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EFFECTS OF EARLY HANDICAPS ON CHICKENS AS MEASURED BY YOLK ABSORPTION AND BODY WEIGHT TO TWENTY WEEKS OF AGE[1, 2]

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GENERAL PROBLEM AND LITERATURE

That growth is markedly influenced by environmental factors is well known. The precise effects and optimum conditions have been the subject of so many investigations that reference can be made only to those which have the most direct bearing on the experiments reported here. Most of the previous investigations have been concerned with the results obtained when the experimental subjects were kept continuously under the particular environmental conditions. The point with which the present experiments are primarily concerned is the question of how permanent the effects of environmental handicaps are, when those handicaps are maintained for only a short time, during the early life of the subjects.

There are in the literature numerous indications that individuals may recover completely, even when adverse conditions have been

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[1] Contribution No. 9 from the Division of Poultry Husbandry, University of California Agricultural Experiment Station.

[2] This investigation was conducted under the direction of Dr. S. J. Holmes, whose criticism and suggestions are gratefully acknowledged. The author wishes to acknowledge also the constant interest and encouragement of Dr. W. A. Lippincott, the skillful management of the chicks by H. B. Mugglestone, and the technical assistance of Miss Henrietta Rhoades and Mrs. E. K. Mosher, who made many of the routine observations and carried through a large part of the computation. Mrs. Marie Paterson prepared the manuscript for publication and assisted in reading the proofs.

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long continued. Thus Osborn and Mendel (1915) found that rats whose growth had been suppressed for long periods by inanition still retained the capacity to grow, so that growth recurred at periods far beyond the age at which it ordinarily ceases.

Several investigators had previously found that growth could be retarded or even suppressed for brief periods at an early age without permanent effects on weight. Minot (1891) states that a young guinea pig may lose one-third of its weight from intestinal catarrh and make good the loss later, and cites Pagliani (1879) as showing that undersized children brought up in poverty may recover in the most surprising manner if placed under favorable circumstances. Hatai (1907, p. 320) found that "so far as the weight of the body and central nervous system are concerned, the effect of a twenty-one day period of partial starvation on albino rats thirty days old is eventually completely compensated." Boas (1912) noted that in children, while retardation of early growth is made up by abnormally rapid development at a later period, an unduly prolonged retardation produced permanent effects. Aron (1910, 1914) working with dogs and rats, and Morgulis (1911, 1913) with salamanders, observed that periods of inanition were followed by periods of very vigorous growth.

Several investigations have been concerned with the effects of starvation on particular organs (Aron, 1911; Jackson, 1913, and 1917; Stewart, 1916), measuring the differential loss of weight suffered by the several organs and tissues during starvation.

As Aron (1911) points out, most of the scanty experimental evidence heretofore collected on this topic pertains to subjects which have been stunted in their growth by underfeeding, and he raises the question as to whether the conclusions drawn from such a mode of inhibition apply equally well to other conditions of retarded growth.

Shapiro (1905) chloroformed young kittens twice a day and observed a marked retardation in growth, and later recovery after the treatments were stopped. However, he used only three kittens, alternating them as experimental and control animals. A few observations were made by Richon and Perrin (1908) on the retardation of growth in rabbits by injections of nicotine and the recovery after the injections were discontinued. In this case too, only a few animals were used and individuals are cited, some of which compare very favorably with the controls, while others do not.

All of these experiments seem to have been conducted with the point of view typified by the following quotation from Osborne and Mendel (1915, p. 453): "It should be noted that the resumption of growth has not been as perfect in every instance as in the typical records here presented. A positive result in these cases is far more valuable than a failure, because the latter may arise from a variety of extraneous, as well as inherent, causes which he [the investigator] cannot control or discover. In prolonged stunting, the animals may sometimes reach a precarious condition in which their vitality may become impaired beyond the possibility of recovery. They are sensitive to nocuous influences and cannot be expected to show great resistance under the conditions of limited diet. Subsequent statistics may show damage hitherto unappreciated. The factor of safety must be small.''

STATEMENT OF SPECIFIC PROBLEM

A consideration of these facts made it desirable to study the effects of a variety of handicaps, and to measure average results upon groups of individuals compared with control groups. Further, it seemed important to determine the relationship between the permanence of the effects and the extent of the injury as measured by the mortality rate, in groups where the handicap was made severe enough to produce a considerable mortality.

The subjects chosen were baby chicks. This choice made possible the use of two measures of the effects of the experimental treatment—growth rates, and the course of yolk absorption.

The handicaps to which the various lots were subjected included overheating; chilling; complete starvation for different lengths of time after hatching; total deprivation of water for a given period; certain poisons, the particular ones chosen being nicotine sulfate, mercuric chloride, arsenic trioxide, and sodium chloride; and a major operation, in this case the removal of the unabsorbed yolk at one day of age.

PLAN OF EXPERIMENTS

The chicks were Single Comb White Leghorns obtained from a large commercial hatchery, since it was important to have a large representative population which had hatched during a short interval of time. Eggs which are all set at the same time hatch throughout an interval of some 36 hours, and the incubators usually are not opened until the hatch is practically complete. By special arrangement for these experiments, the incubators were opened and chicks furnished which hatched within a 6-hour period.

For the major portion of the experiments approximately 1,800 chicks were used. The exigencies of the experimental treatments to be described made it physically impossible to handle them all in one day. Therefore they were obtained in three separate shipments of 600 chicks each, on October 4, 6, and 8, 1927. These will hereafter be referred to as shipments I, II, and III.

The chicks of shipment I were divided into four equivalent lots. In making up the lots all the chicks were weighed individually when the average age was 24 hours. As they were weighed they were sorted according to weight to the nearest gram. After the entire shipment had been weighed, the chicks in each weight class were distributed equally among the four lots. This procedure was adopted to ensure having the lots as comparable as it was possible to make them at the time the differential experimental treatments were given.

The same procedure was followed for shipments II and III, except that each shipment was divided into nine lots. Eight different experimental treatments were given to eight of the lots, respectively, from shipment II. The same eight treatments were given to eight lots, respectively, from shipment III. One lot from each shipment was used as a control.

The reasons for these differences in procedure between shipment I and shipments II and III arose from the fact that the treatments given the several lots in shipment I (overheating, chilling, and deprivation of water) required that each lot be housed separately for the first few days. This was not essential for the experimental treatments given shipments II and III (starvation,[4] administration of poisons, and removal of yolk at 1 day of age). Hence, advantage was taken of the opportunity to duplicate each experimental treatment on two smaller lots rather than simply carry it out on one larger one. Where more than one lot was given a particular experimental treatment, these may hereafter on occasion be referred to together as an experimental group.

All chicks were individually marked with serially numbered wing bands, and were housed in 8 x 8 foot colony houses having concrete outdoor runs. Each house was equipped with a Lyons thermostatically controlled electric hover. One hundred and fifty chicks were put under each hover, which was of the size to accommodate 350. All the lots of a given shipment (except in shipment I, and those after the

[4] All starved lots were held in chick boxes until the time of their first feeding. This is a standard practice among poultrymen in delayed feeding. For these experiments it seemed desirable, since it prevented the results from being complicated by factors other than inanition, such as litter eating, toe picking, etc.

first few days) were distributed equally among the different houses. This ensured having all environmental conditions except the differential experimental treatments identical, and also put handicapped and control chicks in competition with each other. From the standpoint of the ultimate bearing of these experiments on the general problem of the permanence of effects of early handicaps, this procedure seems preferable to the isolation of differentially treated groups.

At 8 weeks of age the chicks were all moved to larger open front houses without hovers. The sexes were separated, and all of a given sex from a given shipment were put together in one house. About this time all lots suffered mildly from coccidiosis. The outbreak was not serious but, as an inspection of the graphs presented later will show, it caused a slight and approximately equal dip in all the growth curves.

All chicks were fed the same standard ration. A dry mash consisting of ground grains, fish meal, and mineral supplements was before the chicks constantly. Scratch grains were fed in addition after the chicks were one week old. Fresh greens were supplied daily.

Unless otherwise stated all lots were given feed and water when twenty-four hours old. Starvation refers to the withholding of both food and water.

Individual body weights were secured at 1, 2, 3, 4, 5, 6, 8, 10, 12, 16, and 20 weeks of age. The weights were taken by means of a special Toledo scale, giving readings by 1-gram divisions for objects under 500 grams weighed in a small scoop at the end of an extended beam, and by 10-gram divisions for heavier objects weighed on the main platform.

It was not practicable to make observations on the actual progress of yolk absorption in living chicks, in the large numbers which preliminary work had shown to be necessary because of the variability of the process. Therefore an indication of the course of yolk absorption was obtained by killing samples of chicks from each group at different ages and weighing the unabsorbed yolks. The yolk sacs with their contents were carefully dissected out and weighed to the nearest hundredth of a gram on a chemical balance. Yolks weighing less than 0.01 gram were classified as absorbed.

The samples which were killed for yolk weights were always chosen so that the frequency distributions of day-old body weights were the same for all the different groups, and also the same as that of the total group at the start of the experiment. This is an important precaution because of the correlation between day-old body weights and yolk weights, the evidence of which will be presented later.

It was planned to kill 15 chicks from each experimental group at each of the following ages: 1, 3, 5, 7, and 9 days. Because in particular instances this procedure could not be carried out completely, an additional shipment of chicks was obtained, which will be referred to as shipment IV. These chicks were divided into 15 lots of 40 chicks each and were used for yolk determinations of the entire series of handicaps previously tested, and for three additional ones.

All chicks that died were examined for unabsorbed yolk, and for any abnormal postmortem appearances.

All the raw data of the experiments, including yolk weights, mortality data, and body weights of survivors, are presented in tables 20 to 23,[5] in the appendix.

The most convenient plan for analyzing these data is to discuss first certain more or less natural groupings of the various handicaps. After these are discussed separately, the data of the various experiments are combined to allow more general comparisons to be made, of handicapped with control chicks, and of survivors with chicks which died.

EXPERIMENTS ON STARVATION FOR DIFFERENT LENGTHS OF TIME AFTER HATCHING

Since the newly hatched chick has so large a store of nutriment within its body in the form of yolk, the belief has arisen that not only does the chick not require other food during the first two or three days after hatching, but that other food actually interferes with the normal absorption of the yolk, and is thereby injurious to the chick. Practically all recommendations to poultrymen (e. g., Alder, 1924; Vandervort, 1925; Clickner, 1927) contain emphatic warnings that if chicks are fed too early, or too much, the yolk will not be absorbed, and digestive troubles and subsequent losses will result. The period recommended for withholding all feed varies from 48 to 72 hours after hatching, with strictly limited feed for two to three weeks thereafter.

The only figures on yolk absorption we have been able to find in the literature are those given by Virchow (1891) and Schilling and

[5] These tables were for the purposes of publication reduced photographically beyond the point of ready visibility. In this way it was possible to make available for any other workers all the actual raw data. If desired, the figures may of course be re-enlarged photographically, or they may be easily made out with a reading lens.

Bleecker (1928). Virchow (p. 288) gives the unabsorbed yolk weights for six chicks only, as follows:

12 hours old	5.34	grams
36 " "	3.24	"
3 days old	2.50	"
3–4 " "	0.60	"
5–6 " "	0.05	"
6–7 " "	0.43	"

Schilling and Bleeker's paper appeared after the experiments here reported had been completed. Their investigation was directed to the solution of the same general problem of the influence of food consumption upon the rapidity of yolk absorption. They used 75 chicks. All were starved for the first three days. One group was thereafter given food *ad libitum.* The other group was given approximately one-fourth as much feed. The conclusion reached was that through the period of their observations, which included the first nine days after hatching, there was no evidence that the quantity of food consumed influenced the rate of yolk absorption. As will be seen, their conclusion, based upon the quantity of feed given, is in complete agreement with the results obtained in the experiments reported here, on the basis of differing periods of starvation.

Experimental Procedure.—In preliminary trials two periods of starvation—24 hours and 72 hours—had been tested. No significant differences appeared in the rate of yolk absorption in the two groups; there were, however, some indications of a difference in growth rate. It therefore seemed desirable to test a more complete series of periods of starvation, up to the point where some deaths from starvation occurred. This point was found to be 5 days after hatching.[6]

The starved chicks were weighed again just before they were given their first feed, to determine the loss of weight which occurred during the starvation period.

[6] It is interesting to note that autopsies of the starved chicks which died revealed in many cases considerable quantities of unabsorbed yolk, suggesting that the yolk of itself is not sufficient to support life. All of the starved chicks that died showed a characteristic appearance of the alimentary tract, as compared with autopsy findings in dead chicks from other lots at comparable ages. The same appearance was found in chicks from the starved lots killed for yolk determinations before their first feeding. In starved chicks the gizzard was always small and soft walled, and the intestines black and shriveled.

Further evidence that the presence of normal unabsorbed yolk does not indicate that other food is unnecessary was found in the fact that chicks from which the yolk had been removed at 1 day of age withstood starvation nearly as long as unoperated birds. This point is being investigated further, and will be reported more completely at a later date.

TABLE 1

AVERAGE YOLK WEIGHTS (IN GRAMS) OF SAMPLES KILLED AT DIFFERENT AGES, FROM LOTS STARVED FOR VARIOUS PERIODS

Shipment No.	Length of starvation period from hatching					
	1 day (controls)	2 days	3 days	4 days	5 days	4 days, given water
Chicks killed at 3 days old						
III	*3.44±0.91	2.35±0.46	2.54±0.55	2.02±0.34	....	....
IV	2.01±0.18	2.22±0.44	1.67±0.18	2.30±0.29	2.06±0.26	2.01±0.22
Total	2.60±0.41	2.27±0.32	2.00±0.25	2.20±0.22	2.06±0.26	2.01±0.22
Chicks killed at 5 days old						
II	0.31±0.04	0.40±0.05	0.48±0.08	1.26±0.34	....	....
III	0.47±0.17	0.95±0.34	0.65±0.18	1.02±0.17	....	....
IV	0.82±0.16	0.58±0.12	0.77±0.12	0.59±0.10	0.84±0.11	0.97±0.24
Total	0.58±0.09	0.66±0.13	0.66±0.08	0.90±0.12	0.84±0.11	0.97±0.24
Chicks killed at 7 days old						
II	0.12±0.05	0.12±0.07	0.57±0.13	0.47±0.16	....	....
III	0.25±0.14	0.22±0.08	0.09±0.04	0.49±0.14	....	....
IV	0.09±0.04	0.12±0.04	0.24±0.09	0.17±0.05	0.17±0.06	0.20±0.07
Total	0.14±0.04	0.15±0.03	0.30±0.07	0.36±0.07	0.17±0.06	0.20±0.07
Chicks killed at 9 days old						
II	0.00±0.00	0.06±0.04	0.40±0.25	0.53±0.33	....	....
III	*1.31±0.54	0.13±0.08	0.01±0.01	0.07±0.02	....	....
IV	0.22±0.06	0.22±0.07	0.03±0.01	0.06±0.02	0.00±0.00	0.46±0.25
Total	0.41±0.20	0.15±0.04	0.16±0.09	0.27±0.15	0.00±0.00	0.46±0.25

* Note from the raw data in table 20 that each of these two high values is due to a single extreme case.

Effects on Yolk Absorption.—As is apparent from an examination of the average yolk weights for the several groups, presented in table 1 and plotted in figure 1, there were no differences which were significant when tested by their probable errors, or which appeared consistently in the different series.

The high average value for the control chicks of shipment III, killed when 3 days old, is due to a single very large yolk. Omitting this one yolk would reduce the average yolk weight at 3 days of age for this lot from 3.44±0.91 grams to 2.09±0.39 grams, and for the total group of controls, from 2.60±0.41 grams to 2.04±0.19 grams.

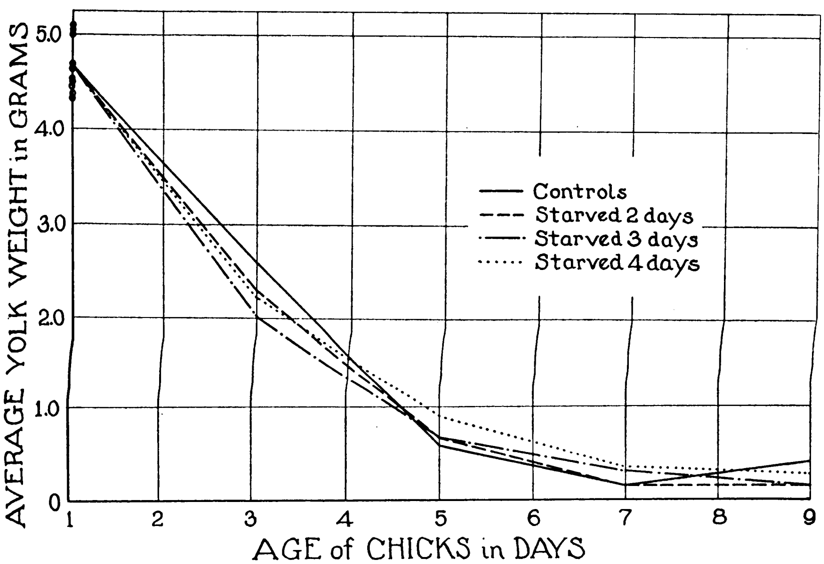

Fig. 1. The average yolk weights of chicks killed at different ages, from groups starved for various periods.

The differences between various samples of the same shipment, killed at 1 day of age, before the lots had received any differential treatment (and, therefore, not included in the table), are of about the same order of magnitude as the later differences. The average yolk weight at 1 day of age for various samples of 15 chicks each, all samples from the same shipment and having the same distribution of body weights, ranged from 4.32±0.16 to 5.00±0.34 grams. Since at 1 day of age the differences between the various averages are obviously due only to random sampling, the lines are all started from the grand average. The various averages are, however, shown as separate points on the graph (fig. 1). The fact that these differences are of about the same magnitude as any of the later ones confirms by actual sampling the evidence from the computed probable errors, that starvation had no effect on yolk absorption marked or consistent enough to be significant with the numbers employed.

Effects on Mortality.—The mortality rates[7] presented in table 2 bring out several points of interest. The first is that the chicks which were starved until 4 days old had a higher mortality than any of the other groups. This higher mortality is shown in both shipments II and III. The increase in mortality is due entirely to a higher death rate in the early weeks of life. After 3 weeks of age, there were no significant differences in mortality between the groups starved for varying periods and the control group.

Further, it is to be noted that in three of the lots, the chicks of shipment III suffered a higher mortality than those of shipment II, and that this difference also was evidenced in the first 3 weeks of life, there being no difference in the later mortality of the two shipments.

Finally, there appears to be no regularity in the differences between the male and female mortality in the various groups. Further discussion of the comparative mortality of the sexes will be deferred until the evidence from all the experimental groups can be considered together.

