INFORMATION SHEET

SHOTGUN CHOKES AND PATTERNS

How often do we hear from a fellow Gun, or read in shooting magazines about the importance of choke? Fixed choke guns, especially traditional English guns, often have chokes regulated to produce a desired pattern for their owners. Multi-choked guns have become widely used, providing a wide range of choke tubes intended to suit different shooting needs. Many Guns use a preferred degree of choke in their first barrel and a tighter one in the second to use its tighter pattern and to extend the range of the second shot. This is often needed against a bird missed or not killed by the first shot and then rapidly departing.

But does choke really work as is widely believed? Does choke really extend the range of a gun?

Belief in the value of choke goes back a long way. Burrard, for example, in 1948 (The Modern Shotgun Part III) states “All shooters know a choke gives a ‘closer’, or more concentrated, pattern than a cylinder barrel ...” and he gives the classic pattern percentages (i.e. the proportions of a cartridge’s pellets which strike a 30in circle, traditionally at 40yd) associated with each ‘point’ of choke at 40yd:

	%
Cylinder	40
Improved Cylinder	50
Quarter	55
Half	60
Three-quarters	65
Full	70

He states that these percentages ”*are approximate for all sizes of guns and shot*“ and that they comprise “a universal rule”. Eley’s famed Shooter’s Diary reproduces these percentages every year.

Gough Thomas in his 1975 “Shotguns and Cartridges for Game and Clay” endorses and expands on these relationships, pointing out they are not absolute and vary somewhat according to the cartridge used. Consequently he recommends viewing the performance of a gun not by its nominal choke but by the *pattern percentage it produces with a particular cartridge.*

John Brindle, a highly knowledgeable expatriate updated our understanding of ballistics in his “Shotgun Shooting: Techniques and Technology” (1984). Here he emphasises the point that a given type of choke can give very variable percentages according to the cartridge, choke profile and degree of choke constriction. The best way of determining how a given barrel or choke patterns is *by using the same cartridge* when, according to both Burrard and Thomas, *fairly consistent and typical percentages should be achieved for each point of choke.*

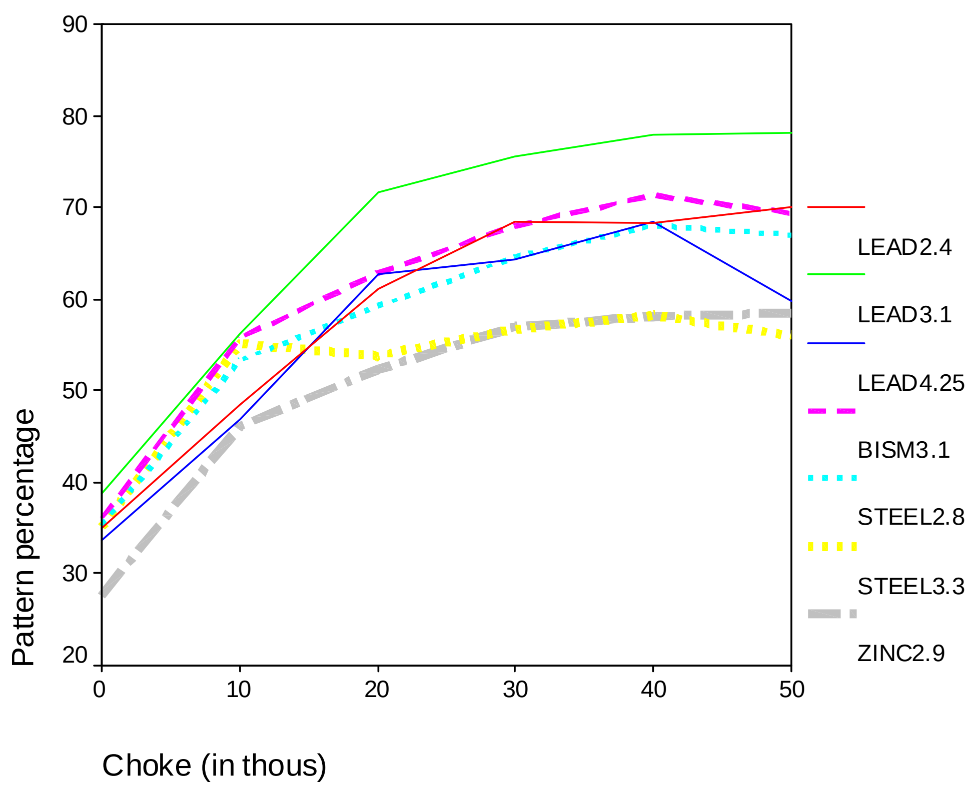
But are they? Does choke really produce consistent increases in pattern percentage?

