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OBJECTIVES:

- TO BRING AN END TO RECREATIONAL DUCK SHOOTING IN SOUTH AUSTRALIA.
- TO PROMOTE CARE FOR NATIVE DUCKS IN GENERAL.

Submission to the South Australian Select Committee on Hunting Native Birds

Geoff Russell, May 2023

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Abstract

A 2022 *Victorian Game Management Authority*[1] (GMA) X-ray survey has confirmed that duck shooters leave at least as many wounded ducks as they retrieve and kill. The reason for this has nothing to do with shooter behaviour, but is a simple consequence of the way shotguns work; it's the physics coupled with the fact that ducks don't fall from the sky like clay targets when hit by a pellet or two. They have to be hit in exactly the right bones or organs; otherwise they fly on and the shooter will think they missed. You can't aim individual shotgun pellets, they hit where they hit by chance. This makes shotguns aimed at flying birds an unreliable killing weapon.

Consequently both hunter *Codes of Conduct* and the *South Australian Animal Welfare Act 1985*[2] (AWA) are *impossible* to adhere to. You can't retrieve and kill a wounded flying duck. Some die slowly, others recover and may be shot again, and again.

The GMA work is simply one piece in a decades long body of research showing that the flying-wounded aren't rare flukes but an unavoidable and large fraction of ducks shot at.

You can't reform duck shooting because you can't change either the physics of shotguns or the anatomy of ducks. There is relatively little research on quail, but what there is is consistent with the work on ducks, which isn't surprising because the mechanism is the same.

1 Introduction

This Submission will:

1. Present the scientific evidence showing that the use of shotguns for shooting native birds in flight is intrinsically inconsistent with the spirit of the AWA.
2. Show that wounding rates cannot be estimated by observing shooters.
3. Show that "ethical hunting", as defined by the *Field and Game Australia*[3] (FAGA) Code of Conduct[4] is impossible when shotguns are used on flying ducks or quail.
4. Show that the *Department of Environment and Water*[5] (DEW) Code of Practice[6] for the humane destruction of birds by shooting in South Australia (COP) is impossible to follow when shooting flying birds with a shotgun.

[1] https://www.gma.vic.gov.au
[2] https://www.legislation.sa.gov.au/lz?path=%2FC%2FA%2FAnimal%20Welfare%20Act%201985
[3] https://www.fieldandgame.com.au
[4] https://www.fieldandgame.com.au/page/code-of-conduct-ethics/
[5] https://www.environment.sa.gov.au/
[6] https://cdn.environment.sa.gov.au/environment/docs/cop_humanedestructionbirds.pdf

I believe the COP reflects the view of the public that all deliberate killing of animals should be done quickly and reliably. 'Reliably' in this context means that animals should not escape wounded to suffer and perhaps die, and die slowly.

I am confident that any slaughterhouse would be immediately closed if 20-50% of animals who were gassed or shot subsequently escaped. Decades of research, frequently by shotgun makers themselves, has shown that this is exactly what happens when shotguns are used on flying ducks. It is not avoidable, but is a simple consequence of the physics.

It is the job of Government Departments to understand the activities they manage. In demonstrating the three points above, this submission will also establish either that the DEW, by publishing an impossible Code of Practice, doesn't understand the activity it is managing, or that it has been deliberately misleading successive Ministers in order to promote an activity which is inconsistent with the humane treatment of animals which is the cornerstone of the AWA.

1.1 Public ethics and Prevention of Cruelty Legislation

Parliaments are expected to pass legislation consistent with ethical standards of the day and to change them as those standards evolve.

1. Every state in Australia has legislation aimed at preventing deliberate cruelty to animals.
2. In addition, every state in Australia has legislation aimed at ensuring that slaughterhouses kill animals as quickly and painlessly as possible.
3. As far as I know, no hunting group has ever produced random sample polling evidence that the general public supports exceptions to this principle for hunters of any kind; regardless of whether they use dogs, knives, rifles, bows or shotguns. There is no evidence that the public thinks shooters should regularly wound animals in considerable numbers by a process that makes them also irretrievable.

1.2 Terminology: downed and flying wounded

The word "cripple" has been used since the 1950s (e.g., (Bellrose 1953)) as a precise technical term in duck shooting research literature. Here's a definition from 1981:

> "*'Cripples' refer to birds that are downed but unretrieved by the original shooter.*" (Van Dyke 1981)

Note that the term *doesn't* cover birds which are hit but not downed.

The word "crippled" hasn't been used in the human context for decades because of insulting connotations. But the concept it embodies is critical for clear thinking about the process of shooting flying ducks with shotguns.

Using the single word "wounding" for two very different concepts is confusing at best and grossly misleading at worst. This submission will use two terms for the two different categories.

1. Downed-wounded
2. Flying-wounded

When discussing scientific literature which uses the word "cripple", we'll use it in the same precise technical sense.

1.2.1 Few downed-wounded survive

People who think of ducks as resources have studied downed-wounded rates because they believe these represent lost resources. The assumption is that almost all of them die. Indeed, the above definition of "cripple" comes from a macabre study where ducks were released with radio collars after having a wing broken (Van Dyke 1981) or fitted with a sleeve to prevent use. Just a few percent healed and survived. Other studies have concluded similarly (Bellrose 1953; Kirby, Reichman, and Schoenfelder 1981), but it's a hard thing to measure.

1.2.2 But many ducks have embedded pellets

How then are we to make sense of X-ray studies in which ducks are sampled *before* a shooting season and a considerable number are found with pellets in their bodies? If almost all of the downed-wounded died, then where did they come from?

Obviously they have been shot, but the numbers found are far too high for them to be downed-wounded. These X-ray studies will be discussed in more detail in Section 4.2.

1.2.3 How many flying-wounded survive?

Keeping in mind that a duck can't be found with embedded pellets in such a survey unless it has recovered. Pellets that pass through a duck will also not be found in such a survey. So we need to factor in an estimate of the death rate of the flying-wounded when we consider the X-ray data.

Recovery, of course, is a relative term. The very first X-ray study of ducks (Whitlock and Miller 1947) was done in the US and the ducks came to the attention of researchers because they didn't migrate with the other ducks. Ducks, like all animals, are susceptible to infection and a wound doesn't have to be large to kill; wild ducks have no access to antibiotics.

1.2.4 No shotgun wound is trivial

Shooting groups publicly ignore the flying-wounding altogether or trivialise it (personal observation). Imagine a roofing nail perforating your abdomen. Depending on the precise path, you might escape infection and major internal damage. But most of us non-shooters would consider that a serious wound. We'd probably visit our nearest hospital. I chose a "roofing nail" in this example, because their shafts have a similar diameter to a #2 steel shotgun pellet. How does that injury in a 70 kg human compare to a pellet through the body of a 1 kg duck? That's a question for anybody advocating the shotgunning of flying ducks.

Figure 1 shows the logical (but not quantitative) relationships between shooting outcomes.

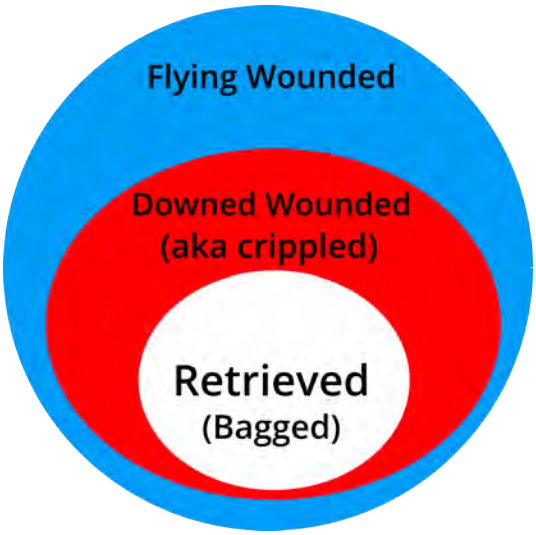


Figure 1: Outcomes from shooting

When watching shooters, It is relatively easy to see if a duck is downed and there have been many studies of the downed-wounded (e.g., (Nieman et al. 1987; Humburg et al. 1982)). But estimating rates of the flying-wounded is much harder. Without some new technology, I'd judge it to be impossible. You may see a duck flinch or change course when the gun is fired, but is that a response to the noise, a hit through the feathers, or an indication of a body strike? It's difficult to make such judgement or

even to have both duck and shooter reliably and simultaneously in your view at a good angle.

Estimating the flying-wounded

The flying-wounded cannot be reliably observed. The size of this cohort can only be estimated after the fact from X-ray surveys and an accurate theory about the process.

Figure 2 shows what a single shotgun pellet can do to a duck. This duck was only retrieved (and euthanased) because of other, less visible, injuries. It had escaped the person who shot it. This kind of bill injury isn't rare. Figure 8, later in the submission, shows that some 7.9% of pellets found in X-ray studies were found in the heads of ducks.

Figure 2: Bill injury (Photo: Russell Millard, *The Advertiser*)

1.3 Killing animals: process, skill, luck

There are three quite different ways of killing animals:

1. Process killing.

   In a slaughterhouse, the outcome for the animal is supposed to be a function of the process. You don't want a process that involves a level of skill in operators that few can master. You want every task to be simple. Compare it to golf. According to a US website[7], only 55% of golfers break 100 and it takes 1-2 years for them to get there. You don't want slaughtering to be like that. In fact, you don't want it to be a matter of skill at all. You want slaughterers to be 100% reliable. It must be a matter of following a simple process and not a matter of mastering a complex skill.

2. Skill killing.

   Shooting a rifle is a skill. Choosing equipment is about knowledge (and money). Some studies have found the percentage of head shot kangaroos to be as high as 96% (Ben-Ami et al. 2014), despite it being a small target and shooting usually happening at night. Clearly many kangaroo shooters are very good. There is very little luck involved. Perhaps an animal moves at the last moment resulting in a missed shot or a wounding. There is nothing like the toss of a coin involved. In all but the windiest of conditions, there is very little projectile deviation due to factors not under the control of the shooter at the ranges involved.

Other studies (Ben-Ami et al. 2014) find high rates of neck and body shots. This is an indication of a less than instantaneous death. But the fact that significant numbers of shooters can achieve high rates of head shots indicates that poor performance shouldn't be regarded as bad luck (due to some kind of random process). Poor shooting is more correctly regarded as the incompetence of casual shooters or perhaps of regular shooters who simply failed to improve regardless of practice; like some golfers.

3. Luck killing.

   Shotguns add a random factor that makes it totally unlike the other two forms of killing. Random processes are complex and not well understood by those without specialised training and skill; hence the popularity of casinos and X-lotto. There are indications that even within the DEW, these processes either aren't understood or are deliberately ignored. The inherent randomness of shotgun patterns implies, as we'll show, that duck shooting can never be carried out in accordance with the DEW Code of Practice.

[7] https://www.golfstorageguide.com/how-many-golfers-break-70-80-90-100/

Randomness makes Code of Practice impossible

The inherent randomness of shotgun patterns implies, as we'll show, that duck shooting can never be be carried out in accordance with the DEW Code of Practice.

2 What is a good shotgun pellet pattern?

Before considering the scientific research into shotgunning, here's a simple picture that is worth a thousand words.

