Extension Circular 479 Revised January 1946

B R U C E L L O S I S

(Undulant Fever)

The Relation of the Disease

To

Dairy Products

Review of Scientific Data

Prepared by

COMMITTEE ON BRUCELLOSIS

Roger W. Morse, B.S.	Extension Dairyman, Chairman
O. H. Muth, D.V.M.	Associate Veterinarian
G. H. Wilster, Ph.D.	Professor of Dairy Manufacturing

Federal Cooperative Extension Service
and Agricultural Experiment Station
Oregon State College
Corvallis

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Wm. A. Schoenfeld, Director
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C O N T E N T S

INTRODUCTION

The number of reported cases of brucellosis in humans in the United States has increased in recent years. Whether this is due to an increase in the actual number of cases or to newer knowledge of the disease available to physicians, seems to be a subject for debate. In Portland, the total number of reported cases was slightly above 200 for the year 1944. The recent higher incidence of the disease there has been largely attributed to the consumption of raw milk and milk products from animals infected with the Brucella organisms. Generally, in Oregon, the possibility of infection from dairy products should be less than it was several years ago, inasmuch as the incidence of brucellosis (Bang's disease) in dairy cows has been considerably reduced.

There has been recent interest by consumers, dairy industry groups, officials, and others in instituting additional methods for the control of the spread of this disease through dairy products. To provide a basis for developing control measures a search has been made in all the available American and foreign scientific publications for facts on this subject, and the findings are presented in this paper. It is believed that they are complete with the exception of data from six unobtainable foreign reports.

It is recognized that some individuals, unfamiliar with scientific abstracts, may find it difficult to make full use of part of the information herein presented. Those who have this difficulty can best get an over-all picture from the discussion appearing on pages 49 to 68, inclusive. The complete abstracts are presented to give anyone concerned with the problem, particularly in the medical and veterinary professions, access to all the available information pertaining to it.

Attention is directed to the data on pages 10 and 11, showing the relationship between brucellosis and certain other diseases. The present brucellosis situation in Oregon should not receive the sole attention of those interested in the control of disease significant to public health. In any attempt to prevent brucellosis in humans, the important sources of the Brucella organisms other than dairy products should also receive consideration.

The complete translations of some of the foreign language articles included in this summary have been placed in the libraries of the University of Oregon Medical School, the State Department of Agriculture and the Oregon State College.

ACKNOWLEDGMENT

The Oregon Agricultural Experiment Station has obtained permission from several publishers to copy statements contained in books published by them.

Excerpts from the following books have been made:

"Brucellosis in Man and Animals" by I. Forest Huddleson. Published by the Commonwealth Fund, New York.

"Brucellosis" by Harold J. Harris. Published by Paul B. Hoeber, Inc., New York.

"Dairy Bacteriology" by Bernard W. Hammer. Published by John Wiley and Sons, Inc., New York.

"The Market Milk Industry" by C. L. Roadhouse and J. L. Henderson. Published by McGraw-Hill Book Company, Inc., New York.

The Experiment Station is also presenting abstracts of data published in Scientific Journals, bulletins and reports, as well as data published in scientific abstracts. The use of this material is acknowledged.

BRIEF SUMMARY

Page

1. Any of the following three species of Brucella organisms may cause brucellosis (undulant fever) in humans:

   (a) Brucella abortus (from cattle) 54,61
   (b) Brucella melitensis (from goats) 54,61
   (c) Brucella suis (from hogs) 54,61

2. Humans may become infected with the bacteria by contact with an animal that has brucellosis, by drinking milk or consuming dairy products containing Brucella, by contact with meat, organs, or body fluids of diseased animals, by the use of vaccine containing living Brucella or through other sources. 15,29,40,54

3. From one-third to three-fifths of all human cases of brucellosis are reported to have been caused by infected raw milk and raw milk products. 11,15,43,63

4. The maximum length of time the Brucella organisms remained viable as reported herein was as follows:

Sweet milk	18 months	42
Sour milk	8 days	21
Sweet cream	37 days	21
Sour cream	9 days	21
Butter	142 days	17
Tilsiter cheese*	91 days	21
Emmenthaler cheese**	49 days	21
Soft cheese***	35 days	21
Ice cream	36 months	25
Sour whey	26 days	34
Cottage cheese	7 days	35
Goat's milk cheese	14 months	47
Cream cheese	24 days	34
Breakfast cheese	22 days	34
In dried nutrient material	121 days	58
When exposed to direct sunlight	4½ hours	58
In wet soil in an unheated cellar	66 days	59
In bovine urine kept at room temperature	4 days	59
In bovine feces	100 to 120 days	59

* A hard, rennet cheese
** A hard, rennet cheese - Known in the United States as Domestic Swiss.
*** A Delicatess cheese - A high-moisture breakfast cheese about 3 cm. in diameter. Made from skim-milk. Probably similar to Limburger.

PART I

Statistics of Diseases Traced to Milk and Milk Products In United States

Excerpts from
Reprint No. 2345 from the
Public Health Reports
Vol. 56, No. 48, Nov. 28, 1941

OUTBREAKS TRANSMITTED THROUGH MILK AND MILK PRODUCTS

Of the eight diseases listed in table 2 as milk-borne, food poisoning caused the most outbreaks, but septic sore throat contributed by far the most cases and deaths.

Table 7.—Outbreaks transmitted through milk products, 1939, by kind of supply

Kind of supply	Number of outbreaks	Number of cases	Number of deaths
Sweet milk, raw	20	1,545	6
Sweet milk, pasteurized	4	477	0
Sweet milk, undesignated	2	19	0
Sweet milk, sweet cream, and ice cream, raw	1	274	0
Sweet milk and butter, raw	1	9	1
Sweet milk or ice cream, pasteurized.	1	8	0
Buttermilk, raw	1	7	0
Buttermilk, sweet cream and sweet milk, raw	1	89	0
Ice cream, raw	1	12	0
Ice cream, undesignated	5	45	0
Cheese, undesignated	2	14	0
Canned milk	1	4	0
Cream, raw	1	6	0
Total	41	2,509	7

Table 7 shows the type of milk and milk products involved. Sweet milk, either alone or in combination, was the vehicle in 30 outbreaks, ice cream in 8, sweet cream in 3, buttermilk in 2, cheese in 2, and butter and canned milk in 1 each. The percentage of outbreaks involving ice cream, either alone or in combination, in 1939 was twice that reported for the preceding 5 years. Of the 5 outbreaks attributed to pasteurized milk, 1 of food poisoning was traced to dirty milk bottles, 1 of gastroenteritis to a plant employee who filled 10-gallon cans, 1 of paratyphoid fever to flooding of bottled milk, while in 2 the manner of contamination was not determined.

Table 2.--Outbreaks, cases, and deaths, 1939, by diseases and by vehicles

Disease	Water supplies			Milk and Milk Products			Other foods			Unidentified vehicles			All vehicles		
	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths
Botulism	--	--	--	--	--	--	9	16	7	--	--	--	9	16	7
Dysentery	3	265	0	2	324	0	2	99	0	5	916	4	12	1604	4
Food Poisoning	--	--	--	12	179	0	88	1347	2	--	--	--	100	1526	2
Gastroenteritis (including diarrhea)	27	1892	0	7	570	0	35	1880	0	5	246	0	74	4588	0
Paratyphoid fever	--	--	--	2	24	0	2	247	1	--	--	--	4	271	1
Scarlet fever	--	--	--	3	42	1	1	27	0	--	--	--	4	69	1
Septic sore throat	--	--	--	6	1282	5	--	--	--	--	--	--	6	1282	5
Trichinosis	--	--	--	--	--	--	4	30	0	--	--	--	4	30	0
Tyhpoid fever	13	97	3	6	51	1	5	99	1	7	41	2	31	288	7
Undulant fever	--	--	--	1	4	0	--	--	--	--	--	--	1	4	0
Not stated	--	--	--	2	33	0	2	37	1	--	--	--	4	70	1
TOTAL	43	2254	3	41	2509	7	148	3782	12	17	1203	6	249	9748	28

States Relations Division

Federal Security Agency
U.S. PUBLIC HEALTH SERVICE
Washington

Sanitation Section

SUMMARY OF MILK-BORNE DISEASE OUTBREAKS REPORTED BY STATE AND LOCAL HEALTH AUTHORITIES AS HAVING OCCURRED IN THE UNITED STATES DURING THE YEARS 1923 - 1941, INCLUSIVE

	Typhoid			Paratyphoid			Scarlet Fever and Septic Sore Throat			Diphtheria			Dysentery			Con. next page
Year	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths	
1923	15	423	31	..	..	..	7	406	6	1	5	0	..	..	..	
1924	25	693	48	10	372	16	6	354	0	1	23	0	2	110	1	
1925	31	580	43	2	37	4	10	1108	8	1	14	1	..	..	..	
1926	49	1189	83	2	19	1	11	1789	10	2	24	0	..	..	..	
1927	24	430	35	2	53	0	4	389	5	2	15	0	..	..	..	
1928	25	421	48	..	..	..	11	1449	55	2	48	0	1	126	17	
1929	29	541	36	1	38	1	19	1891	14	..	..	..	1	8	0	
1930	30	575	41	..	..	..	11	1158	7	..	..	..	1	64	2	
1931	21	217	16	1	22	0	9	1059	8	1	22	0	1	65	0	
1932	23	254	22	..	..	..	9	356	6	..	..	..	..	..	..	
1933	25	299	26	1	17	0	10	753	9	2	19	3	..	..	..	
1934	26	345	27	1	400	0	9	473	8	1	9	0	..	..	..	
1935	16	172	14	2	50	0	11	1065	7	..	..	..	1	131	0	
1936	15	114	5	1	21	0	18	1553	23	..	..	..	..	..	..	
1937	15	208	11	..	..	..	14	1384	3	..	..	..	..	..	..	
1938	18	187	17	..	..	..	12	674	7	1	31	3	2	166	0	
1939	6	51	1	2	24	0	9	1324	6	..	..	..	2	324	0	
1940	14	120	10	..	..	..	5	482	0	..	..	..	2	197	0	
1941	12	120	4	..	..	..	3	219	0	1	5	0	3	126	0	
TOTAL 1923-1941	419	6939	518	25	1053	22	188	17891	182	15	215	7	16	1317	20	

(Continued from page 3)

Year	Food Poisoning and Gastroenteritis			Undulant Fever			Miscellaneous			Total - all diseases		
	Out breaks	Cases	Deaths	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths	Out-breaks	Cases	Deaths
1923	..	..	..	..	..	..	..	..	..	23	834	37
1924	..	..	..	..	..	..	..	..	..	44	1552	65
1925	..	..	..	..	..	..	..	..	..	44	1739	56
1926	1	150	0	..	..	..	3	192	1	68	3363	95
1927	1	50	0	3	17	1	..	..	..	36	954	41
1928	2	104	0	5	21	0	..	..	..	46	2169	120
1929	1	24	0	..	..	..	..	..	..	51	2502	51
1930	6	171	6	..	..	..	..	..	..	48	1968	56
1931	1	13	0	..	..	..	..	..	..	34	1398	24
1932	1	32	0	..	..	..	..	..	..	33	642	28
1933	..	..	..	..	..	..	4	260	1	42	1348	39
1934	5	292	0	..	..	..	..	..	..	42	1524	35
1935	13	411	0	..	..	..	..	..	..	43	1829	21
1936	4	188	0	4	15	0	..	..	..	42	1891	28
1937	12	523	0	..	..	..	2	35	0	43	2150	14
1938	9	627	0	..	..	..	..	..	..	42	1685	27
1939	19	749	0	1	4	0	2	33	0	41	2509	7
1940	17	855	0	4	19	0	1	5	0	43	1678	10
1941	15	483	0	3	96	0	..	..	..	37	1047	4
TOTAL 1923-1941	107	4672	6	20	172	1	12	525	2	802	32784	758

Excerpts from
Supplement No. 62
Public Health Reports
United States Public Health Service, 1927
by Charles Armstrong, Surgeon and
Thomas Parran, Jr., Surgeon

The occurrence of milk-borne outbreaks of disease is a well-recognized fact, the importance of which is indicated in the compilations of milk-borne outbreaks reported by Busey and Kober (1895), Baker (1896), Freeman (1896), Hart (1897), Caroe (1898), Schlegtendal (1900), and Trask (1909). These authors report over 700 milk-borne outbreaks of disease, of which 179 occurred in the United States.

In this report there are presented 612 additional instances in which infected milk or milk products have been instrumental in producing outbreaks of greater or less extent in this country.

