Monitoring thermal conditions during transport of racing pigeons on a vehicle equipped with controlled ventilation

The vehicle

A novel vehicle has been designed and constructed to ensure optimal conditions for pigeons while being transported to races. In particular, the vehicle addresses the specific requirements of the holding period immediately prior to release.

The vehicle design is based on a twin axle step-frame semi-trailer. The basic framework comprises a solid floor, headboard, tailboard and roof. The sides of the vehicle operate as gull-wings to enable easy access to the cages for release of the birds. All the external surfaces, including the floor are insulated to reduce solar heat gain. The internal structure of the vehicle comprises a number of wire cages, to hold the pigeons, which fit into a main framework on the vehicle. Pigeons are loaded into the wire cages then the cages loaded into the vehicle. Overall vehicle height is 4m to comply with the requirement to travel in mainland Europe. Two vehicles have been built, one incorporates an attendants compartment that “replaces” the front stack of cages on either side of the vehicle.

On a typical vehicle carrying 5000 pigeons, there is a potential to produce a total heat output (at 5 Watts per bird) of 25 kW (kilowatts). Studies with poultry suggest that around half of this heat will be “lost” as latent heat (that is heat used in evaporating water from, for example, respired air). Failure to remove this heat (and moisture) will result in localised conditions within the container that are markedly different from the “external conditions”. These conditions may impose an additional “thermal load” on the pigeons, requiring them to expend more effort in maintaining their “normal” body temperature.

When a vehicle is moving, the resultant air movement around and within the vehicle will disperse some of the heat. However, when the vehicle is stationary, and especially on still days with little wind, the consequent ventilation may be inadequate.

The installation of fans on the vehicle ensures that there is adequate air movement around the pigeons at all times – irrespective of vehicle movement.

Fans and ventilation rate

Fans have been installed in the roof of the vehicle along the centre line enabling air to be extracted from the central service corridor. This method has been used, as the vehicle is relatively long. Air extraction at the ends was considered but was likely to lead to significant non-uniformity producing regions of poor ventilation within the vehicle. Sidewall extraction was not possible for operational requirements, as all the birds must be released in less than one minute.

The service corridor along the centre of the vehicle enabled roof extraction to be effective. The presence of this corridor however also made end ventilation more difficult to design, manufacture and operate, as variable sized side inlets would be required for uniform air distribution.

The roof ventilation system is specifically designed for the stationary vehicle in still air, such as on a Ro-Ro ferry. This is likely to be the ‘worst case’ scenario as the motion of the vehicle on the road will increase ventilation as will wind on both the moving vehicle and when it is stationary.

Theoretical calculations were used to determine the required ventilation rate for the vehicles. Two sets of calculations were made, one allowing for the attendant’s cabin located at the front and occupying a 1.2m length. This cabin occupies the space taken by two stacks of cages (total of 14 cages). The two calculations were thus for a vehicle with 18 stacks – 154 cages, and for a vehicle with 20 stacks – 168 cages.

Within each calculation, two stocking densities were considered, namely 30 birds per cage for short journeys and 26 birds per cage for long journeys.

The calculations made the following assumptions:

1. Full-length ventilation slots at the top edge of the release door of each cage of 12mm.
2. The side wall louvred inlets have an open area ratio of 70%.
3. A heat production of 5 watts per bird has been used.
4. The calculated air speed at the cage inlet assumes that air is not able to enter the vehicle by other routes. In practice, it is not possible to ‘seal’ the vehicle and some leakage occurs. Excessive leakage may be detrimental to the uniformity of ventilation and needs to be avoided.
5. The calculated air speed through the gull-wing sides assumes that all the flow is through the louvres; in this case leakage is not likely to detract from the uniformity of ventilation.
6. The derived air temperature lift, i.e. the difference in temperature of the outlet air compared to the inlet air, is based on sensible heat gain only. In practice we have found that, with studies on poultry transport vehicles, around half the sensible heat will be transferred to latent heat of evaporation as there is water present in respired air and also in excreta. Adequate ventilation will assist in keeping the litter dry and in suppressing ammonia production.
7. The values of pressure drop are small which makes this design sensitive to external air movement caused by the motion of the vehicle or wind. In both cases ventilation is likely to increase but can be expected to become non-uniform. The open sides to the cages permit airflow along the length of the vehicle that should help to mitigate the adverse effects of non-uniform ventilation.

