Additional shade to improve outdoor sow welfare and production: A project investigating shade over wallows during summer

Final Report



By
Jo Pluske
John Pluske
Megan Trezona
Cintia Amaral

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Executive Summary

Heat stress is a major environmental issue affecting sow welfare and production. Animals lose heat in the form of sensible (conduction, convection, and radiation) and latent (evaporative) heat. Each mechanism requires a temperature gradient between the animal and its environment (Collier and Gebremedhin, 2015) such that as ambient temperature rises, animals redistribute blood towards the skin in an attempt to increase heat dissipation. However, when ambient temperature increases above the upper critical temperature, as can happen in summer with outdoor sows, evaporation becomes the only route of heat loss. As pigs have few functional sweat glands and a (relatively) thick subcutaneous fat layer, heat loss becomes more difficult. The sow will initiate a variety of strategies to minimise heat production, e.g., reduce feed intake, increase panting, seek cooling (if available), reduce activity, but these mechanisms are not always adequate to completely diminish the impacts of high ambient temperatures (e.g., Lucy and Safranski, 2017; Martínez-Macipe et al., 2020).

High summer temperatures in Western Australia (WA) can induce heat stress, resulting in significant adverse effects on sow productivity in both indoor and outdoor production systems. However, outdoor sows, representing approximately 25% of the sow herd in WA, are likely to be more negatively affected in summer regarding their welfare, physiology, reproductive success and survival. High ambient temperature (and relative humidity), particularly during late pregnancy, can reduce the number of live born piglets (Wegner et al., 2014) and increase the number of stillborn piglets (Omtvedt et al., 1971).

Furthermore, knock-on effects of gestational heat stress can deleteriously impact the growth, survival and meat quality of the progeny (Lucy and Safranski, 2017). For example, piglets born to heat-stressed sows exhibit increased body temperature, show impaired gonad development and accumulate adipose tissue (fat) at the expense of lean tissue during later growth stages (Ross et al., 2015), reducing the economic value of the carcase.

The sow will initiate a variety of strategies to minimise heat production such as reducing feed intake and activity and increasing panting, but these mechanisms are not always adequate to completely diminish the impacts of high ambient temperatures (Martínez-Macipe et al., 2020). Bracke (2011) noted that that pigs wallow for cooling and sun-burn protection and Blackshaw and Blackshaw (1994) remarked that shade for outdoor pigs should be considered in temperatures above 20 °C. Data from organic production systems in Denmark in summer (Andersen et al., 2017) indicated that sows lying in the shade of poplar trees had reduced heat load, as shown by a lower respiration frequency, and reduced their risk of sunburn.

A wallow, in the context of outdoor pig production, is a natural or artificial depression containing water or mud, where pigs can cool themselves in hot weather. Pregnant sows housed outdoors in WA typically have access to both wallows and shade as separate mechanisms for alleviating heat stress. However, the provision of wallows and shade in combination has not been well studied. Specifically, the influence of shade to reduce direct sunlight exposure and evaporation driven water loss from wallows, combined with potential benefits for sow welfare, productivity and progeny outcomes, are unknown.

The aims of this project were to: determine whether the provision of shade over wallows accessed by outdoor gestating sows in summer improved their welfare and reproductive performance; establish if there are net economic benefits associated with provision of shade over wallows provided to outdoor

sows in summer; and extend the project findings to industry. Due to factors external to this project, quantitative productivity and progeny outcomes could not be followed through (Appendix 1).

Findings from this project suggested that the provision of shade over wallows accessed by outdoor gestating sows in summer improved their welfare during hot weather by reducing heat stress as indicated by sows preferring shaded wallows, particularly when the weather was warm.

This study demonstrated that shaded wallows maintained lower mud temperatures and lower air temperatures above the wallow surface than unshaded wallows. Behavioural observations confirmed that sows preferred shaded wallows, particularly when ambient temperature exceeded 32 °C. In contrast to cool days where the paddock, hut and wallow provided comfortable conditions for sows, on warm days the paddock was undesirable and sows sought cooling, preferring shaded wallows if they were available.

A simple economic analysis indicated that providing shade over wallows in summer can be viable particularly if a monetary benefit can be assigned to production and welfare benefits. This finding is further supported if the cost of water increases or if shading reduces the volume of water required to maintain the cooling effectiveness of wallows.

The APIQ✓® Standards for Free Range and Outdoor Bred, Raised Indoors on Straw (APIQ✓® Standards Manual 2022) state that wallows are to be provided where State regulations and the season permits; AND/OR shade (including but not limited to trees, tree lines, hedges, shade stands), sprinklers, or other mechanical means are provided to cool pigs when necessary. Given these requirements, and the possibility of shade structures over mud wallows being an economically superior option to those over water wallows, producers may look to reducing the level of water in wallows when providing shade over wallows.

Outcomes and outputs achieved from this project include: a recommendation that producers consider providing shade over wallows in paddocks running outdoor pigs in Western Australia; a summary page of key points from this project that is available for all pork producers in Western Australia; and a conference abstract detailing specific findings from this project that was presented at the 2025 Australasian Pig Science Association (Inc) (APSA) Conference, November 2025 (Appendix 2).

It is recommended that further work be conducted to examine the effect of shaded wallows on outdoor sow reproductive performance during summer and follow progeny through to slaughter. In addition, the drying climate highlights the need for continued innovation to improve the efficiency of water use in outdoor pig production systems. To that end, an additional trial to assess an automated sensor was done (Appendix 3).

In addition to the findings being presented at the 2025 APSA Conference, on 1st September 2026, a technical forum extending the findings was delivered to pork producers in the Great Southern region of Western Australia (Appendix 4).

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1. Introduction

Heat stress is a major environmental issue affecting sow welfare and production. Animals lose heat in the form of sensible (conduction, convection, and radiation) and latent (evaporative) heat. Each mechanism requires a temperature gradient between the animal and its environment (Collier and Gebremedhin, 2015). As ambient temperature rises, animals redistribute blood towards the skin in an attempt to increase heat dissipation. However, when ambient temperature exceeds the upper critical temperature, as can occur in summer for outdoor sows, evaporation becomes the only effective route for heat loss. As pigs have few functional sweat glands and a (relatively) thick subcutaneous fat layer, heat loss becomes more difficult as ambient temperature increases. The sow will initiate a variety of strategies to minimise heat production, e.g., reduce feed intake, increase panting, seek cooling (if available), reduce activity, but these mechanisms are not always adequate to completely diminish the impacts of high ambient temperatures (e.g., Lucy and Safranski, 2017; Martínez-Macipe *et al*., 2020).

High summer temperatures in Western Australia (WA) can induce heat stress, resulting in significant adverse effects on sow productivity in both indoor and outdoor production systems. However, outdoor sows, representing approximately 25% of the sow herd in WA, are likely to be more negatively affected in summer regarding their welfare, physiology, reproductive success and survival. High ambient temperature (and relative humidity), particularly during late pregnancy, can reduce the number of live born piglets (Wegner *et al*., 2014) and increase the number of stillborn piglets (Omtvedt *et al*., 1971).

