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14. ABSTRACT

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Comparing Advertised Ballistic Coefficients with Independent Measurements

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Abstract
This report addresses the question of ballistic coefficient accuracy. Ballistic coefficients of bullets are important because under or over estimates of ballistic coefficients can dramatically impact predictions of long range trajectory, wind drift, and impact energy. This project compares ballistic coefficients advertised by four well-known bullet companies (Hornady, Nosler, Sierra, and Barnes) with those measured by an independent source (Bryan Litz). G1 and G7 ballistic coefficients were determined using calculations at the JBM Ballistics web site. Many published ballistic coefficients are significantly different from independent measurements, with Nosler's advertised ballistic coefficients showing the largest overestimates.

Introduction

This article compares advertised ballistic coefficients (BCs) of major bullet companies (Hornady, Nosler, Sierra, and Barnes) with ballistic coefficients measured by an independent source. The ballistic coefficient is the ability of the bullet to overcome air resistance in flight. Ballistic coefficients relate the drag deceleration of a projectile to that of a standard bullet. Bullets with higher BCs move through air more efficiently. BC is also the ratio of sectional density of the bullet to its form factor, where sectional density is the weight of the bullet divided by the square of its diameter. Accurate determination of ballistic coefficient is important for predicting long range trajectory, wind drift, and retained energy. Earlier work has shown that manufacturer claims of ballistic coefficients are sometimes significantly exaggerated (Courtney and Courtney 2009). In addition to comparing manufacturer claims of ballistic coefficients with those determined by Bryan Litz, a well-known match shooter and an expert in aerodynamics, G7 ballistic coefficients for a wide variety of bullets are also presented.

Bryan Litz measured ballistic coefficients using a chronograph and acoustic sensors over intervals between the rifle and target. When the bullet was fired, a chronograph measured the bullet's initial velocity. Acoustic sensors measured the time of flight between intervals. The first of four acoustic sensors was positioned at the chronograph, and each subsequent sensor was placed 200 yards further downrange out to 600 yards total. As the bullet flew past each sensor, the supersonic "crack" of the bullet registered and was recorded to a single audio file which is essentially a 'time stamped' trajectory for each shot (Litz 2009). Litz typically shot five bullets per bullet type to determine a ballistic coefficient for each bullet.

The physical difference between the G1 and the G7 ballistic coefficients is that the standard projectile of the G1 has a short nose, flat base, and bears more resemblance to an old unjacketed lead black powder cartridge rifle bullet than to a modern long range rifle bullet (Litz 2009). The G7 standard projectile has a long boat tail and its pointed nose ogive bears a much stronger resemblance to a modern long range bullet than the G1 standard projectile (Litz 2009). Consequently using the G7 ballistic coefficient yields more accurate predictions for most boat-tail bullet designs, especially at long range. The lower number of the G7 BC for a given bullet represents a difference in how the G7 standard drag curve relates to the Mach number; it does not suggest a higher drag.

The G1 and G7 ballistic coefficients measured by Litz have been published in his excellent book, "Applied Ballistics for Long Range Shooting" for a number of bullets, including most of the

Berger line (Litz 2009). However, since Bryan is now the ballistician for Berger Bullets and Berger uses Bryan's numbers, Bryan's numbers are not an independent test of the manufacturer's claims in this case. Furthermore, rather than simply copy the BCs from Bryan's book, the numbers reported here were reverse engineered as described in the Method section below. The results section presents a number of figures and tables comparing the G1 BC with bullet company claims and reporting the G7 BC to enable readers to compute more accurate long range trajectories, wind drift, and retained energy with tools that might not include a built-in library of the Litz G7 ballistic coefficients. Finally, the discussion section discusses some trends that can be observed from the data and the relevance of the findings.

Method

In order to determine the accuracy of the ballistic coefficients of the manufacturing companies of Hornady, Nosler, Sierra, and Barnes, a ballistics calculator was used from JBM. JBM is a free online provider for ballistics calculators. To determine the ballistic coefficient, the trajectory predicted with a given muzzle velocity (feet per second) needed to be calculated first. In determining the velocity at 200 yards the atmospheric conditions of altitude (ft.), humidity (%), temperature (°F), and pressure (in Hg) are constants. The constants used for every bullet for every manufacturing company were 0 ft. altitude, 0% humidity, 59 °F, and 29.92 in Hg. With these constants the velocity of the bullet was calculated using the JBM calculator. With a muzzle velocity of 2800 fps and the calculated velocity at 200 yards was then used with the same atmospheric conditions to determine the G1 and G7 BCs. This process was repeated for all the Litz measurements reported here.

