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Use of Iodine-131 To Measure Movements of Small Animals

Abstract. A technique utilizing iodine-131 was developed to study the movements of *Microtus pennsylvanicus* in the field. Iodine-131 (½ mc) was placed in a polyethylene capsule and inserted beneath the animal's skin. Movements of the animal were then followed for periods of up to 2 weeks by means of a Geiger-Müller counter attached to an aluminum pole.

Radioactive isotopes have been used for approximately 12 years to measure movements of small mammals in the field [Brian (*1*) had used a radioactive isotope (radium sulfate) to study the movements of click beetles as early as 1947.] Godfrey (*2*) placed cobalt-60 in metal leg bands to study the movements of *Microtus agrestis* and Kaye (*3*, *4*) used gold-198 wire, injected subcutaneously, to study the movements of *Reithrodontomys humulis humulis*. Thus, it may be seen that the use of radioactive isotopes to trace the movements of small mammals is not a new technique. However, it was felt that certain modifications might make the isotope technique a much more useful research tool to the field biologist. The method reported here was developed and used to study movements of *Microtus pennsylvanicus* within a bluegrass-timothy seral community.

Iodine-131 dissolved in a sodium sulfite solution was selected for use in this method for the following reasons: (i) the isotope in this form can be handled easily and with minimum contamination of equipment; (ii) its half-life of 8.1 days and the fact that it could be used by other investigators at this university made its use quite inexpensive; (iii) the 8.1-day half-life also makes I^{131} safer to use in the field than an isotope such as Co^{60}; and (iv) I^{131} is a high-energy gamma emitter (0.08 to 0.72 mev), which makes detection in the field relatively easy. To prevent rapid absorption and excretion of the isotope by the animal, the I^{131} was placed in a polyethylene capsule.

The polyethylene capsule was constructed from polyethylene tubing of two sizes, with outside diameters of 0.043 and 0.062 inch, respectively. A 1-inch piece of the smaller tubing was inserted, to a depth of ½ inch, into each end of a 2-inch piece of the larger tubing, which later served as the main body of the capsule. Occasionally it was necessary to seal the joints between the smaller and larger tubing with a drop of Duco cement to assure an airtight seal. A hypodermic needle with a syringe attached was inserted into one end of the unfinished capsule, and a small amount of sodium sulfite solution containing I^{131} was then drawn into the tubing. The amount of activity in the capsule can readily be adapted to experimental conditions by changing the volume or concentration of the I^{131} solution drawn into the tubing. In our field work 0.5 mc of I^{131} was placed in each 1-inch capsule. When the proper amount of solution had been drawn into the tubing, the end of the tubing was removed from the stock solution. The solution in the tubing was then drawn into the central portion. The two ends of the tubing were then cut and sealed with an ordinary woodburning tool.

The reason for placing a section of the smaller tubing in each end of the larger tubing was twofold: (i) it provided additional polyethylene to assure a good seal when the overlapping ends of the tubing were cut and sealed with the woodburning tool, and (ii) it made it possible to place I^{131} solution in the tubing without contaminating the external surface of that part of the tubing which formed the capsule.

After the capsule had been prepared it was inserted subcutaneously into a mouse by the following method. The capsule was placed in a 12-gauge hypodermic needle. The needle and capsule were then inserted beneath the skin of the mouse. The capsule was implanted beneath the animal's skin by gradually withdrawing the needle while pushing the capsule out by means of a wire rod. This insertion technique had been previously used by Kaye (*3*) to insert Au^{198} wire beneath the skin of *Reithrodontomys humulis humulis*. Usually four animals were tagged and released during each study period. Each of these animals had been trapped at least four or five times prior to tagging. This precaution was taken in an attempt to prevent the tagging of transient animals and to gain some idea of the approximate area within which the animal might be found after it had been tagged.

After its release at the point of capture the mouse was followed by means of a Thyac model 389C survey meter attached to an 8-foot aluminum pole (Fig. 1). A Geiger-Müller beta window tube with a wall thickness of 30 mg/cm^2 was placed in the end of the pole, and a small window was cut in the pole beneath this Geiger-Müller tube to facilitate detection of the gamma radiation from the I^{131}. The operator made

Fig. 1. The instrument used to track I^{131}-tagged *Microtus pennsylvanicus* in the field.

sweeps with the pole, checking half-circle areas of 8-ft radius in front and to the side of him to detect the presence of the tagged animal. Activity of ½ mc in the capsule made it possible to determine the approximate location of the mouse when the Geiger-Müller tube was 3 or 4 feet away. The location of the animal was then determined within 3 or 4 inches by using the meter and headphones. The location of a tagged animal several inches below the surface of the ground could not be accurately determined with the equipment and level of activity used in this experiment.

Once the tagged mouse had been found the operator remained in position until the animal moved to another location. The first location was then marked by tossing a numbered pressed wood board, 4 by 4 inches, on the place to be marked. This method of marking made it unnecessary to approach and perhaps disturb the animal. After a tracking period of 1 or 2 weeks the location points were mapped by means of a surveyor's transit and tape. The tagged mice were recaptured at the end of the study period, and the capsules were removed. After removal of the capsules these animals were often retagged in the laboratory and released again for further tracking.