[7] An explanation of the method of calculating these mortality rates should be given, since by killing samples for yolk determinations at different ages, the number of chicks was arbitrarily reduced on these dates. Therefore, for each lot, the number of chicks (multiplied by 100) dying within a period between the killing of samples was divided by the number of chicks at the beginning of the experiment, minus the number of chicks which had been killed up to that time. These mortality rates for the successive intervals of each particular lot were then combined by straight addition to obtain the mortality rate for the lot. This procedure amounts to assuming that the chicks which were killed would have suffered the same mortality rate as the rest of the chicks, and is as fair as any assumption which can be made. It should be stated that special precautions were taken that the samples killed should be unselected with respect to general vigor, or resistance to the particular handicap. This was ensured by making up the samples on paper, by day-old body weight and band number, without any reference to the appearance of the chicks.

In computing the probable errors of the mortality rates, the number of chicks after all the samples had been killed was used in every case as the value of n in the formula, $0.6745\sqrt{\frac{pq}{n}}$. This means that the probable errors tabled are maximum values. Minimum values would be about seven-tenths of the tabled values since about half the chicks of each lot were killed for yolk determinations in the course of the experiment. It should also be noted that it was necessary to use the observed mortality rate in every case for the value of p in the formula, since there were no theoretical values, or values obtained from larger samples, which would be applicable to the various cases. Because of this difficulty, whenever the observed mortality rate happened to be zero, the probable error was automatically zero. Despite these limitations, it seemed worthwhile to include the probable errors, as approximations by which to judge the reliability of the differences observed.

Since all the chicks of shipment IV were killed for yolk weights during the first nine days of their life, mortality rates for the chicks of this shipment were not included. The data, however, are presented in table 21.

Effects on Body Weights of Survivors.—The average body weights at different ages, for the birds which survived the total experimental period of 20 weeks, are presented in table 3 and plotted in figures 2 and 3. The data for the two sexes are treated separately. As with the yolk weights, the plots show only the averages for the total groups given a particular treatment, while the table includes in addition the values for the separate lots.

TABLE 2

MORTALITY RATES* (PER 100) IN LOTS STARVED FOR VARIOUS PERIODS

Shipment No.	1 day (controls)	Length of starvation period from hatching		
		2 days	3 days	4 days
	Total mortality (through 20 weeks)			
II	6.9±2.9	5.3±2.5	13.1±3.8	17.7±4.1
III	16.8±4.0	21.7±5.1	12.5±3.5	35.1±5.1
Total	12.0±2.5	11.5±2.6	12.8±2.6	26.4±3.3
	Early mortality (hatching to 3 weeks of age)			
II	4.1±2.2	2.7±1.7	7.4±3.1	12.4±3.5
III	14.2±3.7	14.6±4.4	12.5±3.5	30.0±4.9
Total	9.3±2.3	7.0±2.1	9.7±2.4	21.2±3.1
	Later mortality (3 weeks through 20 weeks of age)			
II	2.8±1.9	2.6±1.7	5.7±2.7	5.3±2.5
III	2.6±1.8	7.1±3.1	0.0±0.0	5.1±2.3
Total	2.7±1.3	4.5±1.6	3.1±1.3	5.2±1.7
	Comparative sex mortality (through 20 weeks)			
II ♂s	11.8±4.6	0.0±0.0	15.9±5.9	28.3±7.5
II ♀s	0.0±0.0	8.0±3.7	10.2±5.0	8.6±4.2
III ♂s	7.2±3.8	9.9±5.8	13.0±6.1	33.5±7.1
III ♀s	25.8±6.6	32.5±8.5	12.6±4.5	36.3±7.2
Total ♂s	9.7±3.2	5.1±3.0	14.6±4.3	31.0±5.3
Total ♀s	15.1±4.4	17.2±4.0	11.5±3.3	22.3±4.4

* The method of computing these rates is given in the footnote on page 00.

The graphs are plotted on semi-logarithmic paper, because of two advantages which this gives over plotting on arithmetic paper; the slopes of the lines indicate the *rate of gain* instead of the *absolute gain,* and the graphical differences between corresponding points on the several lines are more nearly in accordance with the probable errors of the differences at the various ages.

TABLE 3

AVERAGE BODY WEIGHTS AT DIFFERENT AGES, OF THE CHICKS THAT SURVIVED THE PERIOD OF 20 WEEKS, FROM LOTS STARVED FOR VARIOUS PERIODS

Age of chicks	Shipment II				Shipment III				Total groups			
	Chicks starved for				Chicks starved for				Chicks starved for			
	1 day (controls)	2 days	3 days	4 days	1 day (controls)	2 days	3 days	4 days	1 day (controls)	2 days	3 days	4 days
						Males						
1 day	36.7	36.1	36.0	36.6	36.6	37.4	36.9	36.9	36.7± 0.3	36.7± 0.4	36.4± 0.4	36.8± 0.4
*				28.3*		33.8*	30.2*	27.7*				
1 week	55.6	52.1	52.7	45.9	53.5	54.3	49.3	45.0	54.6± 0.6	53.1± 0.8	51.2± 0.7	45.4± 0.6
2 weeks	84.9	80.3	81.0	74.3	75.6	77.7	72.2	69.3	80.6± 1.4	79.1± 1.4	77.1± 1.4	71.7± 1.4
3 weeks	123.4	122.4	117.5	116.7	118.9	119.3	107.9	106.0	121.4± 2.5	121.0± 2.6	113.2± 2.6	111.1± 2.6
4 weeks	166.7	172.0	165.8	165.5	173.4	162.6	156.4	155.6	169.8± 4.0	167.7± 4.3	161.6± 4.2	160.3± 3.9
5 weeks	235.2	239.8	231.7	227.6	241.6	225.4	215.3	217.7	238.2± 5.5	233.2± 5.5	224.4± 6.2	222.5± 5.3
6 weeks	312.2	312.3	311.8	309.3	314.9	292.3	285.3	281.3	313.4± 6.8	303.1± 7.4	300.0± 8.5	294.7± 7.2
8 weeks	432.0	429.2	415.0	401.8	397.6	354.1	357.5	376.7	416.2±10.4	394.8±10.9	389.4±11.0	388.7±10.3
10 weeks	647.0	628.5	622.0	604.5	592.7	575.5	527.9	596.7	622.0±13.9	604.2±14.0	580.2±15.7	600.4±13.9
12 weeks	932.0	880.0	880.0	876.4	838.2	827.3	755.0	850.0	888.9±17.4	855.8±18.7	824.4±21.2	862.6±16.5
16 weeks	1,419.0	1,330.0	1,338.7	1,311.8	1,285.3	1,250.0	1,182.5	1,278.3	1,357.6±21.5	1,293.3±21.8	1,269.3±25.7	1,294.3±16.9
20 weeks	1,692.5	1,553.8	1,578.7	1,581.8	1,545.3	1,525.5	1,464.2	1,530.8	1,624.9±22.3	1,540.8±25.3	1,527.8±24.2	1,555.2±18.6
Probable error†	±24.9	±39.8	±22.8	±28.0	±34.6	±28.1	±43.3	±23.9				
Number of ♂s	20	13	15	11	17	11	12	12	37	24	27	23
						Females						
1 day	34.7	35.7	36.2	35.8	36.5	35.7	36.0	36.3	35.6± 0.5	35.7± 0.3	36.1± 0.3	36.0± 0.3
*				27.5*		32.5*	29.7*	27.1*				
1 week	57.4	51.3	48.9	43.6	51.1	48.5	47.5	44.0	54.1± 0.9	50.5± 0.9	48.1± 0.5	43.8± 0.5
2 weeks	86.3	74.8	70.2	68.4	69.7	68.8	73.5	64.4	77.7± 1.7	73.0± 1.6	72.1± 1.1	66.9± 1.4
3 weeks	124.9	105.9	99.1	104.8	99.4	102.9	109.6	96.4	111.7± 3.1	105.0± 3.0	105.2± 2.1	101.7± 2.5
4 weeks	164.2	143.6	134.2	151.0	137.1	139.1	153.9	136.3	150.1± 4.4	142.2± 4.7	145.7± 3.2	145.6± 3.7
5 weeks	221.0	194.0	186.1	211.4	187.5	190.8	212.1	190.3	203.6± 6.4	193.1± 6.5	201.3± 4.8	203.6± 4.8
6 weeks	288.4	257.8	243.3	287.2	250.1	246.6	273.5	255.5	268.6± 8.3	254.4± 7.9	260.9± 6.3	275.6± 6.1
8 weeks	371.2	358.0	337.7	390.0	320.7	307.5	352.6	344.5	345.0±10.8	342.7±10.6	346.4± 8.6	373.3± 8.2
10 weeks	555.4	545.2	50.47	569.7	494.3	478.0	534.3	520.9	523.7±14.8	524.8±13.5	521.9±11.6	551.8± 9.5
12 weeks	770.0	753.9	721.3	770.5	683.6	668.0	735.2	711.8	725.2±18.0	727.9±15.6	729.4±13.4	749.0±11.2
16 weeks	1,036.2	1,034.8	996.0	1,024.7	943.6	927.0	989.1	977.3	988.1±20.3	1,002.1±16.6	991.9±15.7	1,007.3±11.8
20 weeks	1,267.7	1,269.6	1,246.7	1,263.7	1,185.7	1,100.0	1,218.1	1,175.5	1,225.2±26.3	1,218.2±21.9	1,230.0±20.6	1,231.3±14.5
Probable error†	±35.7	±22.1	±33.2	±15.7	±37.0	±41.3	±26.0	±24.6				
Number of ♀s	13	23	15	19	14	10	21	11	27	33	36	30

* Average weights of the starved lots just before they were given their first feed.
† [illegible]

It is apparent at once from an examination of the figures and tables, that in starved males and females alike there was a considerable loss of weight, roughly proportional to the length of the starvation period. The inequalities thus developed were maintained for the first few weeks, but were gradually effaced more or less completely.

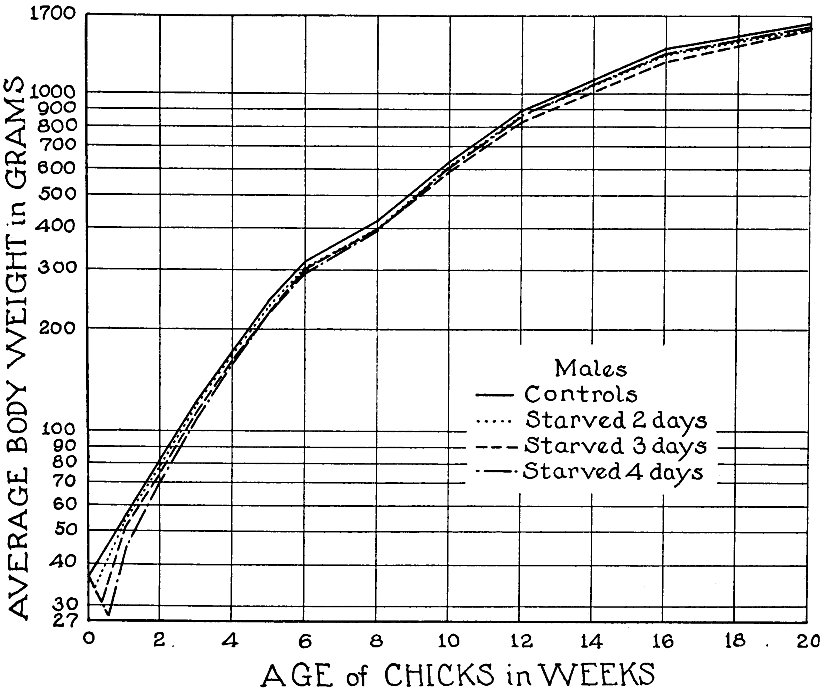

Fig. 2. The average body weights at different ages, of the males that survived the period of 20 weeks, from groups starved for various periods. All four curves start from the same point at one day old. The losses in weight suffered by the several groups during the starvation period were very closely proportional to the respective lengths of the periods. Therefore what appears as a single diagonal line at the left of the graph in reality represents the coincidence of the several curves during the starvation periods.

In the case of the females, at 20 weeks of age there were no significant differences in the average weights of the several groups. In the case of the males, all the groups which had their first feed delayed were at 20 weeks of age slightly, and about equally, below the group which was fed at 1 day of age. These differences are just on the border line of significance; the largest one, that between the chicks fed at 1 day of age and those fed at 3 days of age, is 97.1 ± 33.1 grams.

Examining these differences further, it is seen that while in shipment II all the starved lots had at 20 weeks of age smaller average body weights than the control chicks, in shipment III the lots starved for 2 days and for 4 days had at about 10 weeks of age practically overcome the detrimental effect of the delay in first feeding. Therefore the evidence is not very strong for a permanent effect in the males, and there certainly was no permanent effect in the females.

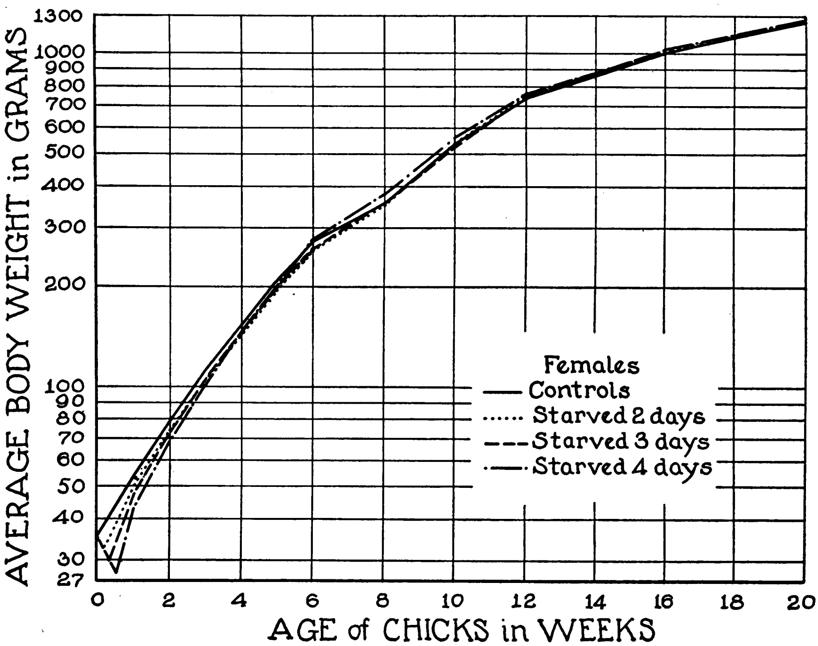

Fig. 3. The average body weights at different ages, of the females that survived the period of 20 weeks, from groups starved for various periods. All four curves start from the same point at one day old. The losses in weight suffered by the several groups during the starvation periods were very closely proportional to the respective lengths of the periods. Therefore what appears as a single diagonal line at the left of the graph in reality represents the coincidence of the several curves during the starvation periods.

It is possible that the tendency toward a more permanent effect in the males which, to anticipate somewhat, was also evidenced in the case of several other handicaps, may have been related to the more severe competition among the cockerels.

The standard deviations and coefficients of variation are given in tables 4 and 5 and are of the same order of magnitude as those found by other investigators working with chicks; see Pearl (1917) and Latimer (1924). The relative variability is of the same order of magnitude as that found in rats; see Jackson (1913) and King (1918, 1919). In all the series the relative variability is lowest, about 10 per cent, at the beginning of independent life, rises to a maximum of around 25 to 30 per cent, and then decreases again.

TABLE 4

STANDARD DEVIATIONS OF BODY WEIGHTS OF DIFFERENT AGES, OF THE CHICKS THAT SURVIVED THE PERIOD OF 20 WEEKS, FROM GROUPS STARVED FOR VARIOUS PERIODS

Age of chicks	Length of starvation period from hatching			
	1 day (controls)	2 days	3 days	4 days
	Males			
1 day	2.8± 0.2	3.0± 0.3	3.0± 0.3	3.1± 0.3
1 week	5.7± 0.4	5.6± 0.5	5.5± 0.5	4.2± 0.4
2 weeks	12.4± 1.0	10.4± 1.0	10.6± 1.0	10.1± 1.0
3 weeks	22.8± 1.8	18.9± 1.8	20.2± 1.9	18.5± 1.8
4 weeks	35.7± 2.8	31.3± 3.0	32.5± 3.0	27.4± 2.7
5 weeks	50.1± 3.9	39.7± 3.9	47.5± 4.4	37.6± 3.7
6 weeks	61.5± 4.8	53.7± 5.2	65.1± 6.0	50.9± 5.1
8 weeks	93.5± 7.3	79.0± 7.7	64.8± 7.8	73.2± 7.3
10 weeks	125.6± 9.8	102.0± 9.9	120.7±11.1	98.5± 9.8
12 weeks	157.3±12.3	136.0±13.2	163.5±15.0	117.4±11.7
16 weeks	194.3±15.2	158.5±15.4	198.0±16.2	128.3±12.0
20 weeks	201.5±15.8	183.7±17.9	186.3±17.1	132.6±13.2
Number of ♂s	37	24	27	23
	Females			
1 day	3.5± 0.3	3.0± 0.3	3.1± 0.3	2.8± 0.3
1 week	6.9± 0.6	7.1± 0.6	4.7± 0.4	5.0± 0.4
2 weeks	13.0± 1.2	13.9± 1.2	9.9± 0.8	11.7± 1.0
3 weeks	24.2± 2.2	25.9± 2.2	18.4± 1.5	20.0± 1.7
4 weeks	34.3± 3.1	40.4± 3.4	28.5± 2.3	29.7± 2.6
5 weeks	49.4± 4.5	55.0± 4.6	42.4± 3.4	39.3± 3.4
6 weeks	63.6± 5.8	67.4± 5.6	56.2± 4.5	49.5± 4.3
8 weeks	83.0± 7.6	90.5± 7.5	76.8± 6.1	66.3± 5.8
10 weeks	113.7±10.4	114.7± 9.5	103.5± 8.2	78.5± 6.7
12 weeks	138.4±12.7	132.9±11.0	118.9± 9.5	90.9± 7.9
16 weeks	156.1±14.3	141.1±11.7	139.8±11.1	96.1± 8.4
20 weeks	202.6±18.6	186.9±15.5	183.4±14.6	117.6±10.2
Number of ♀s	27	33	36	30

The chicks which had been starved for the first 4 days after hatching were (in the females after about 6 weeks, and in the males after about 10 weeks) somewhat less variable than the controls, both in respect to absolute and relative variability. The results further show that the relative variability of the females at 20 weeks of age was slightly in excess of that of the males in every group. The absolute variability was substantially the same for the two sexes.

