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ENVIRONMENTAL PROTECTION AGENCY

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This study performed under Memorandum of
Understanding No. SF 54 373
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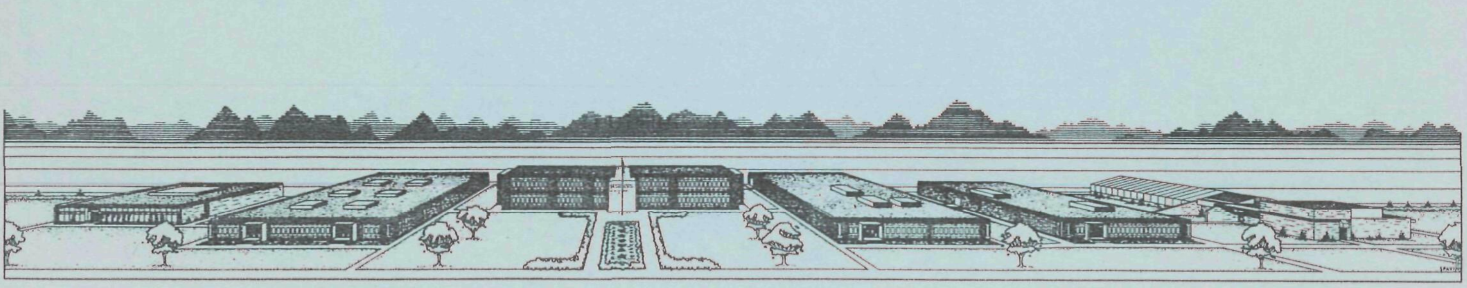

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*Formerly Southwestern Radiological Health Laboratory, part of the U.S. Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service, Environmental Control Administration, Bureau of Radiological Health.

## ABSTRACT

Hay bales were placed 30 to 50 miles from surface ground zero in the predicted downwind direction of the effluent from Project Schooner, conducted December 8, 1968. Subsequent to contamination, the hay was recovered and fed to groups of dairy cows in a controlled ingestion experiment. As noted in similar experiments during the Cabriolet and Buggy cratering tests, the secretion of $^{131}I$ in milk was below expectations. Less than 4% of the ingested $^{131}I$ was secreted in milk, and the peak milk concentration was less than half the expected value.

Concurrent measurements of $^{187}W$ transfer indicated that less than 0.07% of the ingested tungsten was secreted in milk and that the peak concentration in milk was only 0.0002 times the peak concentration of tungsten in hay.

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## I. Introduction

The results of radioiodine studies in dairy cows following the Kiwi TNT and Pin Stripe events[1,2] indicated some differences occurred in the forage-cow-milk system which appeared to depend on the gaseous/particulate ratio of the debris deposited on cow forage. This ratio appears to vary with distance normal to the centerline of the effluent cloud. During the Cabriolet and Buggy tests [3], an attempt was made to confirm this point, but the data obtained were unsuitable for this purpose. Project Schooner presented another opportunity to explore these differences.

Since Schooner was to be executed in December and since dairy cows are fed hay at this time of year, hay was used in this study. Baled hay was placed at selected locations in the expected downwind pattern of the Schooner effluent at distances farther from surface ground zero (SGZ) than those used during Cabriolet and Buggy. After cloud passage, measured amounts of hay from certain locations were fed to dairy cows in a controlled ingestion experiment.

The experiment was planned to accomplish the following objectives:

A. To determine the amount of radioiodines and $^{187}W$ deposited on baled hay and secreted in the milk of cows fed this hay;

B. To determine the differences, if any, in the forage-cow-milk system for these isotopes when the cows are fed hay from bales contaminated by different portions of the cloud;

C. To search for correlations among such parameters as gaseous/particulate ratio, integrated air concentration, planchet deposition and exposure rates on the one hand and forage contamination, peak milk concentration and effective half-life on the other hand.

Project Schooner was a nuclear experiment in a layered tuffaceous medium executed as a part of the Plowshare Program for development of nuclear excavation. Schooner was detonated on 8 December 1968 at approximately 0800 (PST), in Area 20, Nevada Test Site (NTS). The resultant yield was 31 ± 4 kt. Emplacement depth (to the working point) was 108 meters (355 feet).

## II. Procedure

Sixteen stations were established at different azimuths downwind from surface ground zero, stations 1-11 are shown in Figure 1. Each station had 25 bales of hay arranged in a grid pattern (rather than a pile) to maximize the amount of contamination by the effluent cloud. Each station also contained the following samplers:

A. Fourteen 11.4-cm planchets for ground and hay deposition measurements.
B. Two microscope slides for particle size studies.
C. Two air samplers (4.8 l/sec = 10.2 cfm) with Whatman 541 and charcoal filters.

Certain stations had special equipment as follows:

D. Ionization chambers and meteorological instruments - for wind velocity and direction, temperature and gamma exposure rates at both 1 m and 10 m above ground - Stations 2,4,6,8,9,10.
E. Cascade impactor - for particle size and size to activity ratio measurements - Stations 2,4,6,8,10.
F. Portable survey meters with chart recorders - for recording mR/h as a function of time - Stations 7,11,12,13,14,16.

During cloud passage it was noted that the cloud had split into two portions. The upper portion passed near Station 11, and the lower portion (base surge) passed near Station 3. After cloud passage, survey meter readings were made of the beta plus gamma mR/h on the 11.4-cm planchets on top of the hay bales at each station. On the basis of these readings, the hay bales from Stations 3, 10 and 11 were selected for feeding to the dairy cows.

The hay bales from the three selected stations were picked up, covered with plastic and moved to the dairy farm. The hay was chopped, one station at a time, and stored for the ingestion experiment. Sufficient hay was chopped to feed four cows for 10 days at 20 kg per cow per day.

The dairy herd was divided into four groups by a stratified random selection based on the average milk production of each cow. Table 1 shows the cows in each group and other pertinent data. Background samples of hay, grain, water and milk were taken prior to the start of contaminated hay ingestion.