For example, the BC for Hornady .284 caliber Interlock SP 139 grain was determined in this manner. The bullet was looked up in the JBM trajectory (velocity) database under Litz's bullets and then its trajectory was calculated using the atmospheric conditions mentioned above. For a muzzle velocity of 2800 fps, the velocity at 200 yards is 2530.4 fps. A near velocity of 2800 fps and a far velocity of 2530.4 fps at 200 yards was then used to compute the G1 ballistic coefficient, which is .399, and G7 ballistic coefficient, which is .196. The atmospheric conditions for this calculator were also the same conditions as when the trajectory was compared.

Style	Diameter (in)	Mass (gr)	SD (lbs/in²)	Barnes G1 BC	Litz G1 BC	Litz G7 BC	Overestimate (%)
TSXBT	0.308	168	0.253	0.404	0.400	0.2	1.00
TSXBT	0.308	180	0.271	0.453	0.458	0.229	-1.09
TSXFB	0.257	115	0.249	0.335	0.328	0.164	2.13
TSXFB	0.284	175	0.31	0.417	0.406	0.203	2.71
TTSXBT	0.308	168	0.253	0.470	0.445	0.222	5.62
TTSXBT	0.338	225	0.281	0.514	0.507	0.253	1.38

Table 1: Litz and Barnes BCs. The average Barnes overestimate is 1.96%.

Results

The results show the differences in ballistic coefficients between the Litz measurements and the Barnes' claims. Table 1 compares Barnes and Litz BCs to determine the average overestimate which is 1.96%. From the results, Barnes appears to report reasonable and accurate ballistic coefficients for most bullets, considering that Litz only expects his measurements to be accurate to 1%. The Barnes TTSXBT .308 168 has the highest overestimate at 5.62%.

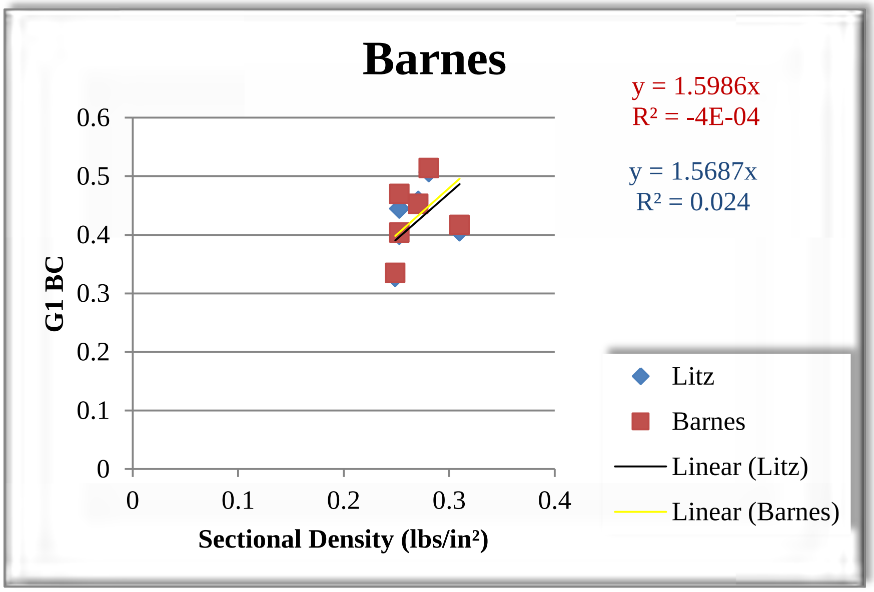

Figure 1: G1 BCs from Barnes and Litz plotted vs. sectional density, along with best-fit lines.

Figure 1 shows G1 ballistic coefficients plotted against sectional density (lbs/in²) for the Barnes bullets measured by Litz. Unlike most other bullets (see below), the sectional density and ballistic coefficients are poorly correlated, suggesting a significant variance in form factors, which is to be expected when flat base bullets are compared with boat tail bullets. If two bullets had the exact same shape, but different masses, the ballistic coefficient should be exactly proportional to the mass. Consequently, the BC to SD ratio is a factor (the reciprocal of the form factor) that indicates how aerodynamic the shape of a bullet is, without regard to resisting drag deceleration due to increased mass. The BC to SD ratio for most of these bullets is close to 1.6, which is typical of many hunting bullets. The sleekest match bullets often have G1 BC to SD ratios close to 1.9 or 2.0, but very few match bullets have had BC claims more than twice the sectional denisty verified by independent sources.

