HOOP STRUCTURE FOR *WEAN TO FINISH PIGS*: MANAGEMENT AND GENDER INFLUENCE IN A SUMMER TRIAL

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Abstract
The study was carried out in a hoop structure at the university's Animal Experimental Unit. Twenty hybrid barrows at 28 kg average body weight and 21 hybrid gilts with 27 kg were populated into two separate pens on 06 of April 2016. The animals were kept in a hoop structure utilizing a deep bedded production system at ambient summer conditions with natural ventilation for 97 days. No clinical heat stress signs were observed during the trial even though the inside temperature was 19.95±0.07°C and the humidity index was 65.15±0.18 over an average of 7,389 inside and outside environmental measurements. The inside temperature was higher (+0.78 °C at $p < 0.000$) and humidity index was lower (-0.74% at $p < 0.000$) than outside measurements. There was a strong correlation between inside and outside temperature ($r = 0.984$ at $p < 0.01$) and humidity index ($r = 0.926$ at $p < 0.010$). Animals were weighed twice per month and they were scanned monthly for body fat and eye muscle depth and area. On 13 of April, at initiation of the experiment, the body weight was 33±0.65 for 20 barrows vs. 31.9±0.59 for 19 gilts ($p = 0.220$) and at delivery to the slaughter house the body weight was 114.25±1.74 kg and 108.71±2.13 kg ($p = 0.049$) respectively. During the entire wean-finish period the average daily gain was 902.70±18.37 for barrows and 850.95±24.15 for gilts ($p = 0.097$) and feed conversion was 2.71 kg feed: kg live weight for barrows and 2.69 kg feed: kg live weight in gilts. The study is encouraging for the use of deep bedded hoop structures on low input farms as a swine wean-finish management system during the Romanian summer environment.
Keywords: *pigs, wean to finish, environment, hoop structure*

Introduction

Hoop structures have been used as effective alternative housing for grow-finish (G-F) swine in the United States, Canada and Australia for over 20 years *(Honeyman & Harmon, Payne, Maltman)*. In Romania a hoop structure and deep bedding system has been operable at Banat University – *Horia Cernescu* Research Unit since 2012. Hoop structures offer a distinct advantage for G-F swine production due to the substantially smaller capital investment for the structure relative to a conventional slatted-floor 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, pigs utilize the deep bedding layer to create warmer spaces for themselves, often burrowing into the bedding. 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 should a farmer decide to discontinue swine production and focus on other enterprises.

In the United States, the savings in operating costs of swine G-F hoops are negated by the added cost of bedding, a slight increase in feed usage and higher labor cost experienced in hoop systems. The final result is that cost/pig produced is nearly equal in both hoop structures and confinement systems *(Honeyman et al.)*. It is reasonable to assume that in Romania, where energy costs are relatively higher than in the United States, and where labor costs are lower, that hoop structures have an advantage in cost of production for G-F hogs. It should also be emphasized that for smaller producers, the substantial up-front capital investment savings for hoops may be a critical factor in the ability of the producer to move forward with a swine feeding enterprise at all *(Honeyman et al.)*.

Data from the United States indicates that G-F swine in hoop structures experience annual performance levels comparable to those raised in conventional slatted-floor confinement facilities. When annual performance is broken down into warm seasons versus cold seasons, there are seasonal performance differences. Hoop raised pigs in warm seasons have higher average daily gain (ADG), reduced days to market and similar daily feed intake (DFI) and feed efficiency (F:G) as confinement raised pigs. The improved performance of hoop raised pigs is thought to be the result of slightly lower in-structure temperatures and improved air movement as well as the ability of the pigs in hoop structures to modify their own environment. In cold seasons however, hoop raised pigs have reduced ADG, increased days to market, higher DFI and poorer (higher) F:G. This poorer cold season performance is generally explained as being the result of the physiological need for greater energy intake for maintenance of body temperature homeostasis. Cold season hoop pigs also exhibited higher backfat thickness at the 10^{th} rib *(Honeyman & Harmon, Magolski & Onan)*. Australian performance data for G-F pigs in hoops indicates improved ADG for hoop raised pigs, but also higher P_2 fat thickness in their carcasses *(Payne)*.