TABLE 5

COEFFICIENTS OF VARIATION OF BODY WEIGHTS AT DIFFERENT AGES, OF THE CHICKS THAT SURVIVED THE PERIOD OF 20 WEEKS, FROM GROUPS STARVED FOR VARIOUS PERIODS

Age of chicks	Length of starvation period from hatching			
	1 day (controls)	2 days	3 days	4 days
	Males			
1 day	7.6±0.6	8.2±0.8	8.2±0.8	8.4±0.8
1 week	10.4±0.8	10.5±1.0	10.7±1.0	9.3±0.9
2 weeks	15.4±1.2	13.1±1.3	13.7±1.3	14.1±1.4
3 weeks	18.8±1.5	15.6±1.6	17.8±1.7	16.7±1.7
4 weeks	21.0±1.7	18.7±1.9	20.1±1.9	17.1±1.7
5 weeks	21.0±1.7	17.0±1.7	21.2±2.0	16.9±1.7
6 weeks	19.6±1.6	17.7±1.8	29.0±2.9	17.3±1.8
8 weeks	22.5±1.9	20.0±2.0	21.8±2.1	18.8±1.8
10 weeks	20.2±1.6	16.9±1.7	20.8±2.0	16.4±1.7
12 weeks	17.7±1.4	15.9±1.6	19.8±1.9	13.6±1.4
16 weeks	14.3±1.1	12.3±1.2	15.6±1.5	9.3±0.9
20 weeks	12.4±0.9	11.9±1.2	12.2±1.1	8.5±0.8
Number of ♂s	37	24	27	23
	Females			
1 day	9.8±0.9	8.4±0.7	8.6±0.7	7.8±0.7
1 week	12.8±1.2	14.1±1.2	9.8±0.8	11.4±1.0
2 weeks	16.7±1.6	19.0±1.6	13.7±1.1	17.5±1.6
3 weeks	21.7±2.1	24.7±2.2	17.5±1.4	19.7±1.8
4 weeks	22.8±2.2	28.4±2.5	19.6±1.6	20.4±1.8
5 weeks	24.3±2.3	28.5±2.5	21.1±1.8	19.3±1.7
6 weeks	23.7±2.3	26.5±2.3	21.5±1.8	18.0±1.6
8 weeks	24.1±2.3	26.4±2.3	22.2±1.9	17.8±1.6
10 weeks	21.7±2.1	21.9±1.9	19.8±1.6	14.2±1.3
12 weeks	19.1±1.8	18.3±1.6	16.3±1.3	12.1±1.1
16 weeks	15.8±1.5	14.1±1.2	14.1±1.1	9.5±0.8
20 weeks	16.5±1.6	15.3±1.3	14.9±1.2	9.6±0.8
Number of ♀s	27	33	36	30

EXPERIMENTS ON ADMINISTRATION OF POISONS

For the particular purposes of these experiments the exact dosage or mode of action of the poisons used was not a primary consideration. The only requirement was the determination of a constant dose which, when administered to all the individuals of a group, would be lethal to a considerable proportion of the individuals, so that comparisons could be made between individuals which survived and those which succumbed, and between survivors and controls.

Various considerations guided the choice of the particular poisons. Nicotine sulfate was used because of the widespread interest in its supposed stunting effect and because of its frequent use as a vermifuge for poultry. Mercuric chloride and arsenic trioxide were tested to determine whether heavy metallic salts, whose elimination is slow, might bring about more permanent effects than the other handicaps used. Sodium chloride was of particular interest because of its universal presence in the diet, and its poisonous action in excessive amounts.

Experimental Procedure.—By preliminary trials, dosages were determined which were lethal to about 30 per cent of the individuals of a group. The most satisfactory way to administer all of the poisons was found to be by mouth, in small gelatine capsules (No. 5). The capsules were dipped in olive oil, and placed well down the throat.

The dosage adopted for nicotine sulfate was a capsule full (0.2 cc.) of a 3 per cent solution. In the preliminary trials an 8 per cent solution had killed every chick to which it was given, a 6 per cent solution had killed 70 per cent of the chicks, and a 4 per cent solution had killed 50 per cent of the chicks. With the 3 per cent solution there was an almost immediate reaction, practically identical for every chick, a complete coma lasting for about fifteen minutes, but very few deaths.

With the other poisons no immediate reaction could be seen, but in a large proportion of the cases of early deaths, certain characteristic postmortem appearances were found associated with each specific type of poisoning.[8]

In preliminary trials, a capsule full of dry sodium chloride killed every chick to which it was given; a capsule half full killed about 50 per cent of the chicks; while of the chicks receiving a capsule one-quarter full none died. The dosage adopted therefore was a capsule one-third full, or 0.06 gram of the pure dry salt. This dose effected a mortality of 18 per cent in the chicks of shipment II; in the chicks of shipment III, however, the mortality was 70 per cent. Since the

[8] The majority of the dead chicks from the nicotine group had very blue shanks and beak, the kidneys congested, and in several cases the right side of the heart filled with black clotted blood; those from the group given sodium chloride had the rectum and cloaca enormously distended, and very pale kidneys; in the chicks which died from the group given mercuric chloride the ureters appeared choked with urates; the chicks which died from the 2 per cent dose of arsenic trioxide showed dark lesions on the liver, but with the smaller doses of arsenic there were no noticeable abnormalities.

latter group received the poison before receiving any feed,[9] two lots in shipment IV were given this same dose. Both lots were given the salt at 24 hours of age, but one lot was fed before it was poisoned, to determine whether the higher mortality obtained in shipment III could be attributed to the difference in age of chicks at the time of receiving poison, or to its administration when the alimentary tract was empty. In the lot that had not been fed before poisoning eighteen chicks died, while in the lot that was fed before poisoning only 11 chicks died. This difference is not nearly so great as that between the mortality suffered by the corresponding lots of shipments II and III.

With both metallic poisons the preliminary trials had indicated a capsule full (0.2 cc.) of a 2 per cent solution as a satisfactory dose. When this dose was used, however, on the chicks of shipment II, so high a mortality resulted that the doses were reduced for the corresponding lots of the later shipments. The chicks of shipments III and IV were given a 1 per cent solution of mercuric chloride, and had a mortality rate practically identical with that of the lot getting the 2 per cent dose, between 35 and 40 per cent. The decrease in dose was evidently counterbalanced by a slight inferiority of the later chicks, or by the later chicks not having been fed before receiving poisons, or by the combined effect of both differences.

All of the chicks given the 2 per cent solution of arsenic died, so that the chicks which were to have been killed at 3 days old were used instead for a second arsenic lot,[10] which was given a 0.5 per cent solution of arsenic. Since the resulting mortality was about 50 per cent, for the corresponding lots of shipments III and IV the dose was reduced to a 0.25 per cent solution. In shipment III, 14 per cent of the chicks died, while in shipment IV there were no deaths. Thus slight differences in the size of dose apparently had a greater influence upon mortality in the case of arsenic trioxide than in the case of mercuric chloride.

Effects on Yolk Absorption.—From the averages presented in table 6 and plotted in figure 4, it would appear at first glance that marked differences were obtained in the yolk weights of the various samples

[9] Since the preliminary trials had shown no difference in results whether the poisons were given at one or two days of age, the chicks of shipment II were not given their poisons until the second day. It was then found to be of advantage, in order to save rehandling of the chicks on the second day, to give the poisons on the first day, before the chicks were put under the hovers. This procedure was accordingly followed with shipments III and IV.

[10] This explains the fact that no samples were killed from shipment II for yolk determinations at 3 days of age.

killed at 3 days old, all of the poisoned groups except that given sodium chloride having yolks averaging less than the control group. However, the differences are not significant, the largest ones being less than twice their probable error. The appearance arises largely from the influence of the one very large yolk already noted in the control group. As stated above, omitting this one observation would make the average for the controls of shipment III 2.09±0.39 grams, and for the total group of controls 2.04±0.19 grams. In the samples killed at 5 and at 7 days old, all the poisoned groups had yolks averaging slightly larger than the controls, but these differences also are not significant. At 9 days old, there was no regularity in the comparisons, nor were any of the differences significant.

TABLE 6

AVERAGE YOLK WEIGHTS (IN GRAMS) OF SAMPLES KILLED AT DIFFERENT AGES, FROM LOTS GIVEN DIFFERENT POISONS

Shipment No.	Controls	Mercuric chloride	Sodium chloride (not fed first)	Sodium chloride (fed first)	Arsenic trioxide	Nicotine sulfate
			Chicks killed at 3 days old			
III	*3.44±0.91	1.71±0.15	....	....	2.04±0.27	1.68±0.25
IV	2.01±0.18	1.66±0.16	2.54±0.23	1.58±0.23	2.05±0.17	1.99±0.25
Total	2.60±0.41	1.68±0.11	2.54±0.23	1.58±0.23	2.04±0.15	1.86±0.18
			Chicks killed at 5 days old			
II	0.31±0.06	0.68±0.20	....	0.98±0.28	0.19±0.06	0.94±0.18
III	0.47±0.17	0.58±0.15	....	....	1.36±0.47	0.68±0.20
IV	0.82±0.16	0.77±0.20	1.16±0.22	1.29±0.31	0.74±0.19	0.99±0.25
Total	0.58±0.09	0.68±0.11	1.16±0.22	1.17±0.22	0.79±0.17	0.88±0.14
			Chicks killed at 7 days old			
II	0.12±0.07	0.45±0.24	....	0.16±0.19	0.22±0.08	0.11±0.07
III	0.25±0.14	0.94±0.42	1.45±0.34	....	0.28±0.11	0.80±0.19
IV	0.09±0.04	0.12±0.19	0.40±0.09	0.36±0.10	0.05±0.06	0.09±0.14
Total	0.14±0.04	0.48±0.16	0.79±0.18	0.27±0.07	0.16±0.04	0.29±0.08
			Chicks killed at 9 days old			
II	0.00±0.00	0.29±0.17	....	0.17±0.07	....	0.54±0.31
III	*1.31±0.77	0.35±0.19	....	....	0.63±0.33	0.17±0.06
IV	0.22±0.04	0.08±0.04	0.60±0.19	0.09±0.04	0.43±0.18	0.00±0.00
Total	0.41±0.20	0.20±0.07	0.60±0.19	0.13±0.04	0.49±0.16	0.22±0.10

* Note, from the raw data in table 20, that each of these two high values is due to a single extreme case.

From a careful study of the various comparisons to be made, of the various poisoned groups with controls and with each other, and of the several lots which were subjected to the same handicap, it appears that there is only one difference occurring with sufficient regularity to warrant emphasis. The average yolk weights of 10 of the 12 different samples of chicks given sodium chloride were larger than the corresponding averages for the controls. It is unfortunate that from shipment III a complete series of samples was not obtained. As

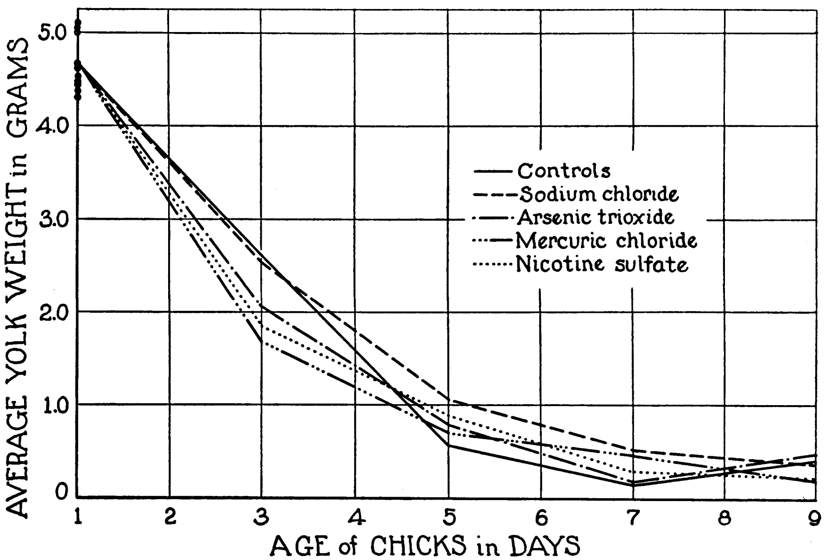

Fig. 4. The average yolk weights of chicks killed at different ages, from groups given various poisons.

has been noted above, the early mortality of this lot was very high, so that it seemed important to keep as many survivors as possible, rather than to kill samples for yolk weights. Two complete series of samples were obtained from shipment IV.

In all shipments, chicks which were given sodium chloride *before* receiving their first feed averaged heavier yolks at every age than the controls. The chicks which were poisoned *after* they were fed also had heavier yolks than the control lot at 5 and at 7 days of age. At 3 and at 9 days of age, however, the yolks averaged slightly less than the controls. These two samples furnished the only exceptions to a generalization that yolk absorption was slower in chicks which received sodium chloride.

Effects on Mortality.—Some references have already been made to the mortality figures in connection with the discussion of the dosages employed. The rates are presented in table 7. The main additional points to be mentioned are the same generalizations which were found to hold for the lots deprived of food for different periods; namely, that there were no consistent differences in the male and female mortality rates, and that the subjection of the chicks to the early handicaps did not cause an increased mortality rate after three weeks of age. The total groups given mercuric chloride and nicotine sulfate had later mortality rates slightly higher than the controls, while those given sodium chloride and arsenic trioxide had mortality rates slightly below the controls. These comparisons, however, did not hold for all of the separate shipments, and were not significant in any case.

TABLE 7

MORTALITY RATES (PER 100) OF THE POISONED AND OPERATED LOTS

Shipment No.	Controls	Mercuric chloride	Sodium chloride	Arsenic trioxide	Nicotine sulfate	Yolk removed
			Total mortality (through 20 weeks)			
II	6.9±2.9	38.5±5.2	18.4±4.3	50.3±5.7	30.5±5.3	25.0±5.1
III	16.8±4.0	36.6±5.3	70.0±4.1	13.6±4.2	23.8±4.8	58.1±6.1
Total	12.0±2.5	38.8±3.7	44.8±3.4	30.3±3.8	26.9±3.6	41.3±4.3
			Early mortality (hatching to 3 weeks of age)			
II	4.1±2.2	36.0±5.1	15.7±4.0	50.3±5.7	19.1±4.5	18.7±4.7
III	14.2±3.7	25.8±4.9	70.0±4.1	13.6±4.2	18.4±4.3	45.2±6.1
Total	9.3±2.3	32.3±3.5	43.7±3.4	30.3±3.8	18.6±3.1	31.8±4.0
			Later mortality (3 weeks through 20 weeks of age)			
II	2.8±1.9	2.5±1.6	2.7±1.6	0.0±0.0	11.4±3.7	6.3±2.9
III	2.6±1.8	10.8±3.4	0.0±0.0	0.0±0.0	5.4±2.6	12.9±4.1
Total	2.7±1.3	6.5±1.8	1.1±0.9	0.0±0.0	8.3±2.2	9.5±2.6
			Comparative sex mortality (through 20 weeks)			
II ♂s	11.8±4.6	36.0±7.2	18.2±5.5	41.6±8.8	31.2±7.4	21.1±6.2
II ♀s	0.0±0.0	41.0±7.4	18.9±6.9	59.1±8.0	30.9±7.5	30.8±8.7
III ♂s	7.2±3.9	41.1±7.4	75.0±6.3	10.4±6.0	21.3±7.2	82.5±6.6
III ♀s	25.8±6.6	32.4±8.0	66.7±5.4	16.3±5.5	26.9±6.3	42.9±9.0
Total ♂s	9.7±3.2	42.2±5.3	41.4±5.0	26.9±5.5	26.4±5.2	44.5±5.6
Total ♀s	15.1±4.4	35.8±5.4	48.4±4.8	33.0±5.0	28.6±4.7	37.0±6.3

Effects on Body Weights of Survivors.—Turning now to the body weights of the survivors, which are presented in table 8 and plotted in figures 5 to 8, several points are to be observed. The first is that the only group which throughout the entire period remained below the control group in all four sub-groups (both sexes separately, and both lots separately) was the group given mercuric chloride. At

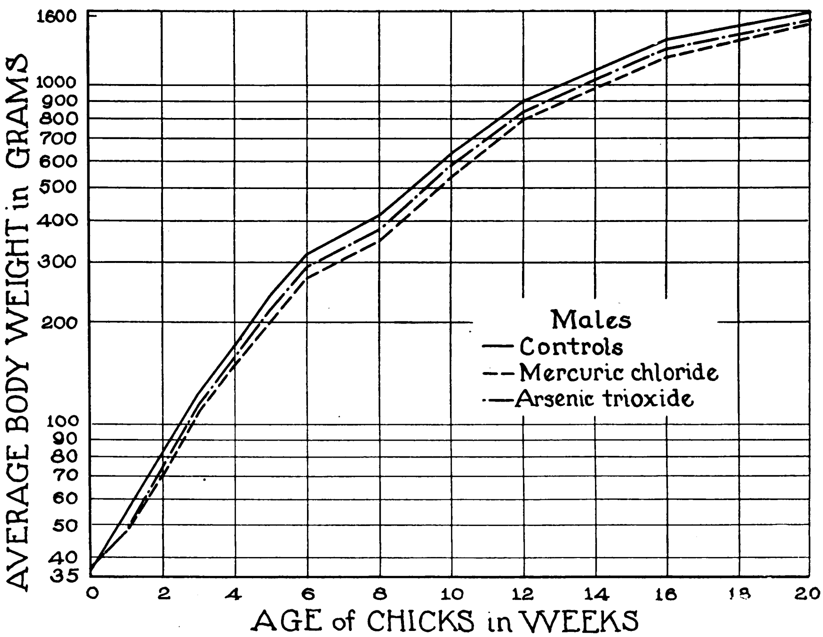

Fig. 5. The average body weights at different ages, of the males that survived the period of 20 weeks, from groups given heavy metallic poisons.

20 weeks of age the males of shipment II which had been given mercuric chloride averaged 152±38 grams lower in body weight than the controls. The difference between the average weights of the females from these same lots was only 53±50 grams. For the corresponding lots in shipment III the difference was 62±72 grams in the case of the males, and 162±59 grams in the case of the females. Combining the lots, the differences for both sexes are just on the border line of significance, being 112±41 grams for the males and 112±42 grams for the females. Thus, while the differences are not significant, the fact that they are all in the same direction is suggestive, and indicates that this point may be worthy of further investigation.

