T H E S I S

WATER CONSUMPTION IN THE BEE COLONY AND THE PROPORTIONS OF SUGAR AND WATER FOR STIMULATIVE FEEDING IN THE SPRING

Submitted by

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It has long been known that bees gather water for the use of the colony especially when brood is being reared.

According to Dr. E. F. Phillips, "At some seasons of the year there is not enough moisture in the hive for the use of the colony, and worker bees carry water to the hive for immediate use, or in some cases to be deposited within the hive. Water is not stored in cells as is nectar but may be placed on top bars or in other places under some conditions. The gathering of water is more noticable in the period of early spring brood rearing and in hot weather than at other times. In certain bee cellars of quite high temperatures it is recorded that an uneasiness of the bees has been relieved by giving water in a feeder.

Mr. Demuth made an observation in the apiary of the Bureau of Entomology. By mistake an entrance reducing block had been pushed into the hive and was not noticed when the time came for these blocks to be removed. It closed the entrance too much during the hot weather of midsummer, so that the normal ventilation of the colony was impeded and evidently the temperature within the hive became too high. When this colony was opened on a

hot day in midsummer it was noted that drops of some liquid were deposited on the frames much in the manner of nectar when it is being brought into the hive during the rush of an exceedingly heavy honey flow. At this time there was a complete dearth of nectar. On tasting this liquid it was found to be water evidently brought to the hive to be evaporated and thus reduce the temperature within the hive, since the evaporation of water causes the absorption of considerable amounts of heat.

In a paper published by De Layens, the well-known French botanist and beekeeper, in the bulletin D'Acelim de France for 1880, page 298, he shows that while considerable amount of water is taken from a water resevoir in the apiary before the honey flow begins, this collection entirely ceases when nectar comes to the hive in considerable amounts. For example, on May 22nd, a total of three liters of water was taken from the reservoir, on the next day this was reduced to one liter and steadily decreased until May 27th, when the honey flow was well on, and when no water was taken from the reservoir by the bees. In another series of observations, he correlates the weight of the collection of water with the weight of the honey gathered by the bees and finds a definite and close inverse correlation. For example, on July 15th, the bees in his apiary took

five liters of water from his reservoir while a strong colony in the apiary gains only 120 grams. There was a steady decrease in the amount of water taken and an equally steady increase in the nectar collected, until on July 19th, no water was taken from the reservoir while the strong colony gathered 1.390 kg.

Another series of interesting observations are recorded by Gendet in L'Apiculteur for 1907, page 164. He noticed, as have many beekeepers, that bees collect water from compost heaps. To determine whether they are attracted by the character of the material which they may collect or whether some other factor is involved, he made certain tests. He found that the standing water about the compost had a higher temperature than that of the surrounding air. He then set out in his apiary two reservoirs containing pure water, one at air temperature and the other somewhat heated. During the month of April the bees collected over 43 liters of water from the reservoir that was heated and only a little over 7 liters from that which was not heated. He made proper allowances for extra evaporation of the heated water in that reservoir. Later on when the outer air became warmer, the bees visited one reservoir as much as another. He also found that it takes a much longer time for a bee to take a load of cold water than of water that is somewhat heated. Several observations are quoted regarding the

amount of water per colony that is taken by the bees and Gendot states that after heating the water, his colonies took an average of almost a half liter daily, most such observations being of smaller amounts per colony. Evidently bees will take enormous quantities of water in spring if it is conveniently placed, and it is safe to assume that they do not take it unless they need it.

At times of a heavy honey flow large quantities of water arising from the evaporation of the excess water in nectar must be eliminated. Various analyses of nectar show that the water content varies greatly, and this is easily observed by any beekeeper. Some unripe honeys, or partly ripened nectar, are exceedingly thin, while in some cases nectar is brought to the hive in a condition of thickness which resembles honey. In general, thick nectars are found in arid regions or in periods of warm weather, as one might expect, while thin nectars are found during early honey flows in springs. Nectars from some species of plants are almost always thin, while that from other species is usually thick.

Relation of Water Consumption to Brood Rearing in the Honey Bee.

Objects: To determine the relation existing between quantity of brood reared and the amount of water consumed per day, and the amount of table salt that bees take with the water when available, and the amount of water per lb. of sugar that will satisfy the demand for water on the part of the bee.

