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A BIOMETRICAL STUDY OF THE MORTALITY OF SINGLE-COMB WHITE LEGHORN CHICKS

EDWIN C. VOORHIES[1] AND GLADWIN A. READ[2]

INTRODUCTION

Constitutional fitness in chickens is gauged primarily by four main criteria: hatchability, livability, rate of growth, and egg production (Warren[18]). The desirability of reliable standards for each criterion for breeds of economic importance is apparent. This investigation deals with the livability of Single Comb White Leghorns, a race of fowls which from the standpoint of numbers equals and perhaps exceeds the numbers of all other breeds combined (Brown[2]).

It has been held that the most reliable measure of relative livability is given by the percentage of chicks alive three weeks after hatching (Dunn[7]). This study involves the first two weeks of life during the brooding period. However, two weeks seem to provide sufficient time for chicks to demonstrate the vitality of their particular strain. In the western section of the country most chicks go out into the open air when they are approximately 10 days old. Although the authors did not possess records covering more than 14 days, this procedure of taking a 14-day record would seem justified by the mor-

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tality curves, which dropped to a low point on the fourteenth day in the brooder. In the absence of infectious disease, accidents, and mismanagement, most of the deaths of young chicks are ascribable to constitutional or general causes. Pearl[14] points out "that there is ever present in vital statistics and from the beginning always has been an attempt to make the incidence of mortality a measure or an index of the incidence of morbidity. Mortality is not and never can be a good index of morbidity, generally speaking. What actually is done is to weaken and impair the value of the statistics in the hope to make them better indices of morbidity." Later deaths are due to a variety of causes, many of them not directly related to vigor, but rather to natural enemies, infectious diseases, and mechanical mishaps. The prevailing opinion among hatcherymen and poultrymen is that under California conditions, these latter forces begin to operate earlier than in the eastern section of the United States, where previous investigations (Jull,[10] Dunn[8]) have been carried on.

There are in the literature numerous indications that chick livability is often influenced to a marked degree by infection with pullorum disease. It has been generally found that the incidence of infection with pullorum disease is much lower among Leghorns than among heavy breeds. According to Beach and Michael,[1] *Bacterium pullorum* is very widespread among flocks of adult chickens. This does not mean that in every infected flock the incidence of infection is high. Records in the Office of the Division of Veterinary Science of the University of California indicate that the average percentage of reactors to the agglutination test in Leghorn flocks tested in California is only about 5 per cent. This is perhaps a fairly reliable index of the conditions of the Leghorn stock as a whole. There are some notable exceptions to this. Bunyea and Hall[3] state that an abrupt rise in the number of deaths 6 to 8 days after hatching, followed by a considerably decreased yet abnormally high mortality up to two weeks, is more suggestive of pullorum disease than a high mortality during the first few days after hatching. In some states freedom from pullorum disease, as indicated by results of the agglutination test, is the basis for official recognition or accreditation of breeding flocks and baby chicks. Roberts and Card[16] found great variation to exist among chicks with respect to their resistance to this disease and suggest the possibility of establishing high resistance as a strain characteristic. Perhaps the low mortality in these studies might in part be accounted for by this fact. The stock herein involved originated from selected but not from 'blood-tested' parents.

Detailed information on chick mortality during the first few days of life is extremely meager. Such data as are existent relate to comparatively few chicks under closely controlled conditions. The literature generally reports mortality at three weeks, while few if any details are given of the daily mortality.

Card and Kirkpatrick[4] reported an average loss for the first two weeks of 7.49 per cent, a figure based on four lots of White Leghorns brooded in three consecutive growing seasons. Dunn,[8] while working with purebred White Leghorn stock, found the following differences in early (three weeks) chick mortality to obtain:[3]

Generation	Per cent mortality in inbred stock	Per cent mortality in non-inbred stock
P^1	3.6	9.4
F^1	19.4	10.0
F^2	17.4	10.9
F^3	24.7	5.8

Warren[18] used 12.2 per cent as his average loss value for comparing the vigor of White Leghorn Chicks with that of first-generation hybrid chicks. Charles and Knandel[5] found the weekly mortality with 1,522 Single Comb White Leghorn chicks to be 1.60, 1.96, and 0.61 per cent respectively for the first three weeks of life.

Dunn,[8] with 746 chicks, found the chick mortality to be approximately 10 per cent of the general population during the first three weeks. Hays and Sanborn found the average mortality for eight weeks during four consecutive years on 2,103 chicks from 128 pullet mothers was 15.50 ± 2.26, while similar data based upon the records of 3,538 chicks from 205 hen mothers was 8.88 ± 0.69. The claim is made that the mortality in chicks to eight weeks of age is not a reliable index of vigor because it bears little relation to mortality rates in the same families after the surviving daughters are placed in laying houses.

Dunn,[7] in studies on the effect of egg fertility on chick mortality, furnishes the following data:

Per cent fertile eggs hatched	Total chicks	Died in first three weeks	Per cent mortality
20–39	162	29	17.90 ± 1.97
40–59	610	79	12.95 ± 0.92
60–79	595	68	11.43 ± 0.88
80–99	210	31	14.76 ± 1.76

From the results of these and other investigations little light can be shed on the problem under investigation.

[3] In the cases in which death was due to accident (such as drowning or being trampled) the record of the chick was deleted.

In 1923 Pearl[15] stated that the data necessary for the construction of complete life tables were available for but two organisms (the fly *Drosophila* and a rotifer) besides man. Since that time Pearl has calculated life tables for a good many other organisms, some of which have been published and more of which have not been published. Other life tables have been calculated by other workers, notably mice by Professor Major Greenwood of the London School of Hygiene and Tropical Medicine. It is hoped that the present study may aid in the construction of the table for the first two weeks of life of chicks.

DATA

In this study mortality records were secured on a total of 6,398,366 chicks (table 1) divided into 6,343 broods.[4] Tables 2 and 3 show the frequency distribution by sizes and month of sale for 1927 and 1928, respectively, while data by size and state for 1929 is given in table 4. The frequency distribution of the broods by sizes for Sacramento, Sonoma, and Los Angeles counties is shown in table 5. The distribution of the broods by size for the entire study is shown in figure 1. All of the records on these chicks fall during the period January 1, 1927, to September 1, 1929.

TABLE 1

DISTRIBUTION OF CHICKS BY STATES, 1927, 1928, 1929

State	Number of chicks				Percentages			
	1927	1928	1929	Total for three years	1927	1928	1929	Total for three years
California	1,714,897	1,086,743	925,455	3,727,095	59.96	79.16	42.74	58.25
Washington	589,723	52,150	593,275	1,235,148	20.62	3.80	27.40	19.30
Utah	250,826	113,750	387,100	751,676	8.77	8.29	17.88	11.75
Idaho	84,900	11,750	38,875	135,525	2.97	0.86	1.80	2.12
Arizona	77,600	41,900	37,950	157,450	2.71	3.05	1.75	2.46
Oregon	52,837	9,600	69,000	131.437	1.85	0.70	3.19	2.05
Montana	40,515	22,500	41,740	104,755	1.42	1.63	1.93	1.64
Nevada	34,480	25,650	35,250	95,380	1.20	1.87	1.62	1.49
Other states*	14,450	8,850	36,600	59,900	0.50	0.64	1.69	0.94
	2,860,228	1,372,893	2,165,245	6,398,366	100.00	100.00	100.00	100.00

* Colorado, New Mexico, Texas, Wyoming.

Source of data: Compilations by author on basis of records furnished by a certain hatchery at Petaluma, California.

[4] The term 'brood' in the sense in which it is used in this study refers to the young birds cared for at one time, as measured by the sales, orders, or shipments of chicks from the hatchery.

TABLE 2

Frequency Distribution of Brood Size, 1927

Month	Size of brood																	Total	Per cent of year's total
	0 to 399	400 to 799	800 to 1,199	1,200 to 1,599	1,600 to 1,999	2,000 to 2,399	2,400 to 2,799	2,800 to 3,199	3,200 to 3,599	3,600 to 3,999	4,000 to 4,399	4,400 to 4,799	4,800 to 5,199	5,200 to 5,599	5,600 to 5,999	6,000 to 6,399	6,400* and up		
January	9	33	29	16	0	9	2	5	0	0	1	0	0	0	0	0	0	104	3.73
February	47	87	129	74	16	37	19	19	0	0	3	0	4	1	1	2	3	442	15.87
March	102	134	191	132	33	54	19	23	6	3	8	1	4	0	0	3	3	716	25.71
April	274	300	251	116	15	35	12	12	3	2	1	1	4	0	1	1	0	1,028	36.91
May	113	60	25	12	3	4	5	2	0	0	0	0	0	0	0	1	1	226	8.11
June	30	17	7	2	0	4	3	0	0	0	0	0	0	0	0	0	0	63	2.26
July	2	1	2	1	0	4	2	0	0	0	1	0	0	0	0	0	0	13	.47
August	8	7	6	3	0	3	1	0	0	0	0	0	0	0	0	1	0	29	1.04
September	10	15	16	9	0	3	1	2	0	1	1	0	4	0	0	0	0	62	2.23
October	13	9	12	6	1	2	1	0	0	1	0	0	0	0	0	0	1	46	1.65
November	6	6	6	1	1	0	1	0	0	0	1	0	0	0	0	0	0	22	.79
December	5	3	16	1	2	2	2	1	1	0	0	0	1	0	0	0	0	34	1.22
Total	619	672	690	373	71	157	68	64	10	7	16	2	17	1	2	8	8	2,785	
Per cent of total	22.23	24.12	24.78	13.39	2.55	5.64	2.44	2.30	0.36	0.25	0.57	0.07	0.61	0.04	0.07	0.29	0.29		100.00

* The size for broods in this class were: January, 12,000-13,000-20,000; February, 13,100-7,000-21,000; May, 20,000; Oct., 13,000.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 3

Frequency Distribution of Brood Size, 1928

Month	Size of brood																	Total	Per cent of year's total
	0 to 399	400 to 799	800 to 1,199	1,200 to 1,599	1,600 to 1,999	2,000 to 2,399	2,400 to 2,799	2,800 to 3,199	3,200 to 3,599	3,600 to 3,999	4,000 to 4,399	4,400 to 4,799	4,800 to 5,199	5,200 to 5,599	5,600 to 5,999	6,000 to 6,399	6,400* and up		
January	14	21	47	19	3	16	4	3	0	1	0	0	1	1	0	1	0	131	9.32
February	41	44	57	37	2	14	8	4	1	0	6	0	1	0	0	0	0	215	15.30
March	81	109	118	64	11	29	13	8	2	1	1	1	1	0	0	2	2	443	31.53
April	84	78	56	28	3	6	5	2	1	1	1	0	0	0	0	1	0	266	18.93
May	60	38	14	7	1	4	0	0	1	0	0	0	1	0	0	0	0	126	8.97
June	14	6	4	1	0	2	1	0	1	0	0	0	0	0	0	1	0	30	2.14
July	9	3	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	16	1.14
August	9	4	11	1	0	1	0	0	0	0	0	0	0	1	0	0	0	27	1.92
September	7	13	7	4	0	5	1	1	1	0	0	0	1	0	0	0	0	40	2.85
October	5	14	6	7	1	1	0	0	1	0	0	0	0	0	0	0	0	35	2.49
November	12	3	9	1	0	1	0	0	0	0	1	0	0	0	0	0	0	27	1.92
December	12	1	11	6	1	7	3	4	0	1	0	0	0	0	0	0	3	49	3.49
Total	348	334	341	176	22	88	35	22	8	4	9	1	5	2	0	5	5	1,405	
Per cent of total	24.77	23.77	24.27	12.53	1.57	6.26	2.49	1.57	0.57	0.28	0.64	0.07	0.35	0.14	0.00	0.36	0.36		100.00

* The size for broods in this class were: March, 9,000–10,000; December, 20,000–8,000–8,000.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

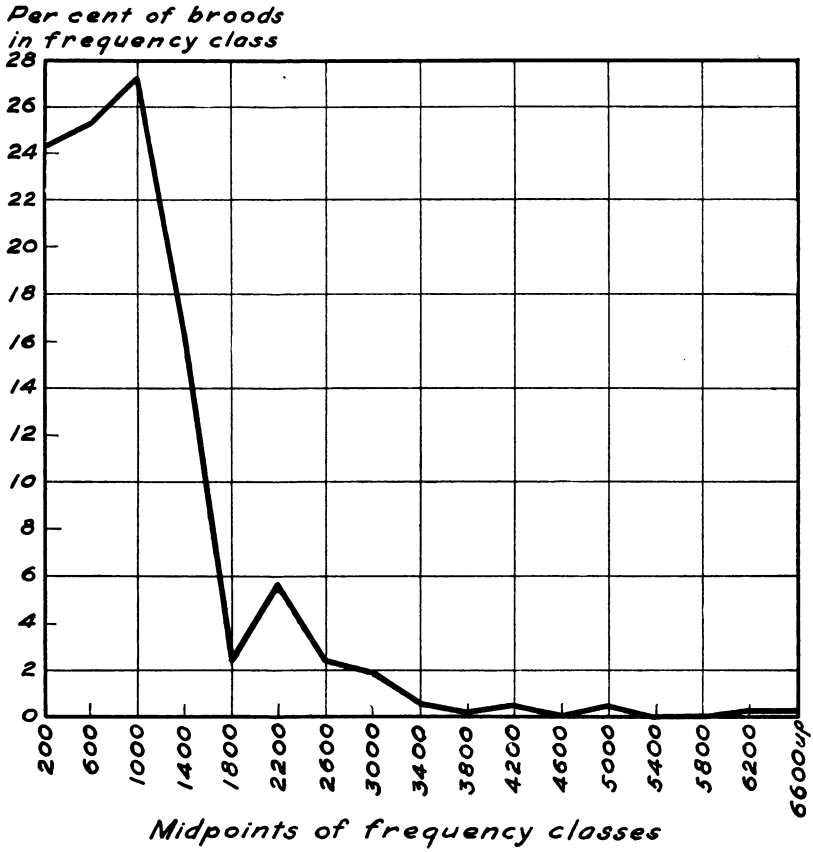

Fig. 1. Distribution of broods by size in the entire study for the three years 1927, 1928, 1929. Approximately 75 per cent of the broods were in the three frequency classes having as midpoints 1,000, 600, and 200. The arithmetic mean for the entire study was between 1,000 and 1,100. (Data based upon calculations made by authors.)

TABLE 4

FREQUENCY DISTRIBUTION OF BROOD SIZE ACCORDING TO STATES, 1929

State	Size of brood																	Total	Per cent of year's total
	0 to 399	400 to 799	800 to 1,199	1,200 to 1,599	1,600 to 1,999	2,000 to 2,399	2,400 to 2,799	2,800 to 3,199	3,200 to 3,599	3,600 to 3,999	4,000 to 4,399	4,400 to 4,799	4,800 to 5,199	5,200 to 5,599	5,600 to 5,999	6,000 to 6,399	6,400* and up		
California	232	218	226	133	15	47	26	23	14	3	3	1	3	0	0	3	2	949	44.08
Washington	39	93	188	140	20	32	9	5	2	0	3	0	0	0	0	0	0	531	24.66
Utah	23	59	88	46	13	25	11	4	4	0	4	1	3	0	1	0	5	287	13.33
Idaho	47	25	11	2	2	1	0	0	0	0	0	0	0	0	0	0	0	88	4.09
Oregon	17	20	15	14	2	4	2	0	0	0	1	0	0	0	0	0	0	75	3.48
Montana	29	19	12	6	0	0	0	2	1	0	0	0	0	0	0	0	0	69	3.20
Arizona	19	20	11	6	1	1	1	0	0	0	0	0	0	0	0	0	0	59	2.74
Nevada	27	9	9	8	1	2	0	0	0	0	0	0	0	0	0	0	0	56	2.60
Other states	13	6	11	5	1	2	0	0	0	0	0	0	1	0	0	0	0	39	1.81
Total	446	469	571	360	55	114	49	34	21	3	11	2	7	0	1	3	7	2,153	
Per cent of total	20.71	21.78	26.52	16.72	2.55	5.29	2.28	1.58	0.98	0.14	0.51	0.09	0.33	0.00	0.05	0.14	0.33		100.00

* The size of broods 6,400 were as follows: California, 12,260, 20,200; Utah, 7,000, 7,000, 7,500, 8,000, 8,000.