TABLE 8

Average Body Weights at Different Ages, of the Chicks That Survived the Period of 20 Weeks, from Poisoned and Operated Lots

Age of chicks	Shipment II						Shipment III						Total groups					
	Controls	Mercuric chloride	Sodium chloride	Arsenic trioxide	Nicotine sulfate	Yolk removed	Controls	Mercuric chloride	Sodium chloride	Arsenic trioxide	Nicotine sulfate	Yolk removed	Controls	Mercuric chloride	Sodium chloride	Arsenic trioxide	Nicotine sulfate	Yolk removed
									Males									
1 day	36.7	37.4	36.5	36.0	36.0	35.5	36.6	37.0	36.8	37.9	36.0	38.4	36.7± 0.3	37.2± 0.4	36.5± 0.4	37.1± 0.4	36.0± 0.4	36.2± 0.4
1 week	55.6	48.9	53.6	43.9	51.5	41.9	53.5	45.9	44.8	50.1	48.4	44.0	54.6± 0.6	47.5± 1.1	51.9± 1.2	47.5± 1.1	50.0± 0.8	42.4± 0.8
2 weeks	84.9	74.9	81.4	68.0	74.7	62.3	75.6	67.2	66.5	75.6	69.2	59.6	80.6± 1.4	71.2± 2.1	78.5± 2.2	72.5± 2.1	72.1± 1.7	61.7± 1.4
3 weeks	123.4	115.2	124.2	106.6	108.3	98.5	118.9	100.7	104.8	120.0	108.6	82.6	121.4± 2.5	108.3± 3.1	120.5± 3.6	114.5± 4.1	108.4± 2.9	94.6± 2.4
4 weeks	166.7	156.5	170.5	147.4	145.0	146.1	173.4	137.5	152.0	168.7	157.3	117.6	169.8± 4.0	147.5± 4.4	167.0± 6.1	159.9± 6.8	150.9± 4.3	139.0± 3.7
5 weeks	235.2	209.6	236.9	203.3	193.6	202.9	241.6	190.0	216.5	229.9	218.4	164.6	238.2± 5.5	200.3± 6.3	233.1± 8.2	218.9± 9.6	205.4± 6.5	193.3± 5.4
6 weeks	312.2	277.4	316.5	266.7	252.2	279.2	314.9	257.3	294.5	301.6	288.0	216.2	313.4± 6.8	267.8± 9.0	312.3±11.0	287.2±12.9	269.2±10.4	263.5± 7.9
8 weeks	432.0	357.3	434.7	355.7	324.5	375.7	397.6	337.0	375.0	383.4	382.5	278.0	416.2±10.4	347.6±12.5	423.3±14.9	372.0±16.5	352.1±11.6	351.3±12.2
10 weeks	647.0	535.5	644.4	538.6	501.8	558.0	592.7	528.0	577.5	608.0	590.0	426.0	622.0±13.9	531.9±17.6	631.7±16.3	579.4±26.1	543.8±18.2	525.0±16.7
12 weeks	932.0	790.9	930.0	790.0	745.5	815.3	838.2	774.0	817.5	867.0	825.0	614.0	888.9±17.4	782.9±22.2	908.6±21.0	835.3±34.8	783.3±22.0	765.0±23.3
16 weeks	1,419.0	1,247.3	1,381.2	1,230.0	1,175.5	1,268.0	1,285.3	1,180.0	1,232.5	1,310.0	1,195.0	1,024.0	1,357.6±21.5	1,215.2±26.0	1,352.9±24.0	1,277.1±42.7	1,184.8±27.1	1,207.0±30.1
20 weeks	1,692.5	1,540.0	1,642.4	1,484.3	1,464.6	1,548.7	1,545.3	1,483.0	1,545.0	1,572.0	1,486.0	1,306.0	1,624.9±22.3	1,512.9±34.8	1,623.8±27.8	1,535.9±48.8	1,474.8±30.7	1,488.0±30.2
P. E.*	±24.9*	±28.7	±31.0	±61.5	±46.2	±23.0	±34.6	±65.4	±54.6	±69.9	±39.7	±76.2	......	......	......	......	......	......
Number of ♂s	20	11	17	7	11	15	17	10	4	10	10	5	37	21	21	17	21	20
									Females									
1 day	34.7	34.3	35.9	35.2	36.0	34.8	36.5	38.3	38.2	35.6	37.3	35.0	35.6± 0.5	36.4± 0.5	37.1± 0.5	35.5± 0.5	36.8± 0.5	34.9± 0.5
1 week	57.4	45.9	54.6	40.6	50.3	43.8	51.1	48.4	46.7	47.5	50.4	42.3	54.1± 0.9	47.2± 1.5	50.7± 1.0	45.9± 1.1	50.4± 0.9	43.1± 0.8
2 weeks	86.3	79.4	80.6	62.2	77.4	64.4	69.7	68.6	66.7	67.0	70.4	60.4	77.7± 1.7	69.5± 2.6	73.6± 1.8	65.9± 1.6	73.2± 1.7	62.5± 1.6
3 weeks	124.9	102.4	119.9	92.8	118.9	98.6	99.4	105.9	104.0	100.9	107.9	91.6	111.7± 3.1	104.3± 4.5	112.0± 2.8	99.0± 2.5	112.3± 3.0	95.3± 3.0
4 weeks	164.2	135.6	160.8	133.6	157.7	141.3	137.1	143.3	148.0	129.2	151.6	134.6	150.2± 4.4	139.6± 6.4	154.4± 4.4	130.2± 3.5	154.0± 4.8	138.2± 5.4
5 weeks	221.0	186.4	216.6	191.6	208.2	194.7	187.5	200.9	200.3	180.9	203.5	187.0	203.6± 6.4	194.1± 9.6	208.4± 6.6	183.4± 5.0	205.4± 6.6	191.1± 8.1
6 weeks	288.4	241.0	279.5	247.8	267.8	264.9	250.1	257.8	265.5	239.5	263.8	251.4	268.6± 8.3	249.8±11.3	272.5± 9.0	241.5± 6.7	265.4± 7.7	258.5±11.7
8 weeks	371.2	327.8	372.7	344.0	344.0	340.0	320.7	319.5	338.2	306.3	545.7	340.6	345.0±10.8	323.4±16.3	355.5±12.3	315.2±7.6	345.0±10.3	340.3±14.1
10 weeks	555.4	501.1	563.6	548.0	531.0	523.3	494.3	436.0	505.5	481.9	530.0	510.6	523.7±14.8	466.8±22.1	534.6±17.0	497.6±12.9	530.4±13.0	517.4±19.5
12 weeks	770.0	703.3	788.2	732.0	753.0	721.1	683.6	596.0	695.5	676.9	726.0	697.5	725.2±18.0	646.8±27.2	741.8±21.2	690.0±15.3	736.8±15.6	710.0±23.5
16 weeks	1,036.2	953.3	1,052.7	1,000.0	1,015.0	985.6	943.6	851.0	972.7	950.6	964.0	986.3	988.2±20.3	899.5±28.5	1,012.7±23.8	962.4±18.3	984.4±20.5	985.9±27.4
20 weeks	1,267.7	1,214.4	1,321.8	1,220.0	1,234.0	1,204.4	1,185.7	1,023.0	1,169.1	1,158.1	1,141.3	1,202.5	1,225.2±26.3	1,113.7±33.3	1,245.5±27.9	1,172.9±22.9	1,178.4±26.9	1,203.5±32.5
P. E.*	±35.7*	±34.8	±39.8	±25.2	±34.0	±33.7	±37.0	±47.5	±42.5	±28.7	±37.3	±57.7	......	......	......	......	......	......
Number of ♀s	13	9	11	5	10	9	14	10	11	16	15	8	27	19	22	21	25	17

* Probable errors of the 20-week weight.

The only other poison which gave uniform results in all sub-groups was sodium chloride. The survivors from this poison showed no material differences in body weight as compared with the controls, in either sex in either of the lots. This was true in spite of the fact that the mortality was very markedly higher in the lot from shipment III than in the lot from shipment II.

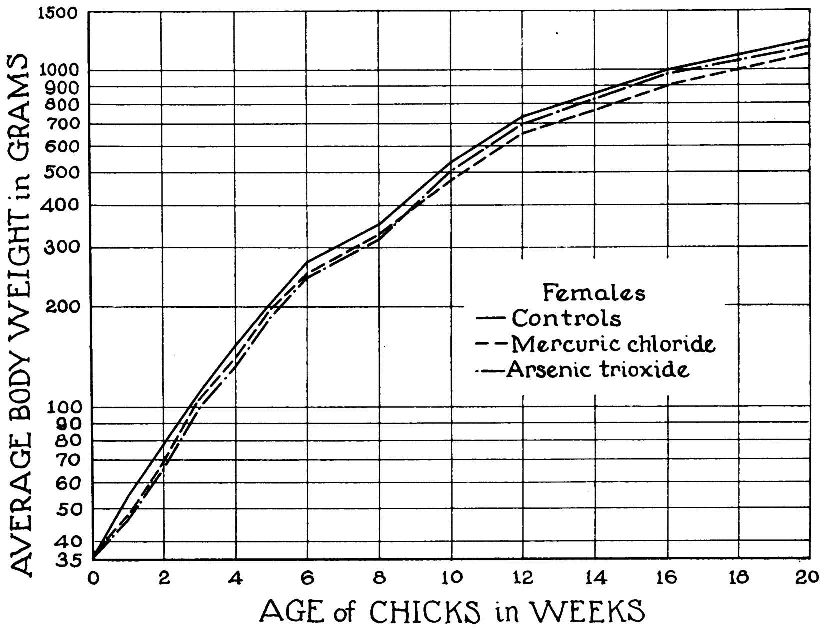

Fig. 6. The average body weights at different ages, of the females that survived the period of 20 weeks, from groups given heavy metallic poisons.

The two arsenic lots gave interesting results, which may be correlated with the differences in mortality effected by the slightly different dosages employed. The males of shipment II (which received the 0.5 per cent dose of arsenic and suffered a 50 per cent mortality) remained markedly lower in weight than the control lot throughout the period of 20 weeks (actual difference, 208 ± 66 grams at 20 weeks), while the males of shipment III (which received the 0.25 per cent dose of arsenic and had only 13 per cent mortality) equalled the controls in body weight.

The females of shipment II given arsenic trioxide equalled the controls after about 10 weeks of age, and those of shipment III after about 2 weeks. Among the females, therefore, while there was eventual recovery in both shipments, the smaller dose apparently allowed a more rapid recovery. When the two shipments are combined they give a spurious appearance of showing a less complete recovery, as compared with the controls, because of the fact that there happened to be three times as many females in the survivors of this lot in shipment III as in shipment II (and shipment III was inferior to shipment II in all lots, as evidenced by both mortality and body weights), so that the average of the total group is heavily weighted with the inferior birds. When the data are properly analyzed, therefore, the females show the more complete recovery than the males which was noted in the cases of starvation.

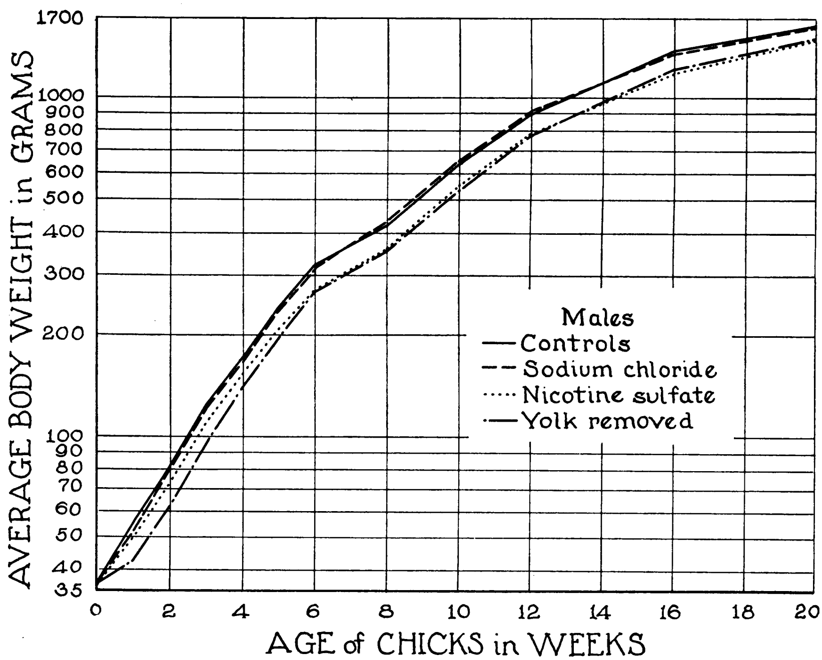

Fig. 7. The average body weights at different ages, of the males that survived the period of 20 weeks, from the operated group, and from groups poisoned by substances normally or frequently administered to chicks.

This same result was obtained with nicotine sulfate. The males remained below the controls in both lots; the differences were 228±54 grams and 59±78 grams for the separate shipments, and 150±38 grams for the total group. The females again showed complete recovery in both shipments.

The main points to be noted from the standard deviations and coefficients of variation in tables 9 and 10 are that there were no significant differences in the standard deviations of the various groups, or of the two sexes. The high value of the standard deviation of the males of the arsenic trioxide group (97±38 grams higher than the controls) is due to a single very small bird which weighed only 710 grams at 20 weeks of age. Omitting this individual would reduce the standard deviation to a value only 20±31 grams above that for the controls, or 222±26 grams. In every case except this one, the relative variability was slightly greater for the females than for the males, as was found to be true in the starved groups.

TABLE 9

STANDARD DEVIATIONS OF BODY WEIGHTS AT DIFFERENT AGES, OF THE CHICKS THAT SURVIVED THE PERIOD OF 20 WEEKS, FROM POISONED AND OPERATED GROUPS

Age of chicks	Controls	Mercuric chloride	Sodium chloride	Arsenic trioxide	Nicotine sulfate	Yolk removed
			Males			
1 day	2.8± 0.2	2.9± 0.3	2.8± 0.3	2.5± 0.3	3.0± 0.3	2.5± 0.3
1 week	5.7± 0.4	7.8± 0.8	8.0± 0.8	6.7± 0.8	5.5± 0.6	5.4± 0.6
2 weeks	12.4± 1.0	14.2± 1.5	14.9± 1.6	13.0± 1.5	11.4± 1.2	8.9± 1.0
3 weeks	22.8± 1.8	21.0± 2.2	24.3± 2.5	25.2± 2.9	19.3± 2.0	15.9± 1.7
4 weeks	35.7± 2.8	29.7± 3.1	41.3± 4.3	41.3± 4.8	29.5± 3.1	24.6± 2.6
5 weeks	50.1± 3.9	42.6± 4.4	55.6± 5.8	58.9± 6.8	44.4± 4.6	36.0± 3.8
6 weeks	61.5± 4.8	61.0± 6.4	74.5± 7.7	78.7± 9.1	70.5± 7.3	52.3± 5.6
8 weeks	93.5± 7.3	84.9± 8.8	101.1±10.5	100.6±11.6	79.0± 8.2	81.1± 8.6
10 weeks	125.6± 9.8	119.3±12.4	110.7±11.5	159.8±18.5	123.9±12.9	110.4±11.8
12 weeks	157.3±12.3	150.6±15.7	142.6±14.8	212.7±24.6	149.7±15.6	154.2±16.4
16 weeks	194.3±15.2	176.7±18.4	163.3±17.0	260.7±30.2	184.4±19.2	199.5±21.3
20 weeks	201.5±15.8	236.3±24.6	188.9±19.7	298.2±34.5	208.7±21.7	200.3±21.4
Number of ♂s	37	21	21	17	21	20
			Females			
1 day	3.5± 0.3	3.4± 0.4	3.3± 0.3	3.1± 0.3	3.4± 0.3	2.8± 0.3
1 week	6.9± 0.6	9.9± 1.1	7.1± 0.7	7.3± 0.8	6.5± 0.6	5.0± 0.6
2 weeks	13.0± 1.2	16.7± 1.8	12.4± 1.2	11.0± 1.1	12.3± 1.2	10.0± 1.2
3 weeks	24.2± 2.2	29.3± 3.2	19.7± 2.0	17.0± 1.8	22.2± 2.1	18.3± 2.1
4 weeks	34.3± 3.1	41.5± 4.5	30.5± 3.1	23.9± 2.5	35.4± 3.4	33.0± 3.8
5 weeks	49.4± 4.5	61.7± 6.8	46.0± 4.7	33.7± 3.5	48.6± 4.6	49.4± 5.7
6 weeks	63.6± 5.8	73.2± 8.0	62.7± 6.4	45.5± 4.7	57.2± 5.5	71.4± 8.3
8 weeks	83.0± 7.6	105.3±11.5	85.6± 8.7	51.3± 5.3	76.4± 7.3	86.1±10.0
10 weeks	113.7±10.4	142.6±15.6	118.0±12.0	87.7± 9.1	96.0± 9.2	119.2±13.8
12 weeks	138.4±12.7	175.9±19.2	147.5±15.0	104.1±10.8	115.9±11.1	143.6±16.6
16 weeks	156.1±14.3	184.2±20.2	165.4±16.8	124.3±12.9	151.9±14.5	167.3±19.4
20 weeks	202.6±18.6	215.5±23.6	194.1±19.7	155.7±16.2	199.2±19.0	198.6±23.0
Number of ♀s	27	19	22	21	25	17

TABLE 10

Coefficients of Variation of Body Weights at Different Ages, of the Chicks That Survived the Period of 20 Weeks, from Poisoned and Operated Groups

Age of chicks	Controls	Mercuric chloride	Sodium chloride	Arsenic trioxide	Nicotine sulfate	Yolk removed
			Males			
1 day	7.6±0.6	7.8±0.8	7.6±0.8	6.7±0.7	8.3±0.9	6.9±0.7
1 week	10.4±0.8	16.4±1.8	17.9±1.9	14.1±1.7	11.0±1.2	12.7±1.4
2 weeks	15.4±1.2	19.9±2.2	22.4±2.4	17.9±2.1	15.8±1.7	14.4±1.6
3 weeks	18.8±1.5	19.4±2.1	23.2±2.5	22.0±2.7	17.6±1.9	16.8±1.8
4 weeks	21.0±1.7	20.1±2.2	27.2±3.0	25.8±3.2	19.5±2.1	17.7±1.9
5 weeks	21.0±1.7	21.3±2.3	25.7±2.8	26.9±3.3	21.6±2.3	18.6±2.0
6 weeks	19.6±1.6	22.8±2.5	25.3±2.8	27.4±3.4	31.1±3.5	19.8±2.2
8 weeks	22.5±1.9	24.4±2.7	27.0±3.0	27.0±3.3	22.4±2.4	23.1±2.6
10 weeks	20.2±1.6	22.4±2.4	19.2±2.0	27.6±3.4	22.8±2.5	21.0±2.3
12 weeks	17.7±1.4	19.2±2.0	17.4±1.8	25.5±3.1	19.1±2.0	20.2±2.2
16 weeks	14.3±1.1	14.5±1.5	13.2±1.4	20.4±2.4	15.6±1.7	16.5±1.8
20 weeks	12.4±0.9	15.6±1.7	12.2±1.3	19.4±2.3	14.2±1.5	13.5±1.5
Number of ♂s	37	21	21	17	21	20
			Females			
1 day	9.8±0.9	9.3±1.0	8.9±0.9	8.7±0.9	9.2±0.9	8.0±0.9
1 week	12.8±1.2	21.0±2.4	14.0±1.5	15.9±1.7	12.9±1.3	11.6±1.4
2 weeks	16.7±1.6	24.0±2.8	16.8±1.7	16.7±1.8	16.8±1.7	16.0±1.9
3 weeks	21.7±2.1	28.1±3.3	17.6±1.8	17.2±1.8	19.8±1.9	19.2±2.3
4 weeks	22.8±2.2	29.7±3.5	19.8±2.1	18.4±1.9	23.0±2.3	23.9±2.9
5 weeks	24.3±2.3	31.8±3.8	22.1±2.3	18.4±1.9	23.7±2.4	25.9±3.2
6 weeks	23.7±2.3	29.3±3.5	23.0±2.5	18.8±2.0	21.6±2.1	27.6±3.4
8 weeks	24.1±2.3	32.6±3.9	24.1±2.6	16.3±1.8	22.1±2.2	25.3±3.1
10 weeks	21.7±2.1	30.5±3.6	22.1±2.3	17.6±1.9	18.1±1.8	23.0±2.8
12 weeks	19.1±1.8	27.2±3.2	19.9±2.1	15.1±1.6	15.7±1.5	20.2±2.4
16 weeks	15.8±1.5	20.5±2.3	16.3±1.7	12.9±1.4	15.4±1.5	17.0±2.0
20 weeks	16.5±1.6	19.3±2.2	15.6±1.6	13.3±1.4	16.9±1.7	16.5±2.0
Number of ♀s	27	19	22	21	25	17