Figure 3 comes from a GMA Youtube clip[8]: *"For ducks' sake, reduce wounding by pattern testing your shotgun"*. It shows what happens when you shoot a piece of paper with a shotgun. You can see the impact points of all the pellets in the shell. Magnify your PDF if you are reading on a screen.

The idea is that you draw a 30 inch diameter circle on the paper and shoot it from your preferred range. You can change the percentage of pellets inside this circle by constricting the barrel a little. The device to do this is called a choke. Some shotguns allow you to change the choke just by unscrewing the old one and screwing in a different one. Traditionally, the choke was a fixed characteristic of the shotgun. There are traditional names for the level of constriction. A *true cylinder* has no constriction at all. The methods of boring barrels to make a slight constriction were developed in the 19th century. A *full choke*, by definition, puts close to 70% of the pellets inside the reference circle at a range of 40 yards (36.5m).

Once the pellets start interacting with the air, the same barrel and shotshell can deliver different percentages to the circle from the same range. Fire 20 shots from the same gun and range and you will get a variety of percentages clustered about an average.

The pattern in Figure 3 was explicitly described as a "good" pattern by GMA guest expert, Daryl Snowdon of the *Sporting Shooters Association of Australia*[9] (SSAA); with a qualifier of "perhaps a little too dense". Why does the GMA not have its own experts? Does it need to get advice from a group it is trying to police and manage? Does the Tax Department produce video advice for taxpayers where it defers to Tax Agents for expertise? Does our DEW have its own experts or does it need help from shooting organisations?

I've put a few rectangles on this image along with some shading. The rectangles each have an area of about 20 in^2 (129 cm^2). This is the area Winchester (shotgun and ammunition manufacturer) researchers found to be *"closely equivalent to the*

[8] https://www.youtube.com/watch?v=umeBwzkeisg
[9] https://www.ssaa.org.au/

Figure 3: A pattern described as good in a GMA youtube clip

vulnerable areas of a mallard"(Lowry 1973) (see Duck shooting research). They decided you need to hit this region with about 4 pellets to be pretty sure of bagging the duck (meaning it would be dead within 5 minutes, or so disabled that you'd have no problem retrieving it). They decided on this criteria after shooting over 2,000 shot ducks, defeathering them and counting entrance and exit wounds; measuring the length of the pellet tract, counting broken bones etc. You name it, they did it.

The mallards used in this research are a little bigger than our Pacific Black ducks. As you can see, this "good" pattern has plenty of large sparsely pelleted areas. The white and pink shading was my first attempt at highlighting the sparser areas of the pattern, before I decided to use rectangles.

You might like to look at how many *more* rectangles you can draw in this "good" pattern without covering 4 or more pellets.

The considerable potential for wounding rather than killing is despite this pattern having about 180 pellets inside the reference circle. Snowdon talked about wanting to get 100 to 150 pellets inside the circle. But even this relatively tight pattern has large sparse areas.

Shotguns patterns are like that; all of them.

Sparse pattern areas

All shotgun patterns have sparsely pelleted areas. And they are in different places on every shot.

Every shot, however well aimed, has a considerable potential to wound. Keep in mind that ducks can be moving at 70+ kph and don't always fly along perfectly smooth paths. You can't *aim* the denser parts of the pattern at the duck because they are in different regions of the pattern from shot to shot.

Randomness

You can't aim the dense regions of a shotgun pattern at a duck, because you can't know where they will be, or even how many there will be.

Consider Figure 4. It shows 4 computer generated patterns. You can still draw plenty of white rectangles in them, but if they look a little better than the "good" pattern above, then you are right.

In a real shotgun, pellets can be deformed during manufacture or the process of firing and they act differently from a perfect sphere. This makes for *more* variability, meaning more sparse areas in the pattern, than the perfect patterns generated by computers. Each pattern has a circle representing the size (to scale) of the area, estimated by Winchester as needing to be hit by 4 pellets to bag a duck. Each circle is 10 inches (25.4cm) from the center of its pattern. Circles are simpler to work with than duck shaped regions and the probability of hitting a circle with a given area is very close to the probability of hitting any other shape with the same area.

That 10 inch (25.4cm) offset of each circle is the aim error. In real shooting, the aim error is, of course, also quite random, but with a well understood form (Washburn 2003). Good shooters have a denser cluster of aim errors than poor shooters. But as you can see, even with high accuracy, one of the 4 shots wounded and another missed entirely. This miss would, in reality have seen the duck hit by pellets but outside the vital region.

Suppose you could fire a thousand shots at a thousand ducks and have perfect knowledge of the outcomes. Take a sheet of paper, draw columns on it headed 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. As each shot is fired, you put a tally mark in the column matching the number of hits. At the end there will be a number column 0 representing clean misses. The dead will be represented by marks in in columns 6, 7, and perhaps higher. If there are marks in the columns with numbers 4 or more, then there will

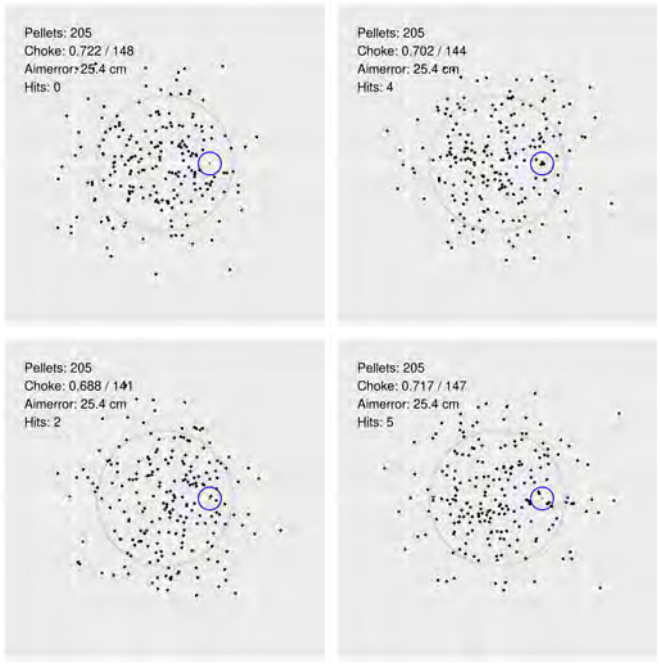


Figure 4: A set of generated patterns

be marks in 1, 2, and 3. It's impossible for this not to be the case. The ducks with 4 or more pellets in them will mostly be dead or downed-wounded. Most of the ducks in column 1 will fly on with no visible signs of the strike. Some ducks in column 2 will be similar, but others will be unlucky and have one or both of those 2 pellets in a vital region.

Figure 5 shows the output of such a process, but with a computer instead of a shotgun. It uses the shotgun pellet distribution that all shotshell makers use (because it is the only one physically possible (Papoulis 1990)). This is bog-standard science; nothing in the least bit surprising or controversial.

You can see that one and two pellet woundings will be common. Some will heal up, some won't. Different skill levels, meaning different aim-error averages, will produce different frequencies of pellet number wounds, but if you sometimes miss and sometimes down, then you will, with absolute certainty produce 1 and 2 pellet woundings; as well as the rest.

3 Hunting ethics

FAGA's Code of Conduct[10] states, among other things:

[10] https://www.fieldandgame.com.au/page/code-of-conduct-ethics/

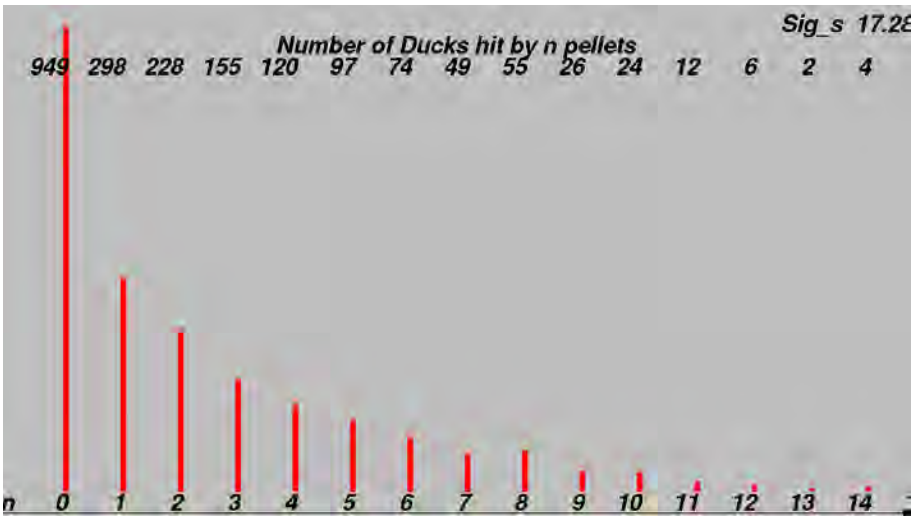


Figure 5: Pellet frequency chart

> *"Hunters should only shoot if: . . . The hunter is confident of hitting and killing the animal or bird. [and]. . . The hunter is able to recover the shot animal or bird."*

It also states:

> *"Every hunter's objective is to achieve the instantaneous death and efficient recovery of every targeted animal or bird"*.

Whoever wrote that knows full well that *every* duck shooter fails in that "instantaneous death" objective with most ducks they shoot. Whoever added the sentence about only shooting when you can retrieve the animal or bird is almost certainly aware of the significant cohort of flying-wounded which cannot be recovered. If that advice is to be followed, a shooter would never pull the trigger. FAGA's Code of Conduct is for reading not for doing.

Spin vs facts

The FAGA Code of Conduct is breached by every duck shooter and FAGA know it. Duck shooters can't recover **any** of the flying-wounded and instantaneous deaths are quite unusual for ducks shot with a shotguns.

This Code was written to mislead the public into thinking that the highly random process of shotgunning flying ducks was in the same category as rifle shooting; it isn't.

Anybody watching a duck shooter retrieve ducks will almost always see the duck alive and attempting to escape prior to retrieval. They will then perhaps see the shooter make efforts to kill the duck, usually by holding the head and "helicoptering/swinging" the rest of the body, despite this being in contravention of the COP.

I've personally watched duck shooters on many occasions in South Australia, and also in Victoria and Tasmania, and I've never seen any shooter kill a duck with a blow to the head as recommended in the COP. I've seen the other method, a second shot, used, but it can still leave the duck alive and needing to be killed.

On opening day of the 2023 duck season in South Australia, I was with a group of people who filmed shooters at Lake George. We have submitted footage to DEW of shooters not even attempting to kill ducks which were clearly alive. Also submitted is footage of shooters using the helicopter swinging method which isn't an approved method of killing ducks.

But, as far as I can tell, no action has ever been taken to enforce the AWA by DEW compliance officers. As far as I can tell, nobody has ever been fined, prosecuted or in any ways sanctioned by DEW compliance officers for failing to kill ducks or killing them badly in any way.

Without enforcement, the COP is as meaningless in the context of duck and quail shooting as the F&G Code of Conduct.

Better regulation can't change the physics of shotgun operation

Shooters behaving badly is a problem that could be fixed, assuming that DEW was radically reformed into an organisation intent on regulating the activity rather than just checking that shooters can count; meaning that they do more than check bags for excess ducks. What can't be fixed is the basic physics of shotgun operation; that is fixed.

