Identification of Transmission Foci of Hydatid Disease in California

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THIRTY-EIGHT autochthonous cases of hydatid disease (*Echinococcus granulosus* infection) had been reported in man in the continental United States exclusive of Alaska up to 1958, according to Katz and Pan (*1*). These authors subsequently added another case from Massachusetts. Also, a case overlooked by them was reported from Florida by Zizmor and Szucs (*2*) in 1945. Brooks and co-authors (*3*) described two cases from Mississippi in 1959, and one additional case from Mississippi was reported by Hutchison and co-authors (*4*) in 1962. In 1964, Chambers (*5*) mentioned that an unpublished hospital survey in the Salt Lake City area had disclosed 17 additional hydatid infections "in native-born Americans." In all, hydatid disease acquired in the United States has been diagnosed in human beings in Arkansas, California, Delaware, Florida, Georgia, Indiana, Louisiana, Maryland, Massachusetts, Minnesota, Mississippi, New York, Tennessee, Utah, and Virginia, as well as in Alaska.

The first verified instance in man of hydatid disease acquired in California was reported by Tucker (*6*) in 1951. The patient was a 14-year-old Japanese-American school boy who was operated on in Los Angeles General Hospital in 1942 for a hydatid cyst of the liver. The patient had grown up on a prune farm in Santa Clara County, south of San Francisco. He had never been outside of California. This boy's family had kept several dogs, and a few sheep ranches were located in the area surrounding his home. A second autochthonous case in a Californian was reported by Lavers (*7*) in a 27-year-old Mexican-American man from whom several cysts of the liver were surgically removed in the Tulare County Hospital in 1955. It was ascertained that this patient also had never been outside of California, but no further epidemiologic data were provided with the case report.

Ward and Bradshaw (*8*) reported a prevalence for hydatid disease of 6 percent in 8,066 swine and of slightly more than 1 percent in 80 cattle examined at slaughter in Mississippi in 1955–56. In post mortem examinations of 33,174 swine slaughtered in Jackson, Miss., Hutchison (*9*) subsequently found a prevalence of 0.9 percent.

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Rates derived from annual reports of the Meat Inspection Division of the U.S. Department of Agriculture indicate that, in the period 1950–62, between 8.7 and 20.7 cattle livers per 100,000 examined in the United States were condemned annually for hydatid cysts (*10*). Light infections in cattle livers do not ordinarily result in veterinary condemnation of the entire organ. No statistics are available on lung cysts in cattle.

Information is almost completely lacking for the United States on the extent of hydatid infection in sheep. In sheep subjected to Federal veterinary inspection at slaughter, parasitic cysts of the lungs are not reported, liver cysts of *Taenia hydatigena* are not differentiated from cysts of *E. granulosus*, and a general diagnostic category of "parasitic cysts of the liver" obscures the presence or absence of hydatid infection. However, the occasional presence of hydatid cysts in sheep slaughtered or autopsied in California has been revealed to us in personal comunications (for example, in communications during 1967 from Dr. Quentin Geiman, Stanford University School of Medicine, Palo Alto, Calif., and from Dr. George Crenshaw and Dr. Norman Baker of the School of Veterinary Medicine, University of California, Davis).

In past surveys of more than 10,000 dogs and in innumerable other reports of intestinal helminths found at autopsy in dogs in the continental United States (exclusive of Alaska), apparently only 15 dogs have been reported infected with *E. granulosus* (*11–15*). These infected animals were from New York, Mississippi, Kentucky, Georgia, Tennessee, and Washington, D.C. Moreover, with the exception of timber wolves (*Canis lupus lycaon*) in Minnesota (*16*), *E. granulosus* has not been described in other definitive hosts in the United States other than dogs (*17–19*).

This paper indicates the prevalence of hydatid infection in sheep slaughtered in northern California and gives the results of a study designed to trace infected sheep to their ranches of origin. Investigations of these infected premises resulted in the identification, apparently for the first time in the United States, of foci of transmission of *E. granulosus*. While Sterman and Brown reported *Echinococcus* infection in two human beings and a dog in the same household in New York City (*15*), it is not certain that these cases were autochthonous. The dog had been imported from Greece, and both of the infected persons had lived in, or had visited, that country.

Figure 1 shows the average annual number of sheep shipped into California for immediate slaughter during the period 1962–66. Including sheep originating from both within and without the State, an annual average of 2,166,000 sheep of all classes were slaughtered in California during this period. Distribution by geographic area of slaughter follows. Figure 1 shows the boundaries of the areas.