Style	Diameter (in)	Mass (gr)	SD (lbs/in²)	Hornady G1 BC	Litz G1 BC	Litz G7 BC	Overestimate (%)
AMAX	0.224	52	0.148	0.247	0.280	0.119	3.78
AMAX	0.224	75	0.214	0.435	0.424	0.212	2.59
AMAX	0.224	80	0.228	0.453	0.463	0.231	-2.16
AMAX	0.243	105	0.254	0.500	0.505	0.252	-0.99
AMAX	0.264	140	0.287	0.585	0.600	0.299	-2.5
AMAX	0.284	162	0.287	0.625	0.617	0.307	1.30
AMAX	0.308	155	0.233	0.435	0.424	0.212	2.59
AMAX	0.308	168	0.253	0.475	0.461	0.230	3.04
AMAX	0.308	178	0.268	0.495	0.481	0.240	2.91
AMAX	0.308	208	0.313	0.648	0.651	0.324	-0.46

Table 2: Litz BCs and Hornady's claims for the Hornady AMAX bullets tested by Litz. The average overestimate is 1.01%.

Table 2 compares Hornady and Litz BCs for the AMAX match bullet design. Having a polycarbonate tip, soft lead, and a relatively thin jacket, the AMAX is not a bad choice for varmint hunting. The average overestimate is 1.01%. The Hornady AMAX .264 140 grain had a conservative estimate, low by 2.5%. Two AMAX bullets were overestimated by more than 3%: the 52 grain .224 and the 168 grain .308.

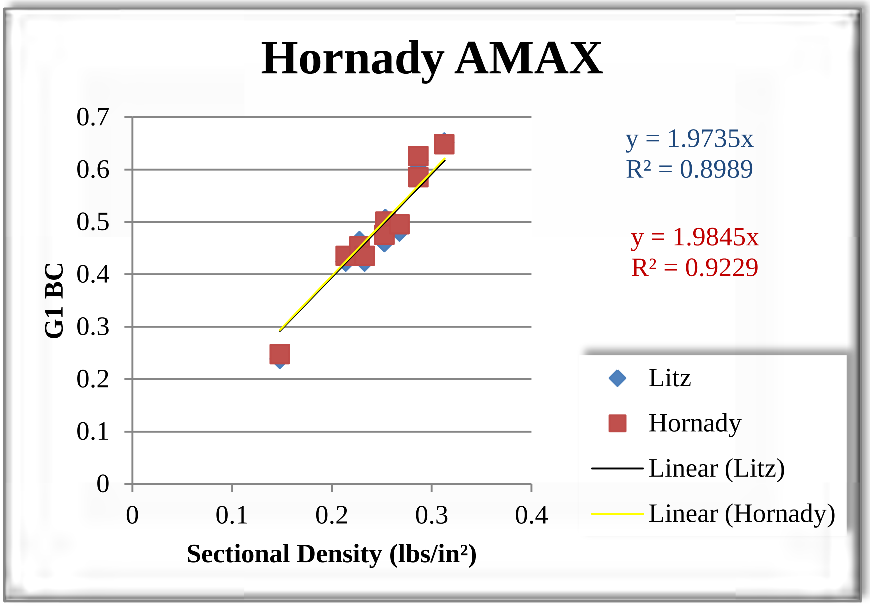

Figure 2: Litz and Hornady G1 BCs vs. sectional density.

Figure 2 shows G1 ballistic coefficients plotted against sectional density (lbs/in²) for the AMAX bullets measured by Litz. The Hornady and Litz G1 BC measurements are close together, and both are highly correlated with the sectional density, suggesting these bullets have nearly the same form factor, likely attributable to similar ogives and boat tail angles. The G1 BC to SD ratio of 1.97 is excellent, showing that the AMAX line of bullets is one of the sleekest on the market. The polycarbonate tip also maintains excellent shot-to-shot consistency of ballistic coefficients, and reliably initiates expansion even at extended ranges. Many manufacturers of both open tip match bullets and polycarbonate tipped bullets make claims of excellent BCs, but the Hornady AMAX is one of the few whose claims have been verified by an independent source.

Table 3 compares the Litz and Hornady BCs for the SST and VMAX lines of bullets which are Hornady's offerings in the polycarbonate tipped non-bonded hunting and varmint arenas, respectively. The average overestimate is 1.79%. The Hornady 58 grain VMAX in .243 had the highest overestimate at 5.04%. The 225 grain SST in .338 had the most conservative estimate, low by 3.38%.