3.1 Deer and ducks, rifles and shotguns

It's worth understanding rifle shooting as a reference point to judge shotgun shooting. The nature of the killing tool has an impact on the ethics of the process. Beating an animal to death with a rubber hose will be slow, painful and abhorrent to almost everybody. Hitting it once with a suitably sized hammer can give a very rapid death.

The DEW information on hunting deer is contained in it's general hunting booklet[11]. It seems DEW has no experts in this area and borrows information from the Australian Deer Association which it recommends to *"ensure deer hunting is humane"*. It is unacceptable that a Government agency tasked with ensuring humane killing takes advice from people it is intending to regulate rather than the (substantial) scientific literature on the activity.

The Victorian GMA, in contrast, has dedicated webpages on deer hunting, including pages on what it calls the "Ethical hunting"[12] of deer. Here is the key advice.

> *"Always try to manoeuvre so that you can rest the rifle for a steady shot . . . It is critical for all deer hunters to be able to identify and hit the target's vital areas, generally the heart/lung zone (just behind the shoulder) . . . Do not shoot unless it is safe to do so and you are confident of a clean hit. . . . Never attempt head shots. The brain is a small target and one can easily miss . . ."*

The DEW booklet uses a GMA graphic of recommended shot placement, but *doesn't* repeat the critical GMA advice: *never attempt head shots*.

Note also that the GMA advice regarding deer is to *break* the F&G Code of Conduct which calls for shooters to aim for an instantaneous death; which would require a head shot. GMA realises that aiming for an instantaneous death risks wounding and causing a very slow death. Is this a symptom of a clear ethical difference between the GMA and F&G, or just more evidence that the F&G Code is simply marketing and not intended to be truthful or accurate.

The GMA advice is based on the reasonable assumption that it is the skill and discipline of the shooter that determines the outcome when shooting deer. A 2003 study (Urquhart and McKendrick 2003) of deer killed in Scotland also found, as highlighted above with kangaroos, significant differences between the numbers of deer requiring more than one shot between professional and recreational shooters.

First you need a level of skill, then you need a quantified knowledge of that level and the range at which you are accurate enough to hit your target, then you need the discipline to resist shooting at longer distances and at angles where your target is obscured by other parts of the anatomy.

But, the result of what the GMA calls ethical shooting for deer is *not* an instant kill.

GMA very clearly prioritises *reliability* of killing over an instant death. In doing this they are trying to make what I've called *skill-killing* as certain and reliable as *process-killing*.

Instead of attempting the instant kill, the GMA is advising shooters to inflict the kind of massive trauma that kills fairly quickly and reliably; but definitely not instantaneously.

[11] https://cdn.environment.sa.gov.au/environment/docs/modern-hunting-in-sa.pdf
[12] https://www.gma.vic.gov.au/hunting/deer/ethical-hunting

Now let's compare that GMA ethical advice on hunting deer with their "Ethical Hunting"[13] advice for ducks. The relevant GMA Code of Practice[14] for duck shooting says shooters must:

> *"shoot to have the animal in the centre of the pattern at the point of impact when using a shotgun."*

There is no advice about resting the shotgun. There is nothing about targeting a particular part of the duck anatomy. How can shotgun users do this without resting the gun? And do it when the bird is flying at 70 kph?

The clear implication is that you *can't* target any vital organ or organs. There is a tacit acceptance in this advice that while there is a component of skill in shooting flying ducks (or quail) with a shotgun, skill is neither necessary or sufficient to kill the duck. A duck can be hit by a single pellet and be dead instantly, or be hit by 6 and continue flying.

The DEW equivalent is in its general hunting booklet rather than the COP. This booklet states:

> *"It only takes a couple of pellets accurately placed to humanely take a bird."*

Whoever wrote this has absolutely no idea of how a shotgun works. Or, more likely, they are trying to mislead people into thinking that a random process look like a skill process.

As we've seen, a shotgun fires a cluster of small round pellets. These pellets, for duck shooting, are generally steel or bismuth. They are light enough to be diverted from their course as they hit air molecules. The cluster is long and grows in width as it travels. The cluster has a width of about a metre at a range of 30 metres.

You can't "accurately place" shotgun pellets

As you can see from the section on the "good" shotgun pattern, you cannot aim shotgun pellets; at best you aim the cluster. The position of the pellets within the cluster and which parts of a duck they hit, if any, is entirely random.

A duck brain is rather smaller than that of a deer. It's even smaller than a teaspoon of water (Iwaniuk and Nelson 2001). The other parts of a duck you need to hit to

[13] https://www.gma.vic.gov.au/hunting/duck/ethical-hunting

[14] https://agriculture.vic.gov.au/livestock-and-animals/animal-welfare-victoria/pocta-act-1986/victorian-codes-of-practice-for-animal-welfare/code-of-practice-for-the-welfare-of-animals-in-hunting-revision-no-1

bring it down are also small. There isn't much duck underneath the feathers. It's about 40% of what you can see when you see a duck in profile, the rest is feathers (Cochrane 1976). Figure 6, from (Cochrane 1976), shows the vital regions of a duck. The duck here is a US Mallard, similar in size and shape to our Pacific Black Duck, but a little bigger.

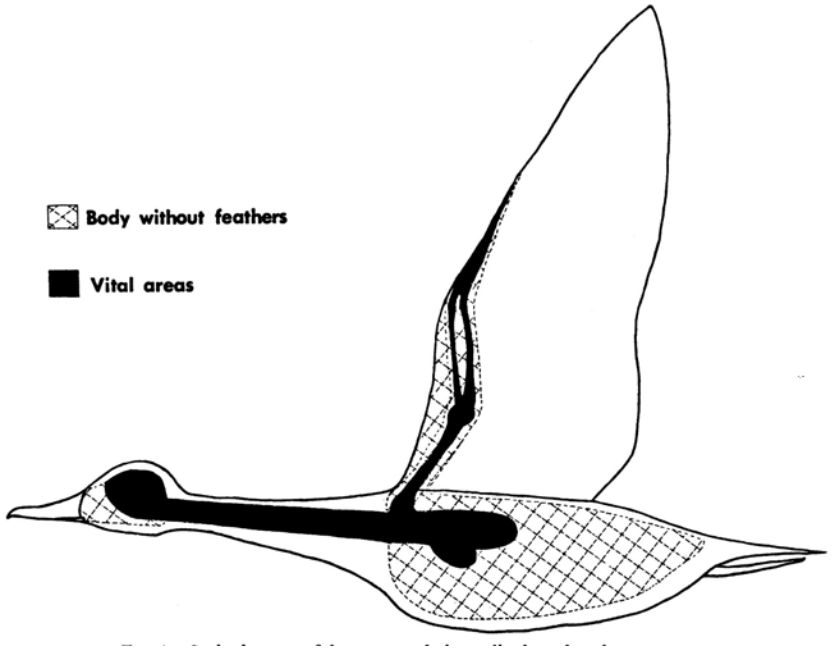


Figure 6: Vital parts of a duck anatomy

The thing to notice about this image is the *ratio* of the vital regions to the rest of the duck.

It's just like roulette (see figure 7). Paint 25% of the slots on a roulette wheel green and the ball will land in green slots on 25% of the throws, averaged over many throws. Based on the above image, the vital region is about 38% of the body. So if a duck is hit in the body with a *single* pellet, then there is a 38% chance it will hit a vital region. If it is hit by two pellets, then both will miss the vital region with a probability of 0.62x0.62=0.38; coincidentally also a 38% chance. That's not speculation, or opinion, it follows strictly from the physics of the situation.

Shotgun roulette

A rifle can be aimed so that shots cluster on a chosen vital organ; head, heart or lungs. Skill determines the diameter of the cluster. In a well targeted shotgun shot, the pellets hit vital organs in proportion to the size of that organ. **Pellets cannot be aimed**.

Figure 8 shows actual locations of embedded pellets by region in ducks (Perry and Geissler 1980). I'll discuss this and other X-ray studies later, but it's pretty clear that small regions have few pellets, as expected. It won't quite match the values predicted from the areas in cross section because these vary with the angle from which the duck is shot. Trying to shoot ducks head on is obviously a poor decision, because the vital areas of the duck are much smaller at this angle. In one study in the late 1960s (Andrews and Longcore 1969), researchers tried shooting ducks head-on, but even with perfectly aimed shotguns it was ineffective (see Experimental research).

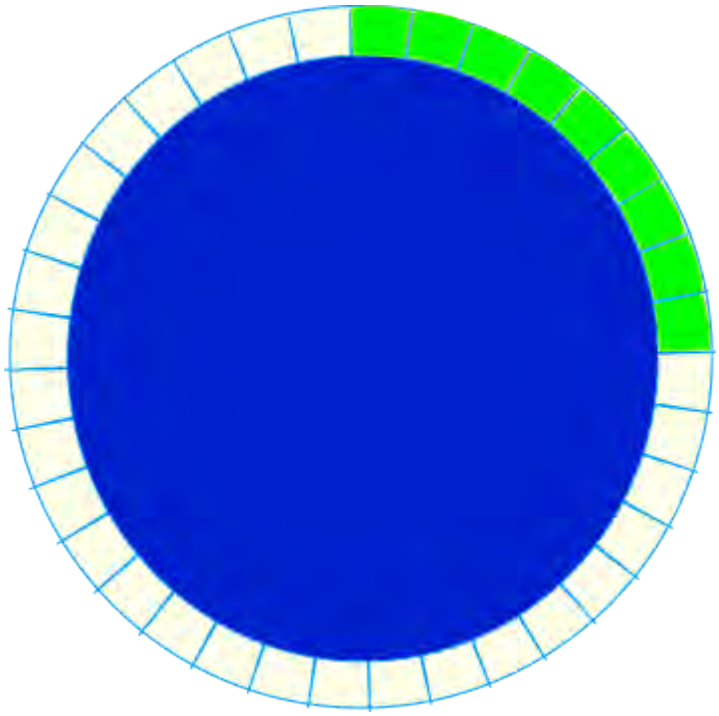


Figure 7: Roulette wheels and wounding

Let's call the *aim-error* the distance between the centre of the pattern and the centre of a duck.

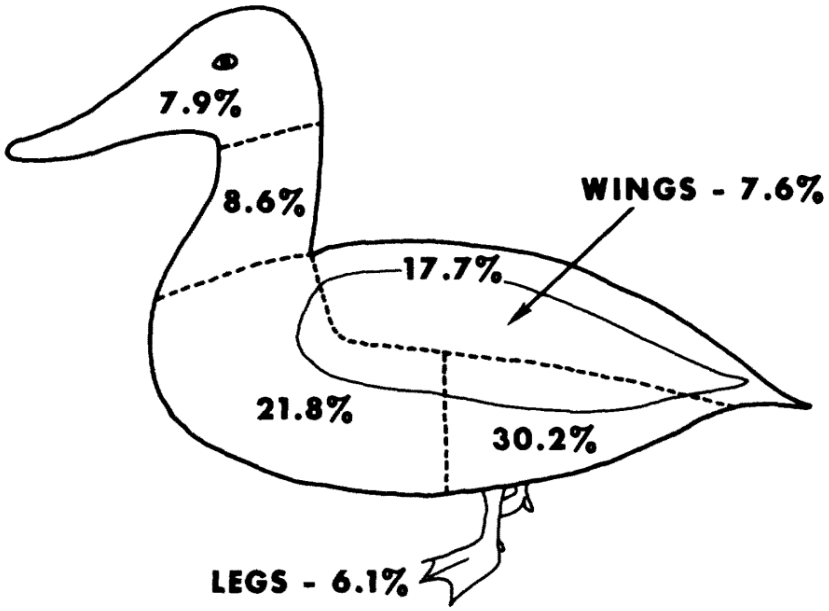


Fig. 2. Location of body shot in canvasbacks fluoroscoped in Wisconsin and Maryland, 1975–77.