Area	*Annual average*
Northern California	1,266,000
San Francisco Bay area	524,000
Rest of northern California	742,000
Southern California	900,000
Los Angeles County	753,000
Rest of southern California	147,000

Materials and Methods

At one slaughter site, a federally inspected meat plant in Solano County where more ewes are slaughtered than at any other in northern California, we examined the livers and lungs of 22,720 adult sheep during the routine slaughtering process throughout the 6-month period December 18, 1967, to June 13, 1968. This plant receives substantial shipments of sheep for immediate slaughter from outside as well as from within the State.

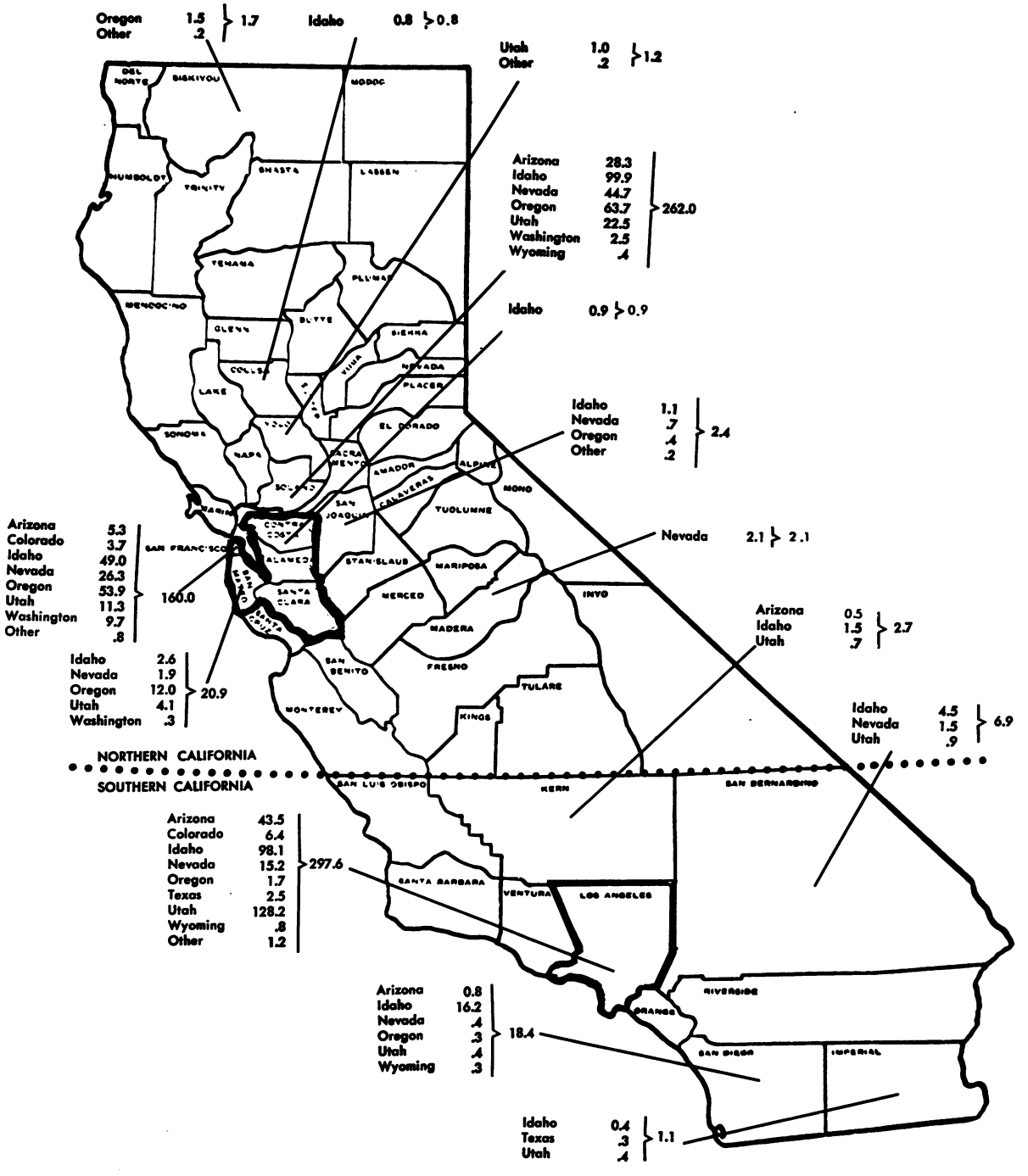
The examination for hydatid cysts was performed at a stage of the slaughtering operation at which the livers and lungs could still be identified with the carcass and its lot number. Examination was by visual observation and by palpation; questionable nodules were occasionally incised. Small, necrotic, or abnormal hydatid cysts may have been missed in this procedure. The livers and lungs were the only organs examined, and all infected organs were removed to the laboratory. Within a few hours after the organs were collected, all detected cysts were carefully examined for a definitive diagnosis as well as for a determination of their fertility.