The G1 BCs for the SST and VMAX models are plotted vs. sectional density in Figure 3. The correlation is very good between BC and SD, showing a consistency of form factor. The one bullet noticably below the trend line is the 117 grain SST in .257. The VMAX and SST lines are not quite as sleek as the AMAX with a BC to SD ratio of 1.78 indicating slightly lower BCs at a given bullet weight.

Style	Diameter (in)	Mass (gr)	SD (lbs/in²)	Hornady G1 BC	Litz G1 BC	Litz G7 BC	Overestimate (%)
VMAX	0.224	40	0.114	0.200	0.191	0.191	4.71
VMAX	0.224	50	0.142	0.242	0.231	0.116	4.76
VMAX	0.224	55	0.157	0.255	0.253	0.127	0.79
VMAX	0.243	58	0.140	0.250	0.238	0.119	5.04
VMAX	0.243	65	0.157	0.280	0.268	0.134	4.48
VMAX	0.243	75	0.181	0.330	0.326	0.163	1.23
VMAX	0.243	87	0.210	0.400	0.392	0.196	2.04
VMAX	0.264	95	0.195	0.365	0.364	0.182	0.27
VMAX	0.277	110	0.205	0.370	0.360	0.180	2.78
VMAX	0.284	120	0.213	0.365	0.368	0.184	-0.82
SST	0.257	117	0.253	0.390	0.374	0.187	4.28
SST	0.264	129	0.264	0.485	0.495	0.247	-2.02
SST	0.284	154	0.273	0.525	0.503	0.251	4.37
SST	0.308	150	0.226	0.415	0.413	0.206	0.48
SST	0.308	165	0.248	0.447	0.449	0.224	-0.45
SST	0.338	225	0.281	0.515	0.533	0.266	-3.38

Table 3: Litz BCs and Hornady's claims for the Hornady SST and VMAX bullets tested by Litz.

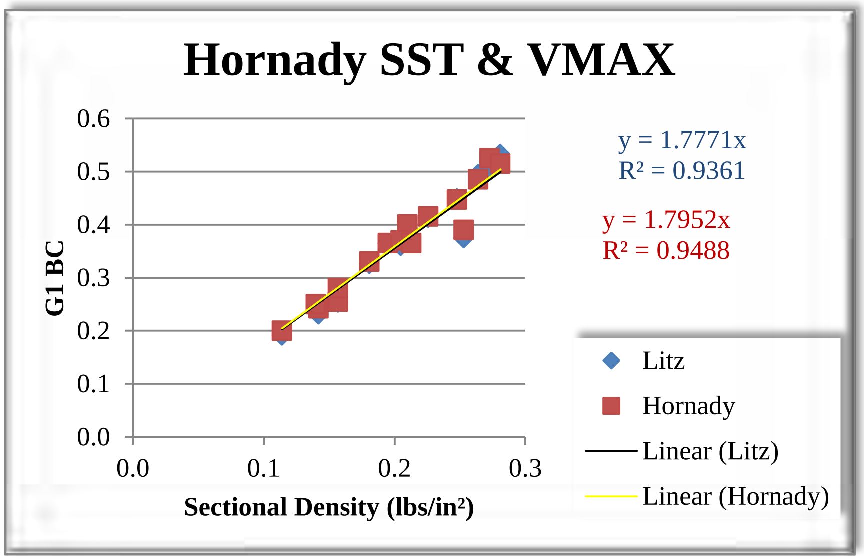

Figure 3: Litz BCs and Hornady's claims for the Hornady SST and VMAX bullets tested by Litz.

Table 4 compares the Sierra and Litz BCs GameKing line of hunting bullets. Sierra's average BC claim is conservative by 2.25%. The Sierra 175 grain GameKing in .284 had a very conservative estimate, low by 10.26%. The 250 grain .338 GameKing was high by 6%. The G1 BCs are plotted against sectional density in Figure 4. The G1 BCs are well correlated with sectional densities, but not as highly correlated as some other designs, indicating some variation in ogives and/or boat tail angles. At 1.81, the ratio of G1 BC to sectional density is good and compares favorably with most other boat tail hunting bullet designs.

Style	Diameter (in)	Mass (gr)	SD (lbs/in²)	Sierra G1 BC	Litz G1 BC	Litz G7 BC	Overestimate (%)
GameKing	0.277	150	0.279	0.483	0.507	0.253	-4.73
GameKing	0.284	150	0.236	0.436	0.441	0.220	-1.13
GameKing	0.284	175	0.310	0.533	0.594	0.296	-10.27
GameKing	0.308	165	0.258	0.404	0.426	0.213	-5.16
GameKing	0.308	180	0.271	0.501	0.485	0.242	3.30
GameKing	0.308	200	0.301	0.560	0.582	0.290	-3.78
GameKing	0.338	250	0.313	0.565	0.533	0.266	6.00

Table 4: Litz BCs and Sierra's claims for the Sierra GameKing.

