Q fever in bovines, present in only 7 States in 1949, is now reported in 35 States. While the incidence of bovine infection appears to be increasing, the extent of transmission to man remains to be determined.

Report on the Nationwide Occurrence of Q Fever Infections in Cattle

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SINCE 1947, Q fever has been recognized as a public health problem in certain areas of the United States, particularly in the Western States. Special investigations have shown that human cases, some of which are severe and protracted, commonly occur in endemic areas in Texas, California, and Idaho. Recent reports (*1*) indicating that Q fever occurs in other States emphasize the need for further investigation of this infection of animals and man. A systematic study of the infection in livestock and of associated human disease is required to define the problem.

Dairy cattle, which are a major reservoir of infection and thus an abundant potential source of human disease, develop only asymptomatic infections. After the causative agent, *Coxiella burnetii*, is introduced into a herd, many animals develop chronic infections and transmit the agent to other additions to the herd; thus the herd usually remains permanently infected. Sheep and goats also are sources of the disease but are of lesser importance because their more limited distribution results in fewer human contacts. Although infection cycles may occur among rodents and arthropods in nature, *C. burnetii* maintains an independent and more important airborne infection cycle among domestic livestock. This airborne transmission, along with the hardiness of the agent and its ability to persist in the environment, suggests a propensity for spreading and becoming a widespread public health problem.

Luoto (*1*) postulates that foci of Q fever occur and are spreading among dairy cattle in many areas of the United States and that the resulting gross environmental contamination will lead to frequent human infection and illness. In order to evaluate the public health significance of Q fever infections a three-phase study is planned: (*a*) the prevalence of the disease among dairy cattle will be determined by serologic surveys; (*b*) where foci of Q fever are found, surveys for human infection will be performed; and (*c*) the surveys will be followed, if indicated, by studies of the disease in man.

This is a report of findings dealing with the distribution, prevalence, and spread of Q fever among dairy cattle.

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Method of Study

Information on bovine infection was obtained by cooperative surveys in which State or local health and agricultural groups in 26 States participated. Herd milk specimens and serums ob-

tained by existing collecting agencies, such as mobile brucella test or milk control laboratories, were tested for antibody against *C. burnetii*. Tests of individual samples of milk or serums, isolation of the agent by guinea pig tests, and epizootiological studies were performed when indicated. Results were confirmed and correlated at the Rocky Mountain Laboratory, Hamilton, Mont.

The capillary-tube agglutination test (CAT) was used to detect antibody against *C. burnetii* in milk and various serums (*2–4*). This test, used in Q fever studies since 1952, has been evaluated by other groups (*5,6*) and found to be specific, sensitive, and reproducible. A close correlation exists between the presence of the agent in milk and of agglutinating antibody in milk or serum of individual animals.

Recent studies by Tjalma (*7*) and those to be reported by Luoto and Brock of tests performed during 1958–59 in Montana and Idaho indicate the reliability of the method for testing pooled milk from entire herds; a positive result indicates the presence of one or more infected animals within the herd. Other studies by Krumbiegel in Wisconsin and Stoenner in Idaho during 1957–59 demonstrated that 79 to 84 percent of milk samples positive in the CA test yielded *C. burnetii* when inoculated into susceptible animals. The percentage of isolations increased directly with the titer of pooled milk, but the agent was not isolated from CAT-negative herd milk. While the exact sensitivity of this method for detecting infected animals within herds is uncertain, the test works effectively under field conditions. Infected herds and animals are being detected in areas where rates of infection among individual cows are only a fraction of 1 percent.

Distribution and Prevalence

Data now available demonstrate conclusively that Q fever occurs among dairy cattle in all parts of the United States. Bovine infections

Figure 1. The known distribution of naturally occurring Q fever infections in the United States