The outbreaks herein reported may be considered as a continuation of the compilations begun by Trask and earlier authors and represent an effort to complete the data for the United States as published up to January 1, 1927. This investigation has been confined to the United States, because the habit of consuming uncooked milk or its products is more common here than in most other countries, and because the available data on foreign countries were in many instances obviously incomplete. The milk-borne outbreaks reported here have been collected wholly from the literature; and while the list could undoubtedly have been extended had the various state, city, and county health officials of the country been circularized, this was not done. It was felt that such a procedure, covering a period of 19 years, would still give incomplete data, and it seems probable, moreover, that the most important and better proved milk-borne outbreaks have been recorded in the literature. Many of the outbreaks are, however, so incompletely described that it has been impossible for the writers to exercise an independent judgment as to whether or not the infection was milk borne. We have, therefore, accepted the conclusions of the investigators on this point. When the description was so incomplete as to location, time, circumstances, etc., as to leave the identity of the outbreak doubtful, or when the investigator has expressed doubt as to the cause of an outbreak, using such terms as "possibly milk borne," etc., it has not been included in this summary.

SUMMARY

1. In addition to 179 milk-borne outbreaks in the United States collected by various authors prior to 1908 there is herewith reported a compilation of 612 additional epidemics traced to milk or its products to 1927.

2. Ordinary raw milk, or its products, was incriminated in 179 outbreaks; "Pasteurized" milk or its products was incriminated in 29 outbreaks, certified milk in 3, while in 356 the character of the incriminated supply was not stated. Ice cream was incriminated in 36 outbreaks, butter in 3, and cheese in 4.

3. Incomplete records of cases and deaths for the 612 herein-reported milk-borne outbreaks indicate the following:

Table 9.—Summary of 612 milk-borne outbreaks

Disease	Number of outbreaks	Number of cases (incomplete)	Number of deaths (incomplete)
Typhoid fever	479	14,968	219
Paratyphoid	7	434	15
Diarrhea and dysentery	6	92	5
Septic sore throat	42	21,045	139
Scarlet fever	40	3,939	20
Diphtheria	26	971	7
Miscellaneous diseases	12	878	5
TOTAL	612	42,327	410

4. A gradual increase in the reported number of milk-borne epidemics in the United States is noted from 1881 to 1914, following which year a decrease is noted.

5. Carriers, active cases, and exchange of infected bottles, in the order named, are noted as the most prolific sources of milk infection by typhoid bacilli.

6. A markedly increased prevalence of milk-borne typhoid outbreaks is noted in August and September.

7. Those outbreaks attributed to carriers reached their greatest incidence of onset during August while in those traced to active cases the highest occurrence was in September.

8. A reversal in the usual age incidence is noted in a few scarlet fever and diphtheria outbreaks traced to milk and is a common feature in milk-borne typhoid fever.

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Note: No cases of undulant fever reported. G.H.W.

Excerpts from article
"Milk and Its Relation to Disease"
by A. W. Fuchs, Senior Sanitary Engineer,
U. S. Public Health Service

(Delivered before Philadelphia College of Physicians, Feb. 5, 1940.)

Incidence of Milk-Borne Disease

Each year between 30 and 50 outbreaks of milk-borne disease have been reported to the Public Health Service by State and local health authorities in the United States. For the 15-year period from 1923-1937 inclusive, 639 milk-borne outbreaks were reported, involving 25,863 cases and 709 deaths. In the order of their importance the diseases included were: (1) typhoid fever, with 369 outbreaks, 6,461 cases, and 486 deaths; (2) septic sore throat, with 75 outbreaks, 9,467 cases, and 117 deaths; (3) scarlet fever, with 84 outbreaks, 5,725 cases, and 52 deaths; (4) dysentery and enteritis, with 34 outbreaks, 1,506 cases, and 26 deaths; (5) paratyphoid fever, with 23 outbreaks, 1,029 cases, and 22 deaths; (6) diphtheria, with 13 outbreaks, 179 cases, and 4 deaths; and (7) miscellaneous diseases, including food poisoning. with 41 outbreaks, 1,496 cases, and 2 deaths.

It should be noted that this compilation does not include sporadic cases of typhoid fever, scarlet fever, septic sore throat, etc., since such sporadic cases have rarely been given sufficient epidemiologic study to determine the role of milk and milk products in their causation.

Nor does this compilation take any note of such diseases as bovine tuberculosis, undulant fever, or infantile diarrhea, which are largely milk borne, but which generally occur as sporadic cases rather than in epidemic form. Park and Krumwiede's (1) figures indicated that in 1913 in some regions about one-fourth of all cases of tuberculosis in children under 16 years of age were of bovine origin; and Rosenau (2) estimated that perhaps 7 percent of all tuberculosis in man was of bovine origin. Today, as a result of widespread tuberculin testing of cattle and increased use of pasteurized milk, these figures are undoubtedly no longer applicable to the United States.

As for undulant fever, or brucellosis, it is difficult to estimate the incidence. In 1937 about 2,500 cases were reported in the United States. Evans (3) states: "We do not know what percentage of the total number of acute cases the reported cases represent. The data on which the number of chronic cases in this country might be estimated is very meagre. We only know that the chronic disease rarely receives the correct diagnosis. If all milk were efficiently pasteurized or boiled before being consumed, there would be no brucellosis except in those occupational groups whose work brings them into contact with infected animals or infected carcasses."

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Why No Raw Milk Can be Guaranteed as Safe

Why cannot raw milk be guaranteed as safe? The answer is, first, that even frequent sanitary inspections of dairies will not insure that infected bottles have been properly sterilized, that a safe water supply is used for cleansing milk utensils, and that milk containers have not been contaminated by flies. And, secondly, the answer is that even frequent health examinations

of herds and of milk handlers sometimes fail to disclose disease or carrier conditions that may be present.

It may be of interest to outline the mode of transmission of three types of milk-borne disease—undulant fever, typhoid fever, and septic sore throat. What precautions, short of pasteurization, can a dairyman take to insure that none of his customers will ever contract any of these diseases by drinking his milk?

In the case of undulant fever, the only recourse open to the dairyman is to have his cows tested for Bang's disease and to slaughter the reactors. Certainly the slaughtered cows will no longer be a menace to his customers. Since repeated testing is required to maintain a herd free from Bang's disease, the dairyman will retest his cattle six months or a year later, and it would be not at all unusual if he discovered another reactor. He would then be faced with some very serious questions: How long had the cow been discharging the Brucellosis organisms in the milk? How many of his customers had consumed his milk supply raw and had contracted the disease? How could he be certain that the same menace would not be disclosed at the next retest?

Excerpts from Reprint No. 2540 from the Public Health Reports
Vol. 59, No. 6 - February 11, 1944 - P. 189-204.

MILK-BORNE DISEASE IN THE UNITED STATES

Each year between 30 and 50 outbreaks of milk-borne disease are reported to the Public Health Service by State and local health authorities in the United States. For the 10-year period 1932-41, inclusive, 408 milk-borne outbreaks were reported, involving 16,305 cases and 213 deaths (1). The diseases included are shown in table 1.

Table 1.—Milk-borne disease outbreaks reported by State and local health authorities as having occurred in the United States during the 10-year period 1932-41, inclusive, by diseases.

Diseases	Outbreaks	Cases	Deaths
Typhoid fever	170	1,870	137
Scarlet fever and septic sore throat	100	8,288	69
Food poisoning and gastroenteritis	95	4,160	0
Paratyphoid fever	7	512	0
Undulant fever	12	134	0
Dysentery	10	944	0
Diptheria	5	64	6
Miscellaneous	9	333	1
Total	408	16,305	213

It should be emphasized that table 1 is a compilation of reported outbreaks and that it does not include sporadic cases of typhoid fever, scarlet fever, septic sore throat, etc. It is logical to assume that a portion of these sporadic cases is due to milk. It should also be emphasized that this compilation does not include tuberculosis of bovine origin or infantile diarrhea nor any significant amount of undulant fever, all of which are largely milk borne, but which usually occur as sporadic cases rather than in epidemic form. As for undulant fever, it is difficult to estimate the actual incidence and the proportion of the cases and deaths which are milk borne. For the 10-year period 1932-41 26,759 cases of undulant fever and 910 deaths from this disease were reported in the United States. The number of such cases and deaths, by years, is given in table 2.

Table 2.— Undulant fever cases and deaths reported in the United States during the 10-year period 1932-41

Year	Cases	Deaths	Year	Cases	Deaths
1932	1,502	62	1938	4,379	116
1933	1,788	72	1939	3,501	121
1934	2,017	65	1940	3,310	116
1935	2,008	98	1941	3,484	71
1936	2,095	107			
1937	2,675	82	Total	26,759	910

According to the reports of several investigators (2) the percentage of undulant fever cases due to milk varies in different localities. In urban areas, where few persons come in contact with livestock of carcasses, the majority of cases are probably due to infected raw milk. In rural areas, a large proportion of cases may be due to contact with livestock or carcasses. The assumption that one-half of the undulant fever cases and deaths in the United States are due to infected raw milk is believed to be conservative.

Estimates of the economic loss due to death and illness are incomplete measures of the true loss, which includes intangible quantities. Nevertheless, a rough estimate of the economic loss in the United States due to milk-borne disease has been attempted. The money value of a human life is assumed to be $20,000. This is a conservative average value based upon calculations by Dublin and Lotka (3) of the present worth of the net future earning capacities of individuals of different ages and different maximum incomes. The cost of a case of disease is influenced by a number of factors and average costs are difficult to estimate. Rough approximations have been made after consulting data given in publications of the Committee on the Costs of Medical Care (4,5). These costs, which include fees and charges for medical attention, nursing, hospitalization, and laboratory services, range from a total of $10 for gastroenteritis or food poisoning to $265 for typhoid fever and $325 for undulant fever. The money value of working time lost through sickness has also been estimated, assuming the value of one working day to be $6. Thus, the estimates of economic loss include three major factors: (1) the value of a life, (2) the cost of diagnosis and treatment of disease, and (3) the value of working time lost.

Using the estimating method described above, the annual economic loss due to milk-borne disease in human beings has been calculated. The estimated loss for each disease is shown in table 3.

Table 3.—Estimated average annual economic loss from milk-borne disease in the United States, based on reports for the period 1932-41.

Disease	Loss from deaths	Cost of diagnosis and treatment	Value of working time lost	Total economic loss
Typhoid fever	$280,000	$50,000	$67,000	$397,000
Paratyphoid fever	---	14,000	18,000	32,000
Scarlet fever and septic sore throat	140,000	14,500	40,000	194,500
Diptheria	20,000	500	---	20,500
Dysentery	---	7,000	8,000	15,000
Food poisoning and gastroenteritis	---	4,000	5,000	9,000
Undulant fever	920,000	435,000	803,000	2,158,000
Total	1,360,000	525,000	941,000	2,826,000

The total estimated annual loss is about $2,800,000. This is an average figure covering the 10-year period 1932-41 and is based upon the data given in tables 1 and 2. The cases and deaths from outbreaks of undulant fever and miscellaneous diseases listed in table 1 were not included in the estimate.

It is desired to emphasize that this estimate of economic loss from milk-borne disease is only a rough approximation. Greater precision would probably not be justified, because of the recognized incompleteness of the reports of both milk-borne disease outbreaks and undulant fever cases. The estimate is believed to be conservative, however, and it can be safely assumed that the actual economic loss is, in round numbers, at least $3,000,000 per year. (It is interesting to note that the annual economic loss due to brucellosis in cattle has been estimated to vary from $30,000,000 to a much higher figure, according to the United States Department of Agriculture, and that due to brucellosis in swine has been estimated as $10,000,000.)

As an illustration of the cost of an outbreak to a specific community, the 1938 outbreak of septic sore throat in an unnamed community of 1,880 inhabitants will be considered briefly. The outbreak consisted of 375 cases with 4 deaths and was caused by raw milk. Using the same unit cost figures as before, it is estimated that the total cost to the community through deaths, cases and loss of working time was about $100,000. It will be shown later in this paper that it would cost only about $12,000 to provide a pasteurization plant to supply the average demand for pasteurized milk in a community of this size. Without detailed computations, it will at once be apparent that large milk-borne epidemics, such as that of typhoid fever in Montreal, Canada, in 1927, which involved approximately 5,000 cases and 500 deaths, cause a staggering financial loss to the community, and that even small outbreaks are worth preventing.

All milk-borne disease is preventable. In conducting effective milk sanitation programs, health authorities promulgate and enforce ordinances or regulations which quite properly include not one but several measures designed to prevent the transmission of disease by milk. These measures concern the health of the animals and the dairy personnel, the methods of operation, the design of the equipment and buildings, and the water supply and excreta disposal facilities. All these measures have definite value in promoting the cleanliness and safety of milk supplies but are not sufficient to guarantee safety. Examinations of cows and of milk handlers can be done at intervals only, and pathogenic organisms may therefore enter the milk for varying periods before the disease condition is discovered. Unless the milk is also pasteurized, it cannot be guaranteed as safe.

