Initial Evidence for the Effectiveness of Subsonic .308 Ammunition for Use in Wildlife Damage Management

Joe N. Caudell
USDA APHIS Wildlife Services, West Lafayette, Indiana

Michael W. Courtney
United States Air Force Academy, USAF Academy, Colorado Springs, Colorado

Clinton T. Turnage
USDA APHIS Wildlife Services, Sherwood, Arkansas

ABSTRACT: The resurgence in popularity of subsonic .30 caliber bullets in 300 Whisper and 300 Blackout has led to the development of bullets that will expand at subsonic velocities. The availability of these bullets has led to questions about the applicability of this caliber for wildlife damage management. We conducted a preliminary investigation to determine the potential of subsonic .30 caliber bullets to quickly incapacitate medium-sized game animals, such as white-tailed deer (*Odocoileus virginianus*) and feral swine (*Sus scrofa*). We tested several bullets, including Lehigh Defense Maximum Expansion (LDME) bullets, reported to expand at 878 ft/s (268 m/s), using ballistic gel and calculating retarding forces and kinetic energy. The retarding force, effects on the ballistic gel, and kinetic energy was similar to those seen in 9 mm hollow point bullets. Based on this initial analysis, .30 caliber bullets fired at subsonic velocities are unlikely to instantly or near-instantly incapacitate a medium sized game-animal unless the central nervous system or heart is directly struck. Additional research should be conducted to further characterize the effectiveness of these bullets and for the potential of subsonic .30 caliber bullets to be used for wildlife damage management.

Key Words: ballistics, subsonic .308, wildlife damage management

Proceedings of the 15th Wildlife Damage Management Conference.
(J. B. Armstrong, G. R. Gallagher, Eds). 2013. Pp. 98-104.

INTRODUCTION

In the wildlife damage management community, selecting a firearm for wildlife control is an important and often debated issue. The ideal firearm would be quiet and instantly or rapidly incapacitate an animal. While the use of suppressors in wildlife damage management have enhanced our ability to work effectively by taking greater numbers of animals that are present in groups and providing a reduced noise signature for homeowners and others in the area, noise suppressors only reduce the noise created by the muzzle blast of the firearm and do not address the noise made by bullets moving at supersonic velocities. The next logical step is to use bullets fired at subsonic velocities to prevent the crack made by the bullet as it passes through the sound barrier. However, rifle bullets are typically designed to strike targets at supersonic velocities.

The recent resurgence in popularity of the .300 Whisper and .300 Blackout, both of which can be safely loaded to fire subsonic .30 caliber bullets, have re-surfaced the question of using .30 caliber subsonic bullets for wildlife control. Until recently, .30 caliber bullets designed for sport hunting would not expand or fragment reliably at subsonic velocities. Lehigh Defense (Quakertown, PA), a relatively small ammunition manufacturing company began producing commercially available .30 caliber bullets manufactured from solid copper or brass that will either fragment or expand at subsonic velocities, depending upon the material used and the design of the bullet (Carter 2012). This development has increased interest in using subsonic bullets for wildlife damage control. However, there are no studies that examine the potential effectiveness of subsonic .30 caliber bullets for wildlife damage control. Many ammunition manufactures often perform this step by testing their ammunition in ballistic gelatin, but these tests are often limited to direct observations of the size of the cavity produced by the bullet and are not evaluated for the potential effects on a live animal. Our objective was to use a combination of standardized ballistic testing methods and modeling as a first step in determining the potential for subsonic .30 caliber bullets to be effective for dispatching medium size mammals, such as white-tailed deer (*Odocoileus virginianus*) and feral swine (*Sus scrofa*).

METHODS

Projectiles were initially selected based on several characteristics that made them likely candidates to perform well in the field. We were primarily interested in bullets that were commercially available and had the potential to near-instantly incapacitate medium-sized game animals with one shot (Caudell 2013). We were primarily interested in testing bullets that would not result in lead contamination; however, we did test one bullet with an exposed lead core. We evaluated the 200 grain Lehigh Defense Maximum Expansion (LDME) solid copper bullet because of the reported 878 fps expansion threshold (Carter 2012). Other lead-free bullets, such as the Barnes Bullets (Mona, UT) Multi-Purpose Green bullet, other solid copper bullets, and the Extreme Shock (Clintwood, VA) subsonic frangible were considered, but not tested. Caudell et al. (2012) had previously used several non-lead bullets in deer projects and had mixed results when shooting deer and elk in the chest cavity and in muscle tissue at subsonic velocities.