The number assigned by the packing plant was recorded for each lot of sheep examined, as was the number of sheep per lot, the number of sheep found infected, the name of the consignor or consignors, and the date. Identification of the

origin of all infected lots was attempted to determine whether the shipment originated within California or had been imported directly for slaughter.

Owners of heavily infected lots from California were informed of the infection. Personal and medical histories were taken of the ranch owners' families, and arrangements were made whenever possible for examination of their dogs and, sometimes, of their sheep and the premises.

Figure 1. Number of sheep shipped into California for immediate slaughter, in thousands, by State of origin



The ranch owners were also informed of the health risk to themselves, their families, and their employees and were advised to consult their physicians.

Radiographic examinations were performed of the lungs of all family members and employees on the ranch on which cases of hydatid disease in human beings were disclosed through this trace-back procedure. All exposed persons were tested intradermally with three antigens, prepared from aseptically collected fluid from a fertile hydatid cyst of sheep origin by lyophilizing the dialyzed fluid and reconstituting it in sterile physiological saline to protein concentrations of 22.4, 2.24, and 0.224 μgm. per ml. The areas of wheals were determined by the method of Pellegrino and Macedo, as described by Kagan and Pellegrino (*20*). Serums from the persons exposed were examined by the indirect hemagglutination and the bentonite flocculation tests. Sheep serums were similarly examined. (The bentonite flocculation tests and the confirmatory indirect hemagglutination tests were performed by Schantz at the National Communicable Disease Center, Public Health Service, Atlanta, Ga., with the assistance of Dorothy Allain and Dr. Irving Kagan.)

Dogs were examined for *E. granulosus* infection by administering, per 10 lbs. of body weight, 15 mg. of arecoline hydrobromide prepared in the form of a 1.5 percent solution. Fasting of the dogs for 12 hours before the examination was requested. A repeated reduced dose of this drug was given to dogs which did not purge in 35–40 minutes. The formed stools that the dogs usually passed first were disregarded, but succeeding passages consisting chiefly of mucus were carefully collected in screw-capped jars and immediately refrigerated. This procedure is approximately 60 percent efficient in detecting routine *Echinococcus* infections in dogs.

Purged specimens were examined after they were mixed with tapwater, washed through metal window screening to remove coarse debris, and subsequently strained through an 80 mesh-per-inch metal sieve to remove the remaining mucus and soluble feces. The material retained on the second sieve was washed into shallow pans containing enough water to facilitate examination. The material was then scrutinized in a strong light against a black background. Intact worms, separated proglottids, or deteriorating strobilae were removed by Pasteur pipet, examined under a dissecting microscope, fixed in Raudabush's solution, and stained with Delafield's hematoxylin and Ehrlich's acid hematoxylin. Tapeworms of other species were also collected and identified. Precautions were taken to avoid contamination of personnel and the laboratory inasmuch as some *E. granulosus* eggs are able to survive even prolonged exposure to formalin and other common germicides (*21*).

After repeated washings and sedimentation in conical sedimenting glasses, the sediment from soil samples collected at random from the vicinity of sheep pens and other ranch sites was examined microscopically in the laboratory for taeniid eggs. Methods of soil examination recommended for other soil-transmitted helminths, but in which sodium hypochlorite solutions (*22*) are used, are unsuitable for detecting taeniid eggs (*21*).

Results

Approximately 1,100 of 22,720 ewes examined for hydatid cysts between December 18, 1967, and June 13, 1968, in the Solano County slaughterhouse were positive, for an overall infection rate of approximately 4.8 percent. The examination for hydatid cysts was carried out on 87 of the 118 days on which ewes were slaughtered. (Ten of the 31 days on which no examinations were done were in March 1968.) The average number of ewes examined per day was 261 in an average of 2.3 lots. The highest infection rates were reached in the months December through March. We have routinely collected hydatid cysts and cysts of *Taenia hydatigena* from this slaughterhouse since the spring of 1967, but only during this 6-month period were accurate infection rates recorded.