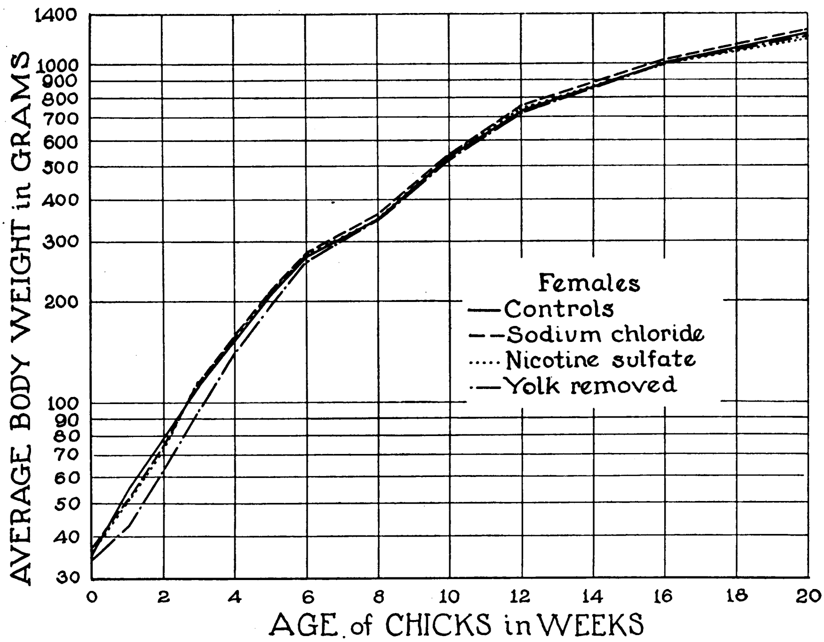

Fig. 8. The average body weights at different ages, of the females that survived the period of 20 weeks, from the operated group, and from groups poisoned by substances normally or frequently administered to chicks.

EXPERIMENTS ON REMOVAL OF THE UNABSORBED YOLK AT ONE DAY OF AGE

Experimental Procedure.—This operation was performed on 64 chicks. Each chick was etherized, an opening about an inch long made in the body wall, the yolk stalk ligatured, the yolk sac and contents completely removed, and the opening sewed up. The operations were performed without aseptic precautions. As soon as the chicks had recovered from the obvious effects of the ether, they were put under the hovers with the other chicks. The mortality was probably higher than would have been the case if more precautions had been taken, but for the purposes of this experiment the high mortality was not disadvantageous, since the questions under investigation were the permanence and selectivity of severe handicaps.

The results obtained in these lots are included with those of the poisoned lots, in tables 8 to 10 and figures 7 and 8.

Effects on Mortality.—As noted previously, in all cases where the treatment of corresponding lots in shipments II and III was exactly comparable,[11] the mortality was markedly higher in the lots of shipment III. The difference was significant only in the early mortality, before 3 weeks of age.

Effects on Body Weights of Survivors.—The growth records point to the same result, several indications of which have already been noted; namely, that the females showed more complete recovery from the effect of an early handicap than the males. The difference between the operated males and the control males at 20 weeks of age was probably significant in each shipment, being respectively 144±34 grams and 239±82 grams, with a difference for the combined lots of 137±38 grams. The corresponding differences between the females were not significant at all. The combined lots gave for the females at 20 weeks of age a difference less than the probable error of the difference (22±41 grams); in shipment II the operated females were slightly but not significantly lower than the controls; in shipment III the case was reversed, the operated females being slightly heavier than the controls.

EXPERIMENTS ON EXPOSURE TO EXTREMES OF TEMPERATURE

Although no exact determination of optimum hover temperature for baby chicks has been made, large fluctuations of temperature are avoided in the belief that if the temperature is held for any considerable length of time either too much above or too much below the optimum, the chicks will be injured. The only experimental work which has been encountered (Lewis, 1911) demonstrated an injurious effect from extreme hover temperatures when measured by the resulting mortality. His period of observation was the first 4 weeks of life. The results obtained were as follows:

Hover temperature (F)	Number of chicks at start	Number of chicks that died
110° throughout period	50	21
100° first 2 days, reduced ½° every day thereafter	50	5
90° first 2 days, reduced ½° every day thereafter	50	12
Varying, from 86° to 120°, with average of 102°	50	34

[11] The treatment of the two shipments was not exactly comparable for the poisoned lots, because of the differences mentioned above, in the age at which the chicks received the poisons, and in point of having had previous feed—and, in the cases of mercuric chloride and arsenic trioxide, in the exact size of the dose.

It therefore seemed of interest to determine whether extreme temperatures maintained for a short time only would produce any effects, on yolk absorption, body weight, and mortality.

Experimental Procedure.—The hover temperature for all the lots where temperature was not the experimental factor was maintained during the first 2 weeks at about 95° F (=35° C) with thermostatic control. After the first 2 weeks the hover temperature was gradually lowered, in accordance with the general practice. For the overheated and chilled lots, continuous temperature records were kept by means of thermographs with the sensitive elements under the hover. For the overheated lot of shipment I, the temperature was held at 115° F (=46.1° C) for the first 3 nights. Although, as shown in table 12, this did not result in a higher mortality as compared with the controls, the chicks at the time gave every indication of having been injured, remaining at the outermost edge of the hover in an attempt to get away from the heat, panting, and appearing drowsy and generally distressed.

The chicks of shipment IV were given much more severe overheating, the temperature being kept at 125° F (=51.7° C) during the first night. As this resulted in no deaths, in the morning the temperature was still further increased, and rose beyond the range of the thermograph. A continuous record of the temperature was therefore not obtained, but readings of chemical thermometers placed under the hover indicated a temperature of about 135° F (=56.7° C). Within 2 hours 12 of the 40 chicks were dead, and the temperature was immediately reduced to 100° F (=37.8° C). Two more deaths occurred during the next 2 hours, and then only 2 more for the rest of the experimental period of 9 days, one of these being at 4 days and one at 7 days of age.

Similarly with chilling, while the treatment of shipment I was not severe enough to result in a higher mortality than occurred in the controls, it did cause an apparent injury to the chicks at the time. The chilled chicks were entirely deprived of artificial heat for 3 nights, and the windows of the house were left wide open. The temperature in the house outside the hover went to a minimum of 43° F (=6.1° C), while the temperature in the midst of the chicks varied between 60° and 70° F (=15–20° C). Each morning the chicks were found huddled together in an effort to keep warm, and as a result appeared bedraggled and lacking in vitality.

The chicks of shipment IV were given a slightly more severe treatment, being put in a chick box on the porch on the north side of the laboratory for 2 nights. The temperature reached a minimum of 38° F (=3.3° C) the first night, and of 33° F (=0.6° C) the second night. The temperature in the midst of the chicks reached 55° F (=12.8° C). Six of the 40 chicks died in the chilled group during the experimental period of 9 days, as compared with no deaths in the controls.

TABLE 11

AVERAGE YOLK WEIGHTS (IN GRAMS) OF SAMPLES KILLED AT DIFFERENT AGES, FROM LOTS EXPOSED TO EXTREMES OF TEMPERATURE, AND LOTS DEPRIVED OF WATER

Shipment No.	Controls	Overheated	Chilled	Water withheld for 5 days
Chicks killed at 3 days old				
I	2.03±0.10	1.84±0.12	2.10±0.22	1.47±0.15
IV	2.01±0.18	1.09±0.13	2.27±0.30	1.76±0.22
Total	2.02±0.09	1.62±0.11	2.16±0.18	1.59±0.12
Chicks killed at 5 days old				
I	0.69±0.09	0.81±0.12	0.71±0.04	1.27±0.15
IV	0.82±0.16	0.71±0.17	0.44±0.05	0.83±0.13
Total	0.74±0.09	0.79±0.10	0.61±0.03	1.09±0.11
Chicks killed at 7 days old				
I	0.28±0.06	0.18±0.04	0.36±0.08	0.56±0.14
IV	0.09±0.04	0.27±0.10	0.20±0.04	0.23±0.03
Total	0.20±0.04	0.20±0.04	0.28±0.05	0.50±0.12
Chicks killed at 9 days old				
I	0.06±0.03	0.00±0.02	0.06±0.02	0.07±0.04
IV	0.22±0.06	0.09±0.03	0.05±0.01	0.02±0.01
Total	0.13±0.03	0.03±0.01	0.05±0.01	0.06±0.03

Effects on Yolk Absorption.—From the averages given in table 11 and plotted in figure 9, it appears that overheating caused some acceleration in yolk absorption, and chilling a slight retardation, but only during the period of actual exposure to temperatures above or below the optimum. In all four samples killed at 3 days of age, differences were found which, although with one exception not significant in themselves, were all consistent as to direction, the overheated chicks having smaller yolks, and the chilled chicks larger yolks, than the controls. The difference between the average yolk weights of the overheated and control groups of shipment I is not at all significant, being very little larger than the probable error of the difference. The corresponding difference in shipment IV, however, is more than four times the probable error of the difference (0.92 ± 0.22 grams). In connection with this it is to be remembered that the chicks of shipment IV were subjected to a more severe overheating than those of

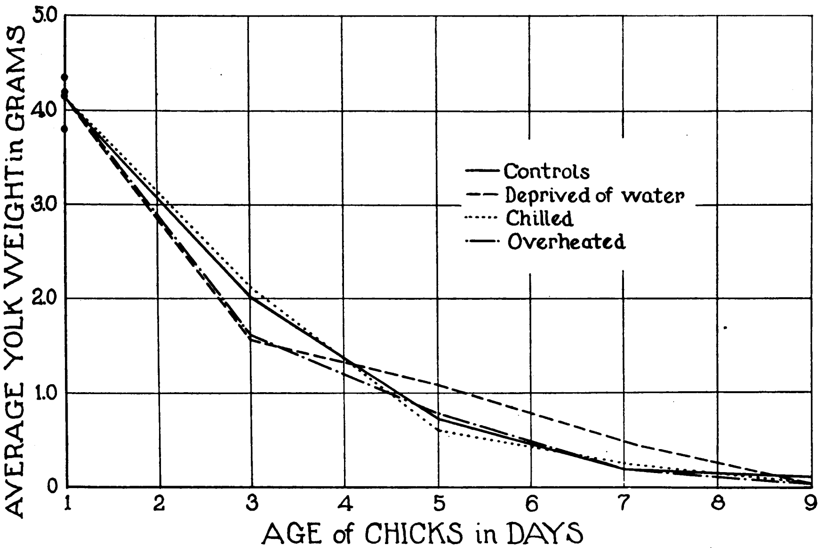

Fig. 9. The average yolk weights of chicks killed at different ages, from groups exposed to extremes of temperature, and from the group deprived of water.

shipment I. In the chilled groups, the differences in both shipments were small, and of no significance in comparison with their probable errors.

The averages at later ages showed no evidence of any permanent effect upon yolk absorption from early exposure to extreme temperatures.

Effects on Mortality.—As previously indicated, the overheating and chilling which the lots of shipment I received did not result in a higher mortality than occurred in the controls. As with the other handicaps discussed so far there was no uniformity in the comparative mortality rates of the two sexes. The rates are shown in table 12.

TABLE 12

MORTALITY RATES (PER 100) OF LOTS EXPOSED TO EXTREMES OF TEMPERATURE AND LOT DEPRIVED OF WATER

Designation	Controls	Overheated	Chilled	Water withheld for 5 days
Total mortality (through 20 weeks)	12.9±2.7	9.1±2.3	12.3±2.6	11.4±2.5
Early mortality (for first 3 weeks)	4.3±1.6	3.5±1.5	2.4±1.2	8.5±2.2
Later mortality (3 wks. through 20 wks.)	8.6±2.2	5.6±1.9	9.9±2.4	2.9±1.4
Total mortality (through 20 weeks) ♂s	17.3±4.0	14.2±4.0	7.9±2.9	13.1±4.1
Total mortality (through 20 weeks) ♀s	7.0±3.1	4.5±2.1	17.3±4.3	10.1±3.2

TABLE 13

AVERAGE BODY WEIGHT AT DIFFERENT AGES, OF THE CHICKS THAT SURVIVED THE PERIOD OF 20 WEEKS, FROM LOTS EXPOSED TO EXTREMES OF TEMPERATURE AND LOT DEPRIVED OF WATER

Age of chicks	Controls	Overheated	Chilled	Water withheld for 5 days
Males				
1 day	37.3± 0.3	38.2± 0.4	37.4± 0.3	37.5± 0.4
1 week	56.3± 0.8	58.0± 0.9	54.1± 0.7	48.5± 0.8
2 weeks	82.6± 1.7	87.0± 2.0	80.1± 1.3	76.3± 1.7
3 weeks	120.2± 2.7	123.2± 3.4	117.4± 2.1	114.6± 3.0
4 weeks	168.0± 4.0	174.5± 5.3	167.0± 3.3	165.8± 4.6
5 weeks	225.7± 5.2	238.2± 7.0	229.8± 4.7	227.0± 6.4
6 weeks	286.1± 6.8	295.2± 8.5	288.5± 5.6	285.5± 8.6
8 weeks	393.9±10.3	412.5±10.1	406.2± 7.6	392.1±12.1
10 weeks	609.2±12.2	643.8±14.9	640.0± 9.7	615.8±16.9
12 weeks	803.8±14.0	847.9±15.7	846.3±11.1	806.9±17.9
16 weeks	1,220.3±19.0	1,289.3±20.5	1,296.3±16.6	1,209.2±25.3
20 weeks	1,510.3±26.3	1,601.0±23.5	1,609.4±19.2	1,514.6±26.6
Number of ♂s	32	29	35	26
Females				
1 day	37.3± 0.3	37.2± 0.3	37.3± 0.4	37.6± 0.4
1 week	56.0± 1.0	56.2± 0.7	54.6± 0.7	48.6± 0.7
2 weeks	81.0± 1.8	82.4± 1.6	77.9± 1.6	73.3± 1.3
3 weeks	112.9± 2.7	114.2± 2.8	113.6± 2.5	104.5± 2.5
4 weeks	154.7± 4.3	160.4± 4.4	159.8± 3.7	151.2± 3.9
5 weeks	204.4± 5.6	219.3± 6.3	219.6± 5.2	201.7± 5.9
6 weeks	257.9± 7.1	272.9± 8.2	277.9± 7.3	258.5± 7.8
8 weeks	361.6± 9.3	374.6±11.1	380.0±10.4	352.1±11.2
10 weeks	545.7±10.8	568.3±14.1	588.9±11.5	545.9±13.4
12 weeks	736.1±13.5	762.2±16.7	771.9±14.9	734.7±15.7
16 weeks	1,016.4±16.8	1,048.1±17.9	1,050.4±18.3	1,030.3±16.9
20 weeks	1,225.4±18.9	1,276.1±21.2	1,240.4±23.7	1,252.1±20.7
Number of ♀s	28	36	27	34

Effects on Body Weights of Survivors.—It is apparent from the averages presented in table 13 and plotted in figures 10 and 11 that neither the overheating nor the chilling effected any significant differences in body weights for either sex or at any age. Among the males, the overheated lots at all ages, and the chilled lots at all ages after 5 weeks were heavier, but not significantly heavier, than the controls. Similarly the females in the overheated lot were slightly heavier at all ages, and in the chilled lots at all ages after 3 weeks.

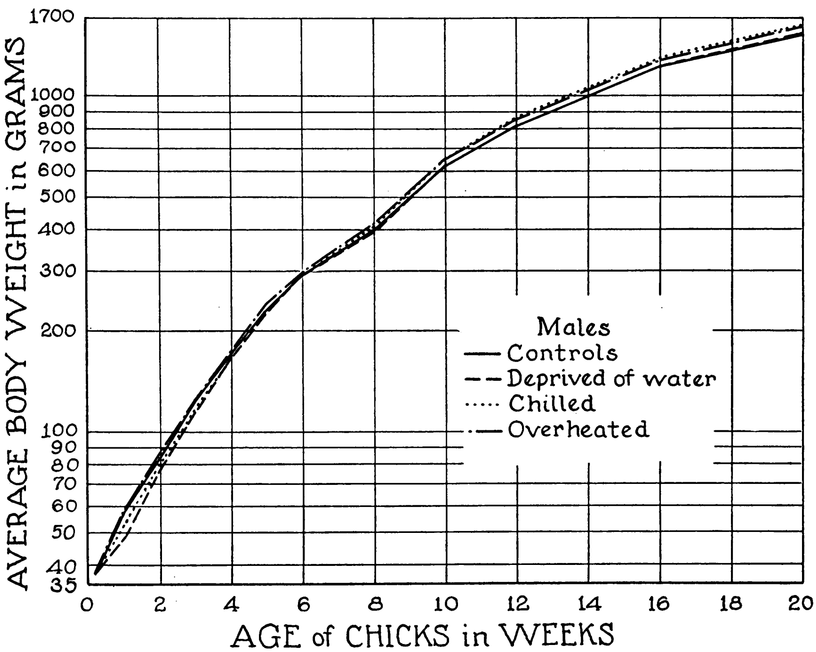

Fig. 10. The average body weights at different ages, of the males that survived the period of 20 weeks, from groups exposed to extremes of temperature, and from the group deprived of water.

In the light of these results it is perhaps unfortunate that the early injury was not made more severe, but at the time it seemed more valuable to determine whether individuals which appeared injured would completely recover, than to show that they could be so severely injured that they would not recover. Showing this in groups where the mortality was not higher than in the controls has the added advantage of showing that later recovery does not necessarily depend upon a selective effect of the mortality, by an elimination of the poorer individuals.

There is only one point worthy of especial mention in connection with the standard deviations and coefficients of variation presented in tables 14 and 15. The control females of this shipment showed a relative variability slightly less than that of the corresponding group of males, whereas, in all other data analyzed so far, the sex difference in relative variability has been the reverse. The difference in this case is, however, absolutely insignificant.