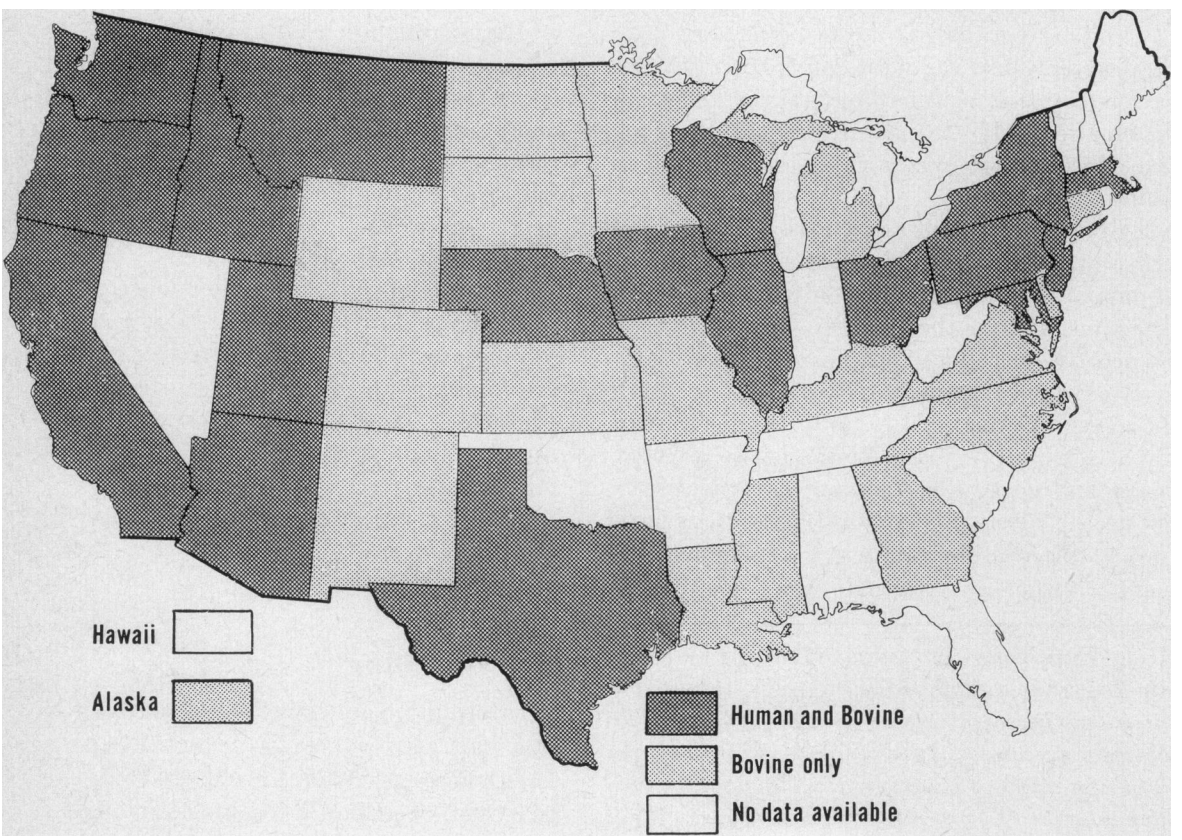
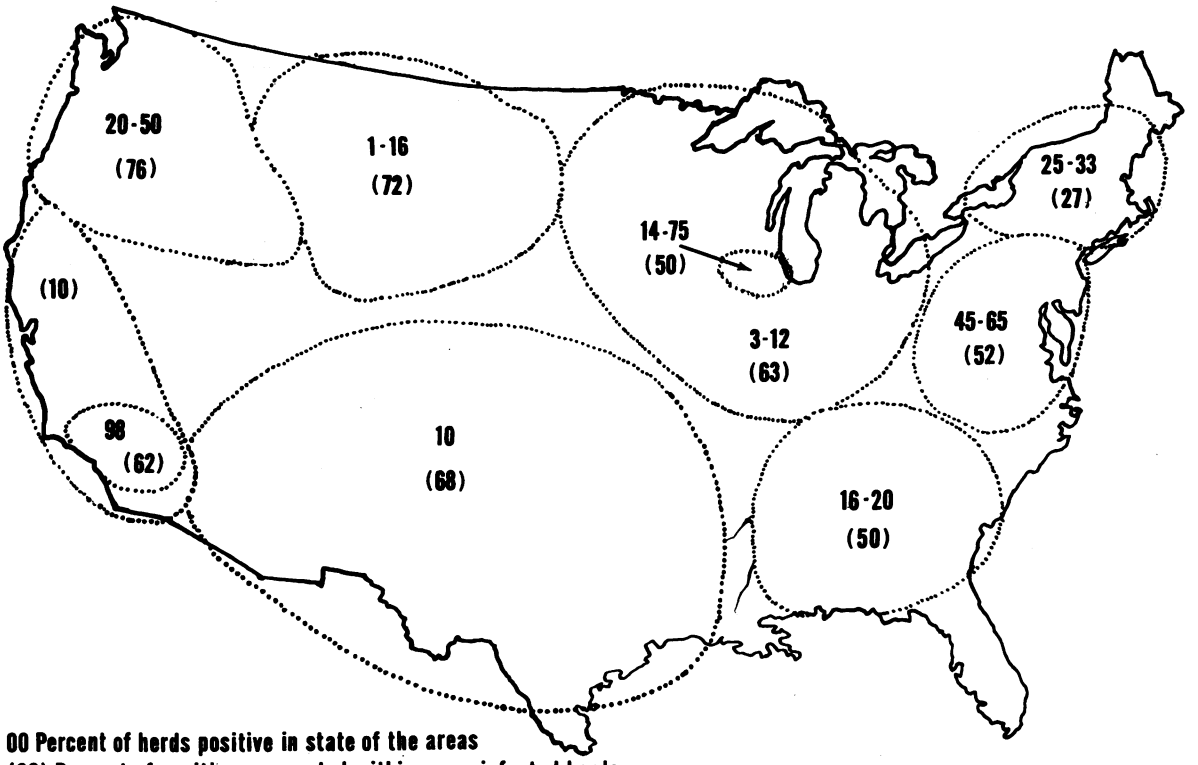


