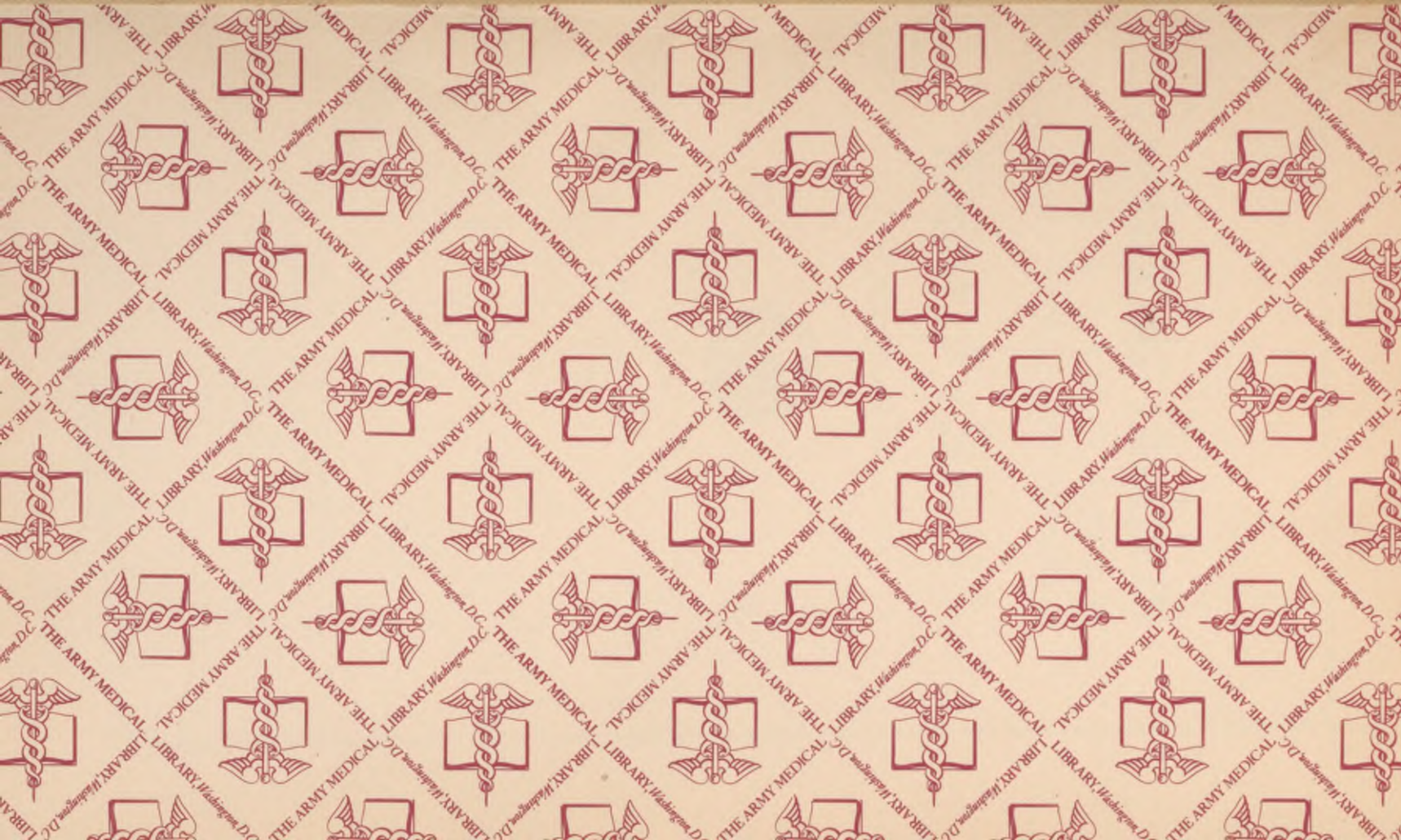
CALIFORNIA DEPT. OF PUBLIC HEALTH

TRICHINOSIS PROBLEM IN CALIFORNIA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Trichinosis Problem
IN CALIFORNIA

Report of a Survey

1940–1941

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Zoologist

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC HEALTH
IN COOPERATION WITH THE
U. S. PUBLIC HEALTH SERVICE

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FOREWORD

The author wishes to express his appreciation to Surgeon L. B. Byington and Medical Director N. E. Wayson, Medical Officers in Charge, Plague Suppressive Measures Laboratory, U. S. P. H. S., for their cooperation in providing office and laboratory space for conducting this work. Thanks are also due to the staff of the survey, who, through their cooperation, made it possible for the work to be carried out smoothly. Mention should also be made of the cooperation of the meat packing industry of the State which willingly supplied us with data and assisted us in procuring specimens.

The epidemiological data were supplied by Miss I. M. Stevens, Supervising Morbidity Statistician. Her generous cooperation in this and other matters is much appreciated.

Several other members of the State Department of Public Health have assisted in the preparation of the manuscript. Their able assistance has greatly facilitated its preparation and thanks are due them.

Trichinosis Problem in California

Health authorities in California have been aware for a number of years that trichinosis is relatively more common in the State than in a number of other States. Since there is no known treatment, drug or otherwise, which will destroy the parasite causing the disease, it is imperative that methods be developed to prevent its occurrence. In order to have available the factual data basic to the development of such methods, the State Board of Public Health directed the institution of a survey of the problem. The survey was specifically charged with determining the role of the garbage fed hog in the problem, the importance of rodents as agents of infection in the hog, the frequency with which the parasite occurs in pork products, the study of the epidemiological aspects of the disease, and to cooperate with the medical profession with regard to the use of the trichina intradermal and precipitin reaction in diagnosing infections with the parasite. The results of this work are herein reported.

A discussion of the organism which causes trichinosis and its life cycle is basic to understanding the problem and the methods by which it might be controlled. The disease is caused by a small parasitic nematode or round worm known as *Trichinella spiralis*. The adult worms are most commonly found in the small intestine. Their size depends on their sex; female worms are 3-4 mm. in length and about 100 microns in diameter; male worms are 1.4-1.6 mm. in length and 40-50 microns in diameter. The infective larvae are found in the striated or voluntary muscle of the same host in which adults occur. These larvae are about 1 mm. in length.

Natural infections with the parasite have been found in many carniverous and omniverous mammals. Chickens and other birds have never been found infected under natural conditions; however, certain birds have been experimentally infected. The larvae do not always develop in a normal manner in these. No infections of cold-blooded animals have ever been reported. Therefore, as far as man is concerned, trichinous meat from mammals, and in particular, pork, is the source of infection.

The life cycle of *Trichinella spiralis*, or trichina as the worm is commonly known, is as follows. Upon the ingestion of meat containing infective larvae, the capsule surrounding the larva is digested off by the action of gastric juice and the young worm is liberated. These then pass into the small intestine where they undergo further development. In this location the sexes develop to maturity, usually within 72

hours, and mate promptly. The female worms then burrow into the mucosa or lining of the intestine and start to discharge living young within six to seven days after infection. Larval production may continue for six or more weeks.

At birth the young larvae are about 100 microns in length and 6 microns in diameter. They migrate from the female worm into the lymph spaces and are carried passively by the lymph flow, through the thoracic duct, into the venous circulation and thence to the right heart. After attaining the arterial circulation by way of the pulmonary capillaries, the larvae are carried to the voluntary muscles.

Larvae are most numerous in the blood stream from the eighth to twenty-fifth day after infection. They may begin to penetrate the muscles as early as the ninth to tenth day after infection, but are extremely difficult to find before the fifteenth day. This is due to their small size and to the fact that relatively few worms have reached the muscles prior to this time.

In the voluntary muscles the larvae penetrate the fibers and undergo rapid growth in the substance of the fibers. Ten days to two weeks after penetration of the fibers, the larvae reach a length of approximately 1 mm. and become spirally coiled, at which time they have reached the infective stage. This stage may be reached as early as 21 days after infection. The presence of the worms in the muscle fibers causes marked degenerative changes resulting in the formation of a membranous capsule or cyst about the larva, so that typical

encysted larvae are found about six weeks after infection. The cysts usually contain a single larva, but two or more larvae have been seen within a cyst. The deposition of calcium about the cyst wall begins in eight to 10 months. Complete calcification may not occur for several years. The larvae may remain alive for several years. When they die they may disintegrate or they may become calcified.

Wright and Brady (1) give a concise description of the symptomatology of trichinosis. This description is quoted below.