TABLE 14

STANDARD DEVIATIONS OF BODY WEIGHTS AT DIFFERENT AGES, OF THE CHICKS THAT SURVIVED THE PERIOD OF 20 WEEKS FROM LOTS EXPOSED TO EXTREMES OF TEMPERATURE AND LOT DEPRIVED OF WATER

Age of chicks	Controls	Overheated	Chilled	Water withheld for 5 days
		Males		
1 day	2.4± 0.2	3.1± 0.3	2.9± 0.2	2.8± 0.3
1 week	6.8± 0.6	7.2± 0.6	6.1± 0.5	5.8± 0.6
2 weeks	14.1± 1.2	15.9± 1.4	11.1± 0.9	13.2± 1.2
3 weeks	22.8± 1.9	27.2± 2.4	18.2± 1.5	22.4± 2.1
4 weeks	33.5± 2.8	42.1± 3.7	29.3± 2.4	34.8± 3.3
5 weeks	44.0± 3.7	56.1± 5.0	41.6± 3.4	48.8± 4.6
6 weeks	57.3± 4.8	67.7± 6.0	48.8± 3.9	64.7± 6.0
8 weeks	86.7± 7.3	80.4± 7.1	66.6± 5.4	91.3± 8.5
10 weeks	102.4± 8.6	118.7±10.5	85.1± 6.9	127.5±11.9
12 weeks	117.7± 9.9	125.4±11.1	97.2± 7.8	135.4±12.7
16 weeks	161.1±13.6	163.9±14.5	145.2±11.7	191.5±17.9
20 weeks	220.4±18.6	187.6±16.6	168.4±13.6	201.0±18.8
Number of ♂s	32	29	35	26
		Females		
1 day	2.6± 0.2	2.7± 0.2	3.1± 0.3	3.1± 0.3
1 week	8.0± 0.7	6.7± 0.5	5.0± 0.5	6.0± 0.5
2 weeks	13.8± 1.2	14.6± 1.2	12.1± 1.1	11.4± 0.9
3 weeks	21.4± 1.9	25.0± 2.0	19.5± 1.8	21.7± 1.8
4 weeks	34.1± 3.1	38.7± 3.1	28.7± 2.6	33.9± 2.8
5 weeks	44.3± 4.0	55.8± 4.4	40.4± 3.7	50.6± 4.1
6 weeks	55.4± 5.0	72.8± 5.8	56.0± 5.1	67.2± 5.5
8 weeks	72.7± 6.6	99.1± 7.9	79.9± 7.3	96.6± 7.3
10 weeks	85.0± 7.7	125.1± 9.9	88.4± 8.1	116.2± 9.5
12 weeks	105.6± 9.5	148.5±11.8	115.0±10.6	135.7±11.1
16 weeks	132.0±11.9	159.6±12.7	140.8±12.9	146.3±12.0
20 weeks	148.1±13.3	188.3±15.0	182.5±16.8	178.9±14.6
Number of ♀s	28	36	27	34

TABLE 15

COEFFICIENTS OF VARIATION OF BODY WEIGHTS AT DIFFERENT AGES, OF THE CHICKS THAT SURVIVED THE PERIOD OF 20 WEEKS, FROM LOTS EXPOSED TO EXTREMES OF TEMPERATURE AND LOT DEPRIVED OF WATER

Age of chicks	Controls	Overheated	Chilled	Water withheld for 5 days
		Males		
1 day	6.4±0.5	8.1±0.7	7.8±0.6	7.5±0.7
1 week	12.1±1.0	12.4±1.1	11.3±0.9	12.0±1.1
2 weeks	17.1±1.5	18.3±1.6	13.9±1.2	17.3±1.7
3 weeks	19.0±1.7	22.1±2.0	15.5±1.3	19.5±1.9
4 weeks	19.9±1.8	24.1±2.2	17.5±1.5	21.0±2.0
5 weeks	19.5±1.7	23.6±2.2	18.1±1.5	21.5±2.1
6 weeks	20.0±1.8	22.9±2.1	16.9±1.4	22.7±2.2
8 weeks	22.0±1.9	19.5±1.8	16.4±1.4	23.3±2.3
10 weeks	16.8±1.4	18.4±1.6	13.3±1.1	20.7±2.0
12 weeks	14.6±1.2	14.8±1.3	11.5±0.9	16.8±1.6
16 weeks	13.2±1.1	12.7±1.1	11.2±0.9	15.8±1.5
20 weeks	14.6±1.2	11.7±1.0	10.5±0.8	13.3±1.2
Number of ♂s	32	29	35	26
		Females		
1 day	7.0±0.6	7.3±0.6	8.3±0.7	8.2±0.7
1 week	14.3±1.3	11.9±1.0	9.2±0.8	12.3±1.0
2 weeks	17.0±1.6	17.7±1.4	15.5±1.5	15.6±1.3
3 weeks	19.0±1.8	21.9±1.8	17.2±1.6	20.8±1.8
4 weeks	22.0±2.1	22.2±1.9	18.0±1.7	22.4±1.9
5 weeks	21.7±2.1	25.4±2.1	18.4±1.7	25.1±2.2
6 weeks	21.5±2.0	26.7±2.3	20.2±1.9	26.0±2.3
8 weeks	20.1±1.9	26.5±2.3	21.0±2.0	27.4±2.4
10 weeks	15.6±1.4	22.0±1.8	15.0±1.4	21.3±1.8
12 weeks	14.3±1.3	19.5±1.6	14.9±1.4	18.5±1.6
16 weeks	13.0±1.2	15.2±1.2	13.4±1.2	14.2±1.2
20 weeks	12.1±1.1	14.8±1.2	14.7±1.4	14.3±1.2
Number of ♀s	28	36	27	34

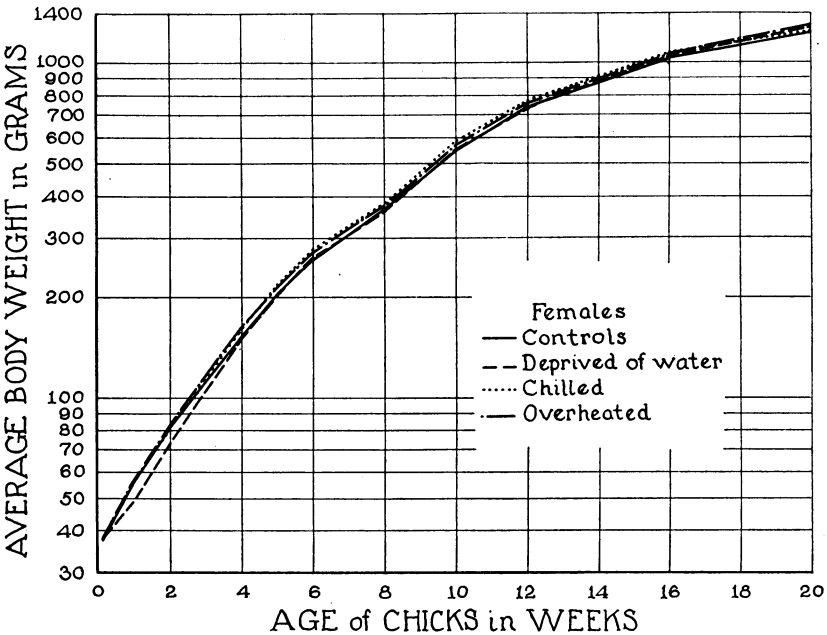

Fig. 11. The average body weights at different ages, of the females that survived the period of 20 weeks, from groups exposed to extremes of temperature, and from the group deprived of water.

EXPERIMENTS ON DEPRIVATION OF WATER

Experimental Procedure.—Preliminary trials had indicated that chicks could be deprived of water for about 5 days. Autopsies showed shriveled intestines, which were not, however, black as in the cases of completely starved chicks. Moreover the skin and mesenteries appeared extremely dry. This period of 5 days was used therefore for one lot of shipment I. Recovery was so immediate and complete, after water was given to the surviving chicks on the fifth day, that the total mortality for the lot was no greater than that of the controls. Therefore in the corresponding lot of shipment IV water was withheld one additional day. Fourteen of the 40 chicks of this lot died, 1 at 5, 9 at 6, 3 at 7, and 1 at 8 days of age, as compared with no deaths among the controls.

The results are included with those of the overheated and chilled groups, in tables 11 to 15 and figures 9 to 11.

Effects on Yolk Absorption.—The chicks deprived of water had, on the average, smaller yolks at 3 days of age than the corresponding control lots. While the difference between the handicapped and control lots of shipment I appears to be significant (0.56 ± 0.18 grams), between the corresponding lots of shipment IV the difference is less than the probable error of the difference (0.25 ± 0.29 grams). When the data from the two shipments are combined, the difference is therefore not significant (0.43 ± 0.18 grams).

In the samples of chicks killed at later ages there were no consistent differences, in spite of the fact that in both shipments the handicap was still being applied up to 5 days of age. The chicks of shipment I which had no water averaged markedly larger yolks than the controls (difference $= 0.58 \pm 0.18$ grams), but those of shipment IV averaged the same as the controls. The evidence, therefore, was not very convincing even as to the immediate effect of deprivation of water upon yolk absorption, and the results show clearly that there was no permanent effect, the samples at 7 and 9 days of age showing no consistent differences as compared with the controls.

Effects on Mortality.—These data have already been discussed in connection with the experimental procedure.

Effects on Body Weights of Survivors.—Both males and females of the lot deprived of water were, at 1 week of age, significantly below the control lot in body weight. This difference was effaced gradually. In both sexes, at about 4 weeks of age the handicapped and control chicks became practically identical in average weights, and remained so for the duration of the experiment.

SUMMARY OF EFFECTS OF EARLY HANDICAPS

From the foregoing detailed examination of the results of the various handicaps the following facts seem to emerge. Yolk absorption, although highly variable within any group of chicks, is after all a relatively stable process, not easily affected by such experimental treatment as were employed. In some cases the latter were so drastic as to result in mortality rates as high as 70 per cent. Even in these cases, however, no large differences in the course of yolk absorption were evident.

Similarly with the effects on body weights, with the varied and severe experimental handicaps, there were few groups in which the average weight of the experimental groups did not equal that of the controls by the age of 20 weeks. In most of the groups complete recovery was shown at 6 weeks of age. In the females the only group which did not show complete recovery was that given mercuric chloride. In the males, there were indications of more permanent effects from several of the handicaps, not significant in the starved groups, but probably significant in the cases of mercuric chloride, nicotine sulfate, yolk removal, and the larger dose of arsenic trioxide.

ANALYSIS OF COMBINED DATA FROM ALL EXPERIMENTS

Certain interesting relationships are brought out by consideration of the combined data of all the experiments. These include the comparisions of mortality rates by sex, comparisons of chicks which died with those which survived, and correlations of day-old body weights with yolk weights, and with later body weights.

Mortality Rates by Sex.—It has been noted already, in connection with the discussion of the various handicaps separately, that there was no apparent differential sex effect in mortality, although several indications were found of a differential effect in body weight (more permanent effect in males). It was thought that by combining the data of the several experiments such a differential effect in mortality might appear. Therefore the sex mortality rates for all the chicks, and for several major groupings, were calculated, with the results shown in table 16.

No difference was found between the male and female mortality for the total group of chicks, the respective rates being 21.8 and 21.0. Dividing the data into three groups corresponding roughly to the severity of the treatment, as severely handicapped, moderately handicapped, and controls, the male and female rates were still practically identical. This was true both when the total mortality to 20 weeks was considered, and when early and later mortality were treated separately.

Early and Late Mortality.—The division into early and late mortality demonstrated further that all the increase in mortality in the severely handicapped groups was evidenced early. There was no evidence that the later mortality of the experimentally injured groups was either higher than the controls, as would result from a permanent injury and increased susceptibility to later chance hazards, or that it was lower than the controls, as might be expected if the early elimination had acted selectively.

TABLE 16

MORTALITY RATES (PER 100) BY SEX, FOR THE ENTIRE AGGREGATE OF CHICKS, AND FOR CERTAIN MAJOR GROUPINGS

Designation	Total mortality (through 20 weeks)		
	Males	Females	Total
Controls	13.3±2.5	11.2±2.7	12.4±1.8
Moderately handicapped	11.7±1.5	12.7±1.6	12.2±1.1
Severely handicapped	38.9±2.5	37.1±2.3	37.9±1.7
Total	21.8±1.3	21.0±1.2	21.4±0.9
	Mortality rates (for first 9 days)		
Controls	4.7±1.5	3.2±1.2	4.1±1.1
Moderately handicapped	4.5±0.9	6.5±1.1	5.6±0.8
Severely handicapped	29.6±2.2	30.5±2.2	30.0±1.6
Total	13.5±1 1	14.4±1.1	14.0±0.8
	Mortality rates (10 days through 20 weeks)		
Controls	8.6±2.1	8.0±2.4	8.3±1.5
Moderately handicapped	7.2±1.2	6.2±1.1	6.6±0.9
Severely handicapped	9.3±1.4	6.6±1.1	7.9±0.9
Total	8.3±0.9	6.6±0.8	7.4±0.6

Comparison of Day-Old Body Weights of Chicks That Died With Those of Chicks That Survived.—Evidence that the early mortality was to a certain extent selective was however obtained from a comparison of the day-old body weights of the chicks which succumbed with the day old body weights of those which survived. The average weights and frequency distributions are presented in table 17.

The data show that, among the males and females alike, the chicks that subsequently died were, at 1 day of age, on the average significantly smaller than the chicks that survived. Further, the chicks that died at ages of 10 days or older were intermediate in day-old weights, between those that died before 10 days of age and those that survived the entire period of 20 weeks.

Finally, the results show that the selective effect was slightly greater among the males than among the females, the difference between the average weights of the cockerels that survived and those that died before 10 days being 1.88±0.20 grams, while the corresponding difference for the pullets was 1.22±0.21 grams. For the cockerels that died before 10 days of age, the average weight was actually slightly less than that of the pullets, so that the sex difference was the reverse of that ordinarily found.

TABLE 17

FREQUENCY DISTRIBUTIONS DAY-OLD BODY WEIGHTS OF CHICKS THAT DIED, COMPARE THOSE OF CHICKS THAT SURVIVED. (SHIPMENTS I–III)

Day-old body weight (grams)	Males			Females		
	Died before 10 days	Died, 10 days −20 weeks	Survived	Died before 10 days	Died, 10 days −20 weeks	Survived
30	2	....	2	4	2	3
31		1	4	2	....	9
32	7	5	15	10	3	34
33	13	1	7	6	....	20
34	15	4	37	17	5	37
35	15	3	50	19	5	41
36	12	7	37	16	2	42
37	8	4	37	8	4	33
38	6	6	49	6	4	40
39	6	4	31	5	2	31
40	3	1	31	4	4	34
41	....	....	9	1	....	7
42	....	1	17	....	....	13
43	....	....	2	1	....	2
44	....	1	1	....	1	4
45	....	....	2	1	....	4
46	....	....	1	....	....	1
47	....	....	....	....	....	....
48	....	....	....	....	....	....
49	....	....	1	....	....	....
Total number of chicks..........	88	38	333	100	32	355
Average body weight..............	35.10±0.17	36.18±0.31	36.98±0.11	35.27±0.18	36.09±0.37	36.49±0.11

TABLE 18

AVERAGE YOLK WEIGHTS OF CHICKS THAT DIED, IRRESPECTIVE OF CAUSE OF DEATH, COMPARED WITH YOLK WEIGHTS OF CHICKS KILLED AT CORRESPONDING AGES

Age of chicks (in days)	Yolk weights of chicks that died	Yolk weights of chicks killed		
	Males and females	Total	Males	Females
1	4.68±0.29	4.54±0.06	4.42±0.08	4.68±0.08
2	3.50±0.14			
3	2.50±0.08	2.00±0.06	1.98±0.08	2.02±0.08
4	2.51±0.16			
5	1.93±0.24	0.82±0.03	0.69±0.04	0.94±0.05
6	0.93±0.12			
7	1.06±0.14	0.31±0.02	0.27±0.03	0.36±0.04
8	0.97±0.21			
9	1.68±0.39	0.21±0.03	0.20±0.05	0.21±0.04

Comparison of Yolk Weights of Chick That Died with Those of Samples Killed at Corresponding Ages.—ks that died, irrespective of the cause of death, showed significant nces in yolk weights from the chicks that were killed at corresp ages. The averages are presented in table 18 and the frequency ributions in table 19. The averages are plotted in figure 12.

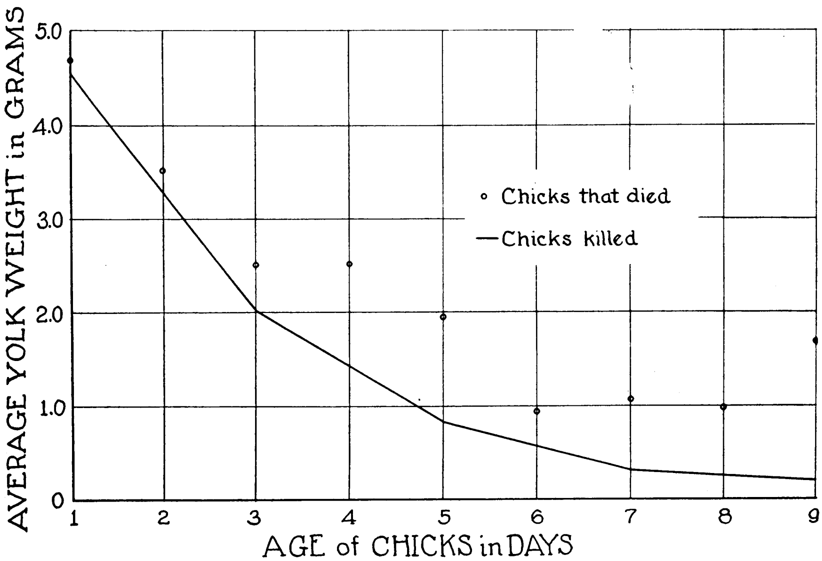

Fig. 12. The average yolk weights of chicks that died, compared with those of chicks killed at corresponding ages.

It is apparent that the chicks that died had on the average larger yolks than those killed at corresponding ages, and that the differences increased with age. These results are quite in accordance with what would be expected, namely, that any disturbance of normal functioning severe enough to cause death would be likely to interfere with the normal metabolism of the yolk.

That it does not always do so, however, is evident from an examination of the frequency distributions in table 20. These tabulations show that many of the chicks that died had yolks of normal size for their age, as compared with samples killed. Conversely, a few of the chicks that were killed, and apparently perfectly normal, had yolks as large as, or larger than, any found in the chicks dying at corresponding ages.