Furthermore, knock-on effects of gestational heat stress can deleteriously impact the growth, survival and meat quality of the progeny (Lucy and Safranski, 2017). For example, piglets born to heat-stressed sows exhibit increased body temperature, show impaired gonad development and accumulate adipose tissue (fat) at the expense of lean tissue during later growth stages (Ross *et al*., 2015), reducing the economic value of the carcase.

The sow will initiate a variety of strategies to minimise heat production such as reducing feed intake and activity and increasing panting, but these mechanisms are not always adequate to completely diminish the impacts of high ambient temperatures (Martínez-Macipe *et al*., 2020). Bracke (2011) noted that that pigs wallow for cooling and sun-burn protection and Blackshaw and Blackshaw (1994) remarked that shade for outdoor pigs should be considered in temperatures above 20 °C. Data from organic production systems in Denmark in summer (Andersen *et al*., 2017) indicated that sows lying in the shade of poplar trees had reduced heat load, as shown by a lower respiration frequency, and reduced their risk of sunburn.

A wallow, in the context of outdoor pig production, is a natural or artificial depression containing water or mud, where pigs can cool themselves in hot weather. Pregnant sows housed outdoors in WA typically have access to both wallows and shade as separate mechanisms for alleviating heat stress. However, the provision of wallows and shade in combination has not been well studied. Specifically, the influence of shade to reduce direct sunlight exposure and evaporation driven water loss from wallows, combined with potential benefits for sow welfare, productivity and progeny outcomes, are unknown.

2. Aims

Aim 1: To determine whether providing (additional) shade over wallows for outdoor gestating sows improves sow comfort and welfare during periods of hot weather and positively influences farrowing performance.

Aim 2: Establish if there are net economic benefits associated with provision of additional shade and wallows provided to outdoor sows in summer.

Aim 3: Extend the project findings to industry e.g., APSA (see Appendix 2); a technical forum for pork producers in the Great Southern (see Appendix 4).

Note: Due to factors external to this project, quantitative productivity and progeny outcomes could not be followed through (Appendix 1).

3. Methodology

The initial intention was to construct shade over wallows in paddocks directly adjacent to paddocks with unshaded wallows. However, due to on-farm issues beyond the control of this project, it was not possible to construct shade over wallows on the designated site (Figure 1). Therefore, project variations (Appendix 1) were written for two new experimental design sites (Figure 2 and 3).

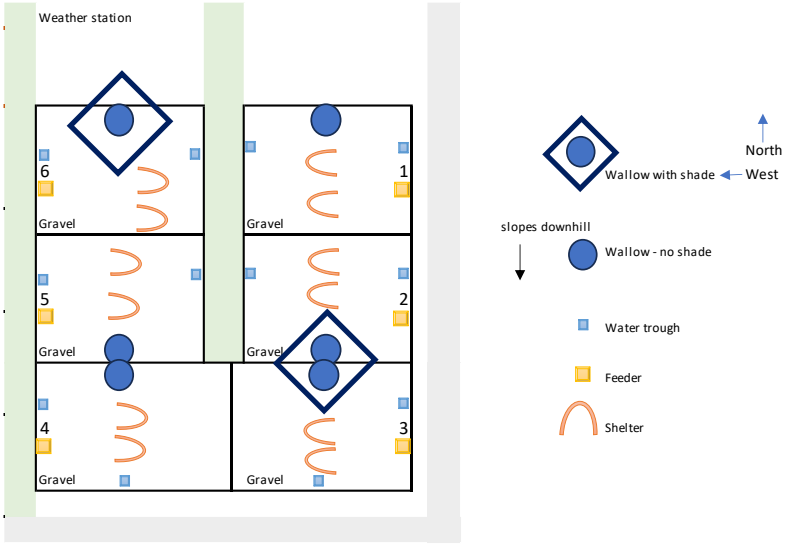


Figure 1. Experimental design site that was expected for the project.

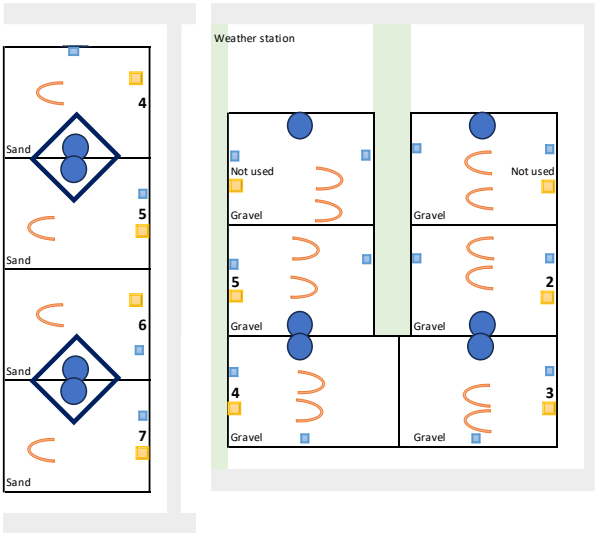
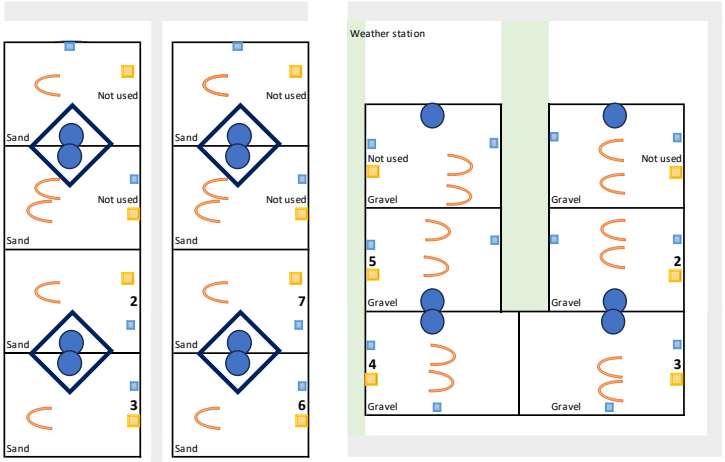


Figure 2. Experimental design sites that were used for the 2023/24 project experiments.

Figure 3. Experimental design sites that were used for the 2024/25 project experiments.



In this regard, it is important to note that different pig genotypes were run at the two sites and so it was not possible to compare production parameters for sows in paddocks with and without shade over wallows. Nevertheless, measurements associated with temperature and behaviour could be taken as described below.

This study was conducted with the following design, replicated over two summers, 2023-24 and 2024-25.

a) Experimental design

The study was conducted on the CMF property at Albany. A total of 496 pregnant sows of mixed parity were managed in groups according to standard farm practices. Each paddock was equipped with two bedded huts (eco shelter style enclosed on three sides), a water trough and a wallow. Sows assigned to Treatment 1 (negative control) were housed in paddocks without shaded wallows and were fed using an electronic sow feeding (ESF) system, which delivered individually allocated daily feed rations across two feeding periods per day. Sows assigned to Treatment 2 (shaded wallow) were housed in paddocks with shaded wallows and were group-fed once daily via ground troughs that provided sufficient feeding space for all animals to access feed simultaneously.

Treatments:
(1) Negative control access to an unshaded wallow (Figure 4);
(2) Access to shaded wallow (Figure 5).



Figure 4. Access to wallow: no shade.