Figure 2. Prevalence of Q fever infection among dairy cows and herds in areas of the United States



00 Percent of herds positive in state of the areas
(00) Percent of positive cows noted within some infected herds

have been demonstrated in 35 States (fig. 1) and have been found recently in all States where a concerted search has been made. Earlier studies indicated that bovine infections were frequent in seven States; namely, California, Wisconsin, Ohio, Iowa, Texas, Arizona, and Idaho (*6–13*). The current surveys in 26 States of 24,551 herds including 353,905 cows confirm and expand earlier findings in some areas and prove the occurrence of considerable bovine infection in 19 additional States—Oregon, Washington, Montana, Wyoming, Utah, South Dakota, Minnesota, Nebraska, Illinois, Michigan, Georgia, North Carolina, Maryland, Pennsylvania, New Jersey, New York, Connecticut, Massachusetts, and Hawaii. Other, more limited, data suggest that bovine infection occurs in nine other States; namely, Louisiana, Mississippi, Virginia (*14*), Colorado, New Mexico, North Dakota, Kansas, Missouri, and Kentucky (*15*). It is likely that infections occur in the remaining 15 unstudied States, most of which are adjacent to or surrounded by infected areas.

An unexpectedly high herd infection rate was encountered in most sections of the country, ranging from 1 to 65 percent within the various States (fig. 2). The finding of high levels of infection among dairy herds along the supposedly infection-free eastern seaboard is of special interest. Wide distribution of foci and variation in prevalence of infection was apparent. Within States having even the lowest rates, up to 14 percent of the herds in some areas were infected. Nearly 100 percent of the herds were infected in areas having more widespread infection. In Wisconsin, with a 7.7-percent herd infection rate, 75 percent of the herds were positive in some counties (*9*).

Not only were herd infections widespread, but a high percentage of infection occurred among animals within herds (fig. 2). Studies of several hundred cows within a dozen herds in each of several parts of the country revealed that over 50 percent of the animals within some herds are positive. Such levels of infection also exist among cows in focal areas where herd infections are infrequent. In Montana, with only

Table 1. Recent observations on the prevalence and spread of Q fever among dairy herds

Region	1948–52		1958–59	
	Number tested	Percent positive [1]	Number tested	Percent positive [1]
Idaho, south-central	438 herds	1. 0	751 herds	17. 0
Eastern States	179 herds	<1. 0	248 herds	47. 0
Mountain States	900 serums	<1. 0	315 serums	30. 0
	364 herds	0	5,536 herds	1. 2

[1] Early tests were done by complement fixation, except for group 1 milks, tested by guinea pig tests, and the 364 herds in group 3, by capillary test. All recent tests used the capillary method.

1 percent of the herds infected, up to 72 percent of the cows within infected herds were positive.

These data on the distribution and prevalence of bovine infection have been extracted largely from reports of participating groups. Detailed reports on studies within individual States will appear elsewhere. In confirming the findings of various investigators, isolations of the agent were made from milks collected in 10 "newly" infected States. Current information indicates that *C. burnetii* is already well-seeded among dairy cattle in all parts of the country.

