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Table of Contents

Land and Water Engineering

- Comparison among Different Irrigation Systems for Deficit-Irrigated Corn in the Nile Valley [ABSTRACT](#) [PDF](#)
Abdrabbo Abdel-Azim Shehata
- Equilibrium Moisture Content of Some Bioplastic Materials for Agricultural Use [ABSTRACT](#) [PDF](#)
Harby H. M. Mostafa
- Effect of Puddling on Puddled Soil Characteristics and Performance of Self-propelled Transplanter in Rice Crop [ABSTRACT](#) [PDF](#)
Bijoy Kumar Behera
- Development of a Digital Recording System for Automation of Class A Evaporation Pan Measurement [ABSTRACT](#) [PDF](#)
Johnson Toyin Fasinmirin
- Evaluation of FAO-56 Penman-Monteith and Temperature Based Models in Estimating Reference Evapotranspiration Using Complete and Limited Data, Application to Nigeria [ABSTRACT](#) [PDF](#)
Omotayo Babawande Adeboye, Jimmy A Osunbitan, , Kenneth O Adekalu, , David Adebimpe Okunade
- Experimental and Numerical Modeling of VersaTrap Type W [ABSTRACT](#) [PDF](#)
Mohamed Sahgiar Ismail

Farm Buildings and Construction

- Glossary of Terms on Animal Housing: Interconnecting Engineering, Physical and Physiological Definitions [ABSTRACT](#) [PDF](#)
Panagiotis Panagakis, Victoria Blanes-Vidal, Thomas Banhazi, Jose Carlos Barbosa, Ephraim Maltz, Vasco Da Cruz, Daniel Berckmans

Equipment Engineering for Plant Production

- Aerial Spray Deposition on Corn Silks Applied at High and Low Spray Rates [ABSTRACT](#) [PDF](#)
Bradley K Fritz
- Modeling NO Emissions of an Off-road Diesel Engine Based on Emission Tests [ABSTRACT](#) [PDF](#)
David R Bostic, Dennis G Watson, Tony V Harrison

Glossary of Terms on Animal Housing: Interconnecting Engineering, Physical and Physiological Definitions

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ABSTRACT

Animal Housing is a multidisciplinary scientific area which requires the involvement of scientists from different fields such as engineers, physicians, animal scientists, veterinarians, etc. Their collaboration requires the establishment and use of a standardized vocabulary that provides consistency and reduces misunderstandings among scientists with diverse background or Nationality. A first dictionary entitled ‘Glossary of Terms on Animal Housing: Basic Engineering, Physical and Physiological Definitions’ has been prepared by a Working Group (Animal Housing in Hot Climate) established under CIGR-Section II. The glossary made reference to Engineering, Thermal Biology and Environmental Physiology disciplines and it aimed at (1) setting-up uniformity in Animal Housing terms related to climatization and to (2) serve as a focal point for the development of valuable new terms and definitions, and become a functional tool for all those involved in this study subject. Furthermore, the glossary can eventually become a background document for opening-up further discussions on the meaning of various terms used in Animal Housing.

Keywords: Animal Housing, Climatization, Glossary, Definitions, Engineering, Environment, Physiology

1. INTRODUCTION

Involvement in Animal Housing research and development (R&D) requires a multi-disciplinary scientific approach based on knowledge from various disciplines such as Engineering, Animal and Veterinary Science. Frequently, at international meetings, in report writing and during expert communication confusion arises associated with the different terminology (e.g. different meaning and choice of terms) used by the participants. The main reasons are: (1) the improper

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translation from the original language into English (most used language in international circles) and (2) the diverse scientific background of participants.

Unfortunately, the discipline-specific Glossaries already developed (ASAE, 2001; IUPS Thermal Commission, 2003) do not sufficiently address the required multi-discipline approach in Animal Housing. This lack of an integrated approach was identified by a Working Group (Animal Housing in Hot Climate) established under CIGR-Section II. Therefore, a sub-group was appointed within the previously mentioned Working Group to coordinate an overall effort aimed at developing a dictionary entitled ‘Glossary of Terms on Animal Housing: Basic Engineering, Physical and Physiological Definitions’. The objectives of the glossary presented in this article were:

- (1) To establish a multi-disciplinary approach in terms associated with Animal Housing
- (2) To serve as a focal point for the development of useful new terms and definitions
- (3) To become a useful dictionary for all those involved in the subject

2. METHODOLOGY

The idea behind the development of the dictionary was not to re-define terms, but rather to find, adjust (if needed) and include many possibly useful terms from various disciplines directly or indirectly related to Animal Housing. An initial draft manuscript was prepared and circulated for commenting among sub-group members in early 2007. This first draft underwent lengthy and extensive revisions based on exchange of ideas and further clarifications. The dictionary was finalized in December 2008.

Before and during the preparation of the dictionary, several issues regarding the extension, organization, level of detail, and sources of information of the dictionary were brought into discussion. Regarding the extension of the dictionary, it was agreed that it should include all possible Animal Housing terms related only to Climatization, and terms not related to this area should not be included.

With regards to the organization of terms, the authors agreed on classifying and separating them into three categories: (1) Engineering, (2) Physical and (3) Physiological. However, inside these three categories, the terms were alphabetically arranged, so that the dictionary could be used as a handbook by those involved in the subject to find specific terms.

Furthermore, it was chosen to distinguish the terms as ‘Animal Science’ or ‘Engineering’ oriented whenever needed [e.g. *Steady state (animal science)*: The state of body heat balance in which there is no positive or negative heat storage when heat gain and heat loss between the body and the environment are equivalent; *Steady state (engineering)*: A stable condition of an open system, in which the relevant variables do not change over time, or in which a change in one direction is continually compensated by a change in another]. It was also decided to limit the level of detail of the glossary so that it could be easily used as practical tool (otherwise terms such as ‘Animal Housing’ or ‘Hot Climate’ would have to be defined). Finally, it was agreed that the dictionary should provide references on those definitions based on previous literature (e.g. engineering handbooks, published glossaries, textbooks, reports, peered reviewed articles, dictionaries) or personal communication, so that in some cases differences or similarities between different definitions could be shown.

P. Panagakis, V. Blanes-Vidal, T. Banhazi, J. C. Barbosa, E. Maltz, V. F. Da Cruz, and D. Berckmans. “Glossary of Terms on Animal Housing: Interconnecting Engineering, Physical and Physiological Definitions” *Agricultural Engineering International: The CIGR Ejournal*. Manuscript 1302. Vol. XI. October, 2009.

3. GLOSSARY OF TERMS

3.1 Interconnection of terms

The present version (<http://www.cigr.org/documents/glossarytermsanimalhousing.pdf>) of the dictionary includes 369 terms under A to Z letters (see Appendix) and the units used are based on the International System (SI). As stated above all basic definitions of terms included were grouped under three major categories (e.g. engineering, physical and physiological), but it should be noted that some terms (e.g. insulation) can be defined differently depending on the area of study considered.

A characteristic example showing the interconnection of various terms within the boundaries of Animal Housing (figure 1) is given below:

A major aspect of Animal Housing is the *ventilation* (engineering term) of the *building* (engineering term) housing the animals that provides the *optimal environment conditions* (physiological term) and ensures *environmental comfort* (physiological term). Engineering design criteria such as the size of *air inlet* (engineering term), the unwanted presence of *infiltration air* (engineering term), the provision of *shade* (engineering term) and the efficiency of *evaporative cooling* (engineering term) have to be studied carefully before a decision can be made. This decision should also account for air *ambient temperature* (physical term) and air *moisture content* (physical term) along with the existence of *draft* (engineering term) causing unpleasant *convection forced* (physical term). As a result, animal *activity movement absolute* (physiological term) and *heat loss* (physiological term) will be influenced and eventually *heat stress* (physiological term) or *heat syncope* (physiological term) will be prevented.

In some cases, the interconnection of terms from different categories is very close. For example, *heat stress* is a physiological term describing a situation of the animals regarding their thermoregulation, but the indices (*heat stress indices*) used to assess the heat stress situation, are engineering terms.

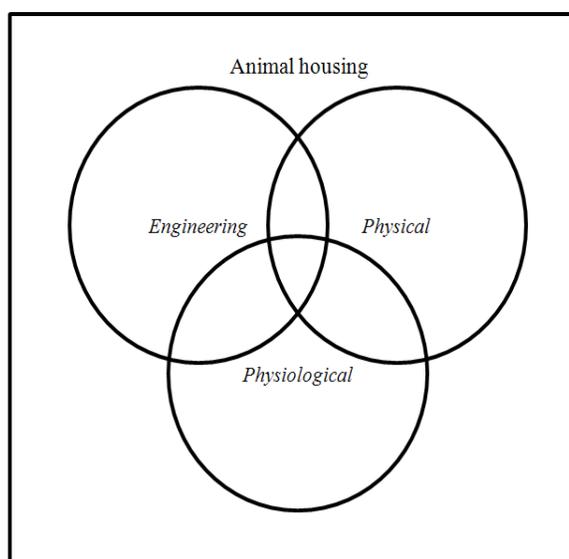


Figure 1. Schematic interconnection of terms

The dictionary obviously reflects the opinion of the Working Group members and it should not be considered as the ultimate complete glossary, since inclusion of other possibly related terms (i.e. Archimedes number, sol-air temperature, etc.) is pending. However, it can hopefully become a background document for opening-up further discussions on the meaning and use of various terms pertaining to ‘Animal Housing’.