The specific objective of this report was to explore the growth of commercial hybrid G-F pigs in a hoop system in Romania during the warm season of the year. Since the growth curves of gilts and barrows differ, with barrows typically exhibiting greater fat thickness at given weights or at given ages *(Latorre et al.),* the possibility that barrows would suffer greater performance reductions from the relatively high temperatures experienced during the warm season in Romania was also of concern. Therefore, a secondary objective was to compare the performance of barrows and gilts in a hoop structure management system.

Materials and methods

Animals and data collection: Forty feeder pigs of a widely used European commercial hybrid line (primarily composed of Large White and Danish Landrace breeding) weighing approximately 25 kg were obtained from Smithfield Romania on 6 April, 2016 and placed in the swine hoop structure at the Banat University of Agricultural Science and Veterinary Medicine in Timisoara, RO. The group consisted of 20 gilts and 20 barrows which were segregated by sex and placed in adjoining pens within the hoop structure. The pigs were acclimated to their new location for 14 days. On the fourteenth day, 13 April, 2016, pigs were weighed, scanned at the last rib for P_2 fat depth, *(Whittemore)* and loin (*longissimus dorsi*) depth, and feed allocated. Pigs also received an ear tattoo for permanent identification on 13 April. The ultrasound scans were obtained either with an *Aloka 500-V (Corometrics Medical System, Wallingford, CT USA)* with a 12 cm, 3.5 MHz probe and analyzed using BioSoft Toolbox II for Swine *(Biotronics, Inc. Ames, IA USA)* or using a *Sonoscape A6V* with an L761V rectal probe operating at 4 MHz *(KeeboMed, Inc. Mount Prospect IL USA)* and measured directly on the instrument screen. Subsequently, the pigs were weighed every two weeks and scanned every four weeks (Scan data is presented in a companion paper).

At scanning dates, unconsumed feed was weighed in order to calculate interim feed efficiency. Delivery to the abattoir occurred on 12 July, 2016. A final pig weight was obtained on 12 July and unconsumed feed weighed back for determination of overall feed efficiency. One gilt suffered a blockage of its colon and was euthanized on 20 June, 2016. That animal's performance is not included in any of the gilt data except for the calculation of feed efficiency.

Feed: Feed was obtained from Smithfield Romania for the duration of the trial. All feed was in pelleted form and consisted of the standard diets used by Smithfield Romania in their G-F swine units. Composition of the feed was adjusted periodically based on pig weight following Smithfield Romania's standard protocol. All feed was packaged in in large plastic totes and was picked up by University staff from the Smithfield feed processing site. Feed was stored on pallets in an unused portion of the hoop structure and feeders filled manually, with all feed weighed using *Ranger Mate (American Calan, Northwood, NH, USA)* and recorded each time additions were made.

Housing: The forty pigs were housed in a hoop structure (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 taut over the arches. The arches are attached to the top of vertical wooden posts inserted 1.25 to 1.50 meters into the ground. 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 typically faced with wooden boards or sheet material to create a "knee-wall" of approximately 1.25 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. The Banat University structure used for this trial has a total exterior dimension of 8.92 X 26.75 m. and has concrete flooring throughout. The two pens in which the pigs were housed were each 6.00 X 8.22 m. This allowed 2.5 m^2/pig which is well above the 1.0 m^2/pig recommended for hoop housing of G-F swine *(Honeyman and Harmon).*

Figure no. 1: Horia Cernescu Research Unit – Swine Unit sector durig trial period

Each pen was equipped with two *AQUAFINISH* wean/finish nipple/cup water fountains and 8 feeder spaces provided by a rectangular swine self-feeder *(Hog Slat, Newton Grove, NC USA)*. Pens were bedded to a depth of approximately 0.30 m. as needed with wheat straw obtained from the university farm. The side of the pen where feeders were located is elevated approximately 0.50 m. above the main floor area and was not bedded. Internal and external temperature and humidity were continuously monitored using a multi-functional wireless digital device *Weather Station PCE-FWS 20*.