"The symptoms of trichinosis are very diverse and may affect any system of the body with the possible exception of the reproductive system. The intensity of the disease is extremely variable and is dependent for the most part on the degree of infection and the resistance of the individual. Thus, one may encounter all gradations of symptoms ranging from a mild, almost subclinical syndrome to those characterizing a severe fulminating fatal infection. Because of this, it is not surprising that all cases of the diseases are not readily recognized and the symptoms are sometimes confused with those of half a hundred other diseases which they may simulate.

"In some cases, the initial response to infection is referable to the gastro-intestinal tract and is manifested by nausea, vomiting and diarrhea. These symptoms may be noted as early as 24 to 48 hours after the ingestion of trichinous meat. Occasionally, they appear later. Many cases of trichinosis show no gastro-intestinal symptoms; such symptoms are most likely to be encountered in severe infections. The fever in most cases is irregular with a peak of about 103° F. However, there are recorded cases in which the temperature has gone higher with a plateau typhoid-like curve or with the intermittent septic type of temperature. The fever usually subsides by lysis during convalescence.

"A persistent edema of the face may appear about the ninth or tenth day of illness. This edema is most apparent in the suborbital tissue and may also involve the conjunctivae with bulbar chemosis. The patient may complain of photophobia. Edema in other parts of the body, particularly the dependent portions, may occur later in the course of the disease.

"Muscle tenderness and soreness are frequently present. Pain is evidenced mostly on movement of the muscles. The myalgia is frequently most pronounced in the larger muscle masses such as those of the thighs, calves, shoulders and back. However, mastication and deglutition may be painful and marked involvement of the diaphragm and intercostals may lead to respiratory difficulties. The tenderness and pain usually reach their height four to six weeks after onset and may not completely subside until a year or two after acute illness.

"Petechiae and ecchymoses may occur subcutaneously in various parts of the body. Subungual splinter hemorrhages are said to be a

diagnostic feature but occur only in a relatively small proportion of the cases. There may be an annoying pruritis with or without skin lesions.

"Electrocardiograph studies indicate that myocardial damage may occur during the acute phase of illness due to the passage of large numbers of larvae through the heart muscle. Not infrequently there is involvement of the central nervous system due to the invasion of the larvae with a resulting clinical syndrome which may simulate closely that of encephalitis, meningitis, or myelitis. The passage of the larvae through the lungs may result in severe congestion which may be followed by bronchopneumonia with fatal termination in the fifth or sixth week of illness. The urine may show a slight amount of albumin and contain casts.

"The acute phase of the disease usually subsides in about six to eight weeks. However, symptoms of muscle pain and tenderness and inordinate fatigue may incapacitate the patient for months and persist for a year or more."

SYMPTOMATOLOGY

Stages	*Time of onset after infection*	*Location of parasites*	*Symptoms which may be exhibited*	*Sometimes tentatively diagnosed as:*
Enteral	24 to 72 hours	Larvae and Adults in Intestinal Lumen and Villi	Nausea Vomiting Diarrhea Constipation Abdominal Pain	Typhoid Fever Food Poisoning Intestinal Influenza Colitis Appendicitis
Parenteral	after 4 to 5 days	Larvae in Blood Stream and Muscles	Eosinophilia Irregular Hyperpyrexia Edema (Especially Suborbital) Conjunctivitis Photophobia Myalgia Sore Throat Dyspnoea Cough Scarlatiniform Rash Rose Spots Urticaria Pleurisy Pneumonia	Arthritis Rheumatism Upper Respiratory Infection Laryngitis Conjunctivitis Influenza Intercostal Neuritis Measles Frontal Sinusitis Asthma Pleurisy Pneumonia
		Larvae Passing Through Heart	Chest Pain Tachycardia Apical Murmurs Dicrotic Pulse	Myocarditis Endocarditis
		Larvae in Brain and Meninges	Severe Headache Malaise Marked Hyperpyrexia Disorientation Delirium Coma	Encephalitis Meningitis Poliomyelitis

The above discussion, which is illustrated by chart 1, shows clearly the complex picture of trichinosis. It is understandable from this how the 50 or more other diseases listed by Hall (2) have been confused with trichinosis. It also indicates that the cases reported in the registration area are probably not a true index of the extent of the occurrence of the disease.

The records of the California State Health Department show that 722 cases of trichinosis have been reported during the past eleven years (1930 through 1940), 715 of which originated within the State. This is an average annual case rate of 11.3 per 100,000 population (based on the estimated 1935 population). Undoubtedly most of these cases represent frank, fully developed trichinosis. That a well organized health department, upon investigation of reported cases, frequently finds more cases is well illustrated by the report of Vener (3) which pointed out that the epidemiological investigation of several suspected cases revealed 25 cases. However, there is no way of tracing unrecognized cases or determining the number of these. Therefore, the number of reported cases does not represent a true index of the prevalence of the disease. Further evidence that infection with trichinae is much more common than indicated by the number of reported cases is provided by the surveys of necropsy material. McNaught and Anderson (4) reported finding an incidence of 24.0 per cent in 200 human diaphragms from residents of San Francisco. Butt & Lapeyre (5) reported an incidence of 18.2 per cent in 170 human diaphragms from residents of the vicinity of Los Angeles. The degree of infection in some of these diaphragms would indicate possible clinical trichinosis although no history of such an illness was obtainable on any of the infected patients.

According to the figures presented by Sawitz (6) California ranked first in the average annual case rate per million population for the seven years, 1930-1936. Sawitz takes care to point out the factors which might influence the veracity of his figures, such as, the efficiency of the reporting of cases and the consciousness of trichinosis on the part of the medical profession in an area. It therefore seems justifiable to believe that the disease may be several times more prevalent than the number of reported cases would indicate.

Laboratory Methods

Various types of specimens were collected for examination for trichinae. They were examined by the digestion-Baermann method as described by Kerr, Jacobs and Cuvillier (7). This is a standard method and is essentially a digestion of the specimen in artificial gastric juice consisting of 5 grams pepsin, 7 cc. concentrated HCl in a liter of water, screening off the larger particles, pouring into

settling funnels and examining the sediment for trichinae. In examining human diaphragms, the digestion-Baermann method was supplemented by a direct microscopic examination using a press as described by Nolan and Bozicevich (8).

The digestion-Baermann method is very dependable for the detection of all infections with living trichinae. Since most swine are slaughtered when less than a year old, it was not necessary to use the direct microscopic examination which is particularly valuable in the detection of infections with dead trichinae. Thus, the data given below are not an absolute incidence of infection, but only relative to the capabilities of infecting man.

With regard to the examination of human diaphragms, it was desirable to determine as far as possible the absolute incidence of infection. The direct microscopic method was therefore used on these specimens as a supplementary method. It was also used on any meat specimens suspected of causing a case of trichinosis or on any specimens suspected of being subjected to preservatives other than boric acid.

Specimens which were several days in transit to the laboratory were shipped in powdered boric acid. This retarded bacterial decomposition but had no effect on the viability of any trichinae contained in them. Such specimens were washed thoroughly in running tap water to remove all of the boric acid before they were digested.

