Institute of Clay Shooting Instructors

# An Investigation of the Ricochet Characteristics of Lead and Iron Shot Pellets

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# An Investigation of the Ricochet Characteristics of Lead and Iron Shot Pellets.

A considerable amount of information[1] is available about the ballistics and shot patterns produced by shotgun cartridges, with early work dating back to the late 1800's. More recently, following the 1999 restrictions placed on the use of lead shot over wetlands in the UK, information on the ballistic performance of iron shot has been widely published, particularly in shooting magazines.

However, very little information on the ricochet characteristics of lead or iron seems to be available.

Although early literature on game shooting with lead shot acknowledged that ricochets did occur, little work seems to have been done on the topic. The ricochet effect may simply have been considered to be one of the inevitable risks associated with the game shooting field, or later, the clay shooting ground; although in the latter case, fields of fire were restricted by barriers and cages.
Of the authors listed in reference[1] only Gough Thomas mentions the dangers of ricochet, in 1971.

Researchers at the Dept. of Forensic Sciences at George Washington University, USA published papers[2] in 1981 and 2005 on the ricochet of OO buckshot (diameter 0.330 inches or 8.38 mm) from concrete and road surfaces. The study was related to the use of buckshot, from short barrelled 12 gauge guns, by law enforcement agencies.

Recently a paper[3] submitted to the European Chemicals Agency, by FITASC, briefly discusses the potential dangers of ricochet with iron shot pellets and lists clay shooting disciplines such as skeet, sporting and the trap discipline of helice as activities of concern.

## The Present Study.

As discussions continue on the possible replacement of lead shot in shotgun cartridges, interest has increased in the wider use of the most economically attractive alternative, iron shot.
Although iron shot has been used for wildfowl shooting over wetlands since 1999, information on the comparative ricochet characteristics of lead and iron pellets is sparse or unreported.

This investigation was designed to gather some basic data on ricochets with lead and iron shot pellets.

The layout of the equipment and design of the ricochet range is shown in Figure 1.
The pattern plate is used routinely in shotgun coaching for studying cartridge and shotgun capabilities and gun-fit work. The backing is multilayer packing cardboard covered with plastic, waterproof, protective sheet.
The pellet patterns were recorded on brown craft paper (90 cm x 120 cm = 1.08 $m^2$), stapled to the backing pillow; this procedure enables the pattern result to be removed and analysed elsewhere. The shot pellets arriving at the pattern plate pass cleanly through the craft paper leaving a clean penetration.
The ricochet plate was constructed by attaching a galvanised steel sheet (1 metre x 2 metres) to a robust plywood foundation. The complete plate structure was attached to a trailer using adjustable braces at the rear of the plate; this allowed the plate to be moved until correctly vertical and then locked in position. Horizontal positioning was achieved by rotating the trailer.

Figure 1. Ricochet Range.

PATTERN PLATE

5 METRES

RICOCHET PLATE

15 METRES

VERTICAL ADJUSTMENT BRACES

SHOTGUN

The shotgun used in the trial was a Beretta 304 12 gauge fitted with quarter choke. The accuracy of the quarter choke, pellet patterning was checked with the cartridges, containing lead shot, that were used in the subsequent ricochet tests.
The conventional British pattern test at 40 yards (36.6 metres) was used, with the pellet count within a 30 inch circle (76.2 cm diameter) being recorded. The shotgun produced quarter choke patterns reliably, with close to 55% of shot pellets within the pattern circle.

The lead and iron cartridges which were tested for ricochet are listed in Figure 2.
The shot pellet content of each cartridge type was determined by removing the shot load from 3 or 4 cartridges and physically counting the number of pellets. Every brand of cartridge varied by just 2 or 3 pellets maximum. The average pellet count was recorded.