Method of Procedure: By running four colonies on each experiment and four checks for evaporation, making daily observations and weighing every month during the building up period in the spring and early summer.

Weighing.

For this experiment the bees were first weighed by a system as follows. The entire colony was weighed in the early morning before the bees had started to the fields. The upper story of the hive was then freed of bees by brushing the bees on the combs of the lower story. This empty body was then weighed together with the bottom board. Next the bees were brushed off the combs in the lower story on to the original upper story and bottom board. This empty lower story was then weighed and the combined weights of the upper and lower stories together with bottom board were subtracted from the weight of the entire colony. This difference gave the weight of the bees. These weighings were made every month.

Measurement of Brood.

The amount of brood was measured by taking a Langstrothe frame and measuring off in equal distances of 1 centimeter across the top and bottom bars and then the end bars. Wire was stretched across both ways forming squares of 1 centimeter. This measuring frame was placed over the brood and the squares that covered the brood were counted giving the amount of brood on that side of the frame.

Watering Apparatus.

This consisted of jars with straight sides. Ten c.c. of water were poured into the jar. A strip of paper was pasted the entire length of the jar, on the outside, and when the water was poured in, the level was marked and recorded on the paper. Then this was repeated until the jar was full. This made a graduated jar. The outside of the jar was now shellaced protecting the paper. After filling with water or sugar syrup, a double cheese cloth was placed over the top of the jar and it was inverted over the cluster thru a hold made in the inner cover. Readings on the jar were made daily. During April, May, and part of June 1921 the observations for this paper were made at Madison, Wisconsin, and also during the spring of 1924 at Fort Collins, Colorado. The later gave

the same results as the first, so I am using the first except the sugar syrup data which was made at Fort Collins. In order to check the amount of water that was lost by evaporation a graduated jar containing water was placed above the cluster with a screen so arranged that the bees were unable to touch the water.

The amount of evaporation each day was deducted from the readings. The tables are shown in the metric system.

Table No. 1.

Daily Recofd of Water Consumed During April and May

Expressed in Cubic Centimeters

April	1	2	3	4	5	6	7	8	9	10
Colony 1	25	125	35	200	215	100	100	100	100	100
Colony 2	25	25	35	65	75	100	125	95	100	100
Colony 3			35	65	15	30	.15	110	0	15
Colony 4			75	175	90	135	115	50	50	30
Colony 5			50	50	65	100	75	75	50	100
Colony 6			30	45	75	90	80	80	70	60

April	11	12	13	14	15	16	17	18	19	20
Colony 1	175	150	250	150	135	100	100	190	135	215
Colony 2	100	75	150	125	135	75	50	150	90	95
Colony 3	30	20	20	25	20	50	40	25	40	10
Colony 4	70	100	100	85	60	35	125	65	100	85
Colony 5	110	100	100	90	70	35	120	175	120	100
Colony 6	70	70	60	60	55	30	40	50	50	40

April	21	22	23	24	25	26	27	28	29	30
Colony 1	170	100	100	155	75	75	50	100	150	200
Colony 2	75	40	75	135	100	25	100	125	75	120
Colony 3	15	5	25	20	25	20	20	85	20	75
Colony 4	145	100	105	95	50	75	5	10	20	40
Colony 5	75	50	100	65	100	95	45	65	150	150
Colony 6	35	20	25	15	10	10	5	Queenless		

May	1	2	3	4	5	6	7	8	9	10
Colony 1	145	100	75	100	100	125	150	125	175	165
Colony 2	150	125	60	55	45	110	150	175	220	160
Colony 3	25	25	80	80	150	155	225	275	175	125
Colony 4	50	30	75	65	75	50	40	65	70	25
Colony 5	130	25	25	30	25	25	225	240	300	225
Colony 6										

Table No. I., Continued

May	11	12	13	14	15	16	17	18	19	20
Colony 1	75	65	35	125	125	120	130	135	130	200
Colony 2	140	230	150	250	150	250	150	295	150	175
Colony 3	175	165	85	80	80	150	175	50	85	190
Colony 4	75	50	25	45	80	100	50	60	175	200
Colony 5	200	240	120	150	125	115	110	60	275	300
Colony 6										