Source of data: Computation by authors based upon hatchery records at Petaluma, California.

TABLE 5

FREQUENCY DISTRIBUTION OF BROOD SIZE OF CHICKS SOLD IN SELECTED CALIFORNIA COUNTIES, 1927, 1928, 1929

County	Size of brood																	
	0 to 399	400 to 799	800 to 1,199	1.200 to 1,599	1,600 to 1,999	2,000 to 2,399	2,400 to 2,799	2,800 to 3,199	3,200 to 3,599	3,600 to 3,999	4,000 to 4,399	4,400 to 4,799	4,800 to 5,199	5,200 to 5,599	5,600 to 6,399	6,000 to 6,399	6,400* to up	Total
1927																		
Sonoma.....	3	11	48	40	14	47	36	28	3	3	8	0	6	1	1	6	3	258
Los Angeles	37	90	104	36	8	18	3	6	0	0	2	0	2	0	0	0	0	306
Sacramento	14	20	17	24	2	4	4	3	0	0	0	0	0	0	0	0	1	89
1928																		
Sonoma	1	5	18	17	4	18	11	6	5	1	5	1	3	1	1	4	5	106
Los Angeles	11	38	45	18	4	9	2	0	0	0	0	0	0	0	0	0	0	127
Sacramento	5	7	11	16	0	5	1	1	0	0	0	0	0	0	0	0	0	46
1929																		
Sonoma	8	2	7	17	4	8	14	10	5	1	2	1	2	0	0	3	0	84
Los Angeles	15	38	42	17	4	6	2	3	0	0	1	0	0	0	0	0	0	128
Sacramento	5	3	9	19	1	4	1	3	1	1	0	0	0	0	0	0	1	48

* The sizes of the broods in this class were, 1927: Sonoma, 7,000, 13,000, 21,000; Sacramento, 20,000; 1928: Sonoma, 8,000, 8,000, 9,000, 10,000, 20,000. 1929: Sacramento, 20,200.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

The chicks were the progeny of not more than 565,000 selected hens,[5] not less than one year old, mated with selected male birds, not less than eight months of age. The egg production of the dam and the sire's dam of each of the males has been from 200 eggs up. The breeding flocks ranged in size from 500 to 5,000 hens and were within a radius of 25 miles of Petaluma, California.

The eggs from which the chicks were hatched were graded at their respective points of origin for shape, weight, and cleanliness. Deliveries of eggs were made to the hatchery at frequent and regular intervals. On arrival at the hatchery, these eggs were regraded and candled. They were incubated and hatched in box-type machines of identical construction, heated and controlled by electricity.

After the hatch, each chick was individually handled and examined for malformations, size, type, and vigor. Those to be brooded outside of the immediate district were shipped when approximately 12 hours old. The balance were held 24 hours longer.

It should be emphasized that the data in this study are based upon commercial records. An account of the procedure followed in the commercial hatcheries at Petaluma may elucidate the analyses of the data which appear in this publication. On the twentieth day after the eggs are placed in the incubator the chicks begin to appear. They are allowed to remain until the twenty-first day, when they are removed. The average length of time that the chick remains in the incubator after hatching is estimated to be 12 hours. If the chicks are to be sent to distant points they are shipped on the twenty-first day, or at the end of the 12-hour period in the incubators. If, however, the chicks are sold in the immediate vicinity, they are kept at the hatchery for 24 hours before being delivered. They would thus be delivered to the buyer on the twenty-second day.

The furthermost points to which the chicks were sent are shown in figure 2. El Paso, Texas, is the most distant point. Since the distance in miles does not necessarily correspond with the number of hours the chicks were kept from feed, the latter data is given in table 6. For example, the approximate time chicks are in transit from Petaluma, California, to Bellingham, Washington, is 59 hours, to El Paso, Texas, 54 hours, etc. The geographical distribution of the chicks during the three years for which data were collected was wide. All of the eleven western states and Texas received shipments, as indicated in table 1. The percentage distribution of chicks varied considerably, especially if 1928 is compared with either 1927 or 1929.

[5] 1927—200,000 hens; 1928—135,000; 1929—230,000.

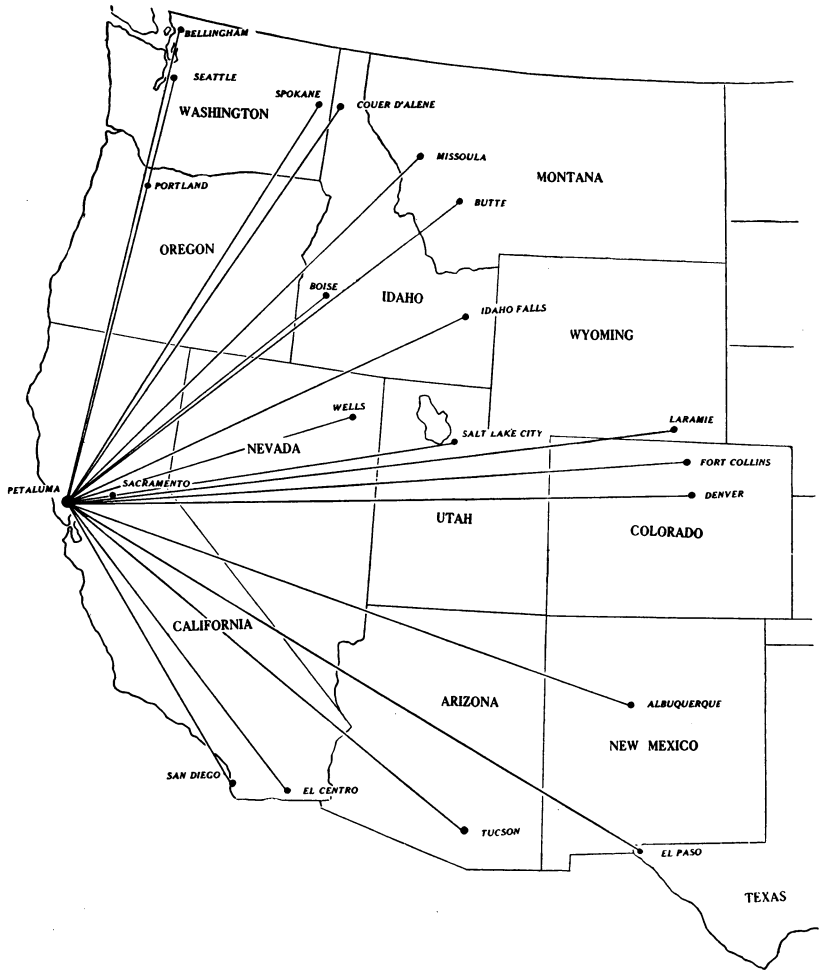

Fig. 2. Records of chicks used in this study were reported from points in all of the western states and Texas. The cities designated show the principal points outside of California to which the baby chicks were shipped. The points furthermost on the map in general represent the greatest distances chicks are shipped from Petaluma. The time occupied en route does not vary directly with the distance (see table 6).

TABLE 6

NUMBER OF HOURS BABY CHICKS ARE IN TRANSIT BETWEEN PETALUMA, CALIFORNIA, AND CERTAIN OTHER CITIES, 1930

City	Hours in transit via Railway Express	City	Hours in transit via Railway Express
Bellingham, Washington	59	Albuquerque, New Mexico	48
Spokane, Washington	43	El Paso, Texas	54
Missoula, Montana	52½	Tucson, Arizona	44
Butte, Montana	45	San Diego, California	27
Laramie, Wyoming	43	El Centro, California	42
Fort Collins, Colorado	56	Boise, Idaho	50½
Denver, Colorado	53	Portland, Oregon	31
Salt Lake City, Utah	39		

Source of data: A. W. Custer, Railway Express, Petaluma, California, March 31, 1930.

In 1928 certain quarantine regulations prevented as large a movement to outside states as usually occurs. A study made of the distribution within California in 1927 indicates that chicks were sent to fifty-five of the fifty-eight counties of the state (table 7). This shows a wide distribution of chicks within the state, with a concentration in Sonoma, Los Angeles, and Sacramento counties (fig. 3).

TABLE 7

DISTRIBUTION OF CHICKS IN CALIFORNIA, 1927 STUDY

County	Number	County	Number	County	Number
Alameda	72,700	Madera	4,800	San Joaquin	15,550
Amador	2,200	Marin	27,550	San Luis Obispo	26,650
Butte	7,000	Mendocino	17,800	San Mateo	2,300
Calaveras	150	Merced	7,300	Santa Barbara	2,300
Colusa	2,450	Modoc	1,000	Santa Clara	16,525
Contra Costa	9,800	Mono	2,300	Santa Cruz	21,600
Del Norte	2,500	Monterey	13,500	Shasta	3,175
El Dorado	750	Napa	23,075	Siskiyou	600
Glenn	5,900	Nevada	1,300	Solano	21,500
Fresno	6,350	Orange	13,450	Sonoma	571,705
Humboldt	24,800	Placer	4,550	Stanislaus	3,600
Imperial	28,150	Plumas	100	Sutter	18,150
Inyo	9,700	Riverside	55,880	Tehama	300
Kern	24,095	Sacramento	118,400	Trinity	400
Kings	7,125	San Benito	5,200	Tulare	22,400
Lake	1,200	San Bernardino	100,290	Tuolumne	3,500
Lassen	7,468	San Diego	34,475	Ventura	23,700
Los Angeles	301,434	San Francisco	1,300	Yolo	7,000
				Yuba	5,900

Source of data: Computations by authors on basis of original data on shipments.

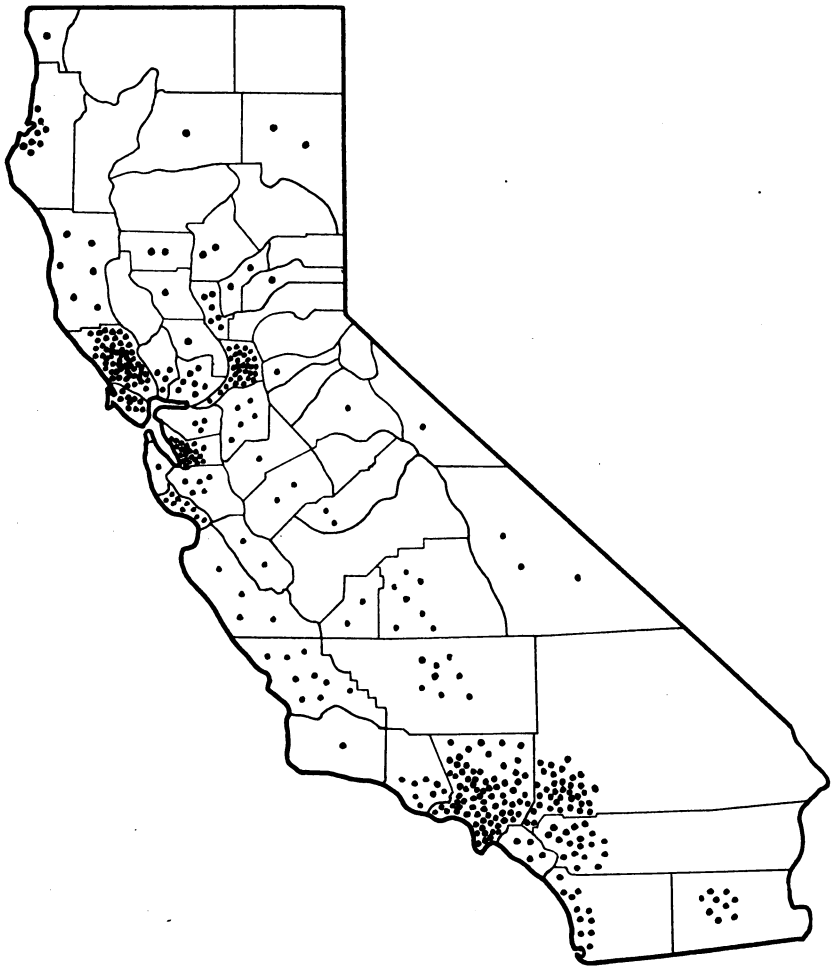

Fig. 3. Calculations made on the 1927 distribution of chicks within California show that shipments were made to 55 counties of the state. 1 dot = 3,000 chicks. (Data from table 7.)

Comparisons between the number of chicks included in this study and the total number of baby chicks shipped from Petaluma will give some idea of the representative character of this study. About 97.5 per cent of the exported Petaluma chicks are handled by Railway Express. In 1927 there were 7,463 shipments totaling 67,311 boxes; in 1928, totals were 5,001 shipments with 46,069 boxes; and in 1929 (to August 31) corresponding data were 6,993 and 72,596. A box contains from 80 to 100 baby chicks according to the season. During the rush season the boxes average 100 chicks. In order to be conservative a figure of 100 is used, and the resulting total shipments by Railway Express out of Petaluma in 1927 would be 6,731,100 chicks. In the 1927 study mortality records were obtained on 2,289,228 chicks brooded outside of Sonoma County. This represents over 34 per cent of the total number shipped out by Railway Express.

The brood-size frequencies have been obtained not only for the various states and for California as a whole but the same calculations have also been made for the three California counties of Sonoma, Sacramento, and Los Angeles (table 5 and fig. 14). These three counties are in three distinct and separate sections of the state.

The few investigations made previously, which have but a remote bearing on this study, were concerned with results obtained under explicitly defined environmental conditions. The present investigation includes a wide range of climate, altitude, brooding units, feeding systems, and managerial abilities. It is commonly assumed that these factors, together with data of hatch and number of hours in transit, have a possible bearing on subsequent brooder mortality. These assumptions are tested in this investigation.

MANNER OF COLLECTING DATA

The original data were collected by the Ad Hoc or Case Record Method. A few days prior to the chicks' departure from the hatchery a stamped mortality card (fig. 4) was mailed to each buyer. On this was typed his name and address, the size of his order, and the scheduled date of shipment or delivery. A brief explanation of the purposes was given on the card, as shown in figure 4.

A sense of appreciation for the friendly interest manifested by their hatchery and a desire to compare their experience with the experiences of fellow poultrymen handling similar stock prompted the majority of buyers to cooperate and comply with this printed request.

———— **INCUBATOR CO.,**

PETALUMA, CALIF.

Name.....

Address.....

.....

Number of Chicks.....

Date Shipped .....

MORTALITY RECORD

Day	*Number*	*Day*	*Number*
1st		8th	
2nd		9th	
3rd		10th	
4th		11th	
5th		12th	
6th		13th	
7th		14th	
Loss 1st Week		*Loss 2nd Week*	

Total Loss in Brooder (14 Days) .....

Number Found Dead on Arrival .....

Total .....

Remarks.....

.....

.....

.....

.....

.....

Signed.....

Fold on This Line

This card is addressed and stamped for return.

All that is necessary when record is completed is to fold together, seal, and drop in the mail box.

This card has been sent to you to be filled out and returned because—

We want to know the truth about your chicks and the best way that we can get this truth is through this record.