The calculations can be summarised as follows:

18 stack vehicle (with attendant cabin) - 9 fans each producing 0.25 m^3/s

20 stack vehicle - 10 fans each producing 0.25 m^3/s

air speed at cage inlet approximately 1 m/s
air speed at louvre inlet approximately 0.5 m/s

ventilation rate in cages approximately 180 air changes per hour

Fan control

The temperature within the roof space determines the number of fans that operate. A temperature sensor is mounted in the roof area on the centre line. A simple control strategy ensures that as the temperature rises, more fans are automatically switched on.

The system starts with two fans running then when the temperature reaches 15°C a further two fans are switched on. At 19°C, there are 6 fans running, at 24°C there are 8 fans running and at 28°C all the fans are operating.

Field evaluation

The performance of the ventilation system, in terms of the temperatures and water vapour densities within the vehicle, has been assessed during the transport of pigeons in Summer 2007 on journeys to Fougeres and Tarbes.

Measurements were made using Gemini TinyTag data loggers that record temperature and relative humidity at 10 minute intervals. Eight data loggers were installed on each trailer at similar specific locations.

External to the trailer:
2 loggers to record ambient conditions – located near the trailer “landing legs”

Within the central trailer passageway, attached to the structure on the inside face of the cages:
2 loggers to record conditions on the 3rd stack from the front (2nd stack on the trailer with the attendant cabin). One logger was at the level of the third row of cages down from the top and the other at the level of the seventh row of cages down from the top.

2 loggers to record conditions on the 6th stack from the front (5th stack on the trailer with the attendant cabin). Vertical placement as described above.
2 loggers to record conditions on the 9th stack from the front (8th stack on the trailer with the attendant cabin). Vertical placement as described above.

The data loggers record temperature and relative humidity but relative humidity is itself dependent upon air temperature and relates to the **relative** capacity of the air to hold water vapour. Consequently, all the data for relative humidity have been converted to water vapour density that is an absolute measure of the water content of the air.

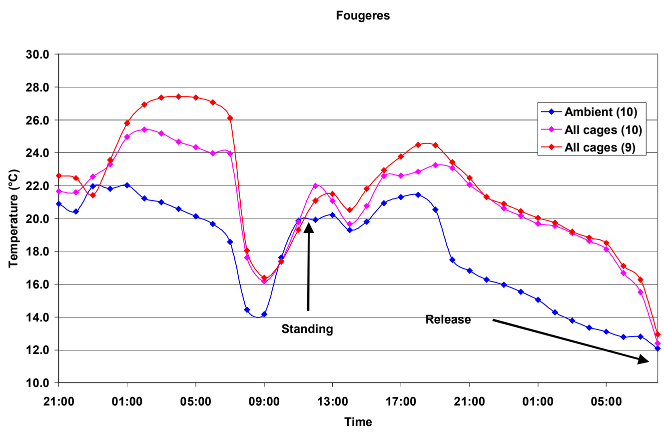
Fougeres

Both trailers travelled to Fougeres in May, arriving at the release site at 11:30am on 18th May then standing until the release time of 07:30am on 19th May.

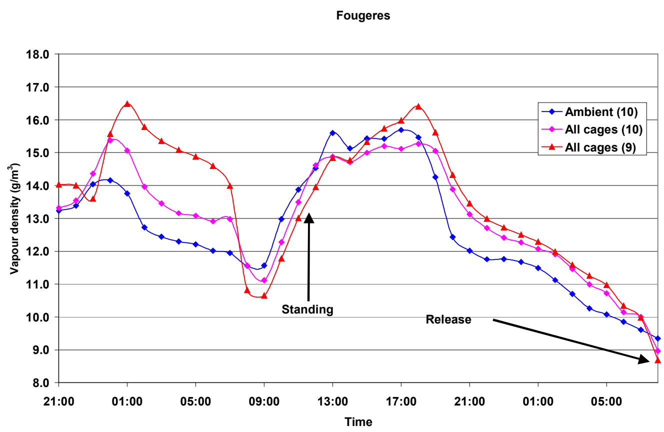
Water ingress confounded a full data set from either of the ambient loggers on the 9 stack trailer (with attendant cabin) but the remaining data had good agreement with data from the corresponding loggers on the 10 stack trailer.