In infected lots of sheep, low infection rates were usually observed in mixed lots originating from a number of consignors. High infection rates were found in lots originating from one or two consignors. The lowest rate of infection from a single consignor of more than 100 head of sheep was 5 percent of 337 sheep. The highest rate was 99 percent of 227 sheep, with an average infection rate of 46 percent in eight such lots. Many animals harbored very heavy infections

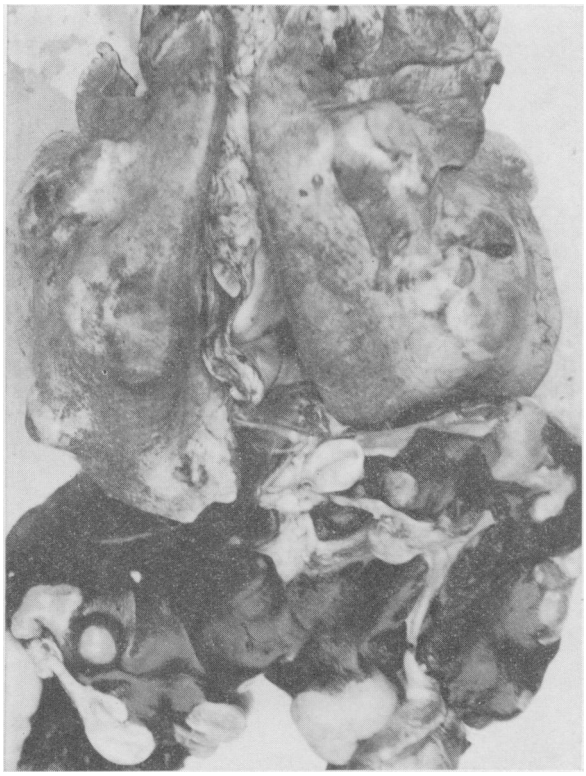


Figure 2. Lungs and liver of ewe from California ranch showing heavy infection with hydatid cysts

in their livers and lungs (fig. 2). Of all cysts examined for fertility, 76 percent of the lung cysts and 84 percent of the liver cysts contained fully developed protoscolices.

In addition to consignments of ewes originating within California, three lots from Idaho and one from Utah were observed to have infection rates of from 25 to 60 percent in lots averaging 141 head.

Heavily infected lots of sheep from single consignors were traced back to eight premises in California. We have visited five of these premises, and the dogs have been examined on four of them (fig. 3). A relatively large proportion of California sheep ranchers are Basques or are of Basque descent and all of the ranches that we located in our study were owned by Basques. All these ranchers had come to the United States as young men 15 to 40 years ago, and their families had been born and raised in California.

Ranch 1, San Joaquin County. The rancher from ranch 1 in San Joaquin County also uses range in Monterey County. The overall hydatid infection rate of ewes examined at slaughter from this ranch was 99 percent of 227 head. Subsequently 43 ewes 4 years of age or older were segregated from approximately 400 sheep which this rancher kept on an island in the San Joaquin River delta. Blood samples were collected from all of these old ewes, and they were skin-tested in the field (figs. 4 and 5) with an antigen prepared from dialyzed sheep hydatid cyst fluid and adjusted to 75μ gm. protein per ml.

Thirteen of the 14 positive reactors to this skin test were donated to the university. The table shows the results of serologic tests on the 13. These sheep were given repeat skin tests 5 months later with a more dilute antigen (2.24μ gm. protein per ml.). Six of the 13 also reacted positively to this antigen; reactions of an additional four sheep were doubtfully positive; the skin reactions of the other three sheep were negative. The lungs of five animals were radiographed, and as of December 1968, six of the 13 sheep have been autopsied. The results of the serology, radiography, and autopsies are summarized in the table.

Studies of the medical histories of the rancher's family revealed that one of his sons, J. O., born June 10, 1960, had been admitted to the Lodi Memorial Hospital at Lodi on August 18,

Figure 3. Sites of California ranches visited

+ Infected sheep

⊕ Infected dogs and sheep

⊞ Infected human beings and sheep

1965, with a suspected ruptured appendix. On that day J. O. had jumped from a flat-bed trailer about 2½ feet from the ground. Upon falling, he sank to his knees and cried and complained all afternoon of not feeling well. That evening he refused to eat dinner and vomited.

On admission to the hospital the boy complained of mid-abdominal pain; his abdomen was tender and moderately distended. Dullness was observed over the right lower chest, and there were decreased breath sounds. J. O.'s rectal temperature was 100.6° F., his pulse was 108, and his respiration was 36. The white blood cell count was 10,700–14,700 with 11 percent eosinophiles. A chest X-ray revealed a large oval density in the right lung base and small densities in the right mid-lung and two densities in the left lung (fig. 6). Abdominal X-rays suggested enlargement of the liver. Exploratory abdominal surgery was performed 5 days after J. O.'s admission to the hospital. A hydatid cyst, approximately 6 cm. in diameter, on the inferior edge of the right liver lobe, had ruptured; three other cysts of up to 10 cm. in diameter extended up to the liver dome. These three cysts and the membranes of the ruptured cyst were removed, and the boy's recovery was uneventful. Microscopic examination of the cysts confirmed a diagnosis of hydatid infection and the presence of fertile cysts.