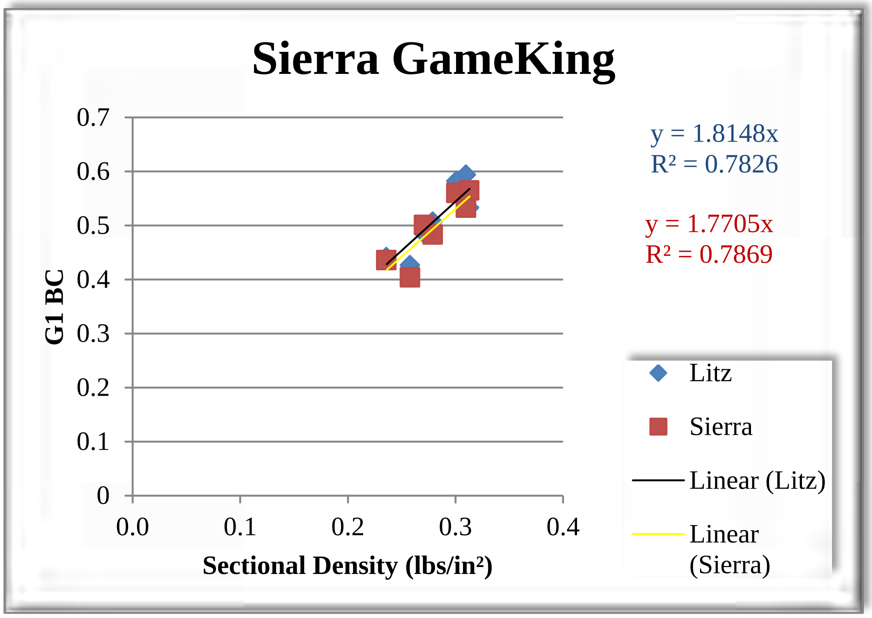

Figure 4: Litz BCs and Sierra's claims for the Sierra GameKing bullets tested by Litz.

Table 5 compares the Sierra and Litz BCs for the famous Sierra MatchKing (SMK). On average, Sierra's BC numbers are conservatively low by 1.11% compared with the Litz numbers. The Sierra 155 grain Palma MatchKing in .308 had the highest overestimate at 17.78%. Other bullets show significant underestimates. For example, Sierra's BC claim for the 69 grain SMK in .224 is 10.95% below the Litz measurement. Sierra's advertised BC for the 168 grain SMK in .284 is 15.86% below the G1 BC as determined by Litz.

Figure 5 shows the G1 BCs plotted agains sectional density for the SMK bullet line. The correlation between BC and SD is very good, except that the BCs for sectional densities below 0.220 tend to fall below the linear trend line. Sierra's open tip MatchKing bullets are popular not only with competition shooters, but also with military snipers and long range hunters as well. In addition to an outstanding reputation for accuracy, the SMK line has a BC to SD ratio above 1.9, indicating they have among the highest BCs for a given bullet weight and caliber.

Style	Diameter (in)	Mass (gr)	SD (lbs/in²)	Sierra G1 BC	Litz G1 BC	Litz G7 BC	Overestimate (%)
MatchKing	0.224	52	0.148	0.225	0.223	0.112	0.90
MatchKing	0.224	69	0.196	0.301	0.338	0.169	-10.95
MatchKing	0.224	77	0.219	0.362	0.380	0.190	-4.74
MatchKing	0.224	80	0.228	0.420	0.435	0.217	-3.45
MatchKing	0.224	90	0.256	0.504	0.514	0.256	-1.95
MatchKing	0.243	70	0.169	0.259	0.263	0.132	-1.52
MatchKing	0.243	95	0.230	0.480	0.465	0.232	3.23
MatchKing	0.243	107	0.259	0.527	0.525	0.262	0.38
MatchKing	0.257	100	0.216	0.386	0.368	0.184	4.89
MatchKing	0.264	107	0.219	0.420	0.461	0.230	-8.89
MatchKing	0.264	123	0.252	0.510	0.522	0.26	-2.30
MatchKing	0.264	142	0.291	0.595	0.604	0.301	-1.49
MatchKing	0.277	115	0.214	0.324	0.323	0.162	0.31
MatchKing	0.277	135	0.251	0.488	0.507	0.253	-3.75
MatchKing	0.284	168	0.298	0.488	0.580	0.289	-15.86
MatchKing	0.284	175	0.310	0.608	0.657	0.327	-7.46
MatchKing	0.308	168	0.253	0.462	0.437	0.218	5.72
MatchKing	0.308	175	0.264	0.505	0.488	0.243	3.48
MatchKing	0.308	180	0.271	0.475	0.495	0.247	-4.04
MatchKing	0.308	190	0.286	0.533	0.542	0.270	-1.66
MatchKing	0.308	200	0.301	0.565	0.572	0.285	-1.22
MatchKing	0.308	210	0.316	0.645	0.635	0.316	1.57
MatchKing	0.308	220	0.331	0.629	0.623	0.310	0.96
MatchKing	0.308	240	0.361	0.711	0.667	0.332	6.60
MatchKing	0.338	250	0.313	0.587	0.630	0.314	-6.83
MatchKing	0.338	300	0.375	0.768	0.766	0.381	0.26
Palma	0.308	155	0.233	0.504	0.428	0.214	17.78