Figure 5. Access to wallow: shade.

Shade over the wallows was provided by a UV-resistant shade cloth that was erected between 4 steel poles. Wallows were monitored over specific periods via camera footage. Wallows were maintained as per the standard farm practices.

b) Measurements

- *Temperature*

Temperatures were recorded for wallow-mud, hut-straw, and paddock-soil using a Thermometer Noncontact Gun (IR-40/+650DGC). Ambient temperatures were recorded using an on-farm weather station (Figure 6) and a Department of Primary Industries and Regional Development (DPIRD) Weather Station (DPIRD, 2024). As there was no difference (P = 0.27) in ambient temperatures between weather stations and the publicly available data, DPIRD data were used as the standard. Ambient temperature above the wallows was measured using loggers.

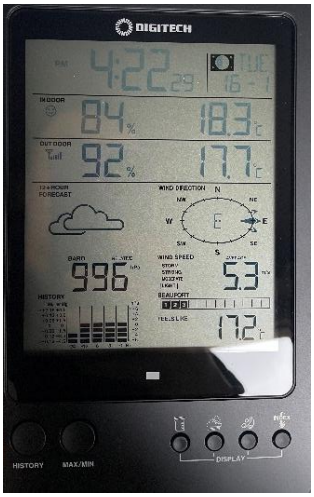


Figure 6. On-farm weather station monitor.

- *Sow behaviour*

The treatments were monitored via camera (Figure 7) footage (a total of 532 records) to determine the percentage of sows at the wallow between 1100 h and 1400 h on selected **cool** days (below 28 °C) and **warm** days (above 28 °C). Cameras were securely mounted out of the reach of sows on metal poles and provided a clear image of the wallow as in Figure 8.



Figure 7. Cam Trail 4K camera.



Figure 8. A screenshot of the camera footage.

Data were grouped and means analysed by paired 1-tailed t-Test (Microsoft® Excel® 2019 V2406, USA). Approval was obtained from the DPIRD Animal Ethics Committee (AEC Project Number: 23-6-26).

- *Wallow management*

Wallows were monitored for water flow and level of total dissolved solids (TDS). To ensure efficient water flow, a trial was conducted to evaluate the performance of temperature-based and soil moisture sensors under farm conditions for controlling sprinkler water flow in wallows (Figure 9). Predefined interval control was also tested.

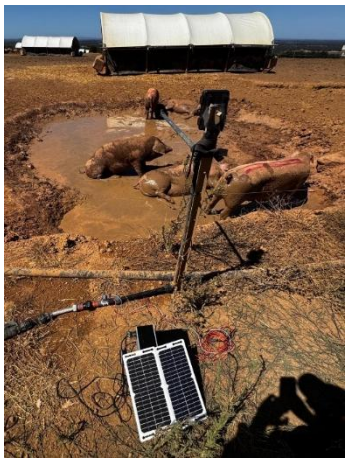


Figure 9. Trial set-up for controlling sprinkler flow.

c) Economic analysis

An analysis was completed in Microsoft® Excel®, whereby biological data was integrated with economic parameters to determine the net benefits of provision of shade and wallows for outdoor sows. A simple payback period analysis provided an indication of the benefits of providing shade over wallows by way of the number of years it would take for the original cost of a shade investment to equal the investment revenue.

P=I/E

where:
P = payback period in years
I = cost of the shade investment
E = expected annual net revenue generated from the shade being provided over the wallow.

4. Results and discussion

a) *Temperature and sow behaviour*

Findings from this project indicate that providing shade over wallows for outdoor, pregnant sows during summer improves welfare under hot conditions by reducing heat stress. This was evidenced by a clear behavioural preference, with sows spending longer periods in shaded wallows, particularly during warm weather, compared to unshaded wallows, which were typically used for short periods before sows returned to the shade of eco shelters.

Clear differences in sow behaviour were observed between treatments, with sows provided access to shaded wallows exhibiting distinct patterns of resource use compared with sows in the unshaded treatment. Less than 1% of sows in the unshaded treatment visited wallows when the ambient temperature was cool. This increased to a maximum of 13.5% of sows at wallows when the temperature was warm (Figure 10). By comparison, 10.4% of sows in the Shaded treatment visited the wallows when the ambient temperature was 28 °C, with up to 65% of sows at the wallow when the temperature was at 38 °C. The mean percentage of sows visiting unshaded and shaded wallows was different ($P < 0.05$) when the temperature was cool (0.3% versus 4.7%) and warm (9.5% versus 35.7%) (Figure 10).

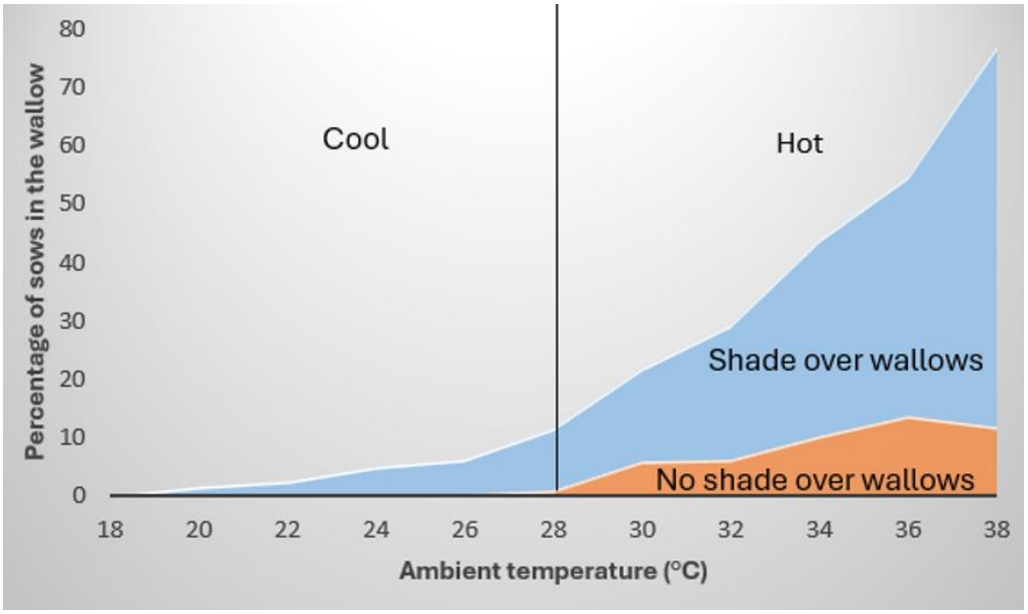


Figure 10. The percentage of sows in wallows for Shaded wallows (■) and Unshaded wallows (■), when the conditions were cool and warm.

Between treatments, there was no difference ($P > 0.05$) in paddock-soil or hut-straw temperatures. However, wallow-mud temperatures were lower ($P < 0.05$) in shaded wallows (Figure 11).

