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FROM THE FIELD

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Is lead-free .22 long rifle ammunition worth a shot?

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Abstract

Scavengers may ingest lead bullet fragments embedded in carcasses and offal left behind from hunting. Most studies focus on big game hunting as a primary source of lead exposure. Yet, millions of small mammals are shot annually for damage control and recreation. Ammunition manufacturers have responded to new regulations and accompanying hunter demand for lead-free bullets by introducing new products. Yet, few lead-free bullets are commercially available for the .22 long rifle, despite being the most popular cartridge in the world. We measured the precision of lead-free CCI Copper-22 ammunition fired from 5 rifles. At 46 m (50 yards), the Copper-22 achieved comparable group sizes to lead-based ammunition for 4 of the 5 rifles. Average group sizes of the Copper-22 ranged from 17 mm to 53 mm (0.7–2.1 in), depending on the rifle. Our testing indicates the Copper-22 bullets offer suitable precision for hunting and shooting small mammals.

KEYWORDS

bullets, copper, lead-free, lead poisoning, nonlead, rifle, rimfire, small mammals

Lead exposure poisons wildlife around the world (Haig et al. 2014). Considerable evidence suggests that wildlife ingest particles of lead hunting bullets (Finkelstein et al. 2012, Krone 2018). When a lead-based bullet impacts an animal, particles of the lead core can splinter away into the tissue (Hunt et al. 2006, McTee et al. 2017). If lead particles are embedded in offal and carcasses that remain in the field, scavengers can ingest lead and later experience the toxic effects, including nervous system impairment, reduced flight performance, and death (Pattee et al. 1981, Haig et al. 2014, Ecke et al. 2017).

Big game hunting receives the most attention as a pathway for lead exposure from bullet fragments (Bedrosian et al. 2012, Haig et al. 2014, Domenech et al. 2020). However, an increasing number of studies report that shooting small mammals with lead-based ammunition also exposes scavengers to lead (Knopper et al. 2006, Pauli and Buskirk 2007, Herring et al. 2016, McTee et al. 2017). A wide variety of species are shot and harvested during recreation and damage control activities. For example, Reeve and Vosburgh (2005) estimated that millions of prairie dogs are shot each year. Thus, when hunters and shooters kill small mammals with lead-based bullets, fragments of lead often remain in the carcasses and are available to scavengers (McTee et al. 2019, Herring et al. 2020).

Hunters and shooters fire various rifle calibers to kill small mammals (McTee et al. 2017). Common cartridges include .22 centerfires, such as the .223 Rem and .22-250 Rem, as well as rimfires, such as the .17 Hornady Magnum Rimfire and the .22 long rifle (LR; McTee et al. 2017). Numerous manufacturers produce lead-free bullets for .22 centerfire applications. Yet, hunters and shooters encounter fewer lead-free options for rimfires. Until recently, lead-free ammunition was unavailable for the .22 LR, the world's most popular cartridge (Epps 2014, Hampton et al. 2020).

In 2016, CCI (Cascade Cartridge Inc., Lewiston, ID, USA) released lead-free ammunition for the .22 LR called the Copper-22. The company reports that the sintered bullet is constructed by compressing copper particles and polymer. The bullet's nose tapers to a hollow point, a feature often intended to maximize bullet expansion and tissue damage (Caudell et al. 2012, Caudell 2013). Compared to most lead-based bullets that weigh between 30 and 45 grains (gr), the Copper-22 weighs 21 gr. Being lighter than lead-based bullets, the Copper-22 has a muzzle velocity of 564 m/s, compared to 216 to 500 m/s for CCI's lead-based ammunition in the same cartridge. The faster velocity of the Copper-22 translates to a muzzle kinetic energy that equals or exceeds that of some lead-based ammunition. Kinetic energy is a major factor toward incapacitation (Caudell et al. 2012), so the Copper-22 could be as lethal as lead-based bullets.

Hampton et al. (2020) tested the efficacy of the Copper-22 bullet by shooting paper targets and culling European rabbits (*Oryctolagus cuniculus*) in Australia. Compared to one type of lead-based bullet, the Copper-22 was less precise, wounded rabbits more often, and cost more, partly due to the number of follow-up shots required to kill wounded rabbits. The authors radiographed rabbit carcasses, and 2 specimens retained a Copper-22 bullet. The projectiles showed no evidence of deformation, a quality that would have increased the bullet's frontal area and possibly damaged more tissue and caused faster incapacitation. Hampton et al. (2020) acknowledged several limitations of their study; one limitation was the shooter fired only one rifle. Bullets can perform differently depending on the rifle setup (McCann et al. 2016), which shooters can customize with quality riflescopes and triggers that enhance the rifle's precision. Consequently, certain rifles may shoot the Copper-22 more precisely. If so, it may perform well enough from specific firearms to kill small mammals as efficiently as lead-based ammunition.