ARTHUR G. JOHANNINGSMEIER
CLARENCE J. GOODNIGHT
Department of Biological Sciences, Purdue University, Lafayette, Indiana

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26 February 1962

Prediction of Ultrafiltration Membrane Performance

Abstract. A theory for ultrafiltration is presented which makes possible the characterization of a membrane at a given temperature and solute concentration by a single experiment at that temperature and concentration. The theory is applied to data in the literature and is shown to be consistent with those data.

Ultrafiltration data show that salt rejection improves as the pressure across the membrane increases (*1–3*). Heretofore, no completely satisfactory explanation of this phenomenon has been presented. An explanation of the phenomenon with a demonstration of its application to experimental data is presented in this report.

Table 1. Summary of calculations of J, J', $\mu_1 - \mu_2$, and $\mu'_1 - \mu'_2$ from data of Ambard and Trautmann (*1*).

Pressures and compositions	J	J'	$\mu_1 - \mu_2$	$\mu'_1 - \mu'_2$
	Data			
$(p_1 - p_2)$, kg/cm²	0.9	2.2	3.5	4.4
Filtrate, ml/hr	37	90	136	168
Filtering solution, NaCl mg/lit.	100	100	100	101
Filtrate, NaCl mg/lit.	89	77	69	67
	Calculations			
Water flow, J g/hr	37	90	136	168
NaCl flow, J' 10^{-3} g/hr	3.29	6.92	9.39	11.2
n_1, 10^{-5} mole/mole	3.08	3.08	3.08	3.11
n_2, 10^{-5} mole/mole	2.74	2.36	2.12	2.06
$RT \ln(1 - n_1/1 - n_2)$, 10^{-3} cal/mole	−2	−4	−6	−6
$RT \ln(n_1/n_2)$, cal/mole	68.2	156	219	240
$\bar{v}(p_1 - p_2)$, cal/mole	0.38	0.93	1.49	1.87
$\bar{v}'(p_1 - p_2)$, cal/mole	0.4	0.9	1.4	1.8
$\mu_1 - \mu_2$, cal/mole	0.38	0.93	1.48	1.86
$\mu'_1 - \mu'_2$ cal/mole	69	157	220	242

The driving force for ultrafiltration is the chemical potential μ. If interference between components is negligible, the flow rate of each component is dependent upon the change in its own chemical potential as it passes from the solution on one side of the membrane to that on the other side and is directly proportional to the degree of change, to at least a first approximation. Then the rate of flow of solvent across the membrane is

$$J = (\mu_1 - \mu_2)/r \qquad (1)$$

where r is the resistance to flow of solvent. If the liquid phases are agitated sufficiently to make film resistances negligible, the major resistance to flow is offered by the membrane, and

$$r = d/D \qquad (2)$$

where d is the thickness of the membrane and D is a modified diffusion coefficient for the solvent in the membrane analogous to the Fick diffusion coefficient.

The analogy between D and the Fick diffusion coefficient can be seen by substituting Eq. 2 into Eq. 1, so that

$$J = [D(\mu_1 - \mu_2)]/d \qquad (3)$$

Equation 3 shows that D relates flow rate to chemical potential gradient, just as the Fick diffusion coefficient relates flow rate to concentration gradient.

The available data show only that D and r do not vary appreciably over a limited pressure range. Variation with temperature, concentration, or other factors remains to be determined.

Similarly, the rate of flow of a dissolved component is

$$J' = (\mu'_1 - \mu'_2)/r' \qquad (4)$$

At constant temperature, the chemical potentials depend upon pressure and the amounts of the dissolved materials present. The resistances remain constant over wide ranges of pressure.

Experimental data from Ambard and Trautmann (*1*) which demonstrate improvement in salt rejection with increase in pressure are shown in Table 1, rows 1 through 4. Calculations based on these data make up the remainder of the table. A temperature of 21°C was

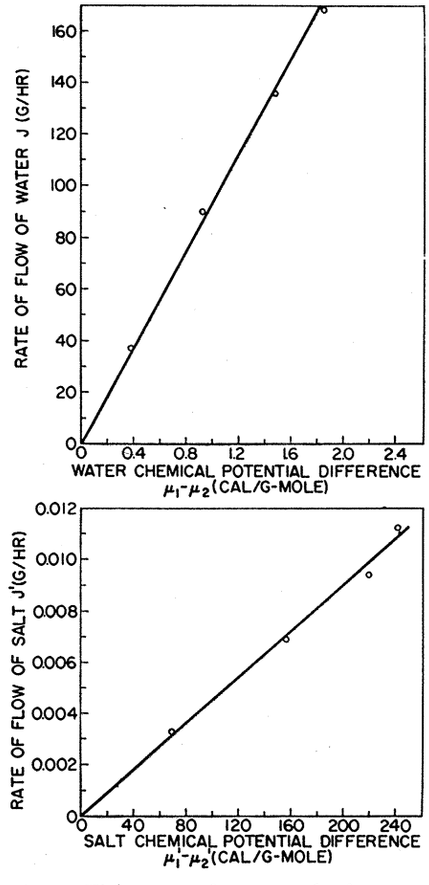

Fig. 1. Flow rates of water and salt across an ultrafiltration membrane as functions of the respective chemical potential differences across the membrane. [From data of Ambard and Trautmann (*1*)]