The most recent information on the subject comes from Roger Giblin and David Compton of University College London's former Ballistic Research Laboratory and was obtained during their pioneering work on the ballistic performance of different types of cartridge. All firings used a standard test barrel with the same widely-used linear tapered chokes at 40yd and cartridges *from the same batch* for each test. Ten cartridges were fired from each choke from cylinder (0 thousandths of an inch constriction) to full choke (nominally 40 thous) plus "super" (50 thous), because fewer firings were found not sufficiently reliable to characterise the pattern of a given choke.

They used three different lead cartridges with pellet size running from 2.4mm (No.7) to 4.25mm (BB+), one bismuth at 3.1mm (No.4), two steel at 2.8mm (No.5) and 3.3mm (No.3), and one zinc at 2.9mm (approx No.5).

Figure 1 shows the general picture from all the test loads with the surprising result that, even with the same cartridge, the pattern percentage does *not increase consistently* with choke. There is a clear increase from cylinder (0 thous) to quarter choke (10 thous) and in most but not all loads from quarter to half choke (20 thous) although sometimes this is only slight. After half choke the increase is only slight at most. Pattern percentage then even decreases, especially from full (40 thous) to super full (50 thous). Clearly this is a real result as it occurs more or less consistently with pellet sizes from No. 7 to BB and with different shot materials and makes of cartridge.

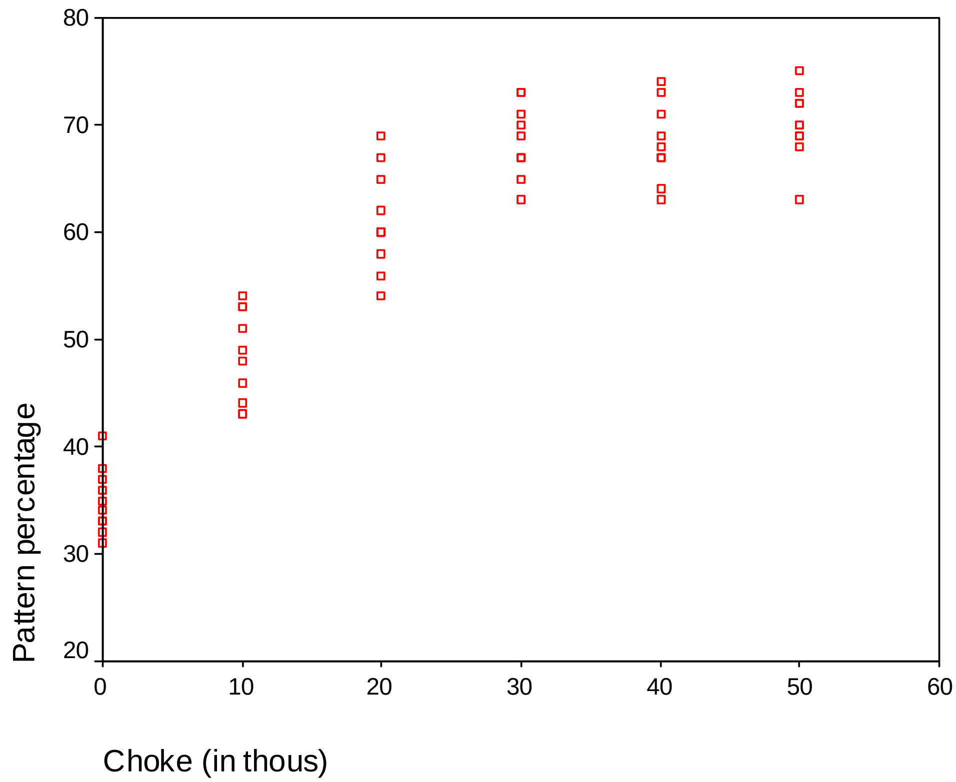
Figure 1. Change in pattern percentage as choke increases



The figure gives only a partial and rather misleading picture, however, since it is based on the *average* of the 10 firings of each cartridge with each choke. While the average is the correct method of summarising the results obtained it does not reveal the often considerable variation in pattern percentage recorded from cartridge to cartridge within each batch of 10.

Figure 2 shows the actual recorded pattern percentage for the lead 2.4mm load at each choke (NB two or more of the same percentage are shown as one symbol). There are fairly consistent results with 10 - 15 percentage points variation at each choke, ie at cylinder it ranged from 31 - 41% and at half choke from 54 - 68%.