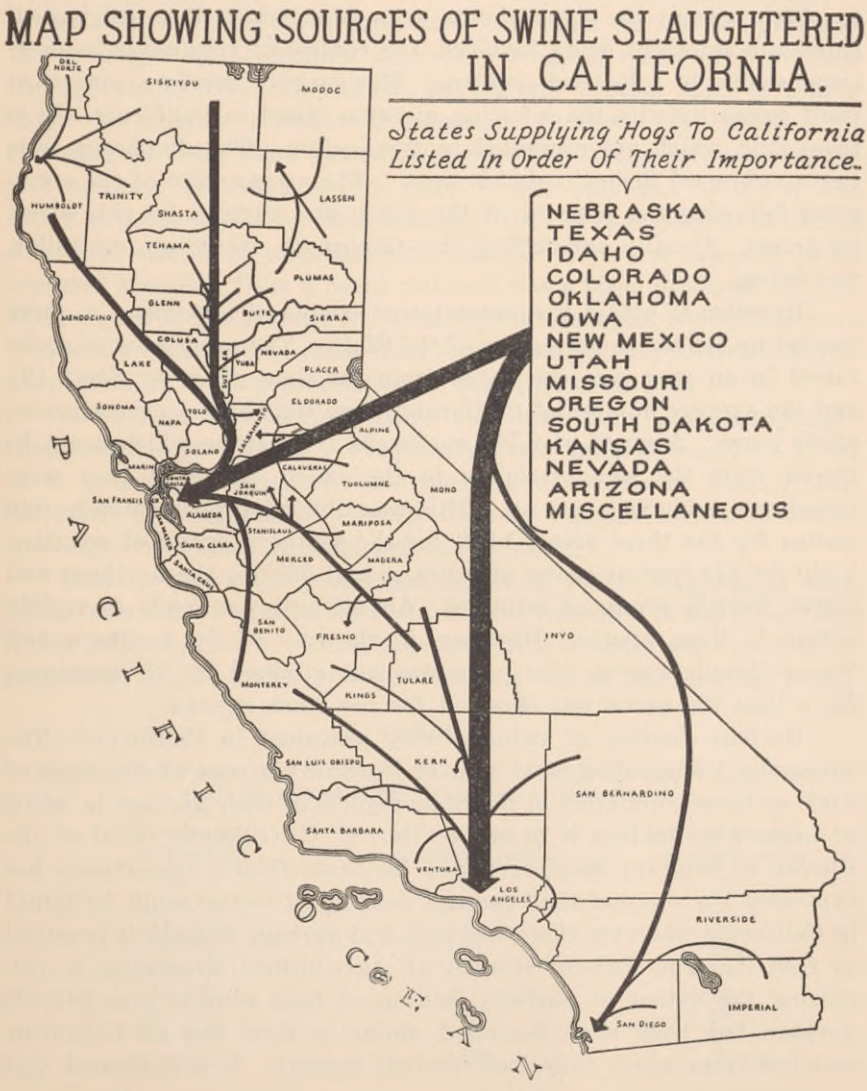
In presenting the data the State has been divided into three areas which provide a better analysis of the problem. These areas are (1) Southern, including Imperial, Kern, Los Angeles, Orange, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara, and Ventura counties; (2) Central, including Alameda, Butte, Colusa, Contra Costa, Fresno, Glenn, Kings, Lake, Madera, Marin, Mendocino, Merced, Monterey, Napa, Sacramento, San Benito, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Solano, Sonoma, Stanislaus, Sutter, Tehama, Tulare, Yolo, and Yuba counties; (3) Northern and Sierra Nevada, including Alpine, Amador, Calaveras, Del Norte, El Dorado, Humboldt, Inyo, Lassen, Mariposa, Modoc, Mono, Nevada, Placer, Plumas, Shasta, Sierra, Siskiyou, Trinity, and Tuolumne counties.

The first, or southern group of counties, represents that portion of the State containing the largest population, mostly urban. It also contains a large proportion of arid desert country as well as large orchard districts. The second, or central group of counties, is the next in population, slightly less than half of which is urban population. It also contains the great valley agricultural area. The third, or northern and Sierra Nevada group of counties, has the smallest population which is largely rural. This area is predominately mountainous although certain portions of it are valuable agricultural districts.

Incidence of Trichina Infection in Swine

The well established fact that man most frequently acquires infection with trichinae through the consumption of raw or insufficiently cooked pork makes necessary a study of pork production and the methods whereby swine might acquire an infection. It also requires an analysis of the sources of pork marketed in California.

Insufficient swine are raised in California to supply the demand, therefore many head are shipped in from other States for immediate slaughter. Map 1 shows the sources of swine slaughtered in California.



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The average number of swine slaughtered here for the past 20 years is about 1,650,000 of which number only about 650,000 were raised within the State. The 1,000,000 imported head are from the following States listed in the order of their importance: Nebraska, Texas, Idaho, Colorado, Oklahoma, Iowa, New Mexico, Utah, Missouri, Oregon, South Dakota, Kansas, Nevada, Arizona, and minor shipments from a few other States. These shipments are affected by the large middle western hog markets, price controlling whether the hogs travel east or west for slaughter. Thus, 60 per cent of the swine slaughter in California is made up from animals whose history it would be impossible for us to obtain except the approximate area from which they originated. Interstate shipment being involved, the control of trichinosis in these swine should be a Federal problem. This survey, therefore, concerned itself primarily with the infection in swine raised in California. It is these data which are presented in this section. The diaphragm was the muscle used throughout this work. The average size of the specimens following the removal of the fascia and surplus fat was about 50 grams. Usually one-half of the diaphragm, including one pillar, was taken.

In order to obtain a representative sample of specimens, a quota was set up for the three regions of the State. The proportion of swine raised in an area was calculated from the data given by Scott (9) and the average number of California swine slaughtered over a period of 20 years. A quota of 5,750 specimens from swine which could be traced from the slaughterhouse to the ranch on which they were raised was arbitrarily set up. This was divided proportionately into quotas for the three areas, 1,680 for the southern group of counties, 3,540 for the central group of counties and 530 for the northern and Sierra Nevada group of counties. An attempt was made to rigidly adhere to these quotas. However, in the case of the northern and Sierra Nevada region, the quota was not attained by 31 specimens. More than the quota was obtained for the other regions.

Garbage feeding of swine is very prevalent in California. The survey by Updegraff showed that at least 85 per cent of the cities of 5,000 or more population in the State dispose of their garbage in whole or in part by feeding it to swine. Mr. C. G. Gillespie, Chief of the Bureau of Sanitary Engineering of the State Health Department has expressed the opinion that garbage feeding of swine could be found in California wherever there was sufficient garbage to make it practical to feed it. The Federal Bureau of Agricultural Economics in discussing the extent of garbage feeding of hogs showed that 246,325 garbage fed hogs were marketed annually from the 42 California counties from which they had received reports. It also showed that

it was a growing industry in 10 counties, declining in five, and stationary in 29. Judging from these data and those provided by the Federal live stock census, it would appear that at least one-third of California swine are raised on garbage. Thus a representative yet conservative portion of our quota of 5,750 specimens would be 1,900 specimens from garbage fed swine.

The swine specimens were collected by visiting the slaughterhouses and determining whether the hogs they purchased could be traced from the lot number of the establishment to the farm from which they originated. In the case of many of the smaller slaughterhouses this was a practical procedure. However, it was not practical in the larger establishments since they received many of their hogs through stockyards, independent buyers and auction sales so that a single lot number represented numerous ranches. The problem of tracing hogs from these sources was solved by using tattooing outfits and marking each hog at the place it was sold and before it was mixed with stock sold by other ranches. It was thus possible to obtain a random sample of identifiable specimens. Care was taken to avoid repeated sampling from a ranch unless it was a large producer of hogs. With regard to the garbage fed hogs, repeated samples were taken more frequently because they came from larger ranches and formed a larger proportion of the hog production in that particular area.

Older hogs such as sows, stags, and boars may not be adequately represented in our series. Frequently these animals would be killed at an entirely different time and perhaps in a different locality than the more choice animals. Special trips to slaughterhouses to secure specimens from such animals were never made.

Table 1 shows the proportion in which swine diaphragms were taken from lots of various sizes which were traceable to the farm from which they originated. Thus, representative samples were secured in proportion to the number of swine from a given lot from a given ranch.

TABLE I

Showing the Proportion in Which Swine Diaphragms Were Taken From a Single Lot of Hogs Traceable to One Ranch

Number of hogs in lot	*Proportion of specimens taken*	*Maximum number specimens taken*
1– 5	all	5
6– 10	1/2	5
11– 25	1/3	8
26– 50	1/4	12
51– 75	1/5	15
76–100	1/7	14
101–150	1/8	18
151–200	1/9	22
over 200	1/10	20 plus

The classification of the specimens depended on the inspection of the ranch. Inspection of the ranch consisted of interviewing the rancher and inspecting the hog pens and food given to the hogs. Information relative to the type and abundance of rodents about the ranch and vicinity was also obtained. From all of this information the specimens were classified in the following feed categories:

1) *Grain,* including cull fruits and vegetables from packing houses and canneries, forage, tankage, but excluding any possibility of raw meat scraps in the diet;

2) *Grain, bought as feeders,* the same as (1) except that the farmer previously had purchased the hogs from other ranches, whom we were unable to trace;

3) *Grain and ranch kitchen scraps,* that is, the small amount of garbage produced at any one of the ranches was fed to the hogs in addition to (1);

4) *Raw garbage,* garbage fed in the condition collected from restaurants, resorts, camps, and households, grain may or may not have been fed as a supplementary feed;

5) *Cooked garbage,* the same as (3) except that the garbage was subjected to sufficient cooking to kill trichinae;

6) *Institutional,* raw garbage from State, county or city institutions which was fed by the personnel of the institution to swine, slaughtered by or for the institution, and the resultant pork consumed by the inmates of the institution;

7) *Raw offal,* offal from farm slaughtered animals fed to swine that would otherwise fall into categories (1), (2), or (3);

8) *Cooked offal,* offal from rural slaughterhouses cooked (frequently under State inspection) in open pots or vats and fed to swine.