The vast majority of the milk-borne disease outbreaks reported to the Public Health Service are due to raw milk. These reports show that the risk of contracting disease from raw milk is approximately fifty times as great as from pasteurized milk (including milk which was only alleged to be "pasteurized milk") (6). That proper pasteurization can and does prevent the transmission of milk-borne disease has been clearly proved to the satisfaction of health authorities by laboratory and commercial-scale experimental work, by epidemiologic methods, by statistical methods, and by animal experimentation. A classical illustration, and perhaps the most striking example of the immediate effect in the reduction of diarrheal diseases of infants by the pasteurization of milk, is that which occurred in a children's institution on Randall's Island, New York City, where a mortality rate of 44 was promptly reduced to 20 with no hygienic measures put into operation other than the pasteurization of all the milk (7). The literature is replete with other examples (8), one of the most recent of which is the experience in the Province of Ontario, Canada, during the first year following the adoption of the compulsory pasteurization act. According to Berry (9) the cases of undulant fever in 1939 were reduced by about 45 percent, the typhoid fever death rate was lowered about 50 percent, and the infant mortality was substantially reduced in areas under the act. Pasteurization is the most important single protective measure which can be applied to milk. For many years the Public Health Service has advised that all milk should be pasteurized or boiled before consumption. There is no doubt that the present extensive use of pasteurization is preventing a great deal of milk-borne disease.

Source: "Brucellosis, a Public Health Problem," by Ward Giltner. Memoir No. 1, Michigan Agricultural Experiment Station. From records in the Danish National Serotherapeutic Institute (Christensen)

RELATION OF AGE, SEX, AND OCCUPATIONS TO UNDULANT FEVER

Age	Contact (animal)		Milk		Question-able		No information received		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
0-4	--	2	1	--	—	1	—	--	1	3
5-9	5	--	8	8	2	3	1	—	16	11
10-14 ...	24	8	15	14	5	3	3	—	47	25
15-19 ...	109	20	31	10	20	6	12	2	172	38
20-24 ...	108	10	28	15	34	4	6	2	176	31
25-29 ...	135	13	44	15	34	10	4	1	217	39
30-34 ...	113	15	47	20	23	8	7	2	190	45
35-39 ...	69	10	29	17	15	3	3	1	116	31
40-44 ...	59	7	30	15	19	6	5	3	113	31
45-49 ...	43	9	30	3	8	12	4	2	85	26
50-54 ...	24	8	15	10	9	1	4	3	52	22
55-59 ...	14	4	15	8	8	1	3	1	40	14
60-64 ...	13	5	3	5	2	5	2	1	20	16
65-69 ...	4	1	1	4	2	—	—	—	7	5
70	1	—	1	2	--	2	—	--	2	4
Unknown .	27	2	9	2	4	1	4	3	44	8
Total ...	748	114	307	148	185	66	58	21	1,298	349

Source: "Brucellosis, A Public Health Problem."
by Ward Giltner. Memoir No. 1.
Michigan Agricultural Experiment Station.
(From H. Zeller)

DISTRIBUTION OF HUMAN BANG'S DISEASE BY OCCUPATION IN GERMANY

1.	Agriculture (husbandman, breeders, herdsmen, servants, hired men, cattle dealers, etc.)	172
2.	Dairying (milkers, peddlers, dealers, etc.)	49
3.	Meat trade (butchers, cutters, skinners, etc.)	15
4.	Artisans and tradesmen (inn keepers, locksmiths, carpenters, masons, harness-makers, merchants, gardeners, etc.)	58
5.	Physicians (includes one with undulant fever contracted out of Germany)	4
6.	Veterinarians	14
7.	Laboratory personnel (students, technical assistants, laboratory helpers and scrubwomen)	8
8.	Officials, teachers	37
9.	Laborers	20
10.	Housewives	32
11.	Other callings (tailors, waiters, hairdressers, bookkeepers, photographers, employers, etc.)	56
12.	Occupation not given	131
	Total	626

The sources of infection of the above 626 cases were:

	No. cases	Percent
Contact with abortion - cattle	124	19.9
Use of raw milk products	211	33.7
Contact with abortion - cattle and raw milk, etc.	53	8.5
Laboratory infection	9	1.4
Other causes	13	2.0
Unknown causes and not specified	216	34.5
Total	626	100.0

PART II

Brucellosis — Dairy Products

1927 — 1935

Abstracts of Literature

BIOLOGICAL ABSTRACTS

Year	Volume	Abstract No.
1927	1	6933

Jour. Am. Med. Assoc. 88 (7) 463-464. 1927.

Agglutination reactions with bovine Brucella abortus antigen were positive in 5 of 69 specimens of blood from fever patients consistently giving negative Widal reactions. "Undulant fever may be more common than suspected."

1927	1	12551

Italy - Malta fever. Community 1885 inhabitants. 40 cases fever, 3 deaths. Due to the use of goat's milk and milk products. Also to contact with infected animals.

1929	3	20538

Amer. Jour. Pub. Health, 17 (12) 1242-1247, 1927.

16 cases undulant fever in Michigan. Unpasteurized cows' milk used.

1930	4	1650

Am. Jour. Pub. Health 18 (6) 743-751, 1928.

Of 378 cows 23 eliminated, Brucella abortus in milk. A bovine strain and a culture from blood of man were viable 142 days after inoculation into butter, but not after 192 days.

1930	4	5099

Jour. Inf. Dis. 43 (4) 273-279, 1928.

Undulant fever distributed widely in New York State. Fourteen patients known to have consumed cows' milk. Many cases undulant fever not diagnosed or reported.

1930	4	22061

Denmark 1929.

Of 4623 patients tested for "Widal" reaction 500 gave positive test agglutination Brucella abortus. Belief nearly all had undulant fever. 391 of 500 cases were males. Most frequent among herdsmen. Death occurred in 7 of 216 cases.

1932	6	4480

Pennsylvania Assoc. Dairy and Milk Inspectors Annual Report 6:108-111, 1930.

Year	Volume	Abstract No.

52 cases of undulant fever discovered in Pennsylvania of which 29 occurred in 1929. Generally caused by drinking raw cows' milk from abortus infected herds in rural communities. "Efficient pasteurization offers the best solution to the problem."

1932 6 10752

Jour. Infect. Dis. 46 (5) 430-34, 1930.

230 samples certified milk sold by 5 dairies in Detroit. Brucella abortus in 4.3% of samples. Average number of bacteria 2 per cc. Highest 8 per cc. Bacteria probably diluted out in composite milk.

1932 6 4478

U. S. Pub. Health Report 45 (24) 1343-1354, 1930.

Of 11 cases undulant fever 9 were investigated. All used raw milk. Evidence indicated cases due to porcine strain of Brucella abortus coming through the milk supply.

1932 6 16698

U. S. Pub. Health Report 46 (39) 2291-2300, 1931.

Milk from one dairy consumed raw. Six cases undulant fever in community of 5,300. September 1, 1930 to January 9, 1931. Of 42 cows 24 gave positive reaction Bang's disease. Pasteurization required until reactors disposed of.

1933 7 18918

Denmark 1931. During 4 years blood from 15,630 patients were sent to Serum institute for Widal reaction. Of these sera from 1647 agglutinated Brucella abortus. The frequency of diagnosed cases were more than twice as great in rural districts as in towns. About 40% of cases of undulant fever presumed due to milk and 60% to contact infection.

1933 7 3845

Scotland 1932. Of 86 farm samples of milk 19.8% were positive for Brucella abortus. Of 83 retail samples 34.9% were positive. All bovine type. Over a period of 16 months 9 cases of undulant fever occurred in the Edinburgh district.

1934 8 11476

Jour. Dairy Science 16 (4) 315-316, 1933.

Brucella organisms were maintained in ice cream longer than 30 months. (Stored at -10° F.)

Year	Volume	Abstract No.
1934	8	18145

France: 2 epidemics undulant fever in fresh cheese 1932. Recommended pasteurization of all milk for cheese.

1934	8	9032

Germany, 1933. Brucella count varied in milk from 0 to 10,000. Colostrum may exceed 50,000 per cc.

1935	9	14299

183 cows in Scotland. 17 yielded Brucella abortus
202 samples butter, margarine, cheese, ice cream yielded no Brucella abortus organisms.

AMERICAN JOURNAL OF PUBLIC HEALTH
Vol. 18, 1928

BRUCELLA ABORTUS IN MILK AND DAIRY PRODUCTS

C. M. Carpenter, Ph. D. and Ruth Boak, M. S.
Diagnostic Laboratory, New York State Veterinary College, Cornell University
Ithaca, N. Y.

Abstract

CONCLUSIONS

1. The cream from samples of milk from 378 cows injected into guinea pigs showed that 23 cows, or 6.08 per cent were eliminating Brucella abortus in their milk.

2. Two bovine strains of Brucella abortus, 5532 and 5549, artificially inoculated into cream and stored at 8° C., remained viable for 8 days. Two other strains, 1 bovine, 80, and 1 human, H-1, more pathogenic for guinea pigs than the above strains, infected guinea pigs for a period of 10 days after being inoculated into cream.

3. The two strains 5532 and 5549 of Brucella abortus artificially inoculated into butter and stored at 8° C, remained viable and infected guinea pigs for periods of 81 and 32 days respectively. The other bovine strain, 80, and culture H-1, isolated from the blood of man, were viable at 142 days after being inoculated into the butter, but not after 192 days.

4. Guinea pigs injected with 17 samples of market creamery butter showed no evidence of Brucella abortus infection at necropsy.

5. Guinea pigs injected with 82 samples of cheeses, mostly imported varieties, failed to show any evidence of Brucella abortus or Brucella melitensis infection.

Drescher und Hopfengartner. Die haltbarkeit der Bengschen abortus-bazillen in milch und milchprodukten. Munch. tier. wschr. 1930, 81, 465-468, 485-488, 496-500, 507-511, 519-522 and 533-536.

The Durability of the Bang Abortion Bacilli in Milk and Milk Products

Abstract

The stability of the B. abortion bacilli was tested in 1. raw milk, 2. sterilized milk, 3. Saya milk, 4. sour milk, 5. kephir, 6. yogurt, 7. sweet cream, 8. sour cream, 9. sweet cream butter, 10. sour cream butter, 11. sweet cream buttermilk, 12. sour cream buttermilk, 13. soft cheese, 14. hard cheese (Tilsit cheese), 15. highly pungent hard cheese (Emmental cheese).

Since many milk products were treated differently in production or in preservation, in all 22 separate experiments were performed.

Cows' milk naturally infected with Bang's bacilli was not available. Therefore the milk or milk products were mixed with abortion cultures which were in each case freshly grown from feti or amniotic membranes and grown then with access of air.

Summary of the results of our experiments

It must be remembered that we were working with artificially infected milk. Naturally infected was not available in the necessary amounts. Discretion must be used in transferring our results to practical conditions.

Abortus bacilli were added to the starting material in abundant amounts. Would they be present in such abundance in naturally infected milk? The resistance of the bacilli to outward influences would also differ in naturally infected milk. Judged by comparison with tuberculosis bacilli, the abortus bacilli naturally secreted by cows would have a greater resistance.

In our experiments we were concerned only with the question of how long the abortus bacilli were capable of living in the material investigated. Did not question whether their number increased or decreased.

In milk or its products, with artificially added Bang bacilli, the bacilli could be detected by the culture and inoculation tests (with subsequent culture proof) as follows:

1. Raw milk - - - - - - - - - - - - - - - up to 21 days
2. Sterilized milk - - - - - - - - - - - up to 28 days
3. Saya milk - - - - - - - - - - - - - - - up to 21 days
4. Sour milk - - - - - - - - - - - - - - - up to 8 days
5. Kephir - - - - - - - - - - - - - - - - - up to 19 days
6. Yogurt - - - - - - - - - - - - - - - - - up to 8 days
7. Sweet cream - - - - - - - - - - - - - - up to 37 days
8. Sour cream - - - - - - - - - - - - - - - up to 9 days
9. Sweet cream butter (refrigerator)- - up to 35 days
   (room temp.) - - up to 28 days
10. Sour cream butter (refrigerator)- - up to 29 days
    (room temp.) - - up to 22 days
11. Sweet cream buttermilk - - - - - - - - up to 39 days
12. Sour cream buttermilk - - - - - - - - up to 9 days
13. Delicatess (soft) cheese (rind) - - up to 35 days
    (interior)- up to 35 days
14. I. Tilsiter cheese (rind) - - - - - up to 35 days
    (interior) - - - up to 91 days
    II. Tilsiter cheese (rind) - - - - - up to 49 days
    (interior) - - - up to 35 days
15. Emmentaler cheese (rind) - - - - - - up to 49 days
    (interior) - - - - up to 49 days

From these limits we determined the following picture results:

Number of days the abortus bacilli stayed alive	Starting material
91	I Tilsiter cheese (interior)
49	Emmentaler cheese (interior and rind)
	II Tilsiter cheese (rind)
37	Sweet cream
35	Sweet cream butter (refrigerator)
	Soft cheese (interior and rind)
	I Tilsiter cheese (rind)
	II Tilsiter cheese (interior)
30	Sweet cream buttermilk
29	Sour cream butter (refrigerator)
28	Sterilized milk
	Sweet cream butter (room)
22	Sour cream butter (room)
21	Raw milk
	Saya milk
19	Kephir
9	Sour cream
	Sour cream buttermilk
8	Sour milk
	Yogurt

(Italicized paragraph:)
We were able to detect Bang abortus bacilli during the time of fitness for consumption in the f llowing 9 milk products: raw milk, sour milk, sweet cream, sour cream, sweet cream butter (both refrigerator and room temperature), sour cream butter (both refrigerator and room temperature), sweet cream buttermilk, sour cream buttermilk and Delicatess (soft) cheese.

