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Studies on the Water Requirements of Farm Animals in South Africa. II.—The Relation between Water Consumption, Food Consumption and Atmospheric Temperature as Studied on Merino Sheep.

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In their comprehensive review "The Water Economy of Farm Animals", Leitch and Thomson (1944) draw attention to the scarcity of data on the water requirements of farm animals the world over. They also point out that much of the available data is incomplete in that details of the type and amount of food consumed and current climatic conditions are not fully recorded. Most of the available work has been done on cattle and details with regard to sheep are extremely meagre. Only one reference to the water consumption of sheep under South African conditions is cited (Brauns 1930).

In the previous paper (this Journal) the authors reported on the effect of intermittent watering on the food intake of merino sheep. It was found that a diminished water consumption adversely affected the intake of lucerne hay but not that of grass hay.

The experiments to be recorded here were designed to throw further light on the relationship between water and food intake and the effect of atmospheric temperatures on both these factors. It is fully realised that the climatic influence cannot be evaluated in terms of any single factor such as temperature, but it is beyond the scope of this article to attempt to analyse the composite effects of the various meteorological conditions which form the climatic environment.

Method.

The investigation was conducted in two separate experiments as follows:—

Experiment 1.—This took place between the 5th and the 24th of February, 1946 (18 days duration).

Experiment 2.—This was an exact repetition of the first experiment and was conducted between the 19th of August and the 27th of October, 1946 (70 days duration).

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In both experiments merino wethers of between 18 months and two years of age and of approximately 70 lb. body weight were used. The animals were housed in individual feeding pens on a concrete floor and under an iron roof. The water and food consumption was measured daily.

In each of the experiments twelve different sheep were used. The animals were divided into three groups of four each and were fed lucerne hay exclusively as follows:—

Group 1.—Lucerne hay and water both *ad lib.*

Group 2.—Water restricted to two litres daily and lucerne hay *ad lib.*

Group 3.—Lucerne hay restricted to 600 gm. daily and water *ad lib.*

The atmospheric temperature and relative humidity were continuously recorded on a thermo-hygrograph placed in the stable at about 18 inches from the ground.

Results.

The full data are recorded in the appendices. Table 1 gives a summary of the averages of the figures obtained.

Table 1.

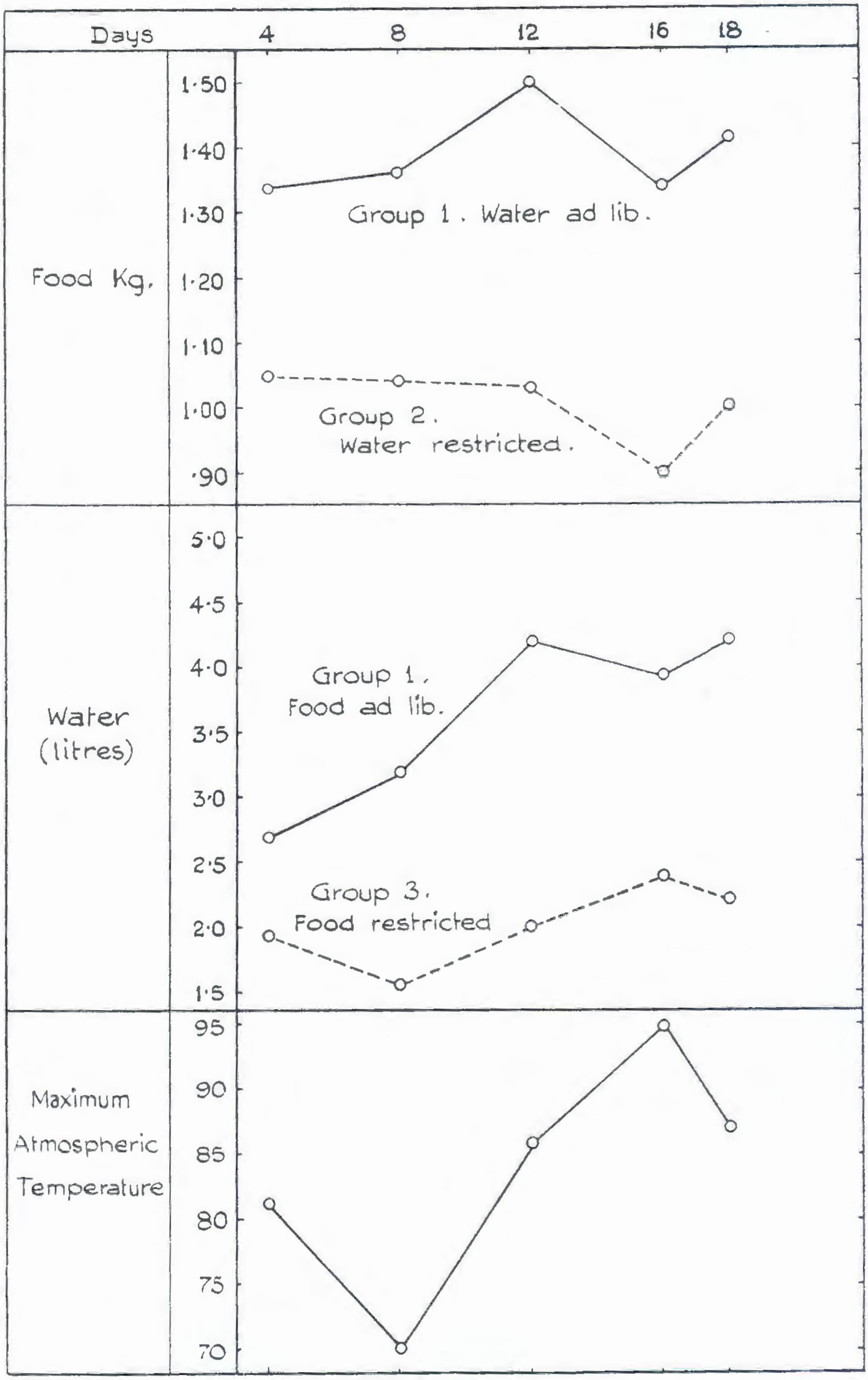
Exp.	Group.	Average Daily Consumption per Sheep.		Ratio of Water to Food.	Body Weight. (lb.).		Average. Maximum Atmos. Temp. (F).
		Hay. (Kg.).	Water (Litres).		Before.	After.	
1 (18 days)	1	1·39	3·80	2·73	69·5	73·5	—
	2	1·00	2·00*	2·00	70·8	68·5	83·3
	3	·60*	1·95	3·25	64·5	59·3	(65·0 to 97·0)
2 (70 days)	1	1·45	4·21	2·90	76·1	89·3	—
	2	1·41	2·00*	1·42	74·6	89·0	84·2
	3	·60*	2·86	4·77	77·3	77·7	(69·0 to 98·0)

