfort, bioclimatic behavior, suburban residence.

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

Resumo

Na introdução, vários aspectos que caracterizam a habitação residencial suburbana-rural foram esclarecidos no município de Juárez, Nuevo León, e relacionados à arquitetura bioclimática-ambiental. O estudo estabeleceu a avaliação de soluções construtivas e sua adaptação térmica local, enquanto a análise dos aspectos bioclimáticos envolveu o comportamento térmico de oscilações de temperatura variáveis. O **objetivo** principal deste trabalho foi caracterizar a temperatura do ar que oscilou em dois espaços estratégicos do estudo de caso de habitação residencial, corredor central no piso térreo e a galeria no último andar, e também determinam a diferença térmica + acumulada no interior em 2017. O **método** foi utilizado com base em comportamento bioclimático que foi o fio orientador da pesquisa, por meio dos fatores que influenciam o conforto de temperatura variável para o exterior e o interior do estudo de caso de habitação residencial, pela tendência do microclima e suas variações térmicas no município de Juárez, Nuevo León. Os **resultados** residiram em gráficos bioclimáticos e com sua discussão quantitativa em tabelas, que determinaram as oscilações de temperatura, para entender se a habitação residencial foi adaptada ao clima local por meio da temperatura cumulativa + diferença durante o dia e mês crítico típico de agosto. As **conclusões** explicam os resultados quantitativos e os resultados que avançam na compreensão do tema da habitação residencial bioclimática.

Palavras-chave: conforto variável, comportamento bioclimático, residência suburbana.

Fecha recepción: Agosto 2017 **Fecha aceptación:** Diciembre 2017

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias   Ciba   ISSN: 2007 - 9990

Introduction

It is predicted that climate change will cause an increase in sea level, more frequent and extreme climatic phenomena and hotter, drier summers, as well as warmer and wetter winters. Montalban and Neila (2016) indicate that this will have a significant impact on the design of the houses: how they will stay fresh and how they will be subjected to more extreme weather conditions. The residential sector is already a significant environmental burden with a high associated operational energy. Climate change and a growing population that requires residency have the potential to exacerbate this situation in earnest.

New paradigms are required, say Kinnane, Gray and Dyer (2017), for the design of residential housing that allows the operation of low carbon dioxide to mitigate climate change. They must also face the reality of unavoidable climate change and adopt strategies to adapt to it in order to face future scenarios. However, any strategy of climate adaptation for housing must also be aware of the adaptation of the needs of the occupants, influenced by the aging of the population and new technologies (Croitoru, Nastase, Sandu and Lungu, 2016).

Victoria, Mahayuddin, Zaharuddin, Harun and Ismail (2017) state that the design of bioclimatic housing is essential to adapt to local climates and provide comfort to the inhabitants, while promoting the characteristics of energy saving. Comfort within the residence can be achieved with less dependence on artificial lighting and mechanical ventilation and with the application of environmentally friendly materials that are environmentally friendly and excellent for absorbing heat, as well as allowing natural ventilation, providing comfort to the occupants.

The analysis of the architectural aspects refers to the type of construction, the form, the materials and construction techniques, while the analysis of the bioclimatic aspects involves the thermal behavior of the construction of the roof slab and the visual , suitable with the microclimate of the environment. For Oikonomou and Bougiatioti (2011) the objective of any bioclimatic study is to document and evaluate, both qualitatively and quantitatively, the aforementioned aspects, in order to draw conclusions about the principles that characterize this architecture and can be integrated into the renovation of housing existing residential properties or the design of new ones.

The traditional architectural typologies of residences can play a crucial role in the contemporary environmental architectural framework due to the numerous attempts - developed in the last decades - to adopt a model of passive housing and bioclimatic criteria. According to a climate-sensitive approach, the interactive and adaptive relationship between construction, site and climate considers a basic rule to reduce environmental impact and improve energy efficiency in residences. In recent years, this concept has extended to the preservation of the cultural identity of places. A high level of adaptive, sustainable and functional performance can be inferred from residential homes, which are based on a series of adaptable and sustainable principles derived from the integration of active and hybrid design approaches (Salkini, Greco and Lucente, 2017).

The bioclimatic design of a residential house refers to the planning of its spaces according to the climate of the region, in order to guarantee the best interior conditions. Both new and existing housing must adapt to climate change to maintain a comfortable and healthy indoor climate. Preferably, the adaptation measures applied in the construction level scale do not require additional energy, ie passive measures. Some previous studies showed that passive measures of adaptation to climate change can have a positive effect on the thermal comfort in summer of residential homes without air conditioning (Van Hooff, Blocken, Timmermans and Hensen, 2016).

The form of the residence and the thermal characteristics regulate to a great extent the amount of energy consumed by the house. To avoid major design flaws, Simurda and Bodnar (2015) state that an architect must include the assessment of the energy consumption of the house in the early stages of the design process.

A changing climate will produce overheating in summer with high temperatures in which conventional residential housing design approaches do not adequately address the risk of future warming. This risk can not be completely identified and avoided, unless historical climatic information and adaptation measures related to construction are considered. (Gul y Menzies, 2012).

The research shows that the residential housing industry in Mexico -say Corobov et al. (2013) - maintains compliance with traditional masonry design methods, in which overheating is not considered a serious concern, whether current or future. At present, no detailed overheating evaluations of the design stage are performed to reduce overheating to the interior as in the residential housing case study.

This work presents several aspects that characterize the residential architecture of the municipality of Juárez, Nuevo León, and may be related to bioclimatic and environmental architecture. The study is based on the documentation and analysis of the architectural and bioclimatic aspects of the residential housing case study. It was also found that the long dwelling of the municipality of Juárez, Nuevo León, practices the bioclimatic residence design. The housing case study, with its passive design for lighting and ventilation -with its constructive solutions-, contributes to its natural adaptation to the warm climatic conditions in the tropical climate. The findings are expected to generate ideas for the design of bioclimatic housing for other modern residences in a tropical climate.

This article discusses the comfortable bioclimatic limits of air temperature in internal environments, where practical observations and theoretical models are related to the thermal sensations of the user of residential housing. Some of the currently accepted models consider the human capacity of adaptation to the environment, reinforcing the old theory that, inside the dwellings, the user's thermal preferences vary depending on the climatic conditions. Even these models, however, generally adopt constant intervals of thermal comfort throughout the day hours. The assumption discussed here is that comfort temperatures accompany the hourly oscillation of the outside temperature.

Thermal comfort has been defined as the mental condition that expresses the satisfaction of the individual with its thermal environment ANSI-ASHRAE (2004). Regarding the definition of environmental conditions of thermal comfort, Vellei, Herrera, Fosas and Natarajan (2017) argue that, among international experts, there are two schools of thought. One of them assumes that, because they are biologically identical, people from any part of the planet must have the same thermal preferences. This group believes, therefore, that comfortable temperature limits can be universal.

The other, say Adekunle and Nikolopoulou (2016), adopts an adaptive approach, as it ensures that, when an environmental change occurs that causes discomfort, users seek to take measures that restore the conditions of thermal comfort. These measures can be from changing clothes to opening or closing windows, operating fans or adjusting a sun protection awning, among others.

There are varied equations of thermal comfort for different climates. Patidar, Jenkins, Banfill and Gibson (2014) deduce that the differences found by several researchers, over time, confirm the need for field studies to be developed in each region.

In addition to potentially representing a greater detail of the concept of temperature comfort zone, in bioclimatic studies -with a model of hourly variation of comfortable limits- there would be other advantages, some of them related to studies on climate adaptation in residential housing. . To identify the effects of each constructive variable on the environmental comfort or on the energy efficiency of residential housing in the municipality of Juárez, Nuevo León, the cumulative values of thermal excess by heat were generally calculated, in days-hour-grade, at Throughout the days of the month and the typical day, considering August the critical month of high temperatures in 2017.

Research hypothesis

If the evaluation of the bioclimatic behavior is carried out, it will be verified that the constructive system adapts to the local climate, determining the accumulation of temperature inside the residential house in the municipality of Juárez, Nuevo León.

Methodology

According to the level of scientific knowledge and observation that the researcher expects to reach, he formulates that the present investigation is, in the first instance, a diachronic study, conformed as a case study, according to the type of information that is expected to be obtained, as well as the level of analysis that must be carried out.

The methodology to be implemented is of multimodal type and by triangulation, since the different methods applied offer a quantitative approach to the problem, facilitating the analysis of the case study in order to evaluate it. At the same time, this research is based on several types of studies to achieve ideal results such as descriptive, bibliographic and field.

Likewise, research is a procedure that allows focusing attention on the behavior of the residential housing case study to obtain broad and deep information, as well as to contrast it bioclimatically. Interview, observation, document analysis and thermal measurement were used. Therefore, it is an experimental research applied to identify bioclimatic temperature patterns only, not previously made, in this type of residential housing in Juárez, Nuevo León.

