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# Optimum Ratio of Concentrate and Roughage for Steers as Affected By Corn Silage and Protein Level

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# Optimum Ratio of Concentrate and Roughage for Steers as Affected by Corn Silage and Protein Level

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PREVIOUS experiments conducted at the University of Idaho Caldwell Branch Experiment Station have established the approximate minimum quantity of alfalfa hay that may be offered with a particular level of concentrate mixture for efficient gains of steers (1). No factual information is available on the replacement value of the dry matter of corn silage as a portion of the alfalfa hay for any specific level of roughage intake in a fattening steer ration, consequently the following studies were conducted.

## Objectives

The obectives of the experiments reported herein were:

1. To compare alfalfa hay with a roughage combination of alfalfa and corn silage—one-third of the dry matter of alfalfa hay being replaced by the dry matter equivalent of corn silage for concentrate-to-roughage intakes ranging from 1 : 3 to 4 : 1.
2. To determine whether the inclusion of a 44 percent protein supplement in the concentrate mixture at the rate of 12 parts per 100 would increase the rate and economy of gains of the steers fed the two roughage rations with the different ratios of concentrate to roughage.

## Experimental Procedure

The outline of the experiment is shown in Table 1. A 3 x 2 x 2 factorial design for comparing the rations was employed in 1953-54. A 4 x 2 x 2 factorial design was used in 1954-55. Sixty grade Hereford steer calves were purchased and assigned to 3 groups of 20 steer calves each on the basis of weight ratios of concentrate to roughage of 1 : 3, 1 : 2 and 1 : 1. These steers were fed during a period of 154 days between the dates of December 16, 1953, and May 19, 1954. A second group of 80 steer calves were purchased and assigned to 4 groups of 20 steer calves each by the same method as was used in 1953, and fed weight ratios of concentrate to roughage of 1 : 1, 2 : 1, 3 : 1 and 4 : 1. These steers were fed during a period of 154 days between the dates of November 30, 1954, and May 3, 1955. Ten steers of each group of 20 were fed a different quantity of protein. Five steers of each 10 were fed a different roughage combination. All feeding was conducted at the University of Idaho Branch Experiment Station, Caldwell, Idaho.

The steers were fed all they would consume twice daily in individual stalls and allowed to remain in the stalls until they stopped eating, this varied from 2 to 3 hours. During the day and

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night between feedings, they were permitted to loaf in lots adjacent to these stalls. Water and salt were available in these lots at all times.

**Table 1.—Plan of experimentation**

| Ratio concentrate to roughage | Number steers | Concentrate protein percent | Number steers | Roughage | Number steers |
|---|---|---|---|---|---|
| **1953-54** | | | | | |
| 1 : 3 | 20 | 9.51 | 10 | H* | 5 |
| | | | | H and S** | 5 |
| | | 13.74 | 10 | H | 5 |
| | | | | H and S | 5 |
| 1 : 2 | 20 | 9.51 | 10 | H | 5 |
| | | | | H and S | 5 |
| | | 13.74 | 10 | H | 5 |
| | | | | H and S | 5 |
| 1 : 1 | 20 | 9.51 | 10 | H | 5 |
| | | | | H and S | 5 |
| | | 13.74 | 10 | H | 5 |
| | | | | H and S | 5 |
| **1954-55** | | | | | |
| 1 : 1 | 20 | 9.51 | 10 | H | 5 |
| | | | | H and S | 5 |
| | | 13.74 | 10 | H | 5 |
| | | | | H and S | 5 |
| 2 : 1 | 20 | 9.51 | 10 | H | 5 |
| | | | | H and S | 5 |
| | | 13.74 | 10 | H | 5 |
| | | | | H and S | 5 |
| 3 : 1 | 20 | 9.51 | 10 | H | 5 |
| | | | | H and S | 5 |
| | | 13.74 | 10 | H | 5 |
| | | | | H and S | 5 |
| 4 : 1 | 20 | 9.51 | 10 | H | 5 |
| | | | | H and S | 5 |
| | | 13.74 | 10 | H | 5 |
| | | | | H and S | 5 |

*The roughage alfalfa hay.
**The roughage was ⅔ alfalfa hay and ⅓ silage (hay basis).

**Table 2.—Concentrate mixtures and quanties of feeds used (parts per 100)**

| Feeds | RATIONS | |
|---|---|---|
| | Low protein | High protein |
| Barley (ground) | 50 | 42 |
| Oats (ground) | 24 | 22 |
| Dried molasses beet pulp | 24 | 22 |
| Oil meal* | | 12 |
| Salt | 2 | 2 |
| Total | 100 | 100 |
| Protein percent | 9.51 | 13.74 |

*Soybean oil meal was used in 1953-54; cottonseed oil meal was used in 1954-55.

The concentrate mixtures and quantities of feeds used in each mixture are shown in Table 2. The alfalfa hay was cut in 1-to-2-inch lengths. The daily feed allowances were weighed to the nearest tenth of a pound. One-half of the daily concentrate allowance and all of the daily alfalfa hay allowance were fed to each steer at the morning feeding. The remaining half of the daily concentrate allowance and all of the daily silage allowance were fed to each steer at the evening feeding. The alfalfa hay was divided equally between the morning and evening feedings for those steers receiving the alfalfa hay as the sole roughage. Soybean oil meal was fed in 1953-54 while cottonseed oil meal was used in 1954-55. The crude protein content of both meals was similar—approximately 44 percent.

The inclusion of 12 parts oil meal in the concentrate mixture gave an approximate 13.74 percent total protein content as compared to 9.51 percent for the concentrate mixture without the oil meal.

## Experimental Results

The data of each individual steer calf have been used for four different summaries as indicated in Tables 3, 4, 5 and 6. These data are summarized as follows:

(1) The average initial and final weights, rate of gains, feed intakes and feed requirements for each 100 pounds of gain of each group of 5 steer calves receiving the same ratio of concentrate to roughage, and percentage of total protein in the concentrate mixture and type of roughage are reported in Table 3.

The feed requirements of those steer groups receiving alfalfa hay and corn silage are reported on total feed per 100 pounds of gain and total feed, air-dry basis, per 100 pounds gain. Corn silage was converted to air-dry (hay) basis by dividing the corn silage quantity by three; the moisture content of corn silage ranges from 62 to 78 percent for the Caldwell, Idaho, area.

(2) The average daily gain and average daily ration and the average feed required for 100 pounds gain of all steers receiving the same protein percentage of the concentrate and the same type of roughage are shown in Table 4. The data of each 15-steer group fed during the winter of 1953-54 represent the total average values of three 5-steer groups fed ratios of concentrate to roughage of 1 : 3, 1 : 2 and 1 : 1. The data of each 20-steer group fed during the winter of 1954-55 represent the total average values of four 5-steer groups fed ratios of concentrate to roughage of 1 : 1, 2 : 1, 3 : 1 and 4 : 1.