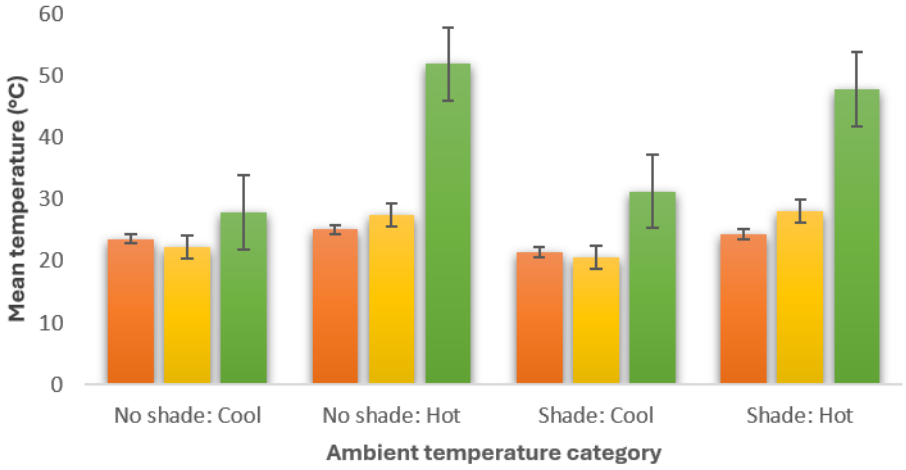


Figure 11. Mean temperature (± SE) of wallow-mud (■), hut-straw (■) and paddock-soil (■).

Within treatments, for cool days, paddock-soil temperatures were not different ($P > 0.05$) to wallow-mud or hut-straw temperatures but, for warm days, paddock-soil temperatures were higher than wallow-mud and hut-straw temperatures $P< 0.05$) (Figure 11).

Within treatments, for cool days, hut-straw and wallow-mud temperatures were not different ($P > 0.05$) but for warm days, hut-straw temperatures were higher than wallow-mud temperatures ($P < 0.05$) (Figure 11).

There was no difference ($P > 0.05$) between ambient temperatures and temperatures above unshaded wallows, but temperatures above shaded wallows were lower ($P < 0.05$) than ambient temperatures (Figure 12).

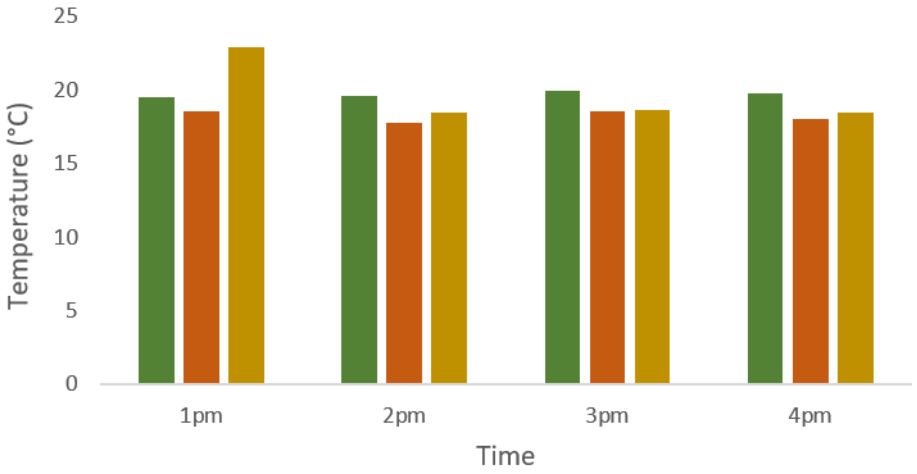


Figure 12. An example of temperature differences over time: ambient (DPIRD) (■), over shaded wallows, (■) and over unshaded wallows (■)

b) *Wallow management*

Due to resource constraints, in-depth analysis of water quality in wallows could not be determined in this project. However, wallows were monitored for water flow and level of total dissolved solids (TDS), a measure of the total minerals dissolved in water.

All wallows had regular clean water flow and did not have any signs of algal buildup. The TDS level varied depending on the water flow with the maximum TDS in a wallow being 3,320 ppm. This level is not excessive given that wallows are not the primary source for drinking water.

During the summer of 2024/25, the farm experienced a severe water shortage, that necessitated changes to wallow management practices. As a result, shaded and unshaded wallows were managed differently. When ambient temperatures were moderate (generally below 33 °C), shaded wallows were not refilled when sufficient damp soil or mud remained, as these conditions continued to provide effective cooling for the sows. While this introduced some variation in treatment management, it also provided valuable insight into the water-saving potential of shaded wallows under commercial conditions. This challenge prompted the development of an additional trial to evaluate the performance of temperature-based and soil moisture sensors for automated control of water application to wallows. Under commercial farm conditions, a simple and cost-effective prototype system performed successfully. The prototype demonstrated the feasibility of sensor-based water management for wallows and highlighted opportunities to further improve system robustness and performance under commercial conditions (Appendix 3).

An additional innovation to this trial to improve the provision of drinking water was the development of an alternative drinker prototype. See Appendix 3 for more detail of this innovation.

c) *Economic analysis*

Given the findings from this project and the prospect of a drying climate where water is less available, two scenarios were considered in the economic analysis.

1. Shade to be provided over wallows containing water (Figure 13).
2. Shade to be provided over wallows containing mud (Figure 14).



Figure 13. Sows in a wallow used in the project (scale: 30mm=1m).



Figure 14. Sows in a wallow containing mud with a shade structure above.

Assumptions associated with the benefits of providing shade over wallows:

a) Annually, a total of 20 sows at any one time used the wallow over a 120-day period during summer;
b) The dimensions of a wallow were based on the scale in Figure 12 (scale: 30mm = 1m);
d) The shade structure covered the wallow with the area being 28 m^2;
e) The cost of the shade structure was between $1,000 and $3,000;
f) Wallows full of water (depth of 0.5 m, volume of 6.29 m^3, resulting in 6,286 L of water in the wallow initially);
g) Wallows filled with just enough water to provide mud (depth of 0.05 m, volume of 0.6286 m^3, resulting in 629 L of water in the wallow initially);
h) 5% of the water was assumed lost per day due to seepage;
i) 5%[1] of the water was assumed lost per day due to evaporation when shade was not provided;
j) Water cost was based on a standard Water Corporation cost of $2.05 per kL;
k) Benefits associated with production and welfare were assumed to range from $0 to $0.10 per sow per day.

The number of years to payback the shade investment was estimated when:

a. the benefits were assumed to reduce evaporation from a wallow full of water;
b. it was assumed that benefits from shade over wallows with mud would also include a reduction in water requirements.

[1] Daily pan evaporation for Narrikup in December 2023 and 2024 was between 6 & 7% (DPIRD 2024)

For both scenarios, the cost of shade was varied from $1,000 ($50/sow) to $3,000 ($150/sow). Production and welfare benefits could not be estimated from the data obtained in this project. However, scenarios of between $0/sow/d and $0.10/sow/d have been included to show the change in payback period when these benefits are included in the analyses (Table 1).

Given the assumptions outlined above, without accounting for production and welfare benefits, providing wallows with both shade and water would only be viable if the shade structure had a lifetime of around 13 years and a cost of $1,000 or less (Table 1). Based on the same lifetime, realising sow production and welfare benefits of at least $0.05/sow/d would result in shade structure costs up to $2,500 being viable. If these sow benefits were increase to $0.10/sow/d, all shade structures costs of $3,000 or less with a lifetime of under 10 years would be viable (Table 1). Providing shade over wallows that contained mud instead of water resulted in the payback time being reduced for all scenarios. Only those with the more expensive shade structures and few sow benefits requiring the shade structure to have a lifetime in excess of 13 years to be viable (Table 1).