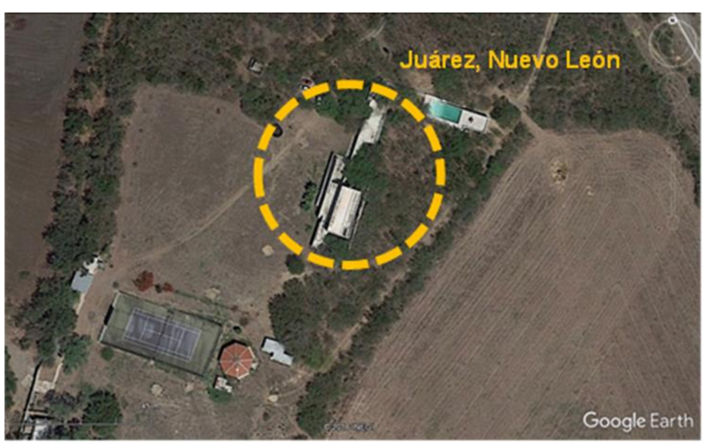
Historical climate analysis of the municipality of Juárez, Nuevo León, Mexico

As a starting point, the historical climate analysis of the municipality of Juarez, Nuevo León, where it is developed from different methodological perspectives, is determined. First, the data are analyzed based on the climatological normals from 1992 to 2016, to achieve the normal means of all climatic variations with a minimum of error, provided by the Meteorological Station of the National Water Commission (CONAGUA). The climatology is contrasted with the thermal data obtained from the digital instruments placed outside the residential housing case study in the critical month, with the highest temperatures of the year.

Determine the study area of residential housing

Based on the urban analysis and growth of the state of Nuevo Leon, it is determined that the study area for residential housing is suburban-rural of 24 hectares, as it is presented in the study area in the municipality of Juárez, Nuevo León , and the location of the residential housing case study (figure 1).

Figura 1. Ubicación de la vivienda residencial estudio de caso



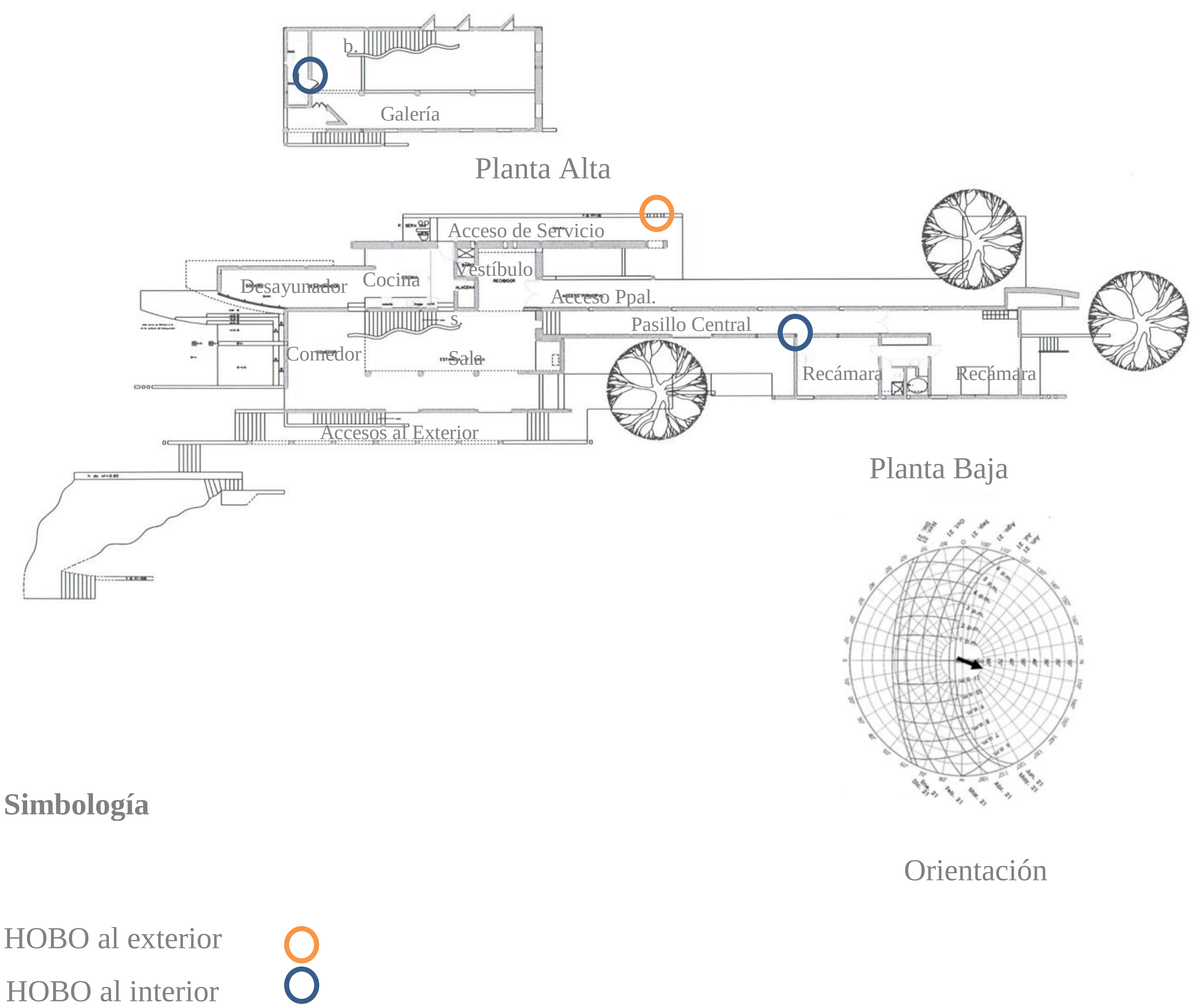
Fuente: Google Earth Pro (febrero de 2017)

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias Ciba ISSN: 2007 - 9990

The residential housing is presented, next, with its architectural plants; In total, it covers 1 000 m2 of construction. It also shows where the digital instruments - called HOBO - were placed for thermal measurements inside and outside the residential housing case study (figure 2).

Residential housing case study

Figura 2. Plantas arquitectónicas y colocación de instrumentos de medición



Fuente: Elaboración propia

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

Figura 3. Vista del pasillo central a la galería en planta alta

Fuente: Elaboración propia

Measurement tools

The thermal measurements are made inside with the HOBO data logger UX100-003 brand Onset with intervals of one hour. For the experiment, the data loggers are located only in well-defined spaces in the public zone -the central hall- and the intimate zone of study and work -galería- (figure 3) for the residential dwelling. According to Velasco et al. (2017), the measurements of air temperature of the spaces varies according to the various factors and activities that influence day and night, both on the ground floor and on the top floor.

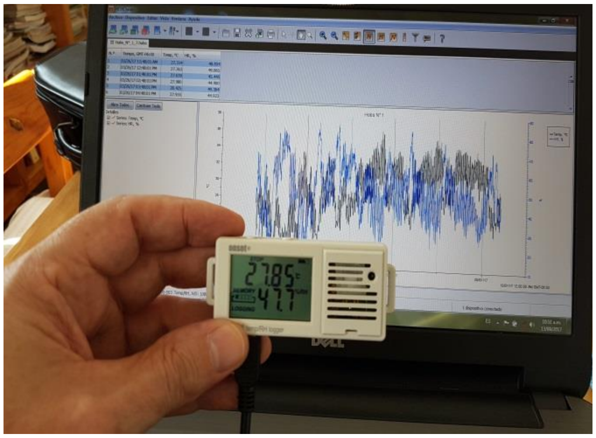
Tabla 1. *Especificaciones del HOBO data logger UX100-003*

Rango de temperatura:	-20.0 ºC a +70.0 ºC
Precisión en temperatura:	± 0.4.0 °C
Rango de humedad relativa:	25.0 % a 95.0 %
Precisión en humedad relativa:	± 04.0 %
Capacidad:	64K bytes
Intervalos de muestreo seleccionables:	0.5 segundos a 9 horas
Duración de la batería:	1 año aproximadamente

Fuente: Elaboración Propia

The instruments are most reliable and accurate (figure 4). However, it is essential, before its placement, a series of verifications prior to its final installation.

