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Ketty PhDee

PART 4: *KETTIE* SHOOTING
Round ball ballistics

Hello Forker! In part one, I highlighted the captions and headlines we will cover in the series; in part two, we indexed the slingshot (*kettie*) lingo terms. In part three, we learned about the No. 1 Rule and touched on P.A.M., Precision versus Accuracy, aiming sights, and debunked the dominant hand myth. In this part, we're going *kettie* ballistic!

Did you receive the memo?

To defer from lectures and ensure that each part of the series remains a substantive and entertaining article, I typically reference various subjects to provide context and practical guidance. As the series progresses, we revisit these subjects in detail. Remember, the objective of this series is to equip you, the athlete, with (a) core knowledge (technical understanding) and (b) essential equipment so that you reach the standard discipline 10 m shooting-range line. However, as stated before - you must be open and ready for an expedient (c) elective knowledge learning curve and self-discovery journey to become a competitive athlete.

No. 1 Rule: Always shoot with eye protection – shooting/safety glasses

Do not even be in the vicinity of slingshot shooting activity without glasses, due to the risks posed by ricochet pellets due to RTS *kettie* frame hits and misdirected (flyer) shots. Frankly, the primary hazard to the operator actually comes from elastic bands failing.

Band Sets

You should cultivate the habit of exchanging your bands within their optimal service cycle, before fatigue sets in and long before a catastrophic event (breaking) occurs. This will ensure there are no failures and, more importantly, consistent shot strings (accuracy) and grouping (precision). You do not drive your vehicle until the tyres burst, but rather keep it well within the legal operational limits. Yet, if it were racing tyres, you would run it only in the top-performing periphery. You should adopt a similar approach with your high-performance *kettie* bands and use the best performance cycle. Flatbands for competition purposes should not only just be fit for use, meaning that they are not withered (visually fatigued, holes, torn, etc.), but they should also be at their peak performance lifespan (file cycle) curve. If a set of optimized tapered competition bands exceeds 300 shots, it is not being utilised to its optimal potential.

Kettie shooting and competition grade flatbands

We are already aware of quite a number of metrics (elements) influencing the lifespan of flatlands, such as, the actual material (formulation), UV (sunlight) exposure, moisture absorption, taper cut, clean cur (edging), length (expansion and compression range), the thickness (guage) and mount ergonomics. These metrics (elements) are part of the precision (internal ballistics) component of the P.A.M. (precision–accuracy matrix), working in on performance (precision) as the foundation of applied accuracy. Reference part 3 – for introduction and explanation of P.A.M. and *precision* versus *accuracy*. We have already stated that only dedicated elastic bands intended (formulated and made) for slingshot shooting must be used. I only use: Ketty Elite Pro bands, from ***www.ketty.co.za,*** the finest handmade, special natural latex formulation, to provide the best shot consistency throughout the flatband cycle. Caveat all, as a general thumb reference, know that straight cut flatbands provides the best longevity.

Kettie (Slingshot) performance

Consider the two primary objects – to be in harmony in the P.A.M Matrix: (A) *precision*- thus internal ballistics (IB) call it "inherent precision potential" of your *kettie,* and (B) *accuracy*- thus external ballistics (EB), in simple terms – "putting that precision on target". The matrix (PAM) is a maze of metrics (elements) in finely tuned balance. *Precision* relies on the actual *kettie* components (parts, material properties, performance, etc.) in synchronisation (the optimal combination) – but it is critical to suit the specific athlete, since the athlete ultimately is also a precision element (metric). While *precision* represents the "optimised theoretical exactitude" of your *kettie* set-up under laboratory test bench conditions, *accuracy* is the application of that precision (exactness) in real-world scenarios, like velocity, gravity (range/distance), wind, and aerodynamics. Remember, precision metrics (elements) are all measurable, whereas accuracy metrics encompasses both measurable and immeasurable elements/factors. We acknowledge that accuracy is inevitably also greatly affected by the operator's skillset (i.e., the athlete's proficiency). Therefore, the athlete should technically be included in the *accuracy* equation, but for the sake of this discussion we keep to the hardware. It is essential to recognise that these two concepts, *precision* and *accuracy,* exact an opposite ideal, and can only be harmonised through compromise. To thwart the meticulous hardware balance we simply have to add the "operator" into the– "fit for purpose" equation – and you really don't need a *Kettie PHDee* to complicate human resources.