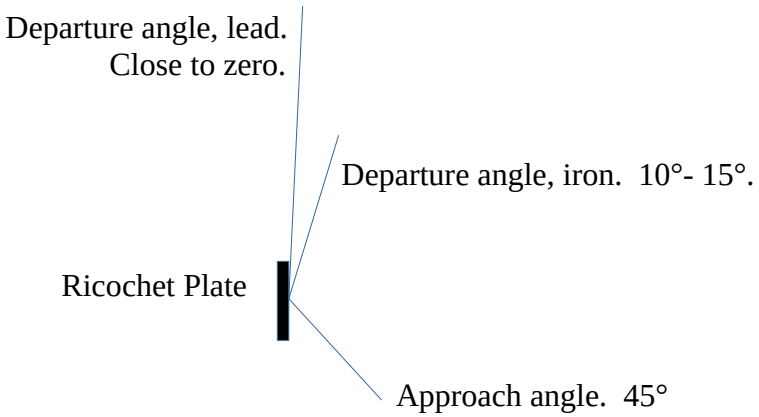
Figure 2. Cartridges Studied in the Trials.

| SHOT | SIZE No. / MM | MANUFACTURER | | LOAD GM | WAD | LENGTH MM | AVERAGE SHOT COUNT |
|---|---|---|---|---|---|---|---|
| Lead | 7½ 2.3 | Hull CompX | UK | 28 | Fibre | 65 | 382 |
| Lead | 5 2.9 | RC Prestige | Italy | 32 | Fibre | 67 | 218 |
| Lead | 4 3.2 | Gamebore Black Gold | UK | 36 | Fibre | 70 | 178 |
| Iron | 9 2.25 | Gamebore Super Steel | UK | 28 | Plastic | 70 | 610 |
| Iron | 5 3.05 | Eley VIP Steel Eco Wad | Spain | 32 | Water Soluble Starch | 70 | 268 |

The Ricochet Tests.

A significant amount of initial experimentation was necessary to establish the suitable angles and distances to give useful shot pattern information. It became apparent that a total flight path of around 20 metres was one useful test regime; this could enable sufficient shot travel to occur prior to ricochet, to allow a reasonable opening of the shot cloud.
The pattern plate was then adjusted to collect the post-ricochet pattern.
Initial longer distances failed to collect many pellets at all, and it became apparent that early expectations about the degree of 'bounce' of shot pellets after ricochet was not occurring.

It also became apparent with lead shot that a very high degree of deformation was occurring during ricochet. The tests were attempting to differentiate between lead and iron shot, so the angle of entry to ricochet was set at 45º.
At this approach angle, which inevitably was slightly variable with a hand-held shotgun using a shooting stick, the iron shot departure angle was between 10º and 15º for all the tests on iron shot. The lead shot departure angle was close to zero; in other words the lead shot effectively 'slid' off the ricochet plate. A similar phenomenon was observed by W. Rowe and co-workers[(2)].




An indication of the degree of deformation of the lead and iron shot, and the potential effects on the resultant shot cloud, can be seen from a close examination of the ricochet plate.

Figure 3 shows ricochet marks of No. 9 iron shot, the small white dots; and No. 7½ lead shot, the elliptical smear marks.
Similar differences were seen between other iron and lead shot impacts, of any shot size.

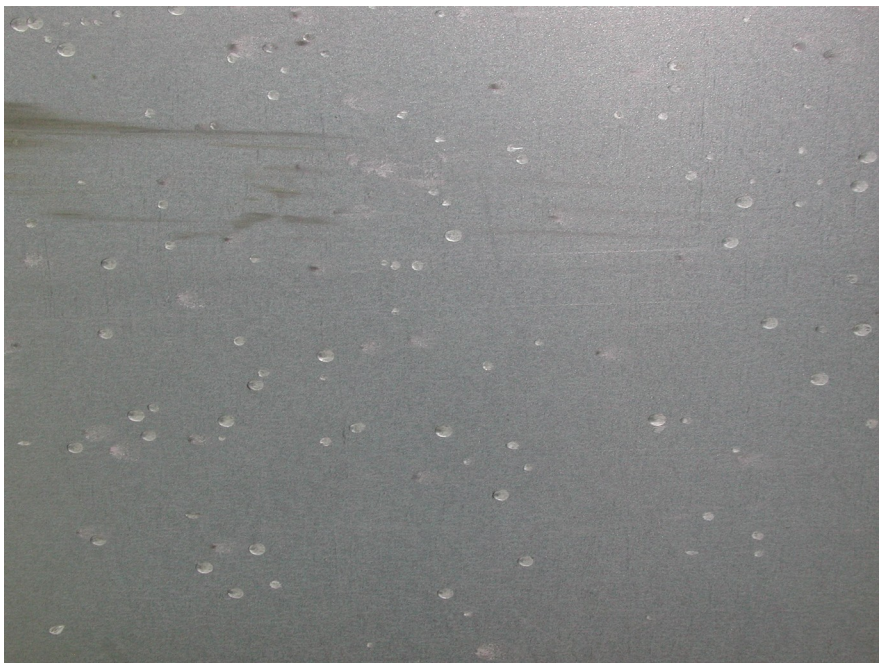


Figure 3.
Ricochet marks of No.9 iron shot and No.7½ lead shot.

