

# Hoop structure for horses during winter season: controlling the low critical temperature

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**Abstract:** Hoop barns, the low input housing structures, can be used in housing horses during fall and winter seasons. One of the hoop structures issue is the level of temperature, which is close to environmental temperature. The aim of this study is to show some technological measures which can overcome the weaknesses of hoop structures such as: feeding strategy, water system and body warming of horses using IR film. The control variable was the skin temperature of six horses, repeatedly measured with FLIR® thermo camera during several levels of environmental temperature. In the study, by using IR heating film at outside temperatures such as 0, -5 and -10°C, the body temperature measured in three body regions (neck, shoulder point and internal angle of eyes) did not differ significantly ( $F=0.167$  at  $p=0.847$ ): without IR heating system, differences were observed ( $F=8.905$  at  $p=0.000$ ). Moreover, in low BCS's animals, below -10°C environmental temperature, in absence of IR heating and if less fiber was present in the diet, low critical temperature signs were observed. In conclusion the hoop structure can be used successfully in horses even when outside temperatures are below low critical temperature of horses if certain conditions are assigned such as: water at 10-15°C, additional hay for fiber, with or without infrared heating.

**Keywords:** hoop structures, low temperature, horse

## 1. Introduction

Hoop structures have been used as effective alternative housing for grow-finish swine in the United States, Canada and Australia for over 30 years [4]. In Romania a hoop structure was studied [6,7,9,10,11, 13] and has been operable at Banat University – Horia Cernescu Research Unit since 2012. Hoop structures offer a distinct advantage for animal production due to the substantially smaller capital investment, relative to a conventional confinement building along with substantial reductions in energy operating cost.

Energy use is reduced because these structures are not heated or mechanically ventilated. In cold seasons, horses utilize the low energy consumption systems - IR heat panels to increase the thermal comfort. During warm seasons, structures with a north/south long axis orientation in open areas, will experience substantial natural air flow for ventilation. In addition, the high arch-shape of the structure creates a "chimney effect" that facilitates natural air flow. Furthermore, hoop structures are also versatile buildings that are easily converted to facilities for other types of livestock or for feed or equipment storage if a farmer decide to discontinue swine production and focus on other enterprises [9].

Finnish researchers investigated the respiratory health effects of loose indoor/outdoor group housing on weanling foals in cold Scandinavian winters (below -20°C in Finland for several consecutive weeks during the winter season) and they found that, generally, the foals did very well in this environment. The general conclusion was that keeping weanling horses in cold loose housing systems does not seem to increase the occurrence

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of respiratory diseases, but special attention should be focused on ventilation, air quality and feeding-practices [12].

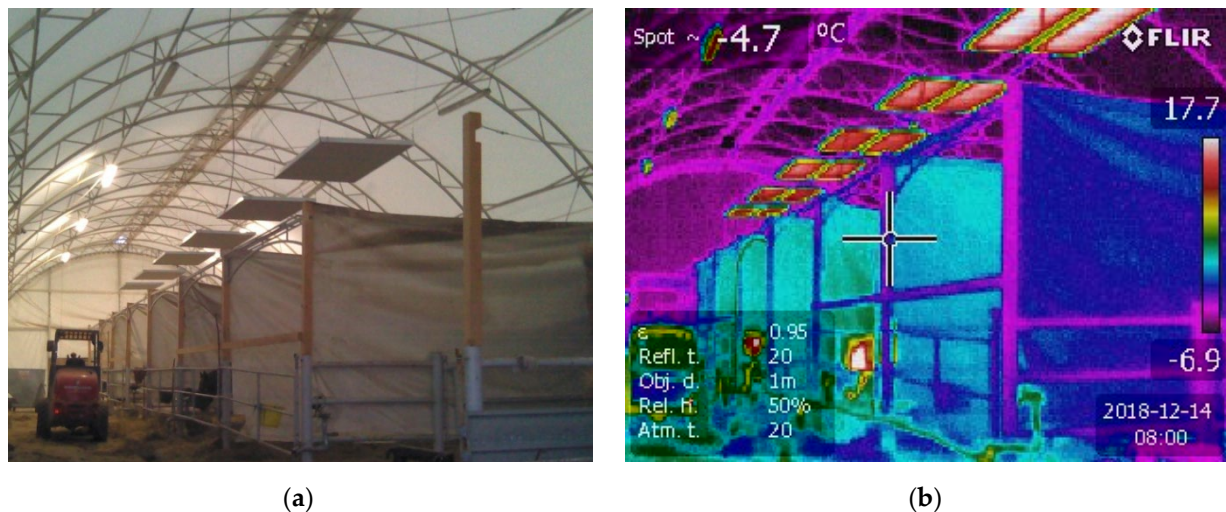
The specific objective of this report was to establish baseline conditions and expectations for keeping horses in hoop systems in Romania during the winter season of the year by using IR heating film panels.