Statistical Analysis: Analysis of growth data was performed using 2-way Analysis of Variance with replication for cumulative weight, with date as one factor and sex as the second factor. Average daily gain was analyzed in a similar fashion. In those instances where the overall analysis indicated significance, least significant difference post-hoc analysis was performed to identify time points where the barrows and gilts differed. Feed efficiency was analyzed using 2-way Analysis of Variance without replication, again with date as one factor and sex as the second factor. Temperature and humidity means were compared using two-sample *Student's* t-tests.

Results and discussions

Growth and Feed Efficiency: Figure 2 illustrates the cumulative growth of the barrows vs. gilts. While there was no sex effect on weight at the beginning of the trial, barrows were heavier over much of the growth period ($p < 0.001$) with the first statistically significant difference at the

6 June weigh date and continuing for the remainder of the finishing period. There was no statistical difference in ADG between the barrows and gilts during any of the G-F time periods ($p = 0.175$). There was furthermore no difference in overall ADG with the barrows at 936 g. and the gilts at 888 g. although there was a trend for the barrows to gain more rapidly ($p = 0.063$). Feed efficiency (F:G) is reported in Table 1.

There was no difference in feed efficiency between barrows and gilts at any time point ($p = 0.99$). Overall grow-finish feed efficiency for barrows was 2.71 and for gilts 2.66 kg feed/kg gain. Feed efficiency did decrease over time ($p = 0.008$) with the first period combined F:G across sexes being 2.23 and the value for the final period being 3.47 kg feed/kg gain.

Table 1

Feed Efficiency (F:G) of Barrows and Gilts

Gender[a]	***Period 1***[b]	***Period 2***	***Period 3***	***Period 4***	***Period 5***	***Overall***[c]
Barrows	2.19	2.20	2.93	3.13	3.58	2.71
Gilts	2.26	2.35	2.60	3.46	3.37	2.66
Combined[d]	2.23	2.28	2.77	3.30	3.47	2.68

[a] No Significant Difference between barrows and gilts at any time point ($p = 0.995$).
[b] Period 1, first 13 days; Period 2, next 28 days; Period 3, next 29 days; Period 4, next 14 days; Period 5, final 6 days. Total feeding period was 90 days.
[c] Overall F:G.
[d] Combined F:G for barrows and gilts. This increased significantly over the feeding period ($p = 0.008$).

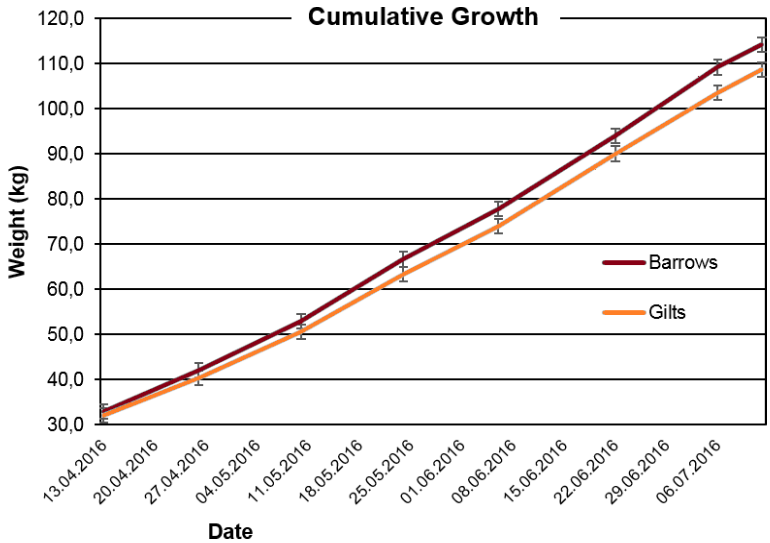


Figure 2: Cumulative growth of barrows vs. gilts over the time course of the G-F period. Both sexes were housed in a hoop structure in adjacent pens throughout the feeding period with weights taken every two weeks except that at the close-out of the trial, the final weight occurred at a one week interval. Error bars represent the Standard Error of the Mean at each time point.

