D13 Multivariate Analysis Applied to Sawed-Off Shotgun Pellet Dispersion

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After attending this presentation, attendees will understand how statistics can model the dispersion of birdshot fired from a 12-gauge sawed-off shotgun and will also learn that the spread of lead birdshot depends only slightly on the barrel length and mainly on the firing range.

This presentation will impact the forensic science community by providing attendees with an appreciation of the fact that, in contrast to previously published works, the dispersion of lead birdshot is best described by a second-order polynomial expression rather than a linear relationship.[1-3]

Statistical techniques have been used to establish a mathematical relationship enabling estimation of the distance from which a shotgun was fired with buckshot ammunition.[4] In the present study, pellet dispersion accompanying the discharge of lead birdshot was analyzed. Shotguns are easy to obtain in several countries as they are considered hunting devices, including sport hunting or pest elimination such as hare, mice, or mink plagues occurring in the fields of southern Chile. Due to their low cost and capability to inflict injury, shotguns (especially those with substantially shortened barrels, also known as "Recortadas" in Chile) are sometimes the preferred weapons for criminal activities. A long-held belief was that pellet dispersion varied greatly with barrel length, hence the motivation for the present study. The objective of this study was to analyze the effects of barrel length and pellet size on pellet dispersion at several distances using two 12-gauge FAMAE™ shotguns. A two-level factorial design was used to analyze the effect of pellet size (5cm-7.5cm), barrel length (33cm-72cm), and the firing distance on pellet dispersion (evaluated as the area of the figure enclosing all leads on the target, the square root of such area, and finally the Matto and Nabar effective radius method, which requires the measurements of x and y coordinates for every single impact on the target).[1] The results demonstrated that pellet size has a dominant influence on pellet dispersion, but barrel length has a nearly negligible influence on pellet dispersion. The effective radius was the best parameter, reaching R2 values of 99.9% vs. 89.x% of the area of the minimum figure around the birdshots and 99.x% for the root of the area.

The second stage involved the development of a response surface methodology to obtain a graphical relation between barrel length and firing range, assuming a second order polynomial as response evaluated for the same functions described above for the pellet dispersion. The chosen method for the experimental design was a Box-Behnken model covering ranges of 33cm, 45cm, and 72cm for the length of the shotgun barrel and 5m, 10m, and 15m for the firing range. After conducting the experiments using only Nº 5 pellets (the most commonly used in Chile), a second degree equation describing lead pattern as a function of the two variables studied was obtained, and an Analysis of Variance (ANOVA) test demonstrated a very good fitness for the effective radius, with R2 values of 99.7% of agreement. Results again exhibited that pellet dispersion is not directly influenced by the length of the weapon's barrel but depends strongly on the distance from muzzle to target. According to these results, the senior method of Matoo and Nabar revealed this is a very good way to estimate the firing range for 12-gauge shotguns,

but by using a parabolic curve instead of the linear approach initially proposed. Surprisingly, the square root of the area enclosing the impacts is a very easy method to calculate the approach to the distance of the firing distance; meanwhile, the ANOVA test showed that it is a statistically acceptable approach to the firing range.

Reference(s):

1. Mattoo B.N., Nabar B.S. Evaluation of effective shot dispersion in buckshot patterns. *J. Forensic Sci.* 1969, 14, 263-269.
2. Wray J., McNeil J., Rowe W. Comparison of methods for estimating range of fire based on the spread of buckshot patterns. *J. Forensic Sci.* 1983, 28, (4), 846-857.
3. Nag N.K., Lahiri A. An evaluation of distribution of pellets due to shotgun discharge. *Forensic Sci. Int.* 1986, 32, 151-159.
4. Nag N.K., Sinha P. An investigation into pellet dispersion ballistics. *Forensic Sci. Int.* 1992, 55(2), 105-130.

Multivariate Analysis, ANOVA, Pellet Dispersion