Table 5: Litz BCs and Sierra's claims for the Sierra MatchKing bullets tested by Litz.

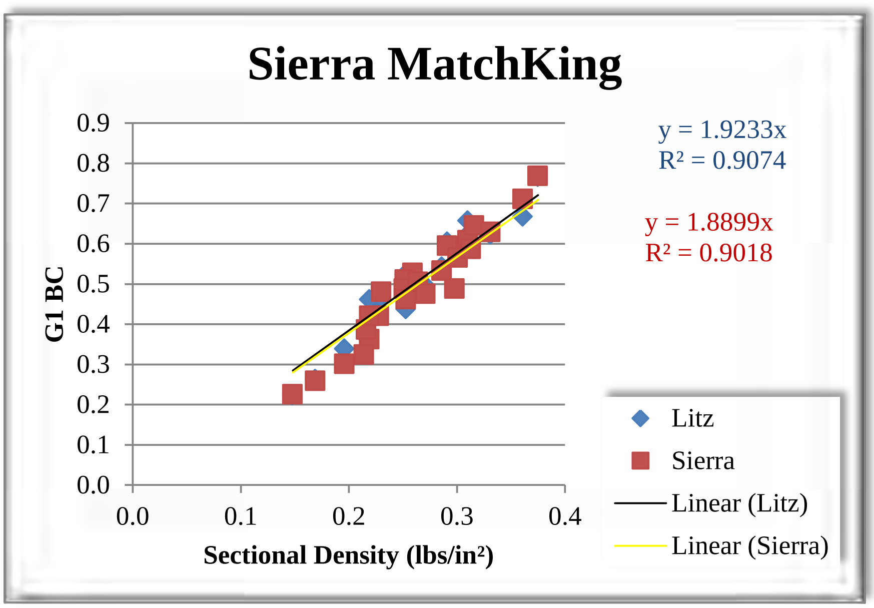

Figure 5: Litz and Sierra BCs for the Sierra MatchKing.

Table 6 compares Nosler and Litz BCs for the Ballistic Tip to determine the average overestimate which is 6.33%. The Nosler 120 grain NBT in .284 had the highest overestimate at 12.7%, with the 115 grain .257 NBT and the 125 grain .308 NBT also having substantial overestimates at 10.76% and 9.58%, respectively. Only two bullets, the 80 grain NBT in .243 and the 140 grain NBT in .277 in Table 6 are within 1% of the Litz measurements, which is Litz's estimated uncertainty in his BC determinations.

Style	Diameter (in)	Mass (gr)	SD (lbs/in²)	Nosler G1 BC	Litz G1 BC	Litz G7 BC	Overestimate (%)
Accubond	0.308	165	0.248	0.475	0.456	0.228	4.17
Accubond	0.308	180	0.271	0.507	0.493	0.246	2.84
NBT	0.224	55	0.157	0.267	0.259	0.13	3.09
NBT	0.243	70	0.169	0.310	0.285	0.143	8.77
NBT	0.243	80	0.194	0.329	0.330	0.165	-0.30
NBT	0.257	115	0.249	0.453	0.409	0.204	10.76
NBT	0.264	120	0.246	0.458	0.428	0.214	7.01
NBT	0.277	140	0.261	0.456	0.455	0.227	0.22
NBT	0.284	120	0.213	0.417	0.370	0.185	12.70
NBT	0.284	150	0.266	0.493	0.458	0.229	7.64
NBT	0.308	125	0.188	0.366	0.334	0.167	9.58
NBT	0.308	150	0.226	0.435	0.406	0.203	7.14
NBT	0.308	165	0.248	0.475	0.455	0.227	4.40
NBT	0.308	180	0.271	0.507	0.483	0.241	4.97

Table 6: Litz BCs and Nosler's claims for the Nosler Ballistic Tip bullets tested by Litz.

