Lead Shot Vs. Steel Shot.

A Science Controversy.

By Bevan McNaughton.

Aim:
To investigate the differences between lead and steel shot in the use in shotgun shells for gamebird waterfowl hunting.

Abstract:
Upon gathering the relevant information needed to write a report about the topic chosen (both sides of the argument) process the information and write it in a controversial report standard.

Why is it Controversial?
At the moment there is promotion by certain groups of the public in banning the use of lead shot in Shotguns for gamebird hunting as lead is causing the death of waterfowl (and other wading birds) deaths by lead poisoning.
(Waterfowl as defined by: [1] Swimming game birds, such as ducks and geese, considered as a group.)
The issue is that Lead poisons and kill waterfowl. Lead shot is ingested whilst feeding and it poses a significant problem. "This problem differs from most environmental contaminations in that it is caused directly by the sport of individuals, the same people who espouse environmental protection and wildlife conservation." [2]

N.B. New Zealand Royal Forest and Bird Society are promoting this change yet there is very little information available in what the New Zealand situation is. There is quite a lot of overseas information and many countries have moved to other shot alternatives besides Lead. The topic is often emotive with both sides of the argument promoting their own views, often overestimated.

Background: **Why did I choose this controversial issue?**
As a waterfowl game hunter this may mean for me a complete change in the way I shoot, it could mean that it is more expensive to go shooting and that there may be more wear on the shotgun I use.
This report only covers steel shot and not the other alternatives including bismuth and tin. This is because steel is identified as a more readily affordable alternative and there is more information on it.
The scientific fields covered are Physics (practical formulae), Chemistry (chemical compounds) and Biology (animal behaviour.)

The History of Lead Shot:
Lead shot has been used in firearms since their first development. Back then it was only considered a metal that was appropriate due to the density (weight) and the momentum it could carry in retrospect to other metals.
Lead shot has posed a threat to waterfowl species now for some time. [3]Waterfowl poisonings were first recorded in the United States in 1874 and in New Zealand in 1956.

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[1] Houghton Mifflin Company. (1992). *The American Heritage® Dictionary of the English Language, Third Edition*

[2] Thomas, V.G. (1995). Canada Aren't Adopting Nontoxic Shot/Sinkers. *Department of Zoology, University of Guelph. International Environmental Affairs (Page 375)*

[3] Evans, Adrian. (October 1992). The density and fate of spent lead gunshot in Otago Wetlands. *University of Otago Wildlife Management research report, Report Number 30.*

The History of Steel Shot:

Steel has been around a much shorter time span than Lead shot. This is because Lead did the job that was needed for shotgun projectiles. [4]Steel was being tested as an alternative since 1949 and tests carried out at that stage depicted too many variables both in the shooter and in the record keeping. Since then tests still continue and have now become more advanced and precise to produce very accurate and useful results.

Ballistical argument:

Steel

Steel has been considered by some people as an inferior substitute for lead for many reasons.
Some of the practical properties that makes steel inferior to lead are as follows:

1. Steel has less momentum than lead.
2. It may mean more wounded sporting waterfowl.
3. The steel pallets are harder, they are not as malleable as lead.
4. Steel has a different firing pattern than lead, it is slightly tighter.
5. Because steel is harder it can 'pit' or damage shotgun barrels of certain ages and makes of shotguns.

Other properties that are not related include:

1. Steel shot is more costly than that in comparison to lead shot.
2. Steel shot has a different numbering system than that of lead. (explained later)

As for lead, below are listed some of the practical properties that make lead inferior in certain circumstances.

Lead

1. Deforms upon firing.
2. Toxic.
3. Deformities cause some pellet drift.

Steel shot has less mass than that to lead in comparison to size. This means that going by the formula momentum = mass x velocity (p=mv) steel will have less momentum (impact) than that of lead shot. This is a detrimental disadvantage. But this was an original case of a happening and due to the formula above an increase in velocity would make up for the downfall of the mass of the pellets. What ammunition manufacturing companies such as Winchester and Remington have now done is a complete revolutionary design in the actual shotshell case and shotshell size. This has allowed for larger shot (therefore each pellet is heavier) to be placed into the shotshell by shortening the wad and producing a smaller yet harder/faster burning powder. Steel shot is made two sizes larger in than lead shot in a 'like volume' load situation. The result is an overcome in the case of a momentum disadvantage but this means that there will still be fewer pellets in each shell in comparison to lead shotshells.

[4] Madson, J. & Kozicky, E. (1973). A Steel Trap for Duck Hunters. *Sports Afield, September 1973. (Pages 66 to 74.)*

[5] The chart to the right shows the size of the shot pellets, the number of pellets in each shell (based on charge weight), and a side-by-side comparison of the pellet count, steel vs. lead.

AVERAGE PELLET COUNT

NOTE: LEAD PELLET NUMBERS SHOWN IN TAN; STEEL SHOWN IN GREEN.