Figure 8: Embedded pellet locations

Deer hunters *can't* reliably hit the centre of a deer brain-sized target despite resting the gun. So how can a duck shooter swing and shoot a flying duck and deliberately choose to put the animal in the centre of the pattern, let alone accurately place pellets in the critical organs and wing bones needed to bring down a duck?

They can't.

So the DEW advice is impossible to follow.

3.2 Shooting clays and shooting ducks

Many studies of duck shooters have counted the shots-per-bagged-bird as a measure of skill. One survey put the range at a bit over 4 up to around 9 (Sanderson and Bellrose 1986). Other individual studies have found 8 (Noer, Madsen, and Hartmann 2007) (for geese) and over 5 (Humburg et al. 1982).

Duck shooter performance is far worse than the close-to-one ratio of shots-per-bagged-clay-target of good trap/skeet shooters.

A recent clay target newsletter[15] lists competition winners by grade: AA, 113 hits from 114 targets; down to C grade, 88 hits from 100 targets. All of these winners have a hit rate close to 1 shot per "bagged" clay target; even the C-graders! The good C grade shooters have a much better hit rate with clay targets than any duck shooters have with ducks. Of course, many duck shooters shoot clay targets and many would have these kinds of skill levels.

Why the big difference?

A duck isn't a clay target. Shells for clay targets have 350 or more pellets. Which means that each pellet is much smaller than the pellets used for ducks. A typical clay target is a disc 11cm in diameter with a thickness of 25-28mm. It's largest profile is about 14 in^2 (95 cm^2). So, roughly speaking you have almost double the pellet count and are trying to hit something half the size of the duck vital area. The increased pellet count means fewer holes in the pattern.

The reason for the difference in shooting performance isn't obvious.

The clay is easily broken. Just a single pellet will usually do the job.

But you need much bigger pellets to penetrate a duck's feathers and skin. Ducks also have critical and not so critical parts of their anatomy. You don't just need a 1-2 randomly flying tiny pellets to hit anywhere on the target, your pellets need to be big and to hit very specific parts of the duck; and that comes down to luck.

The difference between clay target scores and duck hunting "scores" is due to the shift in the balance between luck and skill. With ducks, the dominance of luck is clear in the hit rate (shots per bagged duck). The hit rate isn't a little lower, it is 4 to 9 fold lower!

Once you understand the process, you can see why good shooters may produce more wounded (both downed and flying) than poor shooters.

[15] https://www.claytarget.com.au/documents/ctsn-archives-1947-present/2020-to-2029/2023-ctsn.html

Why can good shooters wound more ducks than bad ones?

Shooters with very low skills rarely get anywhere near the duck. But the kind of shooter who can get close to a perfect score with clay targets will almost always get close enough to put at least one pellet in the duck. So if a good shooter and a poor one walk into a wetland and fire 20 shells, the poor shooter will likely leave few, if any, flying wounded. For the skilled shooter on the other hand, all of the ducks they think they missed will probably be flying wounded.

Should any hunter be "confident of a clean hit" when the duck is in the center of a pattern? At this point it's worth repeating that the pellet cluster has length as well as area. It can be a couple of metres long or more. But this string is moving much faster than a duck, this complicates defining what exactly the centre is.

The simplest way to find out how effective shotguns are at killing when the duck is in the centre of the pattern is to put it to the test. Meaning to conduct a study where ducks are suspended in a "flight like" position so that they can flap their wings, and have a perfectly aimed shotgun shoot them and see if they are all killed and killed quickly.

4 Duck shooting research

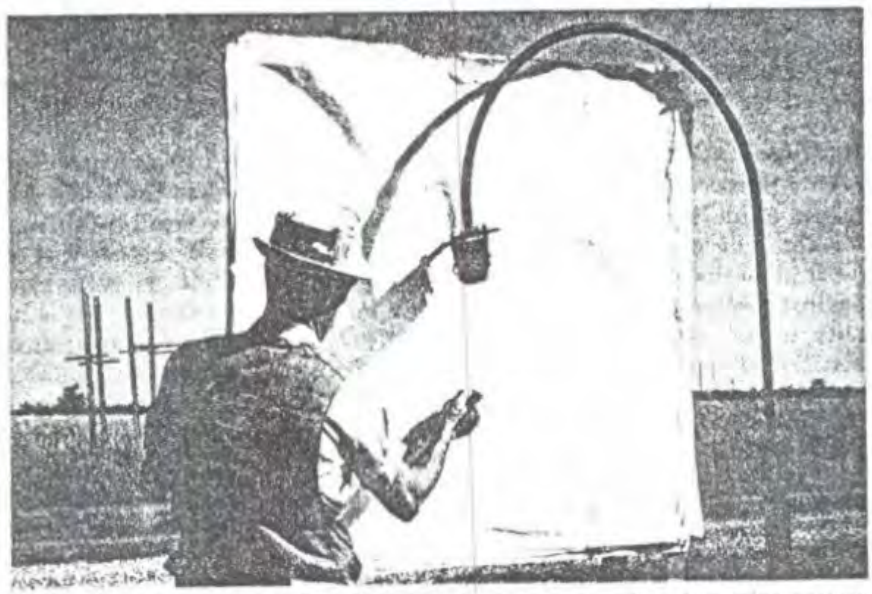
Duck shooting has been very well researched for many years. The physics hasn't changed. The type of shot certainly has, but this only impacts the energy in each pellet at a given range. It doesn't change the statistical structure of the pattern. This section will survey the various kinds of research.

4.1 Experimental research

During the late 1960s and early 1970s, there was considerable research on shotgun effectiveness by Winchester-Olin, a shotshell maker, and the US Fisheries and Wildlife Service (USFWS) (Lowry 1973; Andrews and Longcore 1969; Cochrane 1976; Kozicky and Madson 1973). The result was some careful, if gruesome, research where ducks were hung up and shot.

Two large studies were conducted, each involving over 2,000 ducks.

In both studies, the ducks were tied to an inverted J beam on a trolley so that they would and could flap their wing as the trolley was run along a track. Perfectly aimed shotguns then shot them. See Figure 9.



A patterning board clamped to the transport cart was used to determine pattern centers at the beginning and end of each five-duck test group. Patterning percentages were calculated from pellet counts within a 30-inch circle, and used to determine the center of the pattern. The drawing of the duck on this patterning sheet was made to illustrate the location of a tethered duck during actual testing.

Figure 9: Experimental apparatus for hanging up and shooting ducks

Keep in mind that people walked on the moon in 1969, this kind of precision engineering wasn't difficult; not then and not now. Happily, I doubt anybody would allow such research these days. The non-duck-hunting community has moved on ethically and such research shouldn't be approved by Animal Ethics Committees; if for no other reason than it's been done; we know the results. In the Winchester study (Lowry 1973), the ducks who survived were tethered and kept in pens and periodically tested for their ability to fly. They were subsequently classified as a *survivor* or *cripple*. A "cripple" by definition, was a duck who survived being shot well enough to escape, but who failed a 10-day flight test; the assumption was that these ducks would die. In the USFWS study, ducks who died within 5 minutes and 10 days, but *without* a broken wing bone were classified as a "cripple". The logic is revealing. They assumed that without a broken wing bone, they'd probably escape, despite the seriousness of the injury. This was based on the first systematic study of crippling in the 1950s (Bellrose 1953).

Interestingly, the USFWS classified it's ducks as bagged, crippled and lost, or "missed". The inclusion of the quotes on the word "missed" indicates that they knew perfectly

well that most of their “missed” ducks weren’t missed at all; they were hit by at least one pellet.

Dead ducks from the Winchester study were subsequently autopsied (Cochrane 1976). Meaning they were defeathered and the number and length of all pellet wound tracts was measured.

This enabled Winchester to estimate the number of pellets needed to kill a duck and use this to develop a model. One of their key findings is that the prevailing theory, that ducks were killed by the sheer force of impact of the shot, was wrong.

Ducks are downed by catastrophic injuries

Ducks are killed by major damage to critical bones or organs. You can hit a duck with multiple pellets, but if they don’t hit the critical anatomical structures, the duck will keep flying.

For example, Figure 10 shows a duck, found during an X-ray survey, with 9 embedded pellets (Perry and Geissler 1980). It’s not always clear if such ducks survived a single multiple pellet blasts or a few, but whenever you X-ray ducks, you find these kinds of multi-pellet survivors.

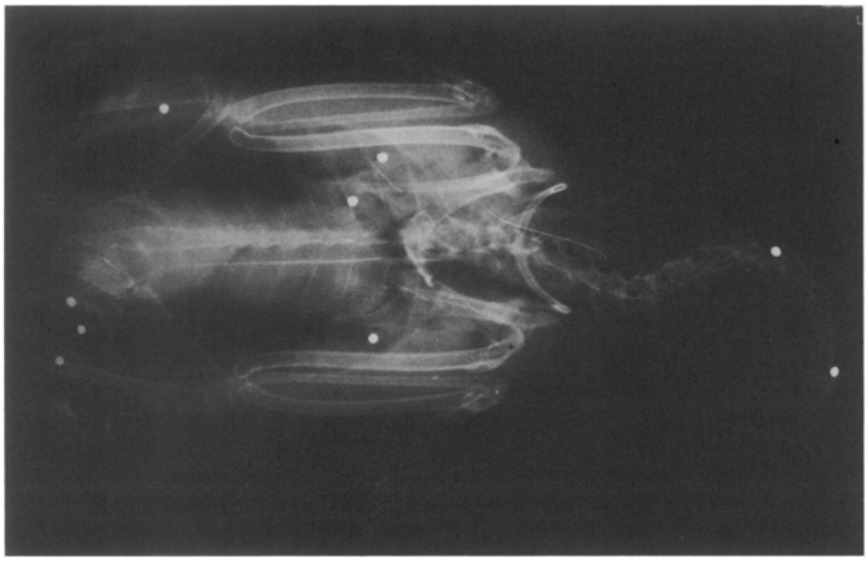


Fig. 3. Radiograph of a live, healthy, adult male canvasback with 9 embedded shot.

Figure 10: Duck with 9 embedded pellets

The model Winchester eventually developed estimated that it needed 4 pellets to hit the vital regions of a duck (heart, lungs, brain, wing bones) to bag the duck; they assessed the area of the vital region to be about 20 in^2 (129 cm^2). Figure 11 is a diagram from the paper (Lowry 1973) summarising this research.