## 2. Materials and Methods

**Animals and data collection:** six horses (Thoroughbreds, Romanian sport horse and Arabian breeds) weighing  $580.83 \pm 17.14$  kg were obtained from private owners on November 2018 by Research Contract no. 6944 from 25.09.2013 and placed in the ruminants hoop structure at the *Horia Cernescu Research Unit*, infrastructure of Life Science University “*King Michael I*” Timisoara, RO. The group consisted of 4 females and 2 males which were placed in individual pens inside the hoop structure after deworming based on fecal analysis. The horses were acclimated to their new location for 15 days. No haircuts were performed during the trial, but one physiological change was observed - an increase in density and length of the horse's coat. On the fifteenth day, horses were weighed and scored for body condition scoring. Subsequently, horses were weighed and scored for BCS every month considering the Henneke's scale [5] for jumping horses. Inside and outside temperature and humidity of hoop were continuously monitored using a multi-functional wireless digital device *Weather Station PCE-FWS 20*. The *FLIR (E50 Multi-Spectral Imaging Dynamic, MSX®, Wilsonville, Oregon, USA)*. A thermocamera was used for collecting the external body temperature of horses several times, when environmental temperature was in the limits established by the study. The body temperature was taken in three points (neck, head – internal angle of eyes and point of shoulder – *figure 2*) during the trial period (December and January) depending on the inside temperature inside the hoop: at  $0.0 \pm 2.0^\circ\text{C}$ , at  $-5.0 \pm 2.0^\circ\text{C}$ , and  $-10.0 \pm 2.0^\circ\text{C}$ .

**Feed:** Feed consisted of two intakes of 2.0 kg of washed oats and three intakes of 3.0 kg of grasses hay (less than 2% of their body weight in hay per day), 40 ml of corn oil daily, salt, vitamins A, D, E and 2:1 calcium-phosphorus mixture. For medical reason, during January one horse received just 1.25 kg of grasses hay per intake. Composition of the feed was analyzed by *Foss InfraXact®* (Hillerød 3400, DK), NIR equipment. Feed was stored in bags in the hoop structure and feeders were filled manually after weighing using *Ranger Mate* (American Calan, Northwood, New Hampshire, USA). Each pen was equipped with one nipple/cup water fountain and one feeder. In order to prevent freezing of pipes, a heating cable was used – the temperature was set to 10-15°C.

**Housing:** The *Experimental Unit* – hoop structure used for this trial has a total exterior dimension of 12 X 36 m and has concrete flooring, although it was primary designed for heifers and redesigned for horses' during the trial (*figure 1*). The primary design feature of these types of structures consists of uniformly spaced metal arches which are covered with a tightly woven plastic tarpaulin which is stretched out over the arches. The arches are attached to the top of vertical posts. These posts serve as the foundation of the structure. The tarp is stretched by means of small winches attached to the exterior surface of the posts. The interior of the posts is faced with wooden boards or sheet material to create a wall of 1.75 meters in height. The arched ends of the structure are typically covered with similar plastic canvass material with some type of roll-up doorway. The end-walls are often partially or completely opened during warm weather to increase air flow and reduce internal structure temperature and totally closed during the cold season. During winter, the one side inlet (15 cm x 36m) and top outlet 30cm x 36 m) were completely open in order to stimulate the air flow and to avoid the formation of condensation drops. The six horses were housed in the hoop structure, one per pen. Each of the six pens in which horses were housed measured 3.6 X 5.50 m. This offered 23.76 m<sup>2</sup> per animal which is more than the recommendation on horse housing for research purposes – [4,8]. Each of the 6 pens were equipped with one heating panel (handmade - two rows of 2 m<sup>2</sup> of heating film, power 200W/m<sup>2</sup>, with long-wave infrared radiation, of 4 μm ÷ 14 μm anchored in arch ceiling structure, parallel with floor, at 3.5 meters high (*figure 1*).