The results of the examination of the swine diaphragms are presented in table 2. In all, 7,034 specimens were examined, 5,934 of which came from swine which were traceable to the ranch on which they were last fed. The figures in the grain, grain and ranch kitchen scraps and raw garbage groups are the significant figures in this table. They show that the frequency of infection in the raw garbage fed hog is 12 times that of the grain fed hog. Apparently the small amount of garbage originating in the ranch kitchen is a minor factor as a source of infection for swine, there being no appreciable difference in the incidence for this group and for the grain group.

TABLE II

Showing the Incidence of Trichina Infection in Swine Slaughtered in California

A. Specimens traceable to ranch

Geographic divisions	Southern California (10 counties)			Central California (29 counties)			Northern and Sierra Nevada area of California (19 counties)			Total		
Quota of specimens for division	1,680			3,540			530			5,750		
Type of food received by hog	Number specimens examined	Number specimens trichinous	Per cent specimens trichinous	Number specimens examined	Number specimens trichinous	Per cent specimens trichinous	Number specimens examined	Number specimens trichinous	Per cent specimens trichinous	Number specimens examined	Number specimens trichinous	Per cent specimens trichinous
Grain	485	6	[1] 1.2	1,762	5	[4] 0.3	189	0	0.0	2,436	11	[9] 0.5
Grain, bought as feeders	64	4	6.3	195	0	0.0	17	0	0.0	276	4	1.4
Grain and ranch kitchen scraps	187	0	0.0	758	2	0.3	164	5	3.0	1,109	7	0.6
Raw garbage	1,012	22	[2] 2.2	616	78	[5] 12.7	73	9	[7] 12.3	1,701	109	[10] 6.4
Cooked garbage	18	0	0.0	16	0	0.0	2	0	0.0	36	0	0.0
Institutional	48	1	2.1	152	0	0.0	29	0	0.0	229	1	0.4
Raw offal	15	0	0.0	21	3	14.3	0	0	0.0	36	3	8.3
Cooked offal	3	0	0.0	83	5	6.0	25	1	4.0	111	6	5.4
Totals	1,832	33	[3] 1.8	3,603	93	[6] 2.6	499	15	[8] 3.0	5,934	141	[11] 2.4

B. Specimens not traceable to ranch

California	554	2	[12] 0.4
States other than California	546	2	[13] 0.4
Grand totals	7,034	145	[14] 2.1

[1] Standard deviation of 1.2% is 0.5
[2] Standard deviation of 2.2% is 0.5
[3] Standard deviation of 1.8% is 0.3
[4] Standard deviation of 0.3% is 0.1
[5] Standard deviation of 12.7% is 1.3
[6] Standard deviation of 2.6% is 0.3
[7] Standard deviation of 12.3% is 3.8
[8] Standard deviation of 3.0% is 0.8
[9] Standard deviation of 0.5% is 0.1
[10] Standard deviation of 6.4% is 0.6
[11] Standard deviation of 2.4% is 0.2
[12] Standard deviation of 0.4% is 0.3
[13] Standard deviation of 0.4% is 0.3
[14] Standard deviation of 2.1% is 0.2

The 5,934 specimens from swine which were traced back to the ranch came from 897 ranches. The distribution of these ranches in the various feed categories is shown in table 3. It will be noted that trichinous specimens were secured from 59 ranches.

TABLE III

Showing the Number of Ranches from Which Swine Specimens Were Secured and the Number of These That Produced Trichinous Swine

Classification of ranch	*Number of ranches*	*Number of ranches with trichinous swine*
Grain	419	7
Grain, bought as feeders	48	2
Grain and ranch kitchen scrap	240	3
Raw garbage	118	43
Cooked garbage	7	0
Institutional	12	1
Raw offal	4	1
Cooked offal	20	2
Total	897	59

The only figures available showing the general incidence in swine in the United States are those given by Schwartz (12), who found an incidence of 0.95 per cent in 13,000 so-called grain fed hogs, and 5.7 per cent in 10,500 garbage fed hogs. There is no indication in this report of the method used in determining the type of food on which these hogs were fed. It is stated that the 13,000 specimens were obtained from swine "that had been raised on farms and fed forage, grain and other feeds, including, in some cases, more or less garbage." It is probable that this group is comparable to our nongarbage fed groups, that is, the grain, grain bought as feeders, grain and ranch kitchen scraps, raw offal and cooked offal groups. If so, then 3,968 of our specimens would be comparable to the so-called grain fed group of Schwartz. In these specimens there were found 31 positive specimens, an incidence of 0.8 per cent. This figure is not materially different from that of Schwartz. Likewise, there is no significant difference between the incidences found in the garbage fed hogs. In other words, the data presented here indicate that the average situation in California is no worse than the average situation in the United States. This is also represented in our figures for swine which originated in states other than California and California swine which were not traceable to the farms, the incidence in these two groups being the same.

The annual report of the Director, Bureau of Animal Industry to the Secretary of Agriculture for 1937 (13) gives an incidence of 3.4 per cent in 3,876 raw garbage fed swine which came mostly from two Pacific Coast States. The difference between this incidence and that

reported herein is 3.0. The computation of the standard deviation of this difference by the formula $\sqrt{\frac{p1q1}{n1} + \frac{p2q2}{n2}}$, where p is the per cent positive, q the per cent negative, and n the number examined, gives 0.6. It therefore appears likely that the difference is statistically significant. However, the samples are not entirely comparable because our sample originated in only part of the area from which the other sample was taken, and therefore the incidence of 3.4 per cent should not be taken as being indicative of the situation in California.

TABLE IV

Classification of the Infected Swine Specimens According to the Intensity of Infection and the Type of Food the Swine Received

Intensity	*0.0–0.09*	*0.1–0.99*	*1.0–9.9*	*10.0–49.9*	*50.0–99.9*	*100.0 and over*	*Total*
Grain	5	2	3	0	1	0	11
Grain, bought as feeders	0	2	0	1	1	0	4
Grain and kitchen scraps	1	0	3	1	0	2	7
Raw garbage	31	41	19	5	4	9	109
Institutional	1	0	0	0	0	0	1
Raw offal	0	3	0	0	0	0	3
Cooked offal	0	1	2	1	2	0	6
California not traced	2	0	0	0	0	0	2
Out of State	0	1	0	0	0	1	2
Total	40	50	27	8	8	12	145
Per cent of total	27.6	34.5	18.6	5.5	5.5	8.3	100.0

The classification of the trichinous swine specimens according to the type of food the hog received and according to the intensity of the infection is shown in table 4. The majority of the infections were light, the lightest being one larva in 79 grams of diaphragm muscle. However, the intensity of infection ranged up to 2,234 larvae per gram of diaphragm muscle. Twenty-seven and six-tenths per cent of the specimens had fewer than one larva per 10 grams of muscle, and 34.5 per cent had more than one larva per 10 grams but fewer than one larva per gram of muscle. Thus, 62.1 per cent of the specimens had an infection of less than one larva per gram of diaphragm muscle. Schwartz found that 70 to 80 per cent of their infected specimens were in this same category. We have therefore found a somewhat greater proportion of more heavily infected specimens. It is recognized that the diaphragm is one of the preferred sites for these parasites and it is probable that the rest of the carcass was more lightly infected. This, however, does not materially lessen the value of the data as an index of the potential hazards of man acquiring an infection from the resultant pork.

A discussion of the source of infection of the swine in the various food categories would be helpful in explaining some of the incidences found. As a matter of convenience, the grain and raw garbage groups will be discussed last.

It is not possible to offer an entirely satisfactory explanation of the possible sources of infection in the grain bought as feeders group. Although the ranch from which these specimens came fed only grain to their swine and therefore the latter remarks about grain fed swine are applicable here, the history of these swine previous to the time they were moved on to the ranch to which we traced them is not obtainable. However, it is improbable that many of these swine were born on garbage feeding ranches, since it is more common for the garbage ranches to buy feeder pigs than to sell them.

The grain and ranch kitchen scrap category represents a group of swine that get a relatively small amount of garbage, namely that originating in the ranch kitchen. The amount of kitchen scraps these swine might get would depend on two factors, the number of people eating on the ranch, which would determine the amount of garbage available, and the number of swine on the ranch. In most cases there would be a very small amount of garbage per hog. Furthermore, meat scraps in such garbage are frequently separated from the rest of the scraps and fed to the dogs and cats on the place. Thus, in our experience it would be the exception rather than the rule that hogs in this category would have access to meat scraps. This does not eliminate the possibility of infection occurring in this manner, but rather indicates that the factors affecting the grain fed swine are chiefly operative here.