* Restricted.

When limited to two litres of water a day the animals in the first experiment consumed only 1 Kg. of lucerne hay daily, as compared with 1·39 Kg. eaten by the controls receiving unlimited water. This depressing effect of a restricted water supply on the appetite was not so marked in the second experiment. In this case the sheep on restricted water took an average of 1·41 Kg. hay per day compared with 1·45 Kg. by the sheep with unlimited water.

This disparity between the results of the two trials can probably be attributed to individual differences in the animals selected, as similar weather conditions prevailed in both experiments.

GRAPH 1.



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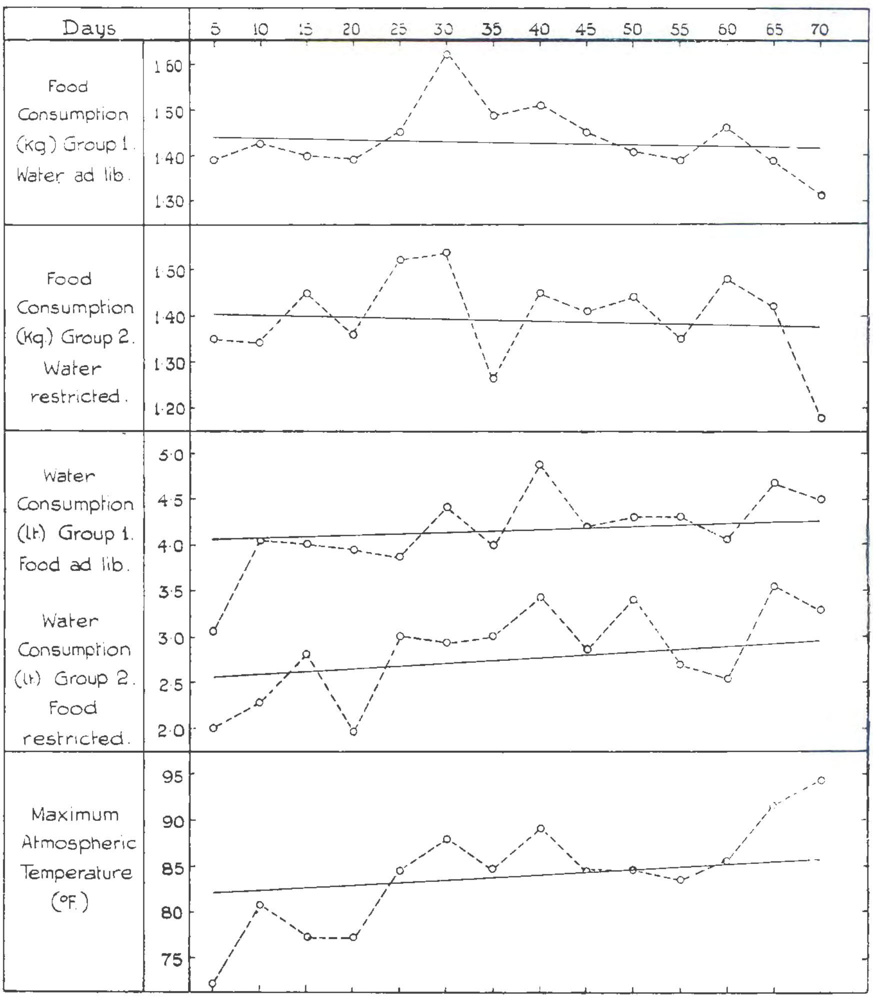
The amount of water and food consumed can be expressed in a ratio giving the amount of water taken per unit weight of food. As will be seen from column 4 of Table 1 this figure was 2·73 and 2·90 respectively for the two experiments when the sheep were allowed free access to both food and water. When water was restricted a greater amount of food was consumed per unit volume of water. When food was restricted, on the other hand, a relatively larger amount of water was consumed.