TABLE 19

FREQUENCY DISTRIBUTIONS OF YOLK WEIGHTS OF CHICKS THAT DIED, COMPARED WITH THOSE OF CHICKS KILLED AT CORRESPONDING AGES

Yolk weight (grams)	Age of chicks (in days)													
	1		2	3		4	5		6	7		8	9	
	Died	Killed	Died	Died	Killed	Died	Died	Killed	Died	Died	Killed	Died	Died	Killed
0.00–0.009	...	...	...	1	...	...	...	4	...	3	61	4	1	149
0.01–0.09	...	...	...	...	...	...	...	17	5	5	83	2	...	31
0.10–0.19	...	...	...	...	...	...	...	20	2	1	11	2	...	9
0.20–0.29	...	...	...	...	...	...	1	27	2	1	14	...	...	4
0.30–0.39	...	...	...	...	2	...	3	30	3	...	13	...	1	6
0.40–0.49	...	...	...	1	4	...	6	44	4	1	6	...	2	3
0.00–0.49	...	...	...	2	6	...	10	142	16	11	188	8	4	202
0.50–0.99	...	...	1	2	37	4	3	72	8	6	33	2	2	15
1.00	...	...	...	4	51	8	2	23	4	7	16	2	1	2
1.50	...	4	6	7	44	9	4	14	5	4	2	...	...	1
2.00	...	11	11	11	35	2	2	17	...	1	1	1	...	1
2.50	1	7	11	15	24	5	1	3	...	1	2	2	...	3
3.00	...	28	7	7	16	5	...	3	1	1	...	...	1	2
3.50	...	44	7	5	7	3	4	3	...	...	...	...	...	...
4.00	2	41	5	2	3	1	...	...	...	1	1	1	1	...
4.50	2	39	5	1	4	...	1	2	...	1	...	...	...	...
5.00	1	19	1	...	...	3	1	1	...	...	...	...	1	...
5.50	...	25	2	...	1	...	...	...	1	...	...	...	...	...
6.00	...	10	2	...	1	...	...	...	...	...	...	...	...	1
6.50	1	12	2	...	1	...	...	...	...	...	...	...	...	...
7.00	...	3	...	...	...	...	...	...	...	...	...	...	...	...
7.50	...	3	...	...	1	1	...	...	...	...	...	...	...	...
8.00	...	2	...	...	...	...	1	...	...	...	...	...	...	...
8.50	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9.00	...	...	...	...	...	...	...	...	...	...	...	...	...	...
9.50	...	1	...	...	...	...	...	...	...	...	...	...	...	...
10.00	...	...	1	...	...	...	...	...	...	...	...	...	...	...
10.50	...	...	...	...	...	...	...	...	...	...	...	...	...	...
11.00	...	1	...	...	...	...	...	...	...	...	...	...	...	...
11.50–11.99	...	...	...	...	1	...	...	...	...	...	...	...	...	...
Total number of chicks	7	250	61	56	232	41	29	280	35	33	243	16	10	227

The correlation between general vigor and yolk absorption indicated by the higher average yolk weights of the chicks that died in comparison with the killed chicks was evidenced also *within* the samples killed, on correlating the percentage gain in body weight with the weight of the unabsorbed yolk. Among the 38 control chicks killed at 5 days old this correlation amounted to $-.31 \pm .10$, and among the 36 control chicks killed at 7 days old, to $-.38 \pm .10$. Stating it in another way: of the chicks killed at 5 days old, those with yolks weighing less than 0.50 grams had gained 20 per cent of their body weight; those with yolks weighing more than 0.50 grams had gained 11 per cent of their body weight. In the chicks killed at 7 days old, those with yolks weighing less than 0.10 grams had gained 31 per cent of their body weight, while chicks with yolks weighing more than 0.10 grams had gained only 16 per cent of their body weight.

These results are contrary to the conclusion reached by Schilling and Bleecker (1928), who state that "there is no indication in this group of chicks that chicks making more rapid gains used up their yolk more rapidly or that slow absorption was accompanied by retarded gains." Their conclusion was reached, however, by a comparison of the body weights of particular individuals at the time they were killed, and without reference to the hatching weights of the same birds. Our experience agrees with theirs in finding individuals furnishing marked exceptions to a direct relationship between rapid gains and rapid yolk absorption; in fact, the low values of the correlation coefficients indicate in themselves that such would be the case. The fact seems worthy of note, however, and of further confirmation, that a significant correlation can be demonstrated. It should be emphasized that this correlation furnishes no evidence for the *causal* relation between yolk absorption and general vigor so commonly assumed. It indicates only that both processes are subject to some common influences, or as stated above, any disturbance of normal functioning is likely to affect both yolk metabolism and general metabolism. Experiments designed to serve as more crucial tests of these particular points are contemplated.

Occasional chicks were found with yolks abnormal in other respects than that of size. Some were putrified, some hardened, and a few bloody. None of these abnormal appearances could be shown to have any relationship to the treatment which the chicks had received. They were found occasionally in all lots, and not only in chicks that died, but also in some which had been killed and were apparently normal.

Whether the killed chicks which showed these abnormalities would have died subsequently it is of course impossible to state.

Some related observations from preliminary experiments are of interest in this connection. While considering the possibility of making repeated observations on the course of yolk absorption in the same chicks, by successive operations and estimation of the amount of yolk present, a few abnormally large, and a few hardened yolks were found. These chicks were able to survive both the effects of the successive operations and the presence of the unabsorbed yolks throughout the period of the preliminary experiments. It is hoped that these experiments can be repeated on a more extensive scale.

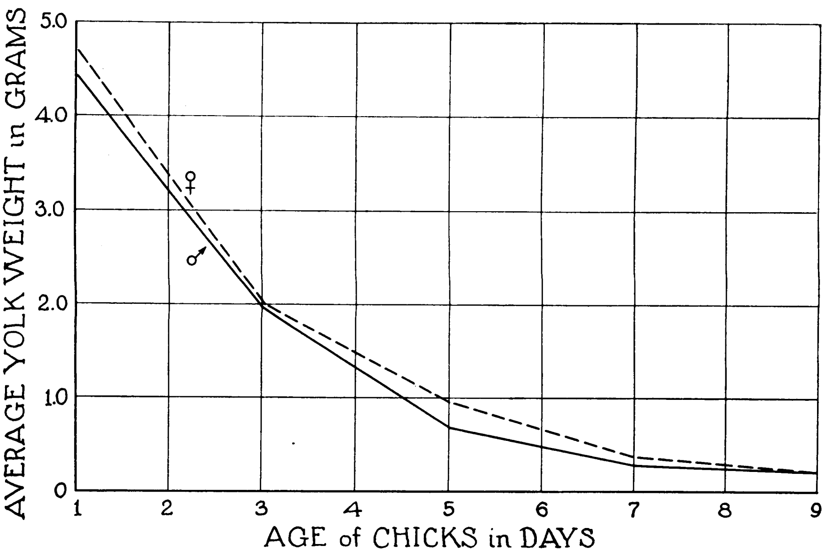

Fig. 13. The average yolk weights at different ages, of males and females separately.

In table 18 are included also the yolk weights for the two sexes separately, for the samples killed at different ages. These averages are plotted in figure 13. The fact that the females averaged slightly heavier yolk weights at every age is interesting, particularly in connection with the smaller average body weight of the females, and the positive correlation between day-old body weights and yolk weights at different ages, discussed below.

Correlation Between Day-Old Body Weights and Yolk Weights at Different Ages.—Mention was made above of the fact that an essential precaution in selecting samples of chicks to kill for yolk weights at different ages was to make, not only the average day-old body weight, but also the frequency distribution of day-old body weights, of the different samples the same. Without this precaution, comparisons could not justifiably be made between the different lots at a given age, or between the samples at different ages within a given experimental lot, as is evidenced by the correlation between day-old body weights and the yolk weights of the chicks killed at various ages.

The correlation coefficients between day-old body weight and weight of unabsorbed yolk, in chicks killed at various ages, were as follows:

Age of chicks	Correlation coefficient
1 day	$+0.48\pm0.03$
3 days	$+0.34\pm0.04$
5 days	$+0.13\pm0.04$
7 days	$+0.02\pm0.04$
9 days	$+0.08\pm0.04$

While perhaps it is not surprising that there was a significant positive correlation between the body weight of the chick and the weight of the yolk at 1 day old, it was surprising to find how long the correlation persisted. It was still significant in the chicks killed at 5 days of age.

These correlations have been worked out also for the two sexes separately and for certain of the shipments separately. The results were in all cases substantially the same.

It was also interesting to note the steepness of the slopes of the regression lines, when average yolk weight was plotted against the day-old body weight. These lines are shown in figure 14. For the chicks killed at 1 day old and at 3 days old, not only were the *absolute* yolk weights on the average larger in the larger chicks, but also the *percentage* yolk weights were considerably higher in the larger chicks. The dotted lines indicate the relation which would exist if the percentage yolk weight were constant for chicks of different body weights, and equal to the average for the entire group. (The average yolk weight for chicks killed at 1 day of age was 12.5 per cent of the day-old body weight, and for chicks killed at 3 days of age, 5.3 per cent of the day-old body weight.)

Since, as a number of investigators have found (see Curtis, 1914, and Atwood and Weakley, 1917), the percentage of yolk in unincubated eggs is slightly lower in the heavier eggs, these results would appear to indicate that of the total yolk present at the beginning of development, relatively less of it is utilized in the course of development of the smaller chicks than in the case of the larger.

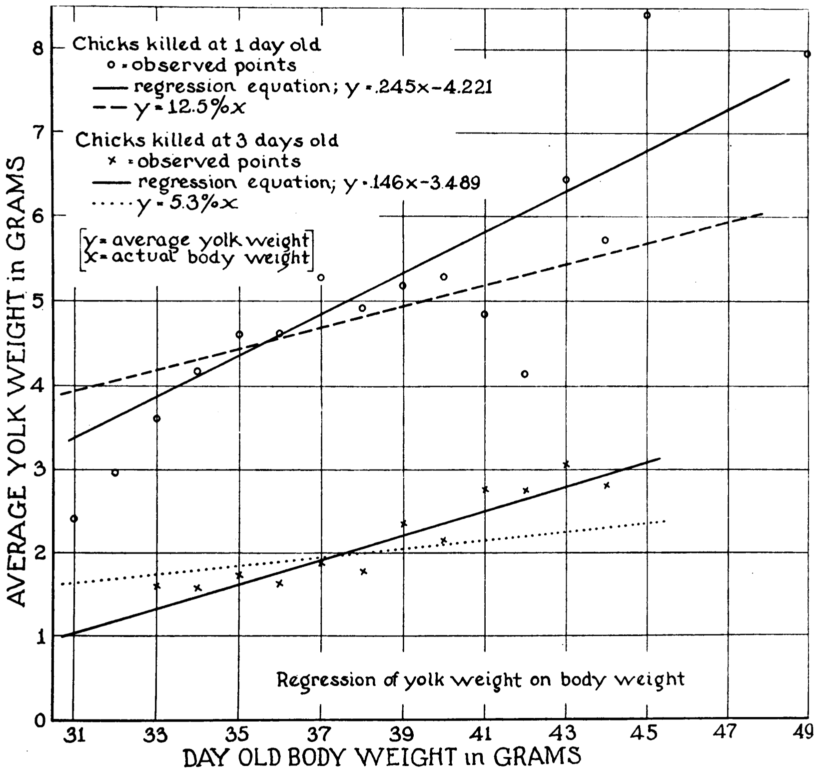

Fig. 14. The regression of yolk weight on day-old body weight, for chicks killed at 1, and at 3 days of age.

Correlation Between Day-Old Body Weights and Later Weights.—While day-old body weight of the chicks proved to be an important factor in equalizing the different experimental groups at the start, because of its correlation with yolk weights and its connection with survival value, it did not appear to be of importance in relation to the later body weights of the chicks. For the controls, the correlations of day-old weights with final weights at 20 weeks were practically zero for both males ($+.04\pm.08$) and females ($+.08\pm.09$). For the entire aggregate of chicks, the correlations were on the border line of significance ($+.12\pm.04$ and $+.11\pm.04$).

The correlations were worked out separately for the different shipments, with the following results:

Shipment	Correlation coefficient	
	Males	Females
I	$+0.24\pm0.06$	$+0.06\pm0.06$
II	$+0.004\pm0.061$	$+0.19\pm0.06$
III	$+0.15\pm0.07$	$+0.11\pm0.06$

There was thus indication of a significant correlation between day-old weights and later weights only in shipment I in the case of the males, and in shipment II in the case of the females.

Correlations for still other groupings, and for other ages, have been worked out, but those presented are sufficient to demonstrate the almost complete lack of correlation between the day-old weights and later weights. This was apparent in all series, and seems to indicate that early inequalities producing variations in size of day-old chicks (such as size of egg, etc.) were in general without permanent effect on body weight. This result is consistent with the conclusion reached from the analysis of the results of subjection of chicks to experimental handicaps, that such chicks in most cases showed complete recovery by 20 weeks of age, when judged by average body weight in comparison with controls.

CONCLUSIONS

1. A variety of early handicaps including poisons, starvation, and high and low temperatures, failed to alter markedly the course of yolk absorption in baby chicks.

2. The same series of early handicaps, and the removal of the unabsorbed yolk when chicks were 1 day of age, failed in general to produce permanent effects in body weights.

3. The doses of mercuric chloride seemed to show a more permanent effect on body weight than the other handicaps, both males and females so treated weighing less at 20 weeks of age than the controls.

4. Nicotine sulfate, the larger dose of arsenic trioxide, and the removal of unabsorbed yolk when chicks were 1 day old, all tended to show permanent effects in males, but not in females. Starvation also gave indications of a more lasting effect in the males, but the effect was not found in all shipments.

5. No consistent correlations appeared between day-old body weights and body weights at 20 weeks of age.

6. There was a significant positive correlation between day-old body weight and the weight of unabsorbed yolk, up to and including the age of 5 days.

7. The mortality of chicks up to the age of 20 weeks was selective in respect to day-old body weights, tending to eliminate the smaller chicks. The early mortality was more stringently selective than the later.

8. Chicks that died, irrespective of cause, had on the average larger unabsorbed yolks than survivors killed at corresponding ages. This difference increased with age during the 9-day period of observation.

9. Among the chicks killed at a particular age, there was found to be a low but significant correlation between yolk absorption and the percentage gain in body weight.

10. The occasional abnormal yolks found, including putrified, hardened, and bloody yolks, could not be shown to have any relationship to the treatment which the chicks had received.

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APPENDIX

RAW DATA

DAY OLD BODY WEIGHT, AND WEIGHT OF UNABSORBED YOLK, IN CHICKS KILLED AT 1 DAY OF AGE.

Shipment I		Shipment II		Shipment III		Shipment II (Yolk removed at 1 day old)	
Body Wt.	Yolk Wt.	Body Wt.	Yolk Wt.	Body Wt.	Yolk Wt.	Body Wt.	Yolk Wt.
32	4.81	33	3.89	33	4.48	33	3.22
33	2.81	33	4.37	33	3.46	32	4.01
33	1.76	33	3.62	34	4.86	33	3.59
33	3.73	33	3.19	34	4.65	34	3.96
33	3.18	34	3.28	34	2.93	34	4.81
33	2.94	34	2.62	34	4.40	35	6.78
33	4.67	34	4.61	34	4.77	35	4.67
34	3.62	35	4.40	34	3.65	35	4.61
34	2.23	35	3.22	34	4.08	35	6.95
34	4.52	35	4.35	34	4.48	35	2.35
34	3.36	35	4.96	34	3.66	36	4.68
34	4.69	35	4.45	35	5.78	36	3.25
35	4.52	35	3.61	35	3.12	36	4.97
35	3.99	35	4.76	35	6.62	37	6.65
35	5.13	36	3.53	36	6.06	37	6.10
35	3.30	36	3.84	36	4.60	37	3.97
35	4.07	37	3.01	36	4.90	38	4.67
35	4.24	37	6.68	36	3.86	38	6.02
36	4.19			36	3.61	39	4.80
36	4.28	[illegible]	[illegible]	36	7.21		
36	3.69	[illegible]	[illegible]	37	5.63	[illegible]	[illegible]
36	4.48	[illegible]	[illegible]	37	5.65	[illegible]	[illegible]

* Sex of this chick not recorded.

DAY OLD BODY WEIGHT, AND WEIGHT OF UNABSORBED YOLK, IN CHICKS KILLED AT 3 DAYS OF AGE

Controls | Length of Starvation Period (3 days, 3 days, 4 days, 5 days, 6 days but ...) | Arsenic Chloride | Sodium Chloride (Fed first, Not fed first) | Arsenic Trioxide | Nicotine Sulfate | Over-heated | Chilled | Deprived of Water | Controls of Shipment I — Shipments II, III, IV

DAY OLD BODY WEIGHT, AND WEIGHT OF UNABSORBED YOLK, IN CHICKS KILLED AT 6 DAYS OF AGE

DAY OLD BODY WEIGHT, AND WEIGHT OF UNABSORBED YOLK, IN CHICKS KILLED AT 7 DAYS OF AGE

DAY OLD BODY WEIGHT, AND WEIGHT OF UNABSORBED YOLK, IN CHICKS KILLED AT 9 DAYS OF AGE

ALL WEIGHTS IN GRAMS, MALES IN ITALICS, FEMALES IN SMALL TYPE.