It was rather difficult to evaluate the hazard in the institutional group. The most constant factor was that in the institutions established for a longer period of time, the entire supply of fresh pork was derived from their own herds. With one exception, the institutions raised all of their own hogs and with one exception they fed only garbage from their own institution. About one-third of the institutions supplemented their fresh pork supply by purchasing ham and bacon in the open market. In handling the meat it was the general practice to trim it for cooking in the institution's butcher shop. The meat scraps from the shop were all rendered for grease. In no case was offal from the kill fed to the hogs. Therefore the opportunities for infection of the herds would come almost entirely from inadequate cooking of the pork in the institution's kitchens, such scraps reaching the hogs in the garbage from the tables. It would appear that this occurs, since one trichinous specimen was found. This specimen came from the institution which was feeding its own as well as garbage from another institution. The second institution purchased its entire pork supply on the open market.

The feeding of raw offal from a slaughterhouse is illegal in California, therefore, the specimens in this category only received offal from the occasionally slaughtered farm animal. The three trichinous

specimens in this group came from one ranch which was concerned in an outbreak of trichinosis and the findings served to conclusively point to the source of the outbreak.

The positive specimens in the cooked offal group came from two establishments. One was a slaughterhouse under State inspection and therefore the offal should have been cooked under inspection. Apparently the process was not properly watched in this case. The other establishment had been a slaughterhouse, but it is now only a meat wholesaling establishment. Trimmings from meat cut for distribution are cooked and fed to hogs. These hogs in turn are slaughtered and the pork is sold through the establishment. No inspection of cooking occurs at this plant.

With regard to garbage as a source of swine infection, an attempt was made to find trichinae in meat scraps gathered from garbage which was to be fed to hogs. They were found once in 37,400 grams of pork scraps, but these trichinae were not viable. In a personal communication, Dr. W. H. Wright, of the National Institute of Health, has informed us about the examination of 555 composite 100-gram samples of pork scraps from residential garbage of Washington, D. C. Of these composite samples, 1.6 per cent were positive for trichinae. One-third of the positives contained viable larvae even though the pork had apparently been partially cooked. Thus it is logical for us to assume that the primary source of infection for the garbage fed hog is the pork in the garbage rather than some extraneous factor.

An insufficient number of specimens was gathered in this work to show what effect the cooking of the garbage would have on the incidence. However, the literature contains several references of value. In the annual report of the Director of the Bureau of Animal Industry for 1937, the results of the examination of 1,860 swine fed on cooked garbage in two Pacific Coast States were reported. Only 0.6 per cent of the specimens was positive. As mentioned earlier, the same report showed 3.4 per cent of 3,876 swine fed on raw garbage in the same area was positive. In the similar report for 1939, no infected specimens were found among 1,000 specimens from swine fed on cooked garbage. Cameron (14) in reporting on the examination of garbage fed swine in Canada, where cooking of garbage prior to feeding it to hogs is required by law, found only 0.2 per cent of the swine infected. The report of the New York State Trichinosis Commission (15) contains the following: "The Commission is informed that England has long required the cooking of garbage fed to hogs. According to information received here, less than 25 cases of trichinosis were reported in England from 1900 to 1941." It would thus appear that the cooking of garbage is an effective method of controlling the infection in garbage fed swine.

The question of where grain fed swine might acquire an infection arises. There are three possible explanations which occur to us; (1) that we failed to determine all of the ranches that feed offal from the occasional hog that might have been slaughtered on the premises; (2) that some of these swine did receive scraps from the ranch kitchen, a fact that was denied by some of the ranchers, but later admitted when the evidence of such scraps was pointed out to them in their hog pens; and (3) that the hog might have eaten an infected rodent. Proof of such an occurrence is exceedingly hard to obtain. Rodents were collected from each of the seven grain ranches from which trichinous specimens were secured and from one of the grain and ranch kitchen scrap feeding ranches. None of the field mice, ground squirrels, gophers or wood rats were found infected although 101 specimens were examined. From one ranch where a history had been obtained that the swine husbandman had seen some hogs eating dead rats that the dogs and cats had killed, we found infected the one rat caught immediately adjacent to the hog pens. None of the 14 rats trapped in the vicinity of the main buildings 500 or more feet away and across a highway were found infected.

On four of the grain ranches having positive specimens it is the practice to irrigate at regular intervals the alfalfa fields in which the hogs foraged. This practice drowned any rodents which might be present in the fields. It would be possible for hogs to eat such rodents when they were turned back into the fields after the water had soaked into the ground. In the area from which these specimens came, gophers and field mice were the most common rodents.

It is presumed that rodents would acquire their infection from eating infected pork scraps thrown to the chickens in the barn yard with the kitchen scraps. The parasite might be maintained and spread through a colony by one or several rodents eating a dead infected rodent.

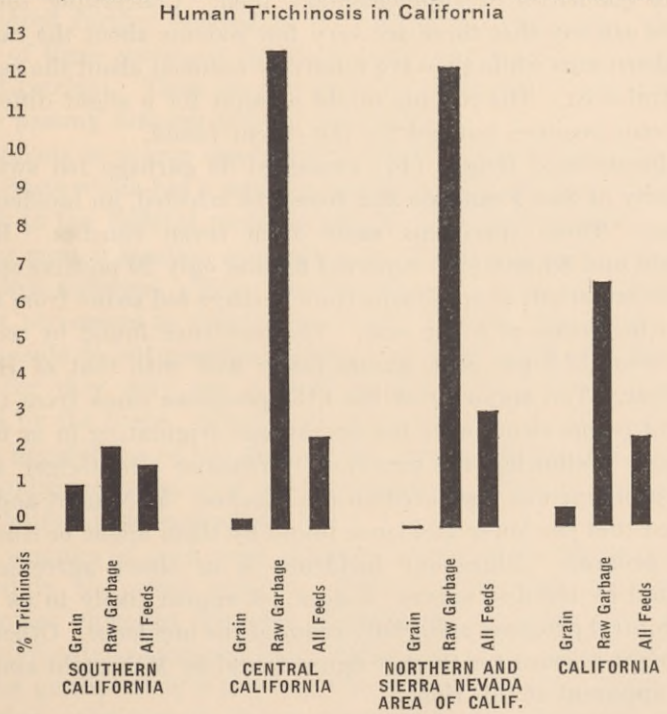
Examination of rats collected about garbage feeding establishments, most of which gave us trichinous swine specimens, showed that nine of 154 specimens taken were infected with trichinae, an incidence of 5.4 per cent, which approximates the incidence found in the garbage fed hog.

An attempt was made to obtain opinions from the farmers as to whether hogs eat rats or other rodents. Amongst the 795 which were questioned, 80 stated that they had seen hogs eat rats, 104 stated that hogs would probably eat rats but that they had never seen it, 15 stated that hogs would eat rats after they had been killed, one stated that hogs would kill rats but not eat them, 111 stated that hogs would not eat rats, and the remainder, 447 had no opinion on the subject. We can

conclude from this that hogs will eat rats and other rodents but that it is not a common occurrence. Therefore, the possibility of a hog acquiring an infection from rats or other rodents is probably rather uncommon.

The incidences of infection in the three areas, as shown in table 2 and graph, are interesting because of their divergence. As far as can be determined the number of specimens in the important categories is in the proper proportion to the total. For instance, there are more garbage fed hogs in the southern region than there are grain fed hogs and hence more specimens from garbage fed swine were obtained. Although the difference in per cent positive for grain fed hogs in the southern and central areas is 0.9, the difference does not appear to be statistically significant. With regard to the garbage fed hog, the difference in the incidence in the two areas is 10.5 and it appears likely that this difference is statistically significant.

Relative Importance of Grain and Raw Garbage Fed Swine as Sources of Human Trichinosis in California



The reasons for the low incidence in the garbage fed hog of the southern area are not immediately apparent. Possible factors which would affect this figure are (1) the amount and character of meat scraps in the garbage, (2) the type of garbage, (3) the ratio of the amount of

garbage to the amount of supplementary food fed, and (4) the presence of rodents even though it is known they play only a minor role. There is no way of determining factual data on the first point; however, some indirect evidence is available from the examination of pork products as reported and discussed in the next section. With regard to the second point, it is our impression that the bay area, which has the largest urban population in the central region, disposes of most of its household garbage by other methods; thus it is chiefly the "swill" or wet restaurant garbage which is being fed to hogs. In the southern region it is the common practice to dispose of household and restaurant garbage by feeding it to hogs (see also Updegraff, l.c.). Third, the amount of supplementary food given depends on the individual feeder and the quantity and quality of the garbage he is feeding. It must be granted that a higher incidence would be expected in hogs fed a small amount or no supplementary nongarbage food. It is not known whether our figures for the southern area largely represent ranches using considerable quantities of supplementary food. Concerning the fourth point, we can say that there are very few rodents about the ranches in the southern area while they are relatively common about the ranches in the central area. The rodents might account for a slight difference in the per cent positive, but not for the extent found.

