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MODELLING FOR RESEARCH ON CHEMICAL CONTROL OF MAMMALS IN NEW ZEALAND

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ABSTRACT: Development of predictive formulae or qualitative statements about the probable outcome of control campaigns entails knowledge of bait quality and distribution, behaviour, vagaries of weather at the time of the control campaign, and other factors which govern the probability that the target animals will accept bait.

This paper collates experience in recognising, estimating and using some of these variables for predicting the outcome of large-scale poisoning, and discusses possible approaches to the solution of some hard-core problems.

INTRODUCTION

Mammalian pest control in New Zealand has been concerned for many years with some serious problems resulting from the introduction of deer, marsupials, lagomorphs, rodents and birds. Although several of the mammals have turned out to be fairly harmless additions to the fauna, European red deer, fallow deer, chamois and rabbit, Himalayan thar, the Australian red-necked wallaby and brush-tailed opossum and feral goats and pigs have become very important pests. An immense amount of effort has been devoted to their control. Over the past 20 years, sustained control campaigns, the inroads of recreational hunting, the development of commercial game meat markets and in some cases malnutrition, have caused great reduction in the numbers of most of these animals.

Surveys have commonly shown reductions of deer densities exceeding 50 per cent and ranging up to 90 per cent (Challies, 1973; Batcheler, 1973c). Regarding goats, pigs, chamois, thar and wallabies, there have been few attempts at numerical assessment of change. With few exceptions, numbers killed per hunter per day are down by 50 per cent or more (unpubl. New Zealand Forest Service data) while condition as measured by body weight, or horn or antler growth are improving (Lambert and Bathgate, 1973 unpublished). It can be concluded that the technology of control by hunting on foot, by helicopter, by aerial broadcasting of baits or hand-laying of poisoned cuttings of preferred shrubs, is adequate to deal with most of the problems.

However two species, the European rabbit (*Oryctolagus cuniculus*) and the Australian brush-tailed opossum (*Trichosurus vulpecula*) continue to pose some intractable problems. Opossums in many of the forested regions are causing considerable damage to protection forests, production forests, and pastures adjacent to forest cover. They have also been implicated in maintenance of bovine tuberculosis in a few districts.

By comparison, rabbit numbers have been greatly reduced over most of the country. Extensive and repeated aerial and ground poisoning campaigns, hunting by gun and dog teams, and hunting by spotlight from vehicles, have been carried out over virtually all "rabbit prone" country for the past 25 years. The campaign still costs about $NZ 4.5 million per annum. In the same period there have been major changes in farming practices, particularly in oversowing grasslands with clover and grass seed, and topdressing with superphosphate, trace elements, and sulphur. These changes have reinforced direct control since the taller, more luxuriant swards are less favourable to rabbits (Bull, 1956; Howard, 1958). But in a few areas, particularly the low-rainfall regions of inland South Island where pastures are open and response of vegetation is very slow, sustained and intensive hunting and poisoning have failed to reduce rabbits to tolerable numbers.

THE PATTERN OF CONTROL BY POISONING

As described in another paper in this Conference (Godfrey, 1974), aerial baiting in winter with poison 1080 on chopped carrots has been the most widely used method for controlling rabbits and opossums. In some areas oats are used in late summer against rabbits, and in others, phosphorus, arsenic or (very rarely) strychnine are used instead. Typically, in rabbit control, the alternative poisons have been used where farmers have claimed that 1080 poses an intolerable hazard to farm dogs (which may be killed by scavenging upon 1080-poisoned carcasses) or livestock, or where its use has been blamed for past failures of control operations.

To a large extent the first two of these problems are illusory. The risk to dogs has been contained by many farmers who muzzle them and keep them scrupulously well fed while there is the slightest risk of danger through scavenging. Likewise, dangers to livestock can be minimised if poison concentrations are kept to the low levels specified from experimental work (McIntosh, 1958; Rowley, 1960), and if Government facilities are used for assaying residual toxicity of baits before stock are returned to treated areas.

The Demography of Success or Failure

There is considerable evidence that condition and density of the pest population influence the kill. In field trials with opossums, the percentage kill is inversely related to condition, and positively related to density (Batcheler, Darwin and Pracy, 1967). The effect, judged from a series of trials between 1956 and 1959 with pollard based baits, is doubly density dependent, in that the highest per cent kill and the least absolute number of survivors can be expected where initially density is highest and fat reserves are smallest. The importance of condition as a predictive measure of probable kill has been confirmed from a series of trials with an inexpensive grain bait by Bamford and Martin (1971).