We believe that true chick quality can be determined only by getting the results in the brooders of all our customers and making an average of all reports.

Every customer should accurately know his early brooder loss. It will be of value to compare with other records and with general average of all the customers.

Your record will be held confidential. Only the totals of all the records and their general average will be published. This report will be mailed to you.

Your record obtained will be of value to both of us. Give us your actual results on your chicks during the first fourteen days in the brooder, then

PLEASE MAIL PROMPTLY

Thank You.

———— INCUBATOR CO.

Fig. 4. Reports are sent to the hatcherymen on the blanks pictured above. The mortality records on which this study is based were calculated from these records.

The data used were collected from the commercial records of hatcheries at Petaluma, California. If the investigation could have been planned in advance certain other data would have been obtained. The authors have been limited to the commercial records available. It should be noted in view of what has been said that the first day of the mortality record is at least the second day after hatching, and in some cases the third day after hatching. Unquestionably this accounts in no small measure for a few of the discrepancies which will be found in the mortality records. It will thus be seen that in some instances chicks dying enroute to their destination would not be counted in the 14-day record of mortality which has been obtained. On the other hand these same chicks, had they been brooded at or near Petaluma, might have been recorded on the first day of the mortality record.

THE PROBLEM

The purpose of this study was to measure and describe in detail the distribution, variability, and extent of the initial 14-day mortality of Single-Comb White Leghorn Chicks, produced and brooded under so-called 'commercial conditions.' Under commercial management chicks are reared primarily for the purpose of making flock replacements. Those whose vitality and general appearance indicate a constitutional deficit are immediately discarded. This culling practice obviates the possibility of accurate comparisons with experimental data. It is reasonable to assume that the management involved in the latter will consistently yield the highest possible livability.

Hatcherymen and purchasers of baby chicks are vitally interested in certain specific problems which this paper may serve to elucidate in either a direct or an indirect manner. The 'quality' of the baby chicks is an ever-present topic in the minds of both buyer and seller. This study has been undertaken with this partially in view. The time of starting the feeding of baby chicks and the subsequent mortality is also important in the minds of all concerned. In this study some comparison can be made between the mortality of chicks kept from feed for at least 60 to 72 hours and those brooded within the state, receiving feed earlier in their lives. On this problem but little evidence of a direct nature can be obtained.

It is also within the scope of this paper to show whether or not there has been any marked change during the three years 1927, 1928, and 1929 in the distribution, variability, and extent of the initial 14-day loss sustained by the raisers of the chicks herein considered.

The hatchery business is an industry of considerable economic importance in California. Lippincott[11] states that the first commercial hatchery in the United States was established in California in 1886. Voorhies[17] reports 262 commercial hatcheries operating in 1926 with a total capacity of 7,781,342 eggs and estimates the capacity of all the hatcheries in the state in that year at approximately 8,000,000 eggs.

ANALYSIS OF DATA

As previously indicated, the primary purpose of this study concerns itself with the distribution of chick mortality. Tables 8, 9, and 10, consider the two variables of time and place, and constitute the basic data as determined by summarizing mortality records for 6,343 broods. A quarantine regulation governing the interstate movement of hatching eggs, baby chicks, and breeding poultry virtually stopped all exports to Washington, Oregon, and Idaho in 1928. This fact accounts for the relatively small number of chicks dying in those three states in that year.

The crude death rate for the three years which the study covered is given in table 11. The crude death rate, according to Pearl,[14] is untrustworthy for any but the broadest and roughest conclusions and estimates. The authors believe the table to be of interest, but on account of the relatively small number shipped to states other than California, Washington, and Utah, comparisons between states are apt to be misleading. Comparing the crude death rates for the entire study during each of the three years with those for California, Washington, and Utah, it will be found that California was below the rate for the entire study during two of the three years, Utah was below two out of three years, and Washington was above for all three years.

Gross comparisons between the three years for the entire study are facilitated by referring to table 12, which shows the actual number of chicks surviving at the close of each one of the 14 measured days, the average daily mortality sustained by the poultrymen involved, and the calculated odds or chances that any individual chick actually had of reaching the fifteenth day alive. In these tables the mortality occurring each day is expressed as a percentage of the total number of chicks surviving at the close of the preceding day and not as a percentage of the total number involved. The empirical probability of life values are expressions of the cumulative livability percentages multiplied by a constant (in this case 10) and stated inversely.

TABLE 8

DISTRIBUTION OF CHICK MORTALITY BY DAYS, 1927

2,860,228 Chicks

State	Day														Total 14 days
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
California	4,742	6,398	10,081	12,218	14,696	13,397	11,394	8,705	6,840	5,756	4,975	4,331	3,858	3,472	110,863
Washington	4,453	5,092	5,919	6,582	5,262	3,818	2,903	2,534	1,956	1,637	1,386	1,146	1,162	955	44,805
Utah	1,601	1,619	1,536	1,981	1,732	1,646	1,250	1,103	823	801	597	621	494	466	16,270
Idaho	573	942	769	968	772	650	578	576	343	335	341	253	250	164	7,514
Arizona	623	1,453	935	918	762	566	418	328	241	225	216	210	137	133	7,165
Oregon	334	353	376	493	472	467	298	258	188	140	126	110	137	77	3,829
Montana	199	249	234	296	315	300	198	168	166	127	90	82	73	48	2,545
Nevada	202	192	155	222	200	197	184	153	136	145	115	105	57	63	2,126
Other states*	69	113	95	107	100	76	54	54	44	51	66	40	27	17	913
Totals	12,796	16,411	20,100	23,785	24,311	21,117	17,277	13,879	10,737	9,217	7,912	6,898	6,195	5,395	196,030

* Colorado, New Mexico, Texas, Wyoming.

Source of data: Computations by authors. Original data obtained from hatchery records at Petaluma, California.

TABLE 9

Distribution of Chick Mortality by Days, 1928

1,372,893 Chicks

State	Day														Total 14 days
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
California	3,051	4,107	5,772	8,879	10,678	9,805	8,544	6,626	5,513	4,664	3,907	3,481	3,121	2,894	81,042
Washington	245	365	466	466	495	328	355	256	258	186	164	119	142	115	3,960
Utah	518	548	651	866	874	882	859	780	584	453	381	280	266	222	8,164
Idaho	53	68	93	126	99	75	76	58	36	40	34	26	38	11	833
Arizona	157	164	224	274	296	264	198	167	139	113	95	83	83	48	2,305
Oregon	48	72	79	78	49	44	34	31	27	23	18	24	17	21	565
Montana	142	150	237	282	251	211	175	148	114	115	91	81	100	66	2,163
Nevada	66	139	150	256	238	189	141	128	104	80	78	68	49	49	1,735
Other states*	31	54	95	142	77	68	50	43	37	39	34	23	23	10	726
Totals	4,311	5,667	7,767	11,369	13,057	11,866	10,432	8,237	6,812	5,713	4,802	4,185	3,839	3,436	101,493

* Colorado, New Mexico, Texas, Wyoming.

Source of data: Computations by authors. Original data obtained from hatchery records at Petaluma, California.

TABLE 10

DISTRIBUTION OF CHICK MORTALITY BY DAYS, 1929

2,096,245 Chicks

State	Day														Total 14 days
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
California	3,044	4,257	5,904	7,722	8,573	8,036	6,457	5,019	4,066	3,616	2,970	2,533	2,493	2,438	67,128
Washington	2,713	3,755	5,059	6,603	6,056	4,838	3,862	3,335	2,726	2,397	2,067	1,789	1,632	1,446	48,278
Utah	2,177	2,859	3,906	4,526	4,200	3,443	2,734	2,423	1,983	1,636	1,488	1,239	1,107	1,008	34,729
Idaho	456	560	791	874	799	517	493	405	283	248	197	179	156	130	6,088
Arizona	169	234	339	390	474	374	281	217	143	111	97	97	66	67	3,059
Oregon	369	418	618	653	603	500	499	408	282	240	220	289	160	135	5,394
Montana	410	361	536	571	510	362	277	266	185	140	143	148	123	107	4,139
Nevada	172	200	274	343	387	352	283	253	222	151	193	183	104	108	3,225
Other states*	275	400	522	763	608	462	395	301	262	197	156	145	89	90	4,665
Totals	9,785	13,044	17,949	22,445	22,210	18,884	15,281	12,627	10,152	8,736	7,531	6,602	5,930	5,529	176,705

* Colorado, New Mexico, Texas, Wyoming.

Source of data: Computations by authors. Original data obtained from hatchery records at Petaluma, California.

TABLE 11

CRUDE DEATH RATE DURING 14-DAY BROODING PERIOD, 1927, 1928, 1929, PER 10,000

State	1927	1928	1929
California	646	746	725
Washington	760	759	814
Utah	649	718	897
Idaho	885	709	1,566
Arizona	923	550	806
Oregon	725	589	782
Montana	628	961	992
Nevada	617	676	915
Other states*	632	820	1,275
Total	685	739	843

* Colorado, New Mexico, Texas, Wyoming.

Source of data: Compilations by authors on basis of formula:

$$R = K\left(\frac{D}{P}\right)$$

K = Constant (in this case 10^4)
D = Deaths from all causes
P = Total population

TABLE 12

CUMULATIVE DISTRIBUTION OF CHICKS BROODED DURING 1927, 1928, 1929 (ENTIRE STUDY), CLASSIFIED ACCORDING TO LENGTH OF LIFE

Day	1927			1928			1929 (to August)		
	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000
On arrival	2,860,228	0.000	929	1,372,893	0.000	923	2,165,245	0.000	915
1	2,847,432	.447	934	1,368,582	.314	927	2,155,460	.452	920
2	2,831,021	.576	939	1,362,915	.414	931	2,142,416	.605	926
3	2,810,921	.710	947	1,355,148	.570	936	2,124,467	.838	934
4	2,787,136	.846	955	1,343,779	.839	944	2,102,022	1.057	945
5	2,762,825	.872	964	1,330,722	.972	955	2,079,812	1.057	955
6	2,741,708	.764	971	1,318,856	.892	963	2,060,928	.908	964
7	2,724,431	.630	978	1,308,424	.791	971	2,045,647	.741	972
8	2,710,552	.509	983	1,300,187	.630	978	2,033,020	.617	978
9	2,699,815	.396	987	1,293,375	.524	983	2,022,868	.499	983
10	2,690,598	.341	990	1,287,662	.442	987	2,014,132	.432	987
11	2,682,686	.294	993	1,282,860	.373	991	2,006,601	.374	991
12	2,675,788	.257	995	1,278,675	.326	994	1,999,999	.329	994
13	2,669,593	.232	998	1,274,836	.300	997	1,994,069	.297	997
14	2,664,198	0.202	1,000	1,271,400	0.270	1,000	1,988,540	0.277	1,000

Source of data: Computations by authors based upon tables 1, 8, 9, and 10.

It will be noted by referring to these frequencies that there is a spread of 14 points or chances of life between 1927 and 1929, in favor of 1927 (table 12). This is due to a drop in livability on the part of out-of-state broods in 1929 (table 14). California brooded chicks had eight less chances of life in 1929 compared with 1927 (table 13).

TABLE 13

CUMULATIVE DISTRIBUTION OF CHICKS BROODED IN CALIFORNIA, 1927, 1928, 1929, CLASSIFIED ACCORDING TO LENGTH OF LIFE

Day	1927			1928			1929 (to August)		
	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000
On arrival	1,714,897	0.000	933	1,086,743	0.000	923	925,455	0.000	925
1	1,710,155	.277	936	1,083,692	.281	926	922,411	.329	928
2	1,703,757	.374	940	1,079,585	.379	929	918,154	.462	933
3	1,693,676	.592	946	1,073,813	.535	935	912,250	.643	939
4	1,681,458	.721	953	1,064,934	.827	943	904,528	.846	948
5	1,666,762	.874	962	1,054,256	1.003	953	895,955	.948	957
6	1,653,365	.804	970	1,044,451	.930	962	887,919	.897	966
7	1,641,971	.689	977	1,035,907	.818	970	881,462	.727	973
8	1,633,266	.530	982	1,029,281	.640	977	876,443	.569	979
9	1,626,426	.419	986	1,023,768	.536	982	872,377	.464	984
10	1,620,670	.354	990	1,019,104	.456	987	868,761	.414	988
11	1,615,695	.307	993	1,015,197	.383	991	865,791	.342	991
12	1,611,364	.268	995	1,011,716	.343	994	863,258	.293	994
13	1,607,506	.239	998	1,008,595	.308	997	860,765	.289	997
14	1,604,034	0.216	1,000	1,005,701	0.287	1,000	858,327	0.283	1,000

Source of data: Computations by authors based upon tables 1, 8, 9, and 10.

Figure 5 shows the distribution of mortality during each of the years of the study. These curves give evidence of considerable regularity except that the peak of mortality in 1927 and 1929 is not as distinct and pronounced as in 1928. The relative kurtosis of the curves for the two previous years is due to the percentage of out-of-state broods. As previously explained, records on chicks sent from Petaluma are started upon the day of their arrival. This practice makes the "first day" at many distant California and out-of-state points the same as the "second" day or even the "third" day at points close to Petaluma.

The relative skewness of each curve has been explained, at least in part, by Parker,[13] who found that deaths from starvation occur about the fifth day. Figure 5 and more especially figure 6, indicate

and confirm the tendency for normal mortality gradually to reach a crisis in 156–168 hours after the hatch. It is significant with respect to the intrinsic character of the chicks involved that this held true for all three years. Comparisons between the daily mortalities in each year may be obtained by referring to table 17. The influence of the lack of out-of-state shipments in 1928 can be seen clearly.

TABLE 14

CUMULATIVE DISTRIBUTION OF CHICKS BROODED OUTSIDE OF CALIFORNIA, 1927, 1928, 1929, CLASSIFIED ACCORDING TO LENGTH OF LIFE

Day	1927			1928			1929 (to August)		
	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000
On arrival	1,145,331	0.000	923	286,150	0.000	926	1,239,790	0.000	908
1	1,137,277	.703	930	284,890	.440	930	1,233,049	.544	913
2	1,127,264	.880	939	283,330	.548	936	1,224,262	.713	920
3	1,117,245	.889	948	281,335	.704	943	1,212,217	.984	930
4	1,105,678	1.035	958	278,845	.885	952	1,197,494	1.215	942
5	1,096,063	.870	967	276,466	.853	960	1,183,857	1.139	954
6	1,088,343	.704	974	274,405	.745	968	1,173,009	.916	963
7	1,082,460	.541	979	272,517	.688	575	1,164,185	.752	970
8	1,077,286	.478	984	270,906	.591	981	1,156,577	.654	977
9	1,073,389	.362	988	269,607	.480	985	1,150,491	.526	982
10	1,069,928	.322	991	268,558	.389	989	1,145,371	.445	987
11	1,066,991	.275	994	267,663	.333	993	1,140,810	.398	991
12	1,064,424	.241	996	266,959	.263	995	1,136,741	.357	994
13	1,062,087	.220	998	266,241	.269	998	1,133,304	.302	997
14	1,060,164	.181	1,000	265,699	0.204	1,000	1,130,213	0.273	1,000

Source of data: Computations by authors based upon tables 1, 8, 9, and 10.

The data involving all of the chicks brooded outside of California will be found in table 14. It will be noted that in each of the three years the fourth day of brooding marks the peak of mortality. This day would in all probability have been the fifth had these chicks been brooded at Petaluma. Comparing the data for chicks brooded outside of California (table 14) with those depicting the brood mortality for chicks brooded in California (table 13), it will be found that the mortality for chicks brooded outside the state was higher for the first four days of brooding. During 1927 and 1928 the daily mortality after the peak had been reached was lower for those brooded outside. For 1929 this latter statement did not hold except for the last day of the period. These facts are clearly brought out in figures 7 and 8.