GRAPH 2.



Experiment 1.

The results of the first experiment are shown in Graph 1, the point plotted being the averages for the groups over periods of four days.

The direct correlation between the amounts of food and water consumed when both were given *ad lib.* (Group 1) can be seen.

Although the experiment was of short duration, there were considerable fluctuations in the weather conditions during the experimental period as shown by the bottom curve.

The effect of atmospheric temperature on thirst can be seen from inspection of the graph. The general trend towards hotter weather caused an increased consumption of water by the sheep receiving unlimited food. The direct correlation between temperature and thirst is much more apparent, however, when the food intake was kept at a constant level (Group 3) by offering a limited amount daily.

Atmospheric temperature would appear to have had no effect on food intake where water was unrestricted, but where the daily water intake was held constant (group 2) there is an indication that a rise in temperature caused a loss of appetite. As will be seen later these facts were confirmed by statistical analysis of the data.

Experiment 2.

As already stated the second experiment was conducted from the late winter (August) to early summer (November). The results are represented in Graph 2, with the points indicating averages over 5 day periods. The calculated trend lines are also included.

As indicated in Graph 2 the atmospheric temperature showed an upward trend during the experimental period. This was accompanied by increased water consumption and a tendency to a slight decrease in appetite. As will be seen the latter was not proved significant on statistical analysis of the data.

Statistical Analysis of the Results.

The individual daily readings were analysed for each experiment separately and the correlations calculated. See Table 2.

Table 2.

Correlation between Water and Food Consumption.

Experiment.	Group I.		
	Sheep No.	Food and Water *ad lib.*	Temp. held Constant Mathematically.
1.	1	·736†	·830†
	2	·133	·151
n = 20	3	·778†	·742†
	4	·699†	·768†
	Group	·605†	·651†
2.	13	·212	·200
	14	·239	·270*
n = 62	15	·166	·195
	16	·630†	·539†
	Group	·298†	·289†

* Significant. † Highly significant.

As will be noted from this table there was a highly significant positive correlation between the daily intakes of food and water in both experiments when the groups as a whole were considered, but that the figures for four particular sheep, No's 2, 13, 14, 15 taken individually, did not show a significant correlation. This would appear to indicate that although the amounts of food and water consumed are definitely related when taken for a group of animals over an extended period of time, there is often no relationship between these amounts for an individual sheep over a 24 hour period. From the detailed records (see appendices) it would appear that the amount of both food and water consumed tended to fluctuate, often independently, when measured on a 24 hour basis.

Thirst will depend not only on food consumption but also on climatic conditions including atmospheric temperature. When this factor was held constant by mathematical calculation, the partial correlation between food and water consumption was found to be only slightly enhanced.

The effect of atmospheric temperature on water consumption was analysed in detail as indicated in Table 3.

TABLE 3.

Correlation between Water Consumption and Maximum Atmospheric Temperature.