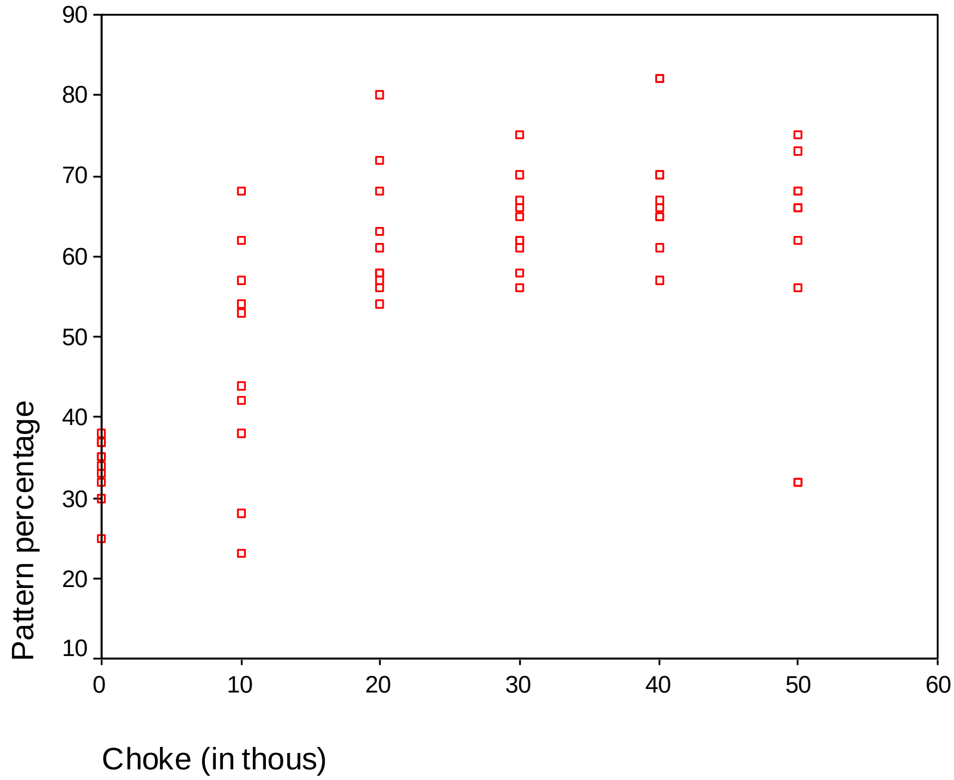
Figure 2. Pattern percentages for no.7 lead shot (2.4mm) with increasing choke



This variation has an important influence on how we interpret the results at different chokes. Standard statistical analysis has to be used to decide where the real rather than apparent differences lie. This shows that the pattern percentage truly increases from cylinder to quarter to half to three-quarter choke but there is no difference from three-quarter to full or super full because of the almost complete overlap of the measured percentages at these three chokes. It is interesting to note that a pattern measured at around 70% could have been fired from a half, three-quarter, full and super full choke!

A very different picture is shown by the lead 4.25mm load (Figure 3). There is enormous variation in the pattern percentages in most batches of 10 cartridges, from quarter choke (from 23 to 68%) to super full (32 to 75%)! Statistical analysis tells us that the only *real* increase in pattern percentage is between quarter (47%) and half choke (63%). The apparent difference between cylinder (34%) and quarter (47%) is rather illusory since all the percentages at cylinder were also recorded at quarter choke. There is no increase in pattern percentage above half choke and the pattern at super full statistically is lower than at full and the same as quarter choke! A percentage anywhere around 60% could be obtained from any choke from quarter to super full!

Figure 3. Pattern percentages for BB+ lead shot (4.25mm) with increasing choke



These results are not confined to lead shot. The bismuth 3.1mm (No.4) showed fairly consistent results but the pattern percentage increased only up to half choke; the steel 2.8mm (No.5) was the same and the zinc 2.9mm (No.'5') up to three-quarter choke. The steel 3.3mm (No.3) was more variable but after quarter choke the pattern on average remained unchanged: a pattern of around 45% could just as easily have come from any choke from cylinder to super full!

What we do learn from these results?

The first obvious point is that *one or two shots on a pattern plate are quite inadequate to give a reliable indication of a barrel's patterning.* Unfortunately the time taken to measure each pattern in the traditional way by counting pellet strikes on the centred 30inch circle rather discourages too many patterns from being measured. But clearly measuring only a few patterns can give very misleading results: for example, three patterns only with the lead 4.25mm at quarter choke could average anything from c. 25% - c. 62%. The only sound guidance is that the more shots at the plate, the more reliable the indication of a particular barrel or choke's characteristics. Five really is the minimum but 10 is much more reliable. Note that it is possible that the average percentage may seem acceptable yet the individual patterns are so variable that it would be worth trying another cartridge to get better results.

This variation from cartridge to cartridge is not unexpected, however well-made each cartridge itself. The main factor is the largely random behaviour of the pellets in the shot cloud as it travels down range. At the same time the various components of a cartridge (case/primer/powder/wad/ shot load/crimp etc) inevitably vary from cartridge to cartridge in small but unpredictable ways. They then interact with each other after firing, probably differently each time, and so further affect how each shot cloud behaves and how many pellets reach the target.