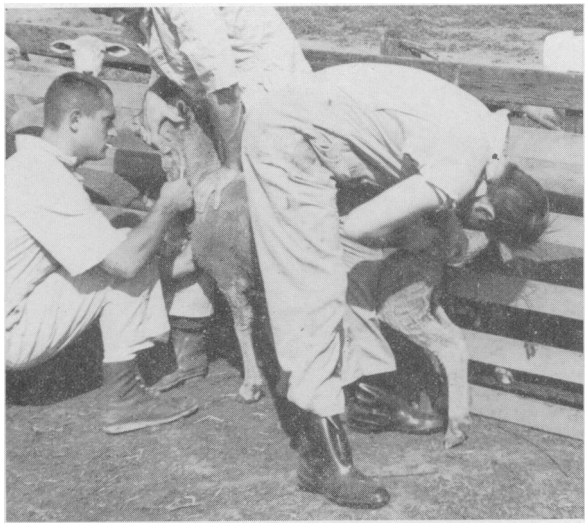


Figure 4. Taking blood sample from ewe's jugular vein and performing skin test in its vulvar fold, ranch 1

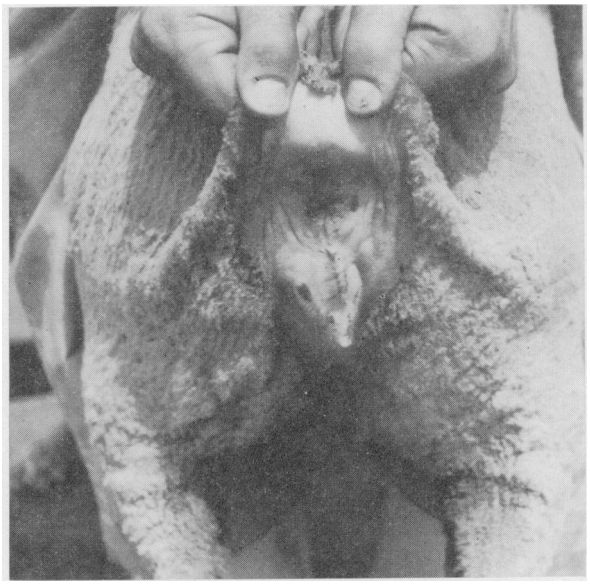


Figure 5. Immediate positive reaction to skin test in ewe's left vulvar fold, ranch 1

J. O. was readmitted to the hospital on November 10, 1965, and February 28, 1966, for right and left thoracotomies. Two cysts (12 cm. and 2 cm. in diameter) were removed from his right lung and one cyst from his left lung. Recoveries in both instances were uneventful.

The other members of J. O.'s family were subsequently examined by chest X-rays, and the 37-year-old father, S. O., was found to have bilateral lung densities consistent with the presence of hydatid cysts. A left thoracotomy was performed on May 1, 1966, and a hydatid cyst 10 cm. in diameter was removed from the lung (fig. 7). Subsequent X-rays of the right lung suggested that a cyst in this organ may have ruptured spontaneously into a bronchus. The results of chest X-rays of other members of S. O.'s family (his wife and three sons) were all negative at that time.

S. O. is a Basque who had come to California from Spain as an immigrant 15 years before our study. He had been a sheepherder in Spain, but for his first 8 years in California S. O. had worked on a dairy farm in Sacramento County. Seven years before his surgery he had purchased his present farm and had begun raising sheep. The infected son, J. O., had never been out of California, although the entire family visited Spain after the father recovered from surgery.

Results of immunodiagnostic tests, thoracic radiographs, and autopsies of 13 ewes from ranch 1

Animal's identification No.	Skin tests		Serologic titers		Thoracic radiograph	Cysts found at autopsy [1]				
	Initial (75 μ gm. protein per milliliter)	Subsequent (2.24 μ gm. protein per milliliter)	Indirect hemagglutination	Bentonite flocculation		Liver		Lungs		*Taenia hydatigena* cysts
						Viable	Calcified	Viable	Calcified	
114	+	−	6, 400	5	ND	−	+	−	+	−
115	+	+	400	−	ND					
118	+	−	1, 600	5	ND					
120	+	−	25, 600	40	ND					
121	+	+	6, 400	10	−					
124	+	+	400	−	+	−	+	+	−	−
129	+	±	200	−	ND					
131	+	±	1, 600	5	+	−	+	+	+	+
133	+	+	200	−	+	−	+	+	+	+
134	+	+	400	−	ND	−	−	+	−	−
137	+	±	400	−	ND	−	+	+	+	+
138	+	±	6, 400	20	ND					
141	+	+	200	−	+					

[1] Studies are still in progress on 7 sheep. ND—not done.