Temperature and Humidity: Table 2 and Figure 3 presents the mean values for indoor and outdoor temperature and humidity for each feeding period and overall, as well as the corresponding growth performance data for barrows and gilts combined for each period. Growth performance is consistent with what would be expected for the weights achieved at by the end of each period. ADG, however, for Period 5 was significantly lower than that for Period 4 ($p < 0.05$) but was not lower than the overall mean ADG ($p = 0.108$).

Table 2

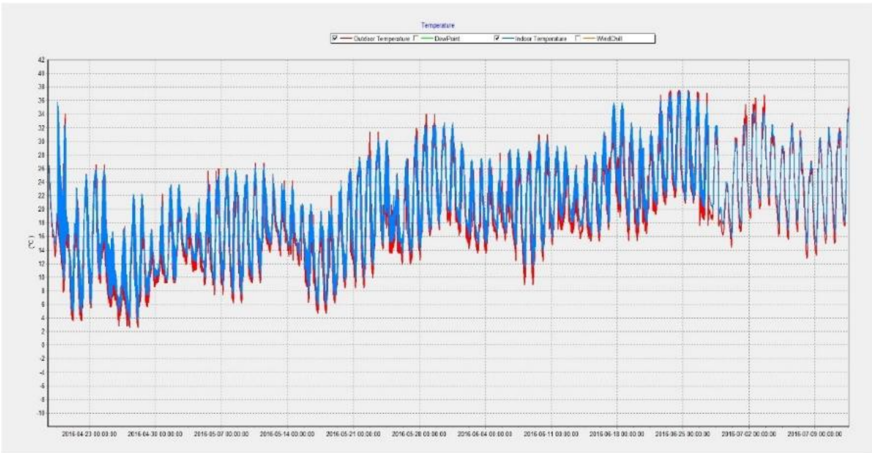
Meteorological Data by Period and Corresponding Growth Performance

Period[a]	**IT** *(°C)*[b]	**OT** *(°C)*	**IH** *(%)*	**OH** *(%)*	**ADG** *(g/day)*	**Weight (SEM)** *(kg)*[c]
1	13.98	13.02	59.96	61.64	670	41.3 (0.66)
2	16.27	15.46	67.28	67.93	850	65.1 (1.14)
3	22.78	21.96	66.25	67.31	934	92.2 (1.39)
4	26.01	25.44	64.32	64.63	1023	106.5 (1.44)
5	23.76	23.14	51.51	51.54	842	111.6 (1.41)
Overall	**19.95**	**19.17**	**65.15**	**65.89**	**913**	

[a] Period 1, first 13 days; Period 2, next 28 days; Period 3, next 29 days; Period 4, next 14 days; Period 5, final 6 days. Total feeding period was 90 days.

[b] IT=Indoor Temperature; OT=Outdoor Temperature; IH=Indoor Humidity; OH=Outdoor Humidity

[c] Mean combined weight for barrows and gilts at end of each feeding period.



