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Efficacy of Cartridge Type and Projectile Design in the Harvest of Beaver

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Abstract

In Norway, Sweden, and Finland most beavers (Castor spp.) harvested are shot with center-fire rifles. Shooting entails problems not encountered in trapping including pelt damage from bullet holes (body shots are common) and escape of wounded animals. It was predicted that beavers shot in the body with splinter projectiles designed to fragment after impact would experience fewer exit holes (i.e., less pelt damage) and less wounding, but more meat loss, than those shot with conventional controlled expansion projectiles. Twenty-two hunters shot 163 beavers during normal hunting. As predicted, exit frequency was lower for splinter (22%) than controlled expansion projectiles (95%) but neither wounding frequency nor meat damage varied significantly. The combined wounding frequency for both projectile types was 4.3%. Ninety-eight percent of the body-shot animals retrieved (n = 111) appeared to die instantly. Beaver hunting with center-fire rifles was considered humane. (WILDLIFE SOCIETY BULLETIN 34(1):127–130; 2006)

Key words

ballistics, caliber, Castor canadensis, Castor fiber, *Eurasian beaver, furbearer, hunting, meat, North American beaver, Norway, pelt quality, shooting, wounding rate.*

Trapping has been the main method of harvesting both the Eurasian (*Castor fiber*) and North American (*C. canadensis*) beavers worldwide since development of the iron leghold trap in Europe in the 16th century (Gerstell 1985, Baker and Dwyer 1987). In Norway, however, the use of leghold traps, for animal welfare reasons, was banned for all species in 1932 (V. Holte, Norwegian Foresters Federation, personal communication). Not until 1972, following development of the quick-killing Conibear trap, was beaver trapping again allowed (Rosell and Parker 1995). In the interim beavers could only be taken in live-traps or shot, and hunting with guns gradually became the dominant harvest method. Hunting in spring, when shooting is most effective, was first allowed in 1981. Presently an estimated 80–90% of all beavers harvested are shot in spring, the majority with center-fire rifles (Parker and Rosell 2004). A similar transition from trapping to hunting occurred simultaneously in neighboring Sweden and Finland where spring shooting is also the normal harvest method (Hartman 1999). The present collective annual beaver harvest for these 3 Nordic countries is approximately 10,000–12,000 animals (Hartman 1999).

Beaver shooting entails several problems not encountered in trapping, including bullet holes that reduce pelt value (Hall and Obbard 1987) and the loss of wounded animals that escape to deep water. Most beavers are shot at the water's edge and those not killed outright usually dive and often disappear. Thus a quick death is necessary to ensure carcass recovery as well as for animal welfare reasons. These problems could seemingly be solved by shooting animals in the head as practiced by some North American trappers (Eastland 2000; Welker 2004*a*,*b*). However most Nordic hunters prefer to make body shots and, indeed, are encouraged to do so (Hartman and Georén 1987), as head shots increase the chances of a miss and may cause more wounding. Head shots also are reported to induce death convulsions that increase the chances of losing animals (Hartman and Georén 1987).

In Norway, beavers can only be shot with rifle ammunition that delivers ≥980 joules of energy at 100 m and only with expanding projectiles. Similar requirements are stipulated by both the Swedish and Finnish game laws. In practical terms the 222 Remington is the least powerful commonly available cartridge that satisfies the minimum energy requirement. Thus, beavers cannot be shot with .22 caliber long-rifle ammunition as they can in some states and provinces in North America.

While an array of expanding projectiles is available in center-fire ammunition, they may be roughly divided into 2 classes: controlled expansion projectiles and splinter projectiles (hereafter CE-projectiles and S-projectiles, respectively). The former often are referred to as soft-point bullets and the latter as varmint bullets. Controlled expansion projectiles have thicker jackets (or are made of solid copper) and are designed to expand slowly with little weight loss. They are normally used to hunt larger mammals that require deep penetration for effective kills. Splinter projectiles, in contrast, have thin jackets, are shorter and lighter, and attain higher velocities. They are designed to fragment explosively shortly after impact with massive local tissue destruction and little penetration. They normally are used to kill smaller pest species of birds and mammals having no meat or pelt value.

Most Nordic beaver hunters traditionally have used the same calibers and controlled expansion ammunition to hunt beavers as they use for larger game. This usually results in total penetration of the animal and considerable pelt destruction from all other shots than those to the head, particularly from the exit hole. Hartman and Georén (1987) suggested that the use of light, fast, and rapidly expanding projectiles on beavers might reduce instances of total penetration of the animal, thereby reducing pelt damage and possibly resulting in quicker kills with fewer animals lost, as more

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of the potential energy in the projectile would be expended within the body. Alternatively, these projectiles, originally designed to kill smaller animals, might kill beavers less efficiently. The massive tissue destruction common with use of these projectiles also might lead to more meat destruction, a definite disadvantage for those hunters who use beaver meat. These issues should be of particular interest to managers in countries, states, or provinces where beavers are primarily hunted, where trapping them has been prohibited (Manfredo et al. 1997, Deblinger et al. 1999), or where beaver harvest strategies are currently being developed as in Central Europe (Parker and Rosell 2004).