**Figure 1.** Normal (a) and FLIR thermocamera (b) images of trial place – six pens in hoop structure each with one IR heating panel suspended in arches of ceiling (Hutu, 2018).

**Statistical Analysis:** Analysis of external body temperature of horses were performed using one-way *Analysis of Variance (ANOVA)* for temperature of three body regions in presence or absence of IR heating panels. All data comparing body temperatures in case of using/not using IR heating was analyzed using two-sample *Student's t*-tests. For lower number of data, the Wilcoxon Signed Ranks Test was used.

### 3. Results and Discussion

**Body weight** was in average  $580.83 \pm 17.14$  kg at the beginning of the study (November 2018) and  $585.83 \pm 18.09$  kg at the end, on 31th of January 2019. The easy training activities were done during the study. In those conditions, even if the temperature in the hoop was lower, horses became heavier - but the difference between the start and finish of the trial cannot be statistically sustained ( $Z = -0.843$  at  $p = 0.339$  - *Wilcoxon Signed Ranks Test*).

**Body condition scoring** was in average adequate for jumping horse ( $BCS = 5.54 \pm 0.12$ ). BSC was assessed three times: during the accommodation period, at the end of December and at the end of January. Major differences were not observed during the study period ( $p = 0.317$ , *Wilcoxon test*): in average BCS was  $5.41 \pm 0.24$  at the beginning of the study (November 2018),  $5.58 \pm 0.20$  in December and  $5.62 \pm 0.22$  at the end of the study period (January 2019).

**Temperature and Humidity:** The inside temperature was higher ( $+1.56$  °C at  $p < 0.001$ ) and humidity index was lower ( $-0.49\%$  at  $p < 0.001$ ) than outside measurements. There was a strong correlation between inside and outside temperature ( $r = 0.925$  at  $p < 0.01$ ) and humidity index ( $r = 0.829$  at  $p < 0.01$ ). There were no clinical signs of low critical temperature among horses even though daily minimum temperatures often exceeded  $-10.0$  °C during January, with one exception. One horse that scored 4.5 in BCS had horripilation, muscle contractions, reduced blood flow at the level of the extremities such as ears, muzzle and legs as a sign of cold stress. As a preventive measure, horses that are body clipped or with low BCS will benefit from a blanket. Blankets are also beneficial for short term, in extremely cold, wet weather [3].

**External body temperature of horses** was measured in three body regions, with and without IR heating film, at outside temperatures such as 0,  $-5$  and  $-10$  °C. *Without IR heating panels*, at previously mentioned environmental temperature, the body temperature measured was  $18.28 \pm 0.74$  °C,  $18.90 \pm 0.72$  °C and  $22.19 \pm 0.65$  °C – in the study, the differences were significant ( $F = 8.905$  at  $p = 0.000$ ). When measured in each body region (middle of neck, shoulder point and internal angle of eyes) the temperature was well differentiated ( $F = 38.34$ ,  $p = 0.000$ ):  $17.79 \pm 0.38$  °C for neck region,  $18.09 \pm 0.63$  °C for shoulder point and  $23.49 \pm 0.50$  °C for internal angle of eyes. The variability between several body regions is normal and was reported by several authors [1].