3.2 Future developments

This document could be potentially converted into a web-based application in the future. Such format would enable the developers to establish links between the different definitions and better reference and/or demonstrate the interconnected nature of the individual entries. In addition, the linking of pictures and/or animations that would better explain the references could become a reality, if such web-based format is used. This proposed additional development could potentially turn this document into a powerful educational tool for students as well as for farm practitioners/managers. In every country, there are different vocational courses developed especially for farm workers and such a web-based application would provide a powerful educational tool for many people in many different countries, given the accessibility of web-based products. Although, such development might require additional resources; this potential project extension would be worth contemplating about in the future.

4. FINAL REMARKS

A dictionary entitled ‘Glossary of Terms on Animal Housing: Basic Engineering, Physical and Physiological Definitions’ has been prepared by a Working Group (Animal Housing in Hot Climate) that was established under CIGR-Section II. It aimed at:

- Establishing a multi-disciplinary approach in Animal Housing terms pertaining to the field of climatization
- Serving as a focal point for the development of useful new terms and definitions
- Becoming a constructive tool for all those involved in the subject

The Glossary of Terms includes 369 terms from the disciplines of Engineering, Thermal Biology and Environmental Physiology. They are organized under three major categories, namely Engineering, Physical and Physiological and can eventually become the background for opening-up further discussions on the meaning of various terms used in ‘Animal Housing’.

5. ACKNOWLEDGEMENTS

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P. Panagakis, V. Blanes-Vidal, T. Banhazi, J. C. Barbosa, E. Maltz, V. F. Da Cruz, and D. Berckmans. “Glossary of Terms on Animal Housing: Interconnecting Engineering, Physical and Physiological Definitions” Agricultural Engineering International: The CIGR Ejournal. Manuscript 1302. Vol. XI. October, 2009.

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APPENDIX

Engineering

Air conditioning, unit: An assembly of equipment for the treatment of air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of a conditioned space. (HVAC, 1987)

Airflow circulation: Pattern of air movement in a livestock building or under a shade. (ASAE, 2001)

Air duct: Pipe, tube or passageway for conveying air. (ASAE, 2001)

Air inlet: Opening designed to supply fresh air to a building (e.g. hole, slot, louver door). (ASAE, 2001)

Air outlet: Opening through which exhaust air leaves a building (e.g. hole, door, window, open ridge, louver or exhaust fan). (ASAE, 2001)

Baffle: Usually flat plate for deflecting, retarding or regulating the flow of fluids or light, as in an adjustable ventilation air inlet. (ASAE, 2001)

Barn: Roofed shelter for livestock (usually with at least one wall closed). (ASAE, 2001)

Barn, cold: Naturally ventilated barn, usually constructed with no or minimum insulation. No supplemental heat is provided and inside temperature varies with outside temperature. (ASAE, 2001)

Blower: A device for producing movement of air. (ASAE, 2001)

Blower, centrifugal: Air-moving device constructed with many blades located on a cylindrical frame which is mounted so the blades are parallel to the axis of rotation. (ASAE, 2001)

Boiler: An enclosed vessel to heat water for the purpose of developing hot water or steam under pressure. (ASAE, 2001)

Building: Roofed and walled structure constructed for permanent use. (ASAE, 2001)

Butterfly door: Hinged sidewall panel, typically used as a ventilation air inlet or outlet. The hinge is normally located slightly above the centre of its vertical height so that the door tends to be self-closing. (ASAE, 2001)

Chimney: Vertical structure used with a stove, furnace or fireplace and enclosing a flue(s) to carry away products of combustion. (ASAE, 2001)

Chimney, vent: Outlet designed to extract air from a livestock building.

Combustion products: Residue resulting from the combustion of a fuel. (ASAE, 2001)

P. Panagakis, V. Blanes-Vidal, T. Banhazi, J. C. Barbosa, E. Maltz, V. F. Da Cruz, and D. Berckmans. "Glossary of Terms on Animal Housing: Interconnecting Engineering, Physical and Physiological Definitions" *Agricultural Engineering International: The CIGR Ejournal*. Manuscript 1302. Vol. XI. October, 2009.

Control: (1) The process by which a physiological variable becomes a function of information generated locally or transmitted from remote sources by neural or hormonal signals (feed forward control); (2) The process by which a physiological system stabilizes (*regulates*) a variable, generally by means of an information loop with negative feedback. (IUPS, 2003)

Control, proportional: A control concept with negative feedback in which the controller activates thermoeffector mechanisms to an extent dependent on the deviation of the controlled variable from its set-point. (IUPS, 2003)

Damper: Adjustable plate or baffle to regulate flow through a duct. (ASAE, 2001)

Dead space: Space in which there is little or no air movement. (ASAE, 2001)

Distribution duct: Inflatable tube or rigid duct through which ventilation air is distributed in the building. (ASAE, 2001)

Earth tempering: Heating and/or cooling of air by moving it through a buried conductor using the thermal mass of the earth to moderate air temperatures. (ASAE, 2001)

Entrainment: The mixing of ambient air with that exiting an air jet from an air inlet or distribution duct. (ASAE, 2001)

Environmental control: Situation under which indoor environment parameters (i.e. temperature, relative humidity, lighting, air movement, radiation, air quality, etc.) in a livestock building, are controlled by appropriate construction (e.g. insulation, orientation) and environmental modifications (e.g. heating, ventilation, cooling; Blanes-Vidal, 2009)

Evaporative cooling: Physical process achieved by bringing into contact non-saturated air with a free water surface, for a specific length of time, causing a decrease in air temperature and an increase in humidity ratio, following a process of adiabatic saturation. There are three main evaporative cooling systems used in animal housing: foggers, misters and evaporative pads. (Albright, 1990; Hellickson and Walker, 1983)

Evaporative cooling efficiency: Ratio of change in saturation achieved by an evaporative cooling system, to maximum potential change in saturation. (Albright, 1990; Hellickson and Walker, 1983)

Evaporative pad system: Evaporative cooling system that withdraws through a fan the air through wet pads into a building. (Barbosa, 2009)

Fan: A device for producing movement of air. (ASAE, 2001)

Fan, air mixing: Air-moving device utilized within a building or under a shade to provide air movement and circulation. It cannot be considered a ventilation system as it does not exchange air between the indoor and outdoor environment. (MWPS, 1990)

Fan, axial flow: Type of fan where propeller-type fan blades rotate in a plane that is at a right angle to air flow. (ASAE, 2001)

P. Panagakis, V. Blanes-Vidal, T. Banhazi, J. C. Barbosa, E. Maltz, V. F. Da Cruz, and D. Berckmans. "Glossary of Terms on Animal Housing: Interconnecting Engineering, Physical and Physiological Definitions" *Agricultural Engineering International: The CIGR Ejournal*. Manuscript 1302. Vol. XI. October, 2009.

Fan hood: Enclosure to protect a ventilation fan from weather, particularly direct wind and precipitation. (ASAE, 2001)

Facility: A building with associated equipment and utilities for production. (ASAE, 2001)

Flue: Chimney liner through which combustion gases and smoke pass. (ASAE, 2001)

Flue gases: Residue resulting from the combustion of a fuel. (ASAE, 2001)

Fogger (Fogging system): Cooling system dispersing water in fine droplets ($\varnothing < 40\mu\text{m}$) so as to provide evaporative cooling to housed animals (ASAE, 2001)

Friction fit insulation: Batt or blanket insulation with no paper backing, usually mineral fiber, held in place by friction against framing members. (ASAE, 2001)

Heat balance, building: The steady-state condition of a structure in which incoming heat plus that produced inside is equal to that leaving the structure.

Heat balance, equation: Equation based on the conservation of energy of an enclosure (e.g. building, facility), under steady-state conditions. (Blanes and Pedersen, 2005)

Heat exchanger: Device that transfers heat between flowing fluids without direct fluid contact; usually metal or plastic tubes with one fluid inside and the other outside. (ASAE, 2001)

Heat lamp: An electric light used to provide radiant heat to newborn animals or to heat an object. (ASAE, 2001)

Heat loss: Common term that refers to gross loss of heat by radiation, convection, and conduction from indoor air in a building to outdoor air (through surfaces and openings). (IUPS, 2003)

Heat pad: A device used to conduct (by direct contact) heat, usually to some type of newborn animal. (ASAE, 2001)

Heat stress, indices: Derived statistics which describe apparent heat stress (i.e. Temperature Humidity Index, Black Globe Temperature Humidity Index, etc.).

Black Globe Temperature Humidity Index (BGTHI): The THI where the dry-bulb temperature is replaced by the Black-globe temperature. (Mader et al., 2004)

Duration: the number of hours inside dry-bulb temperature exceeds the Upper Critical Temperature (UCT). (Panagakis et al. 1991)

Intensity: $I = \int_T \int_t \Delta T \cdot \Delta t$ where: I is the heat-stress intensity in $^{\circ}\text{Ch}$, ΔT is the difference between the predicted inside dry-bulb temperature and the UCT in $^{\circ}\text{C}$ and Δt is the time period during which animals are housed under temperatures higher than the UCT in h. (Panagakis et al. 1991)

Temperature Humidity Index (THI): (1) $THI = aT_{db} + bT_{wb} + c$ where: T_{db} is the dry-bulb temperature, T_{wb} is the wet-bulb temperature, a , b , c are constants depending on species, (2) $THI = 0.8T_{db} + \left[\left(\frac{RH}{100}\right) \times (T_{db} - 14.3)\right] + 46.4$ where: RH is the percentage relative humidity.