Only in the hard cheeses had the bacilli died out before the beginning of the readiness for consumption. The "heating process" of 43° to 56° C. may be the cause of this, and also the long ripening period.

These lengths of the longevity of the bacilli cannot be taken as unchangeable. They vary with conditions.

Remarkable is a contrast of the length of longevity of the bac. in milk products which were soured quickly and intensively with an acid-maker, and in milk products not soured.

Not soured milk products	Length of longevity of abortus bac. in days	Artificially soured milk products	Length of longevity of abortus bac. in days
Raw milk	21	Saya milk	21
		Sour milk	8
Sterilized milk	28	Kephir	19
		Yogurt	8
Sweet cream	37	Sour cream	9
Sweet cream butter (refrigerator)	35	Sour cream butter (refrigerator)	29
Sweet cream butter (room)	28	Sour cream butter (room)	22
Sweet cream buttermilk	30	Sour cream buttermilk	9

Doubtless the souring helps the destructio of the abortus bac. The ratio is 30:15, or as 2:1.

The danger of infection depends naturally on the number of bacilli-containing milk products on the market. The commercial milk we used was free of germs. If a large number contained abortus bacilli, measures would have to be taken to prevent infection.

Heating the milk to kill the germs seems only fitting when it does not harm the further processes.

The evil can only be rooted out if all efforts are made to prevent putting abortus-containing milk on the market. The present attempt at controlling epidemic abortion, which consists mainly in inoculation, is not suited for this. The animals giving off these bacilli must be eliminated. With the great increase of epidemic abortion in our German herds, such a procedure would for economic reasons be forbidden - apart from unusual cases, as pr duction of milk f r children, etc.

Carrieu and Lafenêtre. Fromage frais et fièvre ondulante. Le Lait., 1932, 12, 779-785. Abst.: Vet. Bull. (Weybr) 1934, 4, 124-125.

FRESH CHEESE AND UNDULANT FEVER

Abstract

We shall confine ourselves to present rapidly the account of two true epidemics of undulant fever which we have been able to follow and wherein fresh cheese, in the one, was the principal agent and, in the other, the sole agent in the carrying of the germs.

Between the months of March and May, 1930, at F....., a community of fewer than 1000 inhabitants, 17 cases of undulant fever were reported. An investigation made jointly by the Department of Hygiene and the Veterinary Department shows that although 6 patients were simply under observation (Wright's sero-reaction negative or no sero-reaction) - the 11 other cases were confirmed by the laboratory of the Buisson-Bertrand Institute of Montpelier (Prof. Lisbonne), and, in 8 of that number, no other cause could be found for the fever than ingestion of milk or fresh cheese. Therefore, it was necessary to find, among the animals, those which could have disseminated the microbe of the disease. Attention was at once drawn to the only flock which provided its owner milk destined for sale or for the manufacture of fresh cheese. Now, in that flock of 57 head, 56 ewes and 1 ram, there had been some 20 abortions and widespread double orchitis.

The second (epidemic) presents a completely different aspect; it is not, as a matter of fact, in one single center that it was observed, but in several villages at some distance from each other: these are rather isolated cases appearing at about the same time and in which the real cause was determined only after rigid investigation - since a superficial examination showed no real connection between them, no convincing interrelation. Undulant fever exists, as a matter of fact, in that region, in an endemic form - a great number of cases originating in direct contact with the germ-bearing animal, others from contamination through manure, others from eating milk or fresh cheese. Through minute questioning of the last-mentioned group, one could ascertain the source of the cheeses, and - interesting detail - one learned thus that all had been bought from a vender of L..... who went from village to village spreading the disease among his customers: one could thus trace it by following his cart tracks. Now - and the patients were very positive on this detail - the cheeses accused all had "a very bad taste." Certain cases have the value of real experiments: a woman of M.... who never eats fresh cheese, made an exception and ate some, which, however, she did not like very well; two weeks later, she fell ill. A man of L.... very fond of various cheeses, one day ate one of those and found it so unpleasant to the taste that his family did not taste any; he, too, contracted, and he was the only one who contracted the undulant fever, which, commencing a fortnight later, was not recognized until long afterward. That, then, is our second epidemic, which, if it does not possess the three unities or at least "the unity of place" of our classic theater, nevertheless appeared at noticeably the same time and was found to be depending solely on eating fresh cheeses originating from the same source.

As is seen by the several examples given - and we have not reported them all, for the list would be boresome - the absorption of fresh cheese is often, as we long since noted, the cause of undulant fever; clinical observations and laboratory research are in agreement, and conclusive in this regard. Far from our intention is it to underestimate the important etiological factor of direct contact with the animal affected. There are two types of facts distinctly separate, which necessitates employment of two different prophylactic measures: one, for those who, in their work, come in contact with goats, sheep and perhaps cows stricken with epizoatic abortion - and it is to this category that we should apply the laws dealing with occupational diseases (Dubois and Sollier, 18); these should be warned of the danger they are incurring and should be firmly and insistently advised to undergo preventive vaccination. And, the others, on the other hand - by far the larger number - the consumers of milk and fresh cheese who find it impossible to know the often dangerous source of these products. As to milk, the guilt rests with him who does not insure, before using it, that it has been brought to boiling point; but as to cheese, it is for the producer and the producer alone to be responsible in taking precautions that undulant fever should not spread. And, to that end, he has an extremely simple and remarkably successful means; pasteurization, as we have shown. But this operation, of so great hygienic importance, cannot with our present laws be compelled. Must we then consider pasteurization an exception among cheesemakers? Assuredly not. The first plan which comes to mind, to encourage its practice by the majority, is to deliver a certificate to those (of the cheesemakers) who practice it consistently - understood, of course, that close supervision would be the logical consequence. This certificate would indicate that the cheese sold by these dealers was manufactured with milk brought to, and maintained at a temperature sufficient to destroy the germs of several maladies - in particular, that of undulant fever. Unfortunately, the sale of these products is not solely through the makers themselves and one may imagine the difficulty of inspection when a dealer has in his establishment cheeses "recognized as healthful" and others coming from districts more or less distant where that certificate was not in existence..... So, it appears to us indispensable that, by government order, this method be made obligatory throughout France.

In the sum total, the question of fresh cheese in connection with the transmission of undulant fever is far from being new. It is perhaps for that reason that we have given it our attention again, for it is well not to permit - as too often happens in our times - old matters to be forgotten. Furthermore, recent findings have come to confirm the danger presented by these same cheeses and finally, today, we know exactly what must be done to obtain easily a food free of danger - and that is not so banal a matter!

Microbiology of Frozen Foods

VI. The Survival of Pathogenic Microorganisms in Ice Cream
by G. I. Wallace and Rhoda Crouch, Department of Bacteriology, University of Illinois, Urbana, Illinois. In Journal of Dairy Science Vol. 16 (4) 315-316, 1933.

Abstract

"Undulant fever organisms were frozen in the ice cream for a period of 36 months and in all cases the organisms were still viable and present in sufficient numbers to be rather easily detected."

"Commercial ice cream was thoroughly inoculated with each of these organisms (several species) and samples placed in small vials and frozen at -32.2° C (-10°F)."

"Summary"

"Salmonella enteritidis, Salmonella aertrycke, Brucella abortus (Bang), Brucella abortus Porcine, Brucella melitensis, Mycobacterium tuberculosis, hominis (Strains A, I and S), Mycobacterium tuberculosis bovis and Mycobacterium avium survived freezing in ice cream for periods longer than 30 months. While the artificially inoculated ice cream contained more organisms than would be encountered in ice cream made from naturally infected raw milk, such data suggest that ice cream should not be considered as a safe food just because it is frozen."

Stockmayer, W. Vergleichende untersuchungen uber den bangbakteriengehalt vom rahm, butter, mager under buttermilch, souie versucha uber die konservierung von milchproben. Centralbl. f. Bakt. (Orig) 1934-35, 133, 425-435.

Comparative Studies of the Bang-bacteria Content of Cream, Butter, Skim Milk, Buttermilk, as well as Experiments for the Preserving of Milk Samples (Specimens, Tests)

By W. Stockmayer

Abstract

Summary

Tests were made in the laboratory with naturally infected milk, with cultures on gentian violet and malachite green culture media, to find how the Bang bacteria were scattered and in what amounts in the manufacture of butter, and in what number they are therefore contained in the related milk products. These investigations extended only to pure sweet cream butter and had the following result:

In the natural skimming of milk containing Bang bacteria the cream is enriched with these, while in skim milk only scattered B. bacteria remain.

In milk which naturally contained Bang bacteria, to which 0.5-2% boric acid was added, the number of Bang bacteria showed no considerable reduction within a week. Only with higher temperature (22-24° C) with 1% and 2% boric acid admixture was a moderate decrease in number noticed on the 5th day, which decrease had become strong by the 7th day.

Veloppe and Jaubert. Fromages frais et fievre ondulante. Rev. gen. de med. vet., 1935, 44, 513-523. Abst.: Vet. Bull. (Weybr.), 1936, 6, 408-409.

FRESH CHEESE AND UNDULANT FEVER
(From Revue Generale de Medicine Veterinaire, No. 525, September 15, 1935.)

Abstract

The Brousse cheese, solely concerned in our remarks, is a cheese produced very extensively in the Var district. It is usually sold by the itinerant vendors, who make it, whether from the milk from their own sheep or with milk purchased in part from other sheepherders. As a rule, it is made of sheeps' milk which has been boiled. We say "as a rule," for it is Brousse cheese which fraudulently contains cows' milk. Also it is made with milk heated to a temperature well below 100° C.

Brousse should not be infected when made according to normal technique. But it may happen that, to economize on heat and save time, insufficient simmering of the milk during the heating process may mean that the temperature of all or part of the liquid mass remains lower than 60° C.

This fault in technique maintains the pathogenic force of the milk. Under certain conditions it may even increase it, and Brucella finds in milk heated to 40°-50° a culture medium eminently favorable to rapid multiplication.

Certain authors have denied the possibility of making cheese from boiled milk. Vaillant, in particular, believed that a temperature above 65° causes an alteration of the elements necessary for curdling. Porcher expressed the same opinion. Lafenetre, on the contrary, through personal observation adduces proof that milk raised to a temperature of 80° and above may very well be coagulated. This is also our own finding. It is furthermore the current opinion that Roquefort is made with goats' milk heated to 80°-90°.

Boiling of the milk is therefore a measure which could not affect its utility, even in the cheese industry.

Conclusions:

1. The ingestion of cheese freshly made from milk of sheep afflicted with melitococcia can transmit undulant fever.

2. Heating, to at least 80° and prolonged for thirty minutes, destroys the virulence of the milk.

3. Supervision of heating the milk being practically impossible, the sale of milk and cheese (from infected stock) should be forbidden by law.

4. Since the etiology of undulant fever rests essentially in a brucellic infection of the flocks, prophylactic should first be practiced with the animals concerned, but since melitococcia is not suspected until after cases of undulant fever ensue and are recognized, it is important that reports of this malady be made immediately and in full.

We believe that the sale of milk and fresh cheese should be prohibited any owner of animals infected with melitococcia. However, to correct possible excesses in carrying out such an edict, we think that sale of cheese ripened for at least one month might be authorized.

In the presence of the ever increasing peril in melitensic infection of flocks, it is important that prophylactic measures be unremitting and that the fight for clean, sanitary milk, as that in the case of many other infectious diseases, will bring enormous benefits.

HYGIENE ANNALS (MONTHLY PERIODICAL). ORIGINAL MEMORANDA

Laboratory of general experimental hygiene and meat inspection of the faculty of Veterinary Medicine of the Royal University of Torino, Italy.

Director: Professor L. Cominotti

RESEARCH AND EXAMINATION ON "WHIPPING CREAM" FOR SALE IN THE DAIRIES OF TURIN, WITH PARTICULAR REGARD TO THE PRESENCE WITHIN IT OF GERMS OF THE GENUS "BRUCELLA" AND TUBERCULIN MICROBACTERIA.

Abstract

F. Micheli (I) in the year 1924 illustrating a clinical case of Undulant Fever and recalling others of his numerous previous observations in the subject made several very interesting revelations.....

As for the vehicles of infection he (F. Micheli) expresses the conviction that they are to be found more in raw cows' milk, or even still more in

milk products such as cream, fresh cheeses, and butter, than in water, vegetables, and "aranche" (this might be citrus fruits). In the majority of cases observed by the author himself in that year, it was ascertained that those stricken by the disease had more or less made use of cream.