Charge Wt. (Oz.)			¾	15/16	1	1⅛	1¼	1⅜	1⅝	1¾
Shot Size	Shot Diam. In.		Approximate No. of Pellets Per Load							
T	.200						NOT AVAILABLE IN LEAD			
							67	73	81	92
BBB	.190						NOT AVAILABLE IN LEAD			
							76	84	97	108
BB	.180					56	63	69	78	88
						80	89	97	112	125
1	.160					81	90	99	113	126
						116	129	141	161	177
2	.150		65	82	87	98	109	120	136	152
			94	117	125	141	156	170	195	216
3	.140		81	101	108	122	135	149	169	
			118	149	155	175	194	212	247	
4	.130		101	127	135	152	169	186	211	
			144	180	189	212	237	260	300	
6	.110		167	208	222	250				
			236	295	314	335				
7	.100		224	281	299	336				
			324	381	399	436				

Steel also has a different firing pattern to that of lead. This is because of the shot size and change in the wad design to accommodate larger shot. Steel also has (as already explained) above less pellets in each shell so there will be slightly less pellets being in the pattern. Comparable to lead, steel shot is much harder and therefore stays round whereas lead does not. Steel will therefore fly truer to the target. Tests done by Remington have showed that at 40 yards, a higher percentage of steel pellets will be on target (within a 30" circle) than lead loads. At 60 yards, steel shot not only yields higher pattern percentages, but also more actual pellets are on target as well.

The chart to the right shows the comparisons between lead and steel shot (grouping "like" loads, with the steel pellets being two shot sizes larger than the lead pellet).

[4] The chart compares velocity three feet from the muzzle, as well as retained per-pellet energy downrange. Note that by using a larger steel shot size, comparable velocity and retained energy at desired yardages are maintained. By carefully studying this chart, you can compare the retained energy for steel and lead shot of the same size (e.g., Steel 2 vs. Lead 2), and prove to yourself why a larger steel shot size must be used to yield similar retained-energy values.

ENERGY COMPARISON: STEEL VS. LEAD

Shot Type/Size	3' Velocity (F.P.S.)	Retained Per-Pellet Energy (Foot-Pounds) 30 Yds.	40 Yds.	50 Yds.	60 Yds.
Lead 7½	1330	1.6	1.3	.9	
Steel 6	1365	1.8	1.3	.9	
Lead 6	1330	3.1	2.3	1.8	
Steel 4	1365	3.5	2.5	1.8	
Steel 3	1365	4.6	3.4	2.5	
Lead 4	1330	5.6	4.4	3.4	2.7
Steel 2	1365	5.9	4.4	3.3	2.6
Lead 2	1330		7.5	6.1	4.9
Steel 1	1365		5.7	4.4	3.4
Steel BB	1365		8.9	7.0	5.6
Lead BB	1260		13.8	11.4	9.5
Steel BBB	1300		10.4	8.3	6.7
Steel T	1300		12.5	10.0	8.0

COMPARABLE 2¾" 12-GA. STEEL VS. LEAD

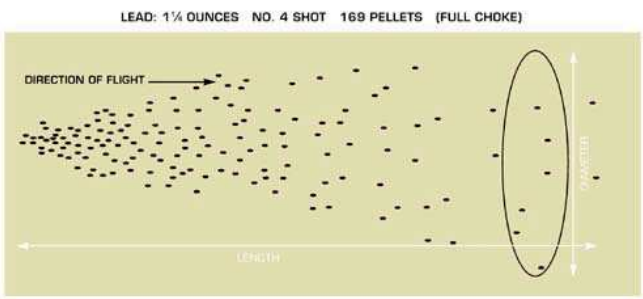
Loads	In Shell Pellet Count	40 Yards Pellet Count	60 Yards Pellet Count
1¼ Oz. #4 Lead	169	70% Average 118	30% Average 51
1 Oz. #2 Steel	125	82% Average 103	50% Average 63
1¼ Oz. #6 Lead	277	74% Average 204	34% Average 94
1 Oz. #4 Steel	189	83% Average 157	36% Average 106

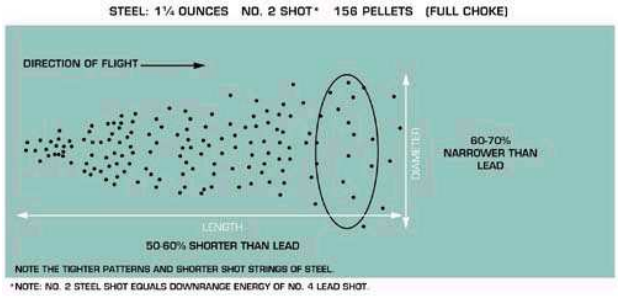
* Using production line 30" full-choke guns and 30" patterning circle; lead loads are non-buffered; 40° F (+ or -) sea level

