The truth about aerial-dropped 1080-poisoned food

Alexis Pietak*
alexis.pietak@gmail.com
www.omecha.org

Aerial-dropped 1080-poisoned food is a hotly contested issue. Anti-1080 proponents claim that the widespread, uncontrolled distribution of highly lethal food into wilderness ecosystems has the capacity to decimate certain bird populations and wreak ecological havoc. Advocates claim that 1080-poisoned food is selective for mammals, and even if bird deaths do occur, the benefits of mammalian predator removal apparently outweigh the risk of bird deaths. According to advocates, aerial-dropped 1080-poisoned food is the only way to protect New Zealand's last stands of flora and fauna, and must be used to control bovine tuberculosis in New Zealand's cattle and deer herds. Who is right? What is the truth about aerial-dropped 1080-poisoned food?

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*Dr Alexis Pietak is a biomedical research scientist, biophysicist, and author who lived in New Zealand from February 2005- May 2011. More information about Dr Pietak can be found at: www.omecha.org

Sticking to the facts

Science, when used correctly, represents humanity's best tool for assessing issues from an objective, rather than emotional position. If we want to consider the 1080 debate from a scientific perspective, it's first important to identify the main *hypotheses* that we're looking for evidence to support. A hypothesis is a best guess at the actual nature of a situation given the information available. Focusing on the issue of New Zealand's bird life, there are two hypotheses maintained by aerial 1080 advocates. The first is that aerial-dropped 1080-poisoned food is selective to mammals like rats and possums, and therefore poses a minimal risk of killing birds. The second hypothesis is that even in situations where 1080-related bird deaths do occur, in the longer term a bird population benefits from enhanced survival and breeding with the extensive eradication of mammalian predators.

Fortunately, the issue of aerial-dropped 1080-poisoned food readily lends itself to an objective assessment using scientifically-based considerations and experiments. Scientific researchers routinely design experiments, and use standard statistical analyses on the resulting observations, to obtain hard-data estimates of the risks/benefits to individuals of a population when they're exposed to a factor like a virus, toxin, or lifestyle habit. While an ecosystem represents an arguably more complex, multifactorial, and difficult system to control, the risks/benefits of aerial poison operations to New Zealand's birds can still be assessed using the very same methods wielded by medical researchers.

As a trained researcher who has looked into the scientific evidence intended to support the hypotheses of aerial-dropped 1080-poisoned food advocates, I can tell you I'm afraid for what's happened and what's happening to New Zealand's ecosystems. Much of the work that has been done, and the quality of data that exists to support the main claims of the aerial-dropped 1080-poisoned food advocates, does not stand up to basic scrutiny. I'd like to share with the most important holes in the evidence base supporting aerial-dropped 1080-poisoned food. In seeing how the evidence stacks up, or fails to stack up, you will hopefully be inspired to help put an immediate stop to aerial-dropped poisoned food in New Zealand.

Does 1080-poisoned food select for mammals?

Let's start with an easy case. The 1080-poisoned food advocating agencies (DoC and AHB) have readily proclaimed 1080-poisoned food to be selective for *mammals*, therefore apparently making it safe for New Zealand's birds. We know this from statements made directly by the DoC such as:

"*New Zealand is well placed to use 1080 because it specifically targets mammals — meaning we can target the predators and pests with limited impact on our native wildlife.*" [1]

Similarly, in response to the question of why New Zealand is the only country to use so much compound 1080, and in such uncontrolled manners, the DoC has responded:

"*Because New Zealand has no native terrestrial mammals except for two species of bat, we are well placed to use a toxin that targets mammals. Other countries which have native mammals that they want to protect use 1080 differently to New Zealand.*"[1, 2]