The preponderous importance of this was later established by the facts of an experience of Micheli who had observed a case in which an entire family, including the servants and a young dinner guest, was stricken after having been served with an abundance of cream.

Several years later, Dr. Cerruti in an investigation of Undulant Fever in Piedmont was able to ascertain that Turin had especially been stricken (186 cases from 1922 to 1928) and that the morbosity of the disease had noticeably increased in the latter years of this period. As for the vehicles of contagion, based upon a series of dates, even if not too accurate, this authority concluded that of all the milk products (cream, butter, ice cream, etc.) milk itself was probably the most innocent because it was usually boiled previous to being consumed.

PART III

Brucellosis — Dairy Products

1936 — 1944

Abstracts of Literature

BIOLOGICAL ABSTRACTS
June-December, 1936

Volume 10 Part 2

13906. MOLINELLI, ERNESTO A. Estudio de la infección profesional por "Brucella" en ambientes urbanos de la República Argentina. (Occupational Brucella infection in several cities of the Argentine Republic.) Semana Med. 40(2083): 1919-1923. 1933.—The group studied included cooks, butchers, milkmen, packing-house and dairy workers. The investigation of specific agglutinin in blood serum gave between 3.7 and 14.8% range of infection. The frequency of positive reactors varies with the occupation (in the order given above), material handled, and years of experience. Workers of long standing show a greater percentage of infection.

BIOLOGICAL ABSTRACTS
January - May 1937

Volume 11 Part 1

4075. STOCKMAYER, W. Vergleichende Untersuchungen uber den Bangbakteriengehalt von Rahm, Butter, Magerund Buttermilch, sowie Versuche uber die Konservierung von Milchproben. Zentralbl. Bakt. I. Abt. Orig. 133 (7/8): 425-435, 1935. Milk from cows eliminating Bang bacteria through the udders was allowed to stand, gravity cream skimmed and churned. Plate counts were made on gentian violet-malachite green media to determine the no. of Bang bacteria in the various stages. The gravity cream was much the richer in organisms than the whole milk; the skim milk contained very few of the organisms. After churning, the buttermilk retained most of the bacteria and few remained in the butter. Washing and working also removed more from the butter. Expts. were run to determine the amt. of boric acid that should be added to milk in storage at different temps. to prevent the growth of saprophytic bacteria without materially reducing the no. of Bang bacteria. At 4-8° C. 0.25% boric acid was sufficient but at room temps. it was necessary to add 0.5-1.0%. 2% boric acid reduced the no. of all types of bacteria at room temps.

BIOLOGICAL ABSTRACTS
January - May 1937
Volume 11 Part 1

9136. ZIMMERMANN, EDMUND. Latente Immunisierung gegen den Erreger der. Bangschen Krankheit durch Milchgenuss. Zentralbl. Bakt. I. Abt. Orig. 134 (3/4): 213-214. 1935. In 1934, 163 sera of persons engaged in dairy work in Landsberg were examined and 18 gave a positive agglutination with Br. abortus in a dilution of 1:50 or more, some as much as 1:200. As there were no signs that any of these people had ever had a recognizable infection with this germ or had ever had any contact with infected cattle, it was assumed that the agglutinins in their blood were due to their use of infected milk.

From: Lyons Société des Ciences Veterinaires
Bulletin 38-40. 1935 - 1937.

RECHERCHES RELATIVE A LA PRESENCE DE BRUCELLA MELITENSIS DANS LE LAIT ET LES FROMAGE DE CHEVRES.
(Research relative to the presence of Brucella melitensis in goats' milk and cheese.)

By M. G. Pères, Director of Veterinary Services of la Drome and l'Ardeche
and
M. P. Granon - Fabre, Doctor, Veterinary at Crest, in collaboration with the Center of Research at Montpellier on Undulant Fever.

Abstract

A diagnosis of melitococcia (Malta fever) was made in April 1934 on an agricultural project belonging to M. F. at B. The farmer's wife was stricken with undulant fever. The clinical diagnosis was confirmed by intradermic test effected with the aid of abortine. The flock was composed of 2 rams and 59 ewes. Of these, 38 had aborted during the latter weeks of the winter. This flock furnished 55 positive reactions. Of 17 goats, 13 of which had aborted in January or February, 15 had definitely reacted.

Therefore, without any possible doubt, it was indeed Brucella melitensis that 10 goats eliminated through their milk 10 months after having presented clinical signs of melitococcia.

The idea ensued to seek the presence of those microbe germs in cheeses made from that milk.

We know, as a matter of fact, that in spite of research previously

made by several authors, agreement has not been established on the point of ascertaining at what exact time Brucella melitensis disappears from cheese. We recall among other works, those of Darbois, who did not find germs after the 16th day, while Maze and Cesari establish in their findings that Brucella abortus is killed in 48 hours by lactic fermentation.

Eight cheeses were prepared with the mixed milk of M. F's goats, with a view to laboratory experimentation.

Only the cheeses which had been ripening for 20 days still held the Brucella melitensis.

These results are naturally somewhat disconcerting and bear witness to the uncertainty of our knowledge as to the development of these microbes in goat cheese.

Pagnini, V. Richerche e considerazione sulla "panna montala" in vendita nelle latterie di Torino, con particolare riguardo alla presenza in essa di germa del genere Brucella e del microbacterio tuberculare. (Presence of tubercle bacilli and Brucella in whipped cream sold in Turin.) Ann. d'ig. (sper). 1937, 47, 213-226.

Summary of Report

Page 224

October 1933 to November 1935 the author did research work to ascertain the possible presence in the whipped cream sold in the city of Torino of the Brucella germ and tubercle bacilli. The samples examined numbered 138. The research was done by inoculation of guinea pigs. The results follow: The mortality of the guinea pigs in the interval of the experiments was on the average 36.59%, with a minimum of 21.42% in November, and a maximum of 83.33% in June. In the 100 samples of the whipped cream, the Br. melitensis was found 2 times, Br. abortus 23 times, tubercle baccilus 14 times. On the basis of this result obtained the author considers the consumption of this whipped cream may endanger human health.

BIOLOGICAL ABSTRACTS
October - December 1938
Volume 12 Part 2

13485. ENGEL, RUDOLF v. Gehauftes Auftreten von Febris undulans (Bang) nach dem Genuss ungekochter Milch. Zentralbl. Bakt. I, Abt. Orig. 142 (3/4): 165-168. 1938. Drinking raw milk from one dairy caused 4 acute and 7 latent cases of Bang's disease. The strain was apparently very virulent, as out of 46 persons thus exposed, 11 acquired an infection.

BIOLOGICAL ABSTRACTS
May - September 1938
Volume 12 Part 1

6797. HARDY, A. V., S. FRANT, and M. M. KROLL. The incubation period in undulant fever. U. S. Publ. Health Rpts. 53 (20): 796-803. 1938. The residents of New York City are supplied almost exclusively with pasteurized dairy products. With rare exceptions undulant fever occurred only in individuals who had been on vacation or business trips out of the city. During the decade 1928-1937, 52 cases involving city residents were reported. In 17 of these an incubation period could be calculated. The median incubation period computed to the onset of the earliest symptoms was 10 weeks, to the onset of severe symptoms 13 weeks, a much more prolonged incubation period than has generally been supposed.

Anon. Transmissibilita dell 'infezione Brucellare all 'uomo mediante i formaggi freschi e grassi. Azione vet. 1937, 6, 258-260. Ast.: Vet. Bull. (Weybr) 1938, 8, 246. p. 258.

TRANSMISSIBILITY OF BRUCELLA INFECTION TO HUMANS BY MEANS OF FRESH CHEESE AND FATS

Abstract

Coronna had demonstrated with many experiments the danger in Sicily from eating fresh cheese,--soft cheese, raw cheese and half-cooked cheese. He advises the preventative pasteurization of milk to prevent infections before making the cheeses mentioned. Mr. Coronna gives statistics from the research station of Sicily for the zones most affected (Palermo, Agrigento, etc.) where a large per cent (20%) of the animals are infected. And he

mentions the research done by Mino, finding goats and cattle of Sicily infected,—hence many humans have to pay tribute to this disease. (Brucellosis)

As a complement to this we take the opportunity to add some of our knowledge about fat (or could be thick) cheese and the possibility of secondary infection of some milk products.

Other than fresh whole milk and fresh cheese as vehicles of spreading undulant fever, one must consider butter and cream, because as Huddleson, Alessandrini and various other authors have observed, butter as well as cream contains more microbes than milk, since the Bruc. adhere to the fat particles and come to the top with these. As proof of this, if one centrifuges (churns) infected milk, one finds more bacteria in the butter than in the sediment. Therefore cheeses which contain much fat are more dangerous than light cheeses and semi-cheeses. Then too, fresh cheeses (types scamorze, raveggioli, tuscani, ricotta) may be contaminated by persons or infected objects, especially by containers aimed to maintain the freshness of some milk products, e.g. fern leaves and cabbage leaves which may have been infected by the faeces or urine of animals or carriers of the virus,—even though the milk from which the cheese was made was pure.

Liechtenstein, G.....P. Das verhalten des erregers des seuchenhaften verwerfens (Bact. abortus Bang) in der milch und einigen milcherzeugnissen. Milchwirtsch. Forsch. 1938, 19, 241-Abst. Deutsche tier. wschr. 1939, 47, 367.

THE BEHAVIOR OF THE AGITATORS (CAUSERS, CAUSATIVE AGENTS) OF EPIDEMIC ABORTION (BACTERIA ABORTUS BANG) FOUND IN MILK AND SOME MILK PRODUCTS

By George Prinz Liechtenstein, Dr. of Engineering

Feb. 11, 1938
(From Dairy Research (Milchwirtschaftliche Forschungen) June '36-Dec. '38)

Abstract

The lactic acid content has an important influence of the life-tenure of the abortus Bang bacteria in milk and its products. According to Lerche, Bang bacteria artificially added to milk up to an acidity degree of 20 SH° may keep for a month almost undiminished in number. Up to an acidity of 24-30 SH° (= pH 5.4 - 4.2) the bacteria for several weeks alive; at 30-35 SH° (= pH 4.2 - 4.0) 4 to 6 days; 35-40 SH° (pH 4.0 to 3.9) some days; 40-45 SH° (pH 3.9 - 3.7) 1 to 2 days, over 45 SH° (= pH below 3.7) one day and less. The experiments tried with whey showed a shorter life period of the Bang bacteria, with the same acidity degrees. No considerable difference between whey and milk could be found though.

On the contrary, the resistivity of different abortion families toward lactic acid is often very different, in his opinion.

Abstractor's note:

S.H. = Soxhlet-Henkel degrees acid
S.H. degrees = number of cc. n/4 NaOH used to neutralize the acid in 100 cc. milk
1 cc. n/4 NaOH = 0.0225 gram lactic acid
Indicator: Phenolphthalein
If 13.4 cc. NaOH used, then percent acid calculated as lactic acid is:

$$\frac{13.4 \times 0.0225 \times 100}{100} = 0.3 \text{ percent}$$

Compare with American method.
18 grams milk used
NaOH used: N/10
Indicator: Phenolphthalein
1 cc. N/10 NaOH = 0.009 gram lactic acid
If 6 cc. N/10 NaOH used, acidity is:

$$\frac{6 \times .009 \times 100}{18} = 0.3 \text{ percent}$$

Acidity in sour buttermilk is approximately 0.75 percent calculated as lactic acid.

In country butter (infected as such with the Bang bacteria) the bacteria kept 50 days, in Lerche's experiments; in dairy butter 67 days (infected same). In butter made of milk from bacteria secreters 40 days, in buttermilk of 28-44 SH° 3 days, when the cream was artificially infected. Carpenter and Boak, who infected butter artificially and kept it at 8°, found life-activity with 2 species even after 142 days - in butter - but they had died after 192 days.

In cream cheese (white cheese), which Lerche made by curdling infected milk, the abortion B. bacteria stayed alive 24 days; in white cheese and breakfast cheese, made the same way, 22 days.

No noticeable decrease of germ content (Brucella abortus) in milk was seen with acidity of 6.0, 13.2 and 20.0 SH° within 12 days. Only after 23 days was the germ content much lower. In milk of 41.0 SH° the germ content on the next day amounted to only 70,000/ccm (about 1/30) - on the second and following days the culture was negative.

In sour (milk) whey the germ (Brucella abortus) content remained almost unchanged on the average for 7 days - here no great difference between this and milk of like acidity. After 26 days the average was 800 germs/ccm (at first 1 mill./cm) in the sour whey. In the milk about 1/40 of the germs were still present.

According to these results therefore the difference in the action of the lactic acid in milk and whey cannot be very considerable. Even if the germ content in the sour whey is only 800/ccm after 26 days, still we may assume that within these 3 days which separate the two cases the germ content

of the milk would have decreased noticeably. For we have seen in the experiments that when a decrease sets in, it increases rapidly within a few days.

