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.

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26 February 1963

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 indicated in Table I. These are snow-free areas all or part of the year, with lakes and ponds that thaw, at least partially, between November and February. Several sites were visited more than once; trips to Cape Evans and Cape Royds were made weekly during the summer to estimate the extent of seasonal changes in the microfauna of two lakes, one at each location.

The organisms collected came from the dried blue-green algal mat ("felt," 2) particularly abundant along the leeward edges of lakes and ponds, from the algal felt covering pond bottoms (in some locations strips become buoyant, detach from their substrate, and are found floating in open water or frozen in the ice at or near the surface), or from moss growing in areas of periodic runoff. Felt or moss brought in from the field was sometimes examined directly for inhabitants. But the more usual procedure was to put a fragment of felt in a finger bowl of distilled water and allow it to soak for a day or two in an illuminated incubator at 4°C. The finger bowl was then scanned at room temperature under a dissecting microscope. Storage at 4°C and reexamination at irregular intervals followed. Individual organisms were selected for closer study by micropipette.

We found micrometazoa of but four major taxa: the Rotifera, Tardigrada, Nematoda, and Turbellaria. With the literature available at the McMurdo laboratory (4) it was possible to identify most of the rotifers and tardigrades (see Table 1), but not the nematodes or turbellarians. In instances where adequate descriptions of rotifer and tardigrade species were available [mostly in Murray's monographs (*1*)], we were able to recognize the forms in question in our collections (12 species of rotifers and 4 of tardigrades). In addition, we have observed a species of bdelloid—*Adineta* sp. (perhaps one of three of that genus listed without description by Murray)—and two species of monogonont rotifers not recorded by Murray, one a loricate type and the other probably a notommatid. Continued taxonomic study awaits the arrival of frozen samples now en route by ship to the United States.

Nearly all samples of wet algal felt contain populations of rotifers, tardigrades, and nematodes. By contrast, the occurrence of microturbellarians is inconstant; conditions favoring their presence have not yet been defined. Rigorous census taking of the various micromatozoa in the natural state is a problem for the future. But semiquantitative aspects of certain populations are so outstanding as to merit brief description. On the bottom of many shallow ponds the red-pigmented rotifer, *Philodina gregaria,* is spectacularly abundant, forming blood-red areas that may be many centimeters in diameter and are often seen beneath a transparent ice cover; each patch consists of a crowded carpeting of attached organisms, one rotifer thick. *Philodina gregaria* is surely the most conspicuous nonmarine invertebrate of the Ross Island area. Another striking population feature, although not macroscopically evident, is the abundance of tardigrades, especially of *Hypsibius arcticus,* in most ponds; a sample of algal felt typically reveals numerous individuals. In warmer climates tardigrades are rarely abundant members of the zoöbenthos.

The year's experience has pointed up certain challenges to future investigators. The simplified fresh-water ecology —with, for example, absence of representatives of such major taxa as the Crustacea, Gastropoda, and Annelida—promises unusual opportunities for studies of natural communities in which the number of biological variables is drastically reduced. For more intensive study of seasonal fluctuation in the zoöbenthos, we recommend as a working area one of the Daily Islands, each of which has but a few ponds, enjoys a calmer, warmer climate than areas on Ross Island, and offers the special advantage of limited human intrusion (see 5).

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Table 1. Distribution of species of fresh-water rotifers and tardigrades found in present study (+ = present).

Species	Locality												
	Ross Island				Victoria Land								
	Naval Air Facility	Cape Evans	Cape Barne	Cape Royds	Wright Dry Valley	Marble Point	Taylor Dry Valley	Stranded Moraines	Daily Islands	Blue Glacier	Hobb's Glacier	Brown Island	Walcott Glacier
ROTIFERA: **Bdelloidida***													
Adineta barbata	+			+			+		+		+	+	+
A. grandis	+	+		+		+	+	+	+	+	+		
Adineta sp.†	+					+							+
Habrotrocha angularis				+		+			+				
H. constricta	+	+		+	+	+	+	+	+	+	+	+	+
Macrotrachela habita	+	+		+	+	+	+			+	+	+	+
Philodina alata	+			+	+	+	+	+				+	
P. antarctica				+		+			+	+	+	+	+
P. gregaria	+	+	+	+	+	+	+	+	+	+	+	+	+
ROTIFERA: **Monogontida**													
Cephalodella tenuior				+					+		+		+
Collotheca ornata var. *cornuta*				+		+	+		+	+	+		+
Epiphanes senta				+			+		+		+		
Pleurotrocha sp.	+	+		+		+					+		
Loricate form				+		+	+				+		
? *Notammatid* sp.	+			+		+	+		+	+	+		
TARDIGRADA													
Hypsibius alpinus	+			+		+	+				+	+	
H. arcticus	+	+		+	+	+	+		+	+	+	+	
H. oberhaeuseri				+		+	+	+	+			+	
Macrobiotus polaris						+	+						

* Armitage and House (*3*) record "*Philodina spp.*" as the only bdelloids; presumably they chiefly found *Philodina gregaria.* † Probably identical with one of three *Adineta* species listed by Murray (*1*) without description.

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5. Supported by grant G-18802 from the National Science Foundation. We thank the U.S. Naval Air Facility-McMurdo for providing helicopter transportation.

11 February 1963