Fit for purpose

Early in the series, we established a few guidelines: 1) We do not make unsubstantiated assumptions – to measure is to know *("meet is weet")* – and therefore, we only use scientific data in decision-making. 2) We do not engage in the same repetitive, humdrum actions and expect a different result. 3) We do not participate in frivolous activities or make changes for the sake of change. 4) We identify specific objectives and outcomes, making informed decisions and taking purposeful (decisive) actions to meet the requirements criteria. Example: Before we set-up flatlands and chase velocity records, let's first examine the "ballistic" requirements of SASF (South African Slingshot Federation) – standard discipline shooting/targets. Let's understand the objective – first. It is not merely a question of complying (meeting) with the ballistic performance to "kill" (knock-over) targets, but rather how to accomplish this as efficiently and consistently as possible, thus not just the competing recipe "fit for purpose" – but the winning recipe: "Ideal for purpose".

Competition Pellets

As a standard practice worldwide, the tournament organiser provides the pellets. SASF standard *kettie* sports code (rules/disciplines) has standardised the ammunition/pellets to 8 mm "steel" round balls. The rules does not reference metallurgical composition. SASF prescribes pellets with a mass (metric) ranging from 30 gr (1.94 grams) to 35 gr (2.26 grams), where 1 gr = 0.0648 grams. I work with the measured (weighed)

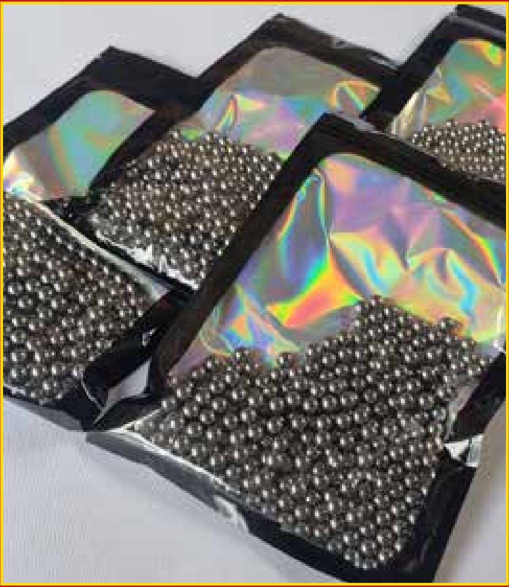
average carbon steel ball weight, which is 32.6 grains (2.11 grams). Standardisation of pellets offers many advantages, from practical recovery to dispensing at events. The 8 mm size is rapidly becoming the global standard, as it provides the best overall *precision* v *accuracy* - ballistic efficiency. It ensures better participation equality; for instance, a person with a weak draw shooting a 7 mm against someone shooting 9.5 mm with a long draw would face a significant disadvantage. Additionally, the actual size of 8 mm - poses a particularly interesting aspect (metric) that necessitates and fosters much better pouch and grip skills, conducive to a more challenging play. The larger the ball, the easier it is to grip consistently, resulting in less grip deviation. However, the downside is much faster drop, heavier bands means more energy, and induced bending moments etc. Thus, good grip technique is crucial and all contribute to the interesting game match play dynamic.

SASF STD Targets

The rule is clear – the target must be knocked down. Let's analyse and understand this statement, i.e. let's define the objective for decisive actions. The maximum energy (force) required for a target to be knocked down according to the standard SASF *kettie* sport shooting code (discipline) technical specifications is 2 fp/e (two foot-pounds of energy). This seemingly simple target energy formula (TEF) is the foundation of a very smart dynamic system and an excellent match play game fundamental to the South African *kettie* shooting National League. The technical aspect is based on (A) real-world actual *kettie* performance, and (B) a concept unique to SASF referred to as the "smallest member" participation. The latter is an organisational management policy and members' orientated development model – in support of SASF's mandate for the national development of the "sport of *kettie* shooting". The philosophy entails that the organisation (SASF) is only as capable (strong/weak) as its basic demographic members, ensuring a large membership and participation base due to the low practical entry-level barrier. Low velocities, translates to – cheaper flatbands, small light weight (affordable) *kettie* frames, etc. to physically smaller in stature athletes. The SASF model is not based on the average member's physical capacity demographic, but the minor 25% margin in demographics and all ventures. In practical terms, this translates to: (A member with) (i) one *kettie* and (ii) one bandset must be able to clear (knock down) all the standard discipline targets (clear the range) in (iii) one national league tournament.