**Table 3.—Average weights, daily gains, daily rations and feed requirements of steer calves fed 2 levels of protein each with alfalfa hay or alfalfa hay plus corn silage in rations containing 6 different ratios of concentrate to roughage.**

| Ratio | Concentrate protein | roughage | No. steers | Average Initial weight | Average Final weight | Average Daily gain* | Daily ration | Feed for 100 lb. gain* | Feed for 100 lb. gain hay basis |
|---|---|---|---|---|---|---|---|---|---|
| | percent | | | lb. | lb. | lb. | lb. | lb. | lb. |
| | | | | 1953-54 | | | | | |
| 1 : 3 | 9.51 | Hay | 5 | 544 | 823 | 1.81 | 16.1 | 868 | |
| 1 : 3 | 9.51 | Hay + silage | 5 | 533 | 782 | 1.62 | 21.7 | 1341 | 895 |
| 1 : 3 | 13.74 | Hay | 5 | 551 | 793 | 1.57 | 14.0 | 892 | |
| 1 : 3 | 13.74 | Hay + silage | 5-4[1] | 524 | 609 | 1.71 | 21.3 | 1246 | 830 |
| 1 : 2 | 9.51 | Hay | 5 | 557 | 803 | 1.60 | 14.1 | 882 | |
| 1 : 2 | 9.51 | Hay + silage | 5 | 522 | 795 | 1.77 | 19.5 | 1100 | 761 |
| 1 : 2 | 13.74 | Hay | 5 | 569 | 834 | 1.72 | 14.6 | 846 | |
| 1 : 2 | 13.74 | Hay + silage | 5 | 527 | 812 | 1.84 | 21.2 | 1146 | 794 |
| 1 : 1 | 9.51 | Hay | 5 | 565 | 843 | 1.80 | 15.1 | 838 | |
| 1 : 1 | 9.51 | Hay + silage | 5 | 524 | 784 | 1.69 | 17.7 | 1046 | 784 |
| 1 : 1 | 13.74 | Hay | 5 | 566 | 850 | 1.84 | 15.8 | 856 | |
| 1 : 1 | 13.74 | Hay + silage | 5 | 529 | 803 | 1.78 | 19.2 | 1081 | 809 |
| | | | | 1954-55 | | | | | |
| 1 : 1 | 9.51 | Hay | 5 | 480 | 799 | 2.07 | 16.0 | 772 | |
| 1 : 1 | 9.51 | Hay + silage | 5 | 472 | 792 | 2.13 | 20.2 | 947 | 710 |
| 1 : 1 | 13.74 | Hay | 5 | 504 | 801 | 1.93 | 15.0 | 776 | |
| 1 : 1 | 13.74 | Hay + silage | 5 | 526 | 786 | 1.69 | 19.2 | 1139 | 854 |
| 2 : 1 | 9.51 | Hay | 5 | 538 | 824 | 1.86 | 14.9 | 804 | |
| 2 : 1 | 9.51 | Hay + silage | 5 | 526 | 805 | 1.81 | 17.3 | 954 | 781 |
| 2 : 1 | 13.74 | Hay | 5 | 498 | 802 | 1.97 | 13.9 | 703 | |
| 2 : 1 | 13.74 | Hay + silage | 5 | 494 | 818 | 2.10 | 16.7 | 793 | 648 |
| 3 : 1 | 9.51 | Hay | 5 | 518 | 774 | 1.66 | 12.7 | 763 | |
| 3 : 1 | 9.51 | Hay + silage | 5 | 524 | 817 | 1.90 | 16.4 | 861 | 739 |
| 3 : 1 | 13.74 | Hay | 5 | 522 | 842 | 2.08 | 15.0 | 723 | |
| 3 : 1 | 13.74 | Hay + silage | 5 | 540 | 848 | 2.00 | 17.0 | 852 | 730 |
| 4 : 1 | 9.51 | Hay | 5 | 533 | 846 | 2.03 | 14.4 | 716 | |
| 4 : 1 | 9.51 | Hay + silage | 5-4[2] | 540 | 800 | 1.79 | 15.5 | 867 | 766 |
| 4 : 1 | 13.74 | Hay | 5 | 514 | 817 | 1.97 | 14.5 | 736 | |
| 4 : 1 | 13.74 | Hay + silage | 4[3] | 500 | 852 | 2.11 | 16.8 | 799 | 755 |

*Least significant differences required for average of 5 steers at 5 percent level: 1953-54, 0.18 lb. av. daily gain—both hay and silage groups; 78 lb. total feed for 100 lb. gain—hay groups; 60 lb. total feed for 100 lb. gain—silage groups, 1954-5, 0.27 lb. av. daily gain—both hay and silage groups; 88 lb. total feed for 100 lb. gain—hay groups; 54 lb. total feed for 100 lb. gain—silage groups.

[1]One steer died of bloat after 112 days on feed. The average daily feed consumption was 13.7 lb. with an average daily gain of 1.83 lb.

[2]One steer died of bloat after being on feed 112 days. The average daily ration was 13.7 lb. with an average daily gain of 1.47 lb.

[3]One steer died of bloat after being on feed 126 days. The average daily ration was 9.5 lb. with an average daily gain of 0.44 lb. The data of this steer was not used.

Table 4.—Average gains, rations and feed requirements of steer calves fed alfalfa hay or alfalfa hay plus corn silage with each protein level.

| No. steers | Concentrate protein | Roughage | Average Daily Gain* | Average Daily Ration | Feed for each 100 lb. gain |
|---|---|---|---|---|---|
| | percent | | lb. | lb. | lb. |
| | | 1953-54 | | | |
| 15 | 9.51 | Hay | 1.74 | 15.0 | 862 |
| 15 | 13.74 | Hay | 1.71 | 14.8 | 862 |
| 15 | 9.51 | Hay + silage | 1.69 | 19.6 | 1160 |
| 15-14[1] | 13.74 | Hay + silage | 1.78 | 18.9 | 1165 |
| | | 1954-55 | | | |
| 20 | 9.51 | Hay | 1.90 | 14.5 | 764 |
| 20 | 13.74 | Hay | 1.99 | 14.6 | 732 |
| 20-19[1] | 9.51 | Hay + silage | 1.91 | 17.4 | 909 |
| 19[1] | 13.74 | Hay + silage | 1.97 | 17.5 | 888 |

[1]See footnotes of Table 3.

*Least significant differences required of 5 percent level, for average of 15 steers; 1953-54, 0.11 lb. av. daily gain—both hay and silage groups; 45 lb. total feed for 100 lb. gain—hay groups; 34 lb. total feed for 100 lb. gain—silage groups; for av. of 20 steers, 1954-55, 0.14 lb. daily gain—both hay and silage groups; 44 lb. total feed for 100 lb. gain—hay groups; 27 lb. total feed for 100 lb. gain—silage groups.

(3) The average daily gain, average daily ration and the average feed required for 100 lb. gain of all steer groups receiving the same ratios of concentrate to roughage and the same type of roughage are shown in Table 5. The data of each 10-steer group represent the total average values of two 5-steer groups fed 2 different protein concentrate mixtures.