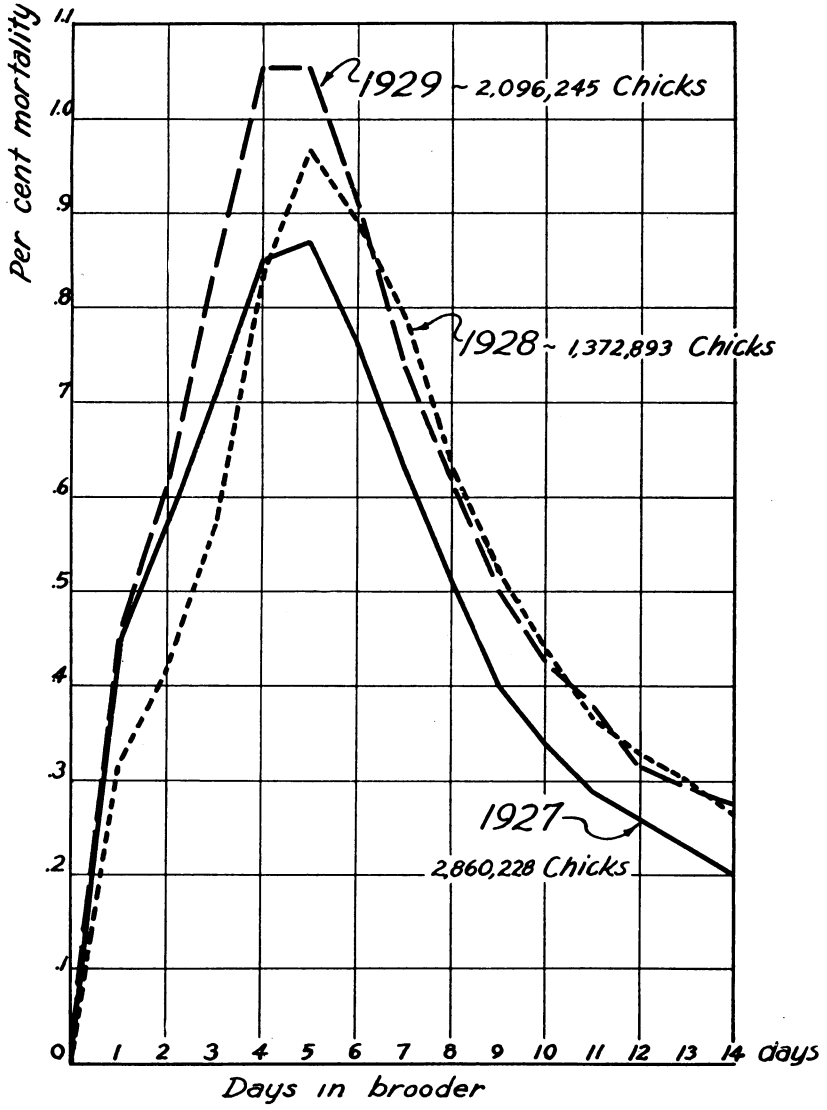

Fig. 5. The distribution of mortality during the initial 14-day brooding period for the three years studied gave evidence of considerable regularity. A rapid rise is shown up to the fifth day, when the peak is reached. Deaths fall off rapidly until the ninth day, when there is a slowing up of the descent. From the ninth to the eleventh day the mortality usually descends to a point where it is lower than it was during the first day. (Data from table 12.)

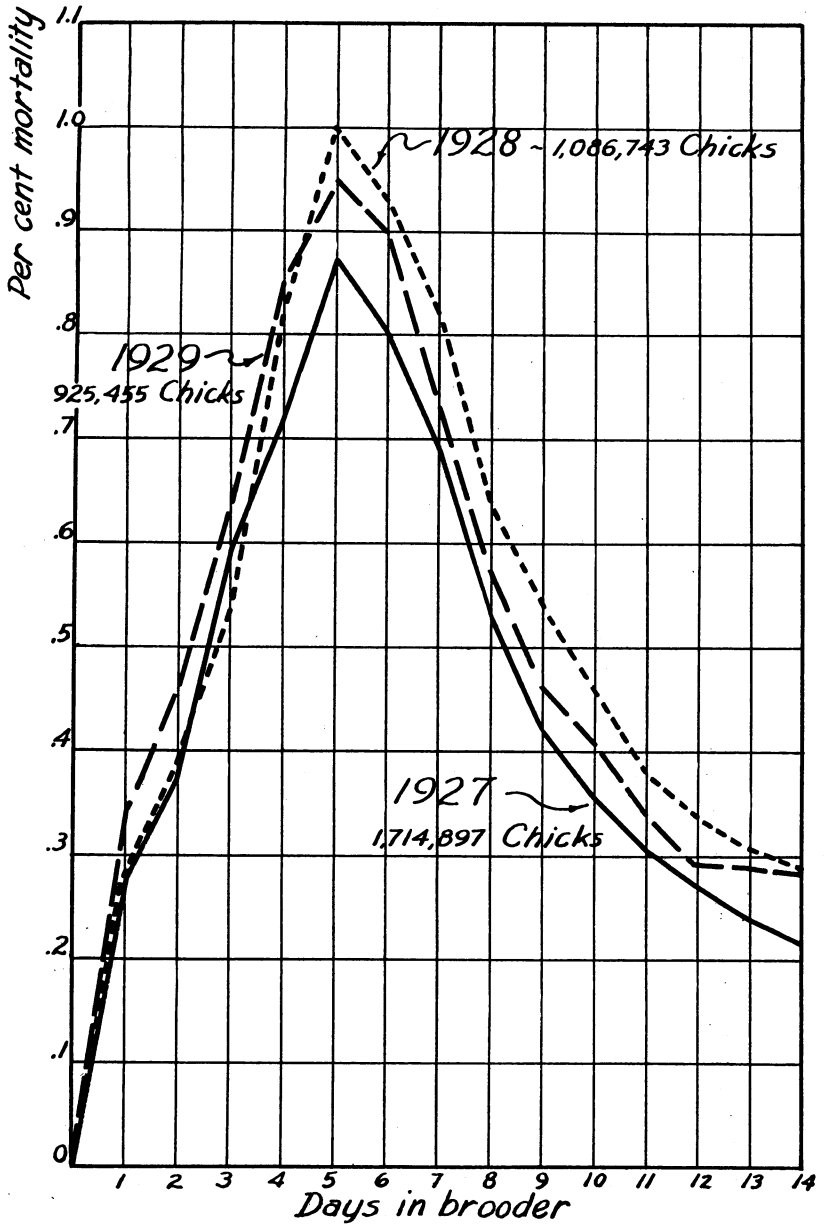

Fig. 6. The distribution of baby-chick mortality in California for the three years 1927, 1928, and 1929 shows more regularity than that for the entire study, largely because the chicks started brooding on the same day. The peak on the fifth day is sharply defined. (Data from table 13.)

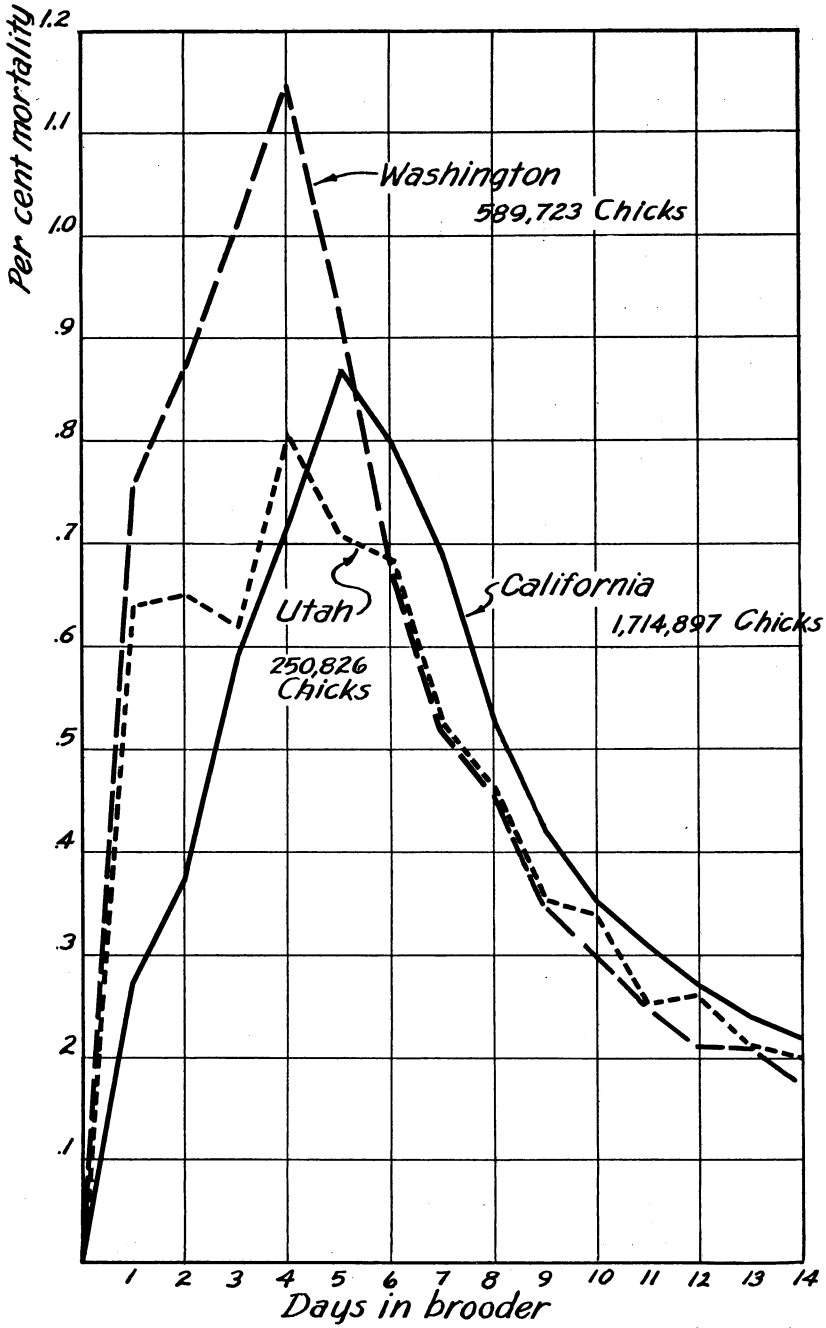

Fig. 7. The distribution of the baby-chick mortality during 1927 clearly shows that the peak of the mortality occurs on the fourth instead of the fifth day in the more distant states. The brooding period is started earlier in California and the mortality peak is at the fifth day of brooding. The influence of the more distant states in the graph in figure 5 can be clearly seen from a study of this figure. (Data from tables 13, 15, and 16.)

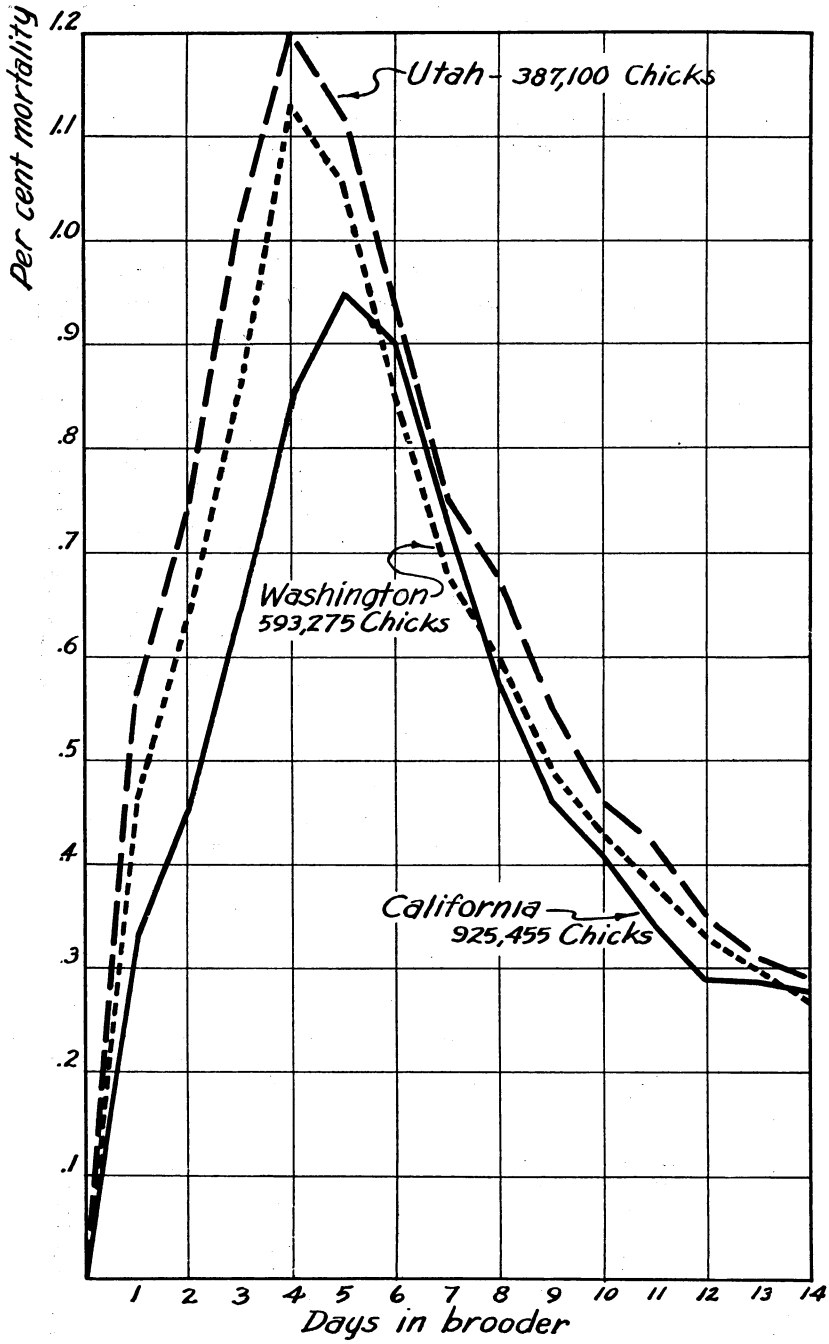

Fig. 8. The distribution of baby-chick mortality in 1929 shows the same general trend as that for 1927, except that the curves for 1929 are even more regular. The peaks of mortality correspond—Utah and Washington on the fourth day and California on the fifth day. (Data from tables 13, 15, and 16.)

TABLE 15

CUMULATIVE DISTRIBUTION OF CHICKS BROODED IN UTAH, 1927, 1928, 1929, CLASSIFIED ACCORDING TO LENGTH OF LIFE

Day	1927			1928			1929 (to August)		
	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000	Number surviving	Mortality, per cent	Empirical probability of life, chances in 1,000
On arrival	250,826	0.000	933	113,750	0.000	926	387,100	0.000	906
1	249,225	.638	940	113,232	.455	930	384,923	.562	912
2	247,606	.650	946	112,684	.484	935	382,064	.743	919
3	246,070	.620	952	112,033	.578	941	378,158	1.022	930
4	244,089	.805	960	111,167	.773	949	373,632	1.197	942
5	242,357	.710	967	110,293	.786	957	369,432	1.124	953
6	240,711	.679	974	109,411	.800	965	365,989	.932	962
7	239,461	.519	979	108,552	.785	972	363,255	.747	970
8	238,358	.461	984	107,772	.719	980	360,832	.667	976
9	237,535	.345	987	107,188	.542	985	358,849	.550	982
10	236,734	.337	991	106,735	.423	989	357,213	.456	986
11	236,137	.252	993	106,354	.357	993	355,725	.417	991
12	235,516	.263	996	106,074	.263	995	354,486	.348	994
13	235,022	.210	998	105,808	.251	998	353,379	.312	997
14	234,556	0.198	1,000	105,586	0.210	1,000	352,371	0.285	1,000

Source of data: Computations by authors based upon tables 1, 8, 9, and 10.

