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An Effective, Economical Method of Reducing Environmental Noise in the Vivarium

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High levels of ambient noise can have detrimental effects on laboratory animal wellbeing and may affect experimental results. In addition, excessive noise can reduce technician comfort and performance. This study was performed to determine whether inexpensive, passive acoustic noise abatement measures could meaningfully reduce noise levels. Sound level measurements for various activities were obtained in the incoming processing room for pigs before and after installing gypsum acoustic paneling, covering metal-to-metal contact points with strips of adhesive-backed rubber, and replacing hard plastic wheels on transport carts with neoprene wheels. The modifications reduced the overall average noise level by 8.1 dB. Average noise levels for each activity were all less than 85 dB after the modifications. Average noise levels can be reduced effectively and economically with passive abatement methods. Intermittent spikes in noise are more difficult to control and may require attention to the individual activity.

Abbreviation: SPL, sound pressure level.

As noted in a special issue of this journal several years ago,[15] environmental noise can affect virtually every system of the body, affecting the wellbeing of both the laboratory animals and the vivarium staff. Although veterinarians and technicians, who spend more time in the animal facilities, may recognize noise problems, frequently investigators are unaware of noise levels or how noise can affect experimental results.[1]

We regularly process incoming pigs in a hogwash that was thought to be one of the noisiest rooms in the vivarium. Added to the stress of being transferred to a new facility, background noise, sounds from the movement of equipment, and vocalization of the animals themselves can compound the existing stress level of the pigs, disturbing their homeostasis and overall health. Not only is the quality of life of the animal diminished by noise, later experimental findings can be affected negatively.[8,12,14] Physiologic changes arising from the stress of loud ambient noise can interfere with the experimental measurements, thus confounding the results of the study.

Short-term exposure of pigs to noise levels in the range of 80 to 97 dB has been observed to increase ambulation scores in proportion to level and frequency.[14] Noise levels over 80 dB have been found to cause behavioral changes in pigs, and the combination of noise and elevated ambient ammonia levels resulted in altered nasal and ocular discharge.[11,13] Although moderate levels of noise (less than 80 dB) had no apparent effect on pigs in one study, higher levels (95 dB) produced an increase in anxiety.[2] Pigs repeatedly exposed to broad-band noise (2 h, 90 dB) displayed markedly increased levels of the stress-related hormones ACTH and cortisol, with reduced social interaction and growth.[8,12] Noise levels in the range of 92 to 102 dB led to infertility, abortion, and decreased growth rate.[17] Acute exposure of pigs to high levels of noise (120 dB) resulted in increased corticosteroid levels, whereas more prolonged exposure led to an increase in catecholamines.[,9,10]

Humans and pigs have similar hearing ranges. The average human hearing range extends from 31 Hz to 17.6 kHz at 60 dB sound pressure level (SPL), with the range of highest sensitivity at 10 dB SPL being 250 Hz to 8.1 kHz.[4] Pigs have a slightly wider overall range, from 42 Hz to 40.5 kHz at 60 dB SPL and a region of high sensitivity at 10 dB SPL from 250 Hz to 16 kHz.[5] Reduction of the overall noise within these overlapping audio ranges is likely to benefit both pigs and humans.

In the current study, we sought to determine whether relatively inexpensive, passive noise-abatement measures could reduce environmental noise in the initial processing room for pigs in the entrance portion of the vivarium. We felt that reducing noise, especially decreasing average levels below 85 dB, would improve environmental conditions for both for the animals and the staff.

Materials and Methods

All animals observed in this study were being used in research approved by the Ethicon Endo-Surgery Institutional Animal Care and Use Committee.