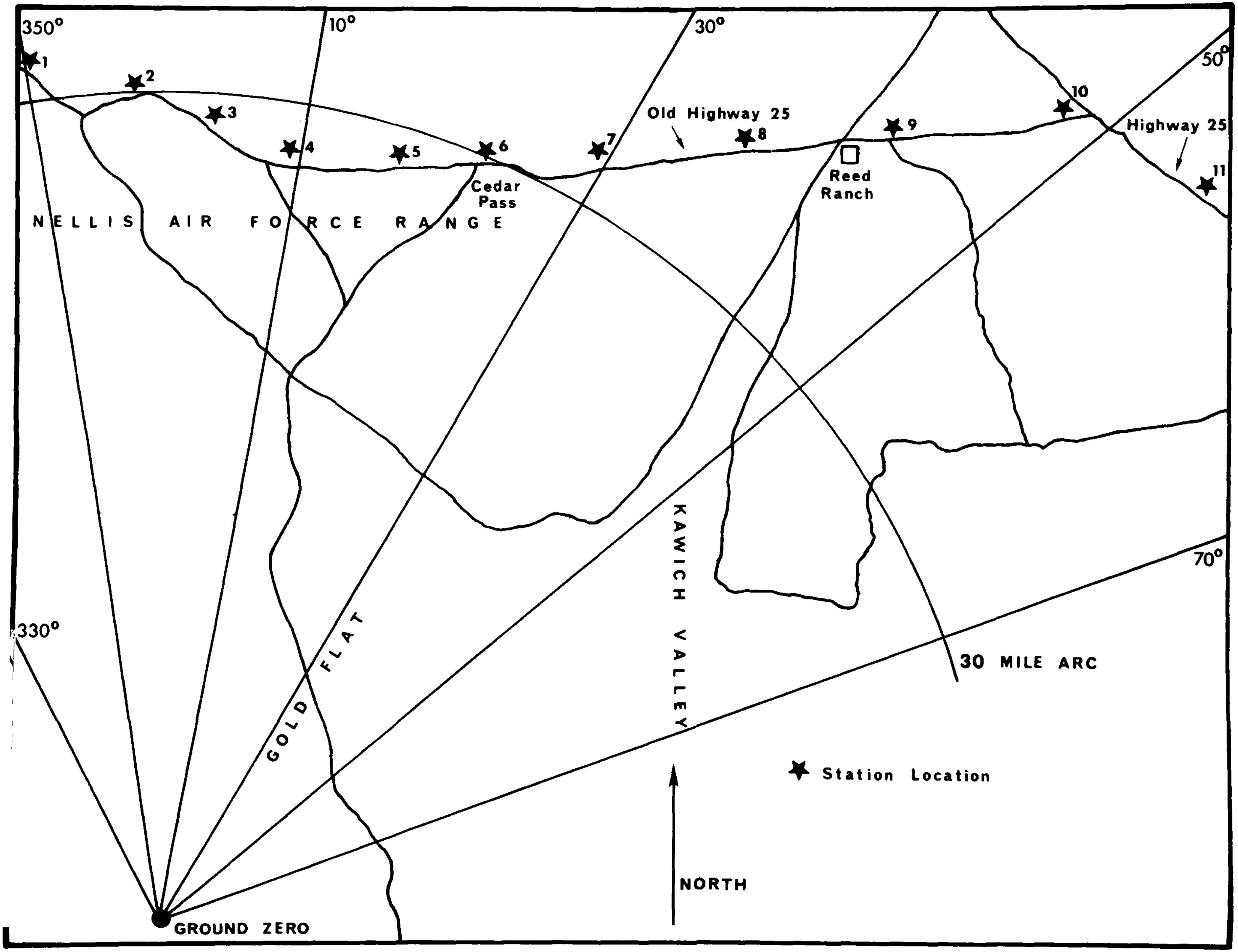


Figure 1. Locations of Sampling Stations 1-11.

During the ingestion experiment, chopped hay was removed from the storage enclosure, sampled and weighed. After each milking, the weighed hay was offered the cows in special feed mangers which prevented loss of hay during feeding. Any residue in the feed mangers after the feeding period was weighed to determine the actual amount consumed. The hay was sampled by taking five handfulls from various locations in each manger. The samples were placed in plastic bags and were then compressed into a standard geometry for counting. The first feeding of the cows was in the afternoon of D + 1.

The cows were kept on the normal twice-a-day milking schedule (approximately 0600 and 1500) until milk sampling was terminated on D + 16. Each cow was assigned an individual milking bucket for the duration of the experiment. At each milking a disposable plastic container was filled with milk from the bucket and formaldehyde added as a preservative. For counting, the contents of the plastic container were transferred to a 3.5-liter Marinelli beaker and adjusted to volume, if necessary, with distilled water. Before adding the water, the milk was weighed to determine the actual volume for use in concentration calculations.

The count median diameter (CMD) of the particulates deposited on the microscope slides at each station was determined optically by use of a calibrated reticule in the eyepiece of the microscope. The CMD was based on the Feret diameter measurement.

The radioactivity in the cloud passing over each station, as measured by the air samplers, is expressed as the integrated air concentration. This term has the units of $\mu Ci\text{-}s/m^3$ and is calculated by adding the total activity on the prefilter to that on the charcoal cartridge and dividing the sum by the sampling rate ($m^3/s$).

One hay bale at each station had a planchet centered on each exposed surface. The activity on the planchets, corrected for the exposed area of the bale, was summed and divided by the weight of the bale to estimate the $\mu Ci/kg$. This estimate can then be compared with the measured value of hay samples and, if sufficiently accurate, could be used instead of grab sampling to estimate forage contamination.

All counting was done with 10-cm NaI(Tl) crystals and associated 400-channel analyzers. The resultant gamma spectra were analyzed by a least squares method.

## III. Results

The group average values for $^{187}W$, $^{131}I$ and $^{133}I$ concentrations in milk are shown in Tables 2-4 and are plotted in Figures 2-6. The $^{131}I$ and $^{187}W$ concentrations in hay are shown in Tables 5-7.

The integrated air concentrations and $\mu Ci/m^2$ deposition for $^{187}W$ and $^{131}I$ are shown for eleven of the study stations in Table 8.

The analysis of milk from control cows (Group IV) and water, grain and uncontaminated forage fed to all groups indicated that the contaminated hay was the only significant source of $^{131}I$, $^{133}I$ and $^{187}W$ in the experimental cow groups.

The data and correlations between the activities measured in planchets and those measured by hay sampling are shown in Table 9 for both $^{187}W$ and $^{131}I$.

Based on the deposition data from the planchets, there was no significant fractionation between $^{187}W$ and $^{131}I$ over the first eleven stations of the sampling arc. Activity levels at Station 12 were too low to be included in the study and the activity levels at Stations 13-16 remained essentially background. The count median diameter of the particles collected on glass slides at each station was also constant ranging only from 0.6 to 0.9 μm. A significant correlation at the 99% confidence level was noted between the size of individual particles and their activity.

## IV. Discussion

Differences in the levels of the milk and forage from the three study areas (Stations 3, 10 & 11)are attributable simply to the total amount of activity deposited. The ratio between stations is relatively constant for the following data: (a) the activity deposited, (b) the peak gamma-exposure rate, (c) the total $^{187}W$ and $^{131}I$ in the milk and hay, and (d) the peak activity in the milk. These ratios are 2-4 times higher for Station 11 than for Station 10 which in turn is 4-5 times higher than Station 3. This same ratio does not hold true for the integrated air concentrations for which

Station 11 was 1.4 higher than Station 10 which, in turn, was 1.3 higher than Station 3. This difference between air concentrations and ground deposition is probably due to the difference in filter to charcoal ratios (F/C) observed. The average F/C ratio for the first three stations on the arc is 15 while the average for Stations 4-11 is five. This indicated difference in particulate to gaseous ratios is compatible with the fact that the first three stations, with the higher particulate component, were exposed to the base surge cloud while the rest of the arc was exposed to the main or higher elevation cloud.

In most measurements made, except in milk, the tungsten activity was approximately 1000 times the $^{131}I$ activity. The observations that only 1/50 as much tungsten as iodine appeared in milk (total percent in milk) and that the milk to forage ratio for $^{187}W$ was only 1/100 the ratio for $^{131}I$, probably were the reasons for the peak milk activity of tungsten being only ten times that of iodine. Table 10 summarizes these data for the two radioisotopes.