With IR heating panels on, the body temperature measured was  $19.99 \pm 0.85^\circ\text{C}$ ,  $19.34 \pm 0.76^\circ\text{C}$  and  $19.61 \pm 0.78^\circ\text{C}$  – in the study, the differences did not differ significantly ( $F=0.167$  at  $p=0.847$ ). It appears clearly that IR body heating panels reduce the variability of body part temperature and the influence of external negative temperature of the environment. Measured in each body region (neck, shoulder point and internal angle of eyes) the temperature was well differentiated ( $F=36.46$ ,  $p=0.000$ ):  $17.79 \pm 0.37^\circ\text{C}$  for neck region,  $17.92 \pm 0.65^\circ\text{C}$  for shoulder point and  $23.23 \pm 0.46^\circ\text{C}$  for internal angle of eyes). Because the aim of using IR heating film is body's warming and not to heat the air of the stable, IR panel heating film had a lower electricity power consumption - for one horse the electrical power consumption is 0.4 kWh (1.44 MJ). For all six pens the electricity consumption was 2.4 kWh (8.64 MJ) which is similar with a domestic air heater.

The FLIR thermocamera used for collecting the external body temperature worked pretty well in cold climate, like other authors suggested [2].

The low critical temperature's signs were observed at environmental temperature below  $-10^\circ\text{C}$  in one horse – it was the case of a horse that had a lower BCS's, in absence of IR heating and with less fiber in the diet – because of colic prevention measure. Horses increase body metabolism through various physiological mechanisms. Bacterial fermentation of forage in the hind gut of the horse is one of them – by this, horses can generate a tremendous amount of heat. As a result, horses can tolerate much colder weather than humans. Practically, the addition of fiber to the diet will increase heat from fermentation.

In conclusion of the study, the hoop structure can be used successfully in horses, even when outside temperatures are below the low critical temperature of horses, if certain conditions are fulfilled such as: water at  $10\text{--}15^\circ\text{C}$ , feed rich in fiber and BSC in optimum ranges.

## 5. Conclusions

Hoop structures can be used for housing horses during the winter season, if an increased diet of grass hay is provided. Increasing the external temperature by using panels with long-wave infrared radiation of  $4\ \mu\text{m}$   $\pm$   $14\ \mu\text{m}$  does increase thermal comfort and will facilitate the housing of horses in extremely cold environments. Because the aim of body warming by IR heating film is not to heat the air of the stable, IR panels had a lower electricity power consumption - for one horse the electrical power consumption is 0.4 KW/hour. Low body condition score imposes the increase of grass hay intake, use of a blanket, or IR heating systems in order to avoid the clinical signs of low critical temperature in the hoop structure.

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### Institutional Review Board Statement:

The study was conducted according to the guidelines of the Low 43 11.04.2014 and approved by the Ethics Committee of Horia Cernescu Research Unit, protocol code POUEX1.1 from 27.05.2016.

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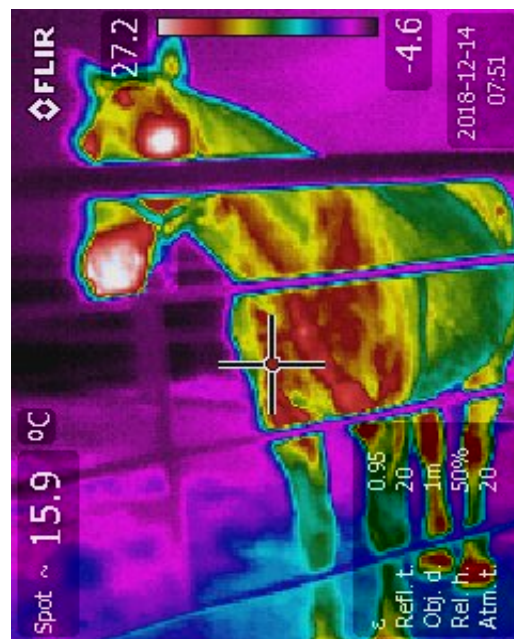


Figure 2. FLIR® IR image with temperature spot on "point of shoulder".

with Gordon, Marza-Rizac Laura with F-Rock, Moaca Marius with Afrodita, Galeancu Stefan whith Navaro) and to trainers Olimpia Rusu and Bogdan Biris for collaboration and giving horse during trial period.

**Conflicts of Interest:** “The authors declare no conflict of interest.”

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