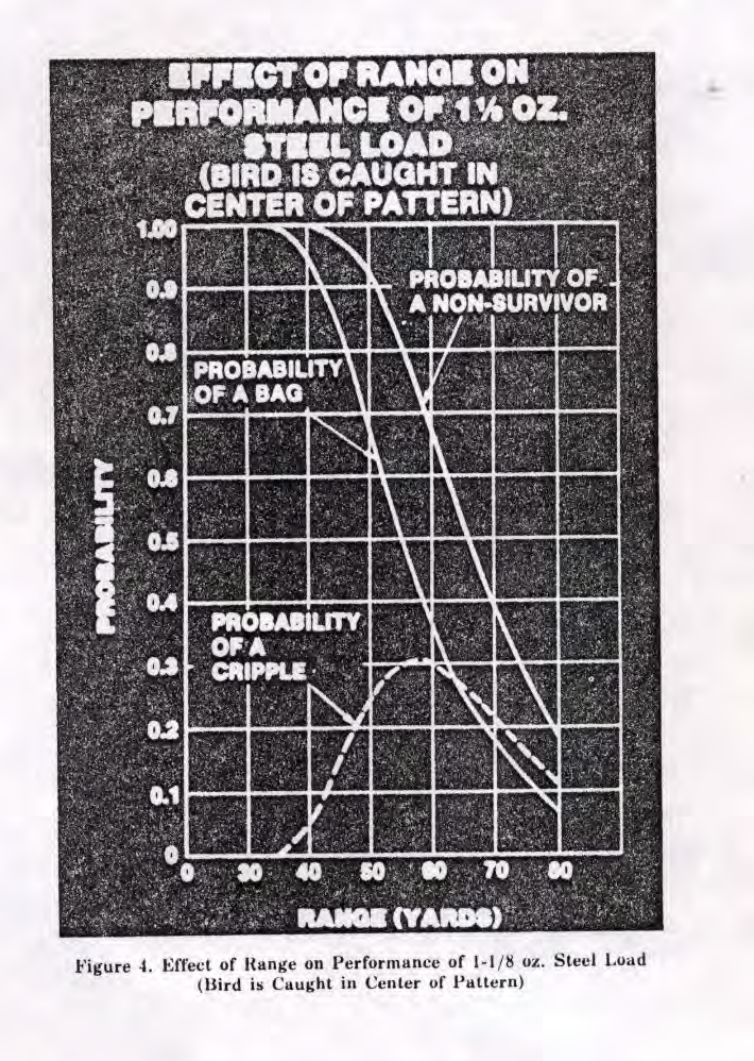


Figure 11: Winchester bagging model

As you can see, at 30 yards (27.4m), with the duck in the *center* of the pattern. The probability of bagging the duck is certain. At 40 yards (36.5m), that probability starts to fall.

The probability of a cripple rises rapidly with the distance away from the centre of the pattern. This is shown in Figure 12, from the same paper.

As you can see, at a range of 30 yards (27.4m), going from an aim error of 10 inches to 15 is enough to drop your probability of bagging the duck to just 1 in 10. Keep in

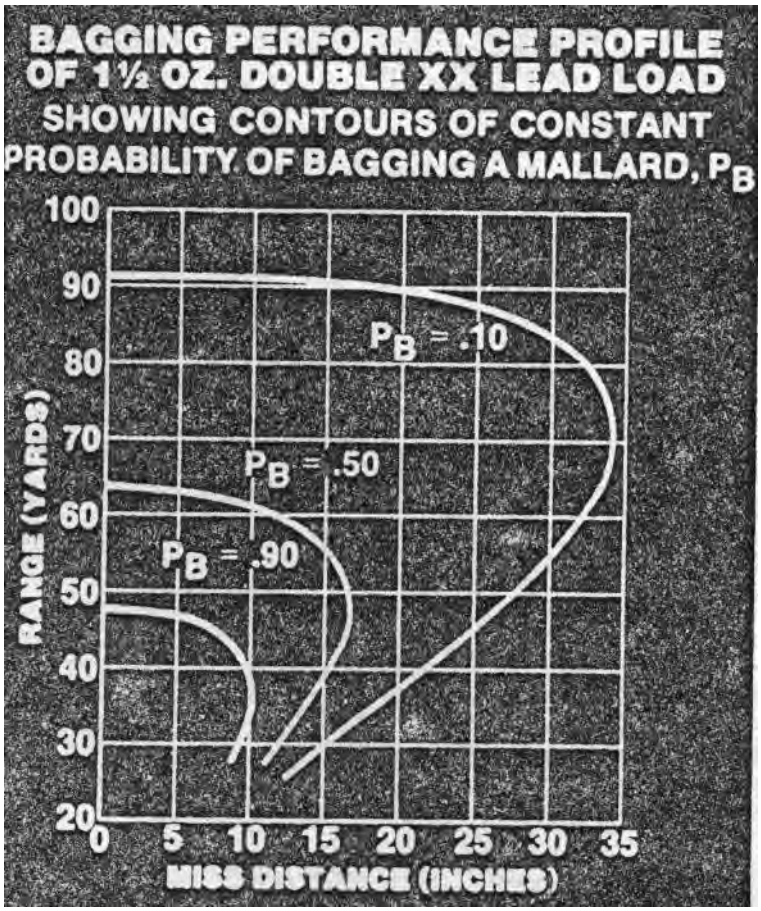


Figure 12: Winchester aimerror model

mind that this image is for lead shot, which is heavier and can kill ducks at a longer range. Advice from GMA is for shooters to avoid shooting at ranges greater than 30m.

For DEW, the advice is different, their hunting booklet species 20m-40m with 45m as reasonable for small ducks. DEW don't mandate this range, or even recommend it, they simply call it "Typical".

Note carefully the shape of the graph at ranges below 30 yards (27.4m). The lines are sloping to the left and converging. What this tells you is that the consequences of small variations in aim error increase your chance of not bagging the duck. This is easily understood if you have a reasonable mental image of the cluster of pellets and the way it spreads out after leaving the barrel. It's like a trumpet. The spread is very small at first and grows quickly as the energy of the pellets is lost. When a duck is at, for example, a range of 10m, then your chances of hitting it are very small, because the cluster hasn't spread much. You may as well be shooting with a rifle. But at a range of 50 yards (45.7m), you can miss by 25 inches and while

your chances of bagging the duck are small, you will always put a pellet or two in it, because the cluster is very wide.

How were Figures 11 and 12 produced? The distribution of pellets in this situation has been understood pretty well since the middle of the 19th century since being discovered by German mathematician C.F. Gauss. Once you decide on a killing crition (4 pellets inside 20 square inches (129 cm^2), the rest is straight forward. It's easier today than it was in the 1960s, but the maths hasn't changed.

The two big studies produced some differences.

Winchester was at pains to demonstrate the superiority of its lead shot. The political context of this research needs to be understood. There were calls to ban lead shot on account of lead poisoned wildlife. The USFWS research demonstrated that steel shot was equally as good at reasonable shooting ranges and Winchester wanted an alternative result to keep selling a very profitable product. The ban was delayed by virtue of gun-lobby politics until 1991.

The Winchester trick to show lead was more effective, was to use shotguns which produced a much higher pattern density. Whereas the USFWS used shotguns producing a pattern density of 70%, the Winchester shotguns got 87% (see (Cochrane 1976; Kozicky and Madson 1973)). This, coupled with perfect aim, gave Winchester the results it was after. In both cases, the dense patterns and perfect aim gave more killing power than any shooter would get under realistic conditions from the same range.

Figure 13 is from the USFWS study (Andrews and Longcore 1969).

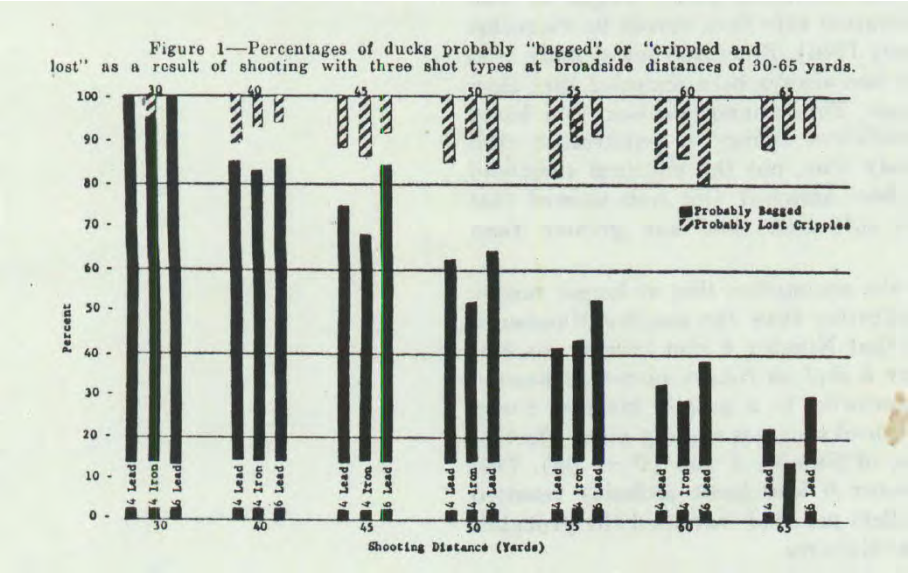


Figure 13: Bagging and cripple rates with perfect aim and full choke

As you can see, bagging rates drop of rapidly with distance. The gaps between the "probably bagged" and "probably crippled" are interesting. Given the perfect aim and full choke, most of these ducks would have been hit, but would still be flying.

It's interesting to compare Figure 13 with the DEW advice in its hunting booklet. The specifications of the weapon used in this study meet those specified in that DEW hunting booklet, but the study found that, even with perfect aim, you only have ~65% chance of "Probably Bagging" a duck at 40m with #4 steel shot with a full choke shotgun. It's pretty clear that DEW is taking, but not checking, technical advice from hunting groups. GMA also uses a similar source of information (US consultant, Tom Roster), but overrides it with a 30m recommended range.

What is the reason for the drop off in killing power over 30 yards (27m) in Figure 13? The Winchester study (Cochrane 1976) found that at 40m, 4 of 11 pellets went right through the duck with #4 steel shot. So there is no lack of killing power at this range. It is simply the increase in pellet spread making for more sparse areas resulting in less pellets hitting the duck. If less pellets hit the duck, then the probability of them hitting vital organs drops. So at 40m, you had an average of over 11 pellets hitting the duck, 7 going right through, but only that ~65% chance of "Probably Bagging" the duck.

4.2 X-ray studies

The first X-ray study of ducks was in the 1940s (Whitlock and Miller 1947) in the US. As mentioned above, researchers were curious about a group of ducks who didn't migrate. An X-ray machine happened to be available, a somewhat rare occurrence in those days, so they X-rayed a sample and found shotgun pellets embedded in their bodies. There have been many similar studies since then; not just on ducks, but also geese, swans and anything else that might get shot. Here is a sample of studies and a plot of the relationship between the size of the duck (or geese) species (Norman 1976; Perry and Artmann 1979; Harper and Storr 1990 ; Perry and Geissler 1980; Havera, Whitton, and Shealy 1992; Madsen and Noer 1996; Hicklin and Barrow 2004; Falk et al. 2006; Krone et al. 2009; Holm and Haugaard 2013). Figure 14 shows a trend line for the ducks from these references, with confidence interval. The relationship is quite strong.

It takes more pellets to bring down a big duck, so more will be able to survive a blast without any vital organ being mortally injured.

Hunting has always been restricted and controlled with regulators trying to keep the killing rate below the replacement rate.