Table 5.—Average daily gains, daily rations and feed requirements of steer calves fed alfalfa hay or alfalfa hay plus corn silage with each ratio of concentrate to roughage.

| No. Steers | Ratio | Roughage | Average Daily Gain* | Average Daily Ration | Feed for each 100 lb. gain* |
|---|---|---|---|---|---|
| | | | lb. | lb. | lb. |
| | | 1953-54 | | | |
| 10 | 1 : 3 | Hay | 1.69 | 14.9 | 879 |
| 10 | 1 : 2 | Hay | 1.66 | 14.3 | 864 |
| 10 | 1 : 1 | Hay | 1.82 | 15.2 | 847 |
| 10-9[1] | 1 : 3 | Hay + silage | 1.66 | 21.5 | 1294 |
| 10 | 1 : 2 | Hay + silage | 1.80 | 20.4 | 1165 |
| 10 | 1 : 1 | Hay + silage | 1.73 | 18.1 | 1064 |
| | | 1954-55 | | | |
| 10 | 1 : 1 | Hay | 2.00 | 15.5 | 774 |
| 10 | 2 : 1 | Hay | 1.92 | 14.4 | 752 |
| 10 | 3 : 1 | Hay | 1.87 | 13.8 | 741 |
| 10 | 4 : 1 | Hay | 2.00 | 14.5 | 723 |
| 10 | 1 : 1 | Hay + silage | 1.91 | 19.7 | 1032 |
| 10 | 2 : 1 | Hay + silage | 1.96 | 17.0 | 867 |
| 10 | 3 : 1 | Hay + silage | 1.95 | 16.7 | 856 |
| 9-8[1] | 4 : 1 | Hay + silage | 1.90 | 16.1 | 850 |

[1]See footnote of Table 3.

*Least significant differences required for average of 10 steers at 5 percent level: 1953-54, 0.13 lb. av. daily gain—both hay and silage groups; 55 lb. total feed for 100 lb. gain—hay groups; 40 lb. total feed for 100 lb. gain—silage groups; 1954-55, 0.19 lb. av. daily gain—both hay and silage groups; 0.63 lb. feed for 100 lb. gain—hay groups; 38 lb. feed for 100 lb. gain—silage groups.

(4) The average daily consumption of the concentrate mixtures, roughages and percent protein intake of each of the 5-steer groups are presented in Table 6.

Table 6.—Average daily consumption of the concentrate mixture, alfalfa hay and corn silage—154 days.

| No. steers | Ratio | Concentrate protein | Concentrate | Alfalfa hay | Corn silage | Protein intake |
|---|---|---|---|---|---|---|
| | | percent | lb. | lb. | lb. | percent |
| | | | 1953-54 | | | |
| 5 | 1 : 3 | 9.51 | 3.90 | 11.81 | | 13.62 |
| 5 | 1 : 3 | 9.51 | 3.62 | 7.24 | 10.81 | 11.41 |
| 5 | 1 : 3 | 13.74 | 3.50 | 10.51 | | 14.70 |
| 5-4[1] | 1 : 3 | 13.74 | 3.56 | 7.08 | 10.68 | 12.39 |
| 5 | 1 : 2 | 9.51 | 4.70 | 9.40 | | 13.19 |
| 5 | 1 : 2 | 9.51 | 4.47 | 6.02 | 9.00 | 11.19 |
| 5 | 1 : 2 | 13.74 | 4.83 | 9.73 | | 14.56 |
| 5 | 1 : 2 | 13.74 | 4.86 | 6.56 | 9.78 | 12.60 |
| 5 | 1 : 1 | 9.51 | 7.56 | 7.56 | | 12.24 |
| 5 | 1 : 1 | 9.51 | 6.66 | 4.35 | 6.65 | 10.66 |
| 5 | 1 : 1 | 13.74 | 7.89 | 7.89 | | 14.32 |
| 5 | 1 : 1 | 13.74 | 7.23 | 4.76 | 7.24 | 12.78 |
| | | | 1954-55 | | | |
| 5 | 1 : 1 | 9.51 | 8.00 | 8.00 | | 12.25 |
| 5 | 1 : 1 | 9.51 | 7.56 | 5.04 | 7.56 | 10.78 |
| 5 | 1 : 1 | 13.74 | 7.48 | 7.48 | | 14.80 |
| 5 | 1 : 1 | 13.74 | 7.21 | 4.81 | 7.21 | 12.83 |
| 5 | 2 : 1 | 9.51 | 9.94 | 4.97 | | 11.27 |
| 5 | 2 : 1 | 9.51 | 9.42 | 3.15 | 4.72 | 10.32 |
| 5 | 2 : 1 | 13.74 | 9.26 | 4.63 | | 14.11 |
| 5 | 2 : 1 | 13.74 | 9.09 | 3.04 | 4.55 | 13.11 |
| 5 | 3 : 1 | 9.51 | 9.51 | 3.17 | | 10.88 |
| 5 | 3 : 1 | 9.51 | 11.58 | 2.58 | 3.85 | 10.17 |
| 5 | 3 : 1 | 13.74 | 11.28 | 3.76 | | 13.96 |
| 5 | 3 : 1 | 13.74 | 10.95 | 2.44 | 3.65 | 13.28 |
| 5 | 4 : 1 | 9.51 | 11.56 | 2.89 | | 10.59 |
| 5-4[1] | 4 : 1 | 9.51 | 10.94 | 1.83 | 2.73 | 10.09 |
| 5 | 4 : 1 | 13.74 | 11.60 | 2.90 | | 14.00 |
| 4[1] | 4 : 1 | 13.74 | 11.86 | 1.98 | 2.96 | 13.35 |

[1]See footnote of Table 3.

## Protein Level

The control of protein intake in this study on the effect of level of protein consumption on rate and economy of gains was fulfilled through the inclusion of 12 parts oil meal in the concentrate mixture. Comparisons were made to determine the difference in rate and economy of gain between a group of steers receiving a concentrate mixture with 12 percent oil meal (13.74 percent crude protein mixture) and a group of steers fed the same mixture (9.51 crude protein mixture) without the oil meal. This system was adopted because it is the most convenient method for the commercial operator to use in practice. This system of regulating the protein intake causes a change in level of protein consumption as the ratio of the intake of concentrate to roughage changes. The intake of total protein decreased as the concentrate intake increased for those groups of steers receiving the 9.51 percent protein concentrate mixture with alfalfa hay. This accounted for a maximum difference of 2.03 percent total protein intake (13.62 — 10.59 = 2.03). The intake of total protein decreased 1.32 percent as the concentrate intake increased for those groups of steers receiving the alfalfa-hay-corn-silage ration. The maximum decrease in the total protein intake was only 0.7 percent for those groups receiving the 13.74 percent protein-concentrate mixture with alfalfa hay. The reverse was true of the groups receiving the 13.74 percent protein-concentrate mixture with alfalfa hay and corn silage. There was an increase of 1.35 percent total protein intake as the consumption of hay was reduced and the concentrate mixture increased.