Both trailers travelled together so it is reasonable, and for clarity, to present only the 10 stack ambient data.

The variations in temperature and vapour density during the journey to Fougeres and while awaiting release are shown below. These plots present the ambient conditions and the average conditions within each trailer based on “pooling” all the data for the respective trailer (i.e the average for all 6 loggers in each trailer).



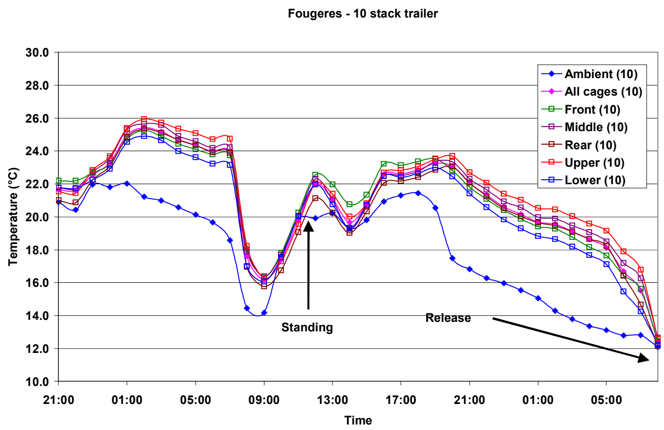
For both temperature and vapour density there is good agreement between the ambient conditions and those within the vehicle.



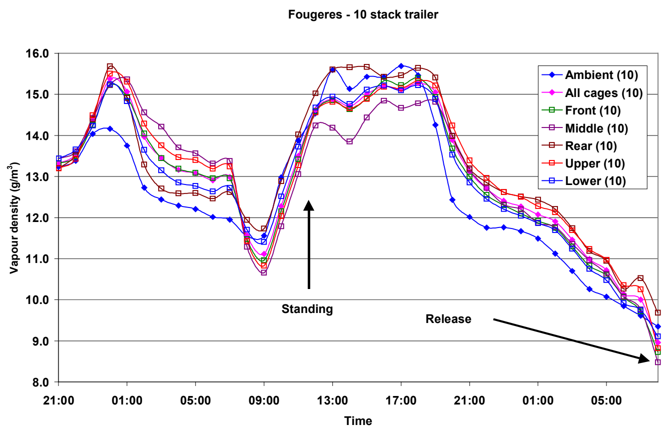
Of particular interest is the 20-hour standing period pre-release where it might be expected that on a “standard” trailer, conditions within the vehicle might have become thermally more demanding for the pigeons.

The recorded data also allow a comparison of the different locations to check for uniformity of conditions. A comparison has been made between front, middle and rear stacks of cages, and between upper and lower levels of cages.

The data plots below are for the 10 stack trailer (and the 9 stack trailer is similar) and present the variation in temperature during the journey, as before, but with the additional data for the different locations.



There are similar variations for changes in water vapour density.



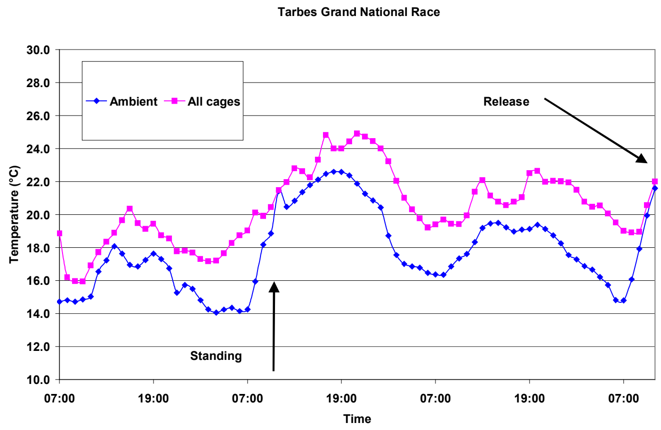
The data demonstrate the uniform nature of the thermal environment throughout the vehicle and the maintenance of acceptable conditions that follow closely the changes in ambient conditions.