Temperature Humidity Velocity Index (THIV): $THI = (aT_{db} + bT_{wb}) V^{-c}$, where: T_{db} is the dry-bulb temperature, T_{wb} is the wet-bulb temperature, V is the air velocity, and a , b and c are constants. (Tao and Xin, 2003)

Heater, hot-water floor: System comprised of a hot-water boiler with connected pipes embedded in floor for circulating hot water. (ASAE, 2001)

Heater, unit: Air heater suspended within a room; air is drawn by fan over a heat exchanger heated either by electricity, steam, hot water, or direct burning petroleum fuel. (ASAE, 2001)

Heater, un-vented: Fuel burning unit heater exhausting combustion products into the heated air stream instead of outdoors. (ASAE, 2001)

Hot-air furnace: Air heat system consisting of a furnace (combustion chamber and heat exchanger), a fan to move air across the heat exchanger, and a bonnet to which a duct system for air distribution may be attached. (ASAE, 2001)

Hover: Suspended cover of wood, canvas or other material, over an area in a pen or stall aimed at conserving heat and minimizing air movement for newborn animals; may include a heat source. (ASAE, 2001)

Infiltration: Air leakage into a structure through cracks and joints (e.g. at windows and doors) caused by mechanical ventilation system, wind pressure and/or differences in indoor and outdoor temperatures. (ASAE, 2001)

Infiltration air: Fresh air that enters a building from the outside, through unexpected inlets. (ASAE, 2001)

Insulation, batt: Natural or synthetic fibrous insulation material packaged in bales and sized to fit between building framing members. (ASAE, 2001)

Insulation, blanket: Natural or synthetic fibrous insulation material packaged in rolls and sized to fit between framing members. (ASAE, 2001)

Intake (or inlet) velocity: Velocity of air as it enters the building through an air inlet. (ASAE, 2001)

Jet throw: The distance incoming air travels from an air inlet before it slows to a low velocity. (ASAE, 2001)

Light trap: Device for allowing passage into or out of a room or container while minimizing transmission of light. (ASAE, 2001)

Loose-fill insulation: Insulation installed by pouring or blowing the insulating material into building walls and ceiling. (ASAE, 2001)

Louver: Slotted ventilation opening allowing air flow while excluding rain, snow or direct light. (ASAE, 2001)

Makeup heater: Furnace, usually on an exterior wall, which adds heat to an incoming forced fresh air stream and exhausts, or distributes, it into the room. (ASAE, 2001)

Mineral wool: Fibrous insulating material of processed slag or rock. (ASAE, 2001)

Mister: System for dispersing water in coarse droplets (e.g. mist system $\varnothing > 100\mu\text{m}$, micromist system $\varnothing = 40 - 100\mu\text{m}$) to provide wetting and/or cooling of livestock and structural surfaces. (ASAE, 2001; Barbosa, 2009)

Modified open front building: Building with one or more walls with large adjustable openings that may be closed or opened, dependent on weather conditions, to moderate building environment. (ASAE, 2001)

Moisture balance: Condition whereby water vapour brought into a building, plus that released inside, is exactly equal to that leaving. (ASAE, 2001)

Moisture barrier: Material which retards the diffusion of moisture vapour through a building structure. (ASAE, 2001)

Moisture proof: Impenetrable to moisture absorption or passage of water in any form. (ASAE, 2001)

Moisture resistive: Relatively impermeable to water diffusion. (ASAE, 2001)

Nebulizer: a device that disperses water in fine droplets to facilitate the evaporative cooling process. (Hellickson and Walker, 1983)

Orientation, building: The position of the building long axis, with regard to the cardinal points. Building orientation is related to prevailing winds and solar radiation and has a significant influence on natural ventilation and indoor climatic conditions. (Barbosa, 2009)

Perimeter insulation: Thermal insulation (usually rigid) installed onto or in a building foundation to reduce perimeter heat flow. (ASAE, 2001)

Plenum: Enclosed space (e.g. attic, basement, box), where air pressure is slightly higher than the outside atmospheric pressure, and that it is used for air circulation and for supplying air to ducts or air inlets. (ASAE, 2001)

Radiant heater: Device that emits thermal radiation that is directed to materials, livestock and/or plants, and partially absorbed by them. (ASAE, 2001)

Ridge vent: Opening along a roof peak for natural ventilation air outlet or an inlet for mechanical ventilation. (ASAE, 2001)

Set-point: Target value of an indoor environment variable (e.g. temperature, humidity, gas concentration), to be achieved by the environmental control system. (IUPS, 2003)

Shade: Building or other object used to shield livestock from direct solar radiation; generally lightweight structure with solid or perforated roof and open walls to permit maximum air movement while blocking direct sunlight. (ASAE, 2001)

Steady state: A stable condition of an open system, in which the relevant variables do not change over time, or in which a change in one direction is continually compensated by a change in another. (Blanes-Vidal, 2009)

Steady-state, heat: The state of indoor air balance there is no positive or negative heat storage, when the heat gain and heat loss, through its boundaries (e.g. heat transmission through building elements, ventilation, animal heat production, etc), are equivalent. (IUPS, 2003)

Temperature stratification: Air zones of different temperatures located from floor to ceiling; caused by non-uniform mixing of air. (ASAE, 2001)

Thermal break: Insulating material between two heat conductors which reduces conduction heat transfer. (IUPS, 2003)

Thermography, infrared: The recording of the temperature distribution of a body from the infrared radiation emitted by the surface. (IUPS, 2003)

Trombe wall: Wall on the south side of passively heated solar structures; constructed with concrete, brick, or adobe, and covered on the outside with glazing. The solar energy heats the wall during the day and heat is released to the structure at night. (ASAE, 2001)

Ventilation: Process of renewing indoor air in a livestock building by supplying outdoor air, in order to provide oxygen, remove noxious gases (e.g. CO₂, NH₃, CH₄) and control indoor temperature and relative humidity. (Blanes-Vidal and Torres, 2004)

Ventilation, curtain wall: Curtain of woven or solid fabric placed over a wall opening and adjusted up and down with a cable-and-winch arrangement so as to vary the ventilation in a livestock barn. (ASAE, 2001)

Ventilation, mechanical: Ventilation caused by mechanical means (e.g. electrically or hydraulically powered fans; ASAE, 2001)

Ventilation, natural: Ventilation caused by wind pressure, or differences in temperature (i.e. in air density) between indoor and outdoor air. (ASAE, 2001)

Ventilation, negative-pressure (or exhaust): System in which air is forced out of a building and in which fresh air from outside is drawn by negative pressure into the building. In a negative pressure ventilation system, fans are installed to exhaust stale air from the building, and fresh, clean air enters into the barn through expected inlets, and through cracks and joints (infiltration; ASAE, 2001)

Ventilation, positive-pressure: System in which outside air is forced into the building, which in turn forces out inside air by positive pressure. In a positive pressure ventilation system, fans are installed to force outdoor clean air into the building, and stale air leaves the barn through expected outlets, and through cracks and joints. (ASAE, 2001)

Ventilation, neutral-pressure: A combination of negative and positive mechanical ventilation systems, without air inlets and outlets. In a neutral-pressure system, fans are installed to force outdoor clean air into the building, and stale air leaves the barn through exhaust fans. (ASAE, 2001)

Ventilation, tilt door: Wall ventilation inlet or outlet which opens inward at the top. (ASAE, 2001)

Ventilation, under-floor: Ventilation system designed to vent the air between slotted floor and waste in under-floor storage; part or all of the building's ventilation may be accomplished by the system. (ASAE, 2001)

Zone cooling: A system having air ducts and downspouts (or drop ducts) to throw a jet of cooled air at the head and neck of animals housed in stalls so as to reduce heat stress in hot climate. (MWPS – 8; 1983)

Physics

Area, effective radiating: The surface area of a body that exchanges radiant energy with the environment through a solid angle of 4π steradians. (IUPS, 2003)

Area, projected: The area of a body (or surface) projected on a plane perpendicular to the direction of collimated beam (projected through an aperture) of radiation. (IUPS, 2003)

Area, total body: The area of the outer surface of a body, assumed smooth. (IUPS, 2003)

Area, wetted: The area of skin which, if covered with sweat (water), would provide the observed rate of evaporation under the prevailing condition. (IUPS, 2003)

Area, solar radiation: The area of a body projected perpendicularly to the sun's rays. (IUPS, 2003)

Capacity, heat: The product of the mass of an object and its specific heat ($J\ ^\circ C^{-1}$; IUPS, 2003)

Capacity, specific heat: The amount of heat needed to raise the temperature of unit mass of a particular substance by one degree Kelvin ($J\ kg^{-1}\ K^{-1}$; IUPS, 2003)

Condensate: Liquid formed when a vapour condenses (e.g. as in an air-conditioning process; ASAE, 2001)

Condensation: Water vapour removed from the air and formed, in a liquid state, on a surface, in a building usually caused by poor insulation and/or high humidity. (ASAE, 2001)

Conductance, thermal: The rate at which heat is transferred between a unit area of two parallel surfaces in a medium separated by a distance L , when a temperature difference of one degree is maintained between them ($W\ m^{-2}\ ^\circ C^{-1}$). It is equal to: k/L , where k is the thermal conductivity. (Blanes-Vidal, 2009)

Conduction: Heat transfer through or between bodies in physical contact; involves no fluid motion. (ASAE, 2001)

Convection: Process by which heat is transferred by fluid currents (e.g. air or water). These currents (movement of particles within a fluid) can be natural driven (by temperature/density changes) or forced. (IUPS, 2003)

Convection, natural: Heat transfer caused by fluid currents (e.g. air or water) moving due to the density and temperature differences existing at different locations within the fluid. (IUPS, 2003)

Convection, forced: Heat transfer caused by motion of fluid imposed externally (e.g. by a pump or fan; IUPS, 2003)

Diffusivity, mass (Diffusion rate, Coefficient of mass transfer diffusion): (1) Amount of matter (e.g. water vapour) transmitted by diffusion through a permeable material, due to gradients in vapour pressure, per unit area and unit time ($kg\ m^{-2}\ s^{-1}$). (2) The constant of proportionality relating the rate of diffusion of a gas to the gradient of its concentration in another gas (e.g. water vapour in air; Cussler, 1997)

Diffusivity, thermal: The thermal conductivity of a substance divided by its density and specific heat capacity at constant pressure. It is a measure of the thermal inertia of a substance (i.e. how rapidly inside temperature changes when surface temperature varies; $m^2\ s^{-1}$).