The 208 grain Hornady (Grand Island, NE) A-Max (HAMAX) bullet was selected for testing because of its relatively large mass and length. Based on previous experience, we did not expect this bullet to expand, but rather to become unstable in tissue and tumble. Because we did not expect this bullet to expand, deform, or break apart, it would not result in lead contamination if used in situations where this is a concern to wildlife managers. We felt the HAMAX would be representative of other long, heavy, non-expanding bullets used primarily for shooting competitions. Because of their heavy weights (>200 grains), these bullets are often commercially available for the .300 Whisper and .300 Blackout loaded for subsonic velocities.

We also modified a 220 grain Nosler (Bend, OR) Partition by drilling a cavity in the back of the bullet and then firing the bullet backwards. This bullet was modified to represent a category that is not commercially available but has the potential to be easily produced by small bullet companies or individuals with a bullet swedging press. A flat-faced bullet with a large, open hollow-point design, similar to those seen in defensive pistol bullets, has the potential to open at subsonic velocities.

Each of the bullets were loaded and fired from a .30-06 Remington 700 with 1 in 10" rifling twist. We fired the LDME into the ballistic media at 830 ft/s (253 m/s), the HAMAX at 1092 ft/s (333 m/s), and the modified, backwards 220 grain Partition at 916 ft/s (279 m/s). The bullets were fired over a Competitive Edge Dynamics Millennium M2 chronograph with verified velocity accuracy of 0.3%.

We fired each bullet into ballistic gelatin block with the dimensions of 15.2 cm x 15.2 cm x 33.0 cm that was prepared to a 10% concentration and calibrated per the FBI protocol developed by Fackler and Malinowski (1985). We recorded each trial with an IDT Motion Pro X4 high-speed camera at 20,000 frames per second and adjusted the camera position and lens for a field of view approximately 15-cm x 60-cm area centered on the ballistic gelatin. A transparency sheet with printed scale and tick marks every 2.5 cm over a distance of 25 cm was placed on the gelatin. We used this scale to calibrate the horizontal distance so that the horizontal position of the bullet could be determined. We manually triggered the high-speed video camera (IDT Motion Pro X4, Integrated Design Tools, Pasadena, CA) at the same time each shot was fired. Video data were recorded at a rate of 20,000 frames per second for 3.2 seconds. We then analyzed each frame of the video and recorded the position of the bullet. We created a spreadsheet with columns for time (shifted for impact at t = 0 s), horizontal position (in pixels), and horizontal position (in feet). We also created a measured velocity column (ft/s) where the velocity was computed as the change in position from the last frame to the current frame divided by the change in time. At 20,000 frames per second, the change in time was constant: 0.00005 s. This change in velocity allowed us to calculate the retarding force for each bullet (Gaylord et al. 2012).

We calculated retarding forces using Newton's Second Law of Motion and the Work-Energy Theorem. The first method we used to calculate the retarding force was Newton's Second Law, $F = ma$, where F = retarding force, m = bullet mass, and a = acceleration. Force = ma is a valid expression of Newton's second law only if the mass is constant. If the mass is changing, such as with a fragmenting bullet, then change in mass over time (dm/dt) needs to be estimated. If a is expressed in ft/s/s and m is in slugs, the retarding force, F, is in pounds.

The second method we used to determine retarding force is based on the Work-Energy theorem, $F = dE/dx$, where dE = change in kinetic energy (the model energy, using the model velocity) between the current frame and the previous frame, and dx = change in position between the current frame and the last, $dx = Vdt$ (Gaylord et al. 2012).

Bullets fully penetrating the gelatin were stopped by impacting a soft armor panel which prevents additional deformation at the low impact velocities. The high-speed video also allows for direct observation of bullet expansion and the temporary stretch cavity.

Kinetic energy of the bullet at muzzle velocity (E_k) was calculated using the formula $E_k = ½ mv^2$ where m = mass of the bullet in grains and v = velocity of the bullet in ft/s. Muzzle energy was calculated in American engineering units rather than SI units for comparison with other reported small arms ammunition.