At the time the infected sheep were traced back to ranch 1 in February 1968, S. O. owned six dogs, all Australian shepherds. Only one of these dogs, a bitch of 7 years that had formerly been a working sheep dog but was now a family pet, had been on this ranch in the period before hydatid disease had been diagnosed in the father and son. Another dog which the family had owned in that period had disappeared, a second had been killed, and a third had been given away. The five dogs working S. O.'s sheep at the time of the 1968 study were all purged with arecoline hydrobromide on three separate occasions, but no *E. granulosus* were found. Most of these dogs did harbor *T. hydatigena*, however—an indication that they had eaten sheep viscera in the past.

Soil samples collected at different locations on this ranch, particularly around salt licks and corrals, were all negative for taeniid eggs.

On July 31, 1968, S. O., his previously infected son, J. O., his three other sons, his wife, and the Basque shepherds employed by him and their families were all skin-tested, their chests were X-rayed, and samples of their blood were collected for serologic testings. Skin-test wheals developed in all these persons but were less than 1 cm.^{2} except in S. O. and one shepherd. A wheal of 1.2 cm.^{2} developed in the shepherd. In S. O., wheals of more than 4 cm.^{2} developed immediately in response to the more concentrated antigens. In neither man did the wheals which developed in response to the most dilute antigen measure more than 1 cm.^{2}. Only S. O.'s reaction was regarded as positive. It was rather surprising that J. O.'s skin test was neg-

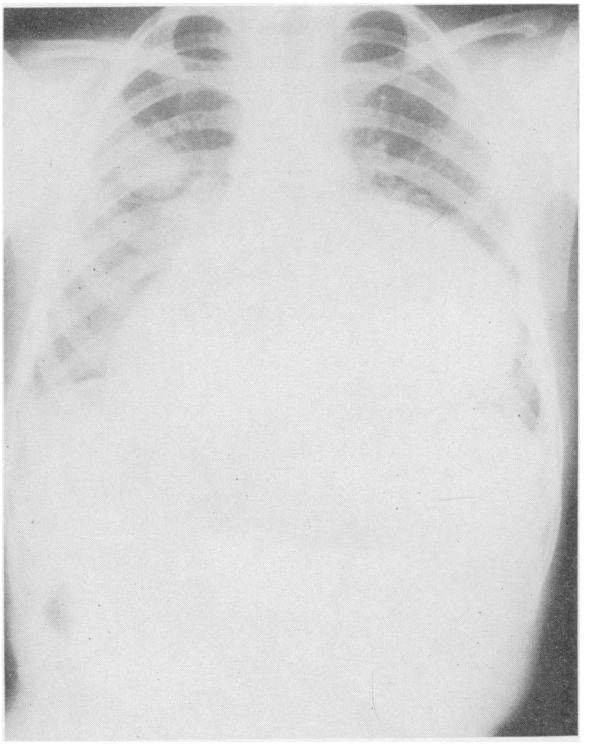


Figure 6. Chest X-ray of 5-year-old J. O., August 1965

ative, particularly since one of his cysts had ruptured intra-abdominally. However, this result may possibly be explained by his age. Serologically, S. O. displayed a titer of 1 : 6,400 and J. O. a titer of 1 : 12,800 on the indirect hemagglutination test. On the Bentonite flocculation test, S. O. displayed a titer of 1 : 10 and J. O. a titer of 1 : 40.

Chest X-rays revealed no positive results or significant new lesions in any of S. O.'s family or in the workers and their families on ranch 1.

Ranch 2, Madera County. The rancher on ranch 2 also uses range in Fresno County. The overall infection rate in ewes examined at slaughter from this ranch was 73 percent of 214 head. These 214 head were among the last ewes left on this ranch. The stock sheep had been sold 5 months before our study of July 1968. Only two 4-year-old dogs, kept as house pets, remained on the premises. An older dog, which had been a working sheep dog, had been killed by a hay mower shortly before the study, and several other dogs had been put in a dog pound. Of the two house dogs examined, one was found infected with *E. granulosus* (fig. 8).