On the other hand, different scientists have proclaimed 1080 to be acutely lethal to mammals and birds alike[3]. Is there any reasoning we could call upon to come to an objective decision about whether or not we should expect 1080-poisoned food to be selective for mammals? Well, yes, I think it's easy to settle this issue objectively! The only rationale we need to agree on is that the selectivity of a poisoned food depends on how much of it a target animal would have to eat in comparison to something we don't want to be killed. So, if a possum needed to eat 1% of its normal daily food intake in 1080-poisoned food, while a bird needed to eat 200% of its normal daily food intake, we could take this as an indication that the 1080-poisoned food is indeed selective for possums, and relatively harmless to the bird. To put it into human terms, the caffeine in coffee is toxic to humans, but only if we drink about 90 cups within a few hours. Since this would be very hard to do, we don't consider coffee to be a lethal substance to humans. In fact, we consume it readily. Yet, if you gave your cat a quarter cup of coffee, he would likely up and die, without any antidote. By this line of reasoning, we'd say coffee is a toxin selective to cats and dogs, but not humans.

The lethal dose of 1080 for possums ranges from 0.8 to 1.5 mg/kg[4]. The lethal dose of 1080 for New Zealand birds is indeed higher than that of possums, ranging from 6.9 to 9.5 mg/kg[5], and according to Canadian toxicologists may be as high as 15 mg/kg[3]. If we take into consideration the average body weights of possums, a small bird such as a tomtit, and a larger bird like a kea; the total daily mass of food consumed by each of these creatures[6]; the lethal dose of 1080 for each creature considering both the normal (6.9 mg/kg) and high (15 mg/kg) ranges of 1080 tolerance for birds; and the concentration of compound 1080 used in cereal pellets and carrot bait (typically 1.5 g/kg), we can estimate the amount of 1080-poisoned food each creature needs to eat to reach a lethal dose in relation to its normal food intake.

The results don't look so good for birds! Possums need only consume 0.4 % of their daily food ration in 1080-poisoned food, yet a smaller tomtit-sized bird with normal to high tolerance need only consume 0.6 to 1.2 % of its daily food intake to reach a lethal dose. A larger kea-sized bird would require only 6 to 12.5% of their daily food ration in 1080-poisoned food to reach a lethal dose. Clearly, 1080-poisoned food, as used in New Zealand's aerial poison drops, has the capacity to easily kill both mammals and birds if it's ingested in quantities that are *small* relative to the normal eating habits of these creatures.

Poisoned food advocates have also claimed that the addition of cinnamon scent and colouring the poisoned food green deter birds from ingesting the lethal pellets. However, studies examining bird preference to baits with and without cinnamon have not found evidence that birds are deterred by cinnamon[7]. In a study of bird feeding on non-toxic cereal bait pellets tagged with fluorescent-dye, green baits were found to have been readily eaten by a number of bird species[8]. Moreover, it's been shown that an insect feeding on 1080 pellets can remain alive while accumulating enough 1080 toxin within itself to serve as a lethal dose to most insect eating (insectivorous) birds receiving as little as 6.4% of their daily insect ration[5], which makes the type of bait irrelevant.

So no, sadly, there are no reasons to believe food poisoned with 1080 is selective for mammals. Unintended deaths of a variety of bird species remain a distinct and deeply troubling possibility considering 2000-5000 kg of pure 1080, enough to kill a biomass of 14 to 35 million humans, is currently dumped into New Zealand's ecosystems every year!

The quality of scientific evidence matters!

Next we need to consider the *quality* of scientific evidence that's being used to support the hypothesis of low bird death risk with aerial-dropped 1080-poisoned food. The academic community has previously determined that the only reliable way to assess bird deaths from aerial-dropped poisoned food is to capture birds, mark them with a coloured band or radio transmitter, release them, and look for them after the poisoned food drop[9-11]. This is called a 'mark-recapture' method. Other methods, such as the 5 minute bird call and count techniques often mentioned in DoC's reports, produce nonsensical data unless the whole bird population is wiped out after a poison drop. The reason for this is that using non-marked techniques, differences in bird behaviour cannot be separated from differences in bird abundance. The weather, presence of a human observer, and unknown bird behaviours are all factors causing daily sightings to go up or down independent of actual bird populations. In short, mark-recapture experiments are considered to be the only way to get a reliable assessment of bird death risk with aerial-dropped poisoned food exposure.