Emissivity: The ratio of the total radiant energy emitted by a body to the energy emitted by a full radiator (black body) at the same temperature. (IUPS, 2003)

Emissivity, directional: The ratio of the thermal radiance of a body in a given direction to that of a full radiator at the same temperature. (IUPS, 2003)

Emissivity, hemispherical: The ratio of the total radiant energy emitted by an element of a surface into a hemisphere to the energy by a similar element on the surface of a full radiator. (IUPS, 2003)

Emissivity, spectral: The ratio of the radiant flux emitted by an element of surface per unit wavelength interval to the flux emitted by a full radiator at the same temperature and in the same waveband. (IUPS, 2003)

Emissivity, window: The ratio of the radiant energy emitted by an element of surface between wavelength λ_1 and λ_2 to the flux emitted by a full radiator at the same temperature and in the same waveband. (IUPS, 2003)

Energy: The capacity of a physical system to do work. It may occur either as chemical, electromagnetic, mechanical or thermal energy. (Blanes-Vidal, 2009)

Enthalpy: The summation of internal energy of a system and the product of its pressure and volume. It represents the heat content of the thermodynamic system. The enthalpy of a mixture (e.g. moist air) equals the sum of enthalpies of the parts (e.g. the dry air and the water vapour; Blanes-Vidal, 2009)

Greenhouse effect: Trapping heat inside a glass or a plastic enclosure, or trapping heat by the earth's atmosphere and thus reducing convective and radiative heat loss.

Heat content, body: The product of the body mass, its average specific heat, and the absolute mean body temperature. (IUPS, 2003)

Heat flow (Heat transfer rate): The amount of heat transferred per unit time, between parts of a body at different temperatures, or between a body and its environment when at different temperatures. (W; Blanes-Vidal, 2009; Encyclopaedia of Science and Technology, 2002)

Heat flux: Heat flow passing through unit area of a given surface (W m^{-2} ; ASAE, 2001)

Heat, latent: Heat energy absorbed or released by a material when it changes phases (e.g. from solid to liquid); no temperature change is involved. (IUPS, 2003)

Heat, sensible: Heat energy transported in the form of conduction, convection and radiation that can be felt or sensed, causes an increase or decrease in temperature and can be measured by a thermometer. (IUPS, 2003; Banhazi, 2009)

Heat transfer: Heat transferred through a medium or system by conduction, convection, radiation evaporation, or a combination of these (e.g. heat transferred from an environment to another environment, when they are separated by a building element; IUPS, 2003; Blanes-Vidal, 2009; Amigo, P. 2000)

Heat transfer coefficient: A parameter that determines the amount of heat that passes through a unit area of a medium or system in a unit time when the temperature difference between the boundaries of the system is one degree ($\text{W m}^{-2} \text{ }^\circ\text{C}^{-1}$; Encyclopaedia of Science and Technology, 2002; Amigo, P. 2000)

Heat transfer coefficient, combined non-evaporative: A parameter that determines the amount of heat that passes through a unit area of a medium or system, by conduction, convection and radiation; in a unit of time, when the temperature difference between the boundaries of the system is one degree ($\text{W m}^{-2} \text{ }^\circ\text{C}^{-1}$; Encyclopaedia of Science and Technology, 2002; Amigo, P. 2000)

Heat transfer coefficient, conductive (k-value, Thermal conductivity): A parameter that determines the amount of heat that passes by conduction, through a unit thickness of a medium or system (e.g. a solid or a stationary fluid), per unit area in a unit of time, when the temperature difference between the boundaries of the system is one degree ($\text{W m}^{-1} \text{ }^\circ\text{C}^{-1}$). (2) A proportionality constant relating heat flux by conduction, and the temperature gradient. (Encyclopaedia of Science and Technology, 2002)

Heat transfer coefficient, convective (h-value, Film coefficient or surface coefficient): (1) A parameter that determines the amount of heat transferred by convection, between a solid surface and a moving fluid in contact with it, or from place to place within a fluid; in a unit of time, when the temperature difference between them is one degree ($\text{W m}^{-2} \text{ }^\circ\text{C}^{-1}$). (2) A proportionality constant relating heat flux by convection, and the temperature gradient. (Encyclopaedia of Science and Technology, 2002; Amigo, P. 2000)

Heat transfer coefficient, evaporative: The net heat transfer per unit vapour pressure gradient caused by the evaporation of water from a unit area of wet surface or by the condensation of water vapour on a unit area of body surface.

Heat transfer coefficient, radiative: The net rate of heat transfer per unit area by the exchange of thermal radiation between two surfaces, per unit temperature difference between the surfaces, or between a surface and the ambient air.

Heat transfer, conductive: The net rate of heat transfer in a solid material or a non-moving gas or fluid (i.e. by conduction) down a thermal gradient, within an organism, or between an organism and its external environment.

Heat transfer, convective: Heat transferred between a solid surface and a moving fluid in contact with it, or from place to place within a fluid. The movement is caused by thermal gradients (natural convection) and/or by external forces such as wind, fans or pumps (forced convection).

Heat transfer, evaporative: The rate at which heat energy is transferred by evaporation from or condensation on the skin and the surfaces of the respiratory tract. (IUPS, 2003)

Heat transfer, global coefficient (Global or overall heat transmission coefficient, U-value, Thermal transmittance): Property of a building element (e.g. wall, ceiling) that indicates its ability for allowing heat transfer through it, due to conduction and convection (i.e. the heat flow per unit area and per unit temperature difference; $\text{W m}^{-2} \text{ }^\circ\text{C}^{-1}$).

Heat transfer rate (Heat flow): The amount of heat transferred per unit time, between parts of a body at different temperatures, or between a body and its environment when at different temperatures.

Humidity, absolute: Mass of water vapour in air per unit volume of air/water vapour mixture. (IUPS, 2003)

Humidity, relative: The ratio of the partial pressure of water vapour present in a volume of moist air to the partial pressure present in saturated air, both at the same temperature and pressure. (IUPS, 2003)

Inertia, thermal: (1) Property of a material that represents its ability to conduct and store heat (i.e. how rapidly internal temperature changes when surface temperature varies; $\text{J m}^{-2} \text{K}^{-1} \text{s}^{-1/2}$).

Insulation, thermal: Material that retards or resists the flow of heat. (ASAE, 2001)

Irradiation: Radiant flow incident on a unit surface area (W m^{-2} ; IUPS, 2003)

Latent heat of fusion: The quantity of heat absorbed (or released), in the reversible change of state, melting (or freezing), of unit mass of solid or liquid, without change of temperature. (IUPS, 2003)

Latent heat of vaporization: The quantity of heat absorbed (or released) by a volatile substance (fluid) per unit mass in the process of its reversible change of state by evaporation (or condensation) under isobaric and isothermal equilibrium conditions. (IUPS, 2003)

Mass transfer: Transport of a vaporizing liquid (usually water) to a moving gas (usually air) in contact with it, per unit area of the liquid surface and per unit difference between the vapour density (saturated) at the surface and the vapour density of the ambient gas. (IUPS, 2003)

Mass transfer, convective: (1) The transport by convection of one component of a non-reactive mixture (usually air–water) across an interface caused by a concentration gradient often accompanied by a transformation of phase and by a simultaneous transfer of heat. (2) Transport of mass (e.g. water vapour) in a fluid (e.g. air) due to the movement of the fluid. (IUPS, 2003)

Mass transfer, diffusion: (1) Transfer of mass from a vaporizing liquid (usually water) to a static gas (usually air) in contact with it, per unit area of the liquid surface and per unit difference between the vapour density (saturated) at the surface and the vapour density of the ambient gas. (2) The movement of matter (e.g. water vapour) through a permeable material (e.g. wall), when there is a vapour pressure gradient between the two faces. (Linares et al., 2000)

Mass transfer diffusion, coefficient (Diffusion rate, Diffusivity): (1) Amount of matter (e.g. water vapour) transmitted by diffusion through a permeable material, due to gradients in vapour pressure, per unit area and unit time ($\text{kg m}^{-2} \text{s}^{-1}$). (2) The constant of proportionality relating the rate of diffusion of a gas to the gradient of its concentration in another gas (e.g. water vapour in air).