Table 1. The payback period (y) for a shade investment over wallows containing water or mud.

Payback (y) for shade that provides benefits to reduce evaporation from wallows				
	Production & welfare benefits ($/sow/d)			
Shade Cost ($/sow)	**$0.00**	**$0.01**	**$0.05**	**$0.10**
50.00	12.9	9.9	5.1	3.2
75.00	19.4	14.8	7.6	4.7
100.00	25.9	19.7	10.1	6.3
125.00	32.3	24.7	12.7	7.9
150.00	38.8	29.6	15.2	9.5
Payback (y) for shade that provides benefits when over mud wallows				
50.00	6.6	5.7	3.7	2.6
75.00	9.9	8.6	5.5	3.8
100.00	13.3	11.4	7.4	5.1
125.00	16.6	14.3	9.2	6.4
150.00	19.9	17.2	11.1	7.7

The cost of water varies depending on the source and availability during summer. Given a drying climate in south Western Australia, water is likely to become scarcer and if so the cost of water will increase.

Table 2 shows the payback period for the aforementioned scenarios when the cost of water is increased by 50%. If this was to occur, the benefits of providing a shade structure over a wallow, such as reducing evaporation, increases. Consequently, shade structures over wallows with water becomes more attractive with an increased water cost (Table 2). Likewise, for those over mud, the viable lifetime of the structure is under 13 years for all scenarios presented in this analysis (Table 2).

Table 2. The payback period (y) for a shade investment over wallows containing water or mud when water cost is increased by 50% to $3.08/kL.

Payback (y) for shade that provides benefits to reduce evaporation from wallows				
	Production & welfare benefits ($/sow/d)			
Shade Cost ($/sow)	$0.00	$0.01	$0.05	$0.10
50.00	8.6	7.1	4.2	2.8
75.00	12.9	10.7	6.4	4.2
100.00	17.2	14.3	8.5	5.6
125.00	21.6	17.9	10.6	7.0
150.00	25.9	21.4	12.7	8.4
Payback (y) for shade that provides benefits when over mud wallows				
50.00	4.3	3.9	2.8	2.1
75.00	6.4	5.8	4.2	3.2
100.00	8.5	7.7	5.6	4.2
125.00	10.7	9.7	7.1	5.3
150.00	12.8	11.6	8.5	6.3

5. Conclusions

Findings from this project indicate that providing shade over wallows used by outdoor gestating sows can improve sow welfare during hot weather by reducing heat stress. This was demonstrated by the strong preference shown by sows for shaded wallows, particularly as ambient temperatures increased.

This finding indicated that shaded wallows may provide a more comfortable space than shelters during hot weather, as air movement is not restricted and the mud in a wallow is cooler than the straw in a hut.

Shading significantly reduced both wallow mud temperatures and the temperatures recorded above the wallow surface compared with unshaded wallows. Combined with behavioural observations, these results confirmed that sows preferentially used shaded wallows, especially when ambient temperatures exceeded 32 °C. On cooler days, when conditions within the paddock, huts and wallows were generally comfortable, wallow use was low. In contrast, during warmer conditions, sows actively sought cooling resources and preferentially occupied shaded wallows where available.

A simple economic analysis indicated that providing shade over wallows in summer can be viable particularly if a monetary benefit can be assigned to production and welfare benefits. This finding is further supported if the cost of water increases or if the quantity of water can be reduced in a wallow.

The APIQ✓® Standards for Free Range and Outdoor Bred, Raised Indoors on Straw (APIQ✓® Standards Manual 2022) state that wallows are to be provided where State regulations and the season permits; AND/OR shade (including but not limited to trees, tree lines, hedges, shade stands), sprinklers, or other mechanical means are provided to cool pigs when necessary. Given these requirements, and the possibility of shade structures over mud wallows being an economically superior option to those over water wallows, producers may look to reducing the level of water in wallows when providing shade over wallows.

Findings from this project were presented in Melbourne at the 2025 Australasian Pig Science Association (Inc) Conference (Appendix 2). A technical forum extending the findings from this project was delivered to pork producers in Albany, Western Australia, on 1st September, 2026 (Appendix 4).

6. Outcomes and recommendations

The following outcomes and outputs were achieved from this project:

a) It is recommended that producers consider providing shade over wallows in paddocks housing outdoor pigs in Western Australia, as shaded wallows were preferentially used by sows during hot weather, suggesting improved thermal comfort, and have the potential to improve water-use efficiency. In addition, due to the drying climate, it is encouraged that innovation development to increase efficiency in delivering water provision to outdoor sows continues.

b) It is recommended that further work be conducted to examine the effect of shaded wallows on outdoor sow production data during summer and that progeny are followed through to slaughter.

c) A summary of key points from this project is available for all pork producers in Western Australia.

d) A conference abstract detailing specific findings from this project was presented at the 2025 Australasian Pig Science Association (Inc) Conference, November 2025. In addition, a technical forum extending the findings was successfully delivered to pork producers in Western Australia on 1st September 2026.

7. References

1. Andersen, H. M-L., Schild, S-L. and Jakobsen, M. (2017). Shade for outdoor pigs is important. ICROFS Report (https://icrofs.dk/en/aktuelt/nyheder/viewnews/artikel/shade-for-outdoor-pigs-is-important/).
2. APIQ Standards Manual (2022) For producers, auditors and stakeholders, Version 5.2 12/2022. Australian Pork Limited. Retrieved from https://australianpork.com.au/sites/default/files/2022-12/APIQ_Standards_Manual_V5.2_12_2022_0.pdf
3. Blackshaw, J.K. and Blackshaw, A.W., 1994. Shade-seeking and lying behaviour in pigs of mixed sex and age, with access to outside pens. Applied Animal Behaviour Science 39, 249-257. doi.org/10.1016/0168-1591(94)90160-0.
4. Bracke, M.B.M. (2011). Review of wallowing in pigs: Description of the behaviour and its motivational basis. *Applied Animal Behaviour Science* **132**:1-13. doi.org/10.1016/j.applanim.2011.01.002.
5. Collier, R. J. and Gebremedhin, K.G. (2015). Thermal biology of domestic animals. *Annu. Rev. Anim. Biosci*. **3:**513–532.
6. DPIRD (2024). The Department of Primary Industries and Regional Development Weather Stations and Radar. Retrieved on 8 January 2024 from https://weather.agric.wa.gov.au/station/NA003
7. Lucy, M.C. and Safranski, T.J. (2017). Heat stress in pregnant sows: Thermal responses and subsequent performance of sows and their offspring. *Mol. Reprod. Dev*. **84:**946–956
8. Martínez-Macipe, M., Mainau, E., Manteca, X. and Dalmau, A. (2020). Environmental and management factors affecting the time budgets of free-ranging Iberian pigs reared in Spain. *Animals* **10:**798. doi:10.3390/ani10050798.
9. Omtvedt, IT., Nelson, RE., Edwards, RL., Stephens, DF. and Turman, EJ. (1971). Influence of heat stress during early, mid and late pregnancy of gilts. *Journal of Animal Science* **32**:312–317.
10. Ross, J.W., Hale, B.J., Gabler, N.K., Rhoads, R.P., Keating A.F. and Baumgard, L.H. (2015). Physiological consequences of heat stress in pigs. *Anim. Prod. Sci.* **55:**1381–1390.
11. Wegner, K., Lambertz, C., Daş, G., Reiner, G. and Gauly, M. (2014). Climatic effects on sow fertility and piglet survival under influence of a moderate climate. *Animal*, **8**:1526–1533.