Hobmaier and Geiger (16) examined 93 garbage fed swine from the vicinity of San Francisco and found 14 infected, an incidence of 15 per cent. These specimens came from seven ranches. Recently, McNaught and Zapata (17) reported finding only 20 positive specimens in 495 examinations of specimens from garbage fed swine from the same area, an incidence of 4 per cent. The incidence found by us for the central area, 12.7 per cent, agrees fairly well with that of Hobmaier and Geiger. The majority of the 616 specimens came from the same area, that is, the swine were fed on garbage originating in or near San Francisco. Following the survey of Hobmaier and Geiger a rodent control program was instituted on the ranches. McNaught and Zapata suggested that the lower incidence found by them might be due in part to this program. Since our incidence is in closer agreement with that found by the first survey, it does not appear likely to us that the rodent control program materially reduced the incidence. Other factors which might account for the low figure found by McNaught and Zapata are not apparent at this time.

The evidence presented in this portion of this report indicates that by abolishing the practice of feeding raw garbage to swine the incidence of swine infection with trichinae would be materially reduced. Thus, there would be less trichinous pork sold in the markets of California.

Trichina Infection in Market Pork Products

Studies of pork products showing the extent of their infection with trichinae are few in number. Hobmaier and Geiger (l.c.) examined pork sausages from 20 agencies, and found sausage from five of these infected. They do not state how many samples were examined to find the trichinous specimens. McNaught and Anderson (l.c.) reported finding two of 10 specimens of pork sausage infected with trichinae. The New York State Trichinosis Commission (l.c.) reported the most extensive survey to date. In their work 471 samples of pork meat products were collected from retail shops in New York State in such a manner that they were representative in area and type of product for sale. Of these, 294 were products to be cooked after sale and 177 were products which were to be eaten without further cooking on the part of the consumer. Eighteen of the 471 specimens, or 3.8 per cent were found infected. Of these 18, four contained living trichinae presumably capable of infecting man. Seven of the 18 were products to be eaten without further cooking on the part of the consumer. However, only one of these contained living trichinae and it was not a federally inspected product. Thus, no live trichinae were found in products of this type passing through federal inspection.

California is unique among other States of the Union because it is the only State which has a meat inspection system which compares very favorably to the Federal meat inspection. The California regulations regarding meat inspection are patterned after the Federal regulations and are well enforced. These regulations apply to all slaughterhouses and meat processors in counties of 27,000 or more population. These establishments do not necessarily have to use the State meat inspection service, for they may use a local service provided that service is approved by the State. Slaughterhouses and meat processors in counties with populations of less than 27,000, but marketing their products in surrounding counties must also be inspected. Thus, most of the meat sold in California is inspected.

The samples of pork meat products examined by the survey were purchased in the retail markets. Therefore the data derived from these samples represent the pork reaching the consumer. In order to obtain representative samples from all sections of the State, the number of samples purchased in a given section depended on the population of that section. One sample for a given area was purchased for each 3,000 population of that area. Since the populace commonly believes that trichinosis is frequently acquired through the consumption of pork products such as salami, the survey is weighted. One-fourth of the samples consisted of products which were presumably processed so that any trichinae contained in them were rendered nonviable.

TABLE V

Showing the Incidence of Trichina Infection in Various Pork Products Purchased on the Retail Market

Products Not Processed to Kill Trichinae

Type of product	*Number of specimens examined*	*Number of specimens positive*	*Per cent of specimens positive*
Fresh link sausage	436	16	3.7
Fresh bulk sausage	620	5	0.8
Fresh pork chops	586	1	0.2
Miscellaneous	29	0	0.0
Ham—cured	34	0	0.0
Bacon—cured	45	0	0.0
Total	1,750	22	1.3

Products Processed to Kill Trichinae

Chorizos	9	0	0.0
Salami	160	0	0.0
Cervelat	7	0	0.0
Mettwurst	12	0	0.0
Headcheese	13	0	0.0
Garlic sausage	10	0	0.0
Blood and tongue sausage	6	0	0.0
Linguisa	8	0	0.0
Liver sausage	18	0	0.0
Bologna	40	0	0.0
Wieners	17	0	0.0
Various loaves	26	0	0.0
Thuringer	17	0	0.0
Ham loaves	222	0	0.0
Canadian bacon	21	0	0.0
Miscellaneous	23	0	0.0
Total	609	0	0.0
Grand total	2,359		

Table 5 shows the incidence of infection with trichinae found in the various pork products. There were 2,359 specimens examined. Of these, 1,750 were fresh products which should have been cooked after purchase and 609 were products the further cooking of which after purchase should not have been necessary. Twenty-two of the 1,750 fresh products were infected with trichinae, as incidence of 1.3 per cent. All of these products came from meat packers located in California. The standard deviation of 1.3 is 0.3 when computed by the formula $\frac{\overline{pq}}{n}$ as used in the previous section. Further analysis of the data shows that the pork product most commonly found infected was the fresh link sausage, and the next most commonly infected product was the bulk sausage. There are, of course, similar products. The mean weight of the fresh products examined was 130 grams with a range from 22 to 775 grams.

A possible explanation for this distribution of infected material among the types of pork products lies in the fact that the sausages are made up of trimmings from general pork cuts, pork which would

not look well on the counter of the butcher shop, and that from old sows, boars and stags. The link sausages are largely made up by the packing house and therefore would be more apt to contain the poorer grade of pork than would the bulk sausage which was frequently prepared and ground by the retail butcher.

TABLE VI

Showing the Types of Pork Products Infected and the Degree of Infection In Each Type

Positive number	*Type of product*	*Weight of product (grams)*	*Number of trichinae recovered*			*Number per gram of product*
			Live	*Dead*	*Total*	
1	Link Sausage	161	36	2	38	0.2
2	Bulk Sausage	775	25	0	25	0.3
3	Bulk Sausage	150	402	83	485	3.2
4	Bulk Sausage	115	0	3	3	0.03
5	Link Sausage	183	15	1	16	0.09
6	Link Sausage	211	125	6	131	0.6
7	Pork Chops	152	85	0	85	0.6
8	Link Sausage	128	3	1	4	0.03
9	Link Sausage	116	4	4	8	0.07
10	Link Sausage	230	21	7	28	0.1
11	Link Sausage	166	3	0	3	0.02
12	Link Sausage	140	8	0	8	0.06
13	Link Sausage	150	0	1	1	0.01
14	Bulk Sausage	289	0	6	6	0.02
15	Link Sausage	146	16	0	16	0.1
16	Bulk Sausage	171	38	0	38	0.2
17	Link Sausage	162	0	1	1	0.01
18	Link Sausage	144	2	0	2	0.01
19	Link Sausage	134	254	1	255	1.9
20	Link Sausage	145	3	0	3	0.02
21	Link Sausage	222	3	0	3	0.01
22	Link Sausage	173	24	5	29	0.2

Table 6 shows the degree of infection in the pork products. Twelve, or more than half of the infected specimens, contained fewer than one larva per 10 grams of sample, eight contained fewer than one larva per gram of sample, but more than one larva per 10 grams of sample. The remaining two infected specimens contained more than one larva per gram of sample. The table also shows that 18 of the specimens contained viable trichinae and three contained only nonviable larvae. Whenever possible the viability of the trichinae was checked by feeding the larvae to a guinea pig. All infections showing 50 or more larvae were so checked; that is, four of the 22 samples. In each case an infection was established in a guinea pig, thus proving the viability of the larvae.

None of the 609 products processed to kill trichinae before being retailed contained either living or dead larvae. The mean weight of these samples was 134 grams with a range from 31 to 460 grams. These products were divided into 16 types as shown in table 5. All but one of these products were inspected by either Federal, State or

State approved local inspection. The one uninspected product was probably produced illegally. These results show the advantage of an inspection system, since inspection of this type of product is conducted particularly against trichinosis. It operates on the assumption that all pork being used in such products may contain trichinae and therefore must be processed either by (1) freezing at a specified temperature over a specified period of time; (2) salting at the required concentration and storing under lock and key over a specified period of time; or (3) by heating to a specified temperature for a specified period of time. The efficiency of these methods as enforced under Federal inspection is continually being checked. The annual reports (l.c.) show that the laboratory examination of more than 8,000 samples of such inspected pork revealed that none of the products contained living trichinae, although dead trichinae were found a number of times.