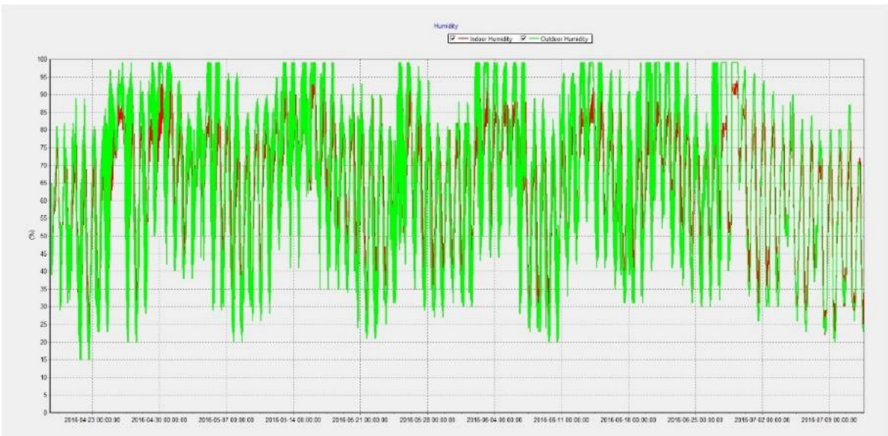


Figure 3: Indoor –outdoor temperature *(up)* and indoor –outdoor Humidity index *(down)* during a trial period. The output of *Weather Station* software.

The inside temperature was higher (+0.78 °C at $p < 0.001$) and humidity index was lower (-0.74% at $p < 0.001$) than outside measurements. There was a strong correlation between inside and outside temperature ($r = 0.984$ at $p < 0.01$) and humidity index ($r = 0.926$ at $p < 0.01$). There were no clinical signs of heat stress among the pigs even though daily maximum temperatures often exceeded 35.0° C during the Periods 4 & 5.

Discussion

Performance of the pigs in this trial compares favorably with industry standards. For example, benchmark data for wean-finish feeders in the United States who were enrolled in the *MetaFarms (Burnsville, MN, USA)* data management system during 2013 (approximately 900,000 total animals) indicated a mean ADG of 700 g/day. The pigs in this trial had a mean ADG for gilts and barrows combined of 913 g/day. This is certainly favorable relative to the USA commercial swine operation data. Part of that improvement can be contributed, however, to the fact that performance is typically better in small groups in research environments relative to commercial settings *(Koketsu).*

The same USA database reports an average F:G of 2.60. The pigs in this trial had an overall F:G of 2.68, clearly very comparable. A comparison to data from Denmark (composite of about 10% of all Danish G-F swine operations) for 2008 indicates very acceptable performance as well. The Danish herds had ADG just under 900 g/day and F:G of 2.83 for finishing operations *(Aarestrup et al.).* Pigs in this trial performed essentially equally for ADG and were numerically superior to the Danish performance for feed efficiency. This would indicate that hoop structures are a viable alternative for smaller low-input farms in Romania due to their low initial capital requirements and animal performance equal to established norms.

It has been shown that ADG and F:G for pigs is optimized between 10 and 20° C *(Nichols et al.).* The last three periods in the current study all had average temperature higher than 20° C (Table 1). However, examination of the growth data corresponding to those periods indicates that hoop structure raised swine perform well under these relatively warm conditions. Pigs in this trial maintained excellent growth rates even during the hotter periods of the trial. Average daily gain reached its maximum during Period 4 when average temperatures were also highest. During Period 5 however, ADG dropped off. That may be explained in part by the fact that the barrows in particular, were reaching maturity and their growth curves were perhaps beginning to plateau at that point. Furthermore, there were some very hot days at the end of this period (temperature maximums near 35° C). In addition, this growth period was only 6 days in length, so random variation over time, or carryover from the stress of the previous weighing may have reduced the mean ADG as well. In summary however, the pigs performed well in the hoop structure in spite of some heat challenge, again indicating that these structures are a viable option for grow-finish production in Romania.