As in the Cabriolet and Buggy experiments, the low milk to forage ratios in all three cow groups; the low percent in milk, and the long effective half-life in milk during feeding indicated that the $^{131}I$ was less biologically available in the Schooner debris than in other experiments.[4-6] The relatively long $T_{eff}$ for $^{133}I$ indicates that this radioiodine was also less available. The $^{131}I$ values one would expect, based on other studies[1,2,4-6], are: peak milk concentration in 2-3 days; percent in milk of 8-10, and $T_{eff}$ in milk of 4-5 days.

This low biological availability was apparently true for the $^{187}W$ also. In a multiple ingestion experiment [7] using a solution of $Na_2WO_4$ administered to four cows, the average percent recovered in milk was 0.6, or about ten times as much as was recovered in this experiment.

These results suggest that $^{187}W$, though present at activity levels 1000 times the levels of $^{131}I$, presents less of a hazard than radioiodine because of the smaller transfer to milk, the shorter effective half-life in milk and the apparent lack of concentration in a specific organ.

The data from the planchets fixed to hay bales indicate reasonable correlation between planchet and hay deposition for $^{131}I$. The $^{187}W$ correlation was good only for one of the three sets of data. This may have been caused by analytical errors more than any other factor. The use of the planchet on top of the bale resulted in a better estimate of the concentration in hay than the use of all five planchets. This is advantageous since, realistically, a single deposition collector is the most probable occurrence at a given location.

The $T_{eff}$ for $^{131}I$ in hay, as shown in Figures 2-4 is nearly normal for the procedures employed in this study. After retrieval from the field stations, the hay was put through a chopper and immediately stored in a protective enclosure. Thus, the activity in the hay would decrease only by radioactive decay and by some loss of particles during handling. The loose particles, however, would be caught in the lower levels of the chopped hay and this would tend to increase the activity in the later feedings.

The correlative data, which can be derived from Table 10, indicate that the planchet data ($\mu Ci/m^2$) and the peak gamma mR/h (measured 1 m above ground) will yield reasonably good predictions of the peak milk concentration, as was true in the Cabriolet and Buggy experiments. The integrated air concentration ($\mu Ci\text{-}s/m^3$) gave a poor prediction of this parameter; however, the prediction is much improved if the integrated air concentration is divided by the filter/charcoal ratio. This tends to support the assumption made in the TNT(1) and Pin Stripe(12) experiments that the particulate/gaseous make-up of the debris from nuclear tests has some bearing on the forage-cow-milk transfer of radioiodine.

The reduced biological availability, in the cow, indicated by the results of the last three cratering tests (Cabriolet, Buggy, and Schooner) suggests some change has been made in the device design or emplacement techniques since the earlier test.(4) This change is beneficial, at least in the sense that the hazard to humans drinking milk produced in the downwind fallout pattern of these three tests has been markedly reduced.

## V. Summary

Baled hay and monitoring instruments were placed at 16 stations located on an arc which was 30 to 50 miles downwind of the Plowshare cratering test code-named Schooner. After the test, hay from three of the contaminated stations was fed to groups of dairy cows. Sufficient contaminated hay was available to feed the cows twice-a-day for ten days. Surveillance data were also obtained at the three stations.

As was indicated in the Cabriolet and Buggy experiments, the biological availability of $^{131}I$, $^{133}I$ and $^{187}W$ was much reduced compared to previous experiments. Less than 4% of the $^{131}I$ and less than 0.07% of the $^{187}W$ ingested by the cows was secreted in their milk.

The surveillance data indicated that either the areal deposition ($\mu Ci/m^2$ on planchets) or the 1 m peak gamma mR/h were useful for predicting the peak concentration which would appear in cow's milk. There was also an indication that the particulate/gaseous ratio in the debris deposited at the experimental stations had some effect on the peak concentration of radioiodine in the milk. The prediction of peak milk concentration from air sampler data was improved if the integrated air concentration was divided by the filter/charcoal activity ratio.

## REFERENCES

1. S. C. Black, D. S. Barth, R. E. Engel and K. H. Falter, Radioiodine studies following the transient nuclear test (TNT) of a KIWI reactor, Southwestern Radiological Health Lab. Report SWRHL-26r, Las Vegas, NV 1969.

2. D. S. Barth, R. E. Engel, S. C. Black and W. Shimoda, Dairy Farm radioiodine studies following the Pin Stripe Event of April 25, 1966, Southwestern Radiological Health Lab. Report SWRHL-41r, Las Vegas, NV 1969.

3. S. C. Black, E. W. Bretthauer and D. N. McNelis, Radioiodine studies with dairy cows following two Plowshare experiments, SWRHL-85r published September 1971.

4. S. C. Black, R. E. Engel, D. S. Barth and V. W. Randecker, Radioiodine studies in dairy cows following the Palanquin event, Southwestern Radiological Health Lab Report PNE-914F, Las Vegas, NV. September 1971.

5. R. E. Stanley, S. C. Black and D. S. Barth, $^{131}I$ dairy cow studies using a dry aerosol. Southwestern Radiological Health Lab. Report SWRHL-42r, Las Vegas, NV 1969.

6. W. Shimoda, S. C. Black, K. H. Falter, R. E. Engel and D. S. Barth, Study of a single dose $^{131}I$ - $^{126}I$ ratio in dairy cows, Southwestern Radiological Health Lab. Report SWRHL-27r, Las Vegas, NV. 1970.

7. A. Mullen, E. W. Bretthauer, and R. E. Stanley, Excretion of radio-tungsten by the dairy cow. Presented at the American Chemical Society Annual Meeting, Chicago, IL. 1970.

TABLE 1

COW GROUPING, MILK PRODUCTION AND FEEDING SCHEDULE FOR THE PROJECT SCHOONER EXPERIMENT

| Group No. | Cow | Daily Milk Production (liters) | Group Average Daily Milk Production (liters) | Beta + Gamma mR/h on hay at 0800 D + 1 | Remarks |
|---|---|---|---|---|---|
| | 27 | 24.3 | | | |
| | 39 | 16.7 | | | Fed 10 kg of hay from |
| I | | | 19.1 | 90-110 | |
| | 43 | 11.1 | | | Station 11 twice daily |
| | 46 | 24.2 | | | |
| | 16 | 17.4 | | | |
| | 36 | 10.5 | | | Fed 10 kg of hay from |
| II | | | 16.7 | 18-30 | |
| | 84 | 16.2 | | | Station 10 twice daily |
| | 86 | 22.8 | | | |
| | 13 | 18.7 | | | |
| | 35 | 9.1 | | | Fed 10 kg of hay from |
| III | | | 13.7 | 8-10 | |
| | 47 | 13.9 | | | Station 3 twice daily |
| | 62 | 13.1 | | | |
| | 11 | 28.7 | | | |
| | 12 | 18.8 | | | Control group, fed |
| IV | 21 | 27.4 | 24.7 | | |
| | 44 | 21.5 | | | uncontaminated hay. |
| | 83 | 27.1 | | | |

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN MILK, AVERAGE FOR FOUR COWS OF GROUP I.