The danger of infection by cream is great, even though the germ count (Brucella abortus) of the original milk was slight, because of the strong increase which the Bang bacteria undergo in the preparation of the cream - according to Stockmayer up to about 14-fold, with natural skimming. By the use of cream therefore an infection may occur, if it was obtained from the collective milk of rather large infected herds, even if no infection was possible through the milk itself. If for example, in a herd of 10 cows there is one that secretes the Bang bacteria, then the amount of Bang bacteria in the cream will be as high as in the milk of this one Bang-secreter, since the bacteria increase 10-fold in the cream. The danger of infection, also in all products made by processing the cream, will be essentially increased in so far as a reduction of the germ content was not effected by souring.

Today one, in souring cream for making butter, limits himself generally to an acidity of 30 SH°. Since with this degree of acidity the germ content in whole milk stayed unchanged at least 2 days, then we do not count on a much less germ content in sour cream butter than in that from sweet cream, granted that the conditions in the cream were the same. The souring of the cream will be finished mostly in 24 hours and the degree of acidity of 30 SH° can act on the bacteria during the making of the butter. (30 SH° = 0.675 percent lactic acid.)

The danger of infection by buttermilk is not to be underestimated, because of the strong transference of the Bang germs into it - especially since it is often used as feed, and is also used much as a drink because of its dietetic action. The danger will however be of less duration with sour cream buttermilk because of the degree of acidity.

Hartmann found that the bacteria in table-curds (cottage cheese), made of rennet or by souring, lived to the 7th day when artificially infected, while the acidity in the rennet-souring on the 1st, 2nd, 3rd, 4th, 5th, 6th, and 7th days amounted to 54, 87, 89, 85, 94, 78 and 88 SH°; and with the souring process amounted to 45, 71, 73, 68, 82, 73, and 73 SH°.

Summary

1. Animals with negative blood serum titre secrete the bacteria with the milk only in the rarest cases. Therefore the milk from animals which are serologically negative may practically be assumed to be bacteria-free.

2. Conscientious pasteurizing makes the use of infected milk, as well as its products, absolutely safe.

3. Degrees of acidity up to 20 SH° effect in milk and whey only after some days a noticeable decrease in the bacteria content. Degrees above 40 SH° mostly produce a killing of the Bang germs in 1-2 days.

4. Therefore the Bang bacteria content in raw milk experiences no decrease during the time of the milk's fitness for use. Its content of bacteria will mostly be too slight to cause an infection.

5. Chiefly cream and products made from it are to be regarded as sources of infection.

6. An infection through other milk products is not to be assumed.

7. When artificially infected milk was used it was not possible to observe an adverse effect of whipping the cream upon the number and the life span of the bacteria in it.

8. In artificially infected milk the Bang germs multiply very well. Whether an increase occurs depends on the temperature and the degree of acidity, mainly.

9. An agglutination of the Bang bacteria, when centrifuging, causes a strong transmission of the bacteria into the sediment. It also seems to injure the correct germ-counting.

BIOLOGICAL ABSTRACTS
January - July, 1939

Volume 13 Part 1

6285. LIECHTENSTEIN, GEORG PRINZ. Das Verhalten des Erregers des seuchenhaften Verwerfen (Bac. abortus Bang) in der Milch und einigen Milcherzeugnissen. Milchwirtsch. Forsch. 19 (4): 241-259. 1938. The presence of Brucella abortus in milk and dairy products was ascertained by cultivation on glycerol of glucose agar with gentian violet and malachite green. In the case of natural infection, the plates were incubated in an atmosphere where the air was partly replaced by illuminating gas. Pure cultures were capable of growing in air. The bacteria were found mostly in cream, rarely in skim milk. Churning does not affect them, and they survive in sweet cream butter from raw cream, and in buttermilk. Pasteurization eliminates the Bang bacteria completely. Acidification must go fairly high to destroy them. At 0.64% lactic acid and 14°C. their number did not decrease at all for 2 days and a few individuals survived 8 days. At 37°, the bacteria multiply in milk. At lower temps., multiplication is not so good, but no data are given.

BIOLOGICAL ABSTRACTS
August - December 1939
Volume 13 Part 2

11685. DOLMAN, C. E., VIVIENNE HUDSON, and D. G. B. MATHIAS. Further observations on brucellosis in and around Vancouver. Canadian Publ. Health Jour. 30 (2): 100-104. 1939. Isolations of Brucella abortus from and whey agglutinin titres of raw milks before and after a cow reactor elimination campaign fail to show any improvement of the milk supply. Pasteurization of all market milk is strongly recommended. Oral administration of killed Br. abortus cells in increasing weekly doses did not increase the serum agglutinin titre of 8 human subjects. Br. abortus was isolated from the milk of several cows having no specific agglutinins in 1:100 dilutions of either blood or whey.

BIOLOGICAL ABSTRACTS
August - December 1939
Volume 13 Part 2

11684. DOLMAN, C. E., VIVIENNE HUDSON, and D. G. B. MATHIAS. Further observations on Brucellosis in and around Vancouver. Canadian Publ. Health Jour. 30 (1): 47-49. 1939. Brucella abortus was isolated on the first attempt from 8 of 32 samples of milk selected for consistent positive whey agglutinin records. Only 38% of pooled raw milk samples were negative for Brucella agglutinins during an 8-month campaign of elimination of reactors from the herds while previously 33% of the milk samples were negative. Since the start of the campaign 12 culturally-positive samples have been obtained from 61 unselected milks. The incidence of brucellosis does not seem to have been lowered by this method of control and compulsory pasteurization of all milk is considered the only satisfactory method of eliminating milk-borne brucellosis.

THE VETERINARY BULLETIN
1939

Vol. 9. No. 4 pp 217-284 April

MELLO, A. & MASTROFRANCISCO, N. (1939) A manteiga como veiculo de infecçao pela Brucella. (Butter as a Possible Vehicle of Brucella Infection.) Rev. Industr. anim. 1. 19-27. 3 figs. (Numerous refs.) (English summary).

It is stated that 20% of dairy herds of Sao Paulo are infected with brucella, and that the percentage has doubled in a decade. The authors do not know of any case of human brucellosis contracted from bovines in Brazil.

Three different batches of butter were made, some from raw, and some from pasteurized milk, and infected with mixed Br. abortus and Br. melitensis, and various injections were made into g. pigs. The results varied, depending on the age and acidity of the butter, and some of the strains used are said to have been of low virulence.

The authors are of the opinion that butter or whey may act as a vehicle of brucella infection, but consider such transmission of infection to be rare.

BIOLOGICAL ABSTRACTS
June - December 1940

Volume 14 Part 2

15016. ELKINGON, G. W., G. S. WILSON, J. TAYLOR, and F. FULTON. Mild epidemic of undulant fever in a boys' school due to drinking raw milk. Brit. Med. Jour. 1940 (4133): 477-479. 1940.

BIOLOGICAL ABSTRACTS
August - December 1941

Volume 15

11024. ROSATI, T. I. Gelati di creama quali fonte die malattie infettive degli animali transmissibili all'uomo con particolare riguardo alle brucelle. (Ice cream as a source of infective annimal diseases transmissible to man, with particular reference to Brucella.) Riv. Sanit. Sicil. 26: 187-

200. 1938. Results of the examination of ice cream samples in Palermo. Of 73 guinea pigs inoculated with 3 ml. of ice cream 3 yielded the Malta fever organism. Tubercle bacilli were not found in any sample, bovine tuberculosis being almost unknown in Sicily. In 23% of the samples the bact. count exceeding 5 million per ml. Brucella melitensis, tubercle bacilli, and mastitis streptococci introduced into milk were found unchanged in ice cream. (Abstract from that in Zbl. Bact. I. Ref. 132, 105, 1939.)

BIOLOGICAL ABSTRACTS
August - December 1941
Volume 15

15095. DUKE, F. W. (County Lab. Stafford, England) Brucella melitensis in cow's milk. Lancet 239 (6113): 517. 1940.--Duke believes that this is the first time Br. melitensis has been found in cow's milk in England. The lab. at Stafford tests regularly for the 3 types of Brucella. Heretofore all strains isolated were Br. abortus which requires 10% CO_2 for primary culture. Unexpectedly a culture of Brucella was obtained aerobically which proved after careful culture, serum-agglutination and guinea-pig inoculation criteria to be Br. melitensis. The organism came from a sample of mixed milk from a herd of 76 cows. Later when the individual cows were tested Br. melitensis was present in the milk of 3 cows. At no time in the last 14 years had there been on the farm any goat, which is the usual host of Br. melitensis.

BIOLOGICAL ABSTRACTS
August - December 1941
Volume 15

18725. MORRISON, H. B., and F. E. HULL. The incidence of streptococcic infection in the udders of Bang's disease positive and negative cows. Kentucky Agric. Exp. Sta. Ann. Rpt. 50th (Pt. II): 77-87. 1937.--Milk from Bang's disease positive and negative cows was examined for streptococci and agglutination of Br. abortus. Streptococci were looked for by the Breed technique. If the smear contained 10 or more chains of cocci it was considered positive. Agglutination was detd. in a 1/50 dilution of the whey from the milk by means of the rapid plate test. 710 milk samples were examined; streptococci were found in 46.4% of samples from the Br. abortus reactors and 22.2% of the milk samples from Br. abortus non-reactors. No attempt was

made to correlate incidence of streptococci and clinical evidence of mastitis. No correlation was present between the indicence of streptococci in the individual milk samples and the agglutination of Br. abortus by the same sample. Br. abortus infection may predispose to the occurrence of streptococci in the cow's udder.

BIOLOGICAL ABSTRACTS

Volume 15 1941

18887. MELLO ALEXANDRE, e NATALINO MASTROFRANCISCO. A manteiga como veiculo de infecçao pela Brucella. (Butter as a possible vehicle of Brucella infection.) (With Eng. summ.) Rev. Indust. Animal (Sao Paulo) (2): 19-27. 3 fig. 1938. - Cultures of B. abortus and B. melitensis were added to 3 batches of cream which were then churned. Cultures, buttermilk and butter, both fresh and after keeping for various intervals up to a month, were inoculated into guinea-pigs which were tested for agglutination and later were killed and examined for lesions. Results were somewhat contradictory, partly owing to the doubtful virulence of the bacteria used; the authors concluded that butter might, under exceptional circumstances, convey the infection.

ABSTRACT FROM THE BOOK "BRUCELLOSIS" BY HAROLD J. HARRIS, M.D., PUBLISHED BY HOEBER, NEW YORK, 1941.

The main source of brucellosis is from raw milk from infected animals. It has also been proved that the direct contact of veterinarians, farmers, butchers, meat dealers, and stockyard workers with infected animals and their products is an important source of human infection.

The infectiousness of other dairy products, such as ice cream, cheese and butter, is still a matter of some controversy. The best opinion seems to indicate that the souring of cream renders the organism innocuous so that only butter and cheese made from sweet, unpasteurized cream need be suspected. Until this question has been definitely settled, the use of possibly infected butter, cheese and buttermilk is best avoided. The same may be said of ice cream made from raw milk as the organism is known to survive subfreezing temperatures for long periods.

Carpenter and Boak reported that inoculated cream failed to infect guinea pigs when the pH was 5 or less. They noted that when milk and cream were stored at refrigeration temperatures, the higher the percentage of fat the longer Br. abortus lived. Of 82 samples of cheese selected at random, none infected guinea pigs on inoculation. The acidity of cottage cheese prevented the survival of the organism for more than 48 hours.

ABSTRACT FROM PARENTS MAGAZINE, JULY 1942, "THE THREAT OF UNDULANT FEVER" BY HAROLD J. HARRIS.

Greatest menace is from raw milk of infected animals. Second from contact with infected animals - veterinarians, farmers, etc. Not transmitted from humans except through the milk of an infected mother.

A physician died of brucellosis in New York. The same strain of goat brucella was found in his blood stream as was found in some Italian cheese left in his ice box.

Unpasteurized butter, buttermilk, cheese, and ice cream cannot be considered safe in spite of some evidence that the germ is killed by the souring of milk and cream.

FROM SCIENCE NEWS LETTER, JUNE 12, 1943, "HALF UNDULANT FEVER CASES ARE CAUSED BY RAW MILK."

The most important thing to know about undulant fever, however, is that the way to escape it is to avoid raw milk, raw cream, and ice cream made from raw milk and cream. Pasteurization kills the germs. So does boiling.

BIOLOGICAL ABSTRACTS
February 1942
Volume 16 Number 2

4922. FULTON, J. S. (U. Saskatchewan). Contagious abortion of cattle and undulant fever in man. Canadian Publ. Health Jour. 32: 194-198. 1941.— While contagious abortion has been known to be common in Saskatchewan for many years, it is only recently that a blood testing service has revealed the extent of human Brucellosis. Since 1933, the % of reacting bovine blood samples has been halved as have also the % of positive human blood samples. Results are given of a study of the milk of 60 reacting cows in which 70% were found to yield Br. abortus in their milk. The organism survived at least 18 months in sterile milk at icebox temperatures. Details are given of the Saskatchewan plan of control whereby municipalities are encouraged to foster eradication programs.