In this study we investigated how killing efficiency, pelt damage, and meat loss varied between beavers shot with the 2 projectile types. Based on the foregoing differences in projectile characteristics, we predicted that S-projectiles would cause less pelt damage and kill more efficiently but destroy more meat than CE-projectiles.

Material and Methods

Eurasian beavers ($n = 163$) were shot from mid-March to mid-May, 1991–1999, in southeast Norway. The participating hunters ($n = 22$) were all amateurs with varying degrees of beaver hunting experience. Hunters used their own rifles and selected the ammunition make and projectile type (controlled expansion or splinter) used. Animals were shot as they presented themselves during the course of normal hunting (i.e., no selection for size occurred) (Parker et al. 2001). The 5 cartridges used with respective projectile calibers (inches/mm) were the 222 Remington (0.224/5.69) (Remington Arms, Madison, N.C.), 6.5 × 55 Swedish (0.264/6.71), 270 Winchester (Winchester Ammunition, East Alton, Ill.) (0.277/7.03), 308 Winchester (0.308/7.82) and the 30–06 Springfield (0.308/7.82) (Springfield Armory, Geneseo, Ill.). We pooled data for animals shot with 308 and 30–06 cartridges as these have the same caliber and almost identical ballistics. Likewise, we also pooled data from the ballisticly similar 6.5 × 55 and 270. Thus, we grouped the 5 cartridges into 3 cartridge classes: class 1 = 222, class 2 = 6.5 × 55 and 270, and class 3 = 308 and 30–06. The ranges of projectile weights (g) for CE- and S-projectiles, respectively, were for class 1: 3.2–4.0 and 3.2–3.4, class 2: 8.1–9.7 and 5.5–6.5, and class 3: 9.7–11.7 and 7.1 only. Corresponding projectile muzzle velocities (meters/second) for CE- and S-projectiles, respectively, were approximately for class 1: 1,000–850 and 1,000–950, class 2: 900–850 and 1,000–1,100, and class 3: 950–800 and 1,100 (Braathen et al. 2002). Some participants hunted with several calibers and both projectile types. All 22 hunters shot at least one beaver with CE-projectiles, while 12 shot at least one beaver with S-projectiles. Most of the CE-projectile ammunition used was factory produced, while all of the S-projectile ammunition was hand-loaded. Projectile manufacturers included Lapua (Lapua, Finland), Norma (Åmotfors, Sweden), Nosler (Bend, Oregon), Hornady (Grand Island, Nebraska), Remington (Madison, North Carolina), Federal (Anoka, Minnesota), Sierra (Sedalia, Missouri) and Speer (Lewiston, Idaho).

Hunters recorded the following information for each animal shot: estimated distance shot to the nearest 5 m, the animal's total weight to the nearest kg, and the cartridge and projectile type used. All animals were shot either on land adjacent to the water's edge or standing in shallow water. We measured killing efficiency by classifying each animal's immediate post-shot reaction into one of three categories: 1) immobilized = instant immobilization, sometimes showing brief death convulsions (e.g., slight kicking, tail movement), but the animal could be picked up essentially where shot; 2) retrieved = the animal managed to reach water deep enough to escape in during death throes but shortly after could be retrieved dead nearby, either from the bottom or floating; and 3) lost = the animal disappeared despite confirmed evidence of a hit (e.g., blood, hair, or abnormal behavior) and was never found after reaching the water. Beavers immobilized or retrieved nearby are collectively referred to as retrievable.

We classified pelt damage into 2 categories: animals either with or without an exit hole. Exit holes usually are much larger than entrance holes and, therefore, detract more from pelt value (Hall and Obbard 1987). The data sheet that hunters filled out for each beaver shot included a drawing of the dorsal, ventral, left and right views of a beaver, plus location of the diaphragm. Hunters indicated on these drawings the points of projectile impact and exit. We divided the body into 4 projectile impact zones: thorax (from diaphragm to front edge of the rib cage, neck and head, abdomen (from diaphragm to base of tail), and other impact points (mainly shots impacting the spinal column at points behind the diaphragm).

We necropsied 87 of the animals shot and defined meat damage as the proportion of meat from the shoulders, thighs, and back that normally would have been discarded during the butchering process due to laceration and haemorrhaging. Those shot in the neck and head zone were not included. We made a subjective estimate of the proportion of meat damaged after animals had been dressed and skinned and ranked into one of four percentage categories: 0, 1–10, 11–20, >20%. The senior author made all estimates.