In ballistic terms, it translates to shooting standard steel ammo (pellet) of 32.6 grains (2.1 grams) at 200 f/s (feet per second) at MSL (mean sea level), which will generate in excess of 3 fp/e and 2 fp/e at 20 m. This means an athlete shooting with a very light *kettie* setup (rig) would be able to shoot at 10 m, 15 m, 20 m, and have the energy to knock down targets. The objective: "32.6 grains (2.1 grams) at 200 f/s (feet per second) / 3 fp/e", as the minimum requirement. (Now – how do we improve on the technical objective, to give us an advantage – that is the KETTY PHDee quest!) This modest energy requirement accommodate light frame and very light flatbands, weak and short draw lengths of athletes from – U/13 years to 60+ years veterans, in the mandated SASF National League. It should be noted that U/13 only shoot 10 m and 15 m. Further, it is prudent to note that each standard discipline 10 m, 15 m and 20 m is an individual medals event, similar to athletics, where you only participate in your favourite 100 m, 200 m, 400 m, etc. The youngsters of U/8 – U/13 participate in a 5 meter "domestic development league". "Field target", events are non-standard disciplines, or so-called domestic disciplines, and are shot with clay pellets. We will circle back to this later in the series, but notably in this case would be the difference between junk pellets like so-called "ceramic" (terracotta) pellets with useless ballistics and actual *kettie clay* pellets with great ballistics (magnetic, water soluble, eco-friendly, etc).

It should be noted that although the technical specification for standard indoor *kettie* sport code (rules) requires that the targets are set so that no more than 2 fp/e is required to knock down a target, the minimum energy is 1.5 fp/e to knock

down a target. That is a very small margin! Think PHDee: A *kettie* that shoots 200 feet per second (fs) at point blank, the speed at 10 m is 177 fs, at 15 m is 166 fs and 20 m 156 fs. Thus, technically at 10 m the *kettie* only requires 179 fs. (Speed 0 meters is 200 fs, minus the speed at 10 m at 177fs = 23 fs drop, plus 156 fs (at 20m) = 179 fs, still generating in excess of 2 fp/e). Think carefully before you set up and shoot at these critical levels/margins. The PHDee quest is to shoot at these "convent" and "comfort" levels, but with much better performance.

If shooting an average 8 mm steel ball 200 fs is theoretically baseline, what is the top-end? Is 300 fs/s velocity necessary? You are about to learn that speed (velocity), if misunderstood, it is totally disastrous, and if well understood it is just a component (metric) in the precision equation/PAM. The correct question is: What is the "terminal velocity" required? One should be acutely aware that because this energy is mechanically generated, any additional energy is wasted, and that it has negative effects on the "shooting system", including the athlete, like fatigue, and additional movement (bending moments) of the *kettie* when a greater pull and contraction energy is released. The basic calculations suggest a reference velocity of 240 fs, providing just under 4 fp/e at 10 m and more than 3 fp/e at 20 meters.

Round-Ball (Kettie/Slingshot) External Ballistics (Accuracy)

We have already stated that there is no such thing as a "flat shooting slingshot". The moment the round ball (projectile) is released from the pouch, "pellet drop", due to gravitational force, takes immediate effect. To understand *kettie* ballistics, we must have a proper understanding of general ballistics in order to comprehend the dynamics of the metrics involved, such as bullet/ball size, velocity, drag, bullet drop, and more. We need to determine precisely what the actual gauge or measurement standard is for *kettie* accuracy. When is a *kettie* fit / ideal for the purpose of competition shooting, and when is the accuracy useless, and why?

Unlike modern-day conventional bullets, with elongated cylindrical bodies and a conical ogive to manipulate "bullet drag", the drag of round balls is primarily manipulated/dependent on speed (velocity). Round balls are "dynamically stable" and do not require air pressure to keep the "nose" of the bullet (pellet) pointing, only to maintain the vector. Though, there are two major bullet "stability" (in flight) components: (A) Centre of Gravity (CoG) – centre gravitational balance location (position) within the bullet, defined by the elements such as the shape, and the mass distribution within the shape, interdependent on materials composition (densities/construction) and allocation, such as a lead core, copper jacket, cavities, inserts, in short the "axial form". In a uniform material round ball, GoG is practically centre, and (B) a practical centre - Centre of Pressure (CoP) "point" acting as the point where all the aerodynamic forces actuate through the bullet, at least at these low speeds/velocity. Unlike in a modern bullet, essentially defined by the (i) bullet shape (basics – pointed bullets CoP forward/blunt bullet CoP backwards), constantly changing location within the bullet, because of the (ii) velocity (speed of the bullet) and (iii) air density (air pressure). In a uniform material round ball, GoP is "practically" centre (at low subsonic speeds). Thus negating the adverse effect of the aerodynamic resistance and drag working through the CoP at a point within the bullet in front of the CoG, essentially pushing (forcing) at a point in front of the gravitational balance (pivot point) of the bullet to (that will) tip the bullet over (gyrate (yaw & pitch) / wobble and tumble). As it is a round ball, it therefore theoretically requires no "spin" stabilisation. I stated in 2014: There is nothing more accurate than a round ball – until it is not!

