CONSERVATION
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**CONSERVATION ADVISORY SCIENCE NOTES**

**No. 108**

# EVALUATING THE POTENTIAL HAZARD OF AERIAL 1080 POISON OPERATIONS TO SHORT-TAILED BAT POPULATIONS

(Short Answers in Conservation Science)

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**Department of Conservation, P 0 Box 10-420, Wellington, New Zealand**

ISSN 1171-9834



Reference to material in this report should be cited thus:

Lloyd, B.D., 1994.
Evaluating the potential hazard of aerial 1080 poison operations to Short-tailed bat populations.
*Conservation Advisory Science Notes No. 108,* Department of Conservation, Wellington. 12p.

Commissioned by: Science & Research Division.
Location: NZMS

# EVALUATING THE POTENTIAL HAZARD OF AERIAL 1080 POISON OPERATIONS TO SHORT-TAILED BAT POPULATIONS

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## ABSTRACT

Available relevant information was reviewed to assess the potential hazard of aerial 1080 poison operations to short-tailed bat populations. Although there is insufficient information available to provide a reliable evaluation of the hazards, the information that is available indicates that short-tailed bat populations are unlikely to suffer from direct poisoning by consuming baits. However there is a possibility of secondary poisoning caused by bats consuming arthropods that have fed on 1080 baits. Because of their low fecundity bat populations may take a long time to recover from relatively minor mortality episodes.

## INTRODUCTION

Recent confirmation of the presence of short-tailed bats in a number of mainland forests has prompted concern over the likely impact of aerial broadcast 1080 poison operations on short-tailed bat populations. Spurr (1993) reviewed the literature on the effects of 1080 poison operations on a variety of non-target species and noted that bats had not been monitored in any of the operations reviewed. At present their is insufficient knowledge to make reliable predictions of the effect of aerial 1080 poison operations on short-tailed bat populations, but, because of the urgency to proceed with possum control operations, I have attempted to provide a best assessment of the risks using all relevant information.

## BIOLOGY OF THE SHORT-TAILED BAT (*Mystacina tubenulata*)

Many of the observations described in this section are based on my recent unpublished research.

### Conservation Status

Category A, ie. highest priority threatened species (Molloy & Davis 1992).

**Taxonomic status**

Sole extant species of the ancient New Zealand endemic family Mystacinadae. The family has no close affinities with other bat families, but the super-family Phyllostomoidea of South America are believed to be the nearest relatives (Pierson *et al.* 1986).

**Distribution**

Once found throughout New Zealand the species range is now restricted. It is believed that there are only two remaining populations considered as safe: Little Barrier Island and Codfish Island. The status of mainland populations is uncertain. Daniel and Williams (1984) indicated short-tailed bats may still be present in some forests in Northland, central North Island and North West Nelson. In recent years short-tailed bats have been confirmed as being present in forest areas at Warawara (R.Pierce pes. comm.) and Omahuta (Northland), northern Pureora (Waikato) (C.Ecroyd pers. comm.), Rangataua (Taupo/Turangi) (C.Speedy pers. comm.) and Waitaanga and Egmont (Taranaki) (W.Hutchinson pers. comm.). Widespread surveys to be undertaken during the next few years may clarify the species distribution.

**Population viability**

Recent work indicates the population on Codfish Island is probably in excess of 1000 individuals. The population on Little Barrier may be larger. In the absence of catastrophic events both these populations are probably viable in the long term. There are no estimates of the size or viability of mainland populations but recent field work by myself and John Heaphy indicate the short-tailed bat populations at Rangitaua and Waitaanga may be larger than the population on Codfish Island.

**Fecundity**

Although relatively little is known about the reproductive biology of *Mystacina* maximum fecundity for most temperate bat species is less than one birth per adult female per year. Unlike other small mammals, bats are K-strategists with low fecundity and high longevity (Findley, 1993) hence bat populations may be unable to recover quickly following major mortality events.