Experiment.	Group 1.			Group 3.	
	Sheep No.	Food and Water *ad lib.*	*Food* held Constant Mathematically.	Sheep No.	Food Restricted (·6 Kg.) Water *ad lib.*
1	1	·421	·665$^{\cdot\cdot}$	9	·808$^{\cdot\cdot}$
n = 20	2	·559$^{\cdot}$	·562$^{\cdot\cdot}$	10	·515$^{\cdot}$
	3	·569$^{\cdot}$	·481$^{\cdot}$	11	·543$^{\cdot}$
	4	·458	·643$^{\cdot\cdot}$	12	·676$^{\cdot\cdot}$
	Group	·504$^{\cdot\cdot}$	·567$^{\cdot\cdot}$	Group	·636$^{\cdot\cdot}$
2	13	·352$^{\cdot\cdot}$	·345$^{\cdot\cdot}$	21	·292$^{\cdot\cdot}$
n = 62	14	·314$^{\cdot}$	·337$^{\cdot\cdot}$	22	·512$^{\cdot\cdot}$
	15	·192	·216	23	·166
	16	·596$^{\cdot\cdot}$	·492$^{\cdot\cdot}$	24	·387$^{\cdot\cdot}$
	Group	·353$^{\cdot\cdot}$	·346$^{\cdot\cdot}$	Group	·337$^{\cdot\cdot}$

A highly significant positive correlation was found to exist between the volume of water consumed and the maximum atmospheric temperature recorded during individual 24 hour periods when the figures for the groups were considered. Holding the food constant either mathematically (Groups 1) or experimentally (Groups 3) increased the value of this coefficient in the case of the first experiment but not in the second. See Table 4.

TABLE 4.

Correlation between Food Consumption and Maximum Atmospheric Temperature.

Experiment.	Group 1.			Group 2.	
	Sheep No.	Food and Water *ad lib.*	Water held Constant Mathematically.	Sheep No.	Water Restricted 2 Litre. Food *ad lib.*
1........................	1	—·039	—·568	5	—·307
	2	·014	—·073	6	—·291
n = 20	3	·371	—·139	7	—·487
	4	·030	—·509	8	—·629
	Group	0·90	—·313	Group	—·444
2........................	13	·072	—·003	17	·175
	14	—·055	—·141	18	·033
n = 62	15	—·120	—·157	19	—·231
	16	·387	—·018	20	·057
	Group	·081	—·027	Group	·001

From the above it will be seen that in neither of the experiments could a correlation be found between food consumption and maximum atmospheric temperature when both food and water were allowed *ad lib.* Restricting the water intake to a constant level in the first experiment, however, revealed a highly significant negative correlation between appetite and temperature. This result was confirmed mathematically from the figures from Group 1 when the partial correlation was calculated. Unfortunately this finding could not be confirmed in Experiment 2, although the tendency to an inverse relationship was again apparent.

From Tables 3 and 4 it would therefore appear that a rise in atmospheric temperature within the limits encountered, tended to depress appetite and to increase thirst. When the food was restricted to a constant level of intake, the increased water required for heat dissipation became apparent. When food was given *ad lib.*, however, a rise in temperature tended to depress appetite, so decreasing the water required for metabolic purposes. Under these conditions, therefore, a rise in temperature tended to increase thirst directly but also to decrease it through the effect on appetite. The actual difference measured is, therefore, the sum of the two effects.

KIDNEY FUNCTION.

The low ratio of water to food consumption noted in the sheep on a limited water supply, could only be ascribed to a reduction of water loss mainly by urine concentration. In order to study this aspect of the problem, two sheep from each group were placed in cages at regular intervals during the course of experiment 2. The urine was collected over a 24 hour period at weekly intervals. The data in Table 5 were obtained from five such collections.

TABLE 5.

Urine Collection.

Group.	1.		2.		3.	
Sheep	13	14	17	18	21	22
Average urine volume per 24 hours (c.c.)	657	1,870	824	785	1,727	1,462
Weighted average S.G.	1·046	1·034	1·034	1·058	1·018	1·015
Average urea (gm.) per 100 c.c. urine	4·9	3·1	5·8	6·2	1·3	1·5
Average 24 hours output of urea. gm.	32·8	57·8	47·9	48·2	22·7	22·3
Average daily intake lucerne hay (Kg.)	1·15	1·55	1·37	1·31	·60	·60
Average daily intake water (c.c.)	3,960	4,340	2,000	2,000	3,490	3,470
Water to food ratio	3·4	2·8	1·5	1·5	5·8	5·8

From this table it will be seen that the sheep on a restricted water supply (Group 2) passed a highly concentrated urine, the maximum urea concentration encountered being 8·1 gm. per 100 c.c. urine. The merino sheep is well known to be remarkably economical in its use of water, but attention has so far been focussed on the water absorbing powers of the large intestine. Wright (1936) in discussing the urea concentration test on humans states: "Normal kidneys may concentrate to 4 per cent. or over". The fact that the two sheep in the present experiment maintained a urea concentration of approximately 6 per cent. for a period of 70 days without any clinical signs of kidney damage, would indicate that these animals can also conserve water by high urine concentration.

The two sheep taken at random from Group 1 showed marked individual differences. Although sheep 13 consumed more water per unit weight of hay than sheep 14, the volume of urine passed was considerably less and the urea more concentrated. This can only point to a greater loss of water by channels other than the kidneys. The figures indicate the individual variations in physiological function to be expected when dealing with numbers of animals even under identical conditions.