Statistics

We used an independent samples t-test (2-tailed) to test for differences in the mean distance at which animals were shot and the mean body weight of beavers shot with both projectile types. We used Pearson chi-square to test whether the probability of an exit hole occurring was dependent on cartridge class for both projectile types. We used chi-square goodness-of-fit to test for differences in the proportion of beavers shot with both projectile types that experienced an exit hole or not, were retrieved or not, or experienced 4 different degrees of meat damage. We set the level of statistical significance at $P \leq 0.05$.

Results

The number of beavers shot with each projectile type varied considerably by cartridge class (Table 1). Most were shot with class 3 cartridges (53%) followed by class 2 (33%) and class 1 (14%). When we pooled the 3 cartridge classes by projectile type, however, the proportion of animals shot with each projectile type was similar, being 51% with controlled expansion and 49% with splinter projectiles.

We first selected those animals impacted in the thorax or abdomen ($n = 111$) and pooled the data by projectile type. An exit hole occurred in 95% of those shot with CE-projectiles ($n = 61$) but only 22% of those shot with S-projectiles ($n = 50$) (Table 2). For both CE- and S-projectiles, the probability of an exit hole occurring

Table 1. The number of beavers shot[a] with controlled expansion or splinter projectiles in 3 different cartridge classes, southeast Norway, 1991–1999.

	Projectile type		
Cartridge class[b]	Controlled expansion	Splinter	Total (%)
1	5	16	21 (14)
2	14	65	52 (33)
3	61	22	83 (53)
Total (%)	80 (51)	76 (49)	156 (100)

[a] Excluding 7 animals shot that disappeared and could not be retrieved.
[b] 1 = 222 Remington, 2 = 6.5 × 55 Swedish and 270 Winchester, 3 = 308 Winchester and 30–06 Springfield.

Table 3. The proportion of beavers[a] shot with controlled expansion ($n = 58$) and splinter ($n = 29$) projectiles showing 4 different grades of meat damage[b], southeast Norway, 1991–1999. Chi-square test for difference between distributions: $\chi^2 = 3.672$, $P = 0.299$. Values for controlled expansion projectiles represent the expected distribution.

	Proportion of meat damaged (%)			
Projectile type	0	≤10	11–20	>20
Controlled expansion	26%	41%	23%	10%
Splinter	31%	48%	21%	0%

[a] Includes only animals shot with projectiles impacting either the thorax or abdomen.
[b] Includes damage to meat on the shoulders, thighs, and back.

was independent of cartridge class. Thus, projectile design, and not projectile energy or caliber, was the main factor determining exit frequency. The mean body weight of beavers shot with CE- and S-projectiles was similar ($\bar{x} = 14.7$ kg, SD = 5.3, range = 4–24, $n = 61$ and $\bar{x} = 15.6$ kg, SD = 3.9, range = 5–23, $n = 50$ respectively; $t = 1.03$, $P = 0.31$) as was the mean distance at which animals were shot ($\bar{x} = 55$ m, SD = 38, range 5–150, $n = 61$ and $\bar{x} = 49$ m, SD = 29, range = 5–130, $n = 50$, respectively; $t = 1.02$, $P = 0.31$), suggesting that these 2 factors were not affecting relative projectile performance. The proportion of meat damaged was similar for both projectile types and was generally small at ≤10% for 67% and 79% of those shot with CE- and S-projectiles, respectively (Table 3). Among those animals retrievable, all shot with CE-projectiles ($n = 61$) were immobilized instantly compared to 48 of 50 (96%) for those shot with S-projectiles. We retrieved the remaining two from the water nearby.

All animals shot in the abdomen alone (i.e., without the projectile subsequently passing through the thorax or spinal column), were instantly immobilized regardless of projectile type ($n = 14$ for CE- and $n = 12$ for S-projectiles). For those shot in the head or neck alone, all 14 shot with CE-projectiles were instantly immobilized compared to 12 of 13 shot with S-projectiles. When considering all beavers known or assumed to have been hit ($n = 163$), the proportion lost was similar for both projectile types being 5.9% and 2.6%, respectively, for those shot with CE- ($n = 85$) and S-projectiles ($n = 78$) ($\chi^2 = 1.56$, 1 df, $P = 0.21$).

Table 2. The number of beavers shot[a] with controlled expansion ($n = 61$) or splinter projectiles ($n = 50$) in 3 different cartridge classes that experienced an exit hole, southeast Norway, 1991–1999.