Assuming that the coefficient of digestibility of these rations averages about 75 percent, the total intake of digestible protein approximates the recommended allowances of the National Research Council (2). The total daily protein intake may be below the recommended allowances for a few steers among the groups receiving the 9.51 protein concentrate with alfalfa hay and corn silage.

The inclusion of 12 parts oil meal in the concentrate mixture did not contribute to an increase in gains or feed economies of the steers fed alfalfa hay as the sole roughage for any ratio of concentrate to roughage except those steers receiving 3 parts concentrate and 1 part roughage (Table 3). This exception may be the result of the effects of factors other than the protein intake. The total overall effect of the addition of a protein supplement to these rations is summarized in Table 4. There were no actual differences in either the rate or economy of gains among those steer groups receiving the rations with oil meal and those steer groups receiving the same rations without oil meal when the data of steers fed all ratios of concentrate to roughage were combined into the same protein-roughage groups.

Those 5-steer groups receiving the 12 percent protein supplement mixture with the alfalfa-hay-corn-silage roughage exhibited a more rapid rate of gain in live weight than those groups fed the roughage combination minus the protein supplement. The group fed the 1 : 1 ratio in the 1954-55 series was an exception. Since the reverse was true in the 1953-54 series for these same comparisons, it is logical to conclude that the values obtained in the 1954-55 series for the 1 : 1 ratio group were the result of factors other than the protein.

No significant differences were observed in the feed required for each 100 pounds gain between the two protein levels and alfalfa-hay-corn-silage groups (Table 4).

A statistical study of the rate of gain data indicated an interaction between the change in the concentrate and roughage level with the protein percentage of the concentrate mixture for ratios of concentrate to roughage of 1 : 3, 1 : 2 and 1 : 1 of the 1953-54 series.

No significant differences or interactions were observed in the summaries of the protein data on the average daily gains of the steers fed the ratios of concentrate to roughage of 1 : 1, 2 : 1, 3 : 1 and 4 : 1. during the 1954-55 series.

There was a significant interaction on the basis of feed required for each 100 pounds gain between the change in concentrate and roughage level and protein intake for the silage-fed steers for both series of studies; yet there was no interaction between the feed requirements per 100 pounds gain and the protein intake of the groups of steers fed the various ratios of concentrate to alfalfa hay. This would indicate that the protein intake of the alfalfa-hay-corn-silage fed steers was not meeting the needs so completely as was the protein intake of the steers fed the alfalfa hay as the sole roughage.

### Type of Roughage

There was no apparent consistent difference in the rate of gains between the groups of steers fed alfalfa hay as a roughage and those fed the combination of alfalfa hay and corn silage for any level of concentrate to hay intake (Table 5).

When the weight of corn silage is converted to the air dry basis and used to calculate the total feed required per unit of gain, the steers fed the alfalfa-hay-corn-silage roughage made the most efficient gains for most of the ratio combinations. The exceptions were among the groups fed the low protein concentrate with a ratio of concentrate to roughage of 1 : 3, and among the groups fed the high protein concentrate with a ratio of concentrate to roughage of 1 : 1 during the 1954-55 series.

### Concentrate and Roughage Levels

The average daily gains of the 5-steer groups are not consistently different (Tables 3 and 5). However, there is a general trend of increase in rate of gain as the concentrate in the mixture is increased.

The feed required for each 100 pounds gain decreased with an increase in concentrate intake for all ration combinations. The differences in the feed required for each 100 pounds gain between those groups of steers fed the different ratios of concentrate to alfalfa hay were not statistically significant. Those steer groups fed the alfalfa-hay-corn-silage roughage rations showed statistically significant differences in total feed required for each 100 pounds gain.

## Conclusions

1. The inclusion of 12 parts of 44 percent protein supplement in the concentrate mixture did not consistently increase the rate of gain or reduce the total feed required for each 100 pounds gain for the groups of steers fed any of the ration combinations in this study.

2. The steers fed the alfalfa-hay corn-silage rations required less total feed (silage converted to air dry matter basis) for each 100 pounds gain for all ration combinations except two.

3. The total feed required for 100 pounds of gain for fattening steers decreased as the ratio intake of concentrate and roughage progressed from 1 : 3 to 4 : 1.

4. The average daily gain was not greatly different among the steer groups fed the various ratios of concentrate to roughage during the feeding years, 1953-54 or 1954-55.

### References

1. Keith, T. B., R. F. Johnson and W. P. Lehrer, Jr., 1952. The optimum ratio concentrate to alfalfa hay for fattening steers, University of Idaho Agr. Expt. Sta. Bull. 290.
2. Guilbert, H. R., Paul Gerlaugh and L. L. Madsen, 1950. Recommended nutrient allowances for beef cattle. Nat'l Res. Council, Washington, D. C.

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# Nutritional Status of School Children 15 and 16 Years of Age in Three Idaho Communities

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# Nutritional Status of School Children 15 and 16 Years of Age in Three Idaho Communities

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## Synopsis

IN THE Western Regional study, "Nutritional status of population groups in selected areas of the West," subjects in nine western states were studied with physical and dental examinations, dietary records and biochemical tests to determine the effect of environment and food habits on physical well-being. In Idaho, the subjects were school children 15 and 16 years of age in the Boise, Nampa and Coeur d'Alene areas. These communities were selected to represent the southwestern and the northern parts of the state.

The dental examinations showed that the teeth of the children in the Coeur d'Alene area were severely affected by decay. The lack of fluorides in the water supplies would only partially explain the severity of the dental problem in the northern part of Idaho.

In general, the physical condition of the Idaho subjects was good and few signs which might be associated with nutritional deficiencies were found. Height, weight and age data were compared with the Baldwin-Wood standards and were plotted on the Wetzel Grid. Skeletal age was estimated from X-ray films. None of the subjects had hemoglobin values indicative of anemia. Sedimentation rates were above average for subjects who were overweight as well as for those with infection.

In addition to the blood and urine tests which are customarily part of a medical examination, 10 biochemical blood factors which might be measures of nutritional status were determined. Few of the values were outside the generally accepted limits of normal. Correlation coefficients were calculated to determine interrelationships among these blood factors. More of these interrelationships were statistically significent in the data of the boys than of the girls.

Records of measured food intake were kept for 7 days by each subject. The average calculated intakes of nutrients were near the levels recommended by the National Research Council, except for the iron intake of the girls. Thirty per cent of the subjects, however, reported diets which supplied less than one-half of the recommended allowances of one or more nutrients (most frequently ascorbic acid, calcium and vitamin A). The nutrient intake of those subjects whose diets did not furnish the recommended amounts of nutrients could be improved by a few changes in food habits.

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# Purpose and Plan of Study

The effect of environmental conditions and food intake on physical well-being cannot be determined for human subjects under controlled laboratory conditions. The Western Regional nutritional status study was undertaken on the basis that, in a sense, Nature fixes experimental conditions in a given area, so that a study of subjects in a selected area would give information about the effect of the environmental conditions and established food habits on the physical well-being of persons who had lived a number of years in that area.

The so-called "normal" values for some physical and biochemical measurements are based on a small number of results because few studies have been made on normal groups of subjects. Practically no studies have been made in western areas, so it is not known how well the standards for certain physical and biochemical measurements accepted in other parts of the country really apply to the western population.