RESULTS

The LDME bullet impacted the ballistic gelatin at 830 ft/s (253 m/s) with 306 ft lbs (415 Nm) of kinetic energy (Figure 1).

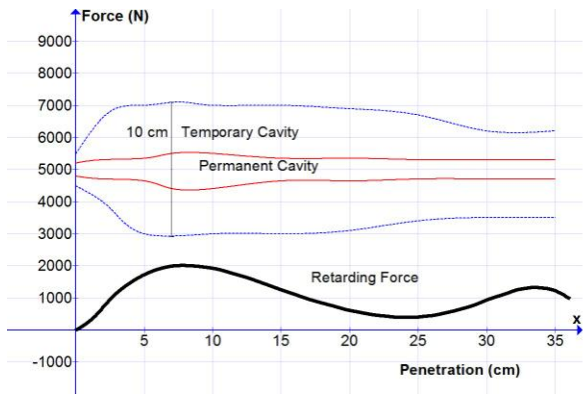

Figure 1. Retarding force, temporary cavity, and permanent cavity of the Lehigh Defense Maximum Expansion bullet impacting ballistic gelatin at 830 ft/s (253 m/s) with 306 ft lbs (415 Nm) of kinetic energy.

The high-speed video shows that the bullet fully expanded in the first 5 cm of penetration. The peak retarding force is close to 2000 N, the maximum temporary cavity diameter was 10 cm, and the peak diameter of the permanent cavity was about 2 cm. The bullet exited the gelatin with a residual velocity of 220 ft/s (67 m/s).

The HAMAX impacted the ballistic gelatin at 1092 ft/s (333 m/s) and 550 ft lbs (746 Nm) of kinetic energy (Figure 2). This bullet did not expand or fragment, but travelled point forward through the gelatin for the first 15 cm of penetration when the bullet began to tumble. Absence of expansion, fragmentation, or tumbling in the first 15 cm of penetration led to small retarding forces and minimal temporary cavity diameter early in the penetration depth because the bullet only lost 70 ft lbs (91 Nm) of energy as it penetrated the first 15 cm. Once it tumbled, the bullet created a peak retarding force close to 2500 N, a peak temporary cavity diameter of 14 cm, and a peak permanent cavity diameter of 3 cm.

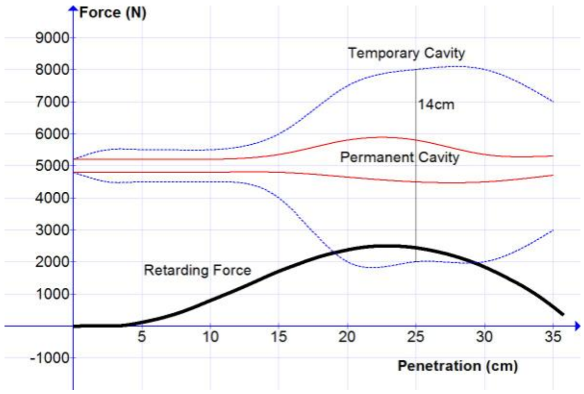

Figure 2. The retarding force, temporary cavity, and the permanent cavity of the Hornady AMAX impacting ballistic gelatin at 1092 ft/s (333 m/s) and 550 ft lbs (746 Nm) of kinetic energy.

The Nosler Partition impacted the ballistic gelatin at 916 ft/s (279 m/s) with 394 ft lbs (534 Nm) of energy (Figure 3). This bullet expanded in the first 5 cm of penetration and created a peak retarding force of 1300 N, a peak temporary cavity diameter of 8 cm, and a peak permanent cavity diameter of 1.5 cm before exiting the gelatin block with a residual velocity of 580 ft/s (177 m/s). Shooting the bullet backwards with a deep and wide drilled hollow-point cavity successfully led to expansion, but the expansion was minimal, and the soft lead did not maintain the maximum expanded diameter which probably reduced the retarding force, temporary cavity, and permanent cavity effects.