The question: Are round balls gyroscopically stable or unstable in flight? Does it have to spin? The answer is rather complicated, but let's narrow it down to the application of *kettie* shooting. A *kettie* is not designed to rotate the pellet (projectile/bullet), unlike a grooved rifle. In layman's terms, we can say that the longer the bullet, the more spin speed (RPM, revolutions per minute) is required to gyroscopically stabilise the bullet, which is mainly achieved by tighter grooves in the rifle barrel and/or higher bullet velocity. However, with a round ball, there is no cylinder to be gyroscopically stabilised, and due to its round form factor, it should be dynamically stable by default. "I agree", until the ball is propelled through the air. It is very evident that round balls from smooth-bore rifles are quite accurate to about 50 meters, and then, to the observer, it looks like erratic flight path dispersion. Perhaps – supersonic flight to 50 odd meters and then long transonic transitioning? It also seems that if the round ball is spinning due to a grooved barrel, it is more stable, resulting in much better groupings at 100 meters. Firstly, the projectile will have an ideal velocity range to stabilise the flight path (vector). At a certain speed, the non-concentricity (the spherical imperfection, inside or outside), like little indents (roughness/jaggedness) of the ball, has an uneven aerodynamic drag effect, and the ball will veer off the velocity vector. Like you would see a cricket ball veer off in a "swinger". Reference part 5 – Aerodynamic pellet jump.

As a matter of interest

To counteract the concentric/spherical imperfections (imbalance) of the ball, it is spun (rotated) on its own axis to equally distribute (balance out /distribute) the imperfections. However, at a certain speed, it leads to processional rotation (wobble) offset around the centre of gravity instead of rotating around the form axle ("centre of the shape"). In simple terms, the uneven weight distribution of the round ball, being off-centre or affected by surface drag, results in a difference between the flight path (bearing) deviation – is slightly off from the heading (velocity vector), creating an angle of attack, with a little extra air pressure on one side, causing the pellet to deviate slightly. Depending on the position (orientation) of the off-centre departure from the barrel, it will eventually disperse around the clock in a round pattern around the clock. The bullet's precessional rotation (wobble) should be regarded similarly to any offset axle or perhaps a unbalanced vehicle tyre. The faster the imbalance spins, the greater the offset wobble (precession) and destructive gyroscopic force.

Round balls, whether it is spinning or not, has the same wind forces trying to deflect it. Wind will deflect a round ball quite severely because of its very poor aerodynamics. We will circle back to this very relevant topic to Field Target (FT) shooting. We will discuss wind directions effects in the part 5.

What is the take away?

Every type of pellet has a sweet speed spot (ideal velocity range). If you have to go faster to meet, for example, a minimum energy level, there will be a trade-off in accuracy. Rather shoot a larger or heavier pellet, especially in field target. Do not use junk clay or steel pellets, example: 8mm Steel balls with such as G1000 +/-25µm tolerance. There is plenty of cheap reconditioned "ball bearings" nicely shiny plated around, which becomes very expensive when precision & accuracy matters. There is no justification for shooting with pellets (ammo), especially clay ammo, that are not fit for purpose. "I am just shooting for fun" – do you have fun shooting miss? Is the objective not to hit targets? Life and certainly your *kettie* shooting career are too short for clowning about and missing targets. Visit ***www.ketty.co.za*** for competition-grade ammo.

Myth busting

You have to spin round balls to fly in a straight line. No, not at all. The optimal velocity and aerodynamic drag are more important for stable flight. Pellet (spherical bullet) imperfections are the root cause of flight path deviation.

Thank you for participating in this "Ketty PhDee" journey as we explore the science and legends, debunk the myths and cultivate solutions to precision kettie shooting. In the next part we discuss *kettie* accuracy and calculating groups. Till next time, safe shooting!