BIOLOGICAL ABSTRACTS
November 1942
Volume 16 Number 9

20799. WORKMAN, T. W. (Yale U.) Short-time high temperature pasteurization. Internat. Assoc. Milk Dealers, plants operating with standard units of Cherry-Burrell, Creamery Package, Electro-pure and York short-time, high-temp. pasteurizers were studied. Temps. and holding times were satisfactory. Every particle of milk was properly treated and the resulting product was fully equal in creaming property, keeping quality and flavor to milk pasteurized by the standard holding method. Thermoduric types of bacteria may be destroyed in a lesser % than with the standard holding method but these bacteria do not have public health significance. Such difficulty can usually be eliminated by a search for unsanitary conditions on the farm of some producer. Laboratory pasteurization at 160° F for 15 sec. was effective in all cases. Bacteria used in the laboratory expts. were 17 strains of Mycobacterium tuberculosis, 74 strains of Brucella abortus, B. suis and B. melitensis, 218 strains of streptococci of human origin, and 186 strains of mastitis types of bacteria.

BIOLOGICAL ABSTRACTS
December, 1942

Volume 16 Number 10

22844. GUILFORD, H. M. (State Bd. Health, Madison, Wis.) Undulant fever. Proc. Ann. Meet. U. S. Livestock Sanitary Assoc. 45: 76-79. 1941.— In Wisconsin, statistics were obtained from questionnaires on undulant fever. In man, the disease attacks 2.4 to 1. About 60% of the cases were derived from raw milk. Other cases were distributed among people drinking pasteurized milk and part of this group had contact with animals. The more malignant goat and hog strains weave back through cattle to man; this may explain why many raw milk consumers have not developed undulant fever. In Wisconsin, cattle are more important than swine in causing undulant fever.

BIOLOGICAL ABSTRACTS
November, 1943

Volume 17 Number 9

22077. JORDAN, CARL F. (Iowa State Dept. Health, Des Moines), IRVING H. BORTS (State Hyg. Lab., Iowa City), DONALD M. HARRIS (Dist. Health Serv. 3, Spencer, Iowa) and JAMES R. JENNINGS (Iowa State Dept. Health, Des Moines). Brucellosis: Consideration of its epidemiology, diagnosis and control. Amer. Jour. Publ. Health 33 (7): 773-779, 1943. The authors present a study of milk-borne brucellosis based on an investigation of 2 cases caused by Brucella abortus and on an epidemic in which B. suis was the inciting agent. A discussion is given of the results of agglutination tests and skin tests on the individuals involved. The value of agglutination and skin testing and of the opsonocytophagic test is given along with an outline of the diagnosis, control, and prevention of this disease.

BIOLOGICAL ABSTRACTS
February, 1943

Volume 17 Number 2

5789. FEEMSTER, ROY F. (Massachusetts Dept. Publ. Health, Boston) Milk-borne disease in Massachusetts 1933-1940. Amer. Jour. Publ. Health 31 (11): 1169-1173. 1941.--A report of milk-borne disease in Massachusetts covering an 8 yr. period is presented. Milk-borne disease continues to decrease

in Massachusetts. Only 4 outbreaks of disease traced to milk have occurred in this State within the last 5 yrs. Since 1926 there has been a light but progressive decrease in the per capita consumption of milk. Of 78 communities, representing nearly 80% of the population, there are regulations requiring that all milk be either pasteurized or certified, and it is estimated that over 90% of the milk consumed in this State is pasteurized. In the State laboratories there has been a further increase in the number of bacteriological examinations performed to guard the quality of milk.

BIOLOGICAL ABSTRACTS
May, 1943

Volume 17 Number 5

14071. BORTS, I. H., D. M. HARRIS, M. F. JOYNT, J. R. JENNINGS, and CARL F. JORDAN. A milk-borne epidemic of brucellosis. Caused by the porcine type of Brucella (Brucella suis) in a raw milk supply. Jour. Amer. Med. Assoc. 121 (5): 319-322. 1943.--Even though an entire family may use raw milk from which Br. abortus can be isolated, it is not unusual for all to escape clinically detectable infection, or for but one such case to develop. On the contrary, if the organism involved is Br. suis, multiple cases are not uncommon, as occurred in the epidemic here reported. Organisms of the Brucella group vary widely in their degree of virulence, which aids in accounting for a disparity of infections. Of 77 cases encountered along one raw milk route, one entire family of 6 developed clinical brucellosis, while in another family 6 of 12 members developed the disease. In blood cultures of 29 persons taken rather late in the disease, growth of Br. suis was obtained in 13. Br. suis was isolated from the milk of 3 out of 4 reacting cows in the dairy herd. Serological evidence of infection was present in 14 of 24 sows that were allowed to mingle with the dairy cows.

BIOLOGICAL ABSTRACTS
May, 1943

Volume 17 Number 5

14205. FORSEK, Z. PRETRAZIVANJE ZAGREBACKOG TRZNOG MLIJEKA NA ZARAZENOST SA B. ABORTUS BANG. (Test of Zagreb market milk for infection with Brucella abortus.) (With Ger. summ.) Jugoslav. Vet. Glasnik 19:3-18. 1939.--When 318 samples of Zagreb market milk were examined for Brucella

infection by an agglutination test, guinea-pig inoculation tests and cultural tests with the media of Stockmayer, Karsten, Lubcke and Huddleson, 9 samples were positive in the agglutination test, of which 6 were also positive in the inoculation test and only 2 in the cultural tests.

BIOLOGICAL ABSTRACTS
June-July, 1943

Volume 17 Number 6

16769. PURRIEL, PABLE, ARISTEO A. PIAGGIO, y ROGELIO RISSO. Investigaciones sobre infección brucelósica realizadas en las usinas de pasteurización de leche de Montevideo "Conaprole." Arch. Uraguayos Med., Cir. y Espec. 20(3): 225-231. 1942. The cooperative "Conaprole" supplies most of Montevideo with milk and milk products. A total of 1193 employees--975 men and 218 women --was tested for brucellosis. The incidence of positives in the men was 13.61% and in the women 27.52%. 50% of the women employed in the offices gave positive reactions; the only possible contacts which they could have had with the organism were the memoranda and milk receipts coming from infected premises. In spite of the high incidence of positive reactions, there were no cases with clinical histories. The authors explain this by presuming that in this pasteurization plant the workers are exposed to constant small doses, sufficient to produce an allergic reaction, but not great enough to cause clinical symptoms.

DAIRY SCIENCE ABSTRACTS

Vol. 5, No. 3 November 1943

BRUCELLOSIS IN INDIA

Polding, J. B., Indian F. vet. Sci., 13, (1), 27-34 (1943). 5 tables. (Imp. Vet. Res. Inst., Mukteswar.)

DAIRY SCIENCE ABSTRACTS
Vol. 5, No. 3 November 1943

BRUCELLA INFECTION IN THE MILK OF STALLED COWS IN URBAN DISTRICTS OF SANTIAGO, CHILE.

Infección por brucellas en la leche de establos del sector urbano de Santiago. SAN MARTIN SOTO, V. Rev. Chilena Hig. Med. preventiva, 5, (1), 25-38 (1942) 3 tables, 10 ref. (Serv. Nac. Salubridad, Santiago.)

Four hundred cows from 60 cowsheds were examined for brucellosis. A total of 25 animals (6.25 per cent) gave positive agglutination tests to Brucella abortus, the titres ranging from 1:25 to 1:800 in the cream. No attempt was made to isolate Br. melitensis though it is suspected that this organism is frequently transmitted to cattle from infected goats and sheep.

Pure cultures of 7 strains of Br. abortus were obtained as follows: 6 to 10 ml. of milk were taken from each quarter of all positive reactors. The samples were placed into sterile tubes and put into cold storage overnight. This permitted the cream to rise to the surface, carrying most of the germs. Two to 3 drops of the cream were then spread on Stafseth plates to which a solution of gentian violet was added to inhibit the development of other Gram-positive organisms. Generally the first colonies appear on the 4th to 5th day. The agglutination test on the milk, being simpler and less dangerous than the cultural test, is preferred by the author who applied it successfully when the Brucella count was as low as 50 per ml. of cream. Four cows, yielding strains 3, 4, 6, and 7, shed the organism only intermittently in their milk.

Thirty-eight milkers and auxiliary staff were also examined. Nine (23.7 per cent) gave positive blood agglutination test. The maximum titre was 1:100.

THE SEASONAL VARIATION IN THE INCIDENCE OF BR. ABORTUS IN RAW MILKS.

Jone, E. R. F., Path, Bact., 55, (3), 357-362 (1943). 2 tables 1 fig., 9 ref. (County Coun. Path. Lab. Maidstone, Kent.)

About 400 raw milks from bulked supplies were examined for Brucella abortus in Lancashire in 1933 and a similar number in Kent in 1939. In both series there was an average recovery of about 15 per cent and a marked seasonal variation ranging from about 3 to 6 per cent recovery to 20 to 30 per cent in January and February—a variation which may account for the great differences in results reported by previous workers. In this survey the organism was recovered from guinea-pigs killed 4 to 8 weeks after inoculation but some evidence is presented showing that the organism may be recovered 6

days or less after inoculation. The appearances of the spleens of infected pigs are described and classified.

THE MILK DEALER
September, 1944

Volume 33

UNDULANT FEVER OUTBREAK IN LEXINGTON BRINGS PASSAGE OF NEW ORDINANCE

Outbreak of undulant fever in Fayette County, Kentucky, traced by Dr. Charles D. Cawood, health officer, to consumption of raw milk from herds infected with Bang's disease, has resulted in passage of a new city ordinance for Lexington, Ky., requiring all raw milk distributors to obtain negative results on three successive tests for Bang's disease. New ordinance went into effect September 16, after two new undulant fever cases brought to 16 the total number of cases in the past 11 months. This is two more than for the entire county in the past seven years.

BRUCELLA ORGANISMS IN GOAT'S MILK CHEESE

Source of data: National Cheese Institute, Chicago, Illinois.

Malta fever (Undulant fever, Brucellosis) in Colorado year 1944 reported by Federal Food and Drug Administration.

Malta fever. Raw goat's milk cheese. Goats with Brucella melitensis infection. 100% infection of guinea pigs inoculated with fresh cheese and with cheese up to 14 months, the oldest tested.

THE INCIDENCE OF MICROBACTERIUM TUBERCULOSIS AND BRUCELLA ABORTUS IN MILK FROM MID AND WEST WALES.

Thomas, B.F. (Abs.) Soc. Agr. Bact. Proc. (1944) 15:48-52, 1945.

Studies were made to determine M. tuberculosis and Brucella in herd bulk milk in the area mentioned. Both infections were found in a rather high percentage of the milk examined.

BRUCELLA IN CHEESE IN ERITREA.

Cilli, V. Bull. Hyg. 18:195-16, Nov. 1943.

Brucella melitensis was isolated from cheese in Eritrea. These cheeses are usually eaten 15-20 days after manufacture. Cilli failed to isolate the organism from cheese seasoned more than 44 days.

WELCHE VORTEILE ERGEBEN SICH AUS EINER ERFOLGREICHEN ABORTUS-BANGBEKÄMFUNG FÜR MILCHWIRTSCHAFT UND MOLKEREIEN?

Seeleman, M.
Deut. Molk-u. Fettwirtsch. 1:297-298, Oct. 29, 1943.

This is a discussion of methods used to detect infection in individual herds by the examination of the milk in the receiving dairy. Vaccination with new vaccines (perhaps strain #19) is also discussed, but there is no full report of experimental work.

RECOVERY OF BRUCELIA MELITENSIS FROM CHEESE MANUFACTURED FROM UNPASTEURIZED GOATS' MILK.

Stiles, G. W. Rocky Mountain M. J. 42:18-25, Jan. 1945.

Of 19 samples of goat cheese manufactured in southwestern Colorado, 8 were positive for B. melitensis. These samples of cheese had been seasoned less than 45 days, exact period not stated.

INFECCIÓN POR BRUCELLAS EN LA LECHE DE ESTABLOS DEL SECTOR URBANO DE SANTIAGO.

San Martin, Soto, V. Rev. Chilena de Hig. y Med. Prev. 5:25-38, 1942.

Brucella were demonstrated in milk originating in the Santiago (Chile) milk shed. Brucella were isolated from cows having a lacto agglutination of 1:50. Only one quarter may be infected. Of 38 milkers and stable boys whose blood was subjected to the agglutination test, 23.6% proved positive.

THE VALUE OF MILK SERUM AGGLUTINATIONS IN SAFEGUARDING RAW MILK SUPPLIES.

Bremer, H. E. J. Milk Technol. 7:26-30, Jan-Feb 1944.

Whey and blood serum from reacting cows were tested for agglutination with Brucella antigen. 71% of 339 cows tested reacted to both tests. Attention is called to the fact that the whey test will not pick out all reactors to the serum test.