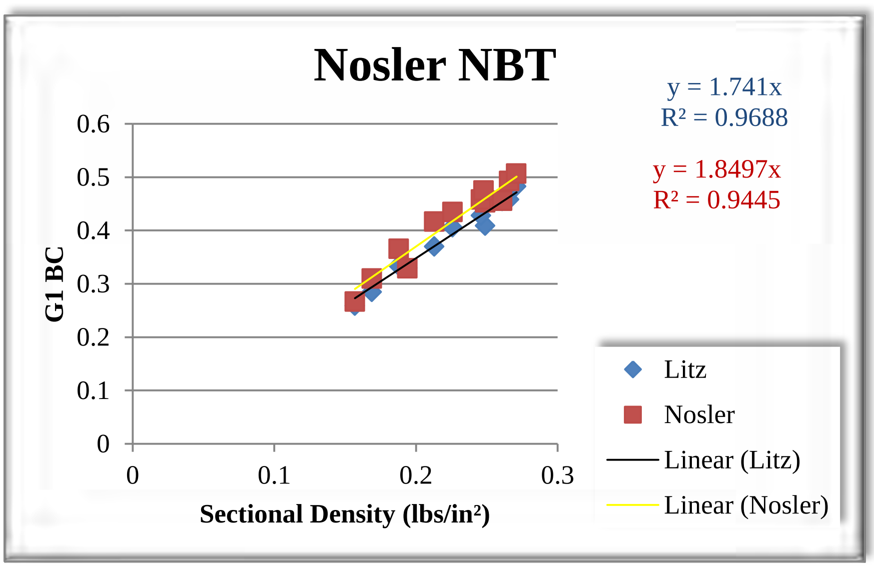

Figure 6: Litz BCs and Nosler's claims for the Nosler Ballistic Tip and Accubond bullets.

There is significant disagreement between many of the Litz measurements and Nosler's claims; however, Figure 6 shows good correlation between BC and SD, indicating uniformity in form factor, attributable to uniformity in ogive shape and and boat tail angle. Nosler's claimed BCs for the Ballistic Tip and Accubond lines yield a BC to SD ratio of 1.85, which would be outstanding and notable among hunting bullets; however, the independent test results yield a BC to SD ratio of 1.74, which is quite mediocre and unremarkable among boat tail hunting bullets.

Table 7 compares the Litz and Nosler BCs to determine the average overestimate of Nosler's claims for the Partition, which is 4.26%. The Partition is a flat base bullet more noted for holding together and providing deep penetration in big game than for its aerodynamic design. The Nosler 175 grain Partition in .284 had the highest overestimate at 11.6%, and the 165 grain Partition in .308 also has a large overestimate at 9.0%.

The G1 ballistic coefficient versus sectional density (lbs/in^2) was then plotted. Just as the last results showed from the Nosler NBT, the Nosler manufacturing company seems to be exaggerating their ballistic coefficients. The Nosler NBT is the bullet with the most overestimated BC of all the bullets studied, followed by the Nosler Partition.

Style	Diameter (in)	Mass (gr)	SD (lbs/in²)	Nosler G1 BC	Litz G1 BC	Litz G7 BC	Overestimate (%)
Partition	0.243	95	0.230	0.365	0.353	0.177	3.40
Partition	0.277	140	0.261	0.432	0.415	0.207	4.10
Partition	0.284	150	0.266	0.456	0.424	0.212	7.55
Partition	0.284	175	0.310	0.519	0.465	0.232	11.61
Partition	0.308	165	0.248	0.410	0.376	0.188	9.04
Partition	0.308	200	0.301	0.481	0.501	0.250	-3.99
Partition PP	0.308	180	0.271	0.361	0.368	0.184	-1.90

Table 7: Litz BCs and Nosler's claims for the Nosler Partition bullets tested by Litz.