	Projectile type			
	Controlled expansion		Splinter	
Cartridge class[b]	Exit hole	No exit hole	Exit hole	No exit hole
1	4	0	2	10
2	9	1	5	15
3	45	2	4	14
Totals[d] (%)	58 (95)	3 (5)	11 (22)	39 (78)

[a] Includes only animals shot with projectiles impacting the thorax or abdomen.
[b] 1 = 222 Remington, 2 = 6.5 × 55 Swedish + 270 Winchester, 3 = 308 Winchester + 30–06 Springfield.
[c] P-value for Pearson Chi-square test of independence between rows and columns for splinter projectiles: $\chi^2 = 0.304$, $P = 0.859$. Values for controlled expansion projectiles required no test.
[d] P-value for Chi-square goodness-of-fit test for difference in the distribution of total values: $\chi^2 = 570.8$, $P \leq 0.001$. Values for controlled expansion projectiles represent the expected distribution.

Discussion

The prediction that S-projectiles would result in fewer exit holes than CE-projectiles in beavers was supported. This primarily seems to be a result of the combined design differences between the two projectile types including S-projectiles' thinner jackets, lower mass, and shorter length compared to CE-projectiles, combined with the S-projectiles' higher velocities. The relative importance of these attributes is difficult to assess, though projectile mass and terminal energy seem to be of less importance. For instance, exit hole frequency was similar for both class 1 and 3 cartridges firing S-projectiles, despite class 3 projectiles having about twice the mass and delivering about 2.5 times the energy at 100 m (Parker and Rosell, unpublished data).

The prediction that S-projectiles would kill beavers more quickly and reduce losses, however, was not supported. All animals shot with CE-projectiles in the thorax, abdomen, or head and neck zones, and subsequently retrieved, were instantly immobilized compared to 96% of those shot with splinter projectiles. This suggests that major hits to any part of the body, regardless of projectile type, almost always leads to immediate unconsciousness and rapid death. Unexpectedly, all abdomen-shot individuals were also instantly immobilized. This differs from shots to the abdomen of larger mammals (e.g., Cervidae) that are often fatal but do not rapidly immobilize the animal, which often prevents recovery. It must be cautioned, however, that only 1 of the 26 abdomen-shot individuals was shot with a class 1 cartridge (in this case with an S-projectile) (i.e., the least powerful class was insufficiently tested in this respect).

The apparently instantaneous unconsciousness observed among most body-shot beavers, regardless of impact point, may have resulted from pressure waves created as energy is transmitted from the impacting projectiles to adjacent tissues (Harvey et al. 1962). Damage to nervous tissue, including brain hemorrhaging, has been observed in pigs and dogs following impact of high-velocity projectiles at points considerably distal to the brain (Suneson et al. 1987, Li et al. 2001). Thus, brain damage may have caused the rapid unconsciousness observed in this study. For terrestrial wildlife, the moment of death is usually regarded as the moment the animal falls and no longer moves (Knudsen 2005).

All but 1 of 27 animals shot in the neck or head were instantly immobilized, thus showing few of the convulsive death spasms predicted by Hartman and Georén (1987) that can lead to losses.

This suggests that Nordic hunters concerned primarily with pelt quality should attempt more head shots, as practiced in North America (Eastland 2000; Welker 2004*a*,*b*). The loss rates of beavers shot with both projectile types were small and must be considered as maximum wounding rates, as some of the animals lost probably died quickly but could not be found under water in the dim light of late evening. The maximum wounding rates presented here were less than those reported for red deer (*Cervus elaphus*) shot by professional stalkers (Bradshaw and Bateson 2000) or wild impala (*Aepyceros melampus*) culled at night (Lewis et al. 1997), despite the fact that the present study was conducted by nonprofessional hunters. The high immobilization rates and low loss rates reported in this study suggest that beaver hunting with center-fire rifles can be conducted in a relatively humane fashion. Though meat damage was similar for both projectile types, it tended to be greater with CE-projectiles as they usually totally penetrated animals.

Management Implications

What might be the ideal projectile design for beavers? If headshots only are made, then projectile choice is immaterial. Headshots also eliminate meat and pelt destruction but are more difficult to make and necessitate shooting at shorter distances with fewer animals taken, a disadvantage if population control is an objective. As the mean distance shot in this study was approximately 50 m, we presume that many could have been safely shot in the head. If body shots are necessary and pelt quality of prime concern, then S-projectiles in the smaller calibers should be preferable, as smaller caliber projectiles may cause fewer exit holes in the long run. Splinter projectiles, due to their fragile construction, also may result in fewer ricochets from water. One disadvantage with S-projectile use is that they can be difficult to obtain as factory-loaded ammunition in calibers larger than 6 mm.

Though the use of S-projectiles should significantly reduce the incidence of exit holes in body-shot beavers, it is uncertain how this reduction would affect final pelt value. However, since both the number and size of holes is considered by pelt graders when assessing damage (Hall and Obbard 1987), animals shot with S-projectiles should receive better prices.

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