**Diet**

*Mystacina* has a broad diet including both volant and non-volant arthropods, fruit, nectar, & pollen (Daniel, 1976 & 1979). Daniel (1979) identified remains of some Arthropod taxa in droppings of free living bats in Northland: Lepidoptera (moths), Orthoptera (weta) Coleoptera (beetles) and Araneae (spiders).

Captive *Mystacina* eat a wide variety of arthropods including many taxa not identified by Daniel (1979) in Northland bat droppings (Daniel 1979, Blanchard 1992, Blanchard pers. comm., and the author's own observations).

Reports that short-tailed bats scavenge vertebrate carcasses and take nestlings appear to be derived from a single paper by Stead (1937). The observations described in this paper are far from convincing proof of the existence of this behaviour and are probably of *M. robusta,* not *M. tuberculata.*

My own observations on both captive and wild bats indicate that the species is extremely flexible, foraging by gleaning in trees and on the ground as well as hunting in the air. They are likely to consume any available arthropods and are capable of consuming relatively large items, I have observed captive bats catch and eat cicadas measuring about 40 mm long. I am currently researching the diet of short-tailed bat on Codfish Island by identifying recognisable fragments in their droppings. Initial result indicate a wide variety of prey items including Tipulids, cockchafer beetles, weta cocroaches and spiders. Weta appear to be a major component of the diet..

**Nightly consumption of arthropods**

Daniel (1979) reported that captive short-tailed bats ate half their own weight of moths per day (this figure excludes the moths wings which were removed). Six short-tailed bats currently held at Wellington Zoo regularly consume more than 30 g of a variety of insects in a night (Blanchard pers. comm.). That is an average individual nightly consumption of 5g of insects. Nectar and pollen are also consumed.

In captivity bats feed nightly whereas in the wild during poor weather conditions individuals may not feed for many nights. When feeding is resumed it is probable individuals consume more than 5g of arthropods in a night. Peak consumption is likely to occur during periods of settled fine weather following bad weather. (The conditions preferred for 1080 operations.)

**Foraging range**

Radiotagged short-tailed bats on Codfish Island have been tracked flying up to 2 km between roost sites and foraging areas in less than 10 minutes. Individuals appear to range widely over most of the 1,336 ha island. In Northland radiotagged short-tailed bats were tracked flying nearly 2 km before their radio-signals were lost. Overseas studies have shown that most small micro-chiropteran bats forage within 1 or 2 km of their roost site though some commute up to 5 km (Mayle 1990). In one study bats were tracked commuting nightly from roost sites to foraging areas 20-30 km away (Sahley *et al*. 1993).

**Hibernation**

Dwyer (1962), Daniel (1979), and Daniel & Williams (1984) all report that *Mystacina* remain active throughout the year. Daniel (1990) stated the species does not undergo seasonal hibernation. In contrast recent field work near Ohakune indicates that the bats in this area do hibernate during winter. The level of bat activity, determined using bat detectors, declined from a high of 2.55 bat-passes/hour in April to 0.0057 bat-passes/hour during June and July. The few bat passes recorded during June and July are consistent with the pattern of seasonal hibernation observed in northern hemisphere microchiropterans, i.e. individuals wake and are active for a few hours every week or two.

**Weight**

Summary statistics for the weights of adult short-tailed bats (excluding pregnant females) are presented in Table 1. There were small but not significant difference between the weights of male and females.