SUMMARY.

1. The consumption of lucerne hay and water by merino sheep has been recorded in two separate but identically conducted experiments under the following conditions:—

(i) Both food and water given *ad lib.*

(ii) Water restricted to 2 litres, food *ad lib.*

(iii) Food restricted to 0·6 Kg. water *ad lib.*

2. A highly significant positive correlation was found between the amounts of hay and water consumed when both were offered *ad lib.*

3. A highly significant positive correlation was also found between the amount of water consumed and the maximum atmospheric temperature for the day. This coefficient was enchanced by feeding a fixed amount of hay in the first experiment but not in the second.

4. No direct correlation could be shown between the hay consumption and atmospheric temperature when water supply was unrestricted.

In the first experiment a highly significant negative correlation was found between these two factors when a fixed amount of water was given, but this could not be confirmed in the second experiment.

5. Urine was collected from representative animals from each group. It was found that the animals on a restricted water supply maintained a low water to food ratio by passing small amounts of highly concentrated urine (urea up to 8·1 gm. per 100 c.c.). Marked variations were found between individual sheep receiving both hay and water *ad lib.* in respect of volume and concentration of urine.

Acknowledgments.

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APPENDIX I.

Experiment 1.

Group.	Sheep.		Days. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1............	1	F.	1·4	1·2	1·1	1·3	1·2	1·2	1·4	1·2	1·5	1·4	1·4	1·4	1·1	1·4	1·3	1·2	1·2	1·2	1·3	1·4
		W.	4·0	3·1	2·8	3·2	3·2	2·6	3·3	2·7	3·9	3·9	4·0	3·8	3·1	4·5	3·6	3·5	3·7	2·9	4·2	3·9
	2	F.	1·4	1·4	1·3	1·3	1·4	1·5	1·4	1·5	1·5	1·5	1·6	1·5	1·4	1·5	1·3	1·5	1·3	1·5	1·5	1·4
		W.	3·4	4·4	3·4	3·2	2·8	3·5	3·1	3·4	3·8	3·7	5·2	3·1	4·3	4·9	4·6	3·8	4·6	3·8	3·3	4·3
	3	F.	1·5	1·4	1·4	1·5	1·4	1·6	1·6	1·4	1·6	1·6	1·7	1·8	1·7	1·5	1·6	1·6	1·7	1·7	1·8	1·3
		W.	4·6	4·1	3·5	3·7	3·1	3·4	3·9	3·1	4·3	4·0	4·9	5·2	4·4	4·1	4·7	3·9	4·3	4·5	5·2	3·7
	4	F.	1·2	1·3	1·2	1·3	1·2	1·3	1·3	1·2	1·3	1·4	1·4	1·6	1·3	1·0	1·2	1·2	1·1	1·2	1·6	1·2
		W.	4·1	3·7	3·9	4·0	2·7	3·3	3·1	3·8	3·8	4·5	4·6	4·8	4·8	2·4	4·0	3·9	3·9	4·7	4·7	4·0
2............	5	F.	1·1	·9	·8	1·0	·9	·9	·9	1·1	1·0	1·0	·9	1·0	·9	·8	1·0	·9	·8	·9	·9	1·0
	6	F.	1·1	·9	·9	1·0	1·0	1·0	·9	·8	1·0	1·0	1·0	·9	1·1	·9	·9	·9	·8	·9	1·0	·9
	7	F.	1·3	1·1	1·0	1·1	1·1	1·1	1·2	1·0	1·2	1·1	1·1	1·0	1·2	1·0	1·0	·9	1·0	·9	1·2	·9
	8	F.	1·3	1·2	1·1	1·1	1·1	1·2	1·3	1·1	1·0	1·0	1·1	1·2	1·0	·9	1·0	1·0	1·0	·9	1·2	1·0
	9	W.	2·5	2·3	2·0	2·5	1·9	1·9	2·4	2·5	2·8	2·7	3·3	2·8	3·1	3·3	2·2	3·0	3·1	3·4	3·1	3·1
	10	W.	2·0	1·9	0·9	1·1	0·5	1·0	1·5	1·6	1·8	1·0	2·0	1·4	2·1	1·7	1·5	1·6	1·7	2·1	1·3	1·9
	11	W.	1·2	1·5	2·1	1·1	1·0	0·8	1·1	1·8	1·1	1·8	1·6	1·3	1·1	2·3	·9	2·1	1·5	1·4	1·5	1·8
	12	W.	2·3	2·8	1·9	1·9	1·6	1·2	1·9	2·2	1·8	1·9	2·6	2·0	2·3	2·3	2·4	2·3	2·3	2·5	2·2	2·2
Temperature ° F.....		Max	80	86	78	82	66	70	65	78	78	86	89	90		91		97	95	96	89	85
		Min.	67	67	63	61	59	58	56	60	63	64	62	60		62		62	64	66	62	54
Humidity percentage		Max	92	95	88	93	95	95	92	94	94	88	93	90		90		95	86	90	88	89
		Min.	59	52	68	52	80	78	79	49	52	40	36	37		38		37	38	33	39	37