These relationships are intuitively predictable, and amount to a formal statement of an old pest control axiom that when numbers are high and condition is poor, the population is "stacked" for a massive kill almost regardless of the technique used.

However, the relative importance of these parameters, and their mode of influence on the result of poisoning, has not been established with reasonable certainty. Condition undoubtedly measures the probability that an animal is hungrier and will therefore be more likely to search for baits. But the role of density *per se*, which is known from partial correlation analysis (Batcheler *et al*., 1967) to exert an effect which is independent of its usual homeostatic relationship with condition, is not so clear. It has been suggested that the effect of high numbers of animals on breakdown of territorial constraints on movement may be significant, but this has yet to be adequately investigated.

Behavioural Aspects of Success or Failure

A great deal of practical experience indicates that the stated significance of these two simple demographic characteristics on control of opossums is equally applicable to rabbits. While this is a reasonable advantage to pest control authorities in the routine task of planning the relative priorities of operations in different areas, it is cold comfort to the farmer or protection forester. Predictability of the percentage which will be killed implies predictability of the percentage which will survive. This in turn implies that, with our current techniques, numbers cannot be efficiently reduced unless they are so high that condition is adversely affected, and significant and often irreversible damage is done to the habitat.

Early experiments in Australia (Rowley 1960, 1963) have shown no evidence of aversion by rabbits to 1080 either at first contact, or following repeated sublethal doses administered in carrot baits. In experimental conditions, followed by much practical experience, the most common cause of failure has been related to unavailability of baits to individual rabbits whose ambit of movement and feeding is outside the area poisoned (Rowley, 1958; Poole, 1963).

An experiment in the sub-arid zone of the South Island (Bell, 1973 unpublished) has further emphasised behavioural traits as a cause of failure of 1080 poisoning operations. In this, rabbits on a 480 acre block were presented at weekly intervals with two non-toxic "free-feeds" of chopped carrots which had been marked with the UV fluorescent dye, Rhodamine B. Each application of bait was sown from the air at one ton per 100 acres - about four times the usual rate - to ensure that adequate bait was available for every animal, and that the whole block was covered. This gave at least 400 baits per animal. About 60 per cent of them were taken within a week of application, and those remaining were concentrated in long grass and steep rocky sites which were not occupied by rabbits.

A further week later, 1080 poisoned bait was sown, without the dye; mortality was assessed by spotlight counts at 75 per cent.

A sample of 242 poisoned animals collected two days after poisoning all showed intense staining of Rhodamine in the mouth, on the fur, the paws, and in the anal area - good evidence that they had all taken a liberal quantity of the non-toxic bait, as well as the toxic material. However, a further week later, when a sample of 63 survivors were shot, only three showed traces of Rhodamine. That is, most of the survivors did not accept either the non-toxic or the toxic bait. Thus, the evidence suggests that the operation failed because about one quarter of the rabbits did not eat carrot baits although each of the three applications theoretically made enormous quantities of bait available. Failure was not caused by aversion to 1080 poison.

Whatever factors precluded acceptance by the survivors - whether it was simple aversion to carrots, innate timidity of some individuals, or effective innaccessibility of baits to them by virtue of social subordination to other members, the failure illustrates the unlikelihood of success by saturation. A change of strategy rather than of materials, is indicated. Perhaps the West Australian technique of mixing non-toxic and toxic oats in a "one shot" operation (Gooding, 1961) suggests the necessary change. "Precocious feeders" are bound by chance to be eliminated quickly, leaving sufficient bait for individuals which are slow to accept it.

Another aspect of the relationship between technique and the ecology of survival is suggested by observations from opossum control operations. Following ingestion of a lethal dose of 1080, many victims return to and die in nests or burrows (for opossums L. T. Pracy pers. comm., in Batcheler, 1968; for rabbits Wodzicki and Taylor, 1957). These nests are avoided by survivors, and if the absolute quality of alternative nests and their spatial arrangement with regard to food resources is inferior, it follows that survivors will be exposed to new hazards which would not have arisen if victims had died at the baiting site. This mechanism may explain the occurrence of deaths for several months after some 1080 poison campaigns against opossums (Batcheler, 1968). These observations also provoke the guess that for both opossums and rabbits, both of which depend on communal burrows or nests, that slow action of the organofluorines - allowing victims the opportunity to return to a nest - may be the most important property of 1080 or any other toxin which might be used against these animals.