**Table 1.** Summary statistics for the weights of adult short-tailed bats (excluding pregnant females).

| | N | Mean (g) | Min (g) | Max (g) | SE |
|---|---|---|---|---|---|
| Codfish (Oct. 93) | 93 | 14.50 | 12.0 | 18.5 | 0.112 |
| Ohakune (Apr. 94) | 7 | 15.01 | 12.6 | 17.0 | 0.643 |
| LBI (Feb. 93) | 24 | 11.95 | 10.1 | 13.6 | 0.203 |
| Omahuta (Oct. 92 - Jun. 93) | 8 | 11.90 | 11.0 | 13.1 | 0.238 |

## SENSITIVITY TO 1080

### $LD_{50}$ estimates

The only estimate of 1080's toxicity to bats is for the American big brown bat *Eptesicus fuscus*: Timm (1983) reported an $LD_{50}$ of 0.15 mg/kg. Calver *et al.* (1989) stated that "it is often difficult to predict the sensitivity of a species to 1080 on the basis of data from other, closely related species". In the absence of any other information I have used three $LD_{50}$ estimates (0.05, 0.15 and 1.0 mg/kg) which encompass the $LD_{50}$ estimate for big brown bats and the variation in $LD_{50}$ estimates for 26 of the 32 non-Australian[1] Eutherian mammal species presented by McIlroy (1982, p511). $LD_{50}$ estimates of 26 of the 32 species are between 0.06 and 1.0 mg/kg- $LD_{50}$ estimates for five species are between 1.0 and 5.0 mg and $LD_{50}$ estimates for one species, *Mus musculus,* is well outside the range, extending from 5.0 to 19.3 mg/kg.

## DIRECT POISONING

To assess the possibility of short-tailed bats feeding directly on toxic baits acceptance trials were undertaken at Wellington Zoo and a non-toxic bait drop was carried out on Codfish Island.

### Bait acceptance trials at Wellington Zoo

Bait acceptance trials have been undertaken using six captive short-tailed bats, from Codfish Island, held at Wellington Zoo. Cereal baits (Wanganui No. 7) and carrot were routinely provided to these bats with other food for many months. Both wet and dry cereal baits were provided; carrot was provided both coarsely diced and as chaff. There was no evidence of feeding on any of these baits even when no other

[1]Toxicity data from Australian native mammals was not used as many have elevated resistances to 1080 as a result of coevolution with naturally occurring 1080 sources (King, Oliver & Mead, 1978; and McIlroy, 1982).

food was provided. Video surveillance using infra-red light on 7 nights confirmed that the bats did not feed on the baits.

**Non-toxic bait field trials on Codfish Island**

Non-toxic Agchem pellets (a cereal based pellet similar to Wanganui No. 7) impregnated with fluorescent tracer dyes (rhodamine-b & pyranine) were broadcast over 200 hectares on Codfish Island in October 1993 at sowing rate of 10 kg/hectare. Seventy six bats were caught in the trial area between 5 & 12 days after the broadcast operation and examined for traces of fluorescence. Droppings collected from these bats and from roosts active during the 3 week period after the drop were also examined for fluorescence. These roosts were either within or at the edge of the trial area. At least one of these roosts was used by more than 400 bats. No fluorescence was noted either on the bats or in droppings.

Estimating the amounts of bait a short-tailed bat must consume to ingest a $LD_{50}$ of 1080.

Table 2 presents the results of calculations to determine the amounts of baits a short-tailed bat must consume to ingest a $LD_{50}$ of 1080. The calculation is repeated with three $LD_{50}$ estimates (0.05, 0.15 and 1.0 mg/kg) which includes the only available estimate of $LD_{50}$ for a bat (Timm 1983), and encompass variation in $LD_{50}$ estimates for 26 of the 32 non-Australian Eutherian mammals presented by McIlroy (1982, p511).

**Table 2.** Estimates of the amounts of bait a 14 g bat must consume to ingest a $LD_{50}$ of 1080

| | $LD_{50}$ estimates (mg/kg) | | |
|---|---|---|---|
| | 0.05 | 0.15 | 1.0 |
| $LD_{50}$ of 1080 | 0.7 ug | 2.1 ug | 14.0 ug |
| Weight of 0.08% bait | 0.88 mg | 2.64 mg | 17.5 mg |
| % of 2 g bait (0.08%) | 00.044% | 0.132% | 00.88% |

**Discussion**

The results of the acceptance trials with captive bats and the field trial on Codfish Island indicate that short-tailed bats will not normally eat cereal-based pellets or carrot baits. Despite this the minuscule size of the toxic dose (i.e. 0.88-17.5 mg of bait, Table 2) is cause for concern as small amounts of baits may be eaten experimentally or as contamination on other food. In these situations the risk of poisoning is likely to be greatest when carrot baits are used because they are surface coated with the toxin.