The birds X-rayed are, obviously, only those who have recovered, there must be others who didn't. These studies raise some difficult questions:

1. How many ducks are hit and don't recover?

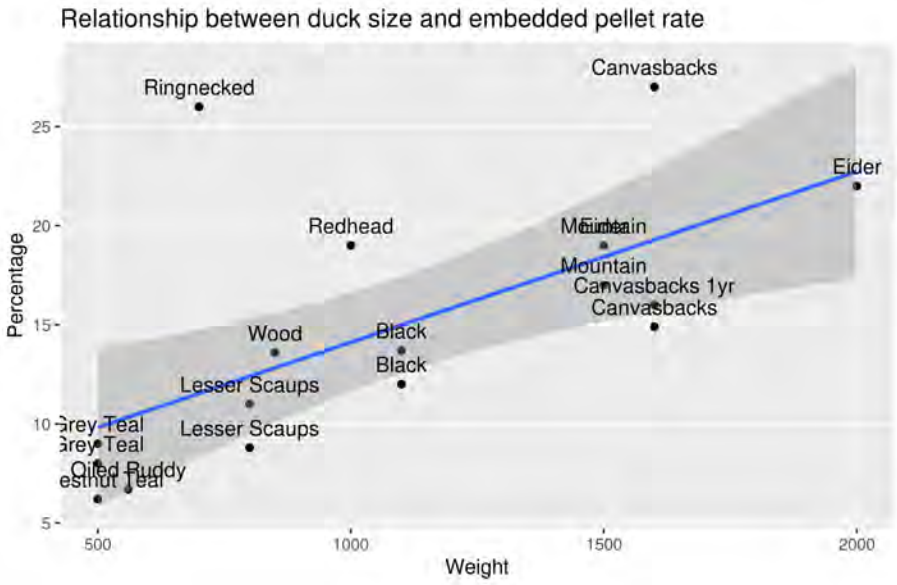


Figure 14: Embedded shot percentage is related to duck size

2. How can shooters shoot a relatively small percentage of the population and leave so many with pellets in them?
3. How many ducks are hit but assumed to be entirely missed?

4.3 The flying wounded and GMA X-ray work

We cited research above that shows that most of the downed-wounded die (Van Dyke 1981). So where to the considerable numbers of ducks found in X-ray studies with pellets embedded in their bodies come from? Obviously, they have to come mostly from the flying-wounded. It should be possible to estimate the numbers of flying-wounded using the X-ray data together with harvest rates, which I'll call the "bag" rate: the percentage of the total population which is bagged.

DEW has done no X-ray studies for decades, as far as I know, so this section will need to use Victorian data. It matters little whether we use SA or Victorian data, the laws of physics are the same in both states.

The object of the section is to demonstrate clearly that many birds are wounded by shooters can never be identified by studies where observers watch shooters. Put simply, many of the birds shooters think they missed cleanly, must have been hit.

We know that the number of birds shooters think they missed is large because of the high shots-per-bagged duck statistic. If the number of shots per bagged duck is between 4 and 9, then that implies that a few ducks are "missed" for each duck bagged.

X-rays of 45,210 ducks in Victoria (Norman 1976) over 16 years between 1957 and 1973 found 4,140 with pellets embedded in their bodies. The rate varied between 6% and 19%, depending on the size of the species. Obviously, this doesn't cover *all* ducks who were hit but not downed. It will miss the ducks who failed to recover from their injury, or who died of other causes (e.g., predation), and it can't detect pellets that went right through the duck, perhaps after puncturing an organ.

A smaller GMA X-ray study[16] of almost 600 ducks in Victoria *after* the 2022 season found a smaller percentage of ducks with embedded pellets: 3.4% overall.

Why the reduction?

In 1991, far closer to the earlier work, it was reported that about 60,000 Victorians were duck shooters (Loyn 1991), with the current number taking part in 2022 being 11,500 of some 23,000 with licences (Kolovos 2023). Clearly, the number of shooters has declined significantly. Given the decline in shooters, a drop in the percentage with embedded pellets is to be expected. It is also still down as a result of very low numbers of ducks killed in the 2020 and 2021[17] Covid-affected years, where the numbers of ducks bagged was about 50,000, just 12.5% of the 400,000 killed in 2018.

But of first-year ducks, some 7.5% had pellets in them. It is a reasonable presumption that these ducks had been wounded in the 2022 season. In the earlier studies, juvenile grey teal had close to 0% embedded pellets *before* their first season being hunted, as expected. But after their first season being shot at, the number with embedded pellets varied between 9% and 24% depending on the year (N.B. I have omitted a couple of outlier years). The 2022 figure of 7.5% is possibly a little high, given the reduced shooting level in 2022 relative to the earlier studies, but it is clearly in the ball-park.

Most studies of downed-wounded (aka "cripples") arrive at a number like 20-30%. For example, Humburg (Humburg et al. 1982) found a range from 26 to 40%, depending on range.

Note carefully that X-ray study percentages are relative to the population whereas downed-wounded percentages are relative to the ducks downed.

What percentage of the population would you need to bag, assuming a downed-wounded rate of 25% to leave 7.5% with embedded pellets?

Let's try some numbers to illustrate the problem. Most numbers in this kind of field are "soft" and aren't known precisely.

A scientific paper would add all kinds of probability distributions and error margins, but my purpose is to give you, the Committee, a feel for plausible scenarios so I'll stick with high school arithmetic.

[16] https://www.gma.vic.gov.au/research/duck-research

[17] https://www.weeklytimesnow.com.au/news/duck-season-uncertainty-as-harvest-reaches-record-low/news-story/aeae2a9eb616f82a24f59889862bf2b0

Figure 15 illustrates the logic. I've used 7.5% as the X-ray study finding, not just because it was the number of first-year ducks found with embedded pellets in the GMA 2022 study, but because it is a conservative figure for the Victorian duck population in a typical year of full (non-covid affected) hunting.

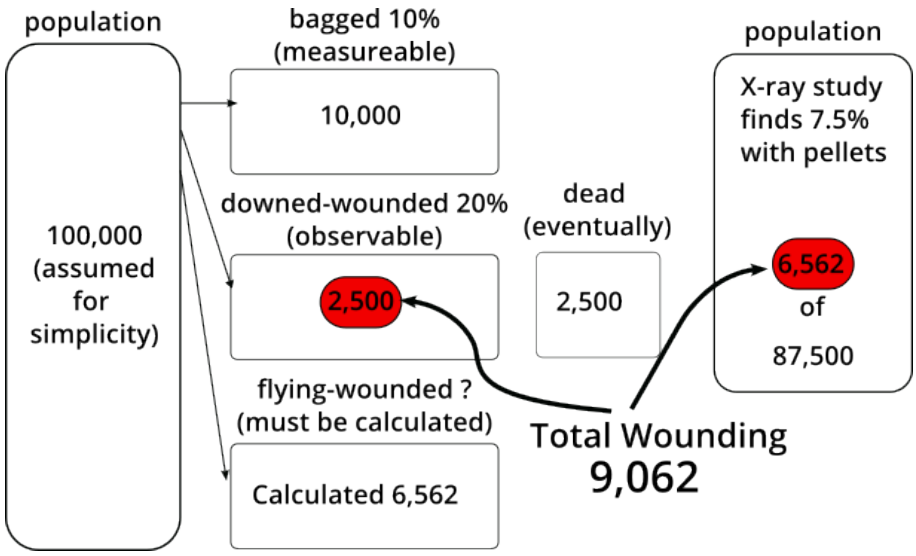


Figure 15: Second illustrative example

The illustration should be clear. If an X-ray study finds 7.5% of ducks with embedded pellets, then the flying-wounded plus the survivors of the downed-wounded cohort divided by the population minus the number bagged and the downed-wounded who died must equal 7.5%.

In the case of the GMA 2022 study, the relevant population is the first-year ducks. The relevant bagged figure is also first year ducks, etc.

If you consider *all* ducks, then the flying-wounded plus the survivors of the downed-wounded cohort divided by the full population minus the number bagged and the downed-wounded who died must equal 3.5%.

In other words, if we know the bag rate, the downed-wounded rate, the survival rate of the downed-wounded and the embedded pellet rate, then we can estimate the flying wounded rate.

Shooters frequently talk as if the flying wounded don't exist. But that's obviously false.

So much for the illustration of the logic. Let's look at plausible estimates for the variable.

The Game Duck Abundance in Victoria[18] report put the desired bag rate at 10% (estimated to be 245,000 ducks) for 2021; about 5 times more than were actually

[18] https://www.gma.vic.gov.au/__data/assets/pdf_file/0008/829574/Abundance-Estimates-for.pdf

killed in that covid affected year and in 2022[19]. So we can presume that this target level is below the replacement rate. This tells us that the number of first-year ducks is at least about 250,000.

Figure 16 shows the level of flying wounded you need to give a 7.5% X-ray finding assuming various levels of first-year duck population (100,000 to 300,000), a downed-wounded rate of 25% with a survival rate of just 10%. We also show results for different bag rates, starting at 2.5%. This figure is obviously an underestimate of the actual flying-wounding rate because it ignores the flying wounded who die as well as the ducks hit by pellets that went right through their bodies without being embedded.

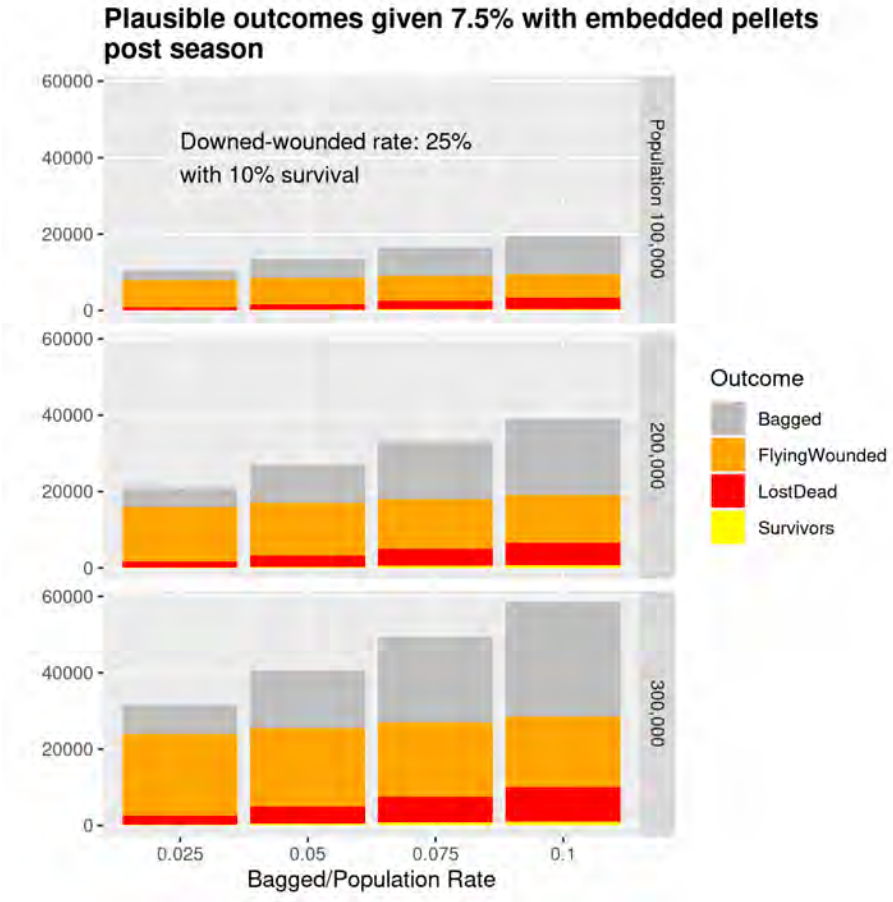


Figure 16: Various scenarios for key population/hunting parameters

The result presumes that the 7.5% estimate is accurate.