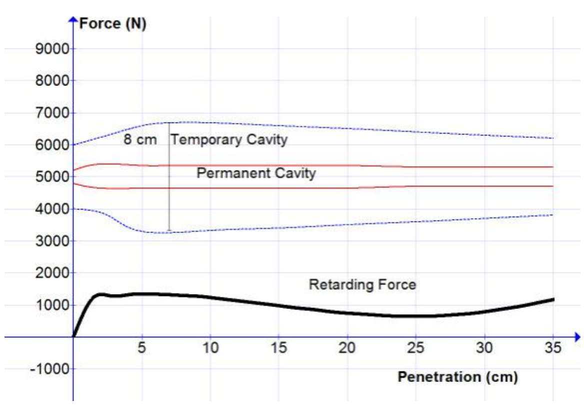

Figure 3. Retarding force curve, temporary cavity, and permanent cavity of the Nosler Partition impacting the ballistic gelatin at 916 ft/s (279 m/s) with 394 ft lbs (534 Nm) of energy.

DISCUSSION

Bullets kill through a combination of forces. Mass, diameter, and shape of the bullet; velocity; and the amount and type of tissue that the bullet and bullet fragments come into contact determine how quickly an animal is incapacitated (Caudell 2013). Whereas a .30 caliber bullet is typically of sufficient size and weight to rapidly incapacitate medium-sized game animals when fired at full power rifle velocities, our preliminary results suggest that .30 caliber bullets fired at subsonic velocities would not cause sufficient damage to rapidly incapacitate medium-sized game, unless the heart, brain, or spine was directly hit by the bullet. The data set reported in this preliminary investigation consists of only 1 test-firing into ballistic gel. Standardized test protocols, such as those used by the Federal Bureau of Investigation and other law enforcement agencies, recommend 5 shots into ballistic gel (Nicholas and Welsch 2004). Additional samples would be required before any statistical analysis could be conducted or before conclusions could be drawn about the behavior of these bullets in ballistic gel.

The LDME expanded as designed; however, the size and shape of the temporary and permanent cavities and the retarding forces were similar shape to that produce by subsonic Winchester "white-box" 9mm hollow-point bullets (Figure 5; Gaylord et al. 2012) which is typically not considered an acceptable caliber for hunting deer, wild hogs, and other medium-sized game. This bullet performed poorly on deer even when placed in the center of the chest in broadside deer in a controlled field experiment (Courtney and Courtney 2007). Whereas 9 mm hollow point bullets are used as a self-defense round; there is an important difference as to how handguns are used in self-defense compared to how rifles are typically used in hunting and wildlife control. In a defensive situation with a handgun, shooters are taught to fire multiple times. Modern semi-automatic pistols are designed for firing multiple bullets at a single target until the threat is stopped or the magazine is empty. Those employed in professional wildlife management typically trained to fire one, accurately placed shot with a rifle. If pistol-caliber bullets or rifle-caliber bullets that have the same terminal ballistics as pistol calibers are used for wildlife control, then shooters may need to alter their training and shooting strategies to fire multiple shots at the target.

The HAMAX entered the ballistic gel and traveled for approximately 15 cm before tumbling. While the peak retarding forces (~2500 N) were slightly higher than the LDME, this did not occur until the bullet had traveled 25 cm into the ballistic gelatin. Because these important wounding mechanisms occur deep in the penetration, the bullet might have minimal effect on a deer shot in the neck where the bullet may exit before these mechanisms become significant. In multiple firings into gelatin over a range of velocities, this bullet did reliably begin to tumble between 15-18 cm deep. However, relying on the tumbling action of an unstable bullet to kill can result in unpredictable effects on the target animals.

The Nosler partition had the lowest peak retarding force (~1300 N), smallest temporary cavity, and smallest permanent cavity. In addition to the poor wound ballistics, the modification to the bullet requires precise milling to ensure the balance of the bullet is not affected and these modified bullets and/or loaded rounds are not commercially available. Consequently, the modified Nosler partition has the least potential as a round used for wildlife control work.

When each of these bullets are compared with other .30 caliber bullets fired at velocities typical of a 30-06 used for hunting, the difference in peak retarding forces is pronounced (Figure 4).