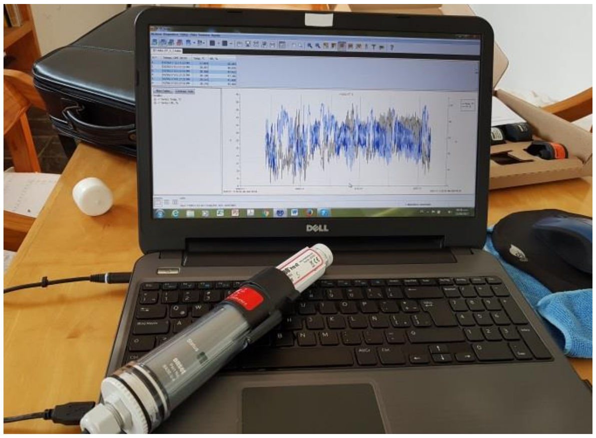
Figura 4. HOBO data logger UX100-003 de interiores



Fuente: Elaboración propia

There are also the HOBO U23 Pro v2, Onset brand (figure 5) for the outdoor temperature of the residential home. Lantitsou and Panagiotakis (2017) state that they must be placed at a considerable height -at least four meters high- during a year and detail the critical month of high temperature, which in this case is August 2017.

Figura 5. HOBO U23 Pro v2 de intemperie



Fuente: Elaboración propia

Specifications of the HOBO U23 Pro v2, data logger

• Outdoor housing for use in the field and high condensation environments.

• High accuracy.

• HR sensor replaceable by the user, allowing a faster response to recovery in condensing conditions.

• External sensors of reduced diameter for installation in confined spaces.

• Optical USB port to transfer data quickly and safely.

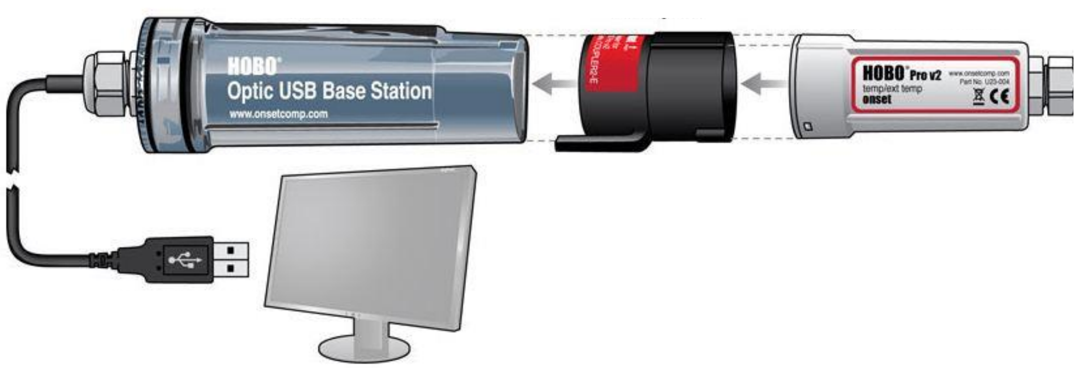
• HOBO Waterproof Shuttle for data handling and recovery in the field.

Required software

An Onset brand U-4 optical base station with coupler is required to operate the HOBO Pro v2.

The HOBO Waterproof Shuttle for transporting field data can also be used as a base station (Figure 6).

Figura 6. Estación base óptica U-4



Fuente: Onset (noviembre de 2017)

In order to preserve the high-resistance housing of the HOBO Pro v2, it is not necessary for them to be placed in any type of structure for their protection. Pérez, Thief of Guevara and Boned. (2016) state that the hour-grade is adjusted and the agreement with the official time in Mexico is made.

Daily log of thermal measurements

The measurements presented by each HOBO UX100-003 data logger of Tmr of the internal spaces and the HOBO U23 Pro v2 with values of T. and H.R. from the outside, where they are placed - say Naima, Mebirika, Belkacem and Claude-Alain (2016) - are exported to a Microsoft Excel spreadsheet in which a table is made with the full exported measurements of air temperature in degrees Celsius (° C) with two decimal places and relative humidity expressed as a percentage with two decimal places, which are used for the entire investigation, as well as to compare with the measurements of air temperature and relative humidity provided for the historical climate analysis by CONAGUA. In the same way, they are used to perform, analyze and manage the information on average temperature and relative humidity per hour, day, week and month -from March 2017 to March 2018-, beginning each change of season in spring 2017.

The daily log of measurements is made up of values of the climatological information - done hour by hour - of each one of the spaces of the residence case study and organized by columns during the year of 2017-2018 in the Microsoft Excel spreadsheet as follows:

Measurement number-date and time-T inside per hour UX100-003 -T daily average indoor UX100-003 -T average weekly indoor UX100-003-T monthly average indoor UX100-003-Daily thermal expansion between the micro and macroclimate UX100 -003-Thermal expansion per hour UX100-003-T outside per hour CONAGUA-T daily average outside CONAGUA-T weekly average outside CONAGUA-T monthly average outdoor CONAGUA-Daily thermal expansion between macro and mesoclimate CONAGUA-Thermal expansion per hour Outdoor CONAGUA-T per hour of U23 in its case-T daily average outdoor U23-T weekly average outdoor U23-T monthly average outdoor U23-Daily thermal expansion between micro and mesoclimate U23-Thermal expansion per hour U23-all these in ° C.

Also in the same worksheet:

Measurement number-date and time-Internal HR per hour UX100-003- Average daily interior HR UX100-003- Average weekly indoor HR UX100-003- Indoor monthly average HR UX100-003-Daily thermal expansion between the micro and the UX100 macroclimate -003-Thermal expansion per hour UX100-003- Outdoor HR per hour CONAGUA- Average daily HR outdoor CONAGUA- Average weekly outdoor CONAGUA- Average monthly outdoor HR CONAGUA-Daily thermal expansion between macro and mesoclimate CONAGUA-Thermal expansion per hour CONAGUA- External HR per hour of U23 if applicable- Average daily HR outside U23- Average weekly average HR U23- Average monthly outdoor HR U23- Daily thermal expansion between micro and mesoclima U23- Thermal expansion per hour U23- All these in percentage.

Elaboration of bioclimatic graphs of temperature (T) in variable comfort zone

The graphs that are made in the zone of variable temperature comfort approach the climatic reality of each space determining, where the bioclimatic behavior of days of comfort, excess and thermal loss of T is obtained, in order to obtain the maximum difference of the days-hours-degree above the upper limit and the minimum, which is the sum of the accumulated days-hours-grade below the lower limit of the variable temperature comfort zone, as well as the minimum thermal amplitude and maximum monthly average temperature.

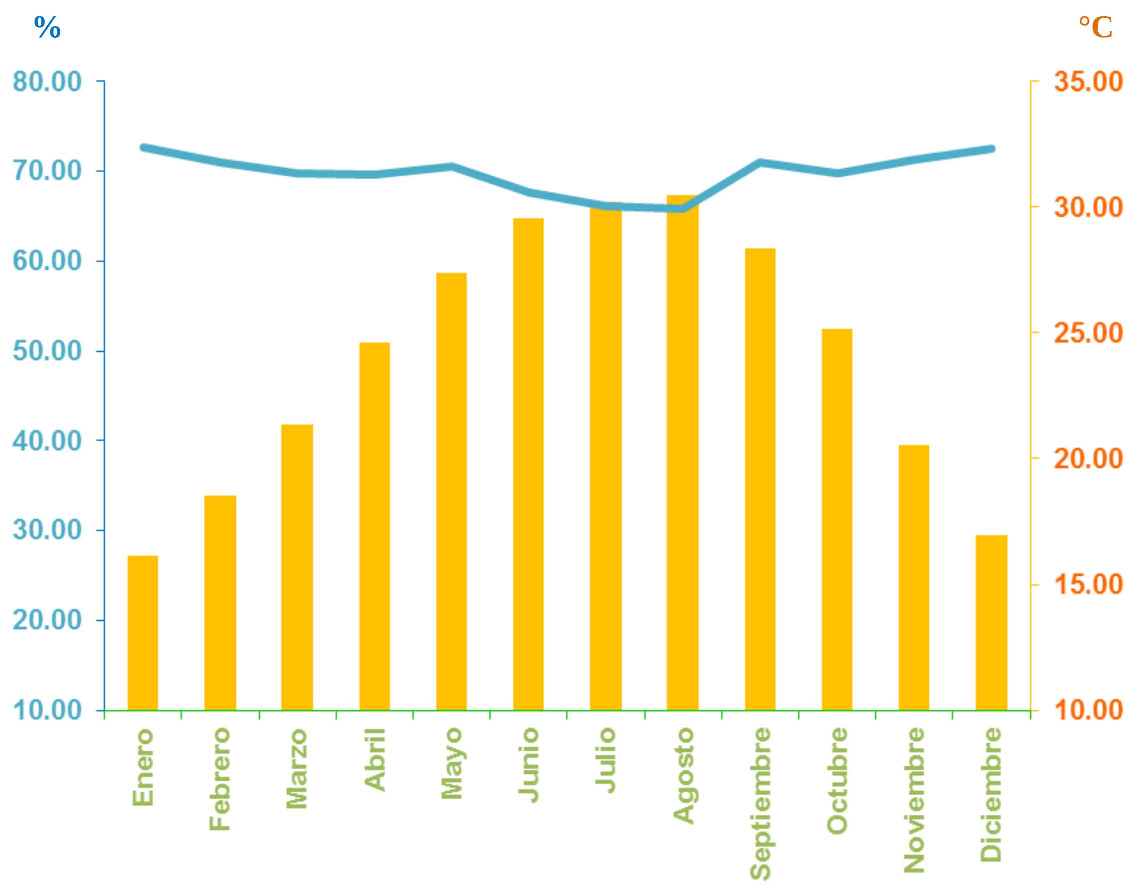
This type of graph -with variable comfort zone- is made after having obtained the upper and lower limits, which fluctuate in 2.5 ° C of the neutral line, in which it allows to be less than 40% of amplitude of variation of the temperature Exterior; that's why it's closer to reality (Roriz, 2003).