The DoC has in fact been performing mark-recapture experiments before and after aerial-dropped 1080-poisoned food operations. A compilation of 23 years of these mark-recapture experiments, representing all 48 experiments assessing 13 unique bird species (4 of them kiwi) was made by DoC scientists Clare Veltman and Ian Westbrooke in a paper released earlier this year[12]. I added in one more experiment concerning the fate of tagged Okarito kea[13], to bring the data set up to 49 experiments. The great thing about this compiled mark-recapture data set is it allows us to assess the quality of data collected in experiments over the years. The data represents the very best evidence available to indicate whether or not aerial dropped 1080-poisoned food kills birds.

Unfortunately, there are *severe* problems with the majority of these experiments. Keep in mind that these experiments intended to find out the *actual* proportion of a whole bird population that's been killed by aerial-dropped 1080-poisoned food from a pre-selected sample of a few individuals that were marked and observed. Now, if you wished to determine the fraction of the whole New Zealand population that supports 1080, and you asked two people what they thought, would you expect this give you a good assessment of the opinion of the remaining 4.4 million? No, probably not. You probably realize that to get some kind of realistic assessment, you'll have to ask many more people to find out the actual proportion.

It's the same thing for the number of birds that are surveyed in an aerial 1080 operation. Since we're talking about capturing and marking live, wild, fragile birds, it's clearly desirable to keep study numbers to a minimum. However, if the sample size of an experimental group becomes too small it becomes impossible to differentiate the effects of exposure to 1080-poisoned food from random chance. The serious danger of choosing sample sizes that are too small is the very real risk of assuming there is no effect of a 1080-poisoned food exposure when in reality there are significant deaths! Before the experiment begins, scientific researchers commonly use statistical methods to estimate the minimum number of individuals in each group required to detect specific death rates with statistical confidence[14, 15]. Unfortunately, DoC scientists have apparently not known this, sometimes only tagging 1 or 2 birds in an 'experiment' to try and find out the effects of 1080-poisoned food on a whole bird population!

The way to look at the quality of the existing experimental data is to calculate something called *95% confidence intervals* on each measure of bird death in each experiment[16]. I have plotted these up for you in **Figure 1** for the 23 years of compiled mark-recapture data. These 95% confidence intervals tell us that many of these experiments have been completely bunk! Some experiments are unable to pinpoint the actual death rate within an interval spanning from nearly 0 to 100% (see Morepork E2 in **Figure 1**)! Of the 49 experiments, 18 out of 49 (or 37%) could not rule out a death rate of 50%, and 8 out of 49 (16%) could not rule out a death rate of 80%. This means that even in experiments where no deaths were observed, high death rates cannot be ruled out in the actual whole treated population.