PURPOSE, DESIGN AND FUTURE OF FIELD EXPERIMENTS

These observations show that density, condition and behaviour interact with the tactics, baits and poisons of a control operation with an intricacy which cannot be seen or interpreted within the constraints of a component-by-component laboratory oriented study. Put another way: practical control conditions are the only ones in which we have much hope of discovering what kinds of problems we are trying to solve.

Successful analysis of control operations also favour large-scale experiments. Where the object is to test a specified bait or method, the experiment must be based on comparison of the selected material (A) with a standard (B), against populations with similar demographic characteristics, and include an assessment of extraneous effects (of weather, seasonal change of behaviour) in an untreated control area (C). Taking account of the logistics of applying bait from the air and the sampling difficulties of estimating the key parameters without disrupting the direct interactions between the population and the test method, each cell in the ABC array involves about 400-500 acres. Without replication, this involves some 1,200 to 1,500 acres per experiment.

Because of this emphasis on large-scale trials, considerable effort has been devoted to developing reasonably accurate and flexible methods for estimating density, reduction of density, condition, and the density, dispersion and disappearance of baits.

For rabbits, numbers seen by spotlight give reasonable estimates of relative density particularly if estimating formulae include allowance for dependence of the count on wind speed, temperature and rainfall. Counts are, however, influenced by height of vegetation, topography and time (Rowley, 1968). Therefore, they give reasonable estimates of relative density, but not absolute density.

The estimation of opossum numbers in dense mountainous forest is virtually impossible by direct methods. Instead, various techniques based on trapping (Batcheler *et al.*, 1967) or interference with non-toxic baits (Bamford, 1970a) have been investigated. They are based on the binomial model derived from the assumption that when individuals are uniformly liable to be caught in a trap (or interfere with a bait), the catch (c) at any time is:

$$c = m[1 - (1 - p)^N]$$

where N is the number of animals, p is their probability of capture, and m is the number of traps or bait stations set. From this:

$$N = \log(1 - c/m)/\log(1 - p)$$

More recently, work has been concentrated on use of fecal pellet counts. Estimates of pellet density are made before and after the poison is laid (N_1 and N_2), either by measuring weighted frequency of occurrence of pellets within bounded plots (Bell, 1973 unpublished), or by measurements of distance from each sample point to the nearest pellet and from that pellet to its nearest neighbour (Batcheler, 1973a). Subsamples of pellets are marked (k_1) at the time N_1 is estimated, and if k_2 of them remain at the time N_2 is measured, per cent kill is given by an approximation of a formula developed for pellet count census of rabbits by Taylor and Williams (1956). The approximation is:

$$\% \text{ kill} = 100 \left[1 - \frac{(N_2 - N_1 k_2/k_1)}{(N_1 - N_1 k_2/k_1)}\right]$$

as given in Batcheler (1973b).

The point-distance-nearest neighbour technique gives good estimates of density, changes of dispersion and disappearance of baits.

Contemporary field techniques for estimating condition have been developed from a basic study of carcass fat of opossums (Bamford, 1970b). He showed that variation of weight of individuals of given length is correlated with fat reserves in the carcass. From this, observed weight divided by standard weight for a given length, gives a simple method which discriminates between populations.

Trials of the ABC pattern, and special purpose trials involving labelling of baits, backed by adequate field techniques, will doubtless form the cornerstone of a definitive bait and tactics development programme. Already, such experiments have been adequate to rank the merits of some bait materials. Given a particular material, estimation of the result compared with prediction based on density and condition gives a sound basis for identifying exceptions to the rules. Demography and density gives a systematic basis for assigning priorities to control operations. Weak points in the strategy of control, and intriguing interrelationships between strategy, pharmacology and the ecology of the target species have been raised and await systematic investigation. Doubtless, many further points and patterns remain to be identified and measured from future trials.

Perhaps however, the cardinal point of this paper is that this work reiterates the utter importance of relating research problems and control techniques to the biology of the animal. It's an old lesson which has to be relearned by pest control organisations everywhere, once the flush of empirical successes begins to founder in the lack of understanding of failures.

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