For this study, we attempted to improve sound conditions during the initial processing of pigs in the hogwash, which is one of the noisiest areas of the vivarium. Processing includes the following steps. First, swine are brought from the transportation vehicle into the holding pens within the hogwash. The animals are allowed to rest together for at least 1 h. The in-processing of the swine begins with a general spraying of both the animals and holding pens with warm water. A technician uses a herding board to select 2 swine at a time and guide them up a ramp into the chute. Once the pair is in the chute, the gate is closed behind them. The 2 pigs then are separated by siding gates within the chute. A transportation cage is attached to the front of the chute with a floor plate and a gate latch from the top of the chute. After the cage is attached, sliding doors are opened on both the chute and cage. The first pig is ushered into the cage, and the sliding doors are closed and latched. The transport cage then is rolled out of the hogwash. The second pig is moved to the front of the chute, and the second sliding door is closed behind the pig. This

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same process is repeated until all the pigs have been processed. Processing of each pig takes about 5 min. For this study, we observed 8 cohorts of 10 to 12 pigs prior to noise abatement installation and 4 similarly sized cohorts afterward.

Sound measurements were based on standard principles[6] by using an Integrating Sound Level Datalogger (Extech Instruments, Waltham, MA, Model 407780) in A frequency and fast time-weighting mode recorded as dB SPL. This meter has a frequency range of 31.5 Hz to 8 kHz, which encompasses the region of interest for pigs and humans. Prior to each sampling session, a Sound Calibrator (model 407766, Extech) was used to verify meter calibration at 94 and 114 dB. Measurements were made every second for the duration of the processing, which was generally 30 to 45 min. By interfacing the meter with a computer, each 1-s datum could be synchronized with specific noise-generating events. Along with the sound level meter, a digital camcorder (model GZ-MG330, JVC, Wayne, NJ) was used to help correlate the noise data with events. All sound and video recording was performed at the same fixed location 3 ft above the floor at the center of the hogwash, which is a rectangular room of approximately 75 ft × 25 ft. Each specific noise event was assigned to one of the following categories: resting, spraying, herding, chute, gate latch, caging, and people. These events are listed in the order of the processing, with the exception of people, which refers to general conversation of the technicians. Results reported are averages of the measurements for noise events equally weighted within each category.

On the basis of an industrial noise consultant's analysis of the area and recommendation, we installed SounBreak Acoustical Panels (Lab Products, Seaford, DE) near the ceiling and around the perimeter of the hogwash room (Figure 1). The sound-absorbing material within the panels is wrapped and heat-sealed within a waterproof polyethylene enclosure; the vendor claims that this arrangement and materials do not promote the growth of bacteria or mold. The enclosure can withstand 190 °F for 30 min. Other remediation efforts included covering metal-to-metal points of contact, such as the gate latch, with strips of adhesive-backed rubber, and replacement of hard plastic wheels on transport carts with neoprene wheels (Darcor, Toronto, Ontario, Canada).

Results

Prior to implementation of noise abatement, the average noise level for each category ranged from a low of 74.6 dB for the resting condition to a high of 90.1 dB for the gate latch, which produced peak values as high as 108 dB (Figure 2). The overall average noise level weighted equally by category was 81.7 ± 5.4 dB. After implementation of noise abatement, noise levels ranged from 63.8 dB for resting to 82.0 dB for the gate latch, with the chute producing the highest peak level of 100 dB. The overall average noise level was reduced to 73.6 ± 6.2 dB. The difference between the overall average noise levels before and after abatement was a decrease of 8.1 dB, and a paired t test indicated that this difference was highly significant ($P < 0.001$).

Decreases in average noise levels occurred for every category. The largest change for any individual category occurred for the resting noise level, which dropped by 10.8 dB. Noises associated with this category are associated primarily with the ventilation system and the pigs themselves. The second greatest decrease, 9.6 dB, was for herding, which also primarily was associated with the swine. The caging category, which included transport of the pigs, displayed the third greatest decrease, 9.3 dB. The smallest change was for the people category, which decreased by only 4.4 dB. The staff was instructed beforehand to make no special effort to decrease their usual speaking levels during either phase of testing.

Figure 1. Noise abatement tiles within the hogwash room.