Ranch 3, Fresno County. The overall infection rate for ewes from ranch 3 when examined at slaughter was 27 percent of 310 head. This rancher had three sheep camps at widely scattered sites with six to eight dogs working at each camp. At the only camp of his that we visited in July 1968, seven dogs were administered arecoline hydrobromide. Two failed to purge, and three of the remaining five were infected with *E. granulosus;* one 4-year-old dog passed a large number of parasites.

Figure 7. Exposed hydatid cyst in left lung of 37-year-old S. O.

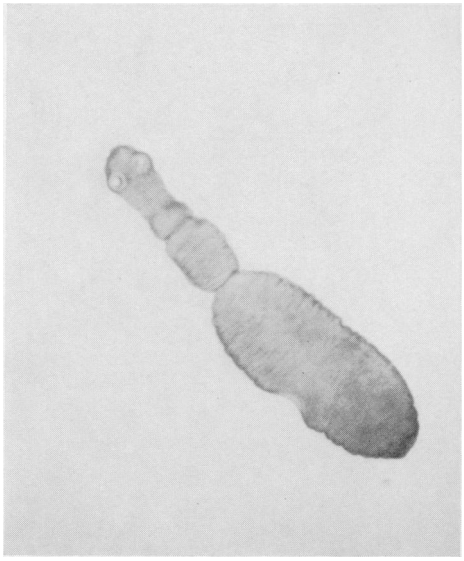


Figure 8. Adult *Echinococcus granulosus* recovered from a dog on ranch 2 after dogs were purged

Ranch 4, Fresno County. The infection rate at slaughter of ewes from ranch 4 was 27 percent of 244 head. Sheep from the ranch were located at three camps. In camp 1, we examined six dogs. One dog failed to purge, and one of the remaining five was heavily infected with *E. granulosus.* In camp 2, three dogs were given arecoline hydrobromide (a fourth dog at this camp had recently disappeared). One dog failed to purge, and no *E. granulosus* were recovered from the other two dogs. At camp 3, two of three dogs examined were infected, one of them very heavily. Studies of the medical histories of persons on ranch 4 revealed that a nephew of the herder at this camp had been operated on for hydatid cysts several years before our study. This nephew had previously herded sheep on the ranch in San Joaquin County from which the owner of ranch 1 had purchased his first sheep. A followup of this case is in progress.

Figure 9. Basque shepherds and dogs

Figure 10. Basque shepherd with his flock and sheep dogs

Discussion

Ranches 2, 3, and 4 were definitely identified as foci of transmission of *E. granulosus*. To our knowledge, these ranches are the first places in the United States in which the complete life cycle of this parasite has been demonstrated. Seven of 17 dogs examined on these three ranches harbored *E. granulosus*, as compared with only 15 dogs previously found harboring this helminth in random examinations of more than 10,000 dogs elsewhere in the United States. In addition, three cases of hydatid disease in human beings were disclosed by this study—two of these cases on a ranch with infected sheep and at least one of them definitely autochthonous to California.

Besides disclosing an appreciable level of hydatid infection in ewes from California, data from our study suggest that similar foci of transmission exist in Idaho and Utah. The epidemiologic value of tracing the origin of food animals found during routine slaughter to be infected is clearly indicated. The procedure of tracing back infected animals is now the principal tool that the Animal Health Division of the U.S. Department of Agriculture uses in campaigns to eradicate bovine brucellosis and bovine tuberculosis, two other infections of public health importance. This procedure is complicated because we have not yet realized a nationwide animal identification system in the United States.

The owners of all of the ranches to which

Figure 11. Sheep dog defecating on pasture

NOTE: Dog was subsequently found to be harboring *Echinococcus granulosus*.

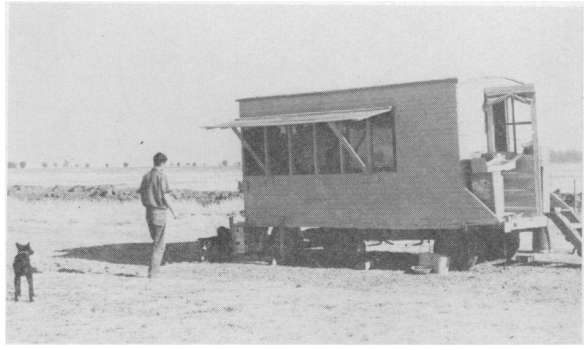


Figure 12. Trailer hut of Basque shepherd. Huts are moved from place to place as sheep graze