Many hunters choose lead-free options to reduce lead exposure to scavengers and the human consumers of game meat (Schulz et al. 2019). Some governments, such as the state of California, USA, have mandated that hunters shoot lead-free ammunition (Kelly et al. 2011). Because of the .22 LR's popularity, it is critical to determine whether alternatives to lead-based ammunition are viable for hunters and shooters. Here, we report a precision test using the Copper-22 from 5 rifles and compare that precision to 3 types of lead-based ammunition.

METHODS

We performed precision testing at MPG Ranch in Montana's Bitterroot Valley, USA (https://www.mpgranch.com/). The property consists of riparian areas, grasslands, and forests. We shot rifles in a draw separating a grassland at an elevation of approximately 1,000 m. Our precision testing included one type of lead-free ammunition and 3 types of lead-based ammunition (Figure 1; Table 1). We shot 2 semi-automatic rifles and 3 bolt-action rifles (Table 2). The make and model of the semi-automatic rifles were the same (Ruger 10/22 Carbine), but their riflescopes and triggers differed. One shooter fired 5, 3-shot groups of each ammunition from each rifle (Table 1) at paper targets placed 46 m (50 yards) away, a common distance for target shooting in the USA. The shooter set the riflescopes to their maximum magnification and shot from a Caldwell The Lead Sled Solo Recoil-Reducing Shooting Rest (Battenfeld Technologies, Inc., Columbia, MO, USA). To prevent excessive barrel heating, which may have altered precision (Wu 2005), the shooter allowed each rifle to rest for >30 min after testing one type of ammunition. The air temperature ranged from 4–7°C, and the wind speed was ≤3 km/hr as recorded by a Davis Vantage Pro2 weather station (Davis Instruments Co., Hayward, CA, USA) installed <100 m from our targets. We determined group sizes by measuring the widest spread across each 3-shot group to the nearest 1 mm (McCann et al. 2016, Hampton et al. 2020). Precision testing occurred on 2 March 2021.

We first ran a 2-way analysis of variance (ANOVA) to test for an interaction between ammunition and rifles. Because we observed an interaction, we then ran separate 1-way ANOVAs to test for differences in group sizes among ammunition fired from individual rifles. When the analysis revealed a treatment effect ($P \le 0.05$), we performed a Tukey's post hoc test to examine differences among group means. We determined which rifles shot the Copper-22 with the best precision by running a 1-way ANOVA followed by a Tukey's post hoc test. We performed statistics and produced graphics in Program R (v.3.6.2, R Core Team 2019) using the RStudio platform (v. 1.2.5033).

FIGURE 1 Photo of the 4 types of .22 long rifle ammunition used for precision testing on 2 March 2021 in western Montana, USA. The names of each ammunition from left to right are CCI Standard Velocity (lead-based), Winchester Super X (lead-based), CCI Stinger (lead-based), and CCI Copper-22 (lead-free)

TABLE 1 Characteristics of the ammunition we fired for precision testing. We shot 5, 3-shot groups at 46 m (50 yards) with 5 different .22 long rifles on 2 March 2021, in western Montana, USA

Manufacturer	Bullet model	Core	Features	Grains	Muzzle velocity (ft/s)	Cost per round (US$)[a]
CCI	Standard Velocity	Lead	Round nose	40	1070	0.08
Winchester	Super X	Lead	Copper-plated hollow point	36	1280	0.11
CCI	Stinger	Lead	Copper-plated hollow point	32	1640	0.18
CCI	Copper-22	Copper	Hollow point	21	1850	0.24

[a]Prices for the CCI ammunition were obtained from searching cci-ammunition.com for boxes of 50 rounds. We ran a search for the Winchester Super X ammunition at midwayusa.com and listed the cost for an ammunition of the same name but with a slightly heavier bullet (37 grains) and faster muzzle velocity (1330 ft/s). The retailer sold this ammunition in boxes of 100 rounds. We conducted both searches on 9 March 2021.

TABLE 2 Rifles and riflescopes used to assess the precision of the CCI Copper-22 at 46 m (50 yards). Testing occurred on 2 March 2021, in western Montana, USA. Manufacturer details are given in parenthesis. The asterisk denotes a rifle equipped with an aftermarket trigger that required less pressure to fire (1 kg [2 lbs 4 oz] compared to 2.7 kg [6 lbs], as advertised)

Rifle	Action	Riflescope
Ruger 10/22 Carbine (*Ruger, Newport, NH, USA*)	Semi-automatic	Simmons 4 × 32 .22 Mag (*Simmons Outdoor Products, Overland Park, KS, USA*)
Ruger 10/22 Carbine* (*Ruger, Newport, NH, USA*)	Semi-automatic	Nikon 3–9 × 40 Prostaff Rimfire (*Nikon Inc., Melville, NY, USA*)
Remington Model 580 (*Remington Arms Co., LLC, Huntsville, AL, USA*)	Bolt-action	Weaver C4 .22 Tip Off (*Weaver Optics, Overland Park, KS, USA*)
CZ 452 (*CZ-USA, Kansas City, KS, USA*)	Bolt-action	Nikon 3–9 × 40 Prostaff Rimfire (*Nikon Inc., Melville, NY, USA*)
Savage Mark II (*Savage Arms [Canada] Inc., Lakefield, Ontario, Canada*)	Bolt-action	UTG 0 x Red Dot/Green Quick Aim (*UTG, Livonia, MI, USA*)