8. Appendices

a) Appendix 1: Project variations

Variations for Project: Improving outdoor sow welfare and production by providing shade and wallows during summer (APC P2225 264)

Project Title: Improving outdoor sow welfare and production by providing shade and wallows during summer.

Brief Description of Services Provision of shade and wallows to outdoor sows in summer: Establish if there are net economic benefits associated with provision of shade and wallows provided to outdoor sows in summer. Deliver a technical forum to pork producers in the Great Southern sharing the outcomes of the project.

Variation 1: 3/7/2024

Proposed Variation for Project: *Improving outdoor sow welfare and production by providing shade and wallows during summer* (APC P2225 264)

Reason: Due to unforeseen circumstances, for the summer of 2023/24, shade that was to be installed over the sow wallows (for Treatment 2) did not occur as planned in the experimental design.

It is therefore proposed that environmental and sow production data would be collected during the 2023/24 summer as detailed in Objective 1 for Treatment 1, negative control (no shade but access to wallow) but Treatment 2, that requires shade with access to wallow, would be done at a different location (where shade is installed over wallows). Due to the derivation from the experimental design, data, as outlined in the application, would be collected as part of a scoping study instead of contributing to Replicate 1. Due to this change, twice as many progeny will be followed through to slaughter in Year 2 in lieu of progeny being considered in Year 1.

No other variations associated with experimental elements of the project are requested, including no change to funding. However, variations associated with date changes due to the delay in exaction of this contract are included in this variation as outlined below.

Changes to Project Agreement APC P2225 264, executed 1/9/2023:

- **SCHEDULE 1 – ITEMISED SERVICE FEES**

  Change: "1. Collect environmental and sow production data during the 2022/23 summer and follow progeny through to slaughter." to "1. Collect environmental and sow production data during the 2023/24 summer."

  Change: "2. Collect environmental and sow production data during the 2023/24 summer and follow progeny through to slaughter" to "2. Collect environmental and sow production data during the 2024/25 summer and follow progeny through to slaughter."

- **SCHEDULE 3 - SERVICES TO BE PROVIDED BY SERVICE PROVIDER DURING THE SERVICE PERIOD**

  Change: "1. Collect environmental and sow production data during the 2022/23 summer and follow progeny through to slaughter." to "1. Collect environmental and sow production data during the 2023/24 summer."

  Change: "2. Collect environmental and sow production data during the 2023/24 summer and follow progeny through to slaughter" to "2. Collect environmental and sow production data during the 2024/25 summer and follow progeny through to slaughter."

Variation 2: 7/8/2025

Variation for Project: ***Improving outdoor sow welfare and production by providing shade and wallows during summer*** **(APC P2225 264)**

Reason: Due to unforeseen circumstances, for the summer of 2024/25, shade that was to be installed over the sow wallows (for Treatment 2) did not occur as planned in the experimental design. Moreover, there was an acute water shortage in the region and water for wallows in all Treatments had to be carefully monitored as opposed to being freely available.

Therefore, environmental and sow production data were collected during the 2024/25 summer as detailed in Objective 1 for Treatment 1, negative control (no shade but access to wallow) but Treatment 2, that requires shade with access to wallow, was done at a different location (where shade is installed over wallows). Due to the deviation from the experimental design, it was not possible to collect progeny data, as outlined in the application, that could be reliably compared across treatments.

No other variations associated with experimental elements of the project are requested.

Proposed changes to Project Agreement APC P2225 264, executed 1/9/2023:

- **SCHEDULE 1 – ITEMISED SERVICE FEES**

  Change: "1. Collect environmental and sow production data during the 2023/24 summer and follow progeny through to slaughter." to "1. Collect environmental and sow production data during the 2023/24 summer."

  Change: "2. Collect environmental and sow production data during the 2024/25 summer and follow progeny through to slaughter" to "2. Collect environmental and sow behaviour data during the 2024/25 summer."

- **SCHEDULE 3 - SERVICES TO BE PROVIDED BY SERVICE PROVIDER DURING THE SERVICE PERIOD**

  Change: "1. Collect environmental and sow production data during the 2022/23 summer and follow progeny through to slaughter." to "1. Collect environmental and sow production data during the 2023/24 summer."

  Change: "2. Collect environmental and sow production data during the 2023/24 summer and follow progeny through to slaughter" to "2. Collect environmental and sow production data during the 2024/25 summer and follow progeny through to slaughter."

b) Appendix 2: APSA Conference

An abstract based on findings from this project was accepted for the 2025 Australasian Pig Science Association (Inc) Conference and presented as a flash talk.

58. Outdoor sows prefer shaded wallows during summer

J. M. Pluske[1], C. A. V. Amaral[2], M. Trezona[2], J. R. Pluske[1]
[1]SciEcons Consulting, Perth, WA 6000, Australia
[2]Craig Mostyn Group, Fremantle, WA 6160, Australia

Corresponding author: John Pluske. Email: jrpluske@bigpond.com

Introduction High summer temperatures can negatively affect the welfare, physiology, reproductive success and survival of outdoor sows. The sow will initiate a variety of strategies to minimise heat production such as reducing feed intake and activity and increasing panting, but these mechanisms are not always adequate to completely diminish the impacts of high ambient temperatures (Martínez-Macipe *et al*., 2020). Bracke (2011) noted that pigs wallow for cooling, and Blackshaw and Blackshaw (1994) remarked that shade for outdoor pigs should be considered in temperatures above 20 °C. Approximately 25% of sows in Western Australia (WA) are housed outdoors and typically have access to wallow-mud, but little is known about the provision of wallows and shade for pregnant sows to reduce heat stress. It was hypothesised that wallow-mud temperature and temperature above the wallow would be lower for shaded wallows than for unshaded wallows resulting in sows preferring shaded wallows, particularly when it is warm.

Material and methods This study was conducted on a commercial property in southern WA during January/February 2024 and 2025. Pregnant sows (mixed parity) were managed in paddocks with huts according to standard farm practices. The study comprised of two treatments, in four paddocks per treatment, both with access to wallows: (1) Unshaded; (2) Shaded (UV-resistant shade cloth constructed over wallows). Wallows were maintained as per standard farm practice. Temperatures were recorded for wallow-mud, hut-straw, and paddock-soil using a Thermometer Noncontact Gun (IR-40/+650DGC). Ambient temperatures were recorded using an on-farm weather station and a Department of Primary Industries and Regional Development (DPIRD) Weather Station (DPIRD, 2024). As there was no difference ($P = 0.27$) in ambient temperatures between weather stations, publicly available, DPIRD data were used as the standard. Temperatures above the wallows were measured using loggers. The treatments were monitored via camera footage (a total of 532 records) to determine the percentage of sows at the wallow between 1100 h and 1400 h on selected cool days (below 28 °C) and warm days (above 28 °C). Data were grouped and means analysed by paired 1-tailed t-Test (Microsoft® Excel® 2019, v2406, Redmond, WA, USA).