Spread of Infection Among Bovines

Reports in the literature suggest spread of infection among bovines in California, Wisconsin, Ohio, and Iowa (*9,10,16*). Recent unpublished observations on the prevalence of bovine infection constitute more conclusive evidence of the spread of Q fever (table 1). These studies were done by CAT procedures while the earlier observations, except for the 364 herds from a mountain State, were based on guinea pig or complement fixation tests. The results are comparable, however, since the sensitivity of these test methods for detecting infections is quite similar (*2, 3*). These findings indicate that dairy herd infections in south central Idaho increased from 1 to 17 percent from 1951 to 1958 (*13*). A great increase occurred in an Eastern State where evidence of bovine infection was not detected in 1949, a little was present in 1952, but 47 percent of 248 herds tested were infected by 1959. Luoto and Stoenner have found that bovine infections increased appreciably in two mountain States between 1952 and 1958 (table 1). Other similar but perhaps less valid observations, because of inadequate baselines of infection, suggest that bovine Q fever is increasing in five Eastern States which

Table 2. Increase of Q fever infection observed among dairy herds in Montana counties and Idaho plants

Site	Montana			Idaho		
	Total tested	Number positive January 1959	Number positive May 1959	Total tested	Number positive October 1958	Number positive March 1959
Total	852	19	37	99	42	90
A	152	8	18	48	15	43
B	316	6	11	25	9	21
C	384	5	8	26	18	26
Percent positive		2. 2	4. 3		42. 3	90. 1

NOTE: Positive indicates herd milk reacted in capillary-tube agglutination test on whole milk.

previously had no evidence of infection (*15*) but now have from 20 to 65 percent of the herds infected. A recent resurvey of a large Iowa milkshed by Tjalma showed a 100 percent increase in herd infections over that detected a year earlier (*5*); a similar increase is being observed by Krumbiegel among herds being resurveyed after 2 years in a Wisconsin milkshed.

Specific studies of the spread of infection among cattle, currently underway in Montana and Idaho, indicate that Q fever is spreading in these rural areas (table 2). Montana, which was considered previously to be free of bovine infection (*3*), now has infection in 1.2 percent of the 5,536 dairy herds tested. Infections increased from 2.2 to 4.3 percent, or from 19 to 34 herds among 852 herds resampled in 3 counties during a 5-month period of 1959 according to unpublished survey data. Within the same period, infections of individual cows increased from 9 to 17 among 32 animals in 2 herds observed. Similar studies by Brock in a heavily infected area of western Idaho show that during a 5-month period, herd infection more than doubled, from 42.3 to 90.1 percent, among 99 grade A herds resampled. The spread of herd infection was not uniform within the same or different areas.

Thus, infection has been shown to be spreading under rural conditions in at least 13 States, regardless of the prevalence of bovine Q fever. While the prevalence and rate of spread appear directly related to concentration of dairy cows, undoubtedly other unknown factors are involved.

Correlation With Human Infection

As could be expected, human infections occur and are diagnosed in areas where Q fever is known to exist in animal reservoirs. As the result of special interest and studies, Q fever is already recognized as a public health problem in some areas. At least 300 human cases were detected in southern California (*17*), and 350 cases were associated with sheep in northern California (*18*), during epidemiological studies in 1948–49. Additional cases are encountered annually. Cases originating from cattle or sheep have been recognized for many years in Texas and south central Idaho where epidemics were studied in 1947 and in 1958 (*19,13*). Ten proven cases and evidence of infection in 85 individuals were found in Iowa by Tjalma where only 3 percent of dairy herds are infected. Human infection has been reported from 18 of the 35 States with known infected cows; an occasional human case is diagnosed in four "newly" infected States, namely, Maryland (*20*), Pennsylvania (*21*), New York, and New Jersey.

The true incidence of human infection, or of disease, within the United States is unknown because many cases are unrecognized. Even during the recognized epidemic in Idaho during 1958, most of the 93 laboratory-confirmed cases reported were diagnosed by about 10 percent of the local physicians, many of whom had diagnosed cases in previous years.

Significance of Findings

The demonstration of widespread bovine infection indicates that Q fever is endemic throughout the United States and that a nationwide problem already exists. The spread of infection even under dispersed rural conditions, as in Montana, sometimes occurs with rapidity and is a matter for concern. Universal bovine infection, similar to that in southern California where 98 percent of the herds are infected, may develop in other parts of the country. Such conditions are already approached in Western States, in Wisconsin, and in several Eastern States. The continuing growth of human and animal populations will result in crowding conditions even more conducive to spread of infection. Continued surveillance will indicate the development and scope of the animal disease problem.

In view of the widespread prevalence of bovine Q fever throughout the United States, information on associated human infections is urgently needed. Q fever is already a public health problem where the disease is endemic, with epidemic outbreaks, but the true magnitude of the problem in the United States remains to be determined. In many respects the failure to recognize Q fever in man is similar to the situation existing when brucellosis in man was first associated with a disease of cattle. From present knowledge concerning Q fever, it is difficult to conceive how infections

in man, perhaps even now occurring unrecognized, can fail to become even more widespread.