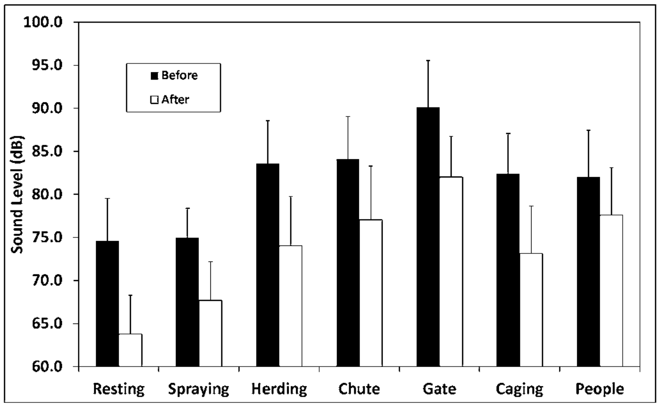

Figure 2. Noise levels (mean ± SEM) due to individual actions before and after installation of noise abatement measures. The overall mean noise level was significantly ($P < 0.001$) lower after installation.

Discussion

Prior to this study, the area within the vivarium used for the intake of swine reached peak noise levels of up to 108 dB. The hogwash was chosen for observation, because its construction materials are primarily concrete and stainless steel. These hard, acoustically reflective surfaces make the hogwash noticeably the loudest location in the vivarium. In addition, this area is an important place of acclimation for the swine, being the first area that they enter. The pigs may arrive in a stressed state that would be compounded by a noisy environment.

A previous study showed that installation of acoustical panels reduced noise levels in a particular animal facility by as much as 15 dB.[3] The goal of the current study was to confirm that ambient noise in the incoming processing room could be decreased effectively and economically. The noisiest events of processing pigs were identified, and noise abatement methods were applied, including placement of rubber on stainless steel material, softer wheels on transport cages, and sound panels on walls. Peak noise levels were reduced to 100 dB, and average levels for all events were less than the recommended 85 dB.[7] This significant improvement was achieved at a total cost of only $18,000, a small fraction of the cost of the physical plant.

The greatest change observed was for the environmental noise associated with the resting state, when the pigs are being acclimated prior to processing. Because no equipment is used during this activity, the reduction in noise is due solely to the addition of the acoustic panels. Typically, resting is the segment of processing that has the longest duration, so the noise reduction leads to a proportionally greater benefit. The loudest event before remediation was closing the gate latch. A specific change on the latch (attachment of adhesive back rubber segments) was responsible for lowering the highest observed peak noise level.

Another substantial change was noted for noise associated with moving the cages. By replacing the wheel material on the carts with a softer neoprene rubber, the noise measured at the centrally located microphone decreased by 9.3 dB. From the pigs' perspective, the decrease in noise was likely even greater, as they were closer to the source than was the microphone. In addition, the wheel change provided the benefit of a smoother ride.

In this study, we did not determine what specific physiologic effects the reduction in noise produced. In a similar study, increased noise levels during unloading and movement of pigs correlated with decreased tissue pH and poorer meat quality, which is considered to be related to increased stress levels.[16] Using the functional relationship derived in the cited meat quality study,[16] the decrease of 8 dB observed in the current study corresponds to preventing a 14% decrease in hydrogen ion concentration (that is, tissue acidity).

Although average levels for all activities were below our target of 85 dB, we still observed peak levels of 100 dB for one activity (the chute) and over 90 dB for 4 others (caging, gate latch, herding, and people). Although there is little evidence that reducing average noise levels below 80 dB provides any substantial benefit, some evidence indicates that short blasts of noise can have detrimental health effects.[17] Future efforts should target these intermittent spikes in noise and may require attention to the individual activity rather than passive noise absorption for the entire room. The modifications used in the current study likely can be applied successfully to other noisy locations within the vivarium.

Although we did not obtain physiologic measurements on the swine in the current study, the absolute changes in noise corresponded to levels known to have effects on stress. The noise abatement modifications had no effect on processing efficiency and were relatively inexpensive. Technicians subjectively reported improved acoustic conditions, and this benefit may improve not only on their personal comfort but also their working effectiveness. Similar passive acoustic measures should be encouraged for any laboratory setting that has either constant or intermittent elevated noise levels.

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