heavily infected lots of ewes were traced were Basques or were of Basque origin. Inasmuch as most of the dogs from the ranches that we examined harbored *T. hydatigena*, it is evident that these dogs are commonly fed sheep viscera or have access to dead sheep, a fact which the shepherds readily admitted. It is the custom among immigrant Basque ranchers to bring to this country as shepherds young Basques who then live with their sheep and their dogs (figs. 9–11), usually in a trailer hut (fig. 12) and often in considerable isolation. These shepherds usually do not speak English, at least initially, and they save their money either to return to Spain or to establish their own flocks or ranches in the United States. It is probable that they follow the same practices in feeding dogs and sheep and in husbandry as in Spain, a country with a high level of hydatid infection in man. Some of these practices would be expected to intensify and extend the transmission of hydatid infection in the United States. In additional studies at the University of California, we plan to investigate further this question of husbandry practices, along with an investigation of the extent of hydatid infection in California among Basque shepherds and their dogs.

Retrospective studies of hospital surgical records in the sheep-raising areas of northern and central California are in progress in our laboratories, as well as a study of the possible role of the coyote in the epidemiology of hydatid infection in California. Coyotes are numerous in many sheep-raising areas in the State, and ranchers report that, while mountain lions and stray dogs visibly excite sheep by their presence in the vicinity, coyotes are able to creep almost unnoticed among flocks of sheep until they have made a kill. Coyotes have also been observed feeding on dead sheep.

Summary

Epidemiologists in the School of Veterinary Medicine, University of California, Davis, found an appreciable level of hydatid (*Echinococcus granulosus*) infection—4.8 percent—in 22,720 ewes examined at slaughter in northern California during 1967–68. Heavily infected lots of sheep were traced by their lot numbers to Idaho and Utah and to eight ranches in four counties of California. On one California ranch, two cases of hydatid disease in human beings, at least one of them autochthonous, were disclosed. Seven of 17 sheep dogs examined on four of these California ranches were positive for *E. granulosus*. Transmission foci of hydatid disease have thus been identified for the first time in California and possibly for the first time in the United States exclusive of Alaska. All the owners of the infected premises were Basques or persons of Basque descent.

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Parasitic Disease Drugs Available at NCDC

The Parasitic Disease Drug Service has been established at the National Communicable Disease Center to satisfy the growing demand for antiparasitic drugs, many of which are unlicensed or not readily available in this country. With increasing involvement of Americans in tropical areas and more sophisticated medical diagnosis, the number of requests for such drugs is expected to increase.

The Center dispensed drugs 178 times in 1968, its first year of operation. All the diseases for which the drugs are used as treatment are rare in the United States, although many are common in other areas, particularly the tropics.

Many of the drugs are not licensed in the United States, but have been used extensively elsewhere. The Food and Drug Administration permits the Parasitic Disease Drug Service to supply each drug to requesting physicians on an investigational basis. In many cases, the availability is a matter of life or death to the patient.

The drugs thus far available are:

Astiban, for treatment of schistosomiasis when caused by *Schistosoma hematobium* and *Schistosoma mansoni*. In many cases, Astiban can be given on an ambulatory basis over a short period of time.

Bithionol, for the treatment of paragonimiasis, found in Southeast Asia, West Africa, and Northwestern South America.

Dehydroemetine, for intramuscular or subcutaneous use for severe intestinal amebiasis and extraintestinal amebiasis—liver abscess. Dehydroemetine is less toxic than emetine and equally effective.

Mel B, for the treatment of sleeping sickness when there is central nervous system involvement. This disease is prevalent in many areas of sub-Saharan Africa.

Niclosamide for cestode infections due to *Taenia saginata, Hymenolepis nana,* and *Diphyllobothrium latum*. This drug can be given to ambulatory patients and is relatively nontoxic.

Pentamidine isethionate, for the treatment of the early stages of African sleeping sickness due to *Trypanosoma gambiense* and for *Pneumocystis carinii* pneumonia, a serious infection seen in newborns, debilitated infants, and adults with altered immunologic response (usually in association with a malignancy). This disease, with an epidemiology that is not understood, is on the increase. The Public Health Service provided drug treatment for more than 100 cases in 1968.

Pentostam, for the treatment of leishmaniasis (kala-azar, oriental sore, and espundia). These infections occur in many areas of the tropics.

Suranin, for treatment of the early stages of sleeping sickness due to *Trypanosoma rhodesiense* and treatment of onchocerciasis (usually in combination with diethylcarbamazine).

Parental chloriquine for treatment of pernicious *Plasmodium falciparum* malaria in which the strain is sensitive to chloroquine and parenteral quinine for treatment of the same infection when the strain is resistant to chloroquine. Both of these drugs are licensed and commercially available in the United States but are sometimes difficult to obtain rapidly.