In the Western Regional nutritional status study, nutritionists in the Agricultural Experiment Station of each of the nine participating states selected the group of subjects to be studied in that state. In Idaho the group selected was teen-age school children in areas with known differences in the prevalence of dental decay. The results of this study have been considered from two angles: (1) how the Idaho subjects compared with similar groups in other parts of the country; (2) the differences found between the groups of subjects from the two sections of Idaho.

## AREAS STUDIED

Idaho has an unusual range of variation in soil, water, latitude and climatic factors which might have an effect on the dental health of children. A study was made of the teeth of freshman students at the University of Idaho in 1950. This study showed that students reared in different areas of the state had widely varying amounts of dental decay (42). Students reared in the southwestern section of the state showed the least incidence of dental decay and those reared in the northern section showed the greatest evidence of decay.

Three communities were selected for study in 1951 on the basis of the area of the state, population, local health facilities and organization and the fluoride content of the municipal water supplies. Two towns were chosen to represent the southwestern section: Boise, with an average fluoride content of 0.5 p.p.m. in the municipal water (typical of the municipal water supplies in much of southern Idaho) and the neighboring town of Nampa, with 1.5 p.p.m. fluorides in its municipal water supply. Coeur d'Alene was chosen to represent the northern section of the state. Subjects from Rathdrum and Post Falls, towns approximately 10 miles from Coeur d'Alene, were included in this group. The municipal water supplies of these three towns were fluoride-free, as were most of the municipal water supplies in northern Idaho.

The population of Boise was approximately 35,000; the principal occupations of the family wage earners as listed by the subjects were skilled labor, clerical or sales, and professional or managerial. Nampa is 19 miles from Boise in the same irrigated valley. Nampa's population was approximately 16,000; the majority of the wage earners were listed as farmers or railroad employees. Coeur d'Alene, a resort center 300 air-miles north of Boise and Nampa, had a population of approximately 16,000; Rathdrum and Post Falls each had less than 1000 population. The occupations most frequently listed in the northern communities were lumbering and farming, skilled labor and unskilled labor.

Ninety-five per cent of the subjects were of British, German, Scandanavian or French extraction, with only minor variations between areas in the distribution of these nationalities. All subjects were of the white race, although two mentioned that they had an Indian ancestor.

The majority of the subjects in each community expressed a preference for a Protestant church. Seventeen per cent of the Nampa subjects, 10 per cent of the Boise subjects and 4 per cent of the Coeur d'Alene subjects were Roman Catholic. Approximately one-sixth of the subjects in Boise and Nampa were listed as members of the Latter Day Saints (Mormon) church.

## SUBJECTS

The subjects, who volunteered to participate in the study, were school children 15 and 16 years of age reared in one of the study communities. A total of 274 subjects completed their records—46 girls and 44 boys in Boise, 54 girls and 40 boys in Nampa, and 50 girls and 40 boys in the Coeur d'Alene area (including 10 girls and 5 boys from Rathdrum and 2 girls and 4 boys from Post Falls). The subjects were students at Boise High School and North Junior High School in Boise, Nampa High School, Coeur d'Alene High School, Rathdrum High School and Post Falls High School.

## ORDER OF WORK

The field supervisor or a nutritionist explained the project to prospective subjects in classrooms or assemblies at the schools and distributed slips to be signed by the parents granting permission for the child to participate in the study. When a student returned the signed permission slip, the nutritionist made an appointment with him for an interview at the school during one of his free periods. At the interview the nutritionist obtained background information about the subject, secured a "diet history"—a description of the subject's usual diet and food habits—and told the subject how to keep a record of his measured food intake for 7 days. She gave the subject an instruction sheet with detailed directions for recording the food intake, forms on which to record each day's food intake and 7 self-addressed stamped envelopes in which to return each record as completed.

When the diet records had been returned, the subject received an appointment for the clinical and dental examinations. A questionnaire to be signed by the parent giving information needed for the medical history was sent with the appointment card. The subject was instructed to come to the clinic without breakfast so that a fasting blood sample could be obtained.

Clinics were held three mornings weekly with six to eight subjects scheduled for examination at each clinic. The Boise and Nampa subjects were examined at the City-County Health Unit in Boise; subjects from Coeur d'Alene, Rathdrum and Post Falls were examined at the Panhandle District Health Unit in Coeur d'Alene. The dental examination was generally scheduled for the same morning, with some subjects going first to the dentist's office and some going first to the clinic.

At a typical clinic, a nurse interviewed the subject to obtain a medical history. Another nurse measured his blood pressure, tested vision and hearing and took X-ray films of his foot and hand for bone density determinations. A medical technician took a 20 ml. blood sample. After the blood sample had been obtained, the subject was offered a lunch of crackers, cheese, apples and milk, because he had come to the clinic without breakfast. The receptionist took the subject's temperature, routed him through the various parts of the clinic examination and had each subject obtain a urine specimen. After the subject had undressed for the physical examination and draped himself with a sheet, he was weighed and measured. The doctor then examined the subject. If the doctor observed any abnormal condition, he sent a report to the subject's parents and family doctor.

At the clinic, the medical technician or the chemist made the urine and blood tests which are usually part of a medical examination. The serum from the remainder of each blood sample was frozen and shipped in dry ice to the Home Economics Research laboratory at Utah State Agricultural College. Three chemists in that laboratory made the biochemical determinations on the serum from all the subjects in the Utah and Idaho phases of the Western Regional nutritional status study.

## PERSONNEL FOR FIELD WORK

**Physicians**
Jack R. Farber
Lynne C. Fredrikson

**Dentists**
Gordon L. Williamson
Walter Matson
Frank O'Halloran
Jack A. Rice
Robert M. Scates
Forest J. Schini

**Nutritionists**
Shirley V. Bring*
Louise S. Rencher
Myrtle B. Adler

**Chemists**
Patricia Wood*
Leora S. Galloway*
Farrin L. Mangelson
John Barnwell*

**Technicians**
Personnel of Division of Laboratories, Idaho State Department of Public Health, Boise
Clifford R. Sweeney

**Nurses**
Jeanne B. Morton
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Public Health nurses, Panhandle District Health Unit, Coeur d'Alene

**Secretaries**
Clara E. Moore
June B. Epstein

**Directors**
Ella Woods
Kathleen Porter Warnick,* Field Supervisor

* Agents of the Human Nutrition Research Branch at some time during the study.

# Dental Examinations

## CLASSIFICATION OF SUBJECTS

In the dental phase of this study, the subjects were those students in the group of volunteers who had been born in and were continuous residents of the communities being studied. Continuous urban residence was not a requirement for participation in this study, but detailed information on places of residence was obtained for each subject, and the dental findings classified accordingly. Students who had not been away from the study community or the adjacent farming district more than two months in any year were considered continuous residents of the area; those who had used the municipal water supply since birth were classed as continuous urban residents. The age and sex distribution of the subjects whose dental findings are reported is given in Table 1.