The dark smear is the impact mark of a cartridge wad.

Shot Patterns of Iron and Lead Cartridges.

To establish a base pattern, for each of the cartridges selected for test, a direct shot at the pattern plate, from 20 metres, was carried out, for a minimum of three patterns.
Typical photo results are reported.
Where appropriate photos are in quite large format, to show detailed pellet strikes.

For the two types of iron shot cartridges, the average pattern counts are shown in Figure 4, followed by the supporting photo patterns in Figures 5 & 6.

Figure 4. Ricochet Data for Iron Shot.

| CARTRIDGE | ACTUAL PELLET COUNT | DIRECT SHOT AT 20 METRES<br>PELLET COUNT ON PATTERN SHEET | | PELLETS IN 30" CIRCLE | | RICOCHET AT 15+5 METRES<br>PELLET COUNT ON PATTERN SHEET | | PELLETS IN 30" CIRCLE | |
|---|---|---|---|---|---|---|---|---|---|
| Eley<br>32 gm<br>No.5 Shot | 268 | 260 | 97% | 252 | 94% | 250 | 93% | 231 | 86% |
| Gamebore<br>28gm<br>No.9 Shot | 610 | 590 | 97% | 532 | 87% | 565 | 92% | 530 | 87% |

A. Direct Shot from 20 Metres.

B. Ricochet Shot from 15 + 5 Metres.

Figure 5. A, B. Eley VIP Steel Pro Eco Wad No.5 Iron Shot 32gm.

Figure 6. A, B. Gamebore Super Steel Plastic Wad No.9 Iron Shot 28gm

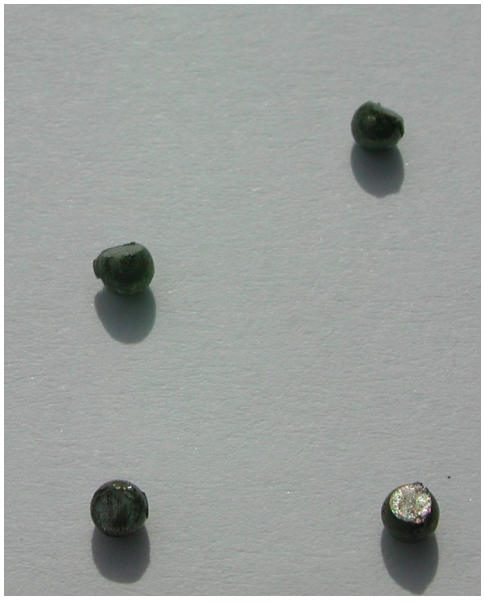
A. Direct Shot from 20 Metres.

B. Ricochet Shot from 15 + 5 Metres.

The patterns given by iron shot, after ricochet, showed pellet holes of a similar shape and size to those exhibited by a direct hit on the pattern plate.
Moreover, the complete shot-cloud integrity was maintained during the ricochet process. Over 90% of the original cartridge contents hit the 1.08m² area of the paper pattern plate, with 86% of No.5 shot and 87% of No.9 shot being focussed in the 30 inch (76.2cm) circle, marking the centre of the shot pattern.

Residues of shot were collected from the base of the pattern plate during the trials and iron and lead shot components were separated with a magnet.
Figure 7 shows an enlarged photograph of No.9 shot collected after ricochet.

Figure 7.



The impact flattening on one side of the iron sphere is clearly visible and remarkably regular from pellet to pellet.
These shot pellets would retain a reasonable amount of ballistic capability and in the absence of the pattern plate "collection pillow" would have a significant and focussed impact energy and ballistic range.