Mass transfer rate: Amount of mass transferred per unit time (kg s^{-1} ; IUPS, 2003)

Microwave: Part of the electromagnetic spectrum with wavelength from 1 to 100 mm. (IUPS, 2003)

Moisture content: Amount of water in a material expressed as a percentage of the oven-dry weight (dry basis) or the wet weight (wet basis) of the material. (IUPS, 2003)

Permeability: Ability of a material to allow moisture to pass through it ($\text{ng water s}^{-1} \text{ m}^{-1} \text{ Pa}^{-1}$; Albright, 1990)

Permeance: Conductance of water vapour per unit area ($\text{ng water s}^{-1} \text{ m}^{-1} \text{ Pa}^{-1}$; Albright, 1990)

Pressure, atmospheric: The pressure due to the weight of the atmosphere as indicated by a barometer. Standard atmospheric pressure is the pressure 101.325 kPa. (IUPS, 2003)

Pressure, dynamic: Pressure of a fluid in motion, measured as the pressure it exerts on a flat surface perpendicular to the direction of its movement. (IUPS, 2003)

Pressure, saturated water vapour: Maximum vapour pressure. It is reached in saturated air. (IUPS, 2003)

Pressure, static: Pressure felt by an object suspended in a stationary fluid or moving with it. (IUPS, 2003)

Pressure, water vapour: Part of the total atmospheric pressure, exerted by water vapour. (IUPS, 2003)

Psychrometrics: The study of physical and thermal properties of moist air. (IUPS, 2003)

Radiance: (1) The radiant intensity in a certain direction divided by the orthogonal projection of this surface element on a plane perpendicular to this direction (W/sr m^2). (2) A measure of the amount of electromagnetic radiation leaving a point on the surface. (IUPS, 2003)

Radiance, thermal: (1) Radiance due to thermal radiation. (2) Amount of electromagnetic radiation leaving a body, associated with its temperature. (IUPS, 2003)

Radiant absorptance, total: The ratio of total radiant flux absorbed by a body (converted to thermal energy) to the total incident flux. (IUPS, 2003)

Radiant energy: Energy travelling in the form of electromagnetic radiation (J; IUPS, 2003)

Radiant energy, spectral: The radiant energy at a specific wavelength, per unit wavelength interval (J m^{-1} ; IUPS, 2003)

Radiant exitance: (1) The radiant flow emitted at all wavelengths by an element of the surface containing the source point under consideration divided by the surface area of that element (W m^{-2}). (2) Net radiant flow emerging from a surface, per unit area (W m^{-2}). This quantity includes radiation emitted, reflected and transmitted by the surface. (Blanes-Vidal, 2009)

Radiant exitance, self: The radiant flux emitted by a surface. (IUPS, 2003)

Radiant exitance, thermal: The radiant flux emitted as thermal radiation by a surface. (IUPS, 2003)

Radiant flow: The amount of radiant energy per unit of time (W; IUPS, 2003)

Radiant flow spectral: The radiant flow per unit wavelength interval at wavelength. (IUPS, 2003)

Radiant flux: The radiant flow per unit area (W m^{-2} ; IUPS, 2003)

Radiant flux, effective: The net radiant flux exchanged with all enclosing surfaces and with any intense directional sources and sinks for exchange of radiant heat by an organism whose surface temperature is hypothetically at ambient air temperature. (IUPS, 2003)

Radiant heating: Heating primarily by thermal radiation. (ASAE, 2001)

Radiant heat exchange: The net rate of heat exchange by radiation between an organism and its environment, usually expressed in terms of unit area of the total body surface (W m^{-2} ; IUPS, 2003)

Radiant intensity: The radiant flow proceeding from a source per unit solid angle in the direction considered (W sr^{-1} ; IUPS, 2003)

Radiant intensity, spectral: The radiant intensity per unit wavelength interval ($\text{W sr}^{-1} \text{ m}^{-1}$; IUPS, 2003)

Radiation, electromagnetic: Energy propagated in the form of electromagnetic waves in various wavelengths (e.g. ultraviolet $4 \times 10^{-5} - 10^{-7}$ cm, visible $7 \times 10^{-5} - 4 \times 10^{-5}$ cm, infrared $0.01 - 7 \times 10^{-5}$ cm, microwave $10 - 0.01$ cm), at the speed of light. (IUPS, 2003)

Radiation shape factor: A dimensionless quantity expressing the fraction of the diffuse energy emitted by a surface (or a source), denoted by the subscript i ; that is received by another surface, denoted by the subscript j ; visible by it and in known geometric relation with it. (IUPS, 2003)

Radiator: An emitter of radiant energy. (ASAE, 2001)

Radiator, full (black-body): An ideal body that allows all the incident radiation, regardless of wavelength and angle of incidence, to pass into it (no reflected energy) and absorbs internally all the incident radiation (no transmitted energy). Hence the blackbody is a perfect absorber of incident radiation. It emits a maximum energy and hence serves as an ideal standard of comparison for a body emitting radiation. (Arbel, 2009)

Radiator, gray-body: A radiator whose spectral emissivity is less than unity, but is the same at all wavelengths. (IUPS, 2003)

Radiator, selective: A radiator with a spectral emissivity less than unity which varies with wavelength. (IUPS, 2003)

Reflectance, radiation: The ratio of the radiant flux reflected by a surface or medium to the incident flux. (IUPS, 2003)

Saturated air: (1) Air that contains the maximum amount of water vapour that it can hold at its temperature and pressure, (2) Moist air confined over its liquid so that the vapour comes into equilibrium with the liquid, when the ambient temperature of the medium is held constant. (IUPS, 2003)

Specific heat: The quantity of heat required to raise the temperature of unit mass of a substance by one degree Celsius ($\text{J kg}^{-1} \text{ }^\circ\text{C}^{-1}$; IUPS, 2003)

Specific heat, volumetric: The product of the density of a material and its specific heat ($\text{J m}^{-3} \text{ }^\circ\text{C}^{-1}$; IUPS, 2003)

Temperature: A measure of the mean kinetic energy of the molecules in a volume of matter (K, $^\circ\text{C}$; IUPS, 2003)

Temperature, ambient: The average temperature of a gaseous or liquid environment (usually air or water) surrounding a body, as measured outside the thermal and hydrodynamic boundary layers that overlay the body ($^\circ\text{C}$; IUPS, 2003)

Temperature, black-globe: The temperature of a blackened hollow sphere of thin copper (usually 0.15 m diameter) as measured by a thermometer at its centre. The black metal ball absorbs radiant heat, and raises the temperature inside. It gives indirect information about the contribution of radiation and wind speed ($^\circ\text{C}$; IUPS, 2003)

Temperature, dew-point: The temperature at which saturation (and first condensation) occurs when an air–water vapour mixture is cooled at constant pressure and constant water vapour content ($^\circ\text{C}$; IUPS, 2003)

Temperature, dry-bulb: (1) The temperature of a gas or mixture of gases indicated by a thermometer exposed to the gas, but shielded from radiation and moisture. (2) Is the ordinary temperature of ambient air, measured by a dry-bulb thermometer ($^\circ\text{C}$; IUPS, 2003)

Temperature, mean radiant: (1) The temperature of an imaginary isothermal “black” enclosure in which a solid body or occupant would exchange the same amount of heat by radiation as in the actual non-uniform enclosure. (2) The temperature at which an object gives out as much radiation as it receives from its surroundings ($^\circ\text{C}$; IUPS, 2003)

Temperature, operative: The temperature of a uniform (isothermal) “black” enclosure in which a solid body or occupant would exchange the same amount of heat by radiation and convection as in the actual non-uniform environment ($^\circ\text{C}$; IUPS, 2003)

Temperature, wet-bulb: The lowest temperature to which it can be cooled by evaporating water adiabatically ($^\circ\text{C}$; IUPS, 2003)

Thermal conductivity: The ability of a material to conduct heat. It is defined as the quantity of heat transmitted in time through a certain thickness in a direction normal to a surface, due to a temperature difference under steady state conditions and when the heat transfer is dependent only on the temperature gradient ($\text{W m}^{-1} \text{ }^\circ\text{C}^{-1}$; Incropera and DeWitt, 1981)

Thermal expansion, coefficient of volumetric: The change in volume at constant pressure of a substance (solid or fluid) per unit volume, per degree change in temperature ($^{\circ}\text{C}^{-1}$; IUPS, 2003)

Thermal inertia for radiant heat: (1) Property of a material that represents its ability to conduct and store heat, during exposure to radiation. (IUPS, 2003)

Thermal capacitance: The resistance of a material to temperature change indicated by the time dependent variations in temperature during a full heating/cooling cycle (a 24-hour day for Earth). Materials with high thermal capacitance possess a strong inertial resistance to temperature fluctuations at a surface boundary and show less temperature variation per heating/cooling cycle than those with lower thermal capacitance. It is defined as: $I = (k\rho c)^{1/2}$, where k is the thermal conductivity, c is the specific heat capacity and ρ is the density ($\text{J m}^{-2} \text{ }^{\circ}\text{C}^{-1} \text{ s}^{-1/2}$).

Thermal resistance: (1) The inverse of the thermal conductance ($\text{m }^{\circ}\text{C W}^{-1}$), (2) A measure of the resistance or opposition of a single material to the flow of heat by conduction.

Thermal resistance, composite: (1) The inverse of the thermal transmittance ($\text{m}^2 \text{ }^{\circ}\text{C W}^{-1}$) (2) A measure of the ability of a composite building element (e.g. wall, ceiling) to resist the flow of heat, due to conduction and convection. (CBD, 1968)

Transmittance (Global coefficient of heat transmission, U-value): (1) Considering a building element (e.g. wall, ceiling) that separates two environments (indoor and outdoor air) at different temperatures, the U-value is the heat flow per unit area and per unit temperature difference between the two environments ($\text{W m}^{-2} \text{ }^{\circ}\text{C}^{-1}$). (2) Property of a building element (e.g. wall, ceiling) that indicates its ability for allowing heat transfer through it, due to conduction, convection and radiation. (Blanes-Vidal, 2009)

Transmittance, radiation: The ratio of the radiant energy transmitted through a body to the total radiation incident on it. (IUPS, 2003)

Units: Labels which distinguish one type of measurable quantity from other types (i.e. length, mass and time are distinctly different physical quantities and therefore have different unit names, meters, kilograms and seconds; Physics and Astronomy Glossary, 2009)

Work efficiency: Work done on an external system per unit of energy expended by an organism in the performance of that work. (IUPS, 2003)

Work rate, negative: The rate of work done on an organism by an external force. (IUPS, 2003)

Work rate, positive: The rate of work done by an organism on an external system. (IUPS, 2003)

Physiology

Acclimation: Physiological or behavioural changes occurring within an organism, which reduces the strain or enhances endurance to strain caused by experimentally induced stressful changes in particular climatic factors. (IUPS, 2003)