**Table 1.—Age and sex distribution of subjects who were continuous residents of three Idaho communities**

| Continuous residence | Girls | | | Boys | | | Total | | |
|---|---|---|---|---|---|---|---|---|---|
| | Number | Average age | | Number | Average age | | Number | Average age | |
| | | yrs. | mos. | | yrs. | mos. | | yrs. | mos. |
| **Area** | | | | | | | | | |
| Boise | 40 | 15 | 10 | 34 | 16 | 0 | 74 | 15 | 11 |
| Nampa | 44 | 16 | 2 | 27 | 16 | 4 | 71 | 16 | 2 |
| Coeur d'Alene | 43 | 15 | 11 | 27 | 16 | 0 | 70 | 15 | 11 |
| **Urban** | | | | | | | | | |
| Boise | 20 | 15 | 8 | 23 | 16 | 0 | 43 | 15 | 11 |
| Nampa | 18 | 16 | 2 | 8 | 16 | 2 | 26 | 16 | 2 |
| Coeur d'Alene | 21 | 15 | 11 | 9 | 15 | 11 | 30 | 15 | 11 |

## METHODS

The dental examinations were done in the offices of the local practicing dentists who cooperated in the study. All subjects from Boise and Nampa were examined by one dentist.[1] The five dentists in Coeur d'Alene[2] each examined an equal number of the Coeur d'Alene subjects. The dentists first charted the filled, extracted and carious teeth which were observed using mouth mirror and explorer; posterior bite-wing X-ray films were taken and the findings subsequently charted. Notations were made on the charts to indi-

[1] Dr. Gordon L. Williamson.
[2] Drs. Walter Matson, Frank O'Halloran, Jack A. Rice, Robert M. Scates, and Forest J. Schini.

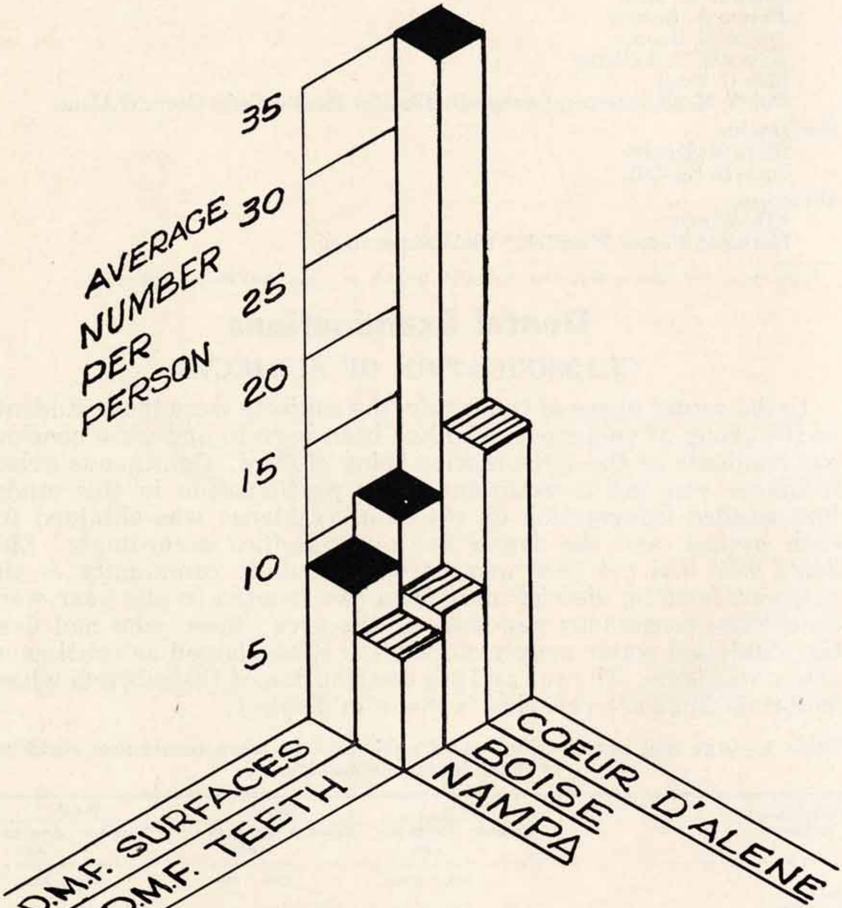


**Figure 1. Comparison of the average numbers of D. M. F. (decayed, missing and filled) teeth and tooth surfaces, without X-ray findings, of school children 15 and 16 years of age who were continuous residents in the Nampa, Boise and Coeur d'Alene areas.**

cate deciduous teeth and teeth which were unerupted or had been extracted for orthodontic reasons or lost by accident. These teeth were not included in summarizing the results.

Dental caries experience was measured by counting the number of teeth and tooth surfaces (excluding deciduous teeth and third molars) which were carious (decayed), filled or extracted because of caries. The symbol D.M.F. (decayed, missing and filled) was used to designate past and present caries experience.

## RESULTS AND DISCUSSION

### Dental Caries Experience

The dental caries experience of the boys and girls examined in the three communities is presented in Table 2. The striking difference in average caries prevalence of the Boise and Nampa subjects compared with the Coeur d'Alene subjects is shown in Figure 1. The average number of D.M.F. teeth of the Coeur d'Alene subjects was more than twice as great as for the Boise and Nampa subjects, and the average number of D.M.F. surfaces was three to four times greater. Not only had far more teeth per person been attacked by decay in the Coeur d'Alene area than in the Boise and Nampa areas, but each tooth had been more severely attacked. For the Boise and Nampa subjects the average number of D.M.F. surfaces was approximately one and one-half times greater than the number of D.M.F. teeth, but for the Coeur d'Alene subjects