May	21	22	23	24	25	26	27	28	29	30
Colony 1	250	140	225	115	170	175	260	275	200	200
Colony 2	150	175	175	190	190	215	210	200	300	330
Colony 3	200	210	235	225	250	300	125	220	240	230
Colony 4	150	100	110	100	105	95	125	100	110	140
Colony 5	75	65	70	35	135	140	135	300	375	325
Colony 6										

May	31
Colony 1	135
Colony 2	250
Colony 3	225
Colony 4	120
Colony 5	250
Colony 6	

Table No. 2

Square Centimeters of Brood

Date	No. of Colony 1	2	3	4	5
March 31	300	99	300	570	150
April 11	1056	810	621	1395	321
April 25	1530	1866	1260	2925	1398
May 5	3057	2359	2820	2880	1650
May 16	3270	3645	2883	3879	2385
May 25	3456	5052	3234	4218	2430
June 2	5142	5130	4158	4515	2715

Table No. 3

Weights of Bees

Colony No.	Date March 31	May 5	June 1	
	Grams			
1	1075	2000	4000	
2	675	1200	2600	
3	975	1650	2975	
4	2000	3900	6000	
5	575	950	1800	
6	600	700	375	Queenless

Table No. 4.

Sugar Syrup Readings in C.C.

April	7	8	9	10	14	15	16	17
Colony No. 1								
Proportion of sugar to water	4-1	1-1	3-1	3-1	14-8	15-8	15-8	15-8
Amount of syrup consumed	210	175	180	450	450	315	375	380
Am't of water consumed	0	100	0	0	20	15	30	20
Colony No. 2								
Proportion of sugar to water	4-1	1-1	3-1	3-1	14-8	15-8	15-8	15-8
Amount of syrup consumed	300	210	325	475	450	410	425	400
Am't of water consumed	0	100	0	0	30	25	15	20
Colony No. 3								
Proportion of sugar to water	4-1	1-1	3-1	3-1	14-8	15-8	15-8	15-8
Amount of syrup consumed	210	200	300	400	400	425	400	425
Am't of water consumed	0	110	0	0	20	15	25	15
Colony No. 4								
Proportion of sugar to water	4-1	1-1	3-1	3-1	14-8	15-8	15-8	15-8
Amount of syrup consumed	350	275	325	390	475	450	475	400
Am't of water consumed	0	0	0	0	35	40	30	10

Table No. 4, Continued

April	18	19	21	22	23	24
Colony No. 1						
Proportion of sugar to water	2-1	2-1	2-1	15-7	15-7	16-7
Amount of syrup consumed	400	315	400	430	450	400
Am't of water consumed	10	5	10	0	0	0
Colony No. 2						
Proportion of sugar to water	2-1	2-1	2-1	15-7	15-7	16-7
Amount of syrup consumed	425	350	425	450	465	425
Am't of water consumed	15	10	15	5	0	0
Colony No. 3						
Proportion of sugar to water	2-1	2-1	2-1	15-7	15-7	16-7
Amount of Syrup consumed	450	375	400	475	400	415
Am't of water consumed	10	15	10	0	0	0
Colony No. 4						
Proportion of sugar to water	2-1	2-1	2-1	15-7	15-7	16-7
Amount of syrup consumed	375	400	450	400	425	375
Am't of water consumed	15	20	15	5	0	0

Table No. 4, Continued

April	25	26	27	28	29	30
Colony No. 1						
Proportion of sugar to water	2-1	2-1	2-1	2-1	2-1	2-1
Amount of syrup consumed	375	400	450	375	350	400
Am't of water consumed	20	20	30	20	30	35
Colony No. 2						
Proportion of sugar to water	2-1	2-1	2-1	2-1	2-1	2-1
Amount of syrup consumed	400	425	400	350	325	425
Am't of water consumed	25	25	30	25	20	40
Colony No. 3						
Proportion of sugar to water	2-1	2-1	2-1	2-1	2-1	2-1
Amount of syrup consumed	150	450	425	375	350	450
Am't of water consumed	20	15	20	15	20	25
Colony No. 4						
Proportion of sugar to water	2-1	2-1	2-1	2-1	2-1	2-1
Amount of syrup consumed	475	450	400	300	325	450
Am't of water consumed	30	20	25	20	15	20