Results Between treatments, there was no difference ($P > 0.05$) in paddock-soil or hut-straw temperatures. However, wallow-mud temperatures were lower ($P < 0.05$) in shaded wallows. There was no difference ($P > 0.05$) between ambient temperatures and temperatures above unshaded wallows but temperatures above shaded wallows were lower ($P < 0.05$) than ambient temperatures (data not shown). Less than 1% of sows in the unshaded treatment visited wallows when the ambient temperature was cool, with a maximum of 13.5% of sows at wallows when the temperature was warm (Figure 1a). By comparison, 10.4% of sows in the shaded treatment visited the wallows when the ambient temperature was 28 °C, with up to 65% of sows at the wallow when the temperature was at 38 °C. The mean percentage of sows in unshaded and shaded wallows was different ($P < 0.05$) when the temperature was cool (0.3% versus 4.7%) and warm (9.5% versus 35.7%) (Figure 1a). Within treatments, for cool days, paddock-soil temperatures were not different ($P > 0.05$) to wallow-mud or hut-straw temperatures but, for warm days, paddock-soil temperatures were higher than wallow-mud and hut-straw temperatures $P< 0.05$) (Figure 1b). Within treatments, for cool days, hut-straw and wallow-mud temperatures were not different ($P > 0.05$) but for warm days, hut-straw temperatures were higher than wallow-mud temperatures ($P < 0.05$) (Figure 1b).

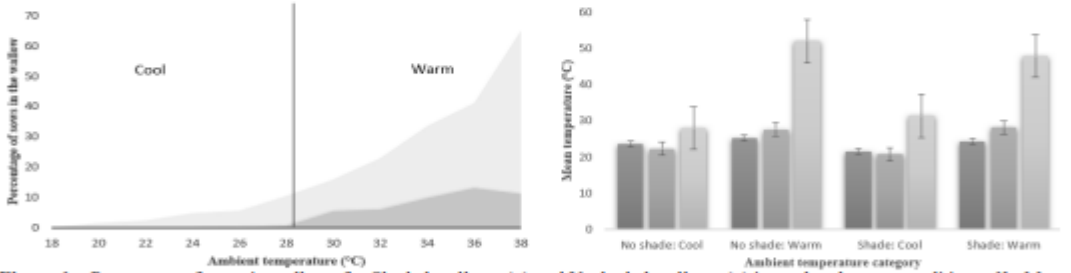


Figure 1a. Percentage of sows in wallows for Shaded wallows (▪) and Unshaded wallows (▪) in cool and warm conditions; **1b.** Mean temperature (± SE) of wallow-mud (■), hut-straw (■) and paddock-soil (■) in cool and warm conditions.

Conclusion and implications This study indicated that wallow-mud and temperatures above the wallow were lower for shaded wallows than for unshaded wallows. Combined with observations of sows visiting wallows, this confirmed that sows preferred shaded wallows, and particularly when ambient temperature exceeded 32 °C. In contrast to cool days where the paddock, hut and wallow were all relatively comfortable for sows, on warm days the paddock was undesirable and sows sought cooling, particularly in shaded wallows if they were available. Further work could establish the economic benefits of shaded wallows for outdoor sows in summer.

Acknowledgements Supported in part by Agricultural Produce Commission, Pork Producers' Committee, and Pork Innovation WA.

References

Blackshaw, J.K., Blackshaw, A.W., 1994. Shade-seeking and lying behaviour in pigs of mixed sex and age, with access to outside pens. Applied Animal Behaviour Science 39, 249-257. doi.org/10.1016/0168-1591(94)90160-0

Bracke, M.B.M., 2011. Review of wallowing in pigs: Description of the behaviour and its motivational basis. Applied Animal Behaviour Science 132, 1-13. doi.org/10.1016/j.applanim.2011.01.002

Department of Primary Industries and Regional Development, 2024. The Department of Primary Industries and Regional Development Weather Stations and Radar. Retrieved on 8 January 2024 from https://weather.agric.wa.gov.au/station/NA003

Martínez-Macipe, M., Mainau, E., Manteca, X., Dalmau, A., 2020. Environmental and management factors affecting the time budgets of free-ranging Iberian pigs reared in Spain. Animals 10, 798. https://doi.org/10.3390/ani10050798

Outdoor sows prefer shaded wallows during summer

Jo Pluske, Cintia Amaral, Megan Trezona, John Pluske

Outdoor sows susceptible to heat stress
Solution - wallows AND/OR shade for cooling

Pregnant sows all with access to:
a hut with straw in each paddock AND;
shaded wallows OR unshaded wallows







Hypothesis: sows prefer shaded wallows, particularly at high temperatures

- Camera footage (Jan/Feb; 11:00h – 14:00h)
- **Maximum** 14% of sows/paddock in unshaded wallows when > 28° C
- **Maximum** 65% of sows/paddock in shaded wallows when > 28° C
- **Mean** percentage of sows in unshaded *vs* shaded wallows was different when cool (< 28° C; 0.3 *vs* 5%) or warm (> 28° C; 9 *vs* 36%)
- On **cool** days (< 28° C): wallow, hut and soil temperatures all relatively similar for sows (~ 20-28° C)
- On **warm** days (> 28° C): hut and paddock temperatures were higher; sows likely sought cooling, particularly in shaded wallows

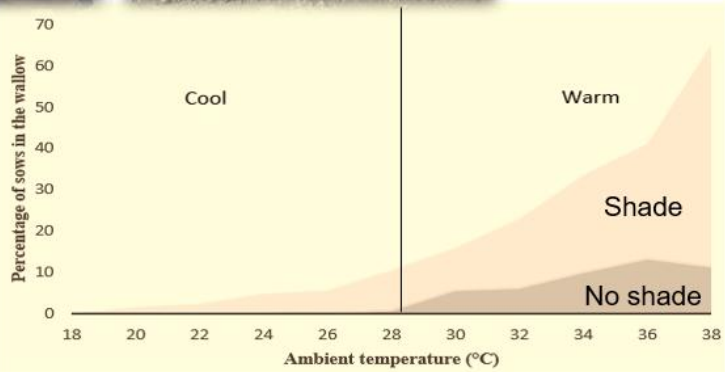


Fig.1 Percentage of sows in wallows *vs* ambient temperature

Conclusions: (1) Sows preferred shaded wallows especially at warmer temperatures; (2) Shade over wallows assists sow thermoregulation; (3) Implications for on-farm water demand in summer

[Supported in part by Agricultural Produce Commission, Pork Producers' Committee, and Pork Innovation WA]

c) Appendix 3: Automated sensor trial

Key Outcomes: Cintia Amaral

The trial evaluated the performance of temperature-based and soil moisture sensors under farm conditions for controlling sprinkler water flow in wallows. Predefined interval control was also tested.

Outcomes: As expected, both sensors (temperature and soil moisture) and the time interval control activated and deactivated water flow automatically without the need for manual operation. The water flow through the sprinkler remained consistent throughout the trial. The images below show the first version of the sensor in operation.