TABLE 16

CUMULATIVE DISTRIBUTION OF CHICKS BROODED IN WASHINGTON, 1927 AND 1928, CLASSIFIED ACCORDING TO LENGTH OF LIFE

Day	1927			1929 (to August)		
	Number surviving	Mortality per cent	Empirical probability of life, chances in 1,000	Number surviving	Mortality per cent	Empirical probability of life, chances in 1,000
On arrival	589,723	0.000	921	593,275	0.000	915
1	585,270	.755	929	590,562	.457	920
2	580,178	.870	938	586,807	.636	926
3	574,259	1.020	948	581,748	.862	935
4	567,677	1.146	959	575,145	1.135	946
5	562,415	.927	968	569,089	1.053	957
6	558,597	.679	975	564,251	.850	965
7	555,694	.520	980	560,389	.684	972
8	553,160	.456	985	557,054	.595	978
9	551,204	.354	989	554,328	.489	983
10	549,567	.297	992	551,931	.432	987
11	548,181	.252	994	549,864	.375	991
12	547,035	.209	996	548,075	.325	994
13	545,873	.212	998	546,443	.298	997
14	544,918	0.175	1,000	544,997	0.265	1,000

Source of data: Computations by authors based upon tables 1, 8, 9, and 10.

Data on Utah and Washington, usually the principal recipients of California exports, are given in tables 15 and 16. Utah is of especial interest because a representative number of broods were reported in each of the three years. It will be observed with respect to livability that Utah poultrymen one year (1927) equaled, the next year (1928) exceeded, and the third year fell below that obtained by California poultrymen. During the days previous to the peak of the mortality, there was a marked tendency for the percentage mortality among chicks brooded in Utah to be higher than for those brooded in California. The tendency for the mortality to be lower after the peak had been reached was noticeable during 1927 and 1928. The reverse was true in 1929. A comparison between the mortality of chicks brooded in Washington and that of chicks brooded in California again shows the mortality previous to the peak to be the higher. On the other hand, after the peak during 1927, the daily mortality was lower with the Washington chicks, while in 1929 the reverse was true, on 7 of the last 10 days being higher, and on 3, lower. Figure 9 depicts the brood mortality by days in Washington in 1927 and 1929. The peaks during both years occur on the fourth day. This figure should be compared with figure 6, which clearly shows that the peak of mortality for chicks brooded in this state occurs on the fifth day of brooding.

Based upon data for 1929, brood sizes shipped to Washington were larger (table 4) than for the other states. The total losses were also larger. This might be due to several factors. Whether the brooding units were actually larger is a matter of conjecture; it seems reasonable to suppose that they were. Dougherty[6] reports that in a brooding survey made by the Division of Agricultural Extension of the University of California, the number of chicks per unit did have an effect on the chick mortality. If this is the case some of the greater losses may be accounted for by this fact. It certainly cannot be claimed that a greater loss is caused by handling in transit, e.g., Utah and Washington compared with California in 1928 and 1929 (table 18). The loss in transit corresponds with at least the first day's loss in California; some of this loss in transit is normal loss. The loss in transit, however, is low. The Post Office Department considers a 'reasonable mortality rate' to be 5 per cent in transit. The difference between losses in 1928 and in 1929 is noticeable. Beginning in 1928 an improved shipping box was introduced.

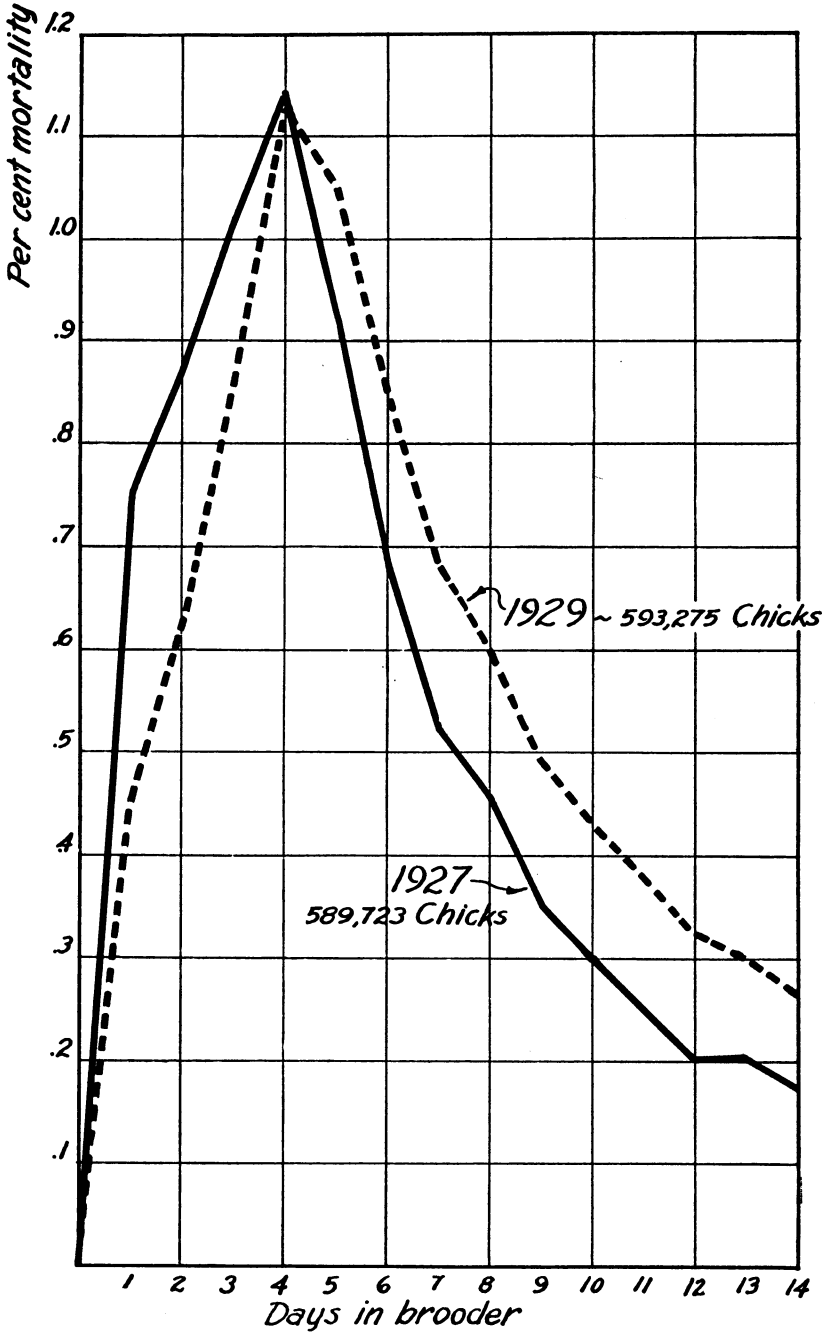

Fig. 9. The graphs depicting the brood mortality in Washington during the initial 14-day period for 1927 and 1929 show the characteristic curves. Note that the mortality peak occurs on the fourth day, which would correspond to the fifth in California. (Data from table 16.)

TABLE 17

DISTRIBUTION OF BABY CHICK MORTALITY IN PER CENT BY DAYS

Day	1927	1928	1929
1	0.447	0.314	0.452
2	.576	.414	.605
3	.710	.570	.838
4	.846	.839	1.057
5	.872	.972	1.057
6	.764	.892	.908
7	.630	.791	.741
8	.509	.630	.617
9	.396	.524	.499
10	.341	.442	.432
11	.294	.373	.375
12	.257	.326	.329
13	.232	.300	.297
14	0.202	0.270	0.277

Source of data: Computations by authors—resume of data in table 16 covering the cumulative distribution of the chicks hatched during 1927, 1928, and 1929.

TABLE 18

LOSS OF BABY CHICKS IN TRANSIT TO CERTAIN STATES, 1927, 1928, 1929

Points in	Number shipped			Number lost			Per cent lost		
	1927	1928	1929	1927	1928	1929	1927	1928	1929
California	877,606	937,010	1,025,364	4,299	5,109	6,865	0.490	0.545	0.670
Washington	153,685	10,200	103,548	1,629	42	554	1.060	0.412	0.535
Utah	520,725	286,575	543,025	7,938	1,654	3,195	1.524	0.577	0.588
Nevada	16,694	23,366	40,860	88	202	171	0.527	0.865	0.419
Arizona	22,379	45,835	40,527	401	690	632	1.792	1.505	1.559
Colorado	37,200	103,772	196,000	741	2,944	1,922	1.992	2.837	0.981
Other states	52,875	24,000	43,861	2,390	151	438	4.520	0.629	0.999
Total	1,681,164	1,430,758	1,993,185	17,486	10,792	13,777	1.040	0.754	0.691

Sources of data: Numbers and losses compiled by authors from files of certain hatcheries at Petaluma, California.

The crude death rate as indicated by the preceding cumulative frequencies and as calculated by the formula[6] $R_c = K\left(\frac{D}{P}\right)$ (Pearl[14]) is an accurate tool for its intended purpose, which is to determine frequencies of occurrence relative to the number exposed to the risk of the occurrence, but it disregards the individual observations which it represents; e.g., based upon the data in table 12, the crude death rate for all of the chicks brooded in 1927, 1928, and 1929 is 71, 77, and 85 per 1,000, respectively. Tables 19 to 30 give the actual number of broods in each frequency class for mortality. For example, in table 19 it is shown that 3 of the 2,785 broods recorded for the year 1927 reported a mortality of between 0 and 1.99 per cent for the first 14 days of brooding during January. For the entire year 117 of the 2,785 broods, or 4.20 per cent of the total, showed a mortality of less than 2 per cent. Calculations will show that 2.88 per cent of the broods sold in January had a mortality of less than 2 per cent. During the three years the percentages of broods in which the loss was less than 6 per cent were 52.06, 54.38, and 44.79 (tables 19, 20, 21). In the latter year 62.07 per cent of the raisers reported losses of less than 8 per cent. In each frequency table, 5 per cent marks the most customary center of distribution (the mode). Obviously, then, the crude death rate does not give a complete picture of what actually occurred. Five per cent is the most likely loss, and around this are grouped the losses of those on the one hand who lose more than the usual number of chicks, and on the other the losses of those who are perhaps more expert in raising chicks than the average person to whom the chicks are sent.

In tables 22, 23, and 24, will be found the frequency distribution of brood mortality in California for the years of the study. It can be calculated that the crude death rate for the years concerned was 67, 77, and 75 per 1,000 respectively (table 13). From tables 22, 23, and 24, it can be calculated that in more than half of the observations each year the loss was less than 6 per cent—56.80, 56.25, and 51.32 per cent for the years 1927, 1928, and 1929, respectively. In two of the years—1927 and 1929—the modal class was from 4.0 to 5.99 per cent, but during 1928 it was from 2.0 to 3.99 per cent. Two more broods were in the latter class in 1928 than in the former—248 compared with 246 (table 23).

[6] R_c = Crude death rate.
K = Constant. (K will be 10^2, 10^3, 10^4, etc., according to whether the basis used is 100, 1,000 or 10,000, etc.)
D = Deaths.
P = Population.

TABLE 19

Frequency Distribution of Brood Mortality,* 1927 (Entire Study)

Month	Frequency class*																	Total for month	Per cent of year's total
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† to 100.0		
January	3	20	30	14	16	8	4	3	2	2	1	0	0	0	0	0	1	104	3.74
February	8	68	145	96	48	25	12	14	8	3	3	1	3	0	0	3	5	442	15.87
March	24	135	214	173	80	40	17	8	4	7	4	1	2	1	0	1	5	716	25.71
April	37	227	280	188	108	58	38	24	6	17	5	7	6	5	2	5	15	1,028	36.91
May	14	55	42	35	27	15	7	10	5	5	1	2	0	3	0	1	4	226	8.11
June	10	16	9	6	6	9	4	0	0	0	0	1	0	1	1	0	0	63	2.26
July	2	4	2	1	1	1	0	1	0	0	1	0	0	0	0	0	0	13	.47
August	2	12	10	4	1	0	0	0	0	0	0	0	0	0	0	0	0	29	1.04
September	8	11	16	8	7	4	3	1	1	0	2	0	0	0	0	0	1	62	2.23
October	6	5	11	9	5	2	1	2	2	0	1	0	1	0	0	1	0	46	1.65
November	2	8	0	2	2	1	2	1	0	0	1	0	0	0	0	0	3	22	.79
December	1	3	10	1	6	4	2	0	1	0	0	2	1	0	0	0	3	34	1.22
Total	117	564	769	537	307	167	90	64	29	34	19	14	13	10	3	11	37	2,785	
Per cent of total	4.20	20.25	27.61	19.28	11.02	6.00	3.23	2.30	1.04	1.22	0.68	0.50	0.47	0.36	0.11	0.40	1.33		100.00

* Class intervals are given in mortality percentages.

† The mortality for broods in this class were: January, 32.6; February, 34.0, 35.4, 41.5, 43.1, 57.0; March, 34.4, 36.0, 37.0, 39.2, 43.0; April, 32.0, 32.0, 35.0, 35.3, 36.0, 37.0, 43.0, 44.4, 56.0, 58,0, 59.0, 61.0, 61.0, 67.1, 86.0; May, 36.0, 40.4, 41.0, 42.0; September, 43.6; November, 37.8, 50.5, 56.0; December, 32.4, 35.3, 41.4.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 20

FREQUENCY DISTRIBUTION OF BROOD MORTALITY, 1928 (ENTIRE STUDY)

Month	Frequency class*																Total for month	Per cent of year's total
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† to 100.0		
January	11	42	24	13	16	10	4	2	1	3	1	2	0	2	0	0	0	131	9.32
February	22	56	57	26	17	13	6	5	4	3	2	1	3	0	0	0	0	215	15.30
March	26	84	131	82	42	21	12	16	9	3	3	4	2	0	2	0	6	443	31.53
April	19	58	68	40	32	20	9	3	2	2	3	0	1	2	0	1	6	266	18.93
May	9	21	23	25	13	10	8	2	0	2	3	1	0	1	1	1	6	126	8.97
June	4	8	5	2	2	2	2	0	0	1	1	3	0	0	0	0	0	30	2.14
July	3	3	0	2	4	2	0	1	0	0	1	0	0	0	0	0	0	16	1.14
August	4	10	3	5	0	2	2	1	0	0	0	0	0	0	0	0	0	27	1.92
September	5	13	7	6	5	0	2	1	0	0	1	0	0	0	0	0	0	40	2.85
October	9	12	3	3	2	1	1	1	0	1	0	0	1	0	0	1	0	35	2.49
November	1	4	6	3	1	2	1	1	0	1	2	0	1	0	0	1	3	27	1.92
December	0	7	6	5	5	5	6	3	3	3	1	2	3	0	0	0	0	49	3.49
Total	113	318	333	212	139	88	53	36	19	19	18	13	11	5	3	4	21	1,405	
Per cent of total	8.04	22.63	23.70	15.10	9.89	6.26	3.77	2.56	1.35	1.35	1.28	0.93	0.78	0.37	0.21	0.28	1.50		100.00

* Class intervals are given in mortality percentages.