TABLE 20

REDUCED TABLE OF RAW DATA ON DAY-OLD BODY WEIGHT, AND WEIGHT OF UNABSORBED YOLK, IN CHICKS KILLED AT DIFFERENT AGES

MORTALITY DATA OF SHIPMENT I

Bird no.	Sex	Day old body weight (grams)	Age at death (days)	Yolk weight (grams)
Controls				
3732	F	36	4	1.70
3667	F	37	7	4.71
3705	M	32	7	.02
3661	M	39	20	.00
3674	M	44	25	.00
3606	F	40	38	.00
3725	M	36	54	.00
3673	M	42	57	.00
3702	M	32	101	.00
3666	M	36	115	.00
Overheated for 8 nights				
3423	F	36	6	5.67
3425	M	34	9	4.14
3384	M	33	10	3.88
3318	M	39	42	.00
3428	F	32	53	.00
3404	M	34	69	.00
3398	M	36	140	.00
Chilled for 3 nights				
3559	F	36	7	.29
3483	F	40	20	.00
3571	M	38	21	.00
3563	F	37	39	.00
3493	M	37	61	.00
3554	M	37	77	.00
3504	F	39	78	.00
3505	F	37	84	.00
3558	F	44	90	.00
Deprived of water for 5 days				
3791	M	39	4	*
3759	F	32	4	1.70
3817	F	41	4	3.72
3776	M	39	5	5.22
3787	F	38	6	.90
3869	M	37	8	.00
3877	M	37	12	.00
3795	M	36	13	.00
3838	F	37	40	.00
3781	F	38	80	.00

MORTALITY DATA OF SHIPMENTS II AND III

Bird no.	Sex	Day old body weight (grams)	Age at death (days)	Yolk weight (grams)
Controls				
4558	M	33	7	.80
4575	M	39	7	1.00
4521	M	31	21	.00
4611	M	37	5	4.90
4797	M	35	7	.92
4762	F	34	8	.00
4775	F	32	12	.10
4820	F	36	16	.00
4774	F	32	18	.10
4769	F	34	37	.00
Starved for 2 days				
4431	F	36	16	.00
4399	F	34	21	.00
4916	M	33	2	2.77
4910	F	30	8	.05
4918	M	33	8	.00
4928	F	34	8	1.30
4938	F	35	14	.00
4897	F	40	34	.00
4931	F	34	36	.00
Starved for 3 days				
4461	F	33	6	.09
4478	*	35	7	*
4503	M	38	9	1.10
4498	F	36	14	.00
4454	M	32	21	.00
4468	M	36	21	.00
4862	F	37	3	3.33
4843	F	32	4	1.00
4857	M	34	7	1.10
4895	F	39	7	.30
4887	F	36	8	.65
4873	M	36	14	.00
Starved for 4 days				
4594	M	32	5	.31
4602	M	34	6	1.80
4596	M	33	7	.00
4610	M	34	7	.80
4649	F	40	7	.40
4639	M	34	17	.00
4603	F	34	31	.80
4640	M	38	51	2.88
4708	F	33	5	1.70
4701	F	31	6	.01
4707	F	33	6	1.00
4722	M	35	6	1.95
4751	F	38	6	.03
4723	F	35	7	1.90
4738	M	36	7	1.00
4750	F	38	7	1.00
4726	M	35	8	2.02
4734	M	36	8	.17
4753	F	39	9	.79
4757	M	40	9	.43
4761	F	45	9	.77
4705	M	32	30	.00
4732	M	36	30	.00
4700	F	30	88	.00
Sodium chloride				
4118	F	34	3	1.84
4125	F	35	3	2.86
4147	M	37	3	2.78
4150	M	38	3	.00
4154	F	39	3	3.34
4100	M	30	4	7.97
4122	F	35	6	1.95
4119	M	34	19	.00
4102	M	32	62	.00
5201	F	31	2	1.87
5202	M	32	2	6.87
5203	F	32	2	1.67
5204	F	32	2	3.47
5205	M	32	2	2.45
5208	M	33	2	2.35
5209	M	33	2	3.87
5212	F	34	2	3.77
5213	F	34	2	2.67
5216	M	34	2	1.84
5217	M	34	2	3.22
5220	M	34	2	2.45
5221	M	34	2	2.70
5222	F	35	2	2.95
5224	F	35	2	2.77
5227	M	35	2	2.90
5228	F	35	2	4.87
5231	F	36	2	5.82
5236	F	36	2	4.72
5242	F	37	2	4.10
5252	M	39	2	5.27
5253	F	30	3	2.25
5206	M	33	3	2.67
5210	M	33	3	2.32
5218	F	34	3	2.45
5225	M	35	3	1.74
5229	F	35	3	2.22
5232	M	36	3	3.57
5233	M	39	3	3.35
5214	F	34	4	.90
5215	M	34	4	3.15
5219	F	34	4	1.55
5234	F	36	4	3.90
5237	F	36	4	3.30
5244	F	37	4	4.38
5248	M	38	4	2.95
5230	M	35	5	.45
5233	F	36	5	3.50
5235	F	36	5	8.30
5250	F	38	5	3.70
5256	M	40	5	3.90
5258	M	40	5	2.89
Mercuric chloride				
4346	M	33	1	.40
4364	M	39	2	4.48
4310	F	30	3	2.62
4315	F	32	3	.79
4332	M	35	3	2.79
4336	M	35	3	2.60
4338	F	35	3	1.37
4341	M	35	3	3.01
4342	F	35	3	2.98
4343	F	35	3	2.19
4344	M	36	3	2.40
4350	F	36	3	1.99
4355	M	37	3	2.06
4368	F	40	3	2.96
4352	F	36	4	1.22
4333	M	35	6	.26
4313	M	32	7	.00
4330	F	34	8	.15
4365	M	39	20	.00
4366	F	39	63	.00
5025	F	37	2	4.15
4985	M	32	2	3.15
4982	M	32	3	1.31
4983	F	32	3	1.59
4984	F	32	3	4.02
4986	M	33	3	3.96
4989	M	35	3	3.62
5002	M	35	3	3.08
5014	M	36	8	2.60
4981	M	31	8	2.60
5004	F	35	9	3.49
5006	F	38	19	.00
5038	M	40	19	.00
5010	M	35	64	.00
4980	F	30	70	.00
5029	M	38	76	.00
5024	F	37	79	.32
Nicotine sulfate				
4175	F	32	2	1.86
4191	F	35	2	2.75
4198	M	35	2	3.38
4205	M	36	2	3.08
4212	F	36	2	3.33
4219	F	37	2	5.66
4229	F	40	2	4.76
4179	M	30	3	.48
4188	F	34	3	2.90
4176	M	33	9	.40
4227	F	40	49	.00
4196	M	35	56	.00
4221	M	38	113	.00
4226	M	39	126	.00
5120	F	30	1	4.58
5123	F	32	1	5.41
5135	F	34	1	4.09
5139	F	34	1	4.13
5173	F	39	1	6.91
5136	F	34	2	3.77
5138	M	34	2	2.67
5126	M	33	7	1.30
5177	M	40	8	.05
5168	M	38	9	5.37
5144	F	35	65	.00
5169	F	38	67	.65
Arsenic trioxide				
4200	M	35	3	2.85
4247	M	33	3	3.99
4257	M	34	3	1.47
4349	F	36	3	1.36
4411	M	35	3	1.69
4419	F	36	3	2.39
4466	F	34	3	3.18
4481	F	36	3	2.24
4619	F	35	3	2.87
4634	F	37	3	2.16
4115	M	34	4	.72
4138	M	36	4	2.97
4340	F	35	4	1.67
4356	F	37	4	5.37
4388	F	33	4	1.77
4394	F	34	4	.87
4490	F	36	4	3.47
4535	M	34	4	1.74
4598	F	33	4	1.97
4607	M	34	4	2.06
4457	F	33	5	.46
4206	M	36	6	.92
5079	F	35	3	2.94
5086	M	36	3	2.37
5056	M	33	7	.00
5085	F	36	7	4.00
5076	F	35	8	.00
5098	F	38	8	1.27
Yolk removed at one day of age				
3923	M	37	2	
3929	F	39	2	
3920	F	43	4	
3903	F	34	5	
3921	M	36	5	
3918	F	35	7	
3905	M	32	36	
3926	M	37	56	
5319	M	36	2	
5322	M	37	5	
5323	M	37	5	
5326	M	38	5	
5314	M	36	6	
5324	M	37	6	
5307	*	33	7	
5311	F	34	8	
5312	M	34	8	
5328	M	38	8	
5317	F	36	9	
5315	F	35	12	
5327	M	38	17	
5303	M	35	19	
5316	F	35	19	
5320	F	36	33	
5313	F	34	38	
5301	M	34	45	
5321	M	36	71	

* Record lost

MORTALITY DATA OF SHIPMENT IV*

Bird no.	Sex	Day old body weight (grams)	Age at death (days)	Yolk weight (grams)
Starved 2 days				
5356	F	41	7	2.65
Starved 3 days				
4302	M	42	3	2.50
4089	F	37	5	3.85
4080	F	35	7	.06
4306	F	45	7	.65
4169	F	40	7	3.33
Starved 4 days				
5378	M	38	5	1.30
5380	F	38	5	.65
5381	M	38	6	.43
5389	F	40	6	.83
5376	F	37	6	.14
5366	F	35	7	.09
5371	F	36	7	.01
5374	M	37	8	.51
5387	F	40	9	.00
5401	M	45	9	.35
Starved 5 days				
2969	M	35	2	10.10
2971	M	35	5	.47
2974	M	36	5	1.79
2979	M	37	5	.37
2988	M	39	5	.43
3840	M	40	5	.42
2977	F	37	5	2.36
2991	F	40	5	.91
3250	M	45	5	2.24
2985	F	38	6	1.02
2995	M	40	6	.62
3239	F	40	6	.34
3244	M	42	6	.69
3247	F	42	6	.69
2989	F	39	6	.92
2986	F	38	7	.02
Starved 4 days (but given water)				
4025	M	40	4	3.70
4013	M	38	5	.34
4016	M	38	5	.48
4000	F	35	6	.04
4005	F	36	6	.55
4007	M	37	6	.11
Deprived of water 6 days*				
5263	F	38	5	1.02
5188	F	35	6	.72
5194	F	36	6	.04
5268	F	39	6	1.78
5270	M	39	6	.23
5272	M	40	6	.47
5277	F	40	6	.32
5278	F	40	6	1.68
5195	M	36	6	.43
5264	M	38	6	.30
5265	F	38	7	1.90
5279	F	41	7	1.30
5288	M	45	7	1.25
5276	M	40	8	4.21
Chilled (to lower temperature than chicks of Shipment I)				
4909	F	37	1	2.50
4833	F	34	2	2.92
5113	F	40	2	4.45
5049	F	40	3	3.18
5115	M	41	6	3.29
5048	M	40	7	.68
Sodium chloride (fed first)				
3885	F	35	2	2.13
3933	M	38	3	3.56
3891	M	37	3	.80
3943	F	40	3	2.65
3884	M	35	4	1.00
3886	F	35	4	3.00
3896	F	38	4	1.30
3897	F	38	4	1.98
3888	F	38	4	1.45
3940	F	40	5	1.58
3953	F	42	7	1.86
Sodium chloride (not fed first)				
3255	M	35	2	1.58
3269	M	38	2	2.18
3273	M	39	2	3.30
3289	M	44	2	6.40
3252	F	35	3	1.56
3254	F	35	3	2.55
3256	F	36	3	1.95
3280	M	40	3	4.35
3276	F	40	3	4.06
3261	M	37	4	1.12
3262	M	37	4	1.50
3253	F	35	4	2.85
3282	F	41	4	5.15
3263	F	37	4	2.01
3266	F	38	4	2.99
3274	M	40	4	1.49
3267	M	38	6	1.37
3278	F	40	7	1.30
Mercuric chloride				
4061	F	40	3	2.02
4047	F	37	4	1.40
4066	M	40	4	3.17
4045	M	36	5	1.52
4051	F	38	5	.22
4050	M	37	5	.65
4053	M	38	6	1.33
4052	F	38	7	2.40
Nicotine sulfate				
3442	M	38	1	4.70
3439	M	38	2	2.45
3440	M	38	2	2.47
3437	F	37	2	1.96
3446	F	39	2	6.05
3297	F	36	4	2.70
3584	F	40	4	5.47
Overheated (to higher temperature than chicks of Shipment I)				
4672	F	35	2	.75
4676	F	36	2	2.45
4677	F	37	2	2.59
4683	F	38	2	2.18
4684	M	38	2	2.08
4685	F	38	2	2.42
4686	F	38	2	3.52
4692	F	40	2	3.67
4766	M	42	2	2.88
4769	M	44	2	3.61
4632	M	45	2	6.98
4690	M	39	2	3.60
4695	F	40	2	4.57
4687	F	39	2	4.60
4674	M	36	4	.58
4765	F	42	7	.10

* There were no deaths within the experimental period of 9 days, in the control lot, or in the lot given arsenic trioxide.

TABLE 21

REDUCED TABLE OF RAW DATA ON MORTALITY

TABLE 22

REDUCED TABLE OF RAW DATA ON BODY WEIGHTS AT DIFFERENT AGES, OF THE MALES WHICH SURVIVED THE EXPERIMENTAL PERIOD OF 20 WEEKS

Males chilled for three nights

Body weight in grams at specified age

[illegible]

Males deprived of water for five days

Body weight in grams at specified age

[illegible]

Control males (Shipment I)

Body weight in grams at specified age

[illegible]

Males given sodium chloride

Body weight in grams at specified age

[illegible]

Males given arsenic trioxide

Body weight in grams at specified age

[illegible]

Males given nicotine sulfate

Body weight in grams at specified age

[illegible]

Males which had yolk removed at one day of age

Body weight in grams at specified age

Bird No.	1 day	1 wk	2 wks	3 wks	4 wks	5 wks	6 wks	8 wks	10 wks	12 wks	16 wks	20 wks
3900	36	46	67	102	143	195	250	350	510	760	1110	1440
3901	35	35	57	87	148	216	306	406	610	870	1340	1660
3906	32	28	44	75	114	146	197	260	430	670	1150	1500
3908	33	40	53	79	108	158	255	310	580	810	1400	1790
3910	34	39	59	102	157	224	262	390	470	680	1170	1450
3912	34	39	61	106	156	215	316	410	620	830	1270	1440
3914	35	46	62	94	125	160	280	500	490	780	1050	1340
3915	35	50	66	134	180	235	330	490	690	930	1330	1590
3916	35	36	68	84	141	235	284	360	510	760	1190	1450
3917	35	42	65	105	160	220	316	400	600	830	1240	1460
3922	36	43	69	90	126	176	285	350	490	720	1120	1550
3926	37	46	74	120	190	264	348	440	660	960	1460	1700
3927	38	45	51	97	146	216	312	470	660	1050	1670	1810
3928	33	46	67	98	148	213	292	360	580	830	1200	1550
3930	39	47	66	107	150	188	228	330	450	740	1230	1480
5500	34	35	46	70	101	141	198	300	380	460	800	1010
5525	37	46	61	97	140	188	184	350	540	720	1080	1280
5530	39	47	58	65	86	112	146	310	520	440	840	1150
5532	40	46	67	88	125	160	196	260	340	560	990	1350
5534	42	48	66	93	156	218	294	370	610	910	1410	1760

Control males (Shipments II and III)

Body weight in grams at specified age

[illegible]

Males starved for 48 hours after hatching

Body weight in grams at specified age

[illegible]

Males starved for 72 hours after hatching

Body weight in grams at specified age

[illegible]

Males starved for 96 hours after hatching

Body weight in grams at specified age

[illegible]

TABLE 23

REDUCED TABLE OF RAW DATA ON BODY WEIGHTS AT DIFFERENT AGES OF THE FEMALES WHICH SURVIVED THE

Control females (fed at 36 hours of age) Shipments II and III

Females starved for 48 hours after hatching

Females starved for 72 hours after hatching

Females starved for 96 hours after hatching

Females given mercuric chloride

Females given sodium chloride

Females given arsenic trioxide

Females given nicotine sulfate

Females which had yolk removed at one day of age

Bird No.	1 day	1 wk	2 wks	3 wks	4 wks	5 wks	6 wks	8 wks	10 wks	12 wks	16 wks	20 wks
	Body weight in grams at specified age											
3902	34	46	73	106	181	202	276	380	590	860	1110	1260
3907	38	37	67	80	125	178	234	306	430	580	800	1100
3909	35	37	51	64	74	86	106	166	280	420	720	1000
3911	36	49	55	106	148	206	278	360	570	770	1080	1250
3913	36	42	60	95	150	183	260	360	660	750	990	1180
3919	36	48	70	122	190	270	375	460	660	960	1260	1300
3926	37	44	63	86	122	156	197	280	480	630	950	1180
[illegible]	40	46	65	106	147	205	292	380	540	680	930	1060
[illegible]	31	48	70	[illegible]	187	264	[illegible]	420	610	860	1110	1240
[illegible]	[illegible]	41	66	100	140	184	[illegible]	[illegible]	480	650	1000	1300
6804	31	45	56	76	104	136	170	330	360	550	800	980
6805	38	38	78	126	206	294	396	560	780	980	1280	1750
6809	38	36	80	86	130	180	240	390	480	870	790	910
6810	36	36	60	91	140	196	270	370	645	800	1070	1300
6818	36	40	67	67	86	132	196	300	460	640	960	1110
6829	39	49	63	92	132	164	252	360	580	750	1040	1370
6861	60	41	61	97	140	190	294	310	490	640	980	1160

Females overheated for three nights

Females chilled for three nights

Females deprived of water for five days

Control females (Shipment I)

The titles of the Technical Papers of the California Agricultural Experiment Station, Nos. 1 to 20, which HILGARDIA replaces, and copies of which may be had on application to the Publication Secretary, Agricultural Experiment Station, Berkeley, are as follows:

1. The Removal of Sodium Carbonate from Soils, by Walter P. Kelley and Edward E. Thomas. January, 1923.

3. The Formation of Sodium Carbonate in Soils, by Arthur B. Cummins and Walter P. Kelley. March, 1923.

4. Effect of Sodium Chlorid and Calcium Chlorid upon the Growth and Composition of Young Orange Trees, by H. S. Reed and A. R. C. Haas. April, 1923.

5. Citrus Blast and Black Pit, by H. S. Fawcett, W. T. Horne, and A. F. Camp. May, 1923.

6. A Study of Deciduous Fruit Tree Rootstocks with Special Reference to Their Identification, by Myer J. Heppner. June, 1923.

7. A Study of the Darkening of Apple Tissue, by E. L. Overholser and W. V. Cruess. June, 1923.

8. Effect of Salts on the Intake of Inorganic Elements and on the Buffer System of the Plant, by D. R. Hoagland and J. C. Martin. July, 1923.

9. Experiments on the Reclamation of Alkali Soils by Leaching with Water and Gypsum, by P. L. Hibbard. August, 1923.

10. The Seasonal Variation of the Soil Moisture in a Walnut Grove in Relation to Hygroscopic Coefficient, by L. D. Batchelor and H. S. Reed. September, 1923.

11. Studies on the Effects of Sodium, Potassium, and Calcium on Young Orange Trees, by H. S. Reed and A. R. C. Haas. October, 1923.

12. The Effect of the Plant on the Reaction of the Culture Solution, by D. R. Hoagland. November, 1923.

13. Some Mutual Effects on Soil and Plant Induced by Added Solutes, by John S. Burd and J. C. Martin. December, 1923.

14. The Respiration of Potato Tubers in Relation to the Occurrence of Blackheart, by J. P. Bennett and E. T. Bartholomew. January, 1924.

15. Replaceable Bases in Soils, by Walter P. Kelley and S. Melvin Brown. February, 1924.

16. The Moisture Equivalent as Influenced by the Amount of Soil Used in its Determination, by F. J. Veihmeyer, O. W. Israelsen and J. P. Conrad. September, 1924.

17. Nutrient and Toxic Effects of Certain Ions on Citrus and Walnut Trees with Especial Reference to the Concentration and Ph of the Medium, by H. S. Reed and A. R. C. Haas. October, 1924.

18. Factors Influencing the Rate of Germination of Seed of Asparagus officinalis, by H. A. Borthwick. March, 1925.

19. The Relation of the Subcutaneous Administration of Living Bacterium abortum to the Immunity and Carrier Problem of Bovine Infectious Abortion, by George H. Hart and Jacob Traum. April, 1925.

20. A Study of the Conductive Tissues in Shoots of the Bartlett Pear and the Relationship of Food Movement to Dominance of the Apical Buds, by Frank E. Gardner. April, 1925.