In summary, rates of downed-wounded reported by shooters in surveys, or found in observational studies by trained observers, see for example (Humburg et al.

[19] https://www.weeklytimesnow.com.au/news/duck-season-uncertainty-as-harvest-reaches-record-low/news-story/aeae2a9eb616f82a24f59889862bf2b0

1982), are *totally incompatible* with the findings in X-ray studies unless there is a very large cohort of flying wounded over and above the downed-wounded. Given the shots per bagged duck of 4 to 9, there are plenty of shots available to inflict damage, because there are many, many shots where shooters think they have missed. What the X-ray studies tell us is that many of these misses weren't clean; they were actually woundings.

The GMA report of its 2022 work accepts that most downed-wounded (aka cripples) die. Nevertheless the GMA report[20] says:

> *"The overall infliction rate of 3.4 per cent cannot be interpreted as the actual rate of wounding as the birds sampled in this study are representative of the apparently small proportion that survive being wounded and are available for examination. The infliction rate can only be used as a proxy index to monitor trends in waterfowl wounding. Direct studies, such as observations of hunters in the field, should be used to determine the actual rate of wounding more accurately."*

This last statement is clearly false. Direct observations of shooting cannot discriminate between a clear miss and the flying wounded.

The GMA report authors don't use the word "cripple", which has a clearly defined meaning and usefully identifies what you can observe. You can't observe the flying wounded (unless somebody comes up with some miraculous new technique). Therefore you *cannot* accurately assess total wounding, as opposed to the smaller component of downed-wounded, by watching shooters.

But all wounding matters. The fact that a duck doesn't fall from the sky doesn't imply a trivial injury. Many people have experienced finding a significant injury after a stressful and strenuous activity, or have consciously ignored a serious injury to complete a critical task. A person famously completed a marathon[21] after having been shot in the head. Others have committed suicide by shooting themselves more than once (Hejna, Šafr, and Zátopková 2012); the first shot didn't incapacitate them. A pain expert recently described the phenomena[22] in people:

> *"So the classic thing to think of is battlefield analgesia. If someone's on a battlefield, they're shot whilst they're running, they won't realise that they've been shot. Why? Because there's an area within the brain, within the brainstem, that kind of stops all pain from coming through whilst you have a more pressing need to survive."*

[20] https://www.gma.vic.gov.au/__data/assets/pdf_file/0010/938548/Wounding-Results-Report-2022-Final-Artwork-Low-pdf

[21] https://www.nytimes.com/1978/11/12/archives/runner-in-a-marathon-had-bullet-in-his-head.html

[22] https://www.thenakedscientists.com/podcasts/naked-scientists-podcast/china-hides-covid-data-problem-pain

The large numbers of ducks found in X-ray studies is clear evidence of ducks behaving similarly. Hunters of other animals also know that they can run long distances with serious injuries when their life is at stake. Cats and deer with crossbow injuries are found from time to time. They are also capable of extraordinary feats when their life is at stake.

In short, there are a considerable number of ducks who are hit, but not downed, many showing no sign of the injury during the first seconds or minutes after being shot. Perhaps the wound will get infected, perhaps not; we have little evidence about the suffering or survival rate of this cohort which is entirely missing from observational studies of duck shooting.

You can't retrieve a duck which can fly

Many duck shooters, claim to act ethically by retrieving ducks they wound. But they can only retrieve the wounded they down, not the wounded who fly on. Nobody can retrieve the flying wounded, and the X-ray studies, combined with downed-wounded studies, prove that this cohort isn't an occasional fluke, but unavoidable and substantial.

4.4 Watching shooters in action

The difficulties of identifying what happens to a duck during duck shooting are immense.

In many fields of research, you want "blind" observers. This doesn't imply they can't see, but that their observations aren't tainted by an interest in the process. Surgeons, for example, can't be trusted to accurately judge the outcome of their surgery so you get somebody else to make judgements without knowing who got the experimental new surgery or the old surgery. The same is true with duck shooting. You can't expect duck shooters to give you accurate information about the number of downed-wounded, and many deny the possibility of flying-wounded (personal observation).

The traditional method of estimated the percentage of downed-wounded was to ask shooters. For decades the US Fish and Wildlife Reference Service used hunter surveys to estimate the rate of downed-wounded at 20% (Norton and Thomas 1994). And in Australia? *Animals Australia* cite a personal communication with GMA Researcher Simon Toop in 2020 for an estimate of 30%. In the absence of any peer reviewed estimate, I'd be betting this figure was arrived at the same way; asking shooters.

A Canadian study (Nieman et al. 1987) of downed-wounded (called “cripples” in the image) compared what shooters said to what (hidden) observers observed.

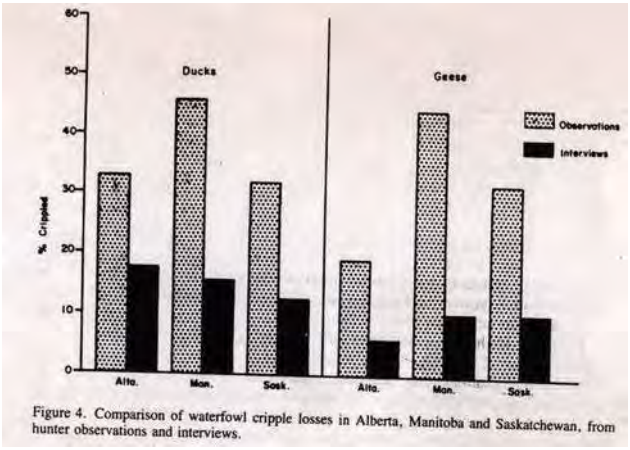


Figure 4. Comparison of waterfowl cripple losses in Alberta, Manitoba and Saskatchewan, from hunter observations and interviews.

Figure 17: Nieman observations of downed-wounded

As you can see from Figure 17, shooters didn’t just miss a few of their downed-wounded, they under-reported these ducks by a factor of 2 to 3 and even 4 for geese.

So basically, unless you think Australian shooters are more accurate or honest than Canadian shooters (from three different Provinces), you can double or even triple anything they tell you about downed-wounded. Perhaps the 30% estimate was arrived at in exactly this way.

The additional issue of *flying-wounded* is something that Australian (and other) wildlife managers seem to think won’t exist if they don’t talk about it.

The interesting thing about the Nieman study was that the observers were hidden from the shooters; that makes it highly unusual. Another large study (Humburg et al. 1982) was designed specifically to test different types of shell. In this study both shooters and observers were unaware which type of shell was being used. During the study, 1,967 ducks were bagged with 10,585 shots by 1,270 shooters; for an average of 5.3 shots per bagged duck. The 4 shell-types tested all shot very dense patterns. At 40 yards (36.5m) with a full choke shotgun (remember this is supposed by definition to put 70% of the pellets in the load into the reference circle), they achieved pattern densities of 85%, 76%, 84% and 85%.

The downed-wounded rates are given in Figure 18.

The figures in Figure 18 were from *observers*, not the shooters themselves. Unlike in the Nieman study, the shooters in this study knew they were being watched and estimates of downed-woundings by shooters and observers were similar.

Interestingly, there were no significant differences between types of shell.

Table 2. Distribution of Schell-Osage shooting results by 3 range intervals.

Distance interval (m)	% Attempts	% Shots	% Bagged	% Crippled	% Misses
<27 m	26.8	28.0	41.4	26.8	20.4
27–37 m	37.3	39.2	41.8	40.9	34.3
≥37 m	35.9	32.8	16.8	32.3	45.4

Figure 18: Humburg downed-wounded (aka cripples) results

Studies where shooters know they are being watched won't change the physics, but it may well change the types of shots shooters attempt. It may certainly change the effort they put into retrieving the downed-wounded.

The Nieman study is one the few large studies of downed-wounded based on direct observations of shooters (Nieman et al. 1987; Hochbaum and Walters 1984; Humburg et al. 1982), and, as far as I know, the only one with *hidden observers*.

4.5 GMA Wounding Reduction Plan

Unsurprisingly, DEW have nothing like the GMA "Wounding Reduction Plan". But would it matter if they did?

The GMA website[23] says that a written plan has been submitted to government. We can guess at its contents by reading the the X-ray monitoring report[24]. This report mentions the Danish wounding reduction project (Noer, Madsen, and Hartmann 2007) carried out on Svalbard pink-footed goose. The critical feature, as assessed by the researchers, was to "simply" reduce the shooting range to 25m.

As you reduce range with a shotgun, you decrease the size of the cluster. This makes it harder to hit anything, but when you do achieve a hit, it will be with a denser

[23] https://www.gma.vic.gov.au/hunting/duck/reduce-wounding

[24] https://www.gma.vic.gov.au/__data/assets/pdf_file/0010/938548/Wounding-Results-Report-2022-Final-Artwork-Low-pdf

pattern. So you'd expect less wounding. If the success rate, measured as number of shots per bagged bird, declines, shooters may well respond by opening their choke. This will give a wider cluster at the reduced distance. This should improve the success rate, but will also increase wounding by virtue of the reduced cluster density.

But close range shooting will have another impact; particularly when using big pellets (up to 4mm for these geese). The shot will go right through the bird. Consider the Winchester study (Cochrane 1976). At 30m, using #4 lead shot, ducks had an average of 3.35 embedded pellets but 15.95 entrance wounds. i.e., most of the pellets went right through the duck. This was in mallards, rather than geese, but it seems likely that some of the reduced wounding is simply the result of a disappearance of the evidence by virtue of the pellets passing straight through the duck. This also raises the question of whether such a wound would be more survivable than one where the pellet(s) remain in the wound.

4.6 Wounded quails

There is a study of quails[25] (Haines et al. 2009) which is very different from anything ever done, as far as I know, with ducks. Researchers caught and "radio tagged" 150 bobwhite quails and then monitored them after shooting. Of the 18 killed by shooters, there were 12 bagged and 6 unretrieved. Did they look for any flying-wounded? Not that I could tell from the paper. But those of the flying-wounded who die are included in their "mortality" equation as H_w.

> *"H_w = mortality rate of animals not noticeably shot, not downed, not retrieved, and subsequently died as a result of shot wounds"*

They claim that H_w could be estimated using telemetry.

Could such a study be done with ducks? After decades of research, I think we have more than enough indirect evidence to know that the number of flying-wounded is substantial, rather than being the occasional freak event. A decision on whether duck and quail shooting should continue can and should be made on the basis of reasonable certainty about the scale of poor outcomes, and we have that. Spending yet another decade refining estimates would be time wasted.