F. = Lucerne Hay (Kg.). W. = Water (litres).

APPENDIX 11

Experiment 2

No. of Group.	No. of Sheep.	F. and W.	1	2	3	4	5	6	7	8	9	10	11	12	13
Group 1........	13	F.	1·2	0·7	0·9	1·1	1·1	1·2	1·2	1·2	1·2	1·2	0·5	1·1	1·3
		W.	3·2	1·0	2·7	2·4	3·0	3·3	3·2	3·6	3·1	2·7	0·4	3·5	3·0
	14	F.	1·6	1·6	1·6	1·5	1·7	1·6	1·5	1·3	1·6	1·7	1·2	1·3	1·6
		W.	3·0	3·8	3·5	3·2	2·0	4·0	6·0	4·0	4·2	4·0	2·2	5·5	40·
	15	F.	1·7	1·1	1·6	1·5	1·7	1·7	1·6	1·4	1·8	1·7	1·5	1·5	1·6
		W.	4·1	3·2	4·3	3·7	1·9	5·7	4·5	5·3	4·3	4·7	3·8	4·4	4·0
	16	F.	1·4	1·5	1·6	1·1	1·3	1·2	1·3	1·5	1·2	1·3	0·6	1·3	1·1
		W.	2·3	3·5	3·6	2·6	3·4	3·6	3·7	3·9	3·5	4·0	3·4	3·4	3·6
Group 2........	17	F.	1·3	1·2	1·3	1·2	1·3	1·2	1·3	1·3	1·4	1·2	0·8	1·0	1·7
	18	F.	1·6	1·4	1·5	1·3	1·3	1·4	1·3	1·2	1·6	1·1	1·0	1·0	1·6
	19	F.	1·6	1·4	1·5	1·4	1·7	1·5	1·5	1·6	1·7	1·3	1·5	1·6	1·7
	20	F.	1·2	1·1	1·4	1·2	1·4	1·1	1·3	1·5	1·9	1·4	1·4	1·4	1·6
Group 3........	21	W.	1·8	2·7	2·1	2·0	2·3	1·7	3·5	2·1	2·6	1·9	2·5	2·9	2·4
	22	W.	2·0	2·5	2·3	2·0	2·0	2·4	1·8	2·8	3·2	2·5	2·3	5·4	3·4
	23	W.	1·6	2·3	2·1	1·3	1·4	1·4	1·7	1·7	2·2	1·7	1·2	2·0	3·3
	24	W.	1·6	2·0	1·9	1·5	1·4	1·3	1·9	2·0	2·6	1·6	1·2	1·8	3·1
Temperature..........		Max...	70	70	69	72	80	80	80	84	81	81	78	76	79
		Min...	38	34	34	35	44	43	41	44	44	50	48	44	43
Humidity............		Max...	75	70	70	66	65	46	59	49	42	74	60	87	72
		Min...	30	22	29	27	18	18	19	18	26	29	34	31	24