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias Ciba ISSN: 2007 - 9990

Results

Historical climate analysis of the municipality of Juárez, Nuevo León, Mexico

Figura 7. Temperatura y humedad relativa media mensual de 1992-2016



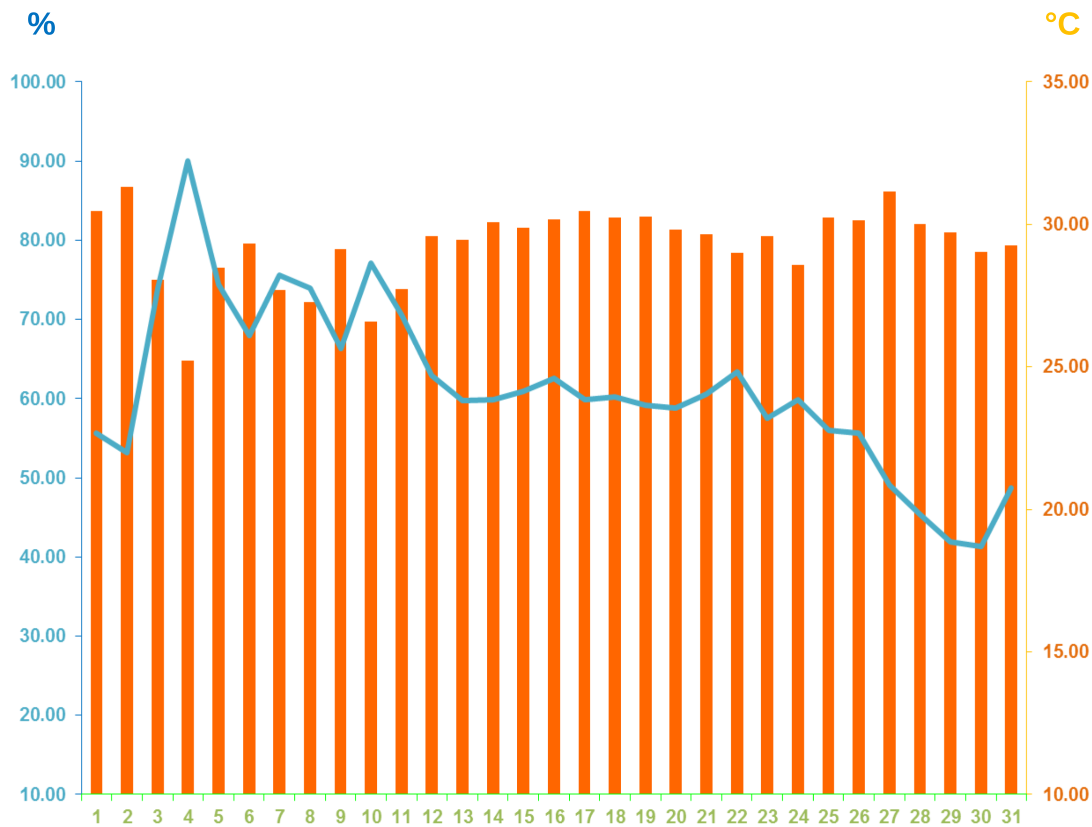
Fuente: CONAGUA (2017)

Tabla 2. *Representación de colores de la Figura 7*

Temperatura del aire
Humedad relativa

Fuente: Elaboración Propia

Figura 8. Temperatura del aire y humedad relativa exterior (agosto de 2017)



Fuente: HOBO U23 Pro v2

Tabla 3. *Representación de colores de la Figura 8*

Temperatura del aire
Humedad relativa

Fuente: Elaboración Propia

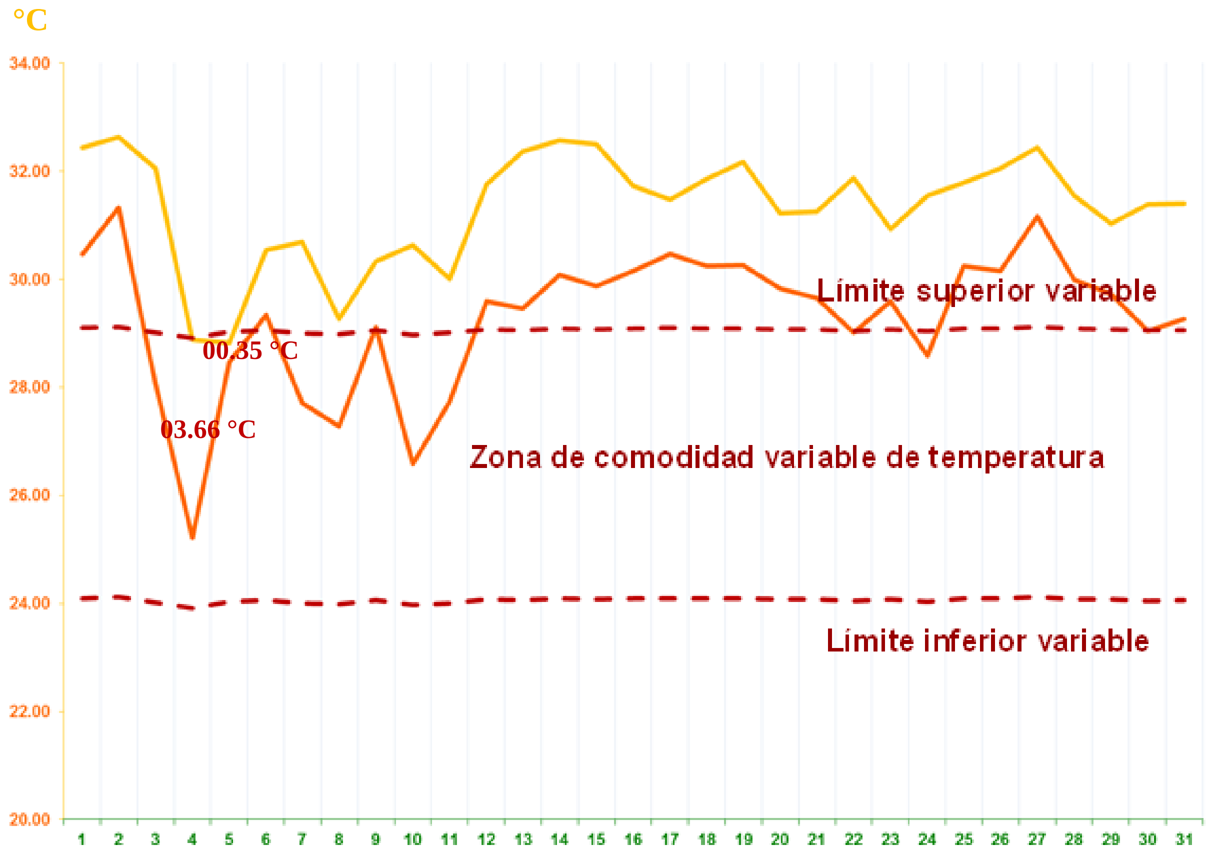
Tabla 4. *Temperatura y Humedad relativa media de Figura 8*

Temperatura media del aire **29.28°C**
Humedad relativa media **61.35%**

Fuente: Elaboración Propia

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias Ciba ISSN: 2007 - 9990

Figura 9. Zona de comodidad variable de temperatura en galería (agosto de 2017)



Fuente: Valores interiores HOBO N° 1. Valores exteriores HOBO U23 Pro v2

Tabla 5. *Días, temperaturas y diferencia térmica en la galería (agosto de 2017)*

Temperatura interior	Temperatura exterior
Días de comodidad de temperatura	**2**
Días de demasía de temperatura	**29**
Días de pérdida de temperatura	**0**
Temperatura media mensual interior	31.33 °C
Temperatura media mensual exterior	29.28 °C
Diferencia -	00.00 °C
Diferencia +	59.35 °C