Acclimatization: Physiological and/or behavioural changes occurring within the lifetime of an organism that reduce the strain caused by stressful changes in the natural climate (e.g. seasonal or geographical; IUPS, 2003)

Activity, movement absolute: Animal behaviour that implies any kind of body's movement or posture. It can be determined or estimated from manual scoring, video records or from different automatic sensing and recording techniques (e.g. passive infrared motion detectors, pedometers, etc.) and is related to animal heat, moisture, carbon dioxide, ammonia, methane and dust production. (Pedersen and Blanes, 2009)

Activity, movement relative: Absolute animal activity expressed in relation to an average of activity (usually, in relation to daily average or pattern). It provides information about the diurnal pattern of animal activity. It can be theoretically approximated by different models and is related to animal heat, moisture, carbon dioxide, ammonia, methane and dust production. (Pedersen and Blanes, 2009)

Activity, digestion: Physiological response because of digestion, resulting in increased animal heat, moisture, heat and carbon dioxide production. (Pedersen and Blanes, 2009)

Acute-phase response: The multi-factorial stereotyped response of an organism that occurs shortly after infection, injury or trauma. (IUPS, 2003)

Adaptation: Physiological and/or behavioural changes that reduce the physiological strain produced by stressful components of the total environment. When it relates to climate, time scale of adaptation is usually longer than acclimatization. (IUPS, 2003)

Adaptation, genotypic: A genetically fixed condition of a species or subspecies, or its evolution, which favours survival in a particular total environment. (IUPS, 2003)

Adaptation, phenotypic: Changes that reduce the physiological and/or emotional strain produced by stressful components of the total environment and occurring within the lifetime of the organism. (IUPS, 2003)

Afebrile: The thermoregulatory state of an organism where core temperature is normal and thermoeffectors are not attempting to increase or maintain core temperature at an elevated level. (IUPS, 2003)

Air conditioning, comfort: The process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the comfort requirements of the occupants of the conditioned space. (HVAC, 1987)

Calorimetry: The measurement of the heat transfer between a tissue, an organ, or an organism and its environment. (IUPS, 2003)

Calorimetry, direct: The direct physical measurement of heat transfer rate of between a tissue, an organ, or an organism and its environment. (IUPS, 2003)

Calorimetry, indirect: The measurement of the rate of transfer of a material involved in the transformation of chemical energy into heat between a tissue, an organ, or an organism and its environment. (IUPS, 2003)

Calorimetry, partitional: The estimation of any single term in the body heat balance equation from direct measurements of all other terms in the equation during the steady state. (IUPS, 2003)

Circadian: Relating to the approximate 24-h periodicity of a free running biological rhythm, or to the exact 24-h periodicity of an environmentally synchronized biological rhythm that persists with an approximate 24-h periodicity when not environmentally synchronized. (IUPS, 2003)

Cold tolerance: The ability to tolerate low ambient temperatures. (IUPS, 2003)

Comfort, environmental: Specific combination of environment conditions (e.g. temperature, humidity, radiation air velocity, air quality) resulting in satisfaction of animals or humans as related to the surrounding environment. (Blanes-Vidal, 2009)

Core, thermal: Those inner tissues of the body whose temperatures are not changed in their relationship to each other by circulatory adjustments and changes in heat dissipation to the environment that affect the thermal shell of the body. (IUPS, 2003)

Critical temperature, evaporative: The ambient temperature above which tachymetabolic animals have no other evaporative heat loss capabilities (e.g. thermal tachypnea, sweating) to effectively control core body temperature, usually resulting in death due to severe hyperthermia. (Kruger et al., 1992)

Critical temperature, hypothermic: The ambient temperature below which tachymetabolic animals have no mechanism (e.g. shivering and/or non-shivering thermogenesis) to control core body temperature, usually resulting in death due to severe hypothermia. (Banhazi, 2009)

Critical temperature, lower: The ambient temperature below which the rate of metabolic heat production of a tachymetabolic animal must be increased (e.g. shivering and/or non-shivering thermogenesis) and heat production also increased (e.g. behavioural strategies, increased energy intake) in order to maintain thermal balance. (Kruger et al., 1992)

Critical temperature, upper: The ambient temperature above which the rate of evaporative heat loss of a tachymetabolic animal must be increased (e.g. thermal tachypnea, sweating), but heat production decreased (e.g. behavioural strategies, reduced energy intake) in order to maintain thermal balance. (Kruger et al., 1992)

Dead space: (1) Those portions, from the nose and mouth to the terminal bronchioles, not participating in oxygen-carbon dioxide exchange (*anatomical*) and (2) The anatomical dead space plus the space in the alveoli occupied by air that does not participate in oxygen-carbon dioxide exchange (*physiological*; Maltz, 2009)

Diurnal: (1) Indicates biological processes (e.g. phases of activity) occurring during the day, as distinct from the night. (2) Occurring daily (during each 24-h period; IUPS, 2003)

Draft (draught): Natural air movement with sufficient velocity, humidity, and/or cold temperature to cause discomfort. (ASAE, 2001)

Endothermy: The pattern of thermoregulation in which the body temperature depends on a high and controlled rate of heat production. (IUPS, 2003)

Evaporative heat gain, body: Evaporative heat transfer from the ambiance to the body due to condensation of vapour on the skin and/or the surfaces of the respiratory tract. (IUPS, 2003)

Evaporative heat loss, body: Evaporative heat transfer from the body to the ambiance by evaporation of water from the skin and the surfaces of the respiratory tract. (IUPS, 2003)

Fasting: Abstaining from food. (IUPS, 2003)

Febrile: A term used to describe the state of an organism during a fever. (IUPS, 2003)

Fever: A state of elevated core temperature which is often, but not necessarily, part of the defensive responses of organisms to the invasion by live or inanimate matter recognized as pathogenic or alien. (IUPS, 2003)

Habituation: Reduction of responses to or perception of a repeated stimulation. (IUPS, 2003)

Heat balance, body: The steady-state condition in which total heat gain in the body equals its heat loss to the environment. (IUPS, 2003)

Heat balance, equation: Equation based on the conservation of energy in an animal's body, under steady-state conditions. (Blanes and Pedersen, 2005)

Heat exhaustion: Muscular weakness, fatigue, and distress, resulting from prolonged exposure to heat. Core temperature is elevated and thermal sweating and cutaneous vasodilatation are commonly but not invariably reduced. (IUPS, 2003)

Heat loss: Common term that refers to gross loss of heat by radiation, convection, and conduction from livestock to the environment. (IUPS, 2003)

Heat production at animal level, latent: Part of total animal heat loss that is produced as latent heat, by evaporation of water from the respiratory tract or skin of the animals. It affects the indoor air by increasing the air water vapour content. (CIGR, 2002; Pedersen et al., 1998)

Heat production at house level, latent: Is the addition of the latent heat produced by the animals, and the part of the sensible heat production from the animals, that is used for evaporating water from wet surfaces inside the livestock building (e.g. wash water, animal wastes, wet skin). It affects the indoor air by increasing the air water vapour content. (CIGR, 2002; Pedersen et al., 1998)

Heat production at animal level, sensible: Part of total animal heat loss that is produced as sensible heat, affecting the surrounding air temperature. (CIGR, 2002; Pedersen et al., 1998)

Heat production at house level, sensible: Is the sensible heat produced inside the building (by animals, heaters, motors, lights), minus the part that it is used for evaporation of water from wet surfaces inside the livestock building. It affects the surrounding air temperature. (CIGR, 2002; Pedersen et al., 1998)

Heat production at animal level, total: Heat released during metabolism. (CIGR, 2002; Pedersen et al., 1998)

Heat strain: Physiological response to heat stress. (IUPS, 2003)

Heat stress: (1) Magnitude of environmental and metabolic heat loads on the animals, which tend to displace their systems from the resting or ground state. It is dependent on the production of heat from the animals, and the environmental conditions that determine the heat transfer between their body and the environment. (2) Situation in which the thermoregulation of the body is highly limited by the conditions of its surrounding environment, comprising high air temperature, high air humidity and/or low air velocity; and occasionally accentuated by a high metabolic heat production.

Heat stroke (Exceptional heat stroke, Sunstroke): An acute syndrome caused by an excessive rise in body temperature, as the result of overloading or failure of the thermoregulatory system, during excessive exposure to sun (sunstroke) or heat (heat stroke). It is worsened when the heat production of the animal increases (e.g. because of higher animal activity and exercising). (Blanes-Vidal, 2009)

Heat syncope: Collapse, usually with loss of consciousness, during exposure to heat. (IUPS, 2003)

Heat tolerance: The ability to tolerate high ambient temperatures. (IUPS, 2003)

Heat transfer: Heat transferred through a medium or system by conduction, convection, radiation evaporation, or a combination of these (e.g. heat transferred from one part of an organism to another, especially between body core and shell; heat transferred between an organism and its environment; IUPS, 2003)

Heat transfer, convective: The net rate of heat transfer in a moving fluid between different parts of an organism, or between an organism and its external environment; it may develop and be amplified by thermal gradients (natural convection) and by forces such as wind, fans, pumps or body movement (forced convection; IUPS, 2003)

Heat wave: Unusual weather conditions, occurring for an extended period of time (i.e. days or weeks), characterized by air temperatures substantially higher than the average temperature registered for that time of year, at that specific region. It can cause heat stress and heat stroke, both for animals and humans. Their effects are accentuated when the relative humidity and the minimum daily temperatures are high, and/or when this severe weather condition lasts for a long period of time (long duration). The specific threshold values for temperatures and duration that are used to define a heat wave vary from region to region. (Blanes-Vidal, 2009)

Heterothermy: The pattern of temperature regulation in a tachymetabolic species in which the variation in core temperature, either nycthemeral or seasonal, exceeds that which de homeothermy. (IUPS, 2003)