| Date | Time | Collection Time Days* | $^{131}I$ nCi/l | $^{133}I$ nCi/l | $^{187}W$ nCi/l |
|---|---|---|---|---|---|
| 12/9 | 1550 | 0 | ND | ND | 0.168 |
| 12/10 | 0740 | 0.66 | 0.319 | 1.26 | 6.82 |
| | 1530 | 1.00 | 0.497 | 1.65 | 12.80 |
| 12/11 | 0750 | 1.67 | 0.736 | 1.26 | 12.80 |
| | 1540 | 2.00 | 0.762 | 1.01 | 11.50 |
| 12/12 | 1040 | 2.79 | 0.936 | 0.727 | 8.80 |
| | 1555 | 3.01 | 0.986 | 0.600 | 7.99 |
| 12/13 | 0745 | 3.66 | 1.00 | 0.427 | 5.01 |
| | 1525 | 3.98 | 0.919 | 0.297 | 3.93 |
| 12/14 | 0740 | 4.66 | 0.899 | 0.162 | 2.63 |
| | 1530 | 4.99 | 0.921 | 0.185 | 2.39 |
| 12/15 | 0750 | 5.67 | 0.951 | 0.116 | 1.62 |
| | 1540 | 5.99 | 1.01 | 0.095 | 1.38 |
| 12/16 | 0720 | 6.65 | 0.889 | 0.052 | 1.07 |
| | 1540 | 6.99 | 0.947 | 0.066 | 0.843 |
| 12/17 | 0730 | 7.66 | 0.872 | 0.049 | 0.543 |
| | 1540 | 7.99 | 0.993 | | 0.499 |
| 12/18 | 0730 | Not milked | | | |
| | 1735 | 9.07 | 0.798 | | 0.291 |
| 12/19 | 0710 | 9.64 | 1.04 | | 0.205 |
| | 1540 | 9.99 | 0.949 | | 0.136 |
| 12/20 | 0740 | 10.66 | 0.780 | | 0.128 |
| | 1540 | 10.99 | 0.579 | | |
| 12/21 | 0710 | 11.64 | 0.277 | | |
| | 1600 | 12.02 | 0.185 | | |
| 12/22 | 0715 | 12.64 | 0.100 | | |
| | 1530 | 12.99 | 0.078 | | |
| 12/23 | 0650 | 13.63 | 0.046 | | |
| | 1545 | 13.99 | 0.032 | | |
| 12/24 | 0705 | 14.64 | 0.021 | | |

*Days after initial feeding

TABLE 3

RADIONUCLIDE CONCENTRATIONS IN MILK, AVERAGE FOR FOUR COWS OF GROUP II

| Date | Time | Collection Time Days* | $^{131}I$ pCi/l | $^{133}I$ pCi/l | $^{187}W$ nCi/l |
|---|---|---|---|---|---|
| 12/9 | 1530 | 0 | ND | ND | 0.327 |
| 12/10 | 0725 | 0.67 | 74 | 386 | 1.56 |
| | 1520 | 1.00 | 142 | 515 | 2.29 |
| 12/11 | 0730 | 1.67 | 186 | 345 | 2.63 |
| | 1530 | 2.00 | 203 | 269 | 2.98 |
| 12/12 | 1025 | 2.79 | 232 | 197 | 2.38 |
| | 1545 | 3.01 | 255 | 186 | 2.05 |
| 12/13 | 0730 | 3.67 | 281 | 110 | 1.47 |
| | 1510 | 3.99 | 270 | 99 | 1.18 |
| 12/14 | 0730 | 4.67 | 269 | 59 | 0.890 |
| | 1515 | 4.99 | 308 | 57 | 0.606 |
| 12/15 | 0730 | 5.67 | 283 | | 0.453 |
| | 1525 | 6.00 | 295 | | 0.396 |
| 12/16 | 0700 | 6.65 | 269 | | 0.274 |
| | 1525 | 7.00 | 291 | | 0.226 |
| 12/17 | 0720 | 7.67 | 277 | | 0.141 |
| | 1530 | 8.00 | 290 | | 0.125 |
| 12/18 | 0730 | 8.67 | Not collected | | |
| | 1715 | 9.11 | 261 | | 0.094 |
| 12/19 | 0700 | 9.65 | 354 | | |
| | 1525 | 10.00 | 365 | | |
| 12/20 | 0725 | 10.67 | 302 | | |
| | 1530 | 11.00 | 202 | | |
| 12/21 | 0710 | 11.66 | 106 | | |
| | 1600 | 12.02 | 70 | | |
| 12/22 | 0715 | 12.66 | 41 | | |
| | 1530 | 13.00 | 27 | | |
| 12/23 | 0650 | 13.65 | 16 | | |
| | 1545 | 14.01 | 19 | | |
| 12/24 | 0705 | 14.66 | 12 | | |

*Days after initial feeding

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN MILK, AVERAGE FOR FOUR COWS OF GROUP III

| Date | Time | Collection Time Days* | $^{131}I$ pCi/l | $^{133}I$ pCi/l | $^{187}W$ nCi/l |
|---|---|---|---|---|---|
| 12/9 | 1505 | 0 | <10 | D | 0.211 |
| 12/10 | 0710 | 0.67 | 45 | 221 | 0.786 |
| | 1500 | 1.00 | 61 | 216 | 2.09 |
| 12/11 | 0710 | 1.67 | 72 | 135 | 1.78 |
| | 1515 | 2.01 | 69 | 127 | 1.76 |
| 12/12 | 1010 | 2.79 | 71 | 81 | 1.21 |
| | 1535 | 3.01 | 65 | | 0.822 |
| 12/13 | 0710 | 3.67 | 62 | | 0.544 |
| | 1500 | 4.00 | 65 | | 0.419 |
| 12/14 | 0710 | 4.67 | 73 | | 0.262 |
| | 1500 | 5.00 | 60 | | 0.259 |
| 12/15 | 0710 | 5.67 | 54 | | 0.175 |
| | 1500 | 6.00 | 63 | | 0.120 |
| 12/16 | 0650 | 6.66 | 64 | | 0.077 |
| | 1510 | 7.00 | 59 | | 0.094 |
| 12/17 | 0710 | 7.67 | 60 | | |
| | 1520 | 8.01 | 63 | | |
| 12/18 | 0710 | 8.67 | Not collected | | |
| | 1700 | 9.10 | 58 | | |
| 12/19 | 0650 | 9.65 | 68 | | |
| | 1515 | 10.01 | 61 | | |
| 12/20 | 0715 | 10.67 | 54 | | |
| | 1520 | 11.01 | 46 | | |
| 12/21 | 0710 | 11.67 | 22 | | |
| | 1600 | 12.04 | 17 | | |
| 12/22 | 0715 | 12.67 | 12 | | |
| | 1530 | 13.03 | <10 | | |
| 12/23 | 0650 | 13.65 | 12 | | |
| | 1545 | 14.02 | <10 | | |
| 12/24 | 0705 | 14.66 | <10 | | |