Fuente: Valores interiores HOBO N° 1. Valores exteriores HOBO U23 Pro v2

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

Discussion

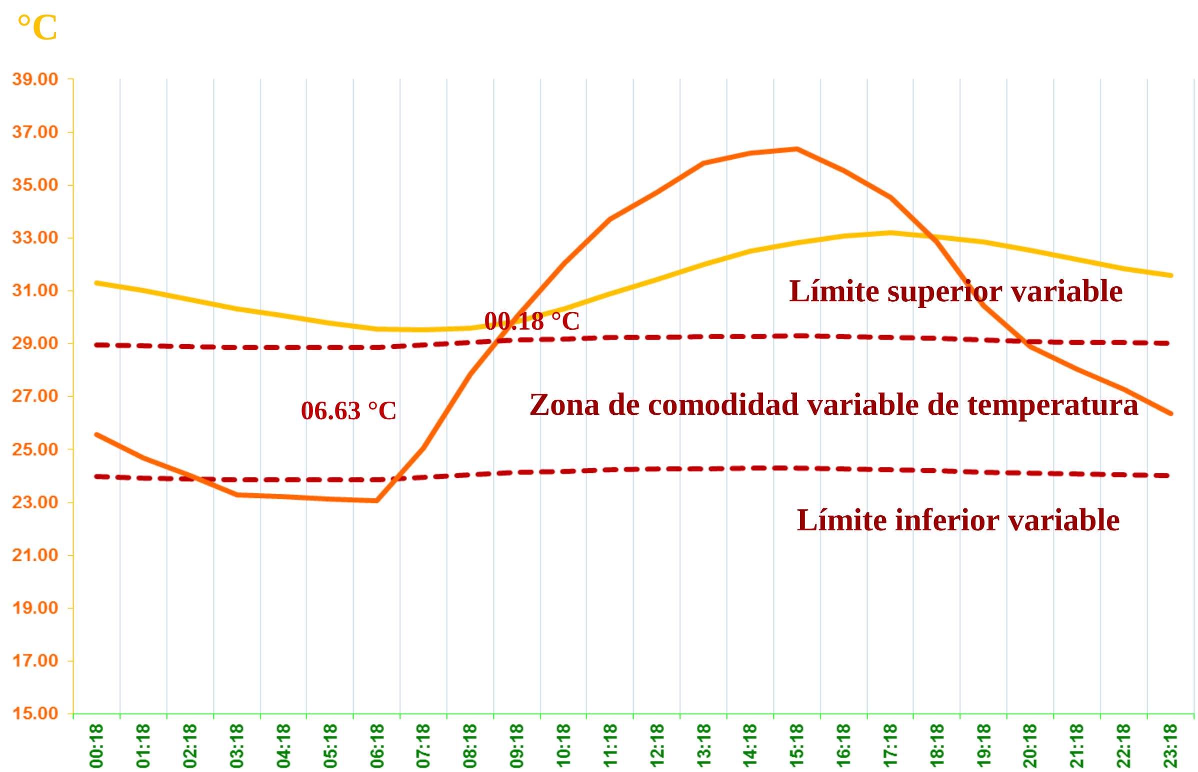
Tabla 6. *Comportamiento bioclimático en la galería (agosto de 2017)*

Días	Comportamiento Bioclimático	L. N. Humphreys	L. Inf. Variable	L. N. Variable	T. Int.	L. Sup. Variable	Dif-	Dif+	T. Ext.
1	**Demasía**	**27.55**	24.15	26.65	**32.44**	29.15	0.00	3.29	**30.47**
2	**Demasía**	**27.55**	24.17	26.67	**32.63**	29.17	0.00	3.46	**31.32**
3	**Demasía**	**27.55**	24.07	26.57	**32.06**	29.07	0.00	2.99	**28.07**
4	**Comodidad**	**27.55**	23.96	26.46	**28.88**	28.96	0.00	0.00	**25.22**
5	**Comodidad**	**27.55**	24.08	26.58	**28.82**	29.08	0.00	0.00	**28.47**
6	**Demasía**	**27.55**	24.11	26.61	**30.54**	29.11	0.00	1.43	**29.34**
7	**Demasía**	**27.55**	24.06	26.56	**30.69**	29.06	0.00	1.64	**27.70**
8	**Demasía**	**27.55**	24.04	26.54	**29.26**	29.04	0.00	0.00	**27.28**
9	**Demasía**	**27.55**	24.10	26.60	**30.34**	29.10	0.00	0.00	**29.13**
10	**Demasía**	**27.55**	24.01	26.51	**30.63**	29.01	0.00	0.00	**26.59**
11	**Demasía**	**27.55**	24.06	26.56	**30.01**	29.06	0.00	0.00	**27.74**
12	**Demasía**	**27.55**	24.12	26.62	**31.76**	29.12	0.00	0.00	**29.60**
13	**Demasía**	**27.55**	24.11	26.61	**32.37**	29.11	0.00	0.00	**29.46**
14	**Demasía**	**27.55**	24.13	26.63	**32.58**	29.13	0.00	3.45	**30.09**
15	**Demasía**	**27.55**	24.13	26.63	**32.49**	29.13	0.00	3.37	**29.88**
16	**Demasía**	**27.55**	24.14	26.64	**31.72**	29.14	0.00	2.59	**30.16**
17	**Demasía**	**27.55**	24.15	26.65	**31.47**	29.15	0.00	2.32	**30.47**
18	**Demasía**	**27.55**	24.14	26.64	**31.86**	29.14	0.00	2.73	**30.24**
19	**Demasía**	**27.55**	24.14	26.64	**32.17**	29.14	0.00	3.04	**30.26**
20	**Demasía**	**27.55**	24.13	26.63	**31.23**	29.13	0.00	2.10	**29.83**
21	**Demasía**	**27.55**	24.12	26.62	**31.26**	29.12	0.00	2.14	**29.66**
22	**Demasía**	**27.55**	24.10	26.60	**31.88**	29.10	0.00	2.78	**29.01**
23	**Demasía**	**27.55**	24.12	26.62	**30.93**	29.12	0.00	1.81	**29.60**
24	**Demasía**	**27.55**	24.09	26.59	**31.54**	29.09	0.00	2.46	**28.58**
25	**Demasía**	**27.55**	24.14	26.64	**31.80**	29.14	0.00	2.66	**30.25**
26	**Demasía**	**27.55**	24.14	26.64	**32.06**	29.14	0.00	2.92	**30.15**
27	**Demasía**	**27.55**	24.17	26.67	**32.44**	29.17	0.00	3.27	**31.16**
28	**Demasía**	**27.55**	24.13	26.63	**31.55**	29.13	0.00	2.41	**30.00**
29	**Demasía**	**27.55**	24.12	26.62	**31.04**	29.12	0.00	1.91	**29.73**
30	**Demasía**	**27.55**	24.10	26.60	**31.38**	29.10	0.00	2.28	**29.05**
31	**Demasía**	**27.55**	24.11	26.61	**31.41**	29.11	0.00	2.30	**29.26**
							0.00	**59.35**	

Fuente: Valores interiores HOBO N° 1. Valores exteriores HOBO U23 Pro v2

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

Figura 10. Día típico zona de comodidad variable de temperatura en galería (agosto de 2017)



Fuente: Valores interiores HOBO N° 1. Valores exteriores HOBO U23 Pro v2

Tabla 7. *Horas, oscilaciones y diferencia térmica del día típico en galería (agosto de 2017)*

Temperatura interior **Temperatura exterior**

Horas de comodidad de temperatura	**0**
Horas de demasía de temperatura	**24**
Horas de pérdida de temperatura	**0**
Oscilación de temperatura interior	03.70 °C
Oscilación de temperatura exterior	13.30 °C
Diferencia -	00.00 °C
Diferencia +	53.90 °C