**Table 2.—Dental caries experience of children 15 and 16 years of age in three Idaho communities**

| Group | | Number of subjects | Average number of teeth | | | | | | Average number of surfaces | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Filled | Carious by clinical exam. | Carious by X-ray exam. | Extracted | D.M.F.[1] | D.M.F. with X-ray findings | D.M.F. | D.M.F. with X-ray findings |
| **Continuous area residents** | | | | | | | | | | |
| Boise | | | | | | | | | | |
| | Girls | 40 | 3.88 | 3.92 | 2.00 | 0.50 | 7.85 | 8.56 | 12.05 | 14.18 |
| | Boys | 34 | 2.65 | 3.82 | 3.12 | 0.29 | 6.62 | 8.26 | 10.32 | 13.56 |
| | Group | 74 | 3.31 | 3.88 | 2.51 | 0.41 | 7.28 | 8.43 | 11.26 | 13.82 |
| Nampa | | | | | | | | | | |
| | Girls | 44 | 4.93 | 2.30 | 2.52 | 0.16 | 7.00 | 8.16 | 10.32 | 13.23 |
| | Boys | 27 | 2.04 | 3.37 | 3.26 | 0.04 | 5.30 | 6.15 | 6.87 | 9.96 |
| | Group | 71 | 3.83 | 2.70 | 2.80 | 0.11 | 6.35 | 7.68 | 8.83 | 11.99 |
| Coeur d'Alene | | | | | | | | | | |
| | Girls | 42 | 8.81 | 7.07 | 5.19 | 2.83 | 16.05 | 17.93 | 39.28 | 44.98 |
| | Boys | 27 | 7.04 | 6.70 | 5.52 | 1.63 | 13.15 | 15.89 | 29.63 | 35.78 |
| | Group | 69 | 8.12 | 6.93 | 5.32 | 2.36 | 14.91 | 17.13 | 35.51 | 41.38 |
| **Continuous urban residents** | | | | | | | | | | |
| Boise | | | | | | | | | | |
| | Girls | 20 | 2.95 | 3.85 | 1.50 | 0.35 | 6.55 | 6.95 | 9.85 | 11.40 |
| | Boys | 23 | 2.04 | 4.09 | 3.22 | 0.09 | 6.13 | 7.96 | 8.48 | 11.91 |
| | Group | 43 | 2.64 | 3.98 | 2.42 | 0.21 | 6.33 | 7.49 | 9.12 | 11.67 |
| Nampa | | | | | | | | | | |
| | Girls | 18 | 2.94 | 1.89 | 1.50 | 0.00 | 4.72 | 5.56 | 5.89 | 7.61 |
| | Boys | 8 | 1.12 | 3.50 | 2.50 | 0.00 | 4.62 | 6.00 | 5.25 | 8.00 |
| | Group | 26 | 2.38 | 2.38 | 1.81 | 0.00 | 4.69 | 5.69 | 5.69 | 7.73 |
| Coeur d'Alene | | | | | | | | | | |
| | Girls | 21 | 10.62 | 7.05 | 6.05 | 2.38 | 16.90 | 18.71 | 39.67 | 45.81 |
| | Boys | 9 | 10.11 | 7.11 | 3.11 | 1.56 | 16.11 | 17.00 | 37.56 | 41.00 |
| | Group | 30 | 10.47 | 7.07 | 5.17 | 2.13 | 16.67 | 18.20 | 39.03 | 44.37 |

[1] D.M.F. teeth do not equal the sum of the filled, carious, and extracted teeth because some of the teeth were both filled and carious.

there were nearly two and one-half times as many D.M.F. surfaces as D.M.F. teeth. In other words, the cavities or fillings in the teeth of the subjects in the Boise and Nampa areas usually involved only one or two surfaces of a tooth, but in the northern area the cavities or fillings involved two or three surfaces.

Portions of the dental examination charts of two of the subjects in this study are shown in Figure 2. These charts were selected as being typical of those for the subjects in the northern and in the southwestern sections of Idaho. The first subject had the same number of D.M.F. teeth as the average for the subjects in the Coeur d'Alene area; the second subject had the same number as the average for the subjects in the Boise and Nampa areas.

The range in number of D.M.F. teeth including X-ray findings for the continuous urban residents was 0 to 20 for the Boise group,

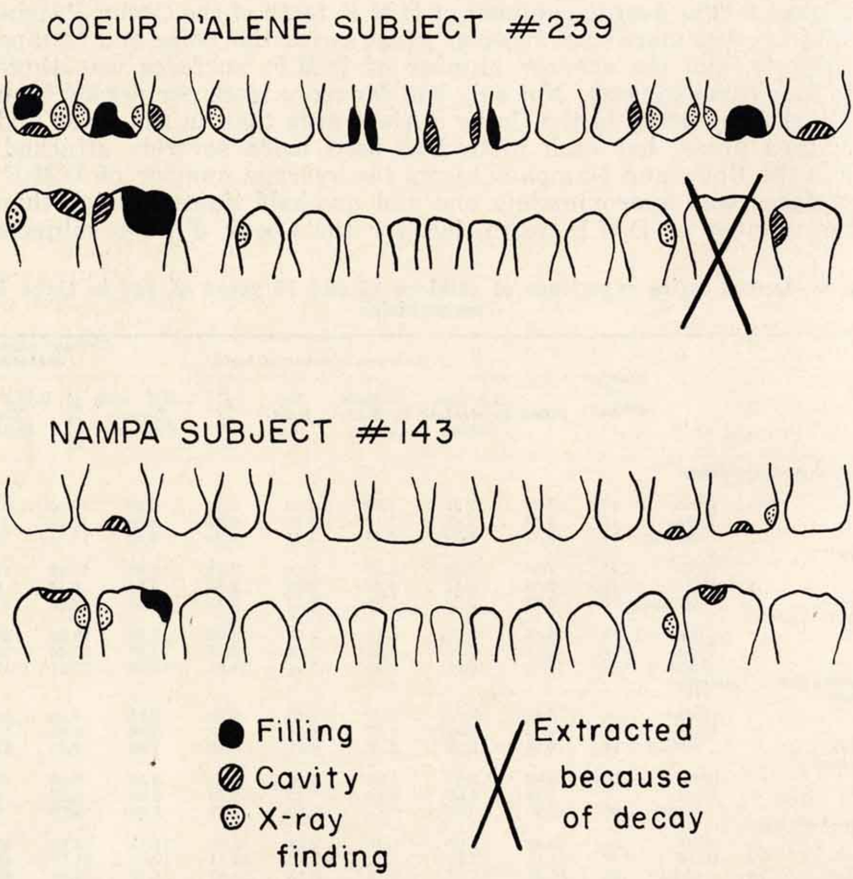


**Figure 2. Portions of typical dental examination charts of subjects from the northern and southwestern sections of Idaho.**

0 to 17 for the Nampa group and 10 to 28 for the Coeur d'Alene group. Five of the subjects in the Boise area and four in the Nampa area had no D.M.F. teeth; two of the Coeur d'Alene subjects had complete upper dentures. The average caries prevalence of the continuous urban residents of Coeur d'Alene, 16.7 D.M.F. teeth or 18.2 D.M.F. teeth including X-ray findings, was higher than has been reported for any corresponding group of subjects.

Comparison of the caries experience of the Boise and Nampa subjects is of particular interest, inasmuch as the fluoride content of the Nampa water (1.5 p.p.m.) is within the range generally considered to be optimum, whereas that of Boise is considerably lower (0.5 p.p.m.). The average number of D.M.F. teeth for the continuous urban residents in Boise was 6.33, with a standard deviation of 4.56; the corresponding group in Nampa averaged 4.69 $\pm$ 3.55 D.M.F. teeth. The Nampa average was 26 per cent lower than the Boise average. For the D.M.F. count including X-ray findings, the figures were 7.49 $\pm$ 4.61 D.M.F. teeth for the Boise group, and 5.69 $\pm$ 4.26 D.M.F. teeth for the Nampa group, 24 per cent lower. These differences, however, are not statistically significant; that is, the probabilities of these differences occurring by chance were about 1 in 10. In the communities studied, as would be true in any town in this state, it was not possible to get a larger number of subjects who were continuous urban residents. Subjects were therefore included who had lived in the adjacent farming area. These children had used municipal water at least while at school, and many had moved one or more times from farm to town. The average number of D.M.F. teeth for the continuous area residents of Boise was 7.28 and of Nampa 6.35, 13 per cent lower. The corresponding figures for the D.M.F. count including X-ray findings were 8.43 D.M.F. teeth for the Boise group and 7.68 D.M.F. teeth for the Nampa group, 9 per cent lower. These differences are not statistically significant.