† The mortality for broods in this class were: March, 44.0, 45.0, 54.0, 55.8, 57.3, 90.0; April, 39.0, 40.6, 44.0, 47.8, 52.6, 63.0; May, 32.0, 37.0, 41.0, 43.0, 57.5, 92.0; November, 37.1, 46.0, 48.0.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 21

Frequency Distribution of Brood Mortality (Entire Study), 1929

Month	Frequency class*																	Total for month	Per cent of year's total
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† to 100.0		
January	2	38	44	27	19	5	10	4	4	2	1	1	0	2	2	0	1	162	7.52
February	16	58	72	53	23	15	9	8	4	7	0	1	2	3	3	0	2	276	12.83
March	27	127	172	127	111	60	37	22	19	17	9	6	7	6	3	1	3	754	35.02
April	22	116	148	124	80	47	35	34	19	10	10	5	6	2	3	4	17	682	31.68
May	7	29	35	24	15	10	9	9	4	6	6	3	3	3	0	2	12	177	8.22
June	2	8	7	7	4	2	2	2	2	0	1	0	1	0	1	0	3	42	1.95
July	2	4	5	4	1	1	1	0	0	1	0	0	0	0	0	0	0	19	.88
August	4	8	11	6	1	3	1	2	3	2	0	0	0	0	0	0	0	41	1.90
Total	82	388	494	372	254	143	104	81	55	45	27	16	19	16	12	7	38	2,153	
Per cent of total	3.82	18.03	22.94	17.28	11.80	6.64	4.83	3.76	2.55	2.09	1.25	0.74	0.88	0.74	0.56	0.33	1.76		100.00

* Class intervals are given in mortality percentages.

† The mortality for broods in this class were: January, 40.6; February, 43.0, 45.5; March, 45.0, 48.9, 61.0; April, 32.0, 35.0, 37.0, 37.5, 38.3, 40.0, 40.4, 44.0, 45.5, 46.3, 47.3, 50.6, 51.0, 51.0, 53.8, 61.0, 83.9; May, 33.0, 32.8, 35.0, 35.3, 37.0, 39.0, 41.0, 46.0, 48.0, 48.0, 50.0, 55.4; June, 37.9, 39.3, 41.0.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 22

Frequency Distribution of Brood Mortality, California, 1927

Month	Frequency class*																	Total for month	Per cent of year's total
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20. 0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	2.0† to 100.0		
January	2	18	29	13	12	6	4	3	1	2	1	0	0	0	0	0	1	92	5.87
February	6	59	104	68	34	14	6	7	8	3	2	1	3	0	0	1	4	320	20.42
March	12	87	132	85	45	17	8	3	0	2	2	0	1	0	0	1	3	398	25.40
April	23	105	133	64	36	23	14	10	4	6	0	0	2	2	1	2	4	429	27.38
May	2	27	23	15	13	7	3	4	2	3	1	2	0	0	0	0	1	103	6.57
June	7	7	8	4	4	6	1	0	0	0	0	0	0	0	0	0	0	37	2.36
July	2	4	2	1	1	1	0	1	0	0	1	0	0	0	0	0	0	13	0.83
August	2	11	9	4	1	0	0	0	0	0	0	0	0	0	0	0	0	27	1.72
September	7	11	16	7	7	4	2	1	1	0	1	0	0	0	0	0	0	57	3.64
October	6	5	9	8	5	2	1	1	2	0	1	0	1	0	0	1	0	42	2.68
November	2	7	0	1	2	0	2	1	0	0	1	0	0	0	0	0	2	18	1.15
December	0	3	10	1	6	4	2	0	1	0	0	1	1	0	0	0	2	31	1.98
Total	71	344	475	271	166	84	43	31	19	16	10	4	8	2	1	5	17	1,567	
Per cent of total	4.53	21.95	30.31	17.29	10.59	5.36	2.74	1.98	1.21	1.02	0.64	0.27	0.51	0.14	0.06	0.32	1.08		100.00

* Class intervals are given in mortality percentages.

† The mortalities for broods in this class were: January, 32.6; February, 34.0, 41.5, 43.1, 57.0; March, 36.0, 37.0, 43.0; April, 44.4, 56.0, 59.0, 61.0; May, 40.4; November, 37.8, 50.5; December, 35.3; 41.4.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 23

FREQUENCY DISTRIBUTION OF BROOD MORTALITY, CALIFORNIA, 1928

Month	Frequency class*																	Total for month	Per cent of year's total
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† to 100.0		
January	9	41	24	12	14	10	4	2	1	3	1	2	0	2	0	0	0	125	12.02
February	21	49	42	22	14	13	5	5	3	3	2	1	3	1	0	0	1	185	17.78
March	22	65	96	54	28	13	8	10	7	3	3	3	0	0	1	0	5	318	30.58
April	9	32	43	21	15	8	4	3	1	1	1	0	1	0	0	1	3	143	13.75
May	6	10	16	15	5	7	5	0	0	1	0	0	0	1	0	1	1	68	6.54
June	3	6	1	1	1	2	2	0	0	1	1	2	0	0	0	0	0	20	1.92
July	3	3	0	2	3	2	0	0	0	0	0	0	0	0	0	0	0	13	1.25
August	3	9	3	5	0	2	1	1	0	0	0	0	0	0	0	0	0	24	2.31
September	5	12	6	6	4	0	2	1	0	0	1	0	0	0	0	0	0	37	3.56
October	9	12	3	3	2	0	1	1	0	1	0	0	1	0	0	1	0	34	3.27
November	1	3	6	3	1	1	1	1	0	1	2	0	1	0	0	1	3	25	2.40
December	0	6	6	5	5	5	6	3	3	3	1	2	3	0	0	0	0	48	4.62
Total	91	248	246	149	92	63	39	27	1	17	12	10	9	4	1	4	13	1,040	
Per cent of total	8.75	23.85	23.65	14.33	8.85	6.06	3.75	2.60	1.44	1.63	1.15	0.96	0.87	0.38	0.10	0.38	1.25		100.00

* Class intervals are given in mortality percentages.

† The mortalities for broods in this class were: March, 44.0, 45.0, 54.0, 55.8, 57.3; April, 40.6, 44.0, 47.8; May, 41.0; November, 37.1, 46.0, 48.0.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 24

Frequency Distribution of Brood Mortality, California, 1929

Month	Frequency class*																	Total for month	Per cent of year's total
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† to 100.0		
January	2	29	33	24	14	2	8	3	4	2	1	1	0	2	2	0	1	128	13.54
February	12	35	43	37	17	10	6	5	3	3	0	1	1	2	1	0	1	177	18.73
March	11	59	70	52	42	22	12	8	4	5	6	2	3	2	2	0	1	301	31.85
April	12	52	52	27	16	11	11	9	3	1	1	1	1	1	0	0	2	200	21.16
May	2	17	17	10	3	2	2	2	1	3	0	0	1	1	0	2	3	66	6.98
June	2	6	2	4	3	1	1	0	2	0	0	0	1	0	0	0	1	23	2.44
July	2	3	3	3	0	1	1	0	0	0	0	0	0	0	0	0	0	13	1.38
August	3	7	11	5	1	3	1	2	2	2	0	0	0	0	0	0	0	37	3.92
Total	46	208	231	162	96	52	42	29	19	16	8	5	7	8	5	2	9	945	
Per cent of total	4.87	22.01	24.44	17.14	10.16	5.50	4.44	3.07	2.01	1.69	0.85	0.53	0.74	0.86	0.53	0.21	0.95		100.00

** Class intervals are given in mortality percentages.*

† The mortalities for broods in this class were: January, 40.6; February, 45.5; March, 61.0; April, 37.0, 53.8; May, 33.0, 35.3, 39.0; June, 39.3.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 25

FREQUENCY DISTRIBUTION OF BROOD MORTALITY, WESTERN STATES MINUS CALIFORNIA, 1927

Month	Frequency class*																	Total for month	Per cent of year's total
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† to 100.0		
January	1	2	1	1	4	2	0	0	1	0	0	0	0	0	0	0	0	12	.99
February	2	9	41	28	14	11	6	7	0	0	1	0	0	0	0	2	1	122	10.02
March	12	48	82	88	35	23	9	5	4	5	2	1	1	1	0	0	2	318	26.11
April	14	122	147	124	72	35	24	14	2	11	5	7	4	3	1	3	11	599	49.18
May	12	28	19	20	14	8	4	6	3	2	0	0	0	3	0	1	3	123	10.10
June	3	9	1	2	2	3	3	0	0	0	0	1	0	1	1	0	0	26	2.13
July	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
August	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0.16
September	1	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	1	5	0.41
October	0	0	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	4	0.33
November	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	4	0.33
December	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	3	0.24
Total	46	220	294	266	141	83	47	33	10	18	9	10	5	8	2	6	20	1,218	
Per cent of total	3.78	18.06	24.14	21.84	11.58	6.81	3.86	2.71	0.82	1.48	0.74	0.82	0.41	0.66	0.16	0.49	1.64		100.00

** Class intervals are given in mortality percentages.

† The mortalities for broods in this class were: February, 35.4; March, 34.4, 39.2; April, 32.0, 32.0, 35.0, 35.3, 36.0, 37.0, 43.0, 58.0, 61.0, 67.1, 86.0; May, 36.0, 41.0; 42.0; September, 43.6; November, 56.0; December, 32.4.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 26

FREQUENCY DISTRIBUTION OF BROOD MORTALITY, WESTERN STATES MINUS CALIFORNIA, 1928

Month	Frequency class*																	Total for month	Per cent of year's total
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† to 100.0		
January	2	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	6	1.63
February	1	7	15	4	3	0	1	0	1	0	0	0	0	0	0	0	0	32	8.72
March	4	19	35	28	14	8	4	6	2	0	0	1	2	0	1	0	1	125	34.06
April	10	26	25	19	17	12	5	0	1	1	2	0	0	2	0	0	3	123	33.52
May	3	11	7	10	8	3	3	2	0	1	3	1	0	0	1	0	5	58	15.80
June	1	2	4	1	1	0	0	0	0	0	0	1	0	0	0	0	0	10	2.72
July	0	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	3	0.82
August	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	3	0.82
September	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0.82
October	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0.27
November	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0.55
December	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.27
Total	22	70	87	63	47	25	14	9	4	2	6	3	2	2	2	0	9	367	
Per cent of total	6.00	19.08	23.72	17.17	12.81	6.81	3.81	2.45	1.09	0.54	1.63	0.82	0.54	0.54	0.54	0.00	2.45		100.00

* Class intervals are given in mortality percentages.

† The mortalities for broods in this class were: March, 90.0; April, 39.0, 52.6, 63.0; May, 32.0, 37.0, 43.0, 57.5, 92.0.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 27

FREQUENCY DISTRIBUTION OF BROOD MORTALITY, WESTERN STATES MINUS CALIFORNIA, 1929

Month	Frequency class*																	Total for month	Per cent of year's total
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20. 0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† to 100.0		
January	0	9	11	3	5	3	2	1	0	0	0	0	0	0	0	0	0	34	2.81
February	4	23	29	16	6	5	3	3	1	4	0	0	1	1	2	0	1	99	8.20
March	16	68	102	75	69	38	25	14	15	12	3	4	4	4	1	1	2	453	37.50
April	10	64	96	97	64	36	24	25	16	9	9	4	5	1	3	4	15	482	39.90
May	5	12	18	14	12	8	7	7	3	3	6	3	2	2	0	0	9	111	9.19
June	0	2	5	3	1	1	1	2	0	0	1	0	0	0	1	0	2	19	1.57
July	0	1	2	1	1	0	0	0	0	1	0	0	0	0	0	0	0	6	.50
August	1	1	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	4	.33
Total	36	180	263	210	158	91	62	52	36	29	19	11	12	8	7	5	29	1,208	
Per cent of total	2.98	14.90	21.78	17.38	13.08	7.54	5.14	4.30	2.98	2.40	1.57	0.91	0.99	0.66	0.58	0.41	2.40		100.00

* Class intervals are given in mortality percentages.

† The mortalities for broods in this class were: February, 43.0; March, 45.0, 48.9; April, 32.0, 35.0, 37.5, 38.3, 40.0, 44.4, 44.0, 45.5, 46.3, 47.3, 50.6, 51.0, 51.0, 61.0, 83.9; May, 32.8, 35.0, 37.0, 41.0, 46.0, 48.0, 48.0, 50.0, 55.4; June, 37.9, 41.0.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

The crude death rate for the western states minus California for the three years was 77, 74, and 92 per 1,000 (table 14). Tables 25, 26, and 27 give the frequency distribution for brood mortality during the three years. Calculations show that the number of observations falling below 6 per cent were 45.98, 48.80, and 39.66 per cent respectively for the years in question. On closer examination, the 1929 results show that 57.04 per cent of the broods showed a mortality of less than 8 per cent. In all three years the most likely loss approximates 5 per cent.

Table 2 and 3 (pages 535 and 536) indicate the relative importance of February, March, and April to the baby-chick industry. During 1927, 78.49 per cent of the broods were hatched in these months (table 2), and during 1928, 65.76 per cent (table 3). Unpublished data confirm these statements.[7] Figure 10 clearly shows the seasonal distribution of chick sales.

The seasonality of brooding in the western states outside of California is reflected in the data collected on baby-chicks sales for the three-month period March, April, and May. The records in the files of the California Cooperative Crop Reporting Service for these three years clearly show the relatively greater importance of these three months for the brooding of chicks in the western states other than California. The percentages of the total year's sales represented by these three months are as follows: 1927, 80.34 per cent; 1928, 81.01 per cent; and 1929, 85.32 per cent, respectively.

February, March, and April are more important to the poultry industry of California from the standpoint of brooding than are the other months of the year. They are, however, relatively less important than the same months in the other western states. The percentages of sales reported in California by the California Cooperative Crop Reporting Service for the three years during the months of February, March, and April combined were 73.20, 62.05, and 71.74 respectively. Corresponding data for these same three months for sales outside of California totaled 86.31, 76.30, and 85.60 per cent, respectively. California poultrymen brood more in 'off seasons.' From the limited data on hand for the three years in question there is an indication of a secondary peak in the sales within the state in September.

[7] In January, 1927, the collection of records on the sales of chicks from California hatcheries was started by Edwin C. Voorhies. Hatcherymen with a total capacity of from 3,200,000 to 5,400,000 eggs have been reporting monthly on sales of baby chicks both within and without the state. In September, 1928, this work was taken over by the California Cooperative Crop Reporting Service. Since the inauguration of this work in California the United States Department of Agricultural Economics has been collecting national statistics on sales of baby chicks.