Fuente: Valores interiores HOBO N° 1. Valores exteriores HOBO U23 Pro v2

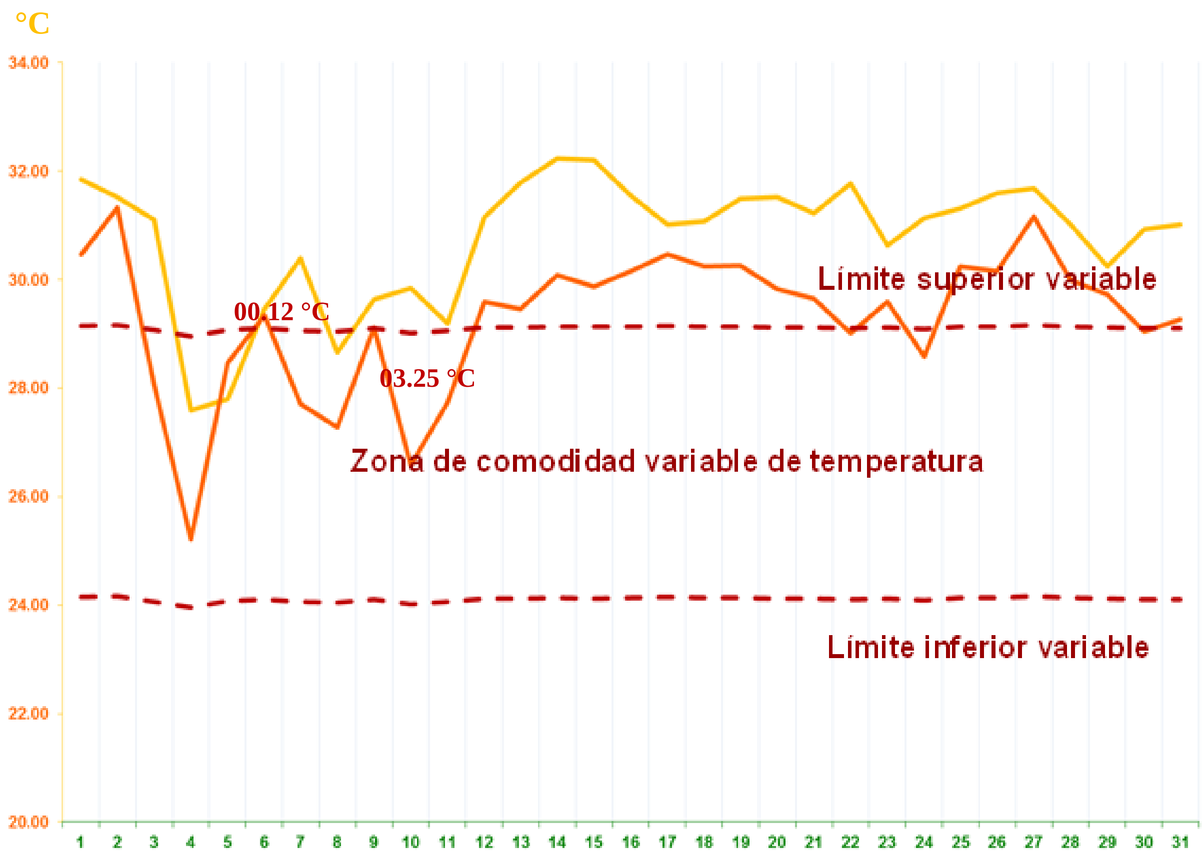
Tabla 8. *Comportamiento bioclimático del día típico en galería (agosto de 2017)*

Hora	Comportamiento Bioclimático	L. N. Humphreys	L. Inf. Variable	L. N. Variable	T. Int.	L. Sup. Variable	Dif -	Dif +	T. Ext.
00:18	**Demasía**	**27.55**	23.97	26.47	**31.30**	28.97	0.00	2.33	**25.56**
01:18	**Demasía**	**27.55**	23.93	26.43	**31.00**	28.93	0.00	2.07	**24.69**
02:18	**Demasía**	**27.55**	23.90	26.40	**30.66**	28.90	0.00	1.76	**24.02**
03:18	**Demasía**	**27.55**	23.87	26.37	**30.33**	28.87	0.00	1.47	**23.30**
04:18	**Demasía**	**27.55**	23.86	26.36	**30.05**	28.86	0.00	1.19	**23.24**
05:18	**Demasía**	**27.55**	23.86	26.36	**29.77**	28.86	0.00	0.91	**23.14**
06:18	**Demasía**	**27.55**	23.86	26.36	**29.56**	28.86	0.00	0.70	**23.06**
07:18	**Demasía**	**27.55**	23.95	26.45	**29.52**	28.95	0.00	0.57	**25.07**
08:18	**Demasía**	**27.55**	24.06	26.56	**29.60**	29.06	0.00	0.54	**27.85**
09:18	**Demasía**	**27.55**	24.13	26.63	**29.86**	29.13	0.00	0.73	**30.04**
10:18	**Demasía**	**27.55**	24.19	26.69	**30.33**	29.19	0.00	1.14	**32.04**
11:18	**Demasía**	**27.55**	24.23	26.73	**30.90**	29.23	0.00	1.67	**33.72**
12:18	**Demasía**	**27.55**	24.26	26.76	**31.44**	29.26	0.00	2.18	**34.73**
13:18	**Demasía**	**27.55**	24.28	26.78	**32.00**	29.28	0.00	2.72	**35.83**
14:18	**Demasía**	**27.55**	24.29	26.79	**32.49**	29.29	0.00	3.20	**36.21**
15:18	**Demasía**	**27.55**	24.29	26.79	**32.82**	29.29	0.00	3.53	**36.37**
16:18	**Demasía**	**27.55**	24.28	26.78	**33.09**	29.28	0.00	3.81	**35.55**
17:18	**Demasía**	**27.55**	24.25	26.75	**33.19**	29.25	0.00	3.94	**34.54**
18:18	**Demasía**	**27.55**	24.21	26.71	**33.05**	29.21	0.00	3.84	**32.84**
19:18	**Demasía**	**27.55**	24.14	26.64	**32.85**	29.14	0.00	3.70	**30.44**
20:18	**Demasía**	**27.55**	24.10	26.60	**32.54**	29.10	0.00	3.44	**28.90**
21:88	**Demasía**	**27.55**	24.07	26.57	**32.18**	29.07	0.00	3.11	**28.03**
22:18	**Demasía**	**27.55**	24.04	26.54	**31.82**	29.04	0.00	2.78	**27.27**
23:18	**Demasía**	**27.55**	24.00	26.50	**31.58**	29.00	0.00	2.57	**26.36**
							0.00	**53.90**	

Fuente: Valores interiores HOBO N° 1. Valores exteriores HOBO U23 Pro v2

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

Figura 11. Zona de comodidad variable de temperatura en pasillo central (agosto de 2017)



Fuente: Valores interiores HOBO N° 4. Valores exteriores HOBO U23 Pro v2

Tabla 9. *Días, temperaturas y diferencia térmica en pasillo central (agosto de 2017)*

Temperatura interior	Temperatura exterior
Días de comodidad de temperatura	**3**
Días de demasía de temperatura	**28**
Días de pérdida de temperatura	**0**
Temperatura media mensual interior	30.76 °C
Temperatura media mensual exterior	29.28 °C
Diferencia -	00.00 °C
Diferencia +	54.35 °C

Fuente: Valores interiores HOBO N° 4. Valores exteriores HOBO U23 Pro v2

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

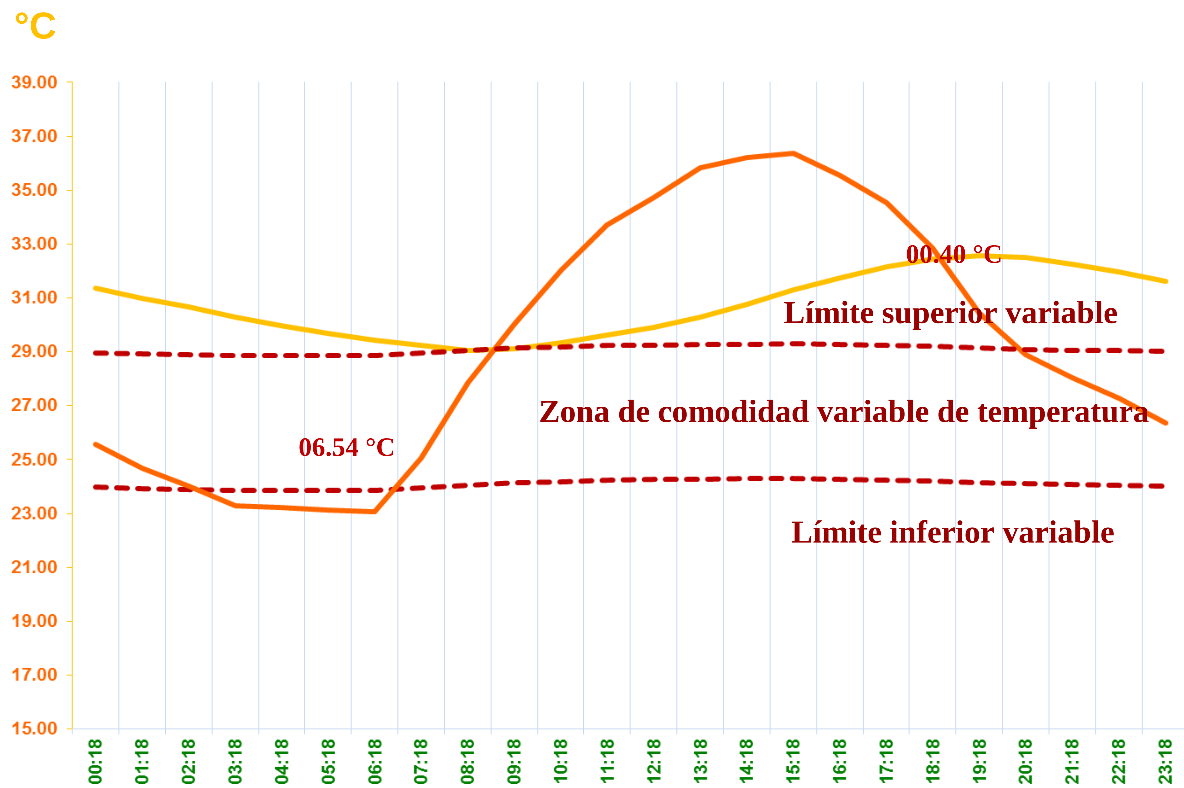
Tabla 10. *Comportamiento bioclimático en pasillo central (agosto de 2017)*