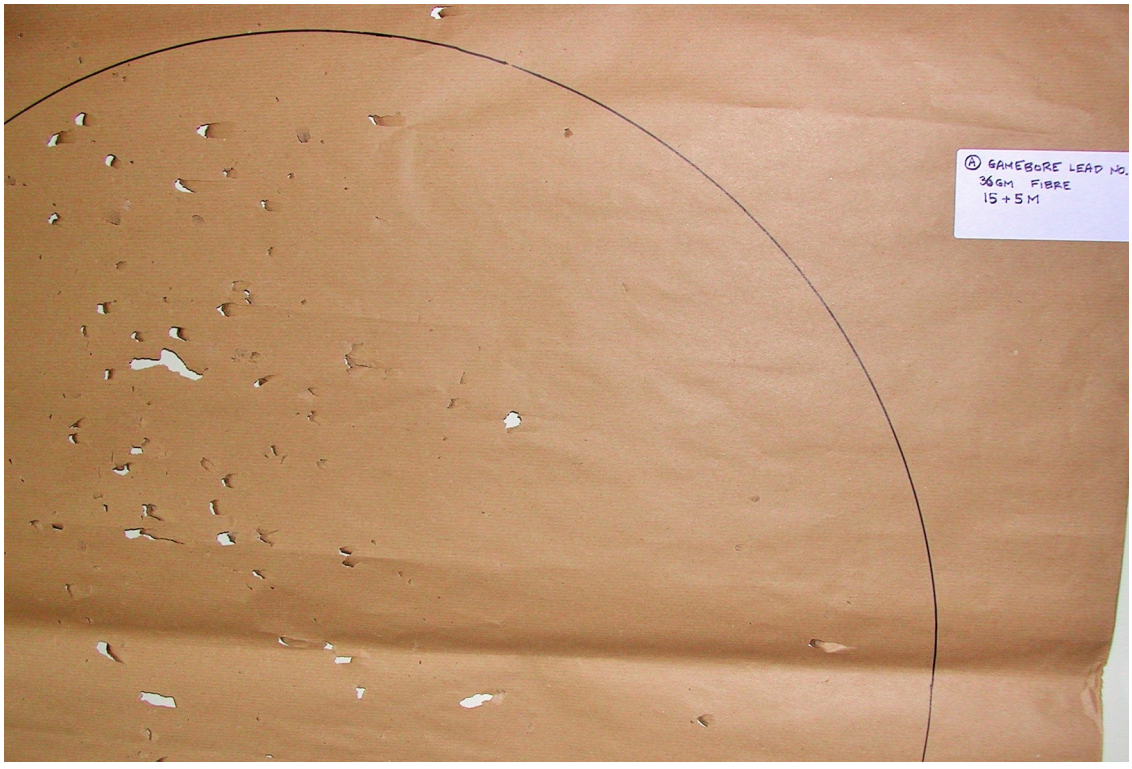
The pattern tests for the three types of lead cartridge are shown in Figures 8, 9 and 10.

A. Direct Shot from 20 Metres.

B. Ricochet Shot from 15 + 5 Metres.

Figure 8. A, B, C. Gamebore Black Gold Fibre Wad No.4 Lead Shot 36gm.

C. Detail of the "Shredding" Effect of Deformed Lead Pellets.



C. Enlarged Detail of Deformed No.5 Lead Pellet and Torn Paper Shred Attached.

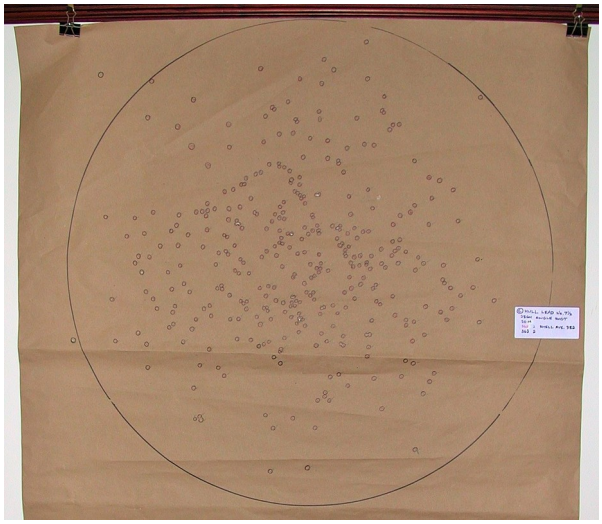
A. Direct Shot from 20 Metres.

Figure 9. A, B, C. RC Prestige Fibre Wad No.5 Lead Shot 28gm.

B. Ricochet Shot from 15 + 5 Metres.

Figure 10 A, B.

Hull CompX  Fibre Wad  No.7½ Lead Shot  28gm.