Heterothermy, local: The pattern of temperature in those parts of the body which comprises the thermal shell of homeotherms. (IUPS, 2003)

Hibernation: The state of winter (sometimes late fall or early spring) lethargy with a reduction in body temperature and metabolism of some animals that are homeothermic temperature regulators when active. (IUPS, 2003)

Homeostasis: General term characterizing the relative constancy of physico-chemical properties of the internal environment of an organism as being maintained by regulation. (IUPS, 2003)

Homeothermy: The pattern of temperature regulation in a tachymetabolic species in which the cyclic variation in core temperature, either nycthemeral or seasonal, is maintained within arbitrarily defined limits despite much larger variations in ambient temperature. (IUPS, 2003)

Hyperthermia: The condition of a homeostatic animal that occurs when core temperature is above its range specified for the normal active state of the species. (IUPS, 2003)

Hyperthermia, induced: The state of hyperthermia produced purposefully by increase in heat load and/or inactivation of heat dissipation by physical and/or pharmacological means. (IUPS, 2003)

Hypothermia: The condition of a homeostatic animal that occurs when core temperature is below its range specified for the normal active state of the species. (IUPS, 2003)

Hypothermia, accidental: The condition of a temperature regulator following an accidental or deliberate decrease in core temperature below its range specified for the normal active state of the species. (IUPS, 2003)

Hypothermia, induced: The state of hypothermia produced purposefully by increasing heat loss from the body and/or inactivation of heat conservation and heat production by physical and/or pharmacological means. (IUPS, 2003)

Insulation, total (INS): Total animal body insulation (INS) = EI + TI ($\text{m}^2 \text{ } ^\circ\text{C day MJ}^{-1}$; NRC, 2001)

Insulation, external (EI): The resistance to heat flow from the skin to the air. The EI is determined by coat depth, hair weight per unit area, hair diameter and air velocity ($\text{m}^2 \text{ } ^\circ\text{C day MJ}^{-1}$; NRC, 2001)

Insulation, maximal tissue (TI): The TI represents the resistance to heat flow from body core to skin, and would therefore be expected to be proportional to body diameter. The latter is relative to body mass and may be estimated by $a \cdot \text{BW}^{0.33}$, an equation true for bodies of similar proportions and of different mass ($\text{m}^2 \text{ } ^\circ\text{C day MJ}^{-1}$; NRC, 2001)

Integrated Relative Thermal-comfort Index (IRTCI): It integrates environmental and physiological condition in which the animal starts to thermoregulate under given housing conditions. (NRC, 2001)

Insensible perspiration: The mass of water passing through the skin by diffusion per unit area in unit time. (IUPS, 2003)

Insensible water loss: The sum of the water lost by diffusion through the skin and water lost in breathing, and excluding any water excreted. (IUPS, 2003)

Katathermometer: An instrument which measures the heat flow from a surface to a cooler environment. (IUPS, 2003)

Metabolic body size: The function of an animal's body size to which standard metabolic rate (or basal metabolic rate) is directly proportional. It takes into account the total body surface and weight, and it is usually referred to as body weight to the power of $3/4$. (IUPS, 2003)

Metabolic heat production: Rate of transformation of chemical energy into heat in an organism (W or $W\ m^{-2}$; IUPS, 2003)

Metabolic level: The metabolic heat production measured under standard conditions during a 24-h period divided by the metabolic body size. (IUPS, 2003)

Metabolic rate: The rate of transformation of chemical energy into heat and mechanical work by aerobic and anaerobic metabolic activities within an organism, usually expressed in terms of unit area of the total body surface. (IUPS, 2003)

Metabolic rate, basal: Metabolic energy transformation calculated from measurements of heat production or oxygen consumption in an organism in a rested, awake, fasting sufficiently long to be in post-absorptive state, and thermoneutral zone. The highest metabolic rate during a specified period of work compatible with sustained aerobic metabolism. (IUPS, 2003)

Metabolic rate, lowest observed: The lowest observed rate of metabolism during specified periods of minimum activity. (IUPS, 2003)

Metabolic rate, maximum: The highest metabolic rate during a specified period of work compatible with sustained aerobic metabolism. (IUPS, 2003)

Metabolic rate, minimum observed: Averaged metabolic rate during specified periods of minimum activity. (IUPS, 2003)

Metabolic rate, peak: The highest metabolic rate that can be induced in a resting animal by any cold environment. (IUPS, 2003)

Metabolic rate, resting: The metabolic rate of an animal that is resting in a thermoneutral environment but not in the post-absorptive state. (IUPS, 2003)

Metabolic rate, standard: Metabolic energy transformation calculated from measurements of heat production or oxygen consumption in an organism under specified standard conditions. (IUPS, 2003)

Metabolism: General term which relates to chemical and physical changes occurring in living organisms. (IUPS, 2003)

Metabolism, anaerobic: Transformation of matter and energy without uptake of oxygen. (IUPS, 2003)

Metabolism energy: All chemical reactions in living matter that provide or release energy. (Blanes-Vidal, 2009)

Nighttime recovery: the nocturnal period with low temperature, during which animals have a significant overnight cooling, over several successive hot days. (Albright, 1990)

Nocturnal: Occurring during the night-time, as distinct from daytime. (IUPS, 2003)

Nychthemeral: Relating to an exact period of 24-h. (IUPS, 2003)

Nychthemeron: A period of 24-h, consisting of a day and a night. (IUPS, 2003)

Optimal body temperature range: The range of body temperatures in which a species carries out its normal daily activity. (IUPS, 2003)

Optimal environment conditions: The range of air conditions (e.g. temperature, relative humidity, air velocity, gas concentration), that causes environmental comfort, and in which a species achieves its maximum genetic potential for growth and/or production. (IUPS, 2003)

Oxygen consumption, maximum: The maximum rate at which an organism can take up oxygen. (IUPS, 2003)

Panting, thermal: Increased respiratory evaporative heat loss due to increased respiratory minute volume. (IUPS, 2003)

Panting resonance: Breathing frequency that allows dissipation of heat more than is generated by the action of panting. (IUPS, 2003)

Passive cutaneous water exchange: The passage through the skin, in either direction of water, down an osmotic gradient per unit area in unit time ($\text{kg m}^{-2} \text{s}^{-1}$; IUPS, 2003)

Passive cutaneous water vapour exchange: The passage through the skin, in either direction, of water vapour, down a water vapour pressure gradient per unit area in unit time ($\text{kg m}^{-2} \text{s}^{-1}$; IUPS, 2003)

Piloerection: (1) Involuntary bristling of hairs or ruffling of feathers. (2) In thermal physiology, an autonomic thermoeffector action, developed in response to cold environment conditions, often associated with behavioural (e.g. postural) adjustments. (IUPS, 2003)

Preferred ambient temperature: The range of ambient temperature, associated with specified radiation intensity, humidity, and air movement, from which an unrestrained human or animal does not seek to move to a warmer or colder environment. (IUPS, 2003)

Q₁₀: The ratio of the rate of a physiological process at a particular temperature to the rate at a temperature 10°C lower, when the logarithm of the rate is an approximately linear function of temperature. (IUPS, 2003)

Regulation: The processes by which a biological system stabilizes variables, generally by information loops (negative feedback control; IUPS, 2003)

Respiratory evaporative heat loss: Rate of heat dissipated by exhalation of air saturated with water vapour (W; IUPS, 2003)

Respiratory minute volume: The product of respiratory volume and frequency. (IUPS, 2003)

Saliva spreading: The spreading of saliva on the body surface, often a deliberate (behavioural) thermoeffector action to cool the surface by evaporation. (IUPS, 2003)

Set-point: The value of a regulated variable which a healthy organism tends to stabilize by the processes of regulation.

Shell, thermal: The skin and mucosal surfaces of the body engaged directly in heat exchange with the environment and, in addition, those tissues under these surfaces whose temperatures may deviate from core temperature, due to heat exchange with the environment and to changes in circulatory convection of heat from the core to the heat exchanging surfaces. (IUPS, 2003)

Shivering: Involuntary tremor of skeletal muscles as a thermoeffector activity for increasing metabolic heat production. (IUPS, 2003)

Sickness behaviour: A group of signs or symptoms which accompany cytokine-producing events, usually with the elevation of body temperature. (IUPS, 2003)

Skin pressure effect on sweating: The inhibition of sweating in the dermatomal area of skin when mechanical pressure is locally applied. (IUPS, 2003)

Specific dynamic effect: Temporary increase in metabolic energy transformation following food intake. (IUPS, 2003)

Steady state: The state of body heat balance in which there is no positive or negative heat storage when heat gain and heat loss between the body and the environment are equivalent. (IUPS, 2003)

Steady-state, heat: The state of body heat balance in which there is no positive or negative heat storage, when heat gain and heat loss between the body and the environment are equivalent.