## INDIRECT POISONING MEDIATED BY ARTHROPODS

**The impact of 1080 on forest invertebrate populations**

Compound 1080 was originally patented as an insecticide but has not been approved for general use as an insecticide because of its high toxicity and persistence (sic) (Rammell & Fleming, 1978). David and Gardiner (1951) reported that plant

material containing 1 mg/kg (i.e. 0.0001%) of compound 1080 was toxic to aphids. It should be noted that as carrots are surface coated with 1080 the surface concentration of 1080 may exceed the nominal concentrations of 0.08% 1080. Generally arthropods feed on the outer surface of baits thus effective toxin concentrations of the bait portions fed on by arthropods may be far higher than 0.08%.

There have been four recent studies on the effects of 1080 operations on invertebrate populations in forests:

Preliminary results reported by Spurr (pers. comm.) indicate no changes in the numbers or types of ground dwelling invertebrates after two aerial 1080 operations.

In contrast preliminary findings in a study by Mead (pers. comm.) monitoring invertebrates during an aerial 1080 operation indicate declines in Collembola, Coleoptera, Lepidoptera, Hemiptera and Diptera and significant disruptions of food chains.

Pierce and Montgomery (1992) monitored weta numbers in a forest area during a 1080 operation. The authors comment that seasonal changes in behaviour complicate interpretation of the results but substantial numbers of weta survived a month after the operation.

Hutcheson (1991) reported differences between insects sampled by Malaise traps in poisoned and unpoisoned areas at Mapara. These differences can not be attributed directly to the effect of poison as the densities of vertebrate grazers and the extent of regeneration were different in the two areas. The study was not designed to assess the short term impact of 1080 operations. Malaise traps sample flying insects, the group of insects least likely to feed on 1080 baits.

**Arthropods and poison baits**

A number of workers have reported observing forest dwelling arthropods feeding the grain based pellets or carrots baits broadcast in forest areas during 1080 operations (Table 3).

**Table 3.** Arthropod groups reported as feeding on baits used in 1080 operations:

Collembolla - springtails (Lloyd & Hackwell 1992, Notman 1989)
Blattodae - cockroaches (McIntyre 1987, Eason *et al* 1993)
Orthoptera - weta (Hutcheson 1989; Lloyd & Hackwell 1992, Eason *et al.* 1993)
Coleoptera - beetles (Notman 1989, Marsh 1968)
Lepidoptera - (Notman 1989)

**The affect of 1080 intoxication on arthropods**

Goodwin & Houten (1991) reported honey bees which had received lethal doses of

1080 by feeding on 1080 jam baits continued to forage for up to 2 hours before showing any effects and that the initial effects were vigorous shaking and inability to hold onto substrate.

Hutcheson (1989) reported disruption of the normal activity patterns of eight weta following consumption of both lethal and sub-lethal doses of 1080. Four of these weta died 5 to 14 days after first eating the toxic baits.

McIntyre (1987) reported that normal anti-predator responses of cockroaches were suppressed following ingestion of 1080.

Thus insects which have consumed 1080 may remain active and therefore available for predation for many days after ingesting the toxin. In addition the abnormal behaviour induced by 1080 intoxication is likely to increase vulnerability to predation by insectivores, including short-tailed bats.