4.7 The laws of physics and ideal shotguns

The laws of physics don't change and shotguns are very simple weapons which work much the same now as they did 200 years ago. The theory of shotgun ballistics Wallack (1977) is based on shotgun pellet patterns having a bivariate normal

[25] https://trace.tennessee.edu/cgi/viewcontent.cgi?article=1339&context=nqsp

probability distribution. This is an ideal which is achieved with uniformly spherical pellets. You can't *improve* on this distribution, it is the result of pellets interacting with the atmosphere. A poorly made shotgun shell might deviate from this ideal by having more or less "stringers" … pellets that leave the barrel and fly off at odd angle due to being deformed. Modern steel or bismuth pellets *might* more closely approach the ideal because more of them are precisely circular than lead pellets of the past (and present). But if that were the case, the clay target community would have rapidly switched to steel decades ago; they didn't and still haven't.

In short, good research from 50 years ago is as relevant today as it was 50 years ago.

Similarly, there is no evidence that shooters or their weapons are any better (or worse) than they were 50 years ago. In 1981, Matthew Dryke (USA) scored 200 out of 200 shooting skeet. Many people hit 199 out of 200 in trap shooting back in the 1970s.

5 Sustainability issues

Aristocracy all over Europe learned a thousand years ago that the only way to make hunting sustainable was to keep the masses out! This they did by punishments ranging from hanging to cutting off limbs.

Hunting has only ever been sustainable if hardly anybody does it.

This is because it is the most inefficient method of food production. If people tried to eat hunted ducks in chicken quantities, there would be no ducks.

There are differences between hunting ducks and hunting tigers, but in both cases, severe restrictions are required to prevent the target species becoming extinct or too rare to justify the time spent. Hunting is one of the few activities where practitioners have to hope that it doesn't become more popular.

The global biodiversity crisis has many causes, but among them is the attitude that we should maximise our exploitation of natural resources. The idea that a downed-wounded duck is a wasted resource is a symbol of this attitude. As is the attitude that we should rush to stock the outback with cattle after a big rain to avoid *wasting* the water.

An alternative ethos is that we should live in a way which minimises the resources we exploit and maximises the land and resources we leave for wildlife. This submission hasn't relied on that alternative ethos. It has looked at duck shooting from the perspective of the general population, as far as it is possible to know this.

6 Conclusions

Shooting flying ducks with shotguns isn't an efficient killing process. It is also crude, cruel and barbaric. It isn't process killing and it isn't skill killing.

If you wanted to efficiently kill wild ducks, then you would trap and gas them. Death would certainly be slower, but at least certain. That would be *process* killing, like a slaughterhouse; rather than *roulette-wheel* killing. Duck shooters like shotguns precisely because they enjoy the weapon and the activity. The love the thrill of being able to do what would be impossible with a rifle.

The common lack of any empathy for the wildlife they hunt is obvious to anybody who has seen them up close. They may dress up in suits to lobby politicians, but those of us who have seen them during shooting see another side. It isn't that all shooters are cruel, many genuinely believe that there are only two outcome to a shot: downed or missed. It's a convenient view, but totally inconsistent with the evidence. Many other shooters really are disturbingly cruel. They will carry a live duck by his or her neck with no concern. They stick to old methods of killing, like "swinging" a duck, because they don't care if the animals dies quickly or slowly.

But even the most compassionate of duck shooters will still wound many ducks; it's the physics. You can't beat the physics any more than you can beat the roulette wheel in a casino.

Dog fights subject animals to considerable pain and suffering. We wouldn't consider "But we eat the dogs" as a legitimate defence. Similarly, eating ducks is also no excuse for gross cruelty.

Shooting ducks and quails with shotguns makes a mockery of the Animal Welfare Act; it's time it went the way of dog fights, cock fights and hare coursing.

References

Andrews, R., and J. R. Longcore. 1969. "The Killing Efficiency of Soft Iron Shot." *Transactions of the North American Wildlife Society Bulletin* 34: 337–45.

Bellrose, Frank C. 1953. "A Preliminary Evaluation of Cripple Losses in Waterfowl." *Transactions of the 18th North American Wildlife Conference* 18: 337–60.

Ben-Ami, D., K. Boom, L. Boronyak, C. Townend, D. Ramp, D. B. Croft, and M. Bekoff. 2014. "The Welfare Ethics of the Commercial Killing of Free-Ranging Kangaroos: An Evaluation of the Benefits and Costs of the Industry." *Animal Welfare* 23 (1): 1–10. https://doi.org/10.7120/09627286.23.1.001.

Cochrane, Robert L. 1976. "Crippling Effects of Lead, Steel, and Copper Shot on Experimental Mallards." *Wildlife Monographs* 51: 8–19.

Falk, Knud, Flemming Merkel, Kaj Kampp, and Sarah E. Jamieson. 2006. "Embedded Lead Shot and Infliction Rates in Common Eiders Somateria Mollissima and King Eiders s. Spectabilis Wintering in Southwest Greenland." *Wildlife Biology* 12 (3): 257–65.

Haines, Aaron M, Fidel Hernandez, Scott E Henke, and Ralph L Bingham. 2009. "A Review of Crippling Loss for Northern Bobwhites." In *National Quail Symposium Proceedings*, 6:44. 1.

Harper, and R. Storr. 1990. In *Report of the Task Force Enquiring into Duck Hunting in South Australia*, edited by K. J. Stokes. National Parks; Wildlife Service S.A.

Havera, Stephen P., Richard M. Whitton, and Robin T. Shealy. 1992. "Blood Lead and Ingested and Embedded Shot in Diving Ducks During Spring." *The Journal of Wildlife Management* 56 (3): 539–45. https://doi.org/10.2307/3808870.

Hejna, Petr, Miroslav Šafr, and Lenka Zátopková. 2012. "The Ability to Act – Multiple Suicidal Gunshot Wounds." *Journal of Forensic and Legal Medicine* 19 (1): 1–6. https://doi.org/10.1016/j.jflm.2011.06.017.

Hicklin, Peter W., and W. R. Barrow. 2004. "The Incidence of Embedded Shot in Waterfowl in Atlantic Canada and Hudson Strait." *Waterbirds* 27 (1): 41–45. https://doi.org/10.1675/1524-4695(2004)027%5B0041:TIOESI%5D2.0.CO;2.

Hochbaum, George S., and C. J. Walters. 1984. "Components of Hunting Mortality in Ducks." *Canadian Wildlife Service Occasional Paper*, no. 52: 29pp.

Holm, Thomas E., and Lars Haugaard. 2013. "Effects of a Danish Action Plan on Reducing Shotgun Wounding of Common Eider Somateria Mollissima." *Bird Study* 60 (1): 131–34. https://doi.org/10.1080/00063657.2012.748715.

Humburg, Dale D., Steven L. Sheriff, Paul H. Geissler, and Tom Roster. 1982. "Shotshell and Shooter Effectiveness: Lead Vs Steel Shot for Duck Hunting." *Wildlife Society Bulletin* 10 (2): 121–26.

Iwaniuk, Andrew N., and John E. Nelson. 2001. “A Comparative Analysis of Relative Brain Size in Waterfowl (Anseriformes).” *Brain, Behavior and Evolution* 57 (2): 87–97. https://doi.org/10.1159/000047228.

Kirby, Ronald E., John H. Reichman, and Ted W. Schoenfelder. 1981. “Recuperation from Crippling in Ducks.” *Wildlife Society Bulletin* 9(2): 150–53.

Kolovos, Benita. 2023. “Victoria Announces Shortened Duck Hunting Season Amid Review of ‘Increasingly Contested’ Practice.” *The Guardian*, February.

Kozicky, E., and J. B. Madson. 1973. “Nilo Shot Shell Efficiency Test on Experimental Mallard Ducks, 1972-3.” *Proceedings of the International Association of Game, Fishing and Conservation* 63: 100–117.

Krone, O., Norbert Kenntner, Anna Trinogga, Mirjam Nadjafzadeh, F. Scholz, J. Sulawa, K. Totschek, P. Schuck-Wersig, and Roland Zieschank. 2009. “Lead Poisoning in White-Tailed Sea Eagles: Causes and Approaches to Solutions in Germany.” *Ingestion of Lead from Spent Ammunition: Implications for Wildlife and Humans*, January, 289–301.

Lowry, E. D. 1973. “The Nilo Lethality Model.” *Proceedings of the International Association of Game, Fishing and Conservation* 63: 117–41.

Loyn, Richard H. 1991. “Assessing and Managing the Impact of Duck Hunting in Victoria — a New Approach.” *Wildfowl* 42: 155–61.

Madsen, Jesper, and Henning Noer. 1996. “Decreased Survival of Pink-Footed Geese Anser Brachyrhynchus Carrying Shotgun Pellets.” *Wildlife Biology* 2 (3): 75–82. https://doi.org/10.2981/wlb.1996.035.

Nieman, Daniel J., George S. Hochbaum, F. Dale Caswell, and Bruce C. Turner. 1987. “Monitoring Hunter Performance in Prairie Canada.” *Transactions of the 52nd North American Wildlife and Natural Resources Conference* 52: 233–45.

Noer, Henning, Jesper Madsen, and Poul Hartmann. 2007. “Reducing Wounding of Game by Shotgun Hunting: Effects of a Danish Action Plan on Pink-Footed Geese.” *Journal of Applied Ecology* 44 (3): 653–62. https://doi.org/https://doi.org/10.1111/j.1365-2664.2007.01293.x.

Norman, F. I. 1976. “The Incidence of Lead Shotgun Pellets in Waterfowl (Anatidae and Rallidae) Examined in South Eastern Australia Between 1957 and 1973.” *Australian Wildlife Research* 3: 61–71.

Norton, Michael R., and Vernon G. Thomas. 1994. “Economic Analyses of Crippling Losses of North American Waterfowl and Their Policy Implications for Management.” *Environmental Conservation* 21 (4): 347–53.

Papoulis, Athanasios. 1990. *Probability and Statistics*. Prentice Hall International Editions.

Perry, Matthew C., and Joseph W. Artmann. 1979. “Incidence of Embedded and Ingested Shot in Oiled Ruddy Ducks.” *The Journal of Wildlife Management* 43 (1): 266–69. https://doi.org/10.2307/3800671.

Perry, Matthew C., and Paul H. Geissler. 1980. “Incidence of Embedded Shot in Canvasbacks.” *The Journal of Wildlife Management* 44 (4): 888–94. https://doi.org/10.2307/3808317.

Sanderson, Glen C., and Frank C. Bellrose. 1986. *A Review of the Problem of Lead Poisoning in Waterfowl*. Illinois Natural History Survey.

Urquhart, K. A., and I. J. McKendrick. 2003. “Survey of Permanent Wound Tracts in the Carcases of Culled Wild Red Deer in Scotland.” *Veterinary Record* 152 (16): 497–501. https://doi.org/10.1136/vr.152.16.497.

Van Dyke, F. 1981. “Mortality in Crippled Mallards.” *Journal of Wildlife Management* 45(2): 444–53.

Wallack, L. R. 1977. *American Shotgun Design and Performance*. Winchester Press.

Washburn, Alan. 2003. “Diffuse Gaussian Multiple-Shot Patterns.” *Military Operations Research* 8 (3): 59–64. https://www.jstor.org/stable/43940945.

Whitlock, S. C., and H. J. Miller. 1947. “Gunshot Wounds in Ducks.” *Jounal of Wildlife Management* 11: 279–81.