Table No. 4, Continued

May	5	6	7	12	13	14
Colony No. 1						
Proportion of sugar to water	15-7	15-7	15-7	15-7	15-7	15-7
Amount of syrup consumed	425	435	475	400	375	300
Am't of water consumed	0	0	0	0	0	0
Colony No. 2						
Proportion of sugar to water	15-7	15-7	15-7	15-7	15-7	15-7
Amount of syrup consumed	450	390	480	450	480	375
Am't of water consumed	0	0	0	0	0	0
Colony No. 3						
Proportion of sugar to water	15-7	15-7	15-7	15-7	15-7	15-7
Amount of syrup consumed	400	380	490	375	475	450
Am't of water consumed	0	0	0	0	0	0
Colony No. 4						
Proportion of sugar to water	15-7	15-7	15-7	15-7	15-7	15-7
Amount of syrup consumed	415	400	450	425	450	450
Am't of water consumed	0	0	0	0	0	0

It will be seen from tables 1 and 2 that there is direct correlation between brood rearing and water consumption. Colony No. 6 became queenless during the period that water was being given to the bees. The amount of water kept decreasing until all the brood was sealed, then the colony refused to take any more water. This table varies somewhat due to the daily variations in temperature. The larger colonies consumed more than the smaller ones.

Sugar Syrup Experiment.

The object of this part of the experiment was to try to determine the correct proportions of sugar and water for spring feeding. In this part of the experiment four colonies in the experimental apiary at Fort Collins were used.

Jars were used the same as in the watering experiment, except that two were given to each colony, one filled with water and the other with a known solution of sugar syrup. The jars were filled in the morning and readings made in the afternoon or before the syrup was all consumed. The colonies were given different proportions of syrup solution and water was always in reach of the bees from the jars above. When equal parts of sugar syrup and water were given, it was found that the bees

consumed about half as much water as they did sugar syrup. Different solutions were used in the course of the experiment as shown in table 4. The results of this experiment showed that the bees in this case preferred a solution consisting of 15 parts of water to 7 parts of sugar. (By weight). With this combination or a thinner solution, they did not touch the water but when the solution was thickened they seemed to need water, thinning it before it was stored in the combs or fed to young bees.

Salt Solution.

In the salt solution it was found that the bees would take only a small amount of salt when first put on in feeders above the colonies. After three days they refused to take any more salt. It seemed that their requirements for salt were very small.

Summary.

In the watering experiment when the temperature went up outside, the bees took more water than when the days were cooler. When brood rearing increased, we had a larger amount of water used by the colony. Stronger colonies used more water than weaker ones. When a colony became queenless and the brood sealed, no water was taken.

In the amount of sugar syrup it was found that

the stronger the solution the more water was taken by the bees. The exact proportions for this experiment being 15 parts of water by weight to 7 of sugar.

In the salt solution the bees took a very small amount when first put on, but did not seem to care for it after a few days.

Table No. 5

Maximum, Minimum and Mean Temperatures

Madison, Wisconsin, 1921

Dates	Max. temp.	Min. temp.	Mean temp.	Dates	Max. temp.	Min. temp.	Mean temp.
April				May			
1	64	27	46	1	48	39	44
2	74	41	58	2	52	35	44
3	80	50	65	3	50	37	44
4	79	60	70	4	67	39	53
5	80	59	70	5	75	43	59
6	67	61	64	6	75	47	61
7	63	42	52	7	75	48	62
8	58	38	48	8	75	47	61
9	42	28	35	9	75	51	63
10	50	26	38	10	74	57	66
11	64	31	48	11	78	56	67
12	70	44	57	12	77	48	62
13	58	41	50	13	56	42	49
14	51	44	48	14	48	38	43
15	46	30	38	15	49	31	40
16	39	27	33	16	62	31	46
17	57	29	43	17	55	46	50
18	68	34	51	18	58	52	55
19	72	41	56	19	83	53	68
20	76	48	62	20	87	67	77
21	60	53	56	21	87	66	76
22	55	45	50	22	92	71	82
23	70	44	57	23	86	64	75
24	82	59	70	24	82	60	71
25	81	62	72	25	82	62	72
26	65	48	56	26	77	61	69
27	48	41	44	27	71	60	66
28	54	38	46	28	85	60	72
29	59	34	46	29	86	62	74
30	64	34	49	30	86	64	75
				31	70	62	66