**Concentrations of 1080 in arthropods after feeding on baits**

Eason *et al*. (1991) reported 1080 concentrations of 0.05 - 0.75 ug/g in sample of live insects (3 centipedes, 1 millipede, 1 unidentified: 0.28 ug/g; 2 cockroaches, 3 termites: 0.48 ug/g; 1 beetle, 2 millipedes, 3 ants: 0.05 ug/g; 2 cockroaches, 1 beetle, 12 termites: 0.75 ug/g) collected from four 1 metre square possum proof enclosures 14 days after a 1080 operation. (Due to a typographic error Pierce and Montgomery (1992) mistakenly reported these 1080 concentrations as 0.05 - 0.75 mg/g i.e 50 - 750 ug/g). The experimental design is strongly biased against collection of insects that have ingested 1080. After feeding on toxic baits they are likely to die or move out of the enclosure. Therefore the low concentrations reported here should be viewed with caution.

Eason *et al*. (1993) collected samples of invertebrates after a 1080 operation using Wanganui No 7 pellets broadcast at 5 kg/ha. The samples were analysed for 1080 residues. No 1080 residue was detected in spiders, beetles, millipedes, centipedes or earth worms. 1080 residues were detected in cave weta, tree weta and cockroaches for up to four weeks after the operation; the results are presented in Table 5 of Eason *et al*. (1993). The highest 1080 concentrations were in samples of tree weta collected 2 days after the operation; the mean concentration of a number of the samples was 12 ug/g, with a maximum concentration of 46 ug/g. It should again be noted that invertebrate samples collected after an operation is likely to be biased against individuals that have ingested 1080 as these individuals are likely to die as a direct result of poisoning or be subjected to an increased probability of predation due to their abnormal behaviour (McIntyre, 1987; Goodwin & Houten, 1991).

Eason *et al*. (1993) also reports on the persistence of 1080 in individual tree weta after administration of a sublethal oral dose of 15 ug/g (i.e. 15 mg/kg). Table 4 (from Eason et al, 1993) summarises the results of this study. 1080 concentrations of 5 ug/g or higher were measured for the first 24 hours, and relatively high concentrations of 1080 persisted for up to 4 days after administration of the 1080 dose.

**Table 4.** 1080 concentrations in tree weta after oral dosing with 15 ug/g 1080 (from Eason *et al.,* 1993).

| Time after dosing h=hours, d=days | 1h | 12h | 24h | 2d | 4d | 6d | 10d | 14d |
|---|---|---|---|---|---|---|---|---|
| 1080 Conc. (ug/g) | 5.5 | 5.8 | 5.0 | 2.8 | 4.5 | 0.2 | .033 | .038 |

Goodwin and Houten (1991) reported concentrations of 3.1, 3.8 and 10 ug/g in samples of honey bees that died of 1080 poisoning.

**Estimating the amounts of 1080 contaminated arthropods a short-tailed bat must consume to ingest a $LD_{50}$.**

Table 5 presents the results of calculations to determine the amounts of 1080 contaminated arthropods a 14 g short-tailed bat must consume to ingest a $LD_{50}$ of 1080. The calculation is repeated with three $LD_{50}$ estimates (0.05, 0.15 and 1.0 mg/kg) which includes the only available estimate of $LD_{50}$ for a bat (Timm 1983), and encompass variation in $LD_{50}$ estimates for 26 of the 32 non-Australian Eutherian mammals presented by McIlroy (1982, p511). The three estimates of 1080 concentration in arthropods (5,10 & 50 ug/g) were chosen to encompass most of the variation in 1080 concentrations reported Eason *et al.* (1993) and Goodwin and Houten (1991).

**Table 5.** Estimates of the amounts of arthropod containing 5, 10 and 50 ug/g of 1080 which a 14 g bat must consume to ingest a $LD_{50}$ dose of 1080.

| | $LD_{50}$ estimates (mg/kg) | | |
|---|---|---|---|
| | 0.05 | 0.15 | 1.0 |
| $LD_{50}$ of 1080 | 0.7 ug | 2.1 ug | 14.0 ug |
| Arthropods @ 5 ug/g | 0.14 g | 0.42 g | 2.8 g |
| Arthropods @ 10 ug/g | 0.07 g | 0.21 g | 1.4 g |
| Arthropods @ 50 ug/g | 0.014 g | 0.042 g | 0.28 g |

Captive short-tailed bats usually do not completely ingest moderate sized (> 10 mm) and large prey items (unpublished observations). They clip off wings and other appendages and sometimes chew up the prey, ingest the juices and spit out the exoskeleton. Intestinal contents are consumed. Thus when a prey item has fed on 1080 baits bats dispose of those fractions of the prey which do not contain 1080.