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355-356a

13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
1·3	1·3	1·2	1·0	1·1	0·7	1·0	0·9	1·1	1·1	1·1	1·3	0·7	0·9	1·5	1·2	1·2	1·4	0·9	1·7
3·0	3·4	3·1	2·7	2·6	1·0	3·8	2·7	2·6	3·8	3·4	2·2	2·0	3·1	2·1	3·3	3·4	2·6	2·1	1·4
1·6	1·8	1·7	1·8	1·7	1·5	1·4	1·6	1·8	1·6	1·6	1·8	1·5	1·6	1·9	1·9	1·9	1·7	1·7	1·0
40·	4·2	3·9	4·4	3·9	2·5	4·2	5·0	3·8	4·6	4·4	4·2	2·6	5·2	4·9	5·4	4·8	5·3	4·4	3·2
1·6	1·8	1·5	1·6	1·7	1·5	1·7	1·6	1·5	1·5	1·6	1·8	1·7	1·7	1·9	1·7	1·8	1·5	1·4	1·6
4·0	4·3	5·8	4·0	4·2	4·8	4·9	4·6	3·5	4·6	4·8	4·5	4·4	4·9	4·2	5·2	4·9	4·2	3·0	4·0
1·1	1·1	1·1	1·3	1·6	1·6	1·3	1·2	1·0	1·5	1·7	1·7	1·6	1·7	2·0	1·9	1·9	1·8	1·7	1·8
3·6	3·1	3·5	3·9	3·8	4·1	3·4	3·2	3 8	4·0	4·7	3·9	4·2	4 7	5·1	4·9	5·2	4·9	4·4	4·4
1·7	1·2	1·3	1·1	1·1	1·0	1·0	0·9	1·4	1·3	1·7	1·6	1·1	1·6	1·5	1·8	1·4	1·0	1·1	0·8
1·6	1·2	1·1	1·4	1·1	1·1	1·0	1·1	1·5	1·3	1·6	1·5	1·4	1·4	1·7	1·6	1·4	1·1	1·0	0·9
1·7	1·6	1·6	1·6	1·7	1·6	1·5	1·4	1·5	1·5	1·6	1·9	1·6	1·5	1·9	1·9	1·5	1·4	1·4	1·6
1·6	1·6	1·8	1·3	1·5	1·4	1·8	1·4	1·4	1·7	1·9	1·6	1·5	1·5	2·0	1·6	1·9	1·2	1·1	1·1
2·4	2·2	1·9	2·3	2·2	1·8	4·5	2·5	2·4	2·9	2·8	3·0	2·6	2·0	4·7	2·8	3·0	2·1	3·6	2·5
3·4	2·0	2·8	2·8	2·4	2·2	2·5	1·4	2·6	3·8	3·3	3·5	2·7	4·0	4·8	3·5	3·4	3·5	2·8	2·8
3·3	2·7	3·8	1·9	1·3	3·8	1·3	1·3	2·0	4·6	2·7	2·7	4·8	1·6	3·2	3·6	2·0	1·8	3·2	1·8
3·1	2·0	2·6	1·8	1·7	3·5	1·7	1·6	2·3	1·6	1·3	3·6	2·8	2·2	4·4	2·7	1·5	4·5	1·8	2·5
79	82	80	79	78	72	74	77	84	83	84	87	82	86	88	88	92	88	75	84
43	46	52	48	48	46	42	43	48	51	48	50	46	49	50	52	50	51	44	47
72	60	57	79	73	40	82	80	72	40	48	70	77	72	58	52	49	42	86	82
24	20	32	47	31	19	30	28	23	23	22	22	30	24	24	22	20	20	42	30

F = Food.

355-356a

355-356b

355-356c

APPENDIX II.

EXPERIMENT 2.

33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	49	49	50	51
1·0	0·9	1·6	1·2	1·6	1·5	1·6	1·5	1·6	1·5	1·5	1·5	1·4	0·6	1·1	0·8	1·4	1·0	0·9
4·0	3·6	5·7	5·5	5·9	5·3	5·6	6·0	4·9	5·9	5·7	3·7	2·6	1·2	4·8	4·1	4·8	5·9	2·7
1·6	1·5	1·6	1·8	1·2	1·0	1·1	1·1	1·0	1·2	1·0	1·0	1·6	1·2	1·5	1·6	1·7	1·6	1·7
6·0	4·6	5·0	4·1	2·9	3·7	3·1	5·5	4·5	4·7	2·6	1·8	4·7	3·4	5·5	5·0	4·3	3·4	5·0
1·4	1·8	1·5	1·7	1·5	1·7	1·5	1·6	1·5	1·4	1·4	1·5	1·6	1·4	1·6	1·5	2·0	1·5	1·5
4·1	3·0	3·7	4·3	4·4	4·6	4·5	4·0	4·3	4·1	4·1	2·3	4·0	3·6	4·9	4·6	4·9	4·0	4·7
1·7	1·6	1·9	1·8	1·8	1·7	1·7	1·7	1·7	1·6	1·7	1·5	1·7	1·5	1·5	1·7	1·7	1·7	1·6
4·8	4·4	4·7	5·9	5·2	5·5	5·0	5·1	4·2	4·0	4·4	4·6	4·6	3·5	4·5	4·2	4·9	4·0	3·6
0·9	1·0	1·1	1·5	1·4	1·5	1·4	1·4	1·4	1·2	1·2	1·4	1·4	1·0	1·0	1·2	1·7	1·6	1·5
0·9	1·5	1·8	1·4	1·1	1·2	1·2	1·4	1·3	1·2	1·3	1·2	1·4	1·2	1·3	1·5	1·6	1·7	1·5
1·5	1·6	1·9	1·7	1·7	1·7	1·7	1·6	1·6	1·6	1·6	1·7	1·5	1·5	1·7	1·6	1·4	1·7	1·2
1·1	1·5	1·7	1·7	1·4	1·5	1·4	1·5	1·7	1·5	1·4	1·3	1·4	1·2	1·5	1·5	1·7	1·4	1·3
3·8	3·8	2·9	3·5	3·9	2·9	4·9	3·4	3·1	4·0	4·4	2·6	4·7	2·6	5·5	1·4	5·6	4·3	5·0
3·3	3·6	3·6	3·2	5·4	4·5	4·8	4·4	4·0	4·7	3·6	2·0	2·9	2·4	5·3	5·1	3·5	2·8	5·1
5·1	2·0	1·5	5·1	3·0	3·2	1·9	1·8	2·0	1·8	1·5	1·6	1·9	4·0	2·0	2·4	2·2	3·2	1·6
2·3	2·1	2·9	2·0	2·5	2·2	2·0	2·6	4·4	2·0	1·8	2·3	1·0	2·2	1·8	2·4	3·0	2·7	2·3
87	87	87	88	88	87	91	90	92	90	82	86	68	85	92	91	83	67	86
45	49	48	47	49	52	54	57	60	65	56	60	58	56	56	56	57	50	60
62	52	56	53	52	58	61	64	60	55	93	89	92	76	46	82	76	95	95
25	23	23	25	24	29	25	28	29	33	56	45	58	33	22	21	38	77	27

