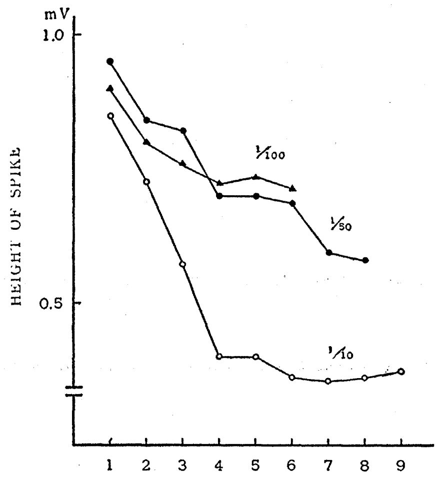

Fig. 2. Decrement in the height of spikes obtained in response to various concentrations of amyl acetate vapor for the same unit.

Odors of *n*-amyl alcohol, *n*-butyl alcohol, florida orange, spike lavender, and clove leaves were used as stimuli. The height of spikes decreased gradually, as did the response to amyl acetate, when high concentrations of these odors were used. When three different odors (all 0.5 ml puff of 1/50) were applied to the same single unit, the average frequency of spikes per second was: amyl acetate 13.0, florida orange 14.1, spike lavender 16.3. No great specificity to odor qualities was observed.

When a 30-second stimulation with amyl acetate was applied, spike height recovered after the initial spikes had decreased in height or had temporarily disappeared, and the newly maintained steady-state frequency was usually lower than that of the initial spikes. In many experiments spontaneous spike discharges were recorded which were inhibited suddenly or accelerated in frequency by olfactory stimulation. Tucker (*4*) reported that with long odor stimulation (0.5 to 1 minute) of the olfactory epithelium, a short phasic response was followed by a steady-state activity of the olfactory nerve twig which was maintained until stimulation ceased.

It is presumed that these positive spike discharges in response to odors were led from the olfactory cell body rather than from its axonal extension. However, why the spike height should decrease so strongly with increase in spike frequency is not yet clear. The decrement of the spike height may result from a change of the membrane resistance in the receptor cell (*7*).

TATSUAKI SHIBUYA
SACHIKO SHIBUYA
Department of Physiology,
Florida State University, Tallahassee

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Population Control in Animals by Overloading Resources with Sterile Animals

Abstract. *Sterile animals might be introduced into a population to overload a resource. As a result, some of the original fertile animals might be lost by migration or death. This process could be repeated until the fertile population was eradicated without the mating required by Knipling's models. This method may be of use in ecology and in economic control of populations.*

In economic practice a population of harmful animals is usually controlled by killing a proportion of the population. This method has also been used by experimental ecologists to study the reactions in a population when its numbers decline (*1*). But no one seems to have used the reverse method of deliberately augmenting the harmful population in order to overload a resource and thus bring about a population "crash." The results of overloading a resource are well seen in two examples, the fate of a deer population on the Kaibab plateau (*2*) and the history of the *Cactoblastis* moth introduced into Australia (*3*). The deer increased after predators had been killed; they damaged their pastures so much that the population crashed and did not subsequently reach the levels that had been maintained under predation. Similarly, *Cactoblastis* was able to increase so rapidly on a superabundant source of food (*Opuntia* cacti) that it permanently reduced both the quantity of the resource and its own numbers to levels nearer those in its original environment in America.

This method has probably not been tested against harmful animals because many of the resources which might be overloaded are also used by man. But in special circumstances this difficulty might be overcome by introducing sterile animals to overload a resource. After the crash the population would be diluted with nonbreeding animals. Repetition of the process could, in principle, lead to complete replacement of fertile animals by sterile ones.

This notion may be illustrated by hypothetical examples. Suppose that the number of animals in a natural population is kept at N_0 by a shortage of an inconsumable resource. For convenience, assume that the resource is shelter during an unfavorable season and that over the short period we are considering, birth rate and death rate equal zero. Assume also that all the shelter is fully occupied and that any animal which leaves it is lost to the population. If any animals are introduced into such a population a struggle for shelter will ensue during which the excess animals will be driven out and lost. If we introduce N_s sterile animals into this population it will settle down after the struggle with a total of N_0 animals, but of these only $N_0^2/(N_0 + N_s)$ will be fertile, the remaining $N_0 - [N_0^2/(N_0 + N_s)]$ being sterile. This conclusion depends on the further assumption that each member of the original population is equivalent to each of the sterile newcomers in the struggle for shelter.

If this "flushing" were repeated with N_s sterile animals at each flush, the population would be progressively diluted by sterile animals (see Table 1).

The efficiency of flushing should be increased by overloading a *consumable* resource. Assume that sterile animals are in such numbers that they deplete the consumable resource to a level at which it will no longer support a population N_0. During the first flush, animals will leave the population by death or emigration until the total number remaining is less than N_0. The total number of fertile wild animals among the survivors will be less than the $N_0^2/(N_0 + N_s)$ which remained in the first model.