The high caries incidence among the Coeur d'Alene subjects as compared with the Boise and Nampa group cannot be explained on the basis of poorer dental care. The Coeur d'Alene area subjects, on the average, brushed their teeth more frequently and had been to a dentist more recently than the Boise and Nampa subjects. Fifty-two per cent of the Coeur d'Alene subjects reported brushing their teeth two or more times per day, compared with 34 per cent of the Boise subjects and 30 per cent of the Nampa subjects. (Brushing the teeth less often than once a day was reported by 17 per cent of the subjects in the southern communities and by 13 per cent of those in Coeur d'Alene.) More than half of the Coeur d'Alene subjects had visited their dentists within 6 months of this study and all had visited a dentist in the preceding 2 years, but 2 years or more had passed since 26 per cent of the Boise subjects and 12 per cent of the Nampa subjects had visited a dentist. An additional 5 per cent of the Boise subjects and 8 per cent of the Nampa subjects had never been to a dentist. Although the Coeur d'Alene subjects needed far more dental work than did the subjects in Boise and Nampa, the amount of the dental work needed in relation to that which had been done was approximately the same for the Coeur d'Alene and Nampa subjects and was highest for the Boise subjects. The ratio obtained by dividing the number of teeth requiring fillings by the number of filled and extracted teeth was 1.04 for the Boise subjects, 0.68 for the Nampa subjects and 0.66 for the Coeur d'Alene subjects.

In each area, approximately 60 per cent of the subjects had been breast fed for more than 3 months. The average number of D.M.F. teeth for the subjects which had been breast fed more than 3 months was 6 per cent lower in Boise and Nampa and 16 per cent lower in Coeur d'Alene than the average for all the subjects which had been breast fed less than 3 months or not at all.

The difference in the fluoride content of the water used in the three communities undoubtedly explains some of the variation in caries-susceptibility in these groups of subjects. On the basis of the studies by Dean *et al.* (21, 22) of children 12 to 14 years of age in 21 cities with varying amounts of fluorides in their water supplies (assuming that the average number of D.M.F. teeth would increase between the ages of 14 and 16 at a rate similar to that at which it increased between the ages of 12 and 14), 16-year-old children in communities with 1.5, 0.5 or 0.0 p.p.m. fluorides in the water supplies would be expected to have about 4.1, 6.7 or 11.2 D.M.F. teeth, respectively. The average number of D.M.F. teeth for the Nampa urban subjects was 4.7, which was somewhat higher than the expected value of 4.1 D.M.F. teeth; the average for the Boise urban subjects was 6.3 D.M.F. teeth, a little lower than the expected value of 6.7 D.M.F. teeth. On the other hand, the value of 16.7 D.M.F. teeth per subject found for the Coeur d'Alene subjects was much higher than the expected value of 11.2, indicating that some factors in addition to the lack of fluorides in the water may be involved in the severe dental health problem in this portion of the state.

Analyses of the five municipal water supplies used by the subjects in this study are presented in Table 3. The water supplies of

**Table 3.—Analyses[1] of the municipal water supplies used by subjects in this study**

| Town | Source | Iron | Magnesium | Calcium | Total hardness as $CaCO_3$ | Fluoride |
|---|---|---|---|---|---|---|
| | | p.p.m. | p.p.m. | p.p.m | p.p.m. | p.p.m. |
| Boise | Several wells | 0.2 to 0.6 | 2.5 to 3.4 | 13 to 34 | 43 to 99 | 0.5[2] |
| Nampa | Artesian wells | 0.0 | 2.5 | 12 | 40 | 1.5 |
| Coeur d'Alene | Lake | 0.3 | 1.9 | 6 | 23 | 0.0 |
| Rathdrum | Surface | 0.5 | 0.8 | 4 | 13 | 0.0 |
| Post Falls | Shallow wells | 0.25 | 2.1 | 8 | 29 | 0.0 |

[1] From Division of Laboratories, Idaho Department of Public Health, 1948-1951.
[2] Average of tap samples. Different wells vary from 0.15 to 3.5 p.p.m. of fluorides.

the three towns in the northern area (Coeur d'Alene, Rathdrum and Post Falls) are lower than the Boise and Nampa water supplies in calcium, magnesium and total hardness, as well as fluorides. No data are available on the concentration in these water supplies of other factors which have been shown to have an effect on dental caries in experimental animals. For example, vanadium (29) and copper (34) have been shown to inhibit dental caries in the hamster, and manganese (45) has been shown to decrease the development of caries in the rat. Boise and Nampa are in a semi-arid region where the soil was formed under conditions of low rainfall, little leaching and desert shrub vegetation; the soil is characterized by a high calcium content. The soil in the Coeur d'Alene area was formed under conditions of more rainfall, high leaching and forest vegetation; the soil is low in calcium (2). Further studies are needed to establish the relationship to caries susceptibility of soil constituents and of minerals in the drinking water.

Environmental and climatic factors, such as elevation, latitude and the usual amount of sunshine, may have an effect on the dental health of children. Dunning (23) compiled reports of the incidence of dental diseases in various parts of the United States and found that dental caries was significantly correlated with latitude and with distance from the sea coast. Coeur d'Alene is 4 degrees of latitude north of the other study communities, but all three communities are approximately the same distance from the sea coast. Detailed climatalogical data covering the life span of these subjects are not available, but records of the number of clear, partly cloudy and cloudy days are available for the three communities for the period 1940-1947. These and related data are summarized in Table 4. According to these records, during the

**Table 4.—Summary of climatological data[1], elevation and latitude of the three Idaho communities studied**

| Community | | Average number of days Clear | Partly cloudy | Cloudy | Elevation | Latitude |
|---|---|---|---|---|---|---|
| | | | | | Ft. | |
| Boise | 53-year record | 138 | 98 | 129 | 2710 | 43°34′N |
| | 1940-1947 | 119 | 101 | 145 | | |
| Nampa | 1940-1947 | 170 | 115 | 80 | 2482 | 43°35′N |
| Coeur d'Alene | 1940-1947 | 131 | 95 | 139 | 2160 | 47°21′N |

[1]From U.S. Department of Commerce, Weather Bureau, Climatological Data, Idaho Section, Annual Reports, 1935-1951.

period 1940-1947 Boise had the lowest average number of clear days—Boise, 119; Coeur d'Alene, 131; Nampa, 170. Long-term records for Boise give the average number of clear days during a 53-year period as 138. Unfortunately, no objective measurements were made of the amount of sunlight in these areas during the period 1935-1951. The Boise-Nampa area had a 5-month period during which the average maximum temperature exceeded 60°, but the Coeur d'Alene area had only a 4-month period of equally warm weather during which outdoor wraps would not interfere with sunlight irradiation. The average precipitation is approxi-