Each of the bullets we fired at subsonic velocities had peak retarding forces ranging from ~1,300 to ~2,500 N. Various hunting and target bullets fired from a 30-06 rifle at velocities typical of hunting ammunition had peak retarding forces of 18,000 to 40,000 N, which results in much larger temporary cavities and, therefore, greater tissue damage in the target animal. However, this increased velocity also increases the noise signature of the bullet.

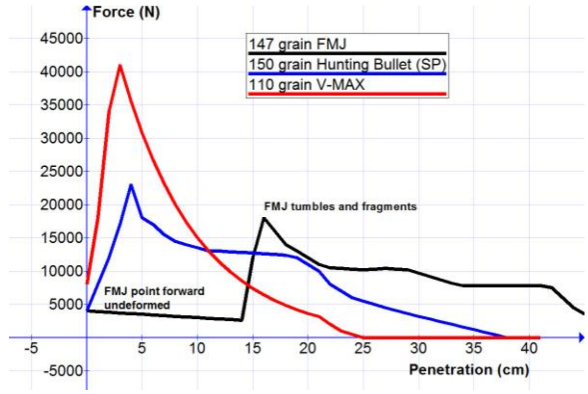

Figure 4. Retarding forces of 147 full-metal jacket (FMJ), 150 grain soft-point hunting bullet, and 110 grain V-MAX .30 caliber bullets fired from a 30-06 at typical velocities using in hunting ammunition. Adapted from Courtney and Courtney (2012).

While it is known that increasing velocity will, for a given caliber, result in increased tissue damage (DeMuth 1966, Santicci and Chang 2004); what is not currently known is the optimum velocity for providing the greatest amount of tissue damage resulting in rapid incapacitation while minimizing the noise signature of the bullet.

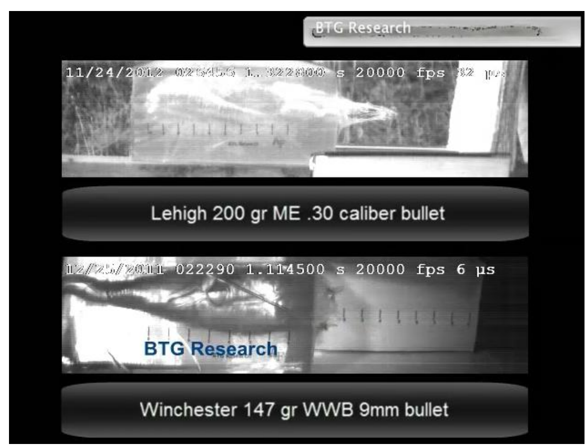

Figure 5. Comparison of the effects of the 200 grain Maximum Expansion (ME) bullet and Winchester White Box (WWB) 147 grain 9 mm bullet, both fired at subsonic velocities.

Kinetic energy is a convenient, physically consistent variable to partially understand the potential for a bullet to cause incapacitation. To illustrate this, Neads and Prather (1991; Figure 5) developed a generalized incapacitation model from the human wound ballistic database, which included a variety of projectiles, for initial assessment of small arms ammunition to determine the likelihood of incapacitation. This model assesses the likelihood of incapacitation against the ballistic dose (i.e., kinetic energy) of a projectile. In general, they found that greater kinetic energy resulted in a greater the chance of incapacitation. When the kinetic energy from subsonic .30 caliber bullets is fit to this model (Figure 6), the expected chance of incapacitation is relatively low.

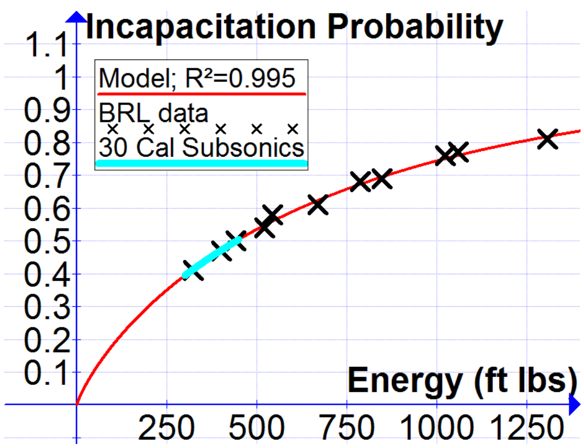

Figure 6. Kinetic energy of .30 caliber 200 grain Lehigh Defense Maximum Expansion bullets, Hornady 208 grain A-MAX bullets, and modified 220 grain Nosler Partition bullets fired at subsonic velocities fit to the ballistic research laboratory (BRL) data developed from a computer simulation model to estimate incapacitation probability (adapted from Neads and Prather 1991).