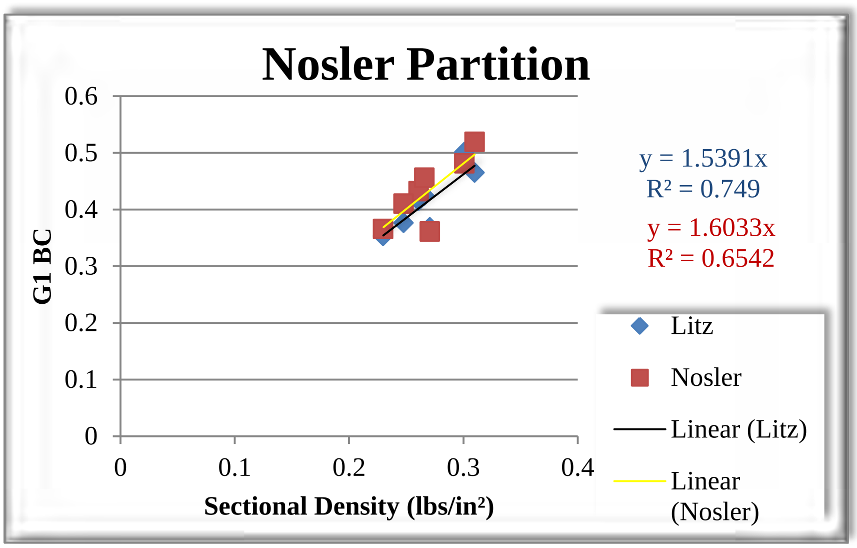

Figure 7: Litz BCs and Nosler's claims for the Nosler Partition bullets tested by Litz.

Discussion

After graphing and comparing all the calculations from the JBM web site, it was found that many published ballistic coefficients are inaccurate. The Hornady AMAX bullet was the least overestimated with a 1.01% embellishment, while the Nosler Ballistic Tip was the most overestimated with a 6.33% overestimate. One might hypothesize that the overestimates of these bullets might be related to their specific uses. BCs of hunting bullets are less likely to be accurate due to the consumers of such bullets being stereotyped as weekend sportsmen rather than precision shooters who will notice a slight inaccuracy while shooting their bullets, thus the manufacturers tend to be more precise with the ballistics of bullets for this type of customer.

The Nosler Ballistic Tip bullet, the most overestimated of all the designs considered in this study, had a 6.33% average overestimate. One of the more overestimated Ballistic Tip models is the 125 grain bullet in .308. One of the authors (MC) has shot this bullet for a number of years in .308 Winchester and 30-06 and has found this bullet to be a reliable performer as a dual purpose deer and varmint load out to 250 yards, but noticed that the bullet experienced noticeably more drop and wind drift than expected when pressed into longer range use. Considering the differences in trajectories predicted from the Nosler and Litz BCs suggests why. For a muzzle velocity of 3200 fps, 20 °F, 0% relative humidity, 29.92 in Hg at sea level, with a 200 yard zero, the Nosler G1 BC of 0.366 predicts a drop of 68.8”, a wind drift of 37.5” in a 10 mph cross wind, and an impact velocity of 1696 fps with an energy of 798 ft-lbs at 600 yards. The Nosler BC predicts a transition to subsonic at 999 yards. Under the same conditions, the Litz G1 BC predicts a drop of 73.5”, a wind drift of 42.5”, and an impact velocity of 1582 fps at 600 yards, with impact energy of 694 ft-lbs. The Litz BC predicts a transition to subsonic at 912 yards.

To further investigate the possibility that Nosler is generating their BCs for marketing purposes rather than to best inform the shooter regarding ballistic performance, the BCs of the Accubond line were compared with the Ballistic Tip line in cases where there was a Ballistic Tip bullet in the same weight and caliber listed in the Nosler Reloading Manual #4. There were seven Ballistic Tip bullets listed in the reloading manual of the same weight and diameter of the Accubond bullets which were introduced several years later. It is notable that 6 of the 7 Accubonds list exactly the same BCs (to three significant digits) in spite of having different boat tail angles and ogives than their Ballistic Tip counterparts. What is the probability that six of the seven Accubond bullets with Ballistic Tip counterparts were actually tested to have identical BCs? In contrast, what is the probability that Nosler decided simply to list the BCs of the Accubond as equal or greater than the Ballistic Tips for the Accubonds with Ballistic Tips in the same diameter and weight regardless of what was actually measured? The average BC to SD ratio for Accubonds with Ballistic Tip analogues is 1.879 (five of seven above 1.9); in contrast, the average BC to SD ratio for Accubonds in weights unique to that design is the more humble 1.788 (only two of 15 above 1.9). One wonders if Nosler felt free to advertise more accurate BCs for Accubonds without Ballistic Tips to which to compare them.

Bibliography

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