*Days after initial feeding

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN HAY FED THE GROUP I COWS

| Date Fed | Time | Feed kg | $^{131}I$ nCi/kg | $^{187}W$ μCi/kg |
|---|---|---|---|---|
| 12/9/68 | p.m. | 9.75 | ND* | 34.300 |
| 12/10 | a.m. | 6.49 | 55.7 | 23.400 |
| 12/10 | p.m. | 5.44 | 38.3 | 65.800 |
| 12/11 | a.m. | 5.64 | 45.3 | 12.500 |
| 12/11 | p.m. | 9.73 | 38.8 | 9.110 |
| 12/12 | a.m. | 7.50 | 41.9 | 5.230 |
| 12/12 | p.m. | 8.10 | 39.6 | 4.730 |
| 12/13 | a.m. | 7.60 | 33.2 | 2.780 |
| 12/13 | p.m. | 8.23 | 24.5 | 2.720 |
| 12/14 | a.m. | 6.68 | 22.8 | 1.060 |
| 12/14 | p.m. | 7.89 | 31.3 | 0.994 |
| 12/15 | a.m. | 8.47 | 26.7 | 1.000 |
| 12/15 | p.m. | 9.68 | 27.1 | 0.523 |
| 12/16 | a.m. | 9.74 | 23.8 | 0.293 |
| 12/16 | p.m. | 9.73 | 22.4 | 0.278 |
| 12/17 | a.m. | 9.12 | 23.3 | 0.166 |
| 12/17 | p.m. | 10.00 | 26.6 | 0.179 |
| 12/18** | a.m. | | | |
| 12/18 | p.m. | 8.73 | 24.2 | 0.070 |
| 12/19 | a.m. | 7.12 | 27.0 | 0.062 |
| 12/19 | p.m. | 8.62 | 18.0 | 0.053 |
| Totals | | 154.62 | | |

*Nondetectable
**The feeding on 12/18/68 a.m. was not given.

TABLE 6

RADIONUCLIDE CONCENTRATIONS IN HAY FED THE GROUP II COWS

| Date Fed | Time | Feed kg | $^{131}I$ nCi/kg | $^{187}W$ μCi/kg |
|---|---|---|---|---|
| 12/9/68 | p.m. | 8.82 | 19.3 | 14.300 |
| 12/10 | a.m. | 6.17 | 16.3 | 7.250 |
| 12/10 | p.m. | 8.17 | 15.3 | 5.580 |
| 12/11 | a.m. | 5.62 | 13.7 | 3.330 |
| 12/11 | p.m. | 9.62 | 14.4 | 2.690 |
| 12/12 | a.m. | 6.78 | 11.5 | 1.530 |
| 12/12 | p.m. | 8.38 | 10.2 | 1.400 |
| 12/13 | a.m. | 6.20 | 5.93 | 0.965 |
| 12/13 | p.m. | 8.19 | 7.90 | 0.726 |
| 12/14 | a.m. | 4.95 | 9.51 | 0.020 |
| 12/14 | p.m. | 7.11 | 9.76 | 0.329 |
| 12/15 | a.m. | 7.32 | 11.2 | 0.233 |
| 12/15 | p.m. | 9.12 | 10.0 | 0.210 |
| 12/16 | a.m. | 9.22 | 9.85 | 0.115 |
| 12/16 | p.m. | 9.01 | 7.57 | 0.095 |
| 12/17 | a.m. | 8.13 | 9.26 | 0.068 |
| 12/17 | p.m. | 10.00 | 7.53 | 0.051 |
| 12/18* | a.m. | | | |
| 12/18 | p.m. | 9.00 | 7.55 | 0.027 |
| 12/19 | a.m. | 6.87 | 12.5 | ND** |
| 12/19 | p.m. | 8.29 | 7.35 | ND |
| Totals | | 156.99 | | |

*The feeding on 12/18/68 a.m. was not given
**Nondetectable

TABLE 7

RADIONUCLIDE CONCENTRATIONS IN HAY FED THE GROUP III COWS.

| Date Fed | Time | Feed kg | $^{131}I$ nCi/kg | $^{187}W$ μCi/kg |
|---|---|---|---|---|
| 12/9/68 | p.m. | 8.97 | 4.27 | 12.000 |
| 12/10 | a.m. | 6.57 | 3.95 | 3.270 |
| 12/10 | p.m. | 7.18 | 2.57 | 1.330 |
| 12/11 | a.m. | 6.83 | 2.56 | 1.090 |
| 12/11 | p.m. | 9.25 | 2.55 | 0.620 |
| 12/12 | a.m. | 6.52 | 2.78 | 0.415 |
| 12/12 | p.m. | 7.20 | 3.17 | 0.457 |
| 12/13 | a.m. | 6.98 | 2.98 | 0.201 |
| 12/13 | p.m. | 8.20 | 2.56 | 0.026 |
| 12/14 | a.m. | 4.39 | 3.26 | 0.015 |
| 12/14 | p.m. | 6.55 | 2.27 | 0.079 |
| 12/15 | a.m. | 7.38 | 2.39 | 0.084 |
| 12/15 | p.m. | 9.20 | 1.96 | 0.047 |
| 12/16 | a.m. | 9.72 | 2.11 | 0.034 |
| 12/16 | p.m. | 9.67 | 1.84 | 0.027 |
| 12/17 | a.m. | 9.59 | 1.72 | 0.014 |
| 12/17 | p.m. | 10.00 | 1.69 | 0.014 |
| 12/18* | a.m. | | | |
| 12/18 | p.m. | 9.23 | 1.49 | 0.006 |
| 12/19 | a.m. | 7.82 | 1.92 | 0.002 |
| 12/19 | p.m. | 8.50 | 1.35 | 0.004 |
| Totals | | 156.76 | | |

*The feeding on 12/18/68 a.m. was not given.

TABLE 8

AIR AND DEPOSITION DATA

| Number | $\gamma$ at 1 m Peak mR/h | Integrated Air Concentration $^{131}I$ μCi-s/m$^3$ | Integrated Air Concentration $^{187}W$ mCi-s/m$^3$ | Filter to Charcoal Ratio | Deposition $^{131}I$ μCi/m$^2$ | Deposition $^{187}W$ mCi/m$^2$ |
|---|---|---|---|---|---|---|
| 1 | 7 | 3.00 | 3.41 | 19.3 | 0.078 | 0.062 |
| 2 | 12* | 8.53 | 10.60 | 12.0 | 0.47 | 0.360 |
| 3 | 14* | 1.53 | 1.88 | 13.7 | 0.39 | 0.407 |
| 4 | 4 | 0.56 | 0.56 | 5.2 | 0.19 | 0.178 |
| 5 | 7* | 0.42 | 0.47 | 4.1 | 0.29 | 0.240 |
| 6 | 8 | 0.82 | 0.72 | 3.5 | 0.39 | 0.316 |
| 7 | 9 | 0.83 | 0.94 | 6.0 | 0.54 | 0.425 |
| 8 | 12* | 1.28 | 1.21 | 5.6 | 0.41 | 0.361 |
| 9 | 13* | 1.51 | 1.35 | 6.0 | 0.36 | 0.368 |
| 10 | 34* | 2.02 | 2.58 | 4.1 | 1.93 | 1.80 |
| 11 | 100 | 3.20 | 3.40 | 6.4 | 6.43 | 6.57 |

*Extrapolated from observed decay data.