**Discussion**

*Mystacina* has been reported to feed on Orthoptera, Coleoptera, Lepidoptera in the wild. There are taxa within these three Arthropod groups which are known to feed on baits (Table 3). Further work is required to determine whether the taxa which feed on baits are prey for *Mystacina*.

Because the one available $LD_{50}$ estimate for bats is 0.15 mg/kg (Timm 1983) and 26 of 32 non-Australian Eutherian mammals had $LD_{50}$ estimates below 1 mg/kg (McIlroy 1982) it is probable that the $LD_{50}$ for Mystacina is also below 1 mg/kg. If this is true the normal nightly consumption of arthropods (i.e. 5 g) far exceeds the quantities of arthropods containing a $LD_{50}$ of 1080 at any of the concentrations considered (Table 5). A single moderately sized (3-4 g) wets which had ingested a sublethal dose of 1080 (15 ug/g) within the previous 24 hours would be sufficient to kill a short-tailed bat.

## INDIRECT POISONING MEDIATED BY VERTEBRATE CARCASSES

The possibility of vertebrate carcasses being a route for indirect poisoning is not considered here because the initial report by Stead (1936) of scavenging by *Mystacina* is unconvincing. (All subsequent reports appear to be derived from Stead's observations.) However further work should be undertaken to clarify whether *Mystacina* does feed on carrion.

## 1080 JAM BAITS

Jam baits containing 1080 are used as an alternative method of possum control. This constitutes a serious hazard to short-tailed bats, as short-tailed bats are nectivorous. Captive individuals feed on honey water avidly.

## CONCLUSION

All available relevant information was reviewed to assess the potential hazard of aerial 1080 operations to short-tailed bat populations. Although there is insufficient information available to provide a reliable evaluation of the hazards, the information that is available indicates that short-tailed bat populations are unlikely to suffer from direct poisoning by consuming baits but the possibility of secondary poisoning caused by bats consuming arthropods that have fed on 1080 baits must be taken seriously.

It should be emphasised that because of the low fecundity of bats (< 1 young/adult female per year) even healthy populations of bats may take a long time to recover from relatively minor mortality episodes.

## RECOMMENDATIONS

1. Further work is required to determine the fate of arthropods during aerial 1080 operations.

2. Surveys should be undertaken for short-tailed bats in all likely mainland forest areas.

3. Before aerial 1080 operations proceed in forests where short-tailed bats have been recorded in the recent past (see Daniel and William 1984) there should be concerted attempts to confirm their absence.

4. If 1080 operations proceed in areas with short-tailed bat populations the impact of the operation on the bat populations should be monitored. Possible monitoring methods are:

- index methods using bat-detector and tape recorder units.
- counts of males at singing trees in the summer.
- counts at colonial roosts during the winter.
- counts at nursery roosts during the summer.
- capture/recapture methods using marked individuals.

None of these methods is well established and considerable work is required to tests their feasibility, to develop baselines and estimate variance levels. As no single method is likely to provide unequivocal results, a set of several methods is preferable.

5. Research should be undertaken on short-tailed bats to:

- determine the size and viability of populations.
- establish methods to monitor populations during 1080 operations.
- describe the diet of short-tailed bats in areas likely to be subject to 1080 operations.
- establish whether lures used on poison baits attract or repel short-tailed bats.
- verify whether short-tailed bats eat carrion.
- obtain toxicity estimates for 1080 in short-tailed bats, using the Approximate Lethal Dose Technique (Tattersall 1982, & BTS 1984).

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