Tarbes

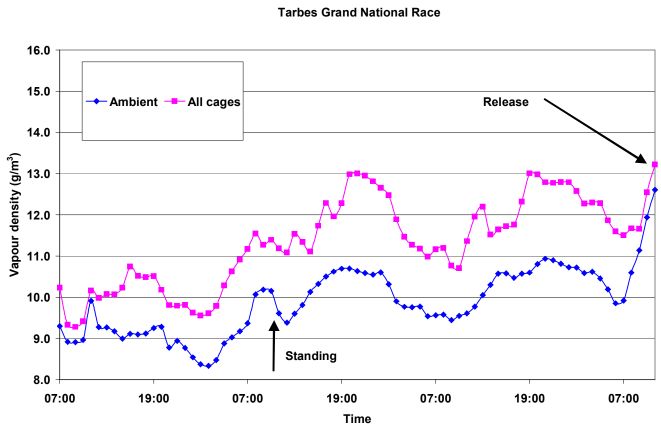
Only one trailer (the 9 stack with attendant cabin) travelled to Tarbes in June 2007. The early departure of the trailer meant that data recording did not start until the vehicle was about to disembark from the ferry.

Data loggers were again placed in the same positions as for the Fougeres journey.

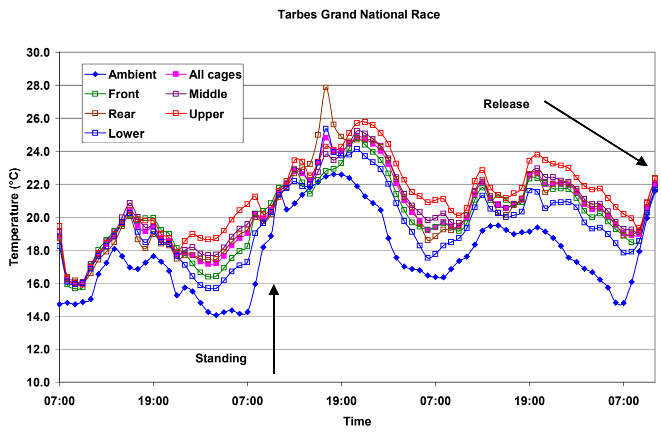
Of interest on this journey was the extended holding period of 46.5 hours prior to the release of the pigeons. The “pooled” data for temperature and water vapour density have been plotted below.



Temperatures within the vehicle follow the ambient diurnal trends but maintain the overall temperature to within 3°C of outside. The water vapour density is maintained similarly.

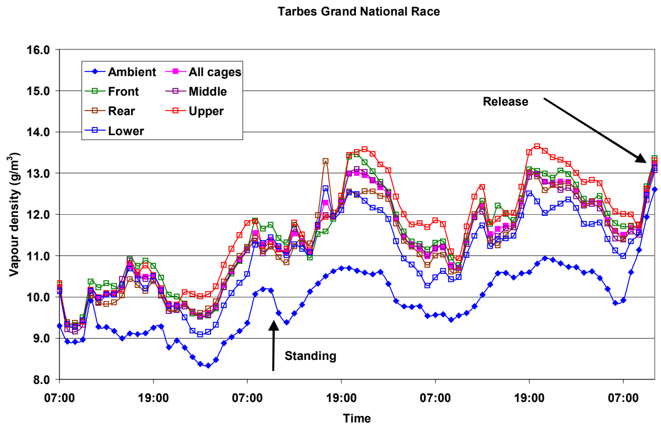


As with the journeys to Fougeres, inspection of the locations within the vehicle confirms a uniform thermal environment throughout the journey including the extended stationary period prior to release.



The “spike” in the temperature and vapour density trace for the rear location may be an artefact associated with the opening of the rear door of the trailer during the standing period.

It is difficult without a full record of events to give a definitive resolution to



such events but such are the challenges of making measurements under fully commercial conditions.

Concluding remarks

The field evaluation of the new pigeon transport vehicle suggests that it is working as designed. The primary concern has always been the potentially detrimental effects of hot weather. Features such as the insulation have ensured that external heat sources are kept to a minimum.

In addition to the direct heat and moisture loads from the birds *per se*, other factors have been taken into consideration. Additional heat from solar radiation has been minimised by the use of insulation in the vehicle construction. The requirement to provide watering for the birds during the journey has been another potential source of concern. Any water that is spilled will evaporate into the airspace within the trailer thus presenting the pigeons with a greater thermal challenge.

The provision of fans to remove both heat AND moisture, from whatever source, has been shown to optimise conditions for the pigeons uniformly throughout the vehicle especially during standing periods prior to release.

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