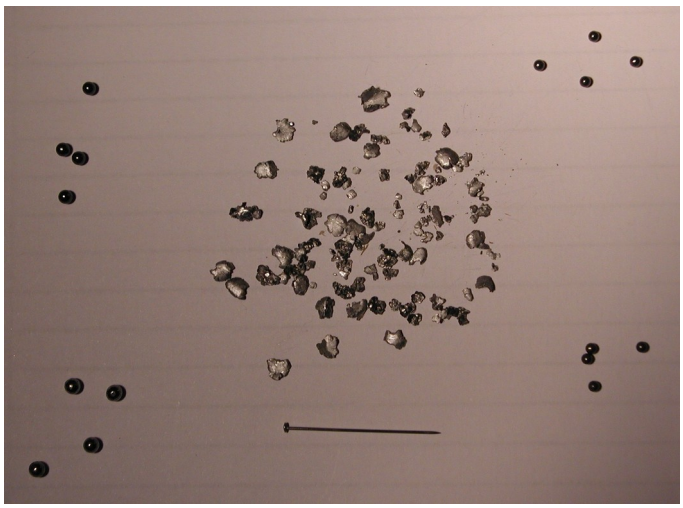
A.  Direct Shot from 20 Metres.

B. Ricochet Shot from 15 + 5 Metres.


Figure 11.  Lead Fragments from Ricochet Arrivals at the Pattern Plate.
With Shot Samples taken from Original Cartridges.

Iron No.5

Lead No.7½



Lead No.4

Iron No.9

In the 20 metre direct shot test at the pattern plate, the three lead cartridge types put very close to 100% of their shot content into a 30 inch (76.2 cm) circle, through the quarter choke barrel; there was an occasional 'flyer' pellet outside.

In the 15 + 5 metre ricochet tests, lead fragments collected from the base of the pattern plate are shown in Figure 11.
On the lead patterns there are only a few impacts that can be attributed to a complete lead shot in spherical form, if any.
Many of the impacts indicate smaller fragments and thin slivers of metal. The tears and shredding effects caused by larger deformed pellets may conceal other impacts.
Attempting to count pattern density and coherence is irrelevant.

If the deformed and destroyed lead shot fragments were allowed to fly freely, in the absence of the pattern plate, the lack of ballistic integrity would probably result in most of the fragments falling to the ground very quickly.

## Conclusion.

The ricochet characteristics of lead and iron shot are significantly different.

The examination of the performance of a range of shot sizes, used in game shooting, vermin control and clay shooting, shows that lead shot loses almost all of its ballistic capability following impact with a ricochet surface; iron shot retains much greater shot pellet and shot cloud integrity.

The implications of these findings need careful consideration and further investigation in respect of the use of iron shot in the field environment and on clay shooting ranges.

In the 150 years of lead cartridge use, in sporting activities, occasional reports of injury occur, associated with ricochet.
More information is required to assess the risks associated with iron shot in these situations.

References.

1. The Gun and its Development. W W Greener, 1881 and further editions.

The Art of Shooting. Charles Lancaster (H A A Thorn), 1889 and further editions.

The Modern Shotgun, Volume 3. Sir Gerald Burrard, 1932 and further editions.

The Mysteries of Shotgun Patterns. G G Oberfell, C E Thompson, 1957.

Shooting Facts and Fancies. Gough Thomas (Garwood), 1971 and 1978.

Shotgunning. The Art and the Science. Bob Brister, 1976.

Practical Ballistics. Lewis Potter, 2014.

2. McConnell M., Triplett G., Rowe W., "A Study of Shotgun Pellet Ricochet".
Journal of Forensic Sciences, Vol. 26 No. 4 1981, pp. 699-709.

Rowe W. F., "The Distribution of Shotgun Pellets after Ricochet from an Intermediate Target Surface".
Forensic Science International, Vol. 155, Issues 2-3, December 2005, pp. 188-192.

3. Palinkas J-F., Chevalier P., Sauvin F., et al. "Technical and Scientific Paper Submitted to the European Chemicals Agency" 17 July 2020.
FITASC- Federation Internationale de Tir aux Armes Sportives de Chasse.

*Note on the Author.*

*Malcolm Plant B.Sc, Ph.D, C.Sci, CChem, MRSC, MICSI gained a doctorate in polymer chemistry, specialising in anti-oxidants for polyolefins. He worked in the chemical industry for forty years in technical and commercial roles, with major European companies.*
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