Storage, body heat: The rate of increase or decrease in the heat content of the body caused by an imbalance between heat production (metabolic heat transformation) and heat loss (W; IUPS, 2003)

Stress: Magnitude of forces external to an organism which tend to displace its systems from the resting or ground state. (IUPS, 2003)

Surface rule: A statement that the basal metabolic rate is proportional to the $2/3$ power of body mass. (IUPS, 2003)

Sweating, non-thermal: A response of the sweat glands to a non-thermal stimulus. (IUPS, 2003)

Sweating, thermal: A response of the sweat glands to a thermal stimulus. (IUPS, 2003)

Sweating topography, thermal: The sequence of the onset of thermal sweating and the differences in sweat rate observed between different skin regions. (IUPS, 2003)

Tachymetabolism: The high level of basal metabolism of birds and mammals relative to those of reptiles and other non-avian and non-mammalian animals of the same body mass and at the same tissue temperatures. (IUPS, 2003)

Temperature coefficient: The ratio between the change in any temperature dependant activity and the defined temperature range within which this change occurs. (IUPS, 2003)

Temperature, core: Ideally, the mean temperature of the thermal core (deep core tissues in the body). In practice it is represented by a specified core temperature, usually rectal or tympanic temperature ($^{\circ}\text{C}$; IUPS, 2003)

Temperature dependence: The influence of the local temperature upon the rate of all molecular transformations and thereby upon practically all cellular and physiological processes. (IUPS, 2003)

Temperature, effective: (1) An index calculated from adjusting actual air temperature with actual air humidity, radiation and/or air velocity. It reflects how easily the animal heat production is lost to the environment, considering all mechanisms (conduction, convection, radiation and evaporation). (2) The temperature at which motionless saturated air would induce, in an animal, the same sensation of comfort as that induced by the actual conditions of temperature, relative humidity, and air movement ($^{\circ}\text{C}$; Blanes-Vidal, 2009)

Temperature lability, controlled: An expression of the extent of the daily and seasonal variations in the level at which core temperature is being regulated. (IUPS, 2003)

Temperature lability, passive: An expression of the extent to which core temperature fluctuates passively (i.e. without the recruitment of thermoeffector activities) when either the rate of heat production or of heat exchange with the environment is varied. (IUPS, 2003)

Temperature, mean body: Ideally, the sum of the products of the heat capacities and temperature of all tissues of the body divided by the total heat capacity of the organism. It is estimated from core temperature and skin temperatures (°C; IUPS, 2003)

Temperature, mean skin: The sum of the products of the area of each regional surface element and its mean temperature divided by the total body (surface) area (°C; IUPS, 2003)

Temperature regulation: The maintenance of the temperature or temperatures of a body within a restricted range under conditions involving variable internal and/ or external heat loads. (IUPS, 2003)

Temperature regulation, autonomic: The regulation of body temperature by autonomic (i.e., involuntary) thermoeffector responses to heat and cold which modify the rates of heat production and heat loss (i.e. sweating, thermal tachypnea, shivering, non-shivering thermogenesis, and adjustments of circulatory convection of heat to the surfaces of the body; IUPS, 2003)

Temperature regulation, behavioural: Any coordinated movement of an organism ultimately tending to establish a thermal environment that represents a preferred condition for heat exchange (heat gain, heat loss, or heat balance) of the organism with its environment. (IUPS, 2003)

Temperature regulation, chemical: Body temperature regulation involving changes in heat production. (IUPS, 2003)

Temperature regulation, physical: Body temperature regulation involving control of the rate of heat flow into or out of an organism. (IUPS, 2003)

Temperature regulation, physiological: (1) Both autonomic and behavioural temperature regulation (preferred). (2) Obsolete synonym for autonomic temperature regulation. (IUPS, 2003)

Temperature regulator: An organism which regulates its body temperature to some extent by autonomic and/or behavioural processes. (IUPS, 2003)

Temperature survival limit, lower: The environmental temperature below which thermal balance cannot be maintained for a long period and animals become progressively hypothermic. (IUPS, 2003)

Temperature survival limit, upper: The environmental temperature above which thermal balance cannot be maintained for a long period and animals become progressively hyperthermic. (IUPS, 2003)

Temperature, tympanic: The temperature of the tympanic membrane. (IUPS, 2003)

Thermal comfort: (1) Satisfaction with the thermal environment (2) Specific combination of environment conditions (temperature, humidity, radiation, air velocity) that produces satisfaction of animals or humans with the thermal environment.

Thermal comfort, zone of: The range of ambient temperatures, associated with specified mean radiant temperature, humidity, and air movement, within which an organism is satisfied with the thermal environment.

Thermal environment: External environmental factors that influence the body heat balance, resulting in thermal comfort or discomfort.

Thermal hyperpnea: (1) An increase in tidal volume associated with an increase in alveolar ventilation occurring during severe heat stress which has caused a large rise in core temperature. (2) Breathing deeper than normal or with an increased respiratory rate, during severe heat stress. (IUPS, 2003)

Thermal strain: In temperature regulators: (1) Any deviation of body temperature induced by sustained thermal stress that cannot be fully compensated by temperature regulation; (2) Any activation of thermoeffector activities in response to thermal stress that cause sustained changes in the state of other, nonthermal, regulatory systems. (IUPS, 2003)

Thermal stress: Any change in the thermal relation between a temperature regulator and its environment which, if uncompensated by temperature regulation, would result in hyper- or hypothermia. (IUPS, 2003)

Thermal tachypnea: A rapid respiratory frequency accompanied by an increase in respiratory minute volume and, commonly, a decrease in tidal volume, in response to a thermoregulatory need to dissipate heat. (IUPS, 2003)

Thermoeffector: An organ system and its action, respectively, that affect heat balance in a controlled manner as part of the processes of temperature regulation. (IUPS, 2003)

Thermoeffector gain: The derivative of the thermoeffector output with respect to body temperature deviation from the set-point. (IUPS, 2003)

Thermoeffector threshold: The level of activity of a potential thermoeffector that is transgressed when it becomes actively involved in temperature regulation. (IUPS, 2003)

Thermoeffector threshold temperature: Describes the level of a specified body temperature (e.g. core temperature or mean body temperature) the transgression of which in one direction, either upward or downward, will activate a certain thermoeffector. (IUPS, 2003)

Thermoeffector threshold zone: The temperature range between two threshold (body) temperatures, for activation of any thermoeffector responses, particularly of metabolic heat production and of evaporative heat loss when no thermal load is present. (IUPS, 2003)

Thermogenesis, non-shivering: Heat production due to metabolic energy transformation by processes that do not involve contractions of skeletal muscles. (IUPS, 2003)

Thermogenesis, non-shivering (obligatory): That component of non-shivering thermogenesis (i.e., heat production unrelated to the contractions of voluntary muscles) that is independent of short-term changes in ambient temperature. (IUPS, 2003)

P. Panagakis, V. Blanes-Vidal, T. Banhazi, J. C. Barbosa, E. Maltz, V. F. Da Cruz, and D. Berckmans. "Glossary of Terms on Animal Housing: Interconnecting Engineering, Physical and Physiological Definitions" *Agricultural Engineering International: The CIGR Ejournal*. Manuscript 1302. Vol. XI. October, 2009.

Thermogenesis, non-shivering, (thermoregulatory): The increase in non-shivering thermogenesis in response to acute cold exposure. (IUPS, 2003)

Thermogenesis, shivering: An increase in the rate of heat production during cold exposure due to increased contractile activity of skeletal muscles not involving voluntary movements and external work. (IUPS, 2003)

Thermoneutral zone: (1) The range of ambient temperature at which metabolic rate is at minimum and temperature regulation is achieved only by control of sensible heat loss. (2) The range of ambient temperature in which normal metabolism provides enough heat to maintain an essentially constant body temperature in homeothermic animals. (IUPS, 2003)

Thermopreferendum: The thermal conditions that an individual organism or a species selects for its ambient environment in natural or experimental circumstances. (IUPS, 2003)

Thermoreactive: Descriptive of neural elements whose activity changes with the temperature of a remote region of the body, due to synaptic input from this region. Note: A central nervous neuron may be both thermoreactive and thermoresponsive (thermosensitive; IUPS, 2003)

Thermoreceptor: Thermosensitive neural element for which both its afferent function and its response characteristics are electrophysiologically identified (thermosensor; IUPS, 2003)

Thermoregulatory conditioned flex: The physiological (autonomic and behavioral) responses of an organism to changes in its thermal environment, which can also be elicited by a conditioned stimulus. (IUPS, 2003)

Thermoregulatory muscle tone: The increase in the electrical activity of the skeletal musculature of a resting tachymetabolic temperature regulator during moderate cooling. (IUPS, 2003)

Thermoresponsive: Neural element which changes its activity in response to changes of its own temperature. (IUPS, 2003)

Thermosensitive: Descriptive of thermoresponsive neural structures with the implication that the neural elements involved provide specific temperature signals. Synonym: temperature sensitive. (IUPS, 2003)

Thermosensor: Neural element or circuitry of neural elements for which it is established by psychophysical criteria or analysis of thermoeffector responses or changes of core temperature that they transduce temperature in such a way that thermal sensation is elicited and/or temperature regulation is adequately stimulated. (IUPS, 2003)

Thermotolerance: A rapid, short acting molecular process associated with the synthesis of several families of heat shock proteins of different molecular weights elicited as a result of acute short sub-lethal heat injury. (IUPS, 2003)

Thermotropism: The turning or movement of a plant or animal in response to a temperature stimulus. (IUPS, 2003)

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Tolerated ambient temperature range: The range of ambient temperature within which the body core temperature can be kept, by means of autonomic thermoregulatory processes, within certain limits typical for the species or the individual under consideration. (IUPS, 2003)

Torpor: A state of inactivity and reduced responsiveness to stimuli (e.g. during hibernation, hypothermia; IUPS, 2003)

Total environment: All environmental factors that exert an influence on an organism and to which an organism must be adequately adapted in order to survive. (i.e. climate, space, competition, feed availability, etc.; IUPS, 2003)

Total heat production: The rate of transformation of chemical energy into heat in an organism plus any heat flow liberated within the body resulting from work done on the organism by an external force (W; IUPS, 2003)

Wallowing: The thermoregulatory increase in evaporative heat loss by spreading an aqueous fluid (e.g. water, mud, urine) on the body surface. (IUPS, 2003)

Warm-blooded: (1) The thermal state of an animal that maintains its core temperature considerably higher than that of the environment when subjected to a low ambient temperature. (2) Tachymethabolic animals. (IUPS, 2003)