While this model does not take into account shot placement, it does provide insight to the effects of a .30 caliber bullet with suboptimal shot placement. Caudell (unpublished data) has had first-hand experience with this when shooting deer with subsonic .300 Whisper ammunition loaded with a 150 grain Barnes MPG bullet. A white-tailed deer moved at the last second and the bullet completely passed through the neck of the animal, "knocked down" the deer, but did not result in incapacitation. The deer was shot a second time and the first wound was evaluated. The first shot missed by less than 2.5 cm and passed through the muscle tissue and out the other side of the animal with only a hole the approximate size of the bullet visible. At first examination, subsonic .30 caliber bullets may seem like the answer to the problem of reducing noise signature. However, the model presented by Neads and Prather (1991) and this anecdotal evidence leads us to conclude that there is almost no margin of error when using .30 caliber subsonic ammunition for wildlife control work.

Even though the LDME bullet performed as advertised, the results of our initial testing and modeling indicate that instant and near-instant incapacitation in medium-sized game animals with any of the subsonic .30 caliber bullets is not likely unless the brain, spinal cord, or heart are directly hit. Data collected from firing additional bullet into ballistic gelatin at the same and varying velocities would allow us to examine the variance of the results using statistical analysis. However, the results of ballistic gelatin can only provide a partial model of the effects on a live target (Nicholas and Welsch 2004). Because of this limitation, additional research should be conducted using freshly euthanized animals as an additional model to further understand the effects of subsonic .30 caliber bullets on animal tissues and systems.

LITERATURE CITED

CAUDELL, J. N. 2013. Review of wound ballistic research and its applicability to wildlife management. Wildlife Society Bulletin 37:824-831.

CAUDELL, J. N., S. R. STOPAK, and P. C. WOLF. 2012. Lead-free, high-powered bullets and their applicability in wildlife management. Human-Wildlife Interactions 6:105-111.

CARTER, A. 2012. Lehigh Defense .300 Whisper bullets. American Rifleman (on-line edition; http://www.americanrifleman.org/ articles/lehigh-defense-300-whisper-bullets/; last accessed on 6/13/2013).

COURTNEY, M., and A. COURTNEY. 2007. A method for testing handgun bullets in deer. Medical Physics. Cornell University Library. http://arxiv.org/pdf/physics/0702107v2; last accessed on 6/15/2013).

COURTNEY, M., and A. COURTNEY. 2012. Ballistics of the 30-06 rifle cartridge. Research Report. http://www.dtic.mil/dtic/tr/fulltext/u2/a570469.pdf; last accessed on 6/15/2013).

DEMUTH, W. E. 1966. Bullet velocity and design as determinants in wounding capability: an experimental study. Journal of Trauma 6:222-232.

FACKLER, M.L., and J.A. MALINOWSKI. 1985. The wound profile: a visual method for quantifying gunshot wound components. Journal of Trauma-Injury Infection & Critical Care. 25:522-529.

GAYLORD, S., R. BLAIR, M. COURTNEY, and A. COURTNEY. 2013. Bullet retarding forces in ballistic gelatin by analysis of high speed video. http://www.dtic.mil/dtic/tr/fulltext/u2/a576989.pdf; last accessed on 6/15/2013).

NEADS, D. N., and R. N. PRATHER. 1991. The modeling and application of small arms wound ballistics. US Army Laboratory Command. Ballistic Research Laboratory, Aberdeen Proving Ground, Maryland. (http://www.dtic.mil/dtic/tr/fulltext/u2/a240295.pdf; last accessed on 6/15/2013).

NICHOLAS, N. C., and J. R. WELSCH. 2004. Ballistic gelatin. Institute for non-lethal defense technologies report. The Pennsylvania State University, Applied Research Laboratory, State College, USA.

SANTUCCI, R. A., and Y.J. CHANG. 2004. Ballistics for physicians: myths about wound ballistics and gunshot injuries. Journal of Urology 17:1408-1414.