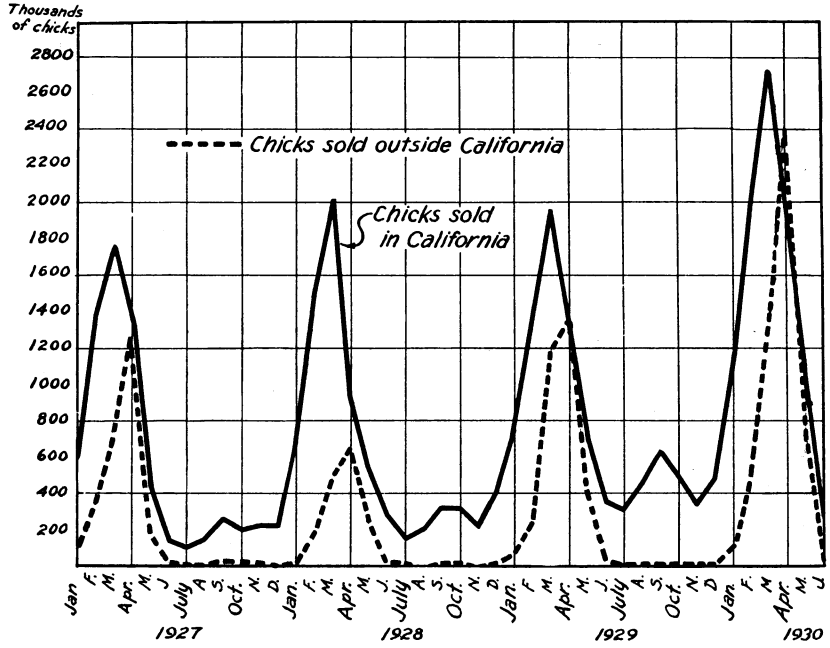

Fig. 10. Sales by California hatcheries of baby chicks both within and outside of California during 1927, 1928, 1929, and 1930. These sales represent from 30 to 40 per cent of the sales made by the hatcheries of California. Although the data plotted were not obtained from the records used in the study, they confirm some of the statements made as a result of the study of the records. Brooding is far more seasonal in the other western states than in California. It can readily be seen that chick sales in California are made earlier than they are in other states. The graphs are plotted from unpublished data on sales of baby chicks.

TABLE 28

FREQUENCY DISTRIBUTION OF BROOD MORTALITY IN SONOMA, LOS ANGELES AND SACRAMENTO COUNTIES, 1927

(The upper rows of numbers are for Sonoma County, the middle rows in italics for Los Angeles County, and the lower rows for Sacramento County)

Month	Frequency class*																
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† and up	Totals
January	0	0	6	3	2	0	0	1	1	1	0	0	0	0	0	0	0	14
	0	*8*	*11*	*3*	*5*	*2*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*31*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
February	0	7	16	19	10	1	3	1	1	1	1	0	0	0	0	0	0	60
	0	*19*	*18*	*15*	*8*	*3*	*0*	*2*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*66*
	0	8	14	4	2	1	0	0	0	0	0	0	0	0	0	0	0	29
March	2	18	23	23	10	2	1	1	0	0	0	0	0	0	0	0	0	80
	2	*19*	*31*	*12*	*7*	*3*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*76*
	0	4	12	5	0	3	0	0	0	0	0	0	0	0	0	0	0	24
April	0	13	15	13	3	1	2	1	0	0	0	0	0	0	0	0	0	48
	4	*23*	*20*	*10*	*7*	*4*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*2*	*0*	*1*	*1*	*74*
	0	3	9	2	1	1	0	0	0	0	0	0	0	0	0	0	0	16
May	0	6	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	12
	1	*7*	*5*	*4*	*2*	*1*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*21*
	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	4
June	1	1	3	0	2	1	0	0	0	0	0	0	0	0	0	0	0	8
	0	*1*	*0*	*1*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*3*
	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2

July	1	2	2	1	0	0	1	0	0	0	0	0	0	0	0	0	0	7
	0	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*3*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August	1	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	7
	1	*3*	*3*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*8*
	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
September	1	0	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	6
	1	*3*	*3*	*1*	*1*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*10*
	0	0	3	0	3	1	1	0	0	0	0	0	0	0	0	0	0	8
October	1	0	1	0	0	2	1	0	0	0	0	0	1	0	0	0	0	6
	2	*1*	*0*	*1*	*1*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*6*
	0	0	1	2	0	0	0	0	0	0	1	0	0	0	0	0	0	4
November	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2
	0	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
December	0	1	3	0	0	2	2	0	0	0	0	0	0	0	0	0	0	8
	0	*1*	*1*	*0*	*3*	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*7*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	7	32	76	64	29	9	10	4	2	2	1	0	1	0	0	0	1	258
	11	*87*	*92*	*48*	*35*	*15*	*4*	*4*	*4*	*0*	*1*	*0*	*0*	*2*	*0*	*1*	*2*	*306*
	0	17	41	14	7	7	2	0	0	0	1	0	0	0	0	0	0	89
Totals in	2.71	20.15	29.45	24.80	11.24	3.49	3.88	1.55	0.78	0.78	0.39	0.00	0.39	0.00	0.00	0.00	0.39	100.00
per cent	*3.60*	*28.43*	*30.06*	*15.68*	*11.44*	*4.90*	*1.31*	*1.31*	*1.31*	*0.00*	*0.33*	*0.00*	*0.00*	*0.65*	*0.00*	*0.33*	*0.65*	*100.00*
	0.00	19.10	46.06	15.75	7.86	7.86	2.25	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	100.00

* Class intervals are given in mortality percentages

† The mortality in this class was as follows: March, Los Angeles, 37; April, Los Angeles, 59, November, Sonoma, 37.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 29

FREQUENCY DISTRIBUTION OF BROOD MORTALITY IN SONOMA, LOS ANGELES AND SACRAMENTO COUNTIES, 1928

(The upper rows of Numbers are for Sonoma County, the middle rows in italics for Los Angeles County, and the lower rows for Sacramento County)

Month	Frequency class*																	
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† and up	Totals
January	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	0	*1*	*0*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*3*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
February	0	7	4	0	1	3	1	0	0	0	0	0	0	0	0	0	0	16
	2	*9*	*7*	*4*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*25*
	0	2	1	4	1	1	0	1	1	2	1	0	0	0	0	0	0	14
March	4	7	9	8	1	2	2	0	1	0	0	0	0	0	0	0	0	34
	3	*14*	*15*	*7*	*2*	*2*	*0*	*1*	*1*	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*47*
	1	4	3	8	5	0	0	0	0	0	0	1	0	0	0	0	1	23
April	0	2	4	0	2	3	1	0	0	0	0	0	0	0	0	1	0	13
	2	*5*	*5*	*3*	*1*	*1*	*1*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*20*
	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
May	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	0	*3*	*4*	*3*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*13*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
June	1	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	4
	0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

July	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	3
	0	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
August	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	2
	1	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*3*
	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
September	1	1	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0	7
	0	*3*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*4*
	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	*3*
October	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	1	*2*	*1*	*1*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*7*
	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
November	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	0	*1*	*1*	*0*	*1*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*4*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
December	0	3	3	2	2	2	2	2	0	1	0	0	1	0	0	0	0	18
	0	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	8	22	27	15	9	11	7	2	1	1	0	1	1	0	0	1	0	106
	9	*40*	*34*	*19*	*7*	*5*	*2*	*3*	*2*	*0*	*2*	*0*	*1*	*1*	*0*	*1*	*1*	*127*
	1	9	6	15	6	1	0	1	1	3	1	1	0	0	0	0	1	46
Totals in per cent	7.56	20.76	25.47	14.15	8.49	10.38	6.60	1.89	0.94	0.94	0.00	0.94	0.94	0.00	0.00	0.94	0.00	100.00
	7.09	*31.50*	*26.77*	*14.96*	*5.51*	*3.94*	*1.57*	*2.36*	*1.57*	*0.00*	*1.57*	*0.00*	*0.79*	*0.79*	*0.00*	*0.79*	*0.79*	*100.00*
	2.17	19.58	13.05	32.62	13.04	2.17	0.00	2.17	2.17	6.52	2.17	2.17	0.00	0.00	0.00	0.00	2.17	100.00

* Class intervals are given in mortality percentages.

† The mortality in this class was as follows: February, Los Angeles, 35; March, Los Angeles, 55.8, Sacramento, 54; April, Los Angeles, 47.8

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

TABLE 30

FREQUENCY DISTRIBUTION OF BROOD MORTALITY IN SONOMA, LOS ANGELES AND SACRAMENTO COUNTIES, 1929

(The upper rows of numbers are for Sonoma County, the middle rows in italics for Los Angeles County, and the lower rows for Sacramento County)

Month	Frequency class*																	
	0 to 1.99	2.0 to 3.99	4.0 to 5.99	6.0 to 7.99	8.0 to 9.99	10.0 to 11.99	12.0 to 13.99	14.0 to 15.99	16.0 to 17.99	18.0 to 19.99	20.0 to 21.99	22.0 to 23.99	24.0 to 25.99	26.0 to 27.99	28.0 to 29.99	30.0 to 31.99	32.0† and up	Totals
	0	3	6	7	1	0	0	0	0	0	0	1	0	0	0	0	0	18
January	*2*	*7*	*4*	*4*	*0*	*2*	*1*	*3*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*24*
	0	1	3	2	2	0	1	0	1	0	0	0	0	0	0	0	0	10
	1	3	3	4	2	2	2	0	0	0	0	0	0	0	0	0	0	17
February	*2*	*3*	*3*	*1*	*3*	*3*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*16*
	1	4	4	5	1	3	1	0	0	1	0	0	0	0	0	0	0	20
	1	2	6	3	2	2	0	0	0	0	0	0	0	0	0	0	0	16
March	*3*	*14*	*7*	*5*	*4*	*1*	*1*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*36*
	1	1	1	2	1	1	0	0	0	1	0	0	0	0	0	0	0	8
	1	5	4	2	0	2	0	0	0	0	0	0	0	0	0	0	0	14
April	*0*	*4*	*10*	*3*	*2*	*0*	*2*	*1*	*0*	*0*	*0*	*1*	*1*	*0*	*0*	*0*	*0*	*24*
	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2
May	*1*	*2*	*4*	*2*	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*1*	*12*
	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
	0	1	1	2	2	0	1	0	0	0	0	0	0	0	0	0	0	7
June	*0*	*2*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*2*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	1	2	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	6
July	*0*	*1*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*3*
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	4
August	*0*	*4*	*2*	*1*	*0*	*0*	*0*	*2*	*1*	*1*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*11*
	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	5
	5	16	23	19	8	7	5	0	0	0	0	1	0	0	0	0	0	84
Total	*8*	*37*	*31*	*17*	*9*	*6*	*4*	*6*	*3*	*1*	*0*	*1*	*2*	*1*	*0*	*1*	*1*	*128*
	2	9	12	11	4	5	2	0	1	2	0	0	0	0	0	0	0	48
Totals in	5.95	19.05	27.38	22.62	9.53	8.33	5.95	0.00	0.00	0.00	0.00	1.19	0.00	0.00	0.00	0.00	0.00	100.00
per cent	*6.25*	*28.91*	*24.22*	*13.28*	*7.03*	*4.69*	*3.13*	*4.69*	*2.34*	*0.78*	*0.00*	*0.78*	*1.56*	*.078*	*0.00*	*0.78*	*0.78*	*100.00*
	4.17	18.75	25.00	22.91	8.33	10.42	4.17	0.00	2.08	4.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00

* Class intervals are given in mortality percentages.

† The mortality in this class was: May, Los Angeles, 39.

Source of data: Computations by authors based upon hatchery records at Petaluma, California.

The performance of chicks brooded in the three California counties of Sonoma, Sacramento, and Los Angeles was studied (tables 28, 29, and 30). These counties represent three separate districts, alike in that poultry is kept on a commercial scale, but quite unlike with respect to climate, history and equipment. Newer districts are generally considered to be more progressive in some matters of management, hence attention is invited to the fact that Sonoma County or the 'Petaluma district' is the oldest of the three from the standpoint of the poultry industry. The Los Angeles area has a climate typical of the south Pacific Coast region. Sacramento County, on the other hand, has a climate representative of the interior valleys of the state. From the standpoints of numbers of poultry and of egg and chicken production, Sonoma and Los Angeles are the ranking counties of the state.[17] Sacramento County in 1925 ranked fifth among the counties of the state from the standpoint of numbers of chickens containing less than Alameda or San Diego County. From either standpoint Sacramento was the most important of any of the interior counties of the state in 1924. Taken as a unit these three counties reported 58.08, 41.76, and 42.52 per cent of the chicks brooded within the state for 1927, 1928, and 1929, respectively. Evidently this is somewhat representative of their place in the industry of the state since these three counties in 1925 accounted for 42.88 per cent of the chicken population of the state and 45.89 per cent of the estimated total egg production.

Tables 28, 29, and 30 show the frequency distribution of mortality by months for these three counties. Table 31 shows the average loss (mode) for the three years for the entire study, the state, and the three counties. It is based upon the results most frequently encountered in each section. Since each average deals with a different number of chicks, direct comparisons may not be strictly valid. However, the number shown in each case would seem to be representative. Only two values (Sacramento County in 1928 and 1929) are based upon less than 100,000 chicks. These modal values are strikingly uniform and a higher probability of life is indicated than is shown by tables 12 to 16, inclusive. In these latter tables the actual mortality is used, while in table 31 it is the modal or most probable mortality that has been calculated.

In table 32 the arithmetic means of the mortality for the three years for the entire study, the state, and the three counties are given, together with the calculated standard deviations and the coefficients of variability. The data enumerated in table 32 are those which the layman usually has in mind when 'average' mortality is mentioned.

The averages (modes) recorded in table 31 are those which the authors feel are far more representative.

TABLE 31

A COMPARISON OF THE AVERAGE (MODAL) LOSS IN THREE COUNTIES WITH THE AVERAGES FOR THE STATE AND FOR THE STUDY; IN PER CENT

Year	Entire study	California	Sonoma County	Sacramento County	Los Angeles County
1927	4.98	4.85	5.10	4.90	4.73
1928	4.80	3.46	4.81	7.00	3.57
1929	4.98	4.88	5.09	5.10	3.59

Sources of data: Computations by authors on basis of formula:

$$\text{Mode} = L + \frac{F_2}{F_2 + F_1} \times i$$

L = Lower limit of modal class. F_1 = Frequency of class next below modal class.
F_2 = Frequency of class next above modal class. i = Class interval.

TABLE 32

MEANS OF MORTALITY FIGURES FOR THE STUDY*

Year	Entire study			Other states			California		
	M	σ	V	M	σ	V	M	σ	V
1927	7.42	6.42	86.55	7.99	7.02	87.88	6.98	5.89	84.58
1928	7.66	7.72	100.73	8.44	9.72	115.14	7.39	6.82	92.39
1929	8.76	7.43	84.86	9.42	8.08	85.79	7.69	6.26	81.35

Year	Sonoma County			Sacramento County			Los Angeles County		
	M	σ	V	M	σ	V	M	σ	V
1927	6.38	4.01	62.90	6.08	2.94	48.32	6.36	5.33	86.37
1928	7.09	5.08	71.68	8.96	8.15	90.92	6.53	6.26	95.80
1929	6.40	3.82	59.69	7.04	4.13	58.72	7.17	6.26	87.36

*M = arithmetic mean of mortalities. V = coefficient of variability.
σ = standard deviation. Source of data: Computations by authors.

As has been pointed out, an average, by itself, has little significance unless the degree of variation in the given frequency distribution is known. If the variation is so great that there is no pronounced central tendency, an average has no significance. That there is a central tendency in the mortality of baby chicks has already been shown (tables 19–21). As yet, however, no measure has been given of the degree to which the items included in the original distributions depart or vary from the central value. It is therefore desirable to measure the degree of variation or dispersion.

In this study the measure which has been used is the standard deviation, or the root-mean-square deviation of the individual items

from the mean. If the distribution were normal or only slightly skewed, about two-thirds of all the cases would be included when a distance equal to the standard deviation is laid off on each side of the mean. In table 32 it is shown that the mean of the mortality rates for the entire study for 1927 was 7.42 per cent. The standard deviation for the entire year was 6.422. Two-thirds of all the cases of mortality are likely to fall on either side of the mean (7.42) within a range of 12.84 per cent. If the standard deviation for the entire study in each of the three years is examined, it will be seen that the dispersion for the three years is fairly regular. It was greater in 1928 than it was in 1927 or 1929, both in the entire study and in all of the divisions into which the study has been segregated. Generally speaking, the dispersion for mortality rates outside of California was greater than that within the state.