The second point is the effect of such variable patterns on the success of our shooting. On a given mallard or pheasant, the number (and energies) of pellets hitting the target from our chosen cartridge may not be as many as we had thought and so may not be enough to penetrate and damage vital tissues to bring about immediate death. The result is a wounded or lost bird. We can help overcome this problem, though, by properly patterning our gun/choke/cartridge combinations beforehand to make sure they do deliver lethal patterns *for each quarry type we pursue and the range at which we expect to shoot it.*

The third point is that one of the long-standing beliefs about choke, that pattern percentages, even from the same batch of cartridges, increase consistently with the degree of choke, does not appear to be wholly true, at least with linear-type chokes!

What about choke extending range?

It appears to be widely believed that the tighter the choke the longer the range of the load. Gough Thomas in his 1975 book, refers to the practical effect of choke, namely *to extend the effective range of the gun.* His Table 2 on page 73 indicates that, for example, a 40% pattern thrown by a cylinder barrel at 40yd is extended to 55yd by a full choke. This appears to be a remarkable effect.

How does it happen? It cannot be the result of the choke constriction since merely reducing the bore of a barrel by such a tiny amount cannot increase the speed of the shot cloud enough to carry it another 15 yards with still enough energy to kill. After all, soon after the pellets leave the barrel their velocity starts to fall.

The effect of choke surely should be to increase the density of the shot cloud. Consequently, a more distant target should be hit with a similar number of pellets as from a more open choke at the closer range. As long as those pellets have enough energy to penetrate to the vital tissues then the more distant bird should be killed.

So much for the theory. What about in practice?

We can turn to the shotgun ballistics model developed by David Leeming at the Royal Military College of Science, using the findings of the Ballistics Research Laboratory.

Firstly, although *in general terms*, all chokes above cylinder give a pattern percentage greater than cylinder, increasing choke thereafter frequently does not give Burrard's "closer" or "more concentrated" pattern, as we have seen. Secondly, "pattern" alone is not sufficient, as patterns themselves do not kill. After all the word "pattern" relates to the distribution of pellets, *in two dimensions only*, across the width of the shot cloud.

Particularly for killing live quarry humanely, what counts is the *number* of pellets striking the target *plus* their energies so that enough pellets penetrate to and damage vital tissues to cause immediate death. Provided then that the cartridge/gun are appropriate for the range of the target (i.e. they deliver enough pellet strikes each with sufficient energy), the main factor in ensuring those pellets hit the target is the *accuracy of the shooter*. The ballistics model demonstrates that the percentage of mallard hit (ie the number hit per 100 shots) falls as choke increases, over all realistic ranges. This is mainly because as pattern (generally) tightens, more accuracy is required to place that pattern on the bird. If accuracy does not increase as choke increases then fewer birds will be hit. Similarly the percentage killed (number killed per 100 shots) also declines.

This finding appears to be contrary to Gough Thomas' contention that "choke extends the effective range of a shotgun" and particularly his specific example that a 40% pattern from a cylinder barrel at 40yds is extended to 55yds by full choke. The shortcoming of this approach is that it takes into account only the pattern (i.e. distribution) and not the vital number and energy of the pellets in the part of the shot cloud that hits the target. The further they travel the more energy pellets lose and the harder it is to punch through the protective feathers and skin of the bird when they do hit it, before they can cause the lethal damage to underlying organs and tissues. Hence, even if a full choke can send further down range a pattern density similar to that from a cylinder barrel, the combined effect of the greater difficulty of hitting a more distant bird, and the rapidly falling energy of the pellets, does not result in a net increase in killing the target bird. Indeed the opposite occurs at least beyond moderate ranges (say 35 - 40 yds) and *irrespective of the choke used the killing rate continues falling with increased range.*

These findings may be surprising and, indeed, may be somewhat troubling as they depart from our long-held beliefs in how shot clouds behave and what to expect from different loads and chokes at different ranges. But we are now beginning to understand so much more about these things, following their careful scientific study and measurement, by means that simply were not available to our forebears. The ballistics of shotgun cartridges are complex and difficult to unravel. People like Burrard and Gough Thomas greatly advanced our knowledge at their time but now we have the advantage of modern technology to take our knowledge further forward again.

As we understand more about how our guns and cartridges work, and then use that new knowledge in our shooting, the more we should enjoy our sport. We should become more successful in the field, with fewer cartridges being fired for the same number of birds in the bag. Moreover, in today's political climate, it is increasingly important to ensure that our shooting results in consistently high levels of immediate kill and recovery of our quarry species. This minimises undesirable losses of birds and hence criticism of our sport.

If our understanding of how shotgun ballistics work has to be adjusted somewhat to achieve these objectives then so much the better for the future. What is becoming clear from recent studies is that, once we have got the right gun/cartridge combination for each type of shooting we do, our skill at shooting and the range at which we shoot then most determine our success in the field.

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