TABLE 9

CORRELATION BETWEEN PLANCHETS AND HAY DEPOSITION

| Station | Estimate by planchet data* All five | Estimate by planchet data* Top only | Measured in hay | Ratios Hay/5 plan | Ratios Hay/top plan |
|---|---|---|---|---|---|
| | | | $^{187}W$ data-μCi/kg | | |
| 3 | 8.5 | 7.26 | 27.6 | 3.2 | 3.8 |
| 10 | 42.0 | 34.6 | 32.8 | 0.78 | 0.95 |
| 11 | 142 | 129 | 313 | 2.2 | 2.4 |
| | | | $^{131}I$ data-nCi/kg | | |
| 3 | 8.1 | 5.84 | 4.75 | 0.59 | 0.81 |
| 10 | 43.2 | 34.4 | 24.2 | 0.56 | 0.70 |
| 11 | 69.3 | 59.3 | 66.2 | 0.95 | 1.11 |

*Activity/$m^2$ of planchets on 5 exposed surfaces of hay bale corrected to surface area of bale and divided by weight of bale. "Top only" indicates planchet on upper surface only was used.

TABLE 10

SUMMARY OF DATA FOR THE SCHOONER EXPERIMENT

| Cow Group | Peak γ mR/h | Planchet Deposit μCi/m² | Integrated Air Concentration μCi-sec/m³ | Filter to Charcoal Ratio | Peak Milk nCi/l | Milk to Forage Ratio* | % in Milk | Time to peak Days | $T_{eff}$ in milk: During feeding days | $T_{eff}$ in milk: After feeding days |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $^{131}I$ Data | | | | | | |
| I | 100 | 6.43 | 3.20 | 6.4 | 1.04 | 0.019 | 3.94 | 9.6 | 63 | 0.75 |
| II | 34 | 1.93 | 2.02 | 4.1 | 0.308 | 0.019 | 2.88 | 10.0 | 30 | 0.86 |
| III | 14 | 0.39 | 1.53 | 13.7 | 0.073 | 0.017 | 2.59 | 4.6 | 38 | 0.74 |
| | | | | $^{187}W$ Data | | | | | | |
| I | 100 | 6510 | 3400 | 6.4 | 12.8 | 0.00019 | .067 | 1.0 | 1.28 | - |
| II | 34 | 1800 | 2580 | 4.1 | 2.98 | 0.00021 | .058 | 2.0 | 1.27 | - |
| III | 14 | 407 | 1880 | 13.7 | 2.09 | 0.00017 | .048 | 1.0 | 1.10 | - |

*The peak milk concentration divided by the peak hay concentration.

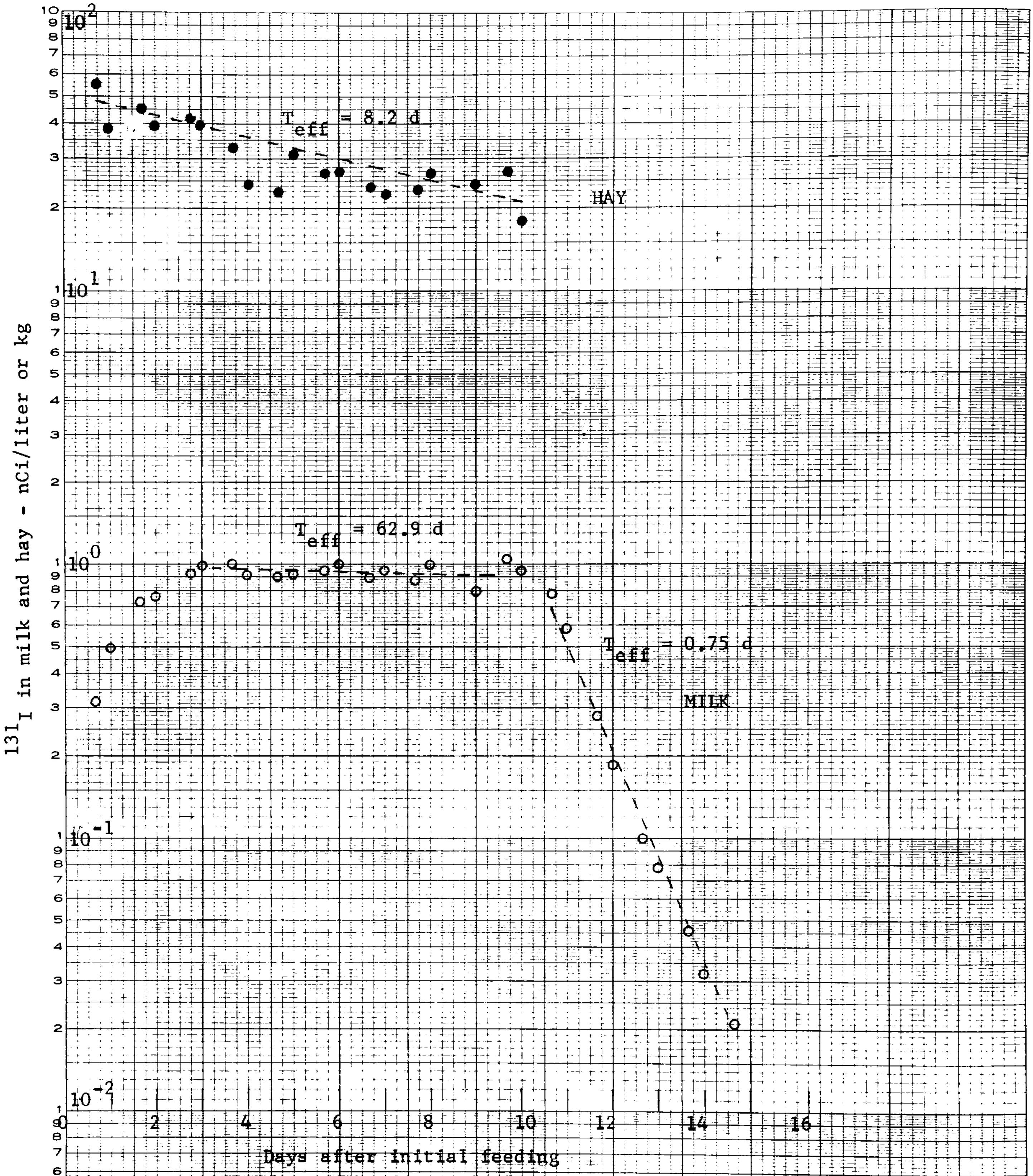


Figure 2. - $^{131}I$ concentrations in milk and hay, Group I cows.