[5] Remington Arms Company, Inc. (1999). Steel vs: Lead. Differences You Should Know. *http://www.remington.com/ammo/pages/shotshell/stlvsld.htm*

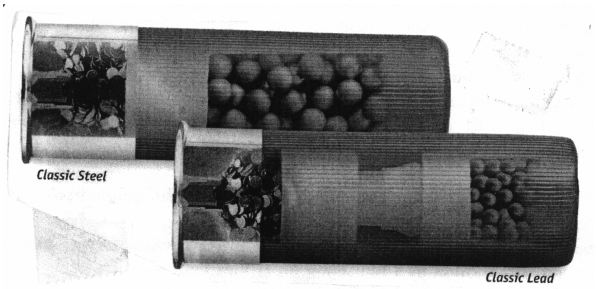
Lead patterning in comparison to steel develops a rather long, large-diameter shot string whereas steel shot because it is around three times harder than lead stays round and develops a shot string that is 50% - 60% shorter and 60% - 70% more narrower than that of lead.

It could be said that steel provides a more precise 'hitting zone' than that of the use of lead shot.





Because steel is harder than lead it also means that there is less 'give' in the shot as it exits the shotgun barrel. This means that in some older types of shotguns the barrel may be prone to excessive wear or even be badly damaged to dangerous to use. Steel will definitely destroy older (pre World War) shotguns as they will not be made to fire the type of new cartridge system. The steel will pit some older barrels if they are not chromed or hardened. Otherwise, most new firearms, which have been produced since Steel shot has been around, will fire with little harm to the actual weapon apart from normal use wear and tear.



Patterning Conclusion:

It appears that lead shot does have a good wide firing pattern and a more persistent number of pellets in its shot string so there is more likely to hit a waterfowl game bird but maybe only to the extent where it wounds it in some cases, this will also mean more wasted pellets that will not hit a specific game bird but may hit other ducks in a mob either killing them or wounding them too. Steel shot has a narrower firing pattern and fewer pellets but provides to be more accurate. This may mean that it will leave less wounded birds but will not hit as many if the shooter is not all on to the target.

The compromise is equal.

Environmental Argument:

The reason behind this report was to find out if steel (as an alternative to lead) was actually worth while using. The major reason for not using lead is that it is fatally toxic. Lead does not break down in the environment to become safe but lingers and remains there.

Lead is able to be ingested by waterfowl whilst feeding of waterway bottoms/water beds for plant and animal (insect, e.g. worms) life, and once ingested the lead shot lies dormant in their gizzard, the gizzard action of waterfowl breaks down the lead into pieces small enough to enter the bloodstream and pass around the body. In many cases one or two pellets is enough to make either kill the bird or to make it ill. If there is a substantial amount of lead shot in the gizzard the bird may die within two days as a previously very healthy and fit bird or it may die after a few weeks by deteriorating away to death. This all depends on the amount of lead it has ingested and the size of the bird (e.g. mallard drake or a mature swan).

Steel is not toxic and is readily broken down. Steel shot will once exposed to the air and/or wet conditions like those in the open and/or on waterways where most game waterfowl are shot will rust away over a few weeks to a year. If waterfowl ingest steel pellets, either rust proof coated (e.g. zinc coated) or bare the gizzard action will break down the pellets and if it enters the blood stream will later be ejected from its system with out any harmful effects.

[6]Studies carried out in the Auckland area showed that 4.7% of birds contained lead shot and another study in Otago showed 6% of birds had some lead shot in their gizzards. Another report done by Adrian Evans reported a recording of pellet densities of 387,500 ha^{-1} in the Kikorai lagoon but his results deem to be invalid due to the limitation of the method of his sampling techniques. Also in Adrian's paper he made assumptions about other effects changing his results but never carried the research through so there may be invalidity in his results.

Environmental Conclusion:
Lead is deemed unsafe for use as a shotshell projectile as it is poisonous. Steel on the other hand is the best alternative, as it has no harmful effects on waterfowl and will biodegrade.

Final Conclusion:

Lead shot is dangerous to the environment in many cases if it is readily available (if it is within browsing reach of waterfowl) but otherwise it is a good shotshell projectile due to its momentum and wide firing pattern.
Steel shot is not harmful to the environment and also is a good shotshell projectile in its steel shotshell applied properties (smaller wad - less padding, larger pellets to compensate for momentum.)

It appears after reviewing the information obtained that steel is indeed proving to be an overall benefitee but mainly due to its non-toxic qualities. The shooting patterns are different but it is not a complete downfall but rather a learning curve for the user.

Although steel shot is not widely used in New Zealand due to anti lead shot pressures, banning lead shot will be of only little loss to the hunter but a gain to the environment.

Steel does provide to be the better alternative.

[6] South, B. (1999). Lead isn't dead yet. *Fish & Game New Zealand. Special issue 8, 1999, (pages 38 to 41.)*

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  This includes many of the diagrams and ballistics tables listed throughout the report.
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