The frequency distribution of the brood mortality in the three counties for the three years are shown in figures 11, 12, and 13. These figures show clearly the tendency for mortality to center at approximately 5 per cent.

With but one exception losses were uniformly lower in 1928 than in 1927 or 1929. The high modal average that prevailed in Sacramento County in 1928 (table 29) can be explained only on the basis of conjecture. The differences between the counties are interesting. Throughout the three years the chicks brooded in Los Angeles County show a lower mortality, whether a comparison is made with the total number of chicks brooded, the number brooded in the state, or the number brooded in Sonoma or Sacramento County. It is not apparent that the chicks in the latter county were spared by the force of mortality despite the fact that most of them were reported during the natural brooding season. Sonoma and Los Angeles counties reported for practically every month of the year.

The broods in Sonoma County were the largest and those in Los Angeles County the smallest of the three counties (tables 5 and 33 and fig. 14) and it can be noted that the broods in Sonoma County average twice as large as those for the entire study. The tendency was for the Sacramento broods to be somewhat larger than the average, while during two out of the three years in question the broods in Los Angeles County were smaller than the average. Sonoma County gives evidence of small absolute dispersion when compared with either Sacramento or Los Angeles County. In the case of Sacramento County the paucity of material undoubtedly had an effect on the final results.

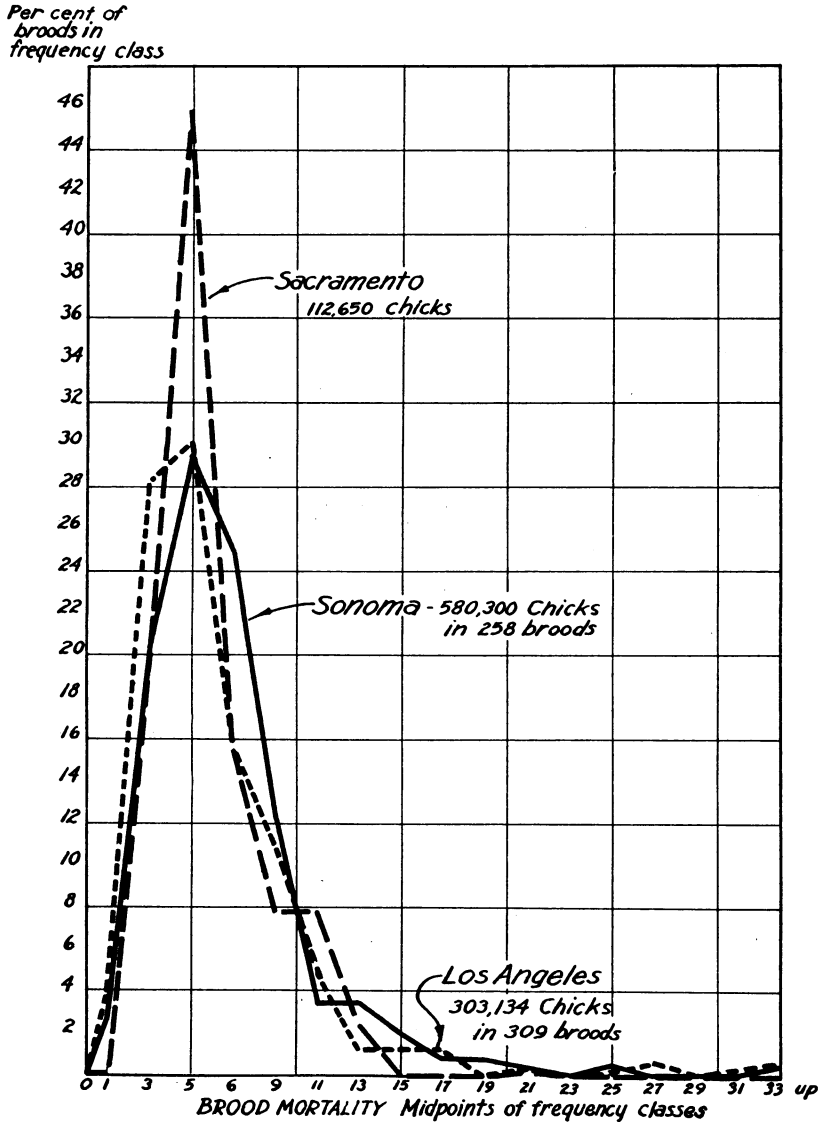

Fig. 11. The frequency distribution of brood mortality in Sonoma, Sacramento, and Los Angeles counties for 1927 shows clearly that although there is uniformity in the mortality distribution, the mode being about 5 per cent, there is, nevertheless, considerable difference in the percentages of broods in the modal class. (Data calculated from table 28.)

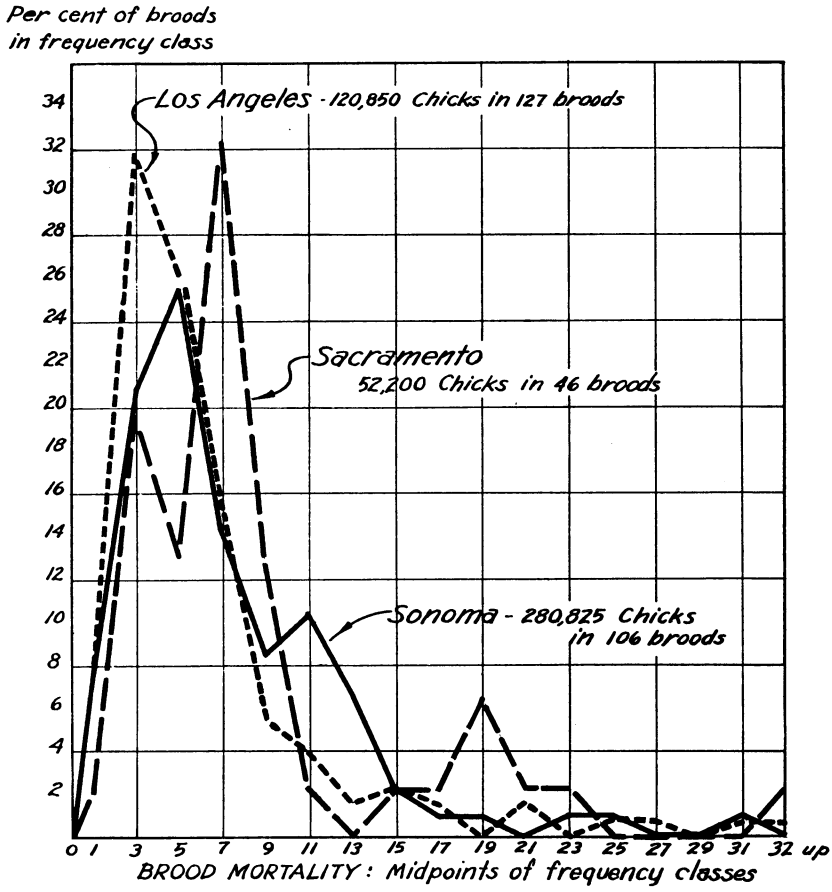

Fig. 12. The modal classes were different for the counties during 1928. The losses in Sacramento County were high, in Los Angeles County low, and in Sonoma County close to the 1927 and 1929 averages. (Data calculated from table 29.)

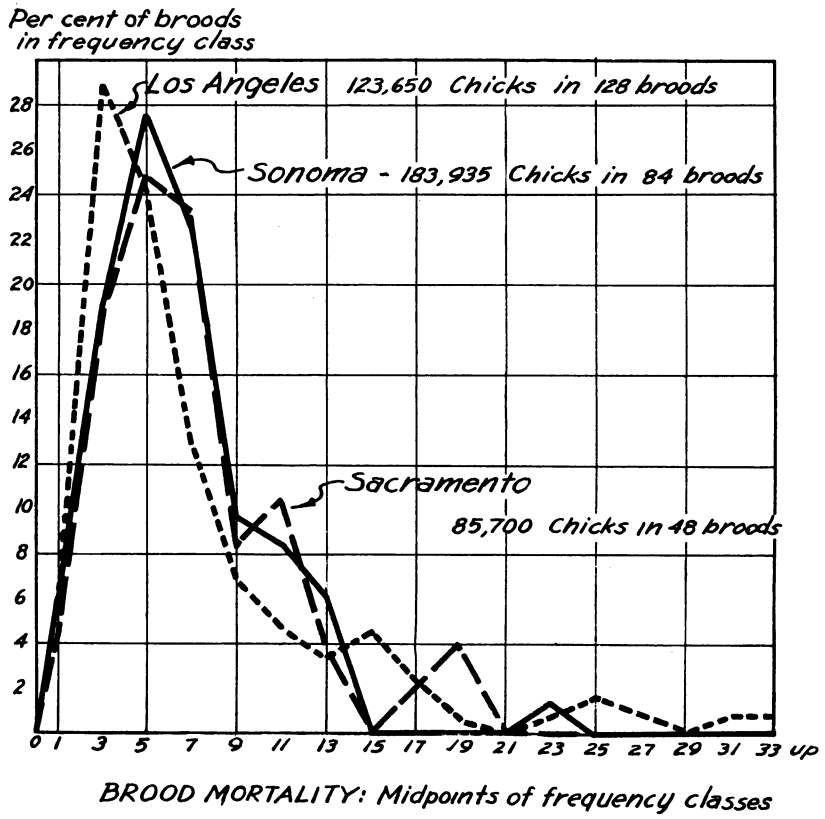

Fig. 13. A study of the frequency distribution of the brood mortality in Sonoma, Sacramento, and Los Angeles counties during 1929 gives evidence that Sonoma and Sacramento counties showed mortalities close to a mode of 5 per cent, while Los Angeles was lower. Figures 11, 12, and 13 show clearly that the mode should normally be about 5 per cent. It is shown plainly that many poultrymen have a lesser mortality. (Data calculated from table 30.)

Poultrymen are of the general opinion that certain months of the year rank as preeminent for brooding. This is very readily seen by brooding reported in this study and by the total sales of baby chicks of a large number of hatcherymen in all sections of the state. An attempt has been made to give a seasonal variation of livability in table 34. It must be borne in mind that this is an historical study,

TABLE 33

ARITHMETIC MEAN OF BROOD SIZES, 1927–1929

Figures represent the number of chicks in each brood

Year	Entire study	Sonoma County	Sacramento County	Los Angeles County
1927	1,073	2,290	1,319	1,026
1928	1,036	2,985	1,399	1,033
1929	1,060	2,229	1,833	1,019

Source of data: Calculations by authors.

TABLE 34

INDICES OF SEASONAL VARIATION OF LIVABILITY, BASED ON ALL CALIFORNIA REPORTS, 1927, 1928, AND 1929

	Actual livability*	Indices of seasonal variation
January	92.72	100.52
February	92.83	100.64
March	92.91	100.72
April	93.01	100.83
May	91.86	99.59
June	92.57	100.36
July	94.03	101.94
August	94.11	102.02
September	93.98	101.88
October	93.03	100.85
November	87.09	94.41
December	88.77	96.24
Average	92.24	100.00

*Weighted arithmetic mean of actual livability percentages.
Source of data: Calculations by authors on basis of original data.

consequently table 34 cannot be interpreted in terms of chick vitality alone. Other factors can and do exert an influence that must be taken into account. Again in evaluating this table it should be remembered that the majority of the chicks were brooded in the three months of February, March, and April. Various interpretations may be attached to the fact that the heaviest hatching months

coincide with the months during which livability was high. It shows at least that chicks sent out at the height of the season have as high a livability as those sold during the other months of the year. This would seem to refute the statement that is sometimes made to the effect that weaker chicks are sold at the height of the brooding season.

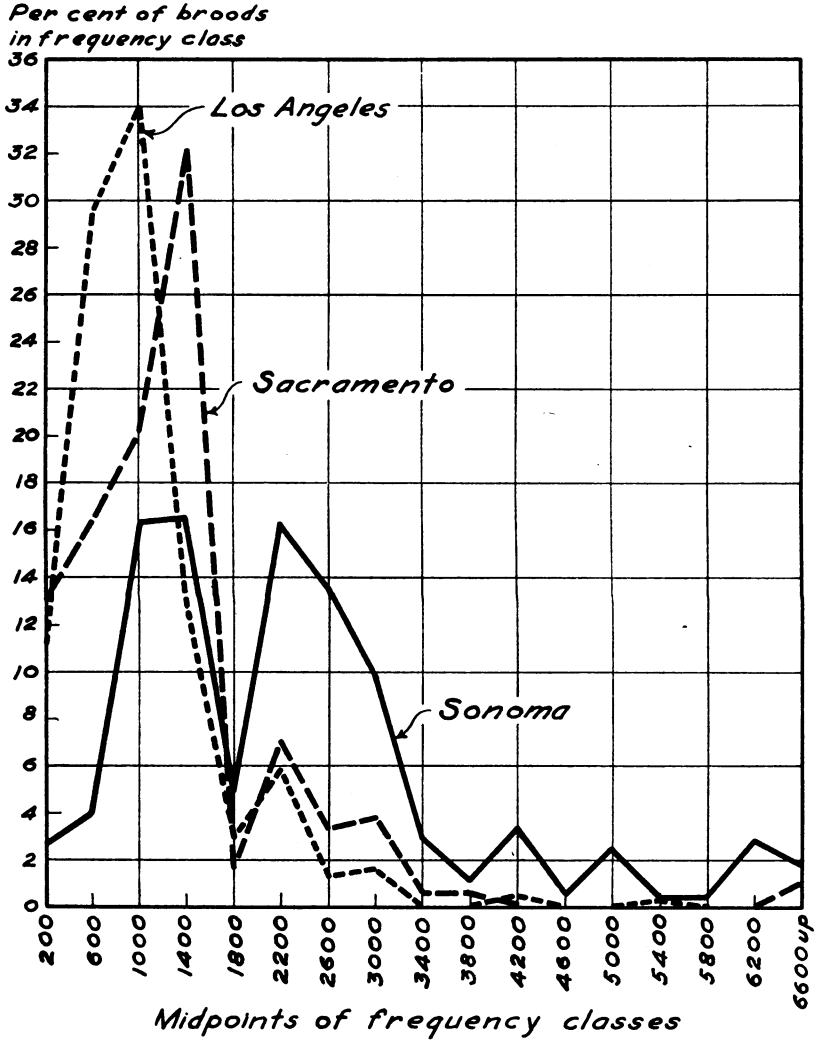

Fig. 14. Distribution of brood sizes in Los Angeles, Sacramento, and Sonoma counties during the three years 1927, 1928, and 1929. Broods in Sonoma County were far larger than in either of the other two counties. Broods in Los Angeles and Sacramento counties were found mainly in the frequency classes with midpoints below 3,400.

CONCLUSIONS

The fifth day marks the peak of mortality during the first 14 days of the brooding period of chicks. After the fifth day losses normally decline.

Indications are that there is a typical curve depicting the chances of life for a baby chick during the first 14 days of the brooding period. Baby chicks have approximately 920 chances out of 1,000 of reaching the fifteenth day of the brooding period.

The modal loss during the initial two weeks of brooding can be considered to be approximately 5 per cent.

There is little difference in the quality of baby chicks sent out by commercial hatcheries from month to month and from season to season.

There are no marked indications that early feeding is an advantage.

There were no marked changes or differences in the distribution, variability, or extent of mortality during the three years studied.

On account of the lack of sufficient data, no conclusions can be drawn from this study concerning the effect of brood size on mortality.

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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:

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

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