TABLE VII

Showing the Distribution of the Pork Products According to Area and the Incidence Found in Each Area

	Fresh Products			*Processed Products*	
Area	*Number examined*	*Number trichinous*	*Per cent trichinous*	*Number examined*	*Per cent trichinous*
Southern	903	5	0.6	365	0
Central	775	17	2.2	231	0
Northern and Sierra Nevada	72	0	0.0	13	0
Total	1750	22	1.3	609	0

Table 7 shows the breakdown of the data into the three regions being considered. It will be noted that five of the 903 samples of fresh products from the southern region were trichinous, an incidence of 0.6 per cent; 17 of the 775 specimens from the central region contained trichinae, an incidence of 2.2 per cent; and none of the 72 specimens from the northern and Sierra Nevada region was trichinous. The difference in the per cent trichinous in the southern and central regions is 1.6, and the standard deviation of this figure is 0.6. Since twice the standard deviation is less than the difference, it would appear likely that the difference is statistically significant.

TABLE VIII

Showing the Proportion of Pork Products Produced in the Region in Which They Were Purchased and the Proportion Produced in Other Regions

	Region in Which Product was Packed				
Region in which product was retailed	*Southern*	*Central*	*Northern and Sierra Nevada*	*Other States*	*Unknown*
Southern	91	0	0	7	2
Central	3.2	90.1	0.3	5.1	1.3
Northern and Sierra Nevada	2	52	37	8	1
Total		92		6	2

It is interesting to note the origin of the products with regard to the area in which packed. As pointed out in the previous section, this does not necessarily mean that the pork originated from swine raised in the region. Table 8 shows that 90 per cent of the products purchased in the southern and central regions was packed in the region. The most lightly populated region received 52 per cent of its products from the central region, 2 per cent from the southern, and 37 per cent of the products were packed within the area. In our experience, 92 per cent of all the products purchased was produced by meat packers in California and 6 per cent supplied from packers located in other States. The remaining 2 per cent was not sufficiently identified to allocate it to the point of origin. Most of the products supplied by out-of-State sources were processed so that trichinae should have been killed, and all of them came from Federally inspected plants.

Referring to the incidence in the garbage fed swine of the areas under consideration (table 2), it will be noted that in the southern region where the incidence in the market products was significantly lower than that in the other regions, the incidence in the garbage fed swine in the area was also significantly lower. The data therefore indicate a marked correlation between the two incidences, the incidence in the garbage fed swine reflecting the incidence in the market pork products. They also indicate that the elimination of the practice of feeding raw garbage to swine would be reflected in the amount of trichinous market pork products.

Trichina Infection in Man

An extensive survey of the incidence of infection in human necropsy material was not undertaken because of the work of McNaught and Anderson, Butt and Lapeyre and the National Institute of Health, U. S. Public Health Service, the latter survey still being under way. These surveys were largely made on diaphragm material from an urban population. We therefore endeavored to obtain supplementary data on the rural population and in particular from the area north of San Francisco. The results of the examination are expressed in table 9.

TABLE IX

Showing the Number and Per Cent Positive of Human Diaphragms in Relation to the Type of Population

Type of population	*Number specimens examined*	*Number specimens trichinous*	*Per cent specimens trichinous*
Rural	11	0	0.0
Urban	49	5	10.2
Unknown	3	0	0.0
Rural (sent to USPHS)	7	0	0.0
Total	70	5	7.1

A total of 70 specimens was received. Of these, seven came from an area having a population of 1,000 or less and were forwarded to the National Institute of Health for their survey. A negative report was received on these specimens. Eleven of the remaining 63 specimens which were examined by us came from areas which are sometimes termed rural, that is, the population was 2,500 or less, 49 came from urban areas and inadequate data were received on three specimens. Thirty-eight of the specimens came from State institutions and all of the positives were among these specimens. The positive specimens contained 1, 4, 7 and 14 calcified cysts with dead larvae in the gram of tissue examined miscroscopically. The fifth positive specimen contained one live and one dead larvae in the 42 grams of material digested.

TABLE X

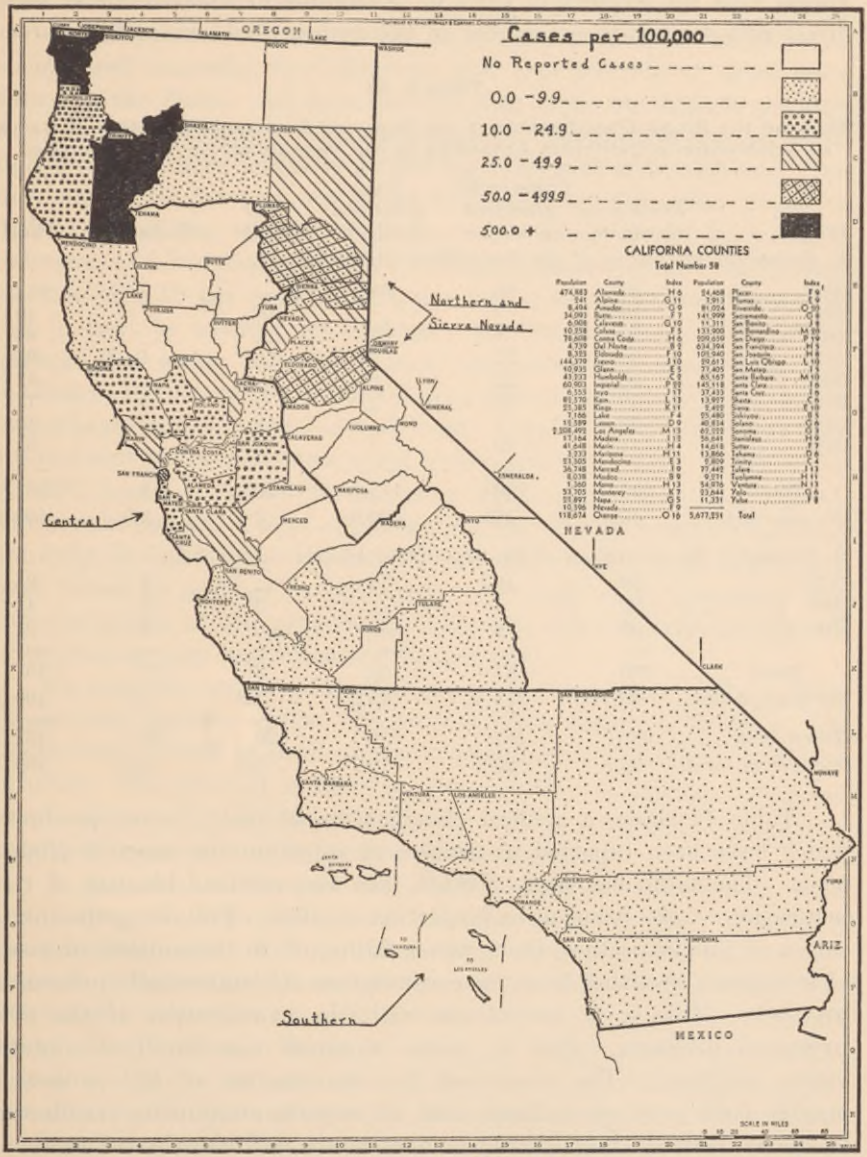
Showing the Trichinosis Case Rate in California and in the Three Subdivisions for the Eleven Year Period, 1930 Through 1940

Area	*No. reported cases*	*Population (estimated 1935)*	*Rate per 100,000*
Southern	112	3,462,753	3.2
Central	484	2,631,987	18.4
Northern and Sierra Nevada	119	228,338	52.1
Total	715*	6,323,074	11.3

* Six additional cases are charged to California, but the disease was acquired in another State.

The distribution of reported cases of trichinosis is rather uneven as shown in map 2. This distribution is based only on the cases reported during the past 11 years. This period is used because the efficiency of the reporting has been much better than during the preceding years. The case rates for the three areas which we are considering are expressed in table 10. Although these data are not an absolute index of cases, as mentioned previously, they indicate the general distribution of cases. Thus, we find that in the largest population group, the southern area, the lowest case rate occurs; in the intermediate population group, the central area has the next highest case rate; and the smallest population group, the northern and Sierra Nevada area, has the highest case rate. The number of cases charged to the various counties is unevenly distributed over the 11-year period. Most of the cases charged to the northern and Sierra Nevada counties represent outbreaks of from five to 44 cases. In the other two groups of counties the proportion of cases occurring in outbreaks is not so high. These data include 25 cases, the reported source for which was bear meat.