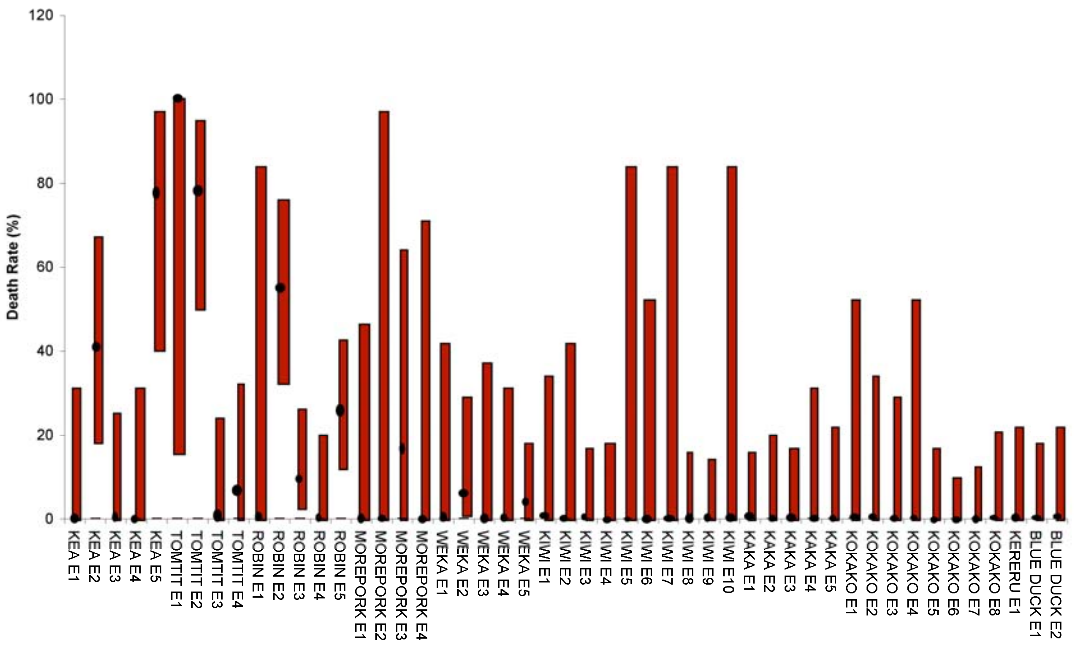

Figure 1: The 95% confidence intervals for the death rate of 1080-poisoned food exposed birds in 49 mark-recapture experiments compiled over 25 years. A black dot represents the basic death rate for a particular experiment. The range of the 95% confidence interval for each death rate is shown as a red bar. With 95% chance, one can expect to find the actual death rate within the confidence interval. A very large 95% confidence interval indicates a poorly designed experiment with very small sample size. For very small sample size and very large 95% confidence interval (e.g. MOREPORK E2), the actual death rate may exist nearly anywhere between 0 and 100%, making the experiment completely ineffectual.

Another thing about the scientific evidence attempting to support the hypothesis of low bird deaths with aerial-dropped 1080-poisoned food is the failure to study the majority of birds that can be identified at high risk from poisoning as they've previously been found dead after an aerial 1080 operation. Out of 31 bird species (19 New Zealand natives) that have been found dead after aerial-dropped poisoned food operations, only 8 have been studied! To put this into human terms, it's as if there's a dinner party where we suspect the roast beef is poisoned. Out of 100 guests that come to the part, 20 are strict vegetarians. After the party, we call up the 20 vegetarians to see how they're doing. Is it a surprise to find out they're all OK? Furthermore, we don't pay attention to reports of deaths in the remaining 80 potentially roast-beef eating guests. As a result of this shoddy investigation, we conclude the roast beef is safe. Arguably, the DoC have studied and put forth the inconclusive data from individuals least likely to be poisoned in an aerial-dropped 1080-poisoned food operation.

Evidence for high death rates

In my own calculations with the set of 23 years of compiled data, I pooled data from experiments for the same bird species using the same bait type (carrot or cereal pellet) to get some kind of statistically valid estimate of bird deaths in the 13 species studied by mark-recapture methods. The results of pooling according to bird and bait type showed that in the tomtit and robin groups exposed to 1080-poisoned carrot bait, the death rate for tomtits may be up to 96% and a death rate for robins up to 42%! In cereal pellet operations, a lower death rate of up to 18% was indicated for tomtits, while a similar death rate of up to 35% was found for robins. Notably, the tomtit and robin represent only 2 studied birds of 16 insectivorous bird species in New Zealand[17]. Insectivores can be identified to be at risk of poisoning as they have been found dead after aerial 1080-poisoned food operations, and due to the risk of secondary poisoning through the insects they base their diets on[5]. The effects of aerial 1080 to the remaining 14 insectivorous bird species remain complete unknowns.