Días	Comportamiento Bioclimático	L. N. Humphreys	L. Inf. Variable	L. N. Variable	T. Int.	L. Sup. Variable	Dif-	Dif+	T. Ext.
	Demasía	**27.55**	24.15	26.65	**31.84**	29.15	0.00	2.70	**30.47**
2	**Demasía**	**27.55**	24.17	26.67	**31.52**	29.17	0.00	2.35	**31.32**
3	**Demasía**	**27.55**	24.07	26.57	**31.11**	29.07	0.00	2.04	**28.07**
4	**Comodidad**	**27.55**	23.96	26.46	**27.60**	28.96	0.00	0.00	**25.22**
5	**Comodidad**	**27.55**	24.08	26.58	**27.80**	29.08	0.00	0.00	**28.47**
6	**Demasía**	**27.55**	24.11	26.61	**29.46**	29.11	0.00	0.34	**29.34**
7	**Demasía**	**27.55**	24.06	26.56	**30.40**	29.06	0.00	1.34	**27.70**
8	**Comodidad**	**27.55**	24.04	26.54	**28.66**	29.04	0.00	0.00	**27.28**
9	**Demasía**	**27.55**	24.10	26.60	**29.63**	29.10	0.00	0.53	**29.13**
10	**Demasía**	**27.55**	24.01	26.51	**29.84**	29.01	0.00	0.83	**26.59**
11	**Demasía**	**27.55**	24.06	26.56	**29.19**	29.06	0.00	0.13	**27.74**
12	**Demasía**	**27.55**	24.12	26.62	**31.15**	29.12	0.00	2.03	**29.60**
13	**Demasía**	**27.55**	24.11	26.61	**31.79**	29.11	0.00	2.68	**29.46**
14	**Demasía**	**27.55**	24.13	26.63	**32.23**	29.13	0.00	3.09	**30.09**
15	**Demasía**	**27.55**	24.13	26.63	**32.21**	29.13	0.00	3.08	**29.88**
16	**Demasía**	**27.55**	24.14	26.64	**31.55**	29.14	0.00	2.42	**30.16**
17	**Demasía**	**27.55**	24.15	26.65	**31.02**	29.15	0.00	1.87	**30.47**
18	**Demasía**	**27.55**	24.14	26.64	**31.08**	29.14	0.00	1.94	**30.24**
19	**Demasía**	**27.55**	24.14	26.64	**31.49**	29.14	0.00	2.35	**30.26**
20	**Demasía**	**27.55**	24.13	26.63	**31.52**	29.13	0.00	2.39	**29.83**
21	**Demasía**	**27.55**	24.12	26.62	**31.22**	29.12	0.00	2.10	**29.66**
22	**Demasía**	**27.55**	24.10	26.60	**31.78**	29.10	0.00	2.68	**29.01**
23	**Demasía**	**27.55**	24.12	26.62	**30.63**	29.12	0.00	1.51	**29.60**
24	**Demasía**	**27.55**	24.09	26.59	**31.14**	29.09	0.00	2.06	**28.58**
25	**Demasía**	**27.55**	24.14	26.64	**31.31**	29.14	0.00	2.17	**30.25**
26	**Demasía**	**27.55**	24.14	26.64	**31.60**	29.14	0.00	2.46	**30.15**
27	**Demasía**	**27.55**	24.17	26.67	**31.68**	29.17	0.00	2.51	**31.16**
28	**Demasía**	**27.55**	24.13	26.63	**31.02**	29.13	0.00	1.88	**30.00**
29	**Demasía**	**27.55**	24.12	26.62	**30.25**	29.12	0.00	1.13	**29.73**
30	**Demasía**	**27.55**	24.10	26.60	**30.93**	29.10	0.00	1.83	**29.05**
31	**Demasía**	**27.55**	24.11	26.61	**31.01**	29.11	0.00	1.91	**29.26**
							0.00	**54.35**	

Fuente: Valores interiores HOBO N° 4. Valores exteriores HOBO U23 Pro v2

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

Figura 12. Día típico zona de comodidad variable de temperatura en pasillo (agosto de 2017)



Fuente: Valores interiores HOBO N° 4. Valores exteriores HOBO U23 Pro v2

Tabla 11. *Horas, oscilaciones y diferencia térmica del día típico en pasillo (agosto de 2017)*

Temperatura interior	Temperatura exterior
Horas de comodidad de temperatura	**2**
Horas de demasía de temperatura	**22**
Horas de pérdida de temperatura	**0**
Oscilación de temperatura interior	03.55 °C
Oscilación de temperatura exterior	13.30 °C
Diferencia -	00.00 °C
Diferencia +	40.35 °C

Fuente: Valores interiores HOBO N° 4. Valores exteriores HOBO U23 Pro v2

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias
Ciba
ISSN: 2007 - 9990

Tabla 12. *Comportamiento bioclimático en pasillo central (agosto de 2017)*

Hora	Comportamiento Bioclimático	L. N. Humphreys	L. Inf. Variable	L. N. Variable	T. Int.	L. Sup. Variable	Dif -	Dif +	T. Ext.
00:18	**Demasía**	**27.55**	23.97	26.47	**31.36**	28.97	0.00	2.39	**25.56**
01:18	**Demasía**	**27.55**	23.93	26.43	**31.00**	28.93	0.00	2.06	**24.69**
02:18	**Demasía**	**27.55**	23.90	26.40	**30.67**	28.90	0.00	1.77	**24.02**
03:18	**Demasía**	**27.55**	23.87	26.37	**30.30**	28.87	0.00	1.43	**23.30**
04:18	**Demasía**	**27.55**	23.86	26.36	**29.96**	28.86	0.00	1.10	**23.24**
05:18	**Demasía**	**27.55**	23.86	26.36	**29.68**	28.86	0.00	0.82	**23.14**
06:18	**Demasía**	**27.55**	23.86	26.36	**29.44**	28.86	0.00	0.58	**23.06**
07:18	**Demasía**	**27.55**	23.95	26.45	**29.23**	28.95	0.00	0.28	**25.07**
08:18	**Comodidad**	**27.55**	24.06	26.56	**29.04**	29.06	0.00	0.00	**27.85**
09:18	**Comodidad**	**27.55**	24.13	26.63	**29.10**	29.13	0.00	0.00	**30.04**
10:18	**Demasía**	**27.55**	24.19	26.69	**29.34**	29.19	0.00	0.15	**32.04**
11:18	**Demasía**	**27.55**	24.23	26.73	**29.63**	29.23	0.00	0.39	**33.72**
12:18	**Demasía**	**27.55**	24.26	26.76	**29.92**	29.26	0.00	0.66	**34.73**
13:18	**Demasía**	**27.55**	24.28	26.78	**30.28**	29.28	0.00	1.00	**35.83**
14:18	**Demasía**	**27.55**	24.29	26.79	**30.75**	29.29	0.00	1.46	**36.21**
15:18	**Demasía**	**27.55**	24.29	26.79	**31.31**	29.29	0.00	2.02	**36.37**
16:18	**Demasía**	**27.55**	24.28	26.78	**31.76**	29.28	0.00	2.48	**35.55**
17:18	**Demasía**	**27.55**	24.25	26.75	**32.15**	29.25	0.00	2.89	**34.54**
18:18	**Demasía**	**27.55**	24.21	26.71	**32.44**	29.21	0.00	3.23	**32.84**
19:18	**Demasía**	**27.55**	24.14	26.64	**32.58**	29.14	0.00	3.44	**30.44**
20:18	**Demasía**	**27.55**	24.10	26.60	**32.52**	29.10	0.00	3.42	**28.90**
21:88	**Demasía**	**27.55**	24.07	26.57	**32.26**	29.07	0.00	3.19	**28.03**
22:18	**Demasía**	**27.55**	24.04	26.54	**31.97**	29.04	0.00	2.93	**27.27**
23:18	**Demasía**	**27.55**	24.00	26.50	**31.62**	29.00	0.00	2.61	**26.36**
							0.00	**40.35**	

Fuente: Valores interiores HOBO N° 4. Valores exteriores HOBO U23 Pro v2

Conclusions

According to the National Oceanic and Atmospheric Administration of the United States (NOAA) and the National Aeronautics and Space Administration (NASA), the month of August 2017 was the hottest recorded in history; They underscored the extremely worrisome trend of the record global average temperature, which is becoming more and more frequent. Recent years have witnessed growing concern about the impact of climate change on housing outcomes, in terms of internal thermal comfort and the energy consumption needed to safeguard said comfort.