The foregoing models are based on simple assumptions in order to illustrate the idea of flushing; they are not

Table 1. Predicted number of animals in a population control experiment.

Fertile	Sterile
Before flushing	
N_0	0
After first flush	
$N_0^2/(N_0+N_s)$	$N_0-[N_0^2/(N_0+N_s)]$
After second flush	
$N_0^3/(N_0+N_s)^2$	$N_0-[N_0^3/(N_0+N_s)^2]$
After xth flush	
$N_0^{(x+1)}/(N_0+N_s)^x$	$N_0-[N_0^{(x+1)}/(N_0+N_s)^x]$

intended to represent any natural populations. However, as has been shown (*2*, *3*), some natural populations do respond to overloading of consumable resources in the way which the models require, and as Errington has shown, other populations are limited by the supply of inconsumable resources. Errington found that the numbers of muskrats (*4*) and bob-white quail (*5*) were limited by the amount and quality of cover in the environment. If the population rose above these limits, the superfluous animals were forced out of the population, usually to be killed by predators.

Flushing may be contrasted with the process of eradication described by Knipling (*6*) in which sterile males lower the birth rate by mating with fertile, wild females. So far the design of field programs with sterile males has been based on the Knipling effect and the results have been interpreted in terms of his models. The existence of flushing and its importance relative to sterile mating could be looked for in such programs. This information may in turn suggest better ways of using sterile animals. For example, if sterile animals were released into a population which was out of its breeding season, unmixed flushing might occur, to be succeeded by the Knipling effect at the onset of the mating season. In other circumstances the two mechanisms might work side by side.

If flushing is considered for use against pests, the resource to be overloaded should be carefully chosen in order to minimize the total damage done by sterile and wild animals during attempted eradication or control. For example, the larvae of many species of Diptera and Lepidoptera use or destroy resources also used by man, but the adults may not do so. Such species might best be treated by overloading one of the adult resources.

Flushing would probably be most easily demonstrated in populations which undergo periodic reduction in numbers, remaining for some time at this low level with one or more depleted or easily overloaded resources. For example, flushing might be tried just before the animals seek shelter at the onset of winter or during a long drought when numbers are low and resources depleted. The susceptibility of a species may be linked with intolerance of overcrowding; obviously a population whose members emigrate or cease to breed at low levels of crowding should be more easily flushed than one in which the animals remain, provided that no other resource is depleted or overloaded. Various influences may be expected to reduce the efficiency of flushing. The methods of rearing and of sterilization may damage the animal in other ways so that it is not equivalent to a wild animal. For instance, ionizing radiation, which is often used to sterilize animals is known to shorten life. Social interaction may favor the established members of a population over artificial or natural immigrants and this too would reduce the efficiency of the process.

Flushing may or may not have economic value but the technique of artificially augmenting natural populations with either sterile or fertile animals could be useful in experimental ecology. When a population is small in relation to its apparent resources the influences which keep it down may be obscure. By augmenting the population, responses to crowding and the nature of the limiting resources (if any) might be made manifest. The complementary technique of removing a proportion of the population has been used to study the reactions to undercrowding in populations of vertebrates such as chipmunks (*7*), birds (*1*), and deer (*8*). Where experimental resources are sufficiently great, more information might be gained by controlled and replicated experiments that use both artificial overcrowding and undercrowding as experimental treatments.

J. Monro

School of Biological Sciences,
University of Sydney,
Sydney, New South Wales, Australia

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Antarctic Micrometazoa: Fresh-Water Species in the McMurdo Sound Area

Abstract. *The multicellular microfauna in fresh-water bodies of Ross Island and the nearby continental coast of Victoria Land is strikingly impoverished with respect to major groups. Yet there are thriving populations belonging to the Rotifera, Nematoda, Tardigrada, and Turbellaria.*

Relatively little study of the fresh-water microfauna of the McMurdo Sound area has been undertaken since James Murray wintered over with the Shackleton party in 1909 at Cape Royds (*1*). A brief reconnaissance was carried out by Dougherty in 1959 (*2*), and rather extensive distributional records have been published more recently by Armitage and House (*3*) as part of a broad limnological program. But Murray's reports provide evidence, largely explicit, for all forms that have subsequently been recorded.

Our research program in the Antarctic (extending from early November 1961 to mid-October 1962) combined field and laboratory work. The facilities of the U.S. Antarctic Research Program's Biology Laboratory on Ross Island were essential to both phases. Initially (during antarctic summer 1961–62) field investigations—primarily systematic collecting from lakes and ponds—were the dominant activity, the laboratory being used for preliminary survey of samples and for storage of material to be studied later. Thanks to transport by helicopter, we were able to explore a diversified section of the Ross Dependency up to about 130 km from the McMurdo base. With the onset of the 1962 winter, work was largely confined to the laboratory.

Major locations investigated on Ross Island and the antarctic mainland are