In addition to tomtits and robins, another bird species where significant 1080-related deaths were observed was the kea. The kea's numbers on planet Earth stand as low as 1,000 to 5,000[18, 19]. My analysis of the compiled data set revealed a 1080-related death rate of up to 37% for kea in cereal pellet operations. The effects of carrot operations on kea have never been studied. A death rate as high as 37% would be extremely damaging for a slow to recover population species such as the kea, which already have such low populations. Moreover, the kea and weka were the only 2 omnivores studied of 21 omnivorous bird species in New Zealand[17]! Omnivores can easily be identified as high poisoning risk due to their innate tendency to ingest a wide variety of food types, and their observed deaths after aerial 1080-poisoned food operations. Again, what is happening to the remaining 19 omnivorous bird species in aerial-dropped poisoned food operations remains a mystery.

Long-term benefits of aerial 1080?

Next we can consider evidence supporting the hypothesis that benefits to birds outweigh the risks. In reality, an extremely low number of reports have explored long-term effects of aerial-dropped poisoned food to birds. The potential *benefits* of a 1080-poisoned food operation to a particular bird species are indicated by a *decreased* death risk to a 1080-poisoned food exposed population. To evaluate long-term benefits, an unexposed control group is essential, as well as longer-term follow ups of the tagged birds at 1 to 4 years after the 1080-poisoned food operation. The unexposed control group gives the death risk rate by natural factors, including predation. Therefore, by simply including a longer-term assessment of the very same experiment that had already been invested in, basic statistics (called *relative risk ratios*[20]) can be used to provide concrete evidence of the relative short-term risks, and some of the potential long-term benefits, of an aerial 1080-poisoned food operation to a particular bird species.

Unfortunately, in the 23 years of collected data a control group has rarely been used at all, with 36 of 49 experiments (or 74%) performed without a control! This is appalling scientific practice! Of those experiments that used controls, the vast majority of experiments followed-up tagged birds to only 3 weeks after the poison operation[12]. The one report I located that followed up birds 25 months after the poison operation found no difference in the lifespan of birds in 1080-treated and untreated areas, indicating no survival benefit at all[21].

Increased breeding success with aerial 1080-poisoned food induced predator removal might benefit specific bird populations in the long term. However, I could find only 3 studies reporting on nesting success of 4 bird species after aerial 1080-poisoned food operations[21-23]. Two of these 3 studies concluded with no significant differences in breeding success! For instance, in spite of a high death rate observed for tomtits in some aerial-1080 operations, the breeding success of tomtits in an aerial 1080 treated area was not significantly different from that of an untreated area[23]. The breeding success of kaka was also not found to be significantly different with 1080 treatment[21]. Only kereru and robins showed increased breeding success in one to two breeding seasons following 1080 treatment[21, 22]. There is no information at all that looks at the longer term 3-4 year adult lifespan or breeding success of New Zealand's birds with aerial dropped 1080-poisoned food. At best, there is only very minimal evidence regarding longer term benefits of an aerial 1080-poisoned food operation in terms of breeding success.

Long-term benefits are not actually expected with aerial-dropped 1080-poisoned food due to the serious unanticipated side-effects that have been observed. A wilderness is a complex system of many interrelated living beings that depend upon, and compete with one another, for survival. Disrupting the balance of that system with the eradication of a pest species can result in serious and unexpected consequences[24]. The outstanding breeding capacity of rats, and the complexities of ecosystem dynamics, means rat populations can recover from over 90% kill rates to levels as much as 5 times *higher* than before an aerial 1080-poison operation, and remain high for up to 6 years[25]! Increases in the number of stoats have also been observed in aerial 1080-treated areas[21]. Another documented unexpected side effect of aerial 1080 operations was stoat prey switching from a diet consisting primarily (74%) of rats and minimal birds (3%) to one consisting heavily (39%) of birds after the 1080-poisoned food drop[26]. Bird species recover much more slowly than their rodent predators[27]. These unanticipated side-effects observed after aerial 1080 operations indicate *increased* predation and *decreased* breeding success for birds in the longer-term.

Aerial-dropped poisoned food: creating an ecosystem of 'weeds'?