Comparison of the performance of barrows versus gilts from this trial indicates results very similar to that found by other researchers. In this trial barrows attained significantly heavier weights during the latter portion of the finishing period than did gilts. This is consistent with the results of other *trials (Hamilton et al., Latorre et al.)*. Both *Latorre et al.* and *Leach et al.* report higher ADG for barrows than gilts. In this trial there was a strong trend ($p = 0.063$) for higher ADG in barrows. The relatively small sample size in this trial undoubtedly influenced the ability to attain statistical significance. The two genders in this trial indicated no significant difference in feed efficiency however, unlike those from both *Leach et al.* and *Latorre et al.* where gilts exhibited statistically better feed efficiency than barrows. It is possible that, were the pigs in this trial grown to heavier weights (for example to 130 – 135 kg), the inherent efficiency of the gilts' extended growth curves would have produced statistically better feed efficiency during the subsequent periods of the finishing time. In any case, it is clear that there was no negative temperature or humidity effect on the performance of either gender during this trial.

Conclusions and implications

Deep-bedded hoop structures as a management system for grow-finish swine allow for growth performance (ADG and F:G) equivalent to that of standard industry confinement facilities. Furthermore, during periods of potential heat stress, swine in hoop structures continue to perform well. The relative performance of barrows and gilts in hoop structures exhibit differences similar to those obtained in typical confinement facilities. Therefore, it can be recommended that hoop structures are a viable, indeed desirable, option for low-input swine G-F operations in Romania.

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References

1. Aarestrup, F.M., V.F. Jensen, H-D.Emborg, E. Jacobsen, H.C. Wegener. 2010. *Changes in the use of antimicrobials and the effects on productivity of swine farms in Denmark.* AJVR 71:726-733.
2. Hamilton, D. N., M. Ellis, K. D. Miller, F. K. McKeith, and D. F. Parret. 2000. *The effect of the Halothane and Rendement Napole genes on carcass and meat quality characteristics of pigs*. J. Anim. Sci. 78:2862–2867.
3. Honeyman, M.S. and J.D. Harmon. 2003. *Performance of finishing pigs in hoop structures and confinement during winter and summer*. J. Anim. Sci. 81:1663-1670.
4. Honeyman, M.S., J.D. Harmon, J.B. Kliebenstein and T.L. Richard. 2001. *Feasibility of hoop structures for market swine in Iowa: pig performance, pig environment, and budget analysis.* App. Eng. in Ag. 17: 869–874.
5. Koketsu, Y. 1997. *Transforming data into knowledge*. PigCHAMP, St. Paul, MN.
6. Latorre, M. A., R. Lazaro, D. G. Valencia, P. Medel, and G. G. Mateos. 2004. *The effects of gender and slaughter weight on the growth performance, carcass traits, and meat quality characteristics of heavy pigs*. J. Anim. Sci. 82: 526-533.
7. Leach, L. M., M. Ellis, D. S. Sutton, F. K. McKeith, and E. R. Wilson. 1996. *The growth performance, carcass characteristics, and meat quality of Halothane carrier and negative pigs.* J. Anim. Sci. 74:934–943.
8. Magolski, J. and G. Onan. 2007. *Growth and carcass parameters of hogs finished in a deep-bedded hoop structure vs. a confinement structure.* American Society of Animal Science Midwestern Branch (Abstr.) pg. 105.
9. Maltman, J. *A review of pig production in hoop shelters on the Canadian prairies (Abstract).* Hoop Barns & Bedded Systems for Livestock Production Conference. Ames, IA, 14 September, 2004.
10. Nichols, D. A., D.R. Ames, R. H. Hines. 1980. *Effect of temperature on performance of finishing swine.* Proceedings: Swine Day, Manhattan, KS, 13 November, 1980, pgs. 14-16.
11. Payne, H. *Deep litter housing systems, an Australian perspective (Abstract).* Hoop Barns & Bedded Systems for Livestock Production Conference. Ames, IA, 14 September, 2004.
12. Stein, T. 2013. *Finishing pig closeout performance improves.* Feedstuffs, November 25, 2013, pg. 15.
13. Whittemore, C. T. 2003. *The science and practice of pig production*. 2nd ed. Blackwell Science Ltd., Osney Mead, Oxford, UK.