Distribution by Counties of Trichinosis, Case Rate Per 100,000 1930 Through 1940 Based on Estimated 1935 Population



Comparing the incidence in the swine diaphragms and market pork products with the case rate shows a striking parallelism, particularly for the central and southern groups of counties (tables 2, 7 and 10). It would appear that the case rates in these two groups of counties reflect the incidence of infection found in market pork products. The association between the incidence in the market pork products and that

in garbage fed swine has already been pointed out. Thus, it would appear that the number of cases of trichinosis in an area would be a direct reflection of the incidence in the garbage fed swine of the area.

TABLE XI

Showing the Broad Classification of the Reported Sources of Infection of Cases of Trichinosis in California According to the Year in Which They Occurred

Year	*Fresh pork products*	*Commercial processed products*	*Home processed products*	*Bear meat*	*Unknown*	*Total*
A. Before the institution of the State Meat Inspection						
1930	58	50	38	--	5	151
1931	19	3	--	18	--	40
1932	18	4	62	--	--	84
1933	32	21	7	--	4	64
1934	20	23	8	--	--	51
1935	38	26	2	--	5	71
1936	29	9	--	2	--	40
1937	31	29	1	2	--	63
Total	245	166	118	22	14	564
Per cent of total	43.4	29.8	20.9	3.9	2.5	100.0
B. Following the institution of the State Meat Inspection						
1938	39	10	12	--	4	65
1939	29	7	--	3	2	41
1940	32	4	12	--	3	51
Total	100	21	24	3	9	157
Per cent of total	63.7	13.4	15.3	1.9	5.7	100.0
Grand total	345	187	142	25	23	721
Per cent of total	47.8	25.8	19.7	3.5	3.2	100.0

Table 11 shows a general classification of the types of products which have been reported as sources of infection for cases of trichinosis. The table has been divided into two sections because of the institution of the State meat inspection in 1937. Following the institution of this inspection, there was a falling off in the number of cases of trichinosis resulting from the consumption of commercially processed products. This is in accordance with the examination of the 609 processed products (table 5), none of which was found to contain viable trichinae. The results of the examination of the processed market pork products indicate that all reports attributing trichinosis to one of these products should be questioned and investigated further.

General Discussion

The data collected by the survey show that as far as California raised swine are concerned, the chief problem in the control of trichinosis lies in the practice of disposing of raw garbage by feeding it to swine. Elimination of this practice would not eliminate the problem

of trichinosis, but it would materially reduce the amount of infected pork products sold in this State.

It was pointed out earlier that there were 1,650,000 head of swine slaughtered annually in California, and that 650,000 of these were raised in the State. All data indicate that there are 250,000 garbage fed swine in California. The incidence for these swine, 6.4 per cent, indicates that there would be 16,000 head infected with trichinae. An incidence of 0.8 per cent was found in nongarbage fed swine, therefore 3,200 head of the 400,000 nongarbage fed swine would be infected. Schwartz (l.c.) in discussing the role of garbage fed swine in trichinosis assumes that 10 per cent of the swine raised in the United States are fed in part or entirely on garbage. He found 5.7 per cent of the garbage fed swine infected. Based on Schwartz's assumption and incidence, 100,000 of the 1,000,000 head of non-California swine would be garbage fed, or 5,700 infected head. Again, Schwartz found that 1.0 per cent of the nongarbage fed swine infected. Thus, 9,000 of the 900,000 head of non-California grain fed swine would be infected. This would indicate a total of 33,900 head of infected swine slaughtered annually in California. At least 47 per cent of this total would have been raised on garbage in California. It would seem, therefore, that the elimination of this practice in California would reduce the amount of trichinous pork sold by nearly 50 per cent.

To state the matter in another way, if we assume that the average dressed hog carcass weighs 150 pounds, then about 5,000,000 of the 247,000,000 pounds of pork produced annually in California would be infected. The removal of infection from California garbage fed swine would almost cut this amount in half. Such a procedure would be a considerable advance in the control of trichinosis.

A good deal of thought and effort have been expended on ways and means of determining the trichina infected hog carcass in the slaughterhouse. To date, all methods developed have been uneconomical or impractical because they are not sufficiently accurate. The microscopic inspection of each carcass is too expensive and does not detect all infections. The skin testing of hogs with trichina intradermal antigen is not only laborious but also not sufficiently accurate according to the report of Spindler, Cross and Avery (18). It has been suggested that each hog carcass might be rendered safe by freezing. This would not be practical from the standpoint of economics.

The question of the methods of disposing of garbage arises. In addition to the practice of feeding it to swine, the following methods are in use: fill and cover, dumping at sea, grinding and discharging into sewers, incineration, reduction, and cooking the garbage before feeding it to swine. All of these methods except reduction and feeding

the garbage to swine treat the material as a valueless product. It must be recognized that garbage has value.

The fill and cover method is practical particularly where waste lands are conveniently available. Even where waste lands were not available, the City of Fresno has worked out a very satisfactory method at a nominal cost for disposing of household noncombustible refuse which is mixed with garbage.

Dumping at sea is not particularly practical on the California coast because the prevailing currents sweep a great deal of the refuse back on the beaches, thus creating a nuisance. The method is used by certain cities for disposing of household garbage and noncombustible refuse.

The grinding and discharge of garbage into sewers effectively disposes of garbage, but its general use would cause the overhauling and rebuilding of many sewage plants. The increased amount of bulk in the sewage would call for increased sewage plant capacity.

Incineration is in use in various places. To handle restaurant or so-called wet garbage in these plants is an expensive process because of the fuel required to dispose of the water in the garbage.

Reduction of the garbage for grease recovers some of the value of the garbage. The use of the process is frequently affected by the price of grease, for when the price of that product falls below the operating costs of the plant there is a temptation to dispose of the garbage by other means.

Judging from the experience in England, Canada, and several sections of the United States, the cooking of garbage before feeding it to hogs is a practical and economical means of disposing of this refuse. Unfortunately, many of the California hog feeders are prejudiced against cooking of the garbage because of an experience of the largest of them. This experience involved an attempt to save several days accumulation of garbage from a large urban center during a period of interruption of transportation facilities. In this case the garbage was thoroughly cooked on gondola cars before being transported. It remained in these cars for 48 or more hours and was still warm when unloaded. Under such circumstances, most of the food value would have been destroyed by the long cooking period.

It would be desirable to have available plans and costs of operating garbage cookers. However, such information is almost nonexistent. The Canadian Department of Agriculture furnishes hog raisers a plan for building a type of cooker which is both economical and effective for small amounts of garbage. Information concerning methods of handling and cooking the tonnage of garbage originating in such cities as Los Angeles and San Francisco does not seem to be available.

From the standpoint of agriculture and swine sanitation the feeding of raw garbage is not considered good practice. The losses of swine on such ranches are greater than they are on grain feeding ranches due to the diseases which are transmitted through the garbage. In California, the most important of these diseases are vesicular exanthema and hog cholera. The attitude of the State Department of Agriculture is reflected in a mimeographed release (19) which indicates that the cooperation of the department is available for any efforts to eliminate the practice.

In conclusion, it appears that the least disruption of present methods of garbage disposal would be to require the cooking of the garbage before it is fed to swine. In most cases this would not require a large capital on the part of the rancher nor would it materially increase the cost to the municipality for disposing of its garbage. Municipalities could not then be accused of contributing to this public health problem.

Summary

The problem of trichinosis in California is no different from that in any other State. By and large it is due to the practice of disposing of garbage from cities, towns, resorts, and camps by feeding it to hogs in the condition in which it is collected. An incidence of 6.4 per cent was found in the 1,701 garbage fed swine examined for trichinae. Such swine provide almost 50 per cent of the trichinous pork sold in California.

The examination of market pork products shows that fresh sausage is the most commonly infected product. A study of the distribution of such products revealed the fact that infected products were more common in areas where the incidence was highest in the garbage fed swine. It would thus appear that the two incidences are related.

The case rate distribution apparently reflects the incidence found in market pork products, which, in turn, is related to the incidence among the garbage fed swine. It thus appears that the number of cases of trichinosis in an area may be a direct reflection of the incidence in garbage fed swine.

The practice of cooking garbage from municipalities before feeding it to swine is being successfully carried out in England, Canada and certain parts of the United States. Since this practice under proper supervision would eliminate nearly 50 per cent of the trichinous pork sold annually on the California markets, it appears that its institution would materially lessen the trichinosis problem without seriously disrupting the present methods of garbage disposal.

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