Regardless of any future implications, the presence of *C. burnetii*, a known pathogen, in animals and their products or environment presents situations which must be faced by responsible agricultural, industrial, and public health groups. Only through coordinated studies by many groups will data become available for evaluation of the problem. Public relations problems arise. Recognition and reporting of human infection should be promoted. Educational, diagnostic, and epidemiological services must be provided, along with possible regulatory and control measures.

Summary

Bovine Q fever must now be considered endemic throughout the United States, since infections are widespread and occur in all 35 States recently studied. Such infections are not only prevalent among cattle, sometimes to an alarming degree, but they are increasing and spreading even in rural areas. The spread of infection is expected to continue and may even accelerate in the future.

Human disease contracted from livestock is already a public health problem in some areas and is being recognized in others previously considered to be free of infection. Unrecognized human disease may occur in areas now known to contain endemic bovine infection.

Concerted nationwide studies of the occurrence and epidemiology of the disease are needed to define factors bearing on its occurrence and spread. Stimulation of the recognition and study of Q fever in man is necessary to ascertain the existence or possible development of a disease problem.

REFERENCES

(1) Luoto, L.: The epidemiology of Q fever in the United States. Am. J. Pub. Health 49: 334–338 (1959).

(2) Luoto, L.: A capillary agglutination test for bovine Q fever. J. Immunol. 71: 226–231 (1953).

(3) Luoto, L., and Mason, D. M.: An agglutination test for bovine Q fever performed on milk samples. J. Immunol. 74: 222–227 (1955).

(4) Luoto, L.: A capillary-tube test for antibody against *Coxiella burnetii* in human, guinea pig, and sheep sera. J. Immunol. 77: 294–298 (1956).

(5) Tjalma, R. A.: Q fever in animals and man in Iowa. State University of Iowa Institute of Agricultural Medicine Bulletin No. 3. Iowa City, 1958.

(6) Tjalma, R. A., and Smith, I. M.: Q fever in Iowa dairy cattle. J. Am. Vet. M. A. 133: 606–610 (1958).

(7) Tjalma, R. A., and Braun, J. L.: Application of the Luoto capillary agglutination milk test to the study of bovine Q fever. Am. J. Pub. Health 49: 1023–1031, August 1959.

(8) Huebner, R. J., Jellison, W. L., and Beck, M. D.: Q fever—A review of current knowledge. Ann. Int. Med. 30: 495–509 (1949).

(9) Kitze, L. K.: Q fever in Wisconsin. Serological evidence of infection in cattle and human beings and recovery of *C. burnetii* from cattle. Am. J. Hyg. 65: 239–247 (1957).

(10) Reed, C. F., and Wentworth, B. B.: Q fever studies in Ohio. J. Am. Vet. M. A. 130: 458–461 (1957).

(11) Irons, J. V., Murphy, J. N., Rich, A. B., and Hill, A. E.: Q fever. Q fever survey in southwestern Texas. Am. J. Pub. Health 39: 485–491 (1949).

(12) Di Salvo, A. F., and Wertman, K.: A serological survey of Q fever in Arizona. J. Am. Vet. M. A. 133: 383–385 (1958).

(13) Stoenner, H. G., Jellison, W. L., Lackman, D. B., Brock, D., and Casey, M.: Q fever in Idaho. Am. J. Hyg. 69: 202–213 (1959).

(14) Martin, J. D.: Zoonoses in the South. Pub. Health Rep. 72: 210–216 (1957).

(15) Shepard, C. C.: Q fever. A serological survey of bovine serums in the United States. Am. J. Trop. Med. 28: 849–855 (1948).

(16) Huebner, R. J., and Bell, J. A.: Q fever studies in southern California. Summary of current results and a discussion of possible control measures. J.A.M.A. 145: 301–305 (1951).

(17) Beck, M. D., Bell, J. A., Shaw, E. W., and Huebner, R. J.: Q fever studies in southern California. II. An epidemiological study of 300 cases. Pub. Health Rep. 64: 41–56 (1949).

(18) Clark, W. H., Lennette, E. H., and Romer, M. S.: Q fever in California. XI. An epidemiological summary of 350 cases occurring in northern California during 1948–1949. Am. J. Hyg. 54: 319–330 (1951).

(19) Topping, N. H., Shepard, C. C., and Irons, J. V.: Q fever in the United States. I. Epidemiological studies of an outbreak among stock handlers and slaughterhouse workers. J.A.M.A. 133: 813–815 (1947).

(20) Baltimore Health Department: First instance of Q fever reported in Baltimore. Scope Weekly, June 4, 1958.

(21) Werrin, M.: Two cases of Q fever investigated. Philadelphia Health Department, 1958.