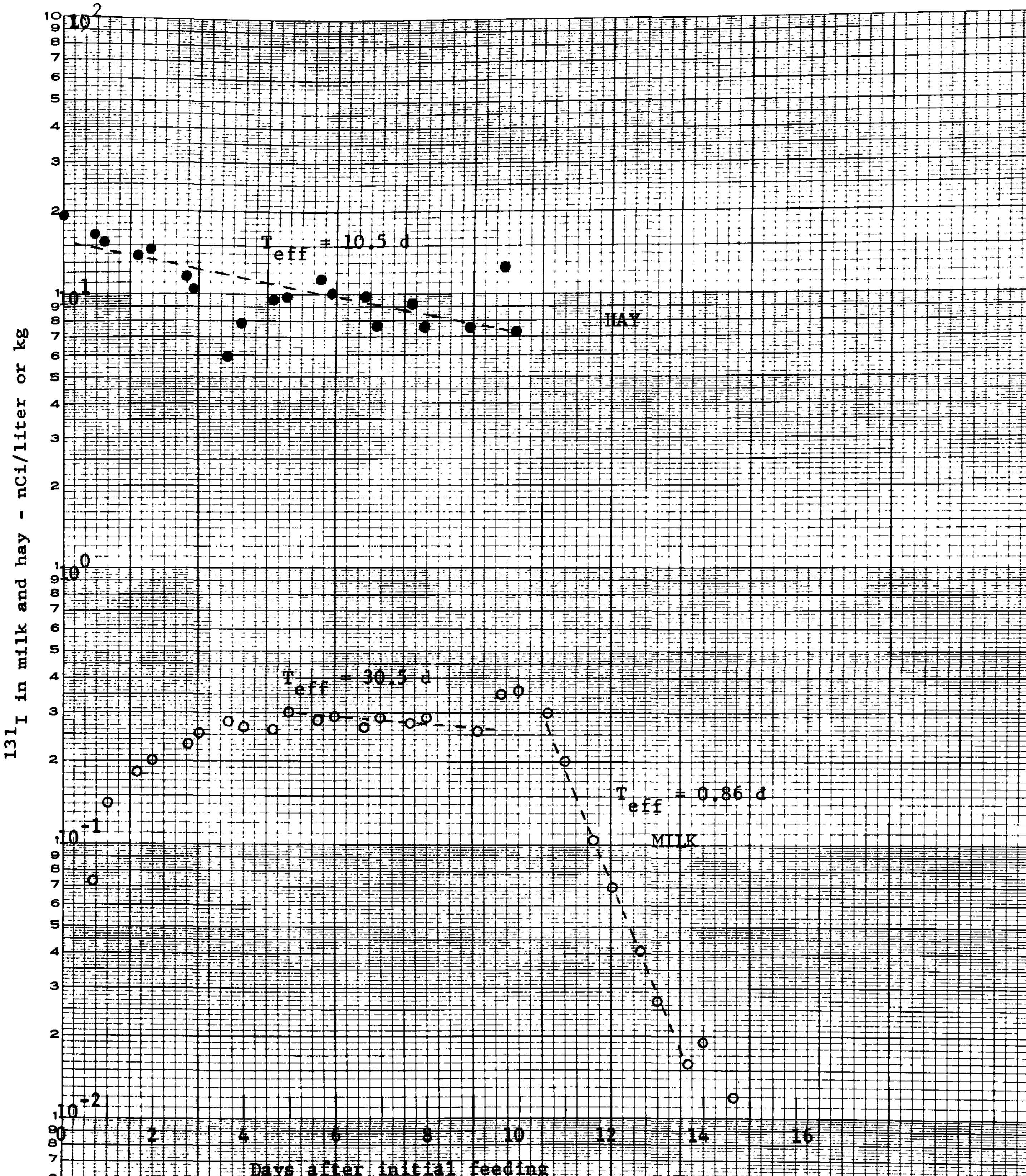


Figure 3.-$^{131}$I concentrations in milk and hay, Group II cows.

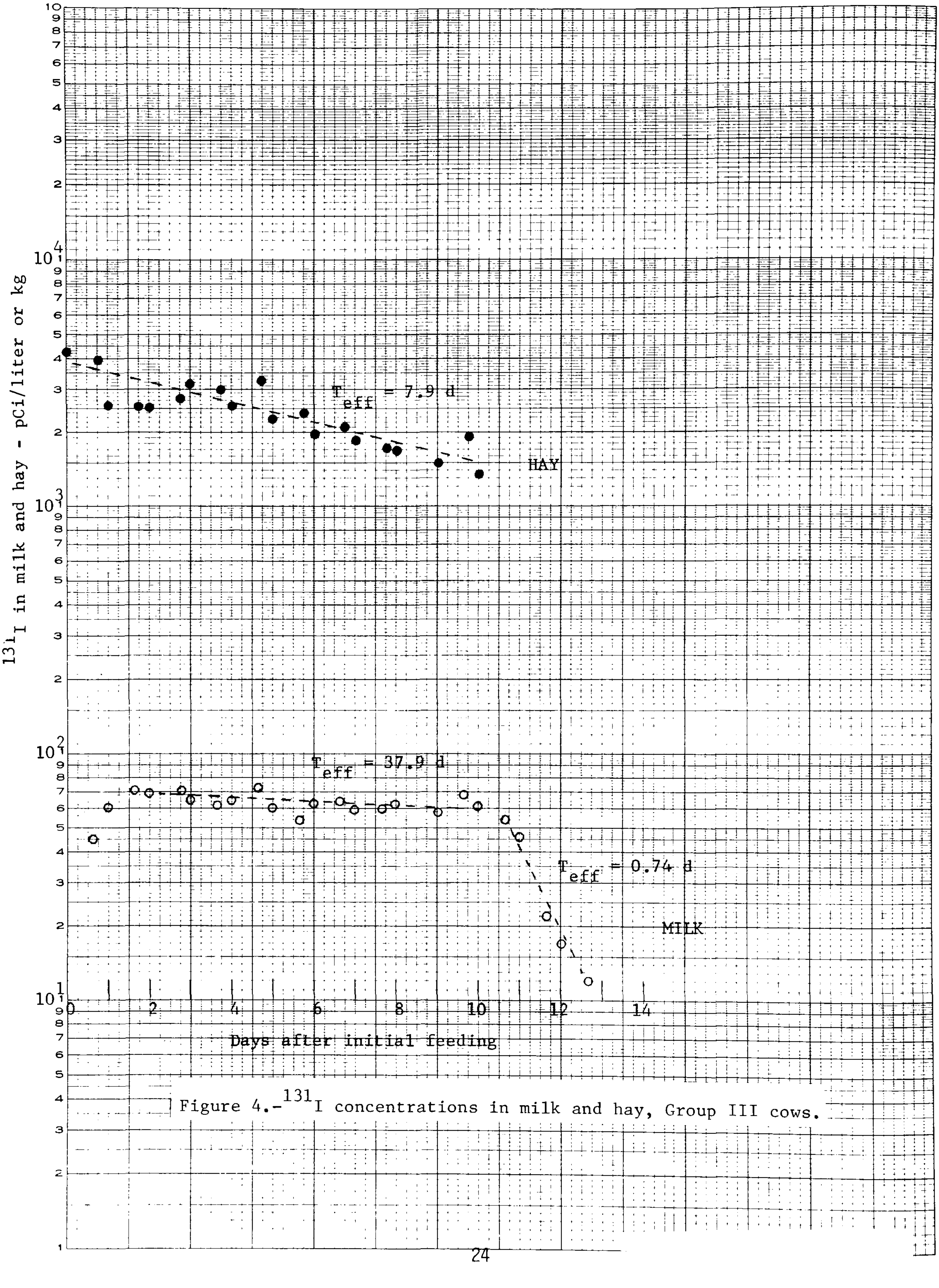


Figure 4.-$^{131}$I concentrations in milk and hay, Group III cows.