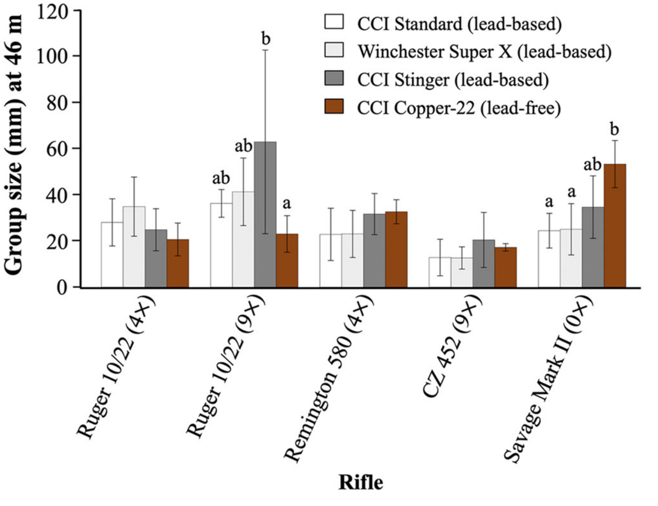

FIGURE 2 Average group sizes for 3 types of lead-based ammunition and one type of lead-free ammunition fired by 5 different .22 long rifles at 46 m (50 yards). For each rifle and ammunition, we shot 5, 3-shot groups at paper targets. Testing occurred on 2 March 2021 in western Montana, USA. The maximum magnifications of riflescopes are given in parenthesis following the rifle name. Error bars represent standard deviation. We ran a Tukey's *post hoc* test to determine differences in precision among ammunition fired from individual rifles. The different letters above bars indicate statistical groupings ($P \leq 0.05$) among ammunition

RESULTS

The Copper-22 shot as or more precisely than the 3 types of lead-based ammunition from 4 of the 5 rifles. Average group sizes for the Copper-22 at 46 m ranged from 17 mm to 53 mm, depending on the rifle (Figure 2). We observed an interaction between ammunition and rifle ($F_{12,80} = 3.74$, $P \leq 0.001$). The Copper-22 fired from the CZ 452 achieved the smallest group sizes, with single groups ranging from 16–20 mm, outperforming the Savage Mark II and the Remington 580 (Tukey's test, $P < 0.001$ and $P = 0.019$, respectively). We observed the largest group sizes with the Savage Mark II. One group measured 37 mm, but the other four group sizes were >50 mm, causing the Copper-22 ammunition to have worse precision than the lead-based CCI Standard Velocity and lead-based Winchester Super X ammunition (Tukey's test, $P = 0.003$; $P = 0.004$, respectively). The Ruger 10/22 carbine equipped with the 9× magnification scope shot smaller groups with the Copper-22 than the lead-based CCI Stinger ammunition (Tukey's test, $P = 0.024$).

DISCUSSION

We shot the Copper-22 from 5 rifles and recorded smaller group sizes than what Hampton et al. (2020) reported ($\bar{x}$ = 59 mm; SD = 13 mm), although our shooting distance was closer (46 m vs. 50 m). With 4 of the 5 rifles, the Copper-22 formed groups at least as small as the groups formed by lead-based ammunition, suggesting it can offer suitable precision for some hunting and pest control applications.

Although most rifles shot the Copper-22 with similar precision to lead-based ammunition, our results do not imply the Copper-22 will incapacitate animals as well as lead-based bullets. In fact, Hampton et al. (2020) reported that Copper-22 bullets wounded rabbits more often than lead-based bullets. Shooters may find that the Copper-22 performs best at close range as bullets will group more precisely and carry more kinetic energy. The manufacturer reports the Copper-22 achieves a muzzle kinetic energy of 217 joules (J), falling inside the range of kinetic energies reported for their lead-based .22 LR bullets (61-259 J), with low-velocity ammunition (i.e., subsonic) reaching the lowest kinetic energies. However, a bullet's kinetic energy may not completely transfer to its living target as tissue damage. Hampton et al. (2020) recorded more pass-throughs on rabbits with the Copper-22 than the lead-based bullet they tested. Pass-throughs ensure maximum penetration but may not maximize wound trauma if the bullet retains considerable kinetic energy upon exiting the animal. Shooters should also be aware that the Copper-22 is lighter and sometimes has a lower ballistic coefficient than lead-based bullets (https://www.cci-ammunition.com/ accessed 12 March 2021), making it more susceptible to wind deflection (Litz 2015).

The Copper-22 provides one of the only lead-free options for the world's most popular rimfire cartridge (Hampton et al. 2020). Hunters and shooters may decide to use the Copper-22 to reduce lead exposure to themselves and wildlife, or because they are required to use lead-free by a landowner or government agency (Epps 2014). Like with all new ammunition, hunters and shooters should test the precision of the Copper-22 at various distances with their firearms, learning at which distances they can confidently place their bullet.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

ETHICS STATEMENT

No ethics statement provided.

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