W = Water.

355-356b

355-356d

355-356c

APPENDIX II *(cont.)*

Experiment 2

52	53	54	55	56	57	58	59	60	61	52	63	64	65	66	67	68	69	70
1·0 4·6	0·5 1·2	1·1 5·9	0·8 6·0	1·4 4·9	1·0 2·6	1·0 5·9	1·2 4·0	0·7 2·4	1·1 5·6	1·3 5·4	0·9 5·6	0·9 5·4	1·0 3·2	0·9 5·1	0·6 2·0	1·0 5·7	0·5 4·8	0·9 2·8
1·6 5·6	1·4 3·6	1·2 4·1	1·7 4·8	1·7 4·0	1·7 4·3	1·6 4·1	1·8 4·3	1·4 3·9	1·4 4·1	1·6 4·4	1·7 3·8	1·7 5·7	1·7 4·8	1·3 4·6	1·4 4·0	1·4 5·7	1·7 3·2	1·8 5·8
1·7 5·3	1·5 4·6	1·3 4·0	1·4 4·5	1·9 4·0	1·7 5·0	1·4 4·2	1·5 4·6	1·5 4·8	1·5 4·8	1·2 3·7	1·4 4·3	1·4 5·2	1·4 4·2	1·6 4·5	1·5 5·2	1·2 4·2	1·5 3·5	1·3 5·0
1·6 3·9	1·6 4·0	1·6 3·7	1·6 4·0	1·8 2·4	1·3 4·0	1·4 4·2	1·8 4·8	1·6 4·6	1·7 4·8	1·3 4·0	1·5 3·1	1·8 5·8	1·6 5·5	1·6 4·5	1·8 5·3	1·5 5·2	1·8 4·6	1·6 5·2
1·2 1·5 1·3 1·4	1·3 1·5 1·6 1·3	1·3 1·3 1·4 1·2	1·3 1·4 1·4 1·3	1·6 1·9 1·7 1·5	1·4 1·6 1·6 1·5	1·3 1·4 1·5 1·4	1·6 1·7 1·5 1·4	1·2 1·4 1·5 1·2	1·2 1·2 1·6 1·1	1·4 1·5 1·8 1·3	1·5 1·6 1·5 1·3	1·5 1·6 1·3 1·4	1·5 1·6 1·5 1·2	1·2 1·4 1·2 1·0	1·3 1·2 1·4 1·1	1·2 1·2 1·0 1·6	1·4 1·4 ·07 1·0	1·4 1·2 0·5 1·3
3·2 2·8 2·0 2·0	2·5 3·1 2·0 2·5	5·4 4·7 1·4 0·6	4·5 2·3 1·2 1·2	3·0 2·3 2·4 1·1	2·0 4·0 3·0 2·2	5·0 2·1 1·4 1·6	5·8 2·8 2·4 2·5	2·5 2·2 2·2 2·0	5·8 5·4 2·0 1·6	5·8 4·8 3·6 3·7	4·8 2·5 2·0 2·0	4·7 5·4 2·8 2·4	5·4 2·7 2·0 2·0	2·8 4·6 2·0 2·2	4·8 1·8 2·0 2·4	5·0 3·5 2·0 2·2	4·2 4·5 3·0 2·6	5·7 5·1 2·4 2·8
89 52	89 56	73 58	77 58	84 56	82 49	87 52	89 54	90 56	89 53	89 58	94 66	94 60	92 60	92 59	92 58	94 63	93 66	98 67
62 29	90 15	80 15	86 48	84 40	95 20	78 24	78 25	58 21	82 32	95 26	78 23	65 26	54 23	50 21	40 20	46 17	76 30	50 22

← 355-356c