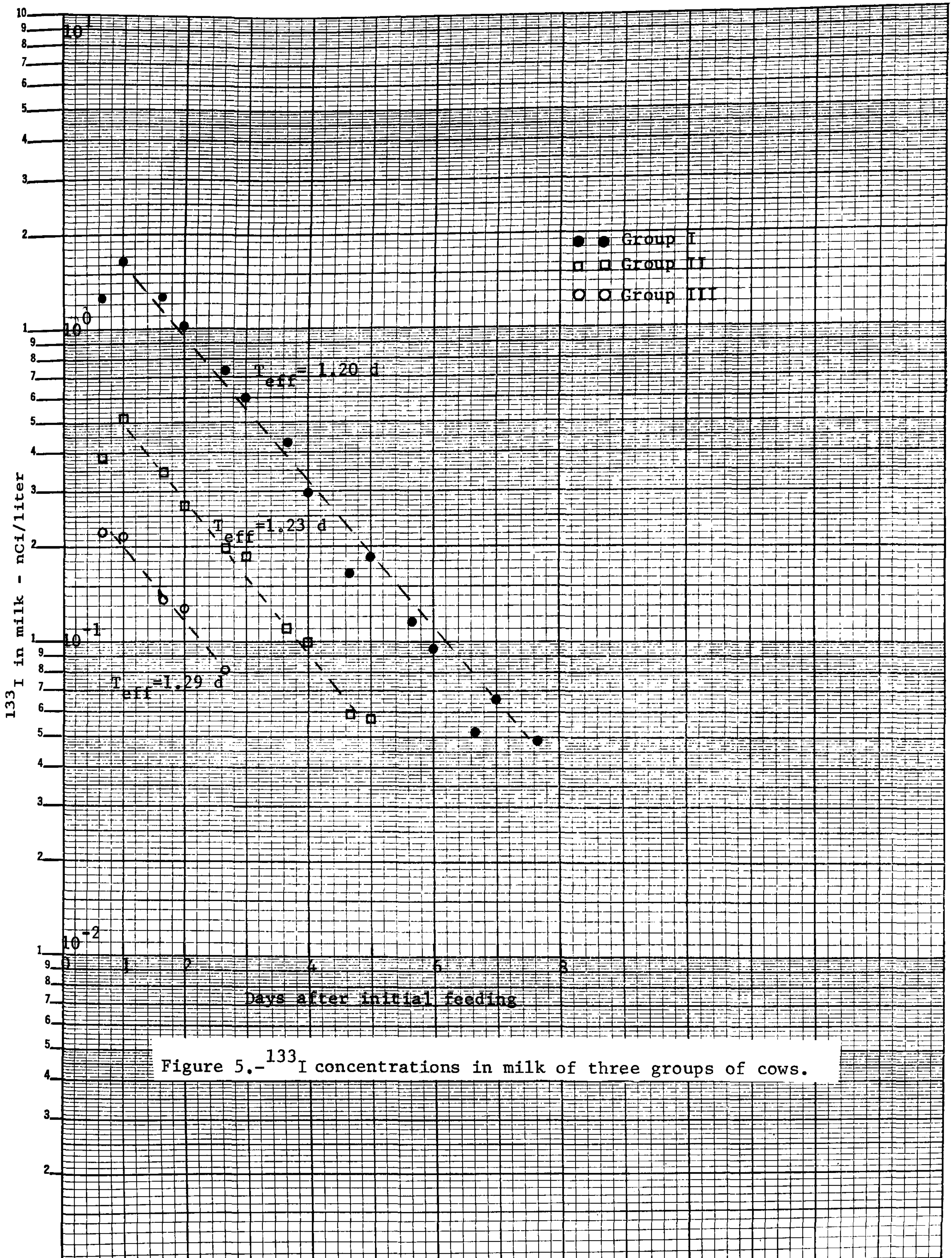


Figure 5.-$^{133}$I concentrations in milk of three groups of cows.

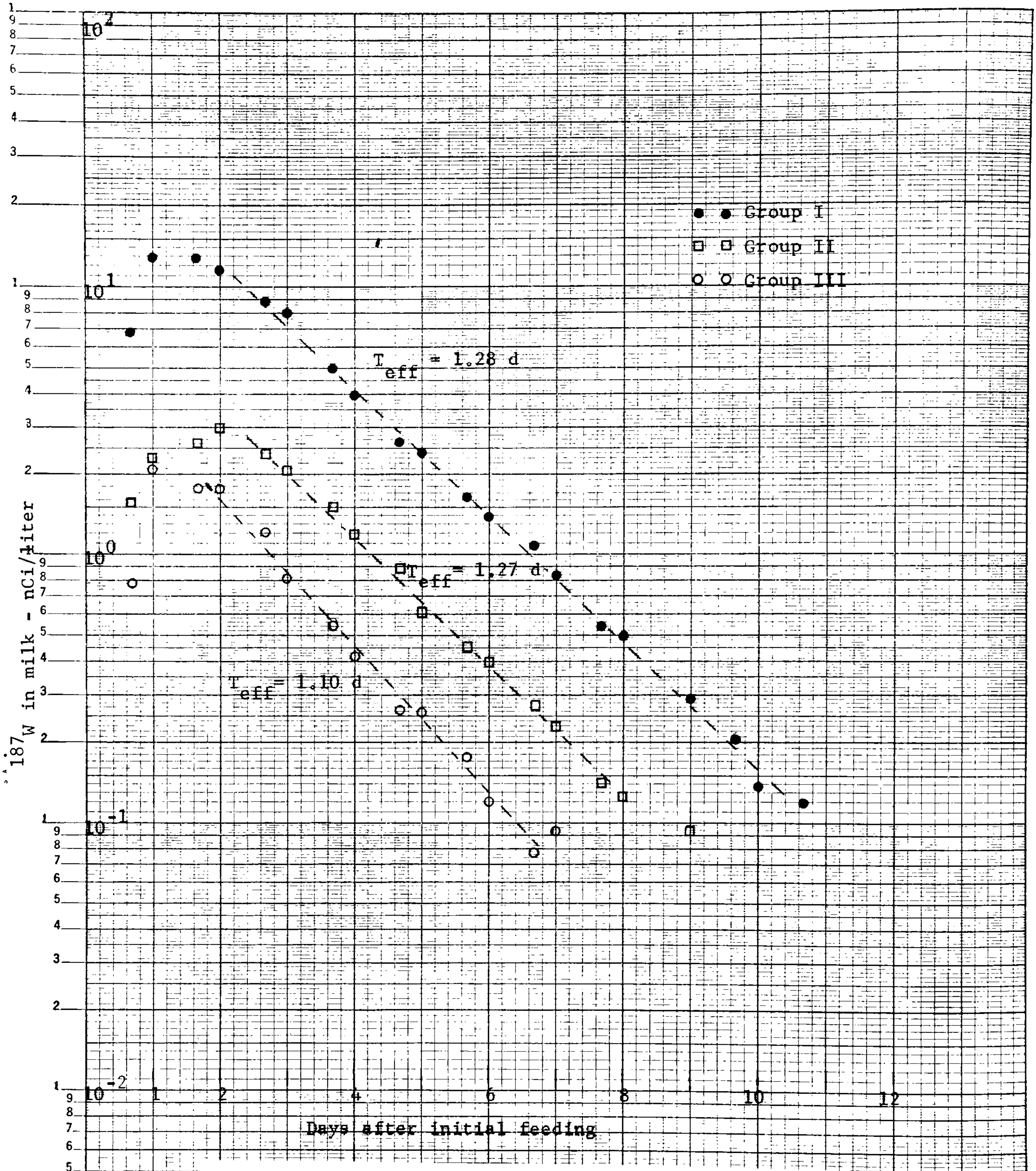


Figure 6.- $^{187}W$ concentrations in milk of three groups of cows.

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