It is not an exaggeration for Vaccari, Gioli, Toscano and Perrone (2013) to say that humanity is now facing the most serious threat of its existence. This is a planetary emergency and a complete response if you wish to have any hope of avoiding the impacts of climate change, dangerous and irreversible.

In relation to the bioclimatic behavior of residential housing, it was determined, by historical climate analysis, that August - with an average temperature of 30.47 ° C - is the critical month in summer. The linear trend of the last 25 years in the municipality of Juárez, Nuevo León is 0.48 ° C.

The central corridor to the interior exhibits a lower average temperature of 30.76 ° C; the gallery, 31.33 ° C because it is on the top floor. The gallery is in greater contact with the walls and, mainly, the roof slab. The maximum thermal amplitude in the gallery in the month of August is of 03.66 ° C and the minimum of 00.35 ° C. The maximum thermal amplitude in the central corridor in that month is 03.25 ° C and the minimum of 00.12 ° C.

In August, the difference + accumulates 59.35 ° C in the gallery and in the central aisle, a difference of + 54.35 ° C. Therefore, the gallery shows two days of comfort and 29 days in excess, while the central corridor has three days of comfort and 28 days of excess.

The typical day in the gallery in August shows a difference + of 53.90 ° C and in the central aisle it accumulates a difference + of 40.35 ° C. The typical day in the central corridor presents 24 hours of excess and in the gallery only two hours of comfort.

The oscillation of temperature inside the gallery on the typical day of August is 03.70 ° C and the outside of 13.30 ° C; in the central corridor, the temperature oscillation inside is of 03.55 ° C.

Finally, it is confirmed that the constructive solutions adopted by the residential housing of the municipality of Juárez, Nuevo León, are not positive in their bioclimatic behavior. To the outside, having lower temperatures than the interior of the housing case study, it is recommended greater ventilation with openings in the upper part so that, by convection, it is cooler and, thus, propose some more effective constructive elements of aeration for mitigate the accumulation of temperature.

It is recommended, as constructive elements, not to forget to remove and add accessories in the residential housing for the summer season such as awnings, screens, shutters, sliding doors, doors with manual mechanisms -to allow or prevent the entry of air-, adjustable windows in various positions and openings, eaves, canopies, grills, pergolas and vegetation. Another way to favor well-being in residential housing case study is to designate different spaces for different hours of the day, so that the user moves to the coolest place, as the hours pass: this is what has been called nomadism in the architecture.

Acknowledgment

In a formal way, I appreciate the deference for the support granted and authorization of the Framework Agreement for Academic Cooperation of the Program for Professional Development, for the higher type subscribed by the General Directorate of Higher Education University with the Autonomous University of Tamaulipas (UAT) for the realization of the short research stay that I currently carry out in the Municipality of Juárez, Nuevo León (Oficio N° DSA/103.5/16/16120).

References

Adekunle, T. O. and Nikolopoulou, M. (2016). Thermal comfort, summertime temperatures and overheating in prefabricated timber housing. *Building and Environment*, *103*, 21-35.

ANSI-ASHRAE. (2004). *Standard 55-2004 Thermal environmental conditions for human occupancy*. Atlanta, United States: ASHRAE.

Corobov, R., Sirodoev, I., Koeppel, S., Denisov, N. and Sirodoev, G. (2013). Assessment of Climate Change Vulnerability at the Local Level: A Case Study on the Dniester River Basin (Moldova). *The Scientific World Journal*, *2013*(1), 1-13. doi: 10.1155/2013/173794.

Croitoru, C., Nastase, I., Sandu, M. and Lungu, C. (2016). Multi-criteria design and impact on energy consumption of a residential house- a parametric study. *Energy Procedia*, *85*, 141-148.

Gul, M. S. and Menzies, G. F. (2012). Designing domestic buildings for future summers: Attitudes and opinions of building professionals. *Energy Policy*, *45*, 752-761.

Kinnane, O., Grey, T., and Dyer, M. (2017). Adaptable housing design for climate change adaptation. *Proceedings of the Institution of Civil Engineers-Engineering Sustainability*, *170* (5), 249-267.

Lantitsou, K. I. and Panagiotakis, G. D. (2017). Thermal analysis of residencies based on solar design principles -a case study in Thessaloniki, Greece. *Fresenius Environmental Bulletin*, *26*(2), 1254-1262.

Montalban Pozas, B. and Neila Gonzalez, F. J. (2016). Hygrothermal behaviour and thermal comfort of the vernacular housings in the Jerte Valley (Central System, Spain). *Energy and Buildings*, *130*, 219-227.

Naima, F., Mebirika, B., Belkacem, D. and Claude-Alain, R. (2016). The traditional house with horizontal opening: a trend towards zero-energy house in the hot, dry climates. *Sustainable Built Environment Tallinn and Helsinki Conference SBE16 Build Green and Renovate Deep*, *96*, 934-944.

Oikonomou, A. and Bougiatioti, F. (2011). Architectural structure and environmental performance of the traditional buildings in Florina, NW Greece. *Building and Environment*, *46*(3), 669-689.

Patidar, S., Jenkins, D., Banfill, P., and Gibson, G. (2014). Simple statistical model for complex probabilistic climate projections: Overheating risk and extreme events. *Renewable Energy*, *61*, 23-28.

Pérez Galaso, J. L., Ladrón de Guevara López, I., and Boned Purkiss, J. (2016). The influence of microclimate on architectural projects: a bioclimatic analysis of the single-family detached house in Spain's Mediterranean climate. *Energy Efficiency*, *9*(3), 621-645.

Roriz, Mauricio. (2003). Flutuações horárias dos limites de conforto térmico: Urna hipótese de modelo adaptativo. En *VII Encontro Nacional de Conforto no Ambiente Construído*. Simposio llevado a cabo en VII ENCAC III COTEDI, Curitiba, Brasil.

Salkini, H., Greco, L. and Lucente, R. (2017). Towards adaptive residential buildings traditional and contemporary scenarios in bioclimatic design (the case of Aleppo). *International High-Performance Built Environment Conference - A Sustainable 2016 Series*, *180*, 1083-1092.

Simurda D. and Bodnar T. (2015). Passive cooling of housing by natural ventilation. *Topical Problems of Fluid Mechanics*, *24*, 87-92.

Vaccari, F. P., Gioli, B., Toscano, P. y Perrone, C. (2013). Carbon dioxide balance assessment of the city of Florence (Italy), and implications for urban planning. *Landscape and Urban Planning*, *120*, 138-146.

Van Hooff, T., Blocken, B., Timmermans, H. J. P., and Hensen, J. L. M. (2016). Analysis of the predicted effect of passive climate adaptation measures on energy demand for cooling and heating in a residential building. *Energy*, *94*, 811-820.

Velasco Martínez, B. N. del C., García Chávez, J. R., and Matsumoto Kuwabara, Y. (2017). Analysis and evaluation of bioclimatic systems to characterize their performance in experimental modules. *Energy Procedia*, *122*, 1094-1099.

Vellei, M., Herrera, M., Fosas, D. & Natarajan, S. (2017). the influence of relative humidity on adaptive thermal comfort. *Building and Environment*, *124*, 171-185.

Victoria, J., Mahayuddin, S. A., Zaharuddin, W. A. Z. W., Harun, S. N., and Ismail, B. (2017). Bioclimatic design approach in Dayak traditional longhouse. *Procedia Engineering*, *180*, 562-570.

Síntesis curricular del Autor

Carlos Alberto Fuentes Pérez

Doctor en Arquitectura con Orientación en Vivienda, con Tesis Doctoral Galardonada como "Investigación de Excelencia" 2011. Profesor-investigador de la Facultad de arquitectura, Diseño y Urbanismo de la Universidad Autónoma de Tamaulipas. Es distinguido con el Perfil deseable PRODEP y es Miembro del Sistema Nacional de Investigadores Nivel I. Integrante del Cuerpo Académico de Calidad del Hábitat UAT-CA-106 Consolidado. Responsable y Colaborador en diversos Proyectos de Investigación y Redes Temáticas de Colaboración Académica en el ámbito de la calidad del hábitat e higrotérmia. Logra segundo Grado de Doctor en Arquitectura por la Universidad de Sevilla, España con Mención de Sobresaliente "Cum Laude" por Unanimidad en 2016.