Aerial-dropped poisoned food is inherently different from other methods of pest control as it represents a single pulse of intense, short-duration predator control that is sporadically applied after 2 to 7 years. In ecological theory, the idea of 'k' and 'r' selected species has been kicking around for a while[28]. An 'r-selected' species is quick to reproduce and makes many offspring, with the rat being a prime example. R-selected species are what we commonly call 'weedy' species. On the other hand, 'k-selected' species are slower to reproduce and have fewer offspring, but live longer and are better able to compete for limited resources, with prime New Zealand examples being endemic birds like the kea. R-selected species dominate in unstable environments and can tolerate huge changes in their population. K-selected species require stable environments and have stable populations that do not tolerate large changes with environmental instability.

The very intense killing-pulse of aerial-dropped 1080-poisoned food is likely creating a highly unstable environment that will select for quick to reproduce 'r-selected' species while decimating populations of slow-to-recover 'k-selected' species. Therefore, a fundamental change in the basic constitution of New Zealand's aerial 1080-treated ecosystems, one which favours weedy species like rats and blackbirds, may be underway. This line of reasoning accounts for the sustained, abnormally high rat populations observed after aerial 1080-poisoned food drops[25].

A viable alternative to aerial-dropped poisoned food is continuous mammalian pest control using controlled-access bait stations and human hunting/trapping of target species (possums, rats, and stoats). These controlled, continuous methods of mammalian pest control have already been shown to be an effective means to recover populations of fragile bird species such as the kaka[29].

Over a period of about 30 years, unmanaged possums also change the constitution of a New Zealand forest by reducing the number of trees like fuchsia, rata, and kamahi, which are replaced by other species in correlation with possum population die-back[30]. Aerial-dropped 1080-poisoned food may be exerting an even more profound change in the constitution of New Zealand's forests by selecting for the weediest mammal and bird species.

Conclusions

Since aerial 1080-poisoned food drops have been going on since 1956, with accelerated use from the 1990's and through to this present day, we'd certainly hope that the best scientific evidence exists to support the main claims of 1080-advocates. By now it should be easy to take a look at this solid body of evidence and conclude that indeed, the evidence generally shows that aerial-dropped poisoned food is selective for mammals, poses minimal mortality risks to birds, and that long term benefits outweigh the risks. Unfortunately, this just isn't the case.

There are no grounds to assume 1080-poisoned food is selective for mammals, with birds requiring only 0.6-12.5% of their daily food ration in 1080-poisoned bait to obtain a lethal dose.

Moreover, the existing hard data set compiling 23 years of experimental mark-recapture data examining the impacts of poisoned food operations to a variety of bird species was found to be deeply flawed due to i) the lack of a control group in the majority of experiments, ii) the use of very small study groups lacking statistical robustness, and iii) the very short duration of experiments.

Statistical analysis of the hard data set revealed significantly high death rates and risk of death for the two insectivorous birds studied (tomtit and robin) and one of the two omnivorous birds studied (kea), with large unknowns for the fate other insectivorous and omnivorous bird species in New Zealand.

Aerial-dropped 1080-poisoned food cannot even be proven responsible for the observed drop in Tb infections in New Zealand's herds, since more extensive aerial-dropped poison food operations were introduced at the same time as improved herd management techniques. Moreover, we cannot overlook the fact that major countries in North America and Europe have obtained a Tb-free status without resorting to killing off all of their native wildlife.

In conclusion, there is insubstantial hard data evidence to support the hypothesis of the mammalian selectivity of 1080-poisoned food, its low risk to a wide array of bird species, or to indicate long term benefits to any bird species. In contrast, there are indications that aerial 1080-operations may decimate certain endemic bird populations and fundamentally disrupt ecosystem dynamics, favouring weedy species like rats. As the risks of toxin persistence and secondary poisoning are *higher* for alternative toxins such as the anti-coagulants *brodifacoum* and *pindone*, an immediate moratorium on all aerial-dropped poisoned food operations is warranted.

Continuous, controlled bait access methods for mammalian predator control (bait stations and trapping) are recommended as viable alternatives to aerial-dropped poisoned food.

Notes

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