<u>Overall overview:</u>

Temperature-based sensor: The sensor was programmed to release water for 3 minutes when the ambient temperature reached 20 °C or higher. Ambient temperature was reassessed at 10-minute intervals over a 2-hour period on 2 consecutive days.

- On day 1 of the trial, the temperature reached 37 °C, and the water was released as expected. The system software recognised the temperature as 40 °C.

- On day 2 of the trial, the temperature reached 20 °C with rainfall. The system recognised the temperature as 20.4 °C, and the water was released as expected for 1 hour. During the following hour, the temperature remained 20 °C with continued rain and wind. Under these conditions, the system software recognised the temperature as 18 °C and did not release water for approximately 1 hour.

Soil moisture sensor: The moisture sensor was quickly tested and worked as expected. However, it only distinguished between dry and wet soil and did not differentiate between varying moisture levels, such as damp and muddy conditions. The farm staff advised that this sensor would be unsuitable for permanent installation in wallows, as sows would be likely to bite and damage the device.

Time interval control: The sensor was programmed to release water every 15 minutes for 2 minutes over 2 hours and worked as expected.

Overall limitations: The water meter did not work as expected, and the water wastage could not be recorded during the trial. It was assumed that, as the device was designed for gardening, it did not perform well under farm conditions.

Improvements required: The second version of the sensor will include a water flow sensor that measures water use by counting electrical pulses generated by a rotating internal turbine as water flows through the device. The battery will be replaced by a rechargeable lithium-ion battery, providing up to three months of operation without recharging or the need for a solar panel. All sensor components will be enclosed within a robust, weather-resistant, and pig-proof housing suitable for outdoor farm conditions and physical interaction by pigs.

The sensor will operate based on:

- Measuring the volume of water supplied to the wallow to reach the desired water level e.g. muddy, damp
- Releasing water until a predefined target level is reached
- Maintaining the target level using pre-determined time intervals
- Limiting the total daily volume of water released
- Adjusting sensor operation and water release frequency based on ambient temperature.

A standard error of 10% will be considered for the ambient temperature and the volume of water supplied to the wallow.

Daily water limits, target water levels, time intervals, and temperatures will be configured via a Bluetooth connection using a smartphone, allowing for the adjustment of system settings without physical access to the device. The image below shows the second version of the sensor prototype incorporating the proposed design improvements.



Image generated by Chat GPT

Alternative drinker

The alternative drinker prototype was designed with a metal structure, with a nipple on top and a drain to collect water that falls while pigs are drinking water (Image 1). The initial thought was to bury half of the metal structure in the ground to provide stability, with the drinker located inside the paddock near the traditional water trough. However, due to concerns raised by farm staff about the metal structure potentially falling onto the electric fence, the design was modified (Image 2). In the modified

setup, the metal structure was half buried outside of the paddock, beyond the electric fence, and the nipple was positioned on a long plastic pipe extending above the traditional water trough.



Image 1

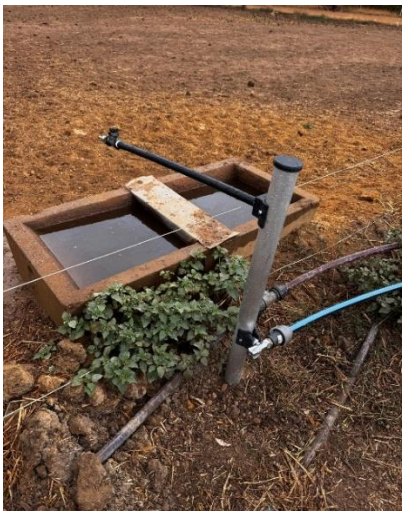


Image 2

Outcomes: Video footage showed that the water flow remained consistent, and no blockages were observed. Video recordings over 4 hours showed that sows did not demonstrate interest in the alternative drinker. Training would therefore be required to encourage the use of alternative drinkers, along with observations over a long period of time to adequately assess sow interaction and acceptance.

Improvements required: A redesign of the alternative drinker would be required, including a concrete integrated water drain (Image 3).



Image 3 (generated by Chat GPT)

d) Appendix 4: Forum for producers

A technical forum extending the findings from this project was successfully delivered to pork producers in Albany, Western Australia, on 1st September 2026. The agenda (below) included three presentations directly related to the project. In addition, Pippa Hepburn (DPIRD) provided an update on a related topic associated with water security. Additional presentations were also included in the forum to update producers on various topics of interest.

PIWA
Pork Innovation WA

PIWA Forum
Welfare, Water and Environment

Tuesday 1st September

3.00pm – 5.30pm followed by dinner
Hilton Garden Inn, Albany

Providing additional shade to improve outdoor sow welfare and production
Megan Trezona, Biosecurity, Animal Welfare & Research Manager, Craig Mostyn Group
John Pluske, Principal Consultant, SciEcons Consulting

Producer experiences with providing additional shade for outdoor pigs
Stephen Harris, Farm Manager, Craig Mostyn Farms

Smart sensors for wallows and alternative drinker design: water-saving innovations for outdoor farms
Cintia Amaral, PhD Candidate, Murdoch University

Case studies on improving farm water security
Pippa Hepburn, Development Officer (Water Science), DPIRD

Door flaps on farrowing huts for improved piglet survival
Megan Lucas, Lecturer (Animal Welfare), The University of Melbourne

Lake Muir Denbarker Community Feral Pig Eradication Group's role and work in the region
Jo Wills, Secretary, LMDCFPEG

Update on addressing environmental challenges identified by the Rotational Outdoor Piggeries Working Group
Jan Cooper, Executive Officer, WAPPA

Drinks & dinner

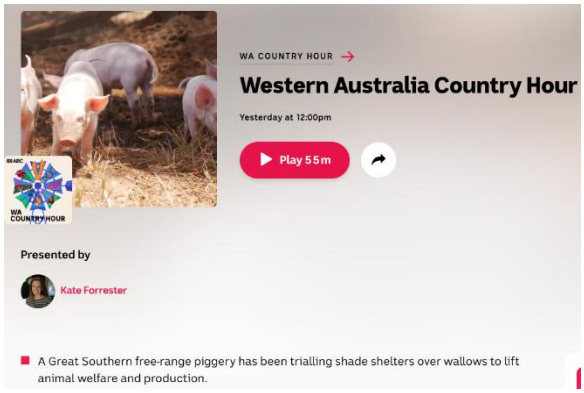
RSVP by 25th August for catering (especially dinner)
Emalyn Loudon via contact@piwa.com.au or 0429 370 289

Project supported by
apc AGRICULTURAL PRODUCE COMMISSION









Directly following the presentations, to delve deeper into providing additional shade for sows, ABC's rural reporter Kate Forrester interviewed Stephen "Harry" Harris of Craig Mostyn Farms, Dr Megan Trezona of Craig Mostyn Group and Dr John Pluske of SciEcons Consulting. The interview was aired on the ABC on 2nd September 2026.

See: https://www.abc.net.au/listen/programs/wa-country-hour/wa-country-hour/107094626

A summary of the Forum was provided in WAPPA News for those producers who could not make the event.