PART IV

Brucellosis — Insects

1936 — 1944

BIOLOGICAL ABSTRACTS
February, 1942
Volume 16 Number 2

5003. RUHLAND, H. H., and I. FOREST HUDDLESON. (Michigan State Coll.) The role of one species of cockroach and several species of flies in the dissemination of Brucella. Amer. Jour. Vet. Res. 2(5): 371-372. 1941.--In attempts to account for the appearance of brucellosis in non-infected herds kept under ideal conditions, the common cockroach (Periplaneta americana) and several spp. of flies (Musca domestica, Muscina stabulans, Stomoxys calcitrans, Caliphora sp. and Lucilia sp.) were selected for study as they are often found in and around dairy barns, and allowed to feed freely for 2 hrs. on a virulent strain of Brucella abortus, then removed to sterile glass containers and removed at intervals for culturing. 110 cockroaches were used in this exp. B. abortus did not remain alive in their intestinal tract for $\geq$ 24 hrs. Data obtained from the flies indicate that the amt. of growth obtained by culturing the droplets was heavier and more free from contamination 48 hrs. after exposure than at earlier periods. Although no flies were cultured later than 96 hrs. after exposure, it is possible that they carry the organism for a considerable period of time.

PART V

Abstracts from Books and Bulletins

1.	Brucellosis in Man and Animals	- Huddleson
2.	Dairy Bacteriology	- Hammer
3.	The Market Milk Industry	- Roadhouse and Henderson
4.	Brucellosis - a Public Health Problem	- Giltner

From: "Brucellosis in Man and Animals"
By I. Forest Huddleson
New York. The Commonwealth Fund. 1943.

BRUCELLOSIS IN HUMAN BEINGS

Synonyms. Undulant fever, Mediterranean fever, gastric fever, Malta fever, rock fever, Gibraltar fever, melitococcie, goat fever, Texas fever, Rio Grande fever, Brucella fever, Bang's fever.

Definition. Brucellosis in man is a systemic or focal infection caused by Brucella melitensis, Brucella abortus, or Brucella suis. The disease is characterized by weakness, fever with morning remissions, occipital or frontal headache, muscular pains, profuse sweats, chills, constipation, secondary anemia, nervous disturbances, and metastatic involvement of the joints, the eyes, and the reproductive organs. The course is of indefinite duration, but may be marked by repeated relapses and may become chronic. The mortality is low.

PART ONE. HISTORICAL SURVEY

While there is reason to believe that the infection in human beings occurred many centuries ago on the plains of the Near East, it was not, however, differentiated and identified as a separate disease until 1861. In this year Marston (295), in his report on fever, gave a full and accurate description of the disease and designated it as Mediterranean or gastric intermittent fever. His description was in part as follows: "By this is meant a fever characterized by the following symptoms and course: a preliminary stage of subacute dyspepsia, anorexia, nausea, headache, feeling of weakness, lassitude, and inaptitude for exertion, mental or physical; chills, muscular pains, and lastly, a fever having a long course 3 to 5 or 10 weeks, marked by irregular exacerbations and remissions, great derangement of the assimilative organs, tenderness in the epigastric region, and splenic enlargement. It is prone to relapses, has a protracted convalescence, and is frequently marked by rheumatism."

The disease in human beings due to Br. melitensis was given the descriptive name "undulant fever" by Hughes (223) in 1897.

Wright and Sample (479) in 1897 made an important contribution to the diagnosis of brucellosis. They demonstrated that the organism which Bruce identified was agglutinated by the serum of those affected with the disease. This finding aided materially in confirming Bruce's original discovery.

Among the military and naval forces quartered on the Island of Malta "undulant fever" had been for years a major cause of disability. For this reason in 1904 the British Government established a Commission, headed by Bruce, to find if possible the source of the disease and effective measures for its prevention. Associated with him were Smith, Horrocks, Shaw, Weir, McNaught, Eyre, Zammit, Kennedy, Johnstone, McCullough, and Clayton. This group of workers labored exhaustively for the first two years with little apparent success. Having eliminated such possible sources as insects, air, sewerage, water, and dust, they had reached an impasse in their search.

Needing a readily available supply of laboratory animals, Zammit decided to conduct experiments to determine whether milch goats might serve. These were, then as now, the chief source of the milk supply for the Island. Before attempting to infect goats, Zammit considered it advisable to examine their blood for specific agglutinins and to his great surprise several of the goats reacted to the agglutination test in a high titer. These observations were confirmed, and the source of the disease then seemed evident. Samples of milk were taken from the goats which had reacted to the agglutination test and were cultured. These were positive and the source of brucellosis stood revealed.

Zammit, in addition to discovering the source of brucellosis, made an important contribution to the foundations upon which the diagnosis of disease in animals and man was being built. He demonstrated that the milk from the udder of an infected goat contained specific agglutinins and that the detection of these was a reliable diagnostic measure.

The history of brucellosis in man in the western hemisphere probably began with the invasions of the Americas by Cortez and his legions. The studies (392) that have been made in recent years as to the prevalence of the disease in the Argentine serve to substantiate this view.

The first authentic case of brucellosis originating in the United States was reported by Craig (67) in 1905. The patient, a nurse in a hospital in Washington, D.C., had never used goat's milk. It is quite possible that the causative organism in this case was Br. abortus or Br. suis. About the time Craig reported his case another important chapter in the epidemiology of the disease in humans was being written. Mr. Thompson of the United States Bureau of Animal Industry was sent to Malta to purchase milch goats. On August 19, 1905, sixty-one female and four male goats were shipped on the S.S. Joshua Nicholson. At Antwerp they were transferred to the S.S. St. Andrew for the United States. The milk of the goats was freely consumed by the crew on both ships. Of twelve men on the Joshua Nicholson, eight became ill from eighteen to thirty-four days after leaving Malta. The other members of the crew drank little of the milk or boiled it. Positive serological observations confirmed the clinical diagnosis of brucellosis. After the goats were placed in quarantine at Athenia, New Jersey, a woman also drank milk from the goats and developed this same infection. All of these goats were slaughtered.

It was not until 1911 that the endemic occurrence of brucellosis in the United States was revealed. Ferenbaugh (116) and Gentry and Ferenbaugh (142) reported in that year that the disease was prevalent in southwestern Texas and came from infective goat's milk. Evidence was also obtained that the disease had been present in Texas for many years.

A major chapter in the history of brucellosis was written in 1918 when Evans (99) reported the results of her comparative study of the organism Br. abortus and Br. melitensis. Her conclusions are of such historical importance that they are here reproduced. She wrote:

"It is only with great difficulty that Bact. melitensis can be distinguished from Bact. abortus. They are alike morphologically, and no difference could be found in their biochemical reactions. The two organisms produced the same results when inoculated into pregnant guinea pigs. The only distinction between the two organisms in cultural characteristics was a more intense brown pigmentation by Bact. melitensis--an insignificant characteristic, which does not appear until after the cultures have been incubated for a week or more. This distinction can be made only when cultures of the two species which have been incubated for the same length of time can be compared. The agglutination reactions in Bact. abortus antiserum do not distinguish the two organisms; and the agglutination reactions in Bact. melitensis antiserum can distinguish Bact. abortus and Bact melitensis only when the agglutinating strength of the serum for both species is known.

"The fact that Bact. abortus and Bact. melitensis are serologically so closely related explains Kennedy's (245) discovery that the milk and the blood serum of a considerable percentage of cows in London contained agglutinins for the Malta fever organism in high dilution. This author was unable to explain his findings, but suggested that agglutination of the Malta fever organism by cow's milk was not necessarily specific, or else that the reaction was indicative of infection with the organism in question--the latter alternative being an explanation too alarming to be acceptable, although he states that he has heard of two cases of undulant fever in people who have never been out of England, and he thinks it possible that there are other cases undiagnosed.

"The very close relationship between Bact. abortus and an organism pathogenic to human beings adds new interest to the subject of the possible pathogenicity of Bact. abortus to human subjects. Considering the close relationship between the two organisms, and the reported frequency of virulent strains of Bact. abortus in cow's milk, it would seem remarkable that we do not have a disease resembling Malta fever prevalent in this country. A possible explanation can be offered. The data presented in the third paper of this series indicate that although there may be numerous abortus-like bacteria in the milk of cows which have aborted, the actual number of virulent bacteria which persist in the milk is not great, or in all probability it is negligible in many cases in which the milk and blood serum contain agglutinins. But the work of the British Commission indicates that Bact. melitensis is very abundant in the milk of infected goats, for those investigators were able by cultural methods to demonstrate the organism in the milk of 10 per cent of the goats of Malta. Since infection is dependent on the amount of infectious material, it may be that this difference in the number of bacteria in the milk of the two species of animals may account for our freedom from disease when cow's milk containing Bact. abortus is consumed. On the other hand, are we sure that cases of glandular disease, or cases of abortion, or possibly diseases of the respiratory tract, may not sometimes occur among human subjects in this country as a result of drinking raw cow's milk? It is certain that the agglutination tests, which have been relied upon for the diagnosis of Malta fever, have not proved per se whether the infections were due to Bact. melitensis or Bact. abortus."

Several attempts were made prior to 1918 to connect Br. abortus with a disease in man, but it apparently was not clear to the investigators just

what to look for. Mohler and Traum (314) as early as 1911, on examining the tonsils of children consuming raw milk, isolated Br. abortus in one instance. A few years later Larson and Sedgwick (262) examined the blood of 425 children that had received raw milk in their diet. Of these, 73, or 17 per cent, gave a positive test. The clinical diagnosis in these cases was tuberculosis or rickets. In 1916 Cooledge (62) conducted an experiment in which 7 human subjects ingested for varying lengths of time milk containing Br. abortus. The subjects remained in good health during and after the experiment, but 5 showed an increase in blood serum antibodies. The increase in antibodies was thought to be due to absorption into the intestine of antibodies in ingested milk. In the light of our present knowledge of antibodies it is doubtful whether this explanation is tenable.

Duncan (92) in Rhodesia was the first to recognize and report cases of brucellosis due to Br. abortus, but the first case in the United States in which the infecting organism was shown to be due to a species of Brucella other than melitensis was reported by Keefer (243) in 1924. It was thought at the time that the infecting species was Br. abortus. Several years later the author had an opportunity to study this culture and it was then found to be Br. suis. This case did much to awaken a new interest in brucellosis in this country. Since it is so important in the history of this infection, the report is reproduced in full (see Case 20, Appendix, page 327).

Since Keefer's report, cases of brucellosis in human beings due to either Br. abortus or Br. suis have been found in all parts of the United States, as well as in Rhodesia, Germany, Denmark, France, Great Britain, Sweden, Argentina, and Brazil. Wherever Br. abortus or Br. suis is found in animals, there will also be found infection in humans. The world-wide distribution of brucellosis in both animals and man has recently been summarized and reported by Thomsen (440).

PART TWO. BRUCELLOSIS IN THE UNITED STATES

EPIDEMIOLOGY

Incidence

The present or past prevalence of brucellosis cannot be determined reliably. There is reason to believe that this clinical entity occurred in the United States and other countries for many years before it was finally commonly diagnosed. Undoubtedly the present completeness of its recognition and reporting varies markedly. However, it is known to be a widely distributed disease. No broad areas have been conclusively shown to be free of Brucella infection in animals and in man.

Variations in known incidence are in part explained by the differences in accuracy of diagnosis. In the United States the reported cases of brucellosis (undulant fever) have steadily increased from 24 in 1925 to 3,427 in 1941. There is reason to believe the true incidence during this period has decreased rather than increased, particularly in recent years. Within the country, however, persisting differences in case rates are evident. Those for the large cities of the east have been consistently low; in contrast, Iowa, Missouri, Kansas, and to a less extent Minnesota, have had rates in excess of those in other regions. The low incidence in urban areas is

readily explained by the relative freedom from exposure to either infected livestock or raw dairy products. The high incidence in the mid-western states is not explained merely by an excess of rural population; the southern states have an even higher proportion of rural residents, though with relatively few cases of recognized brucellosis. Neither can these cases be attributed to any high incidence of Brucella infection in cattle. The examinations by the United States Department of Agriculture reveal a rather marked uniformity in the incidence of infection of these animals. Though the prevalence of contagious abortion in hogs is not accurately defined, it is still evident that in the United States the incidence of recognized brucellosis in man tends to vary directly with the extent of the hog-raising industry. In other lands brucellosis has for many years been a recognized public health problem in goat-raising areas--particularly in the Mediterranean countries. Apart from this, cases have been recognized sporadically and rather infrequently.

With the known wide distribution and high prevalence of Brucella infection of cattle, the low incidence of clinical brucellosis has been striking. It has been noted that there is a higher rate of human infections in areas raising large numbers of hogs and goats.

From:
Dairy Bacteriology
Bernard W. Hammer
pp. 167-176

BRUCELLOSIS

Brucellosis in man is acquired primarily from animals infected with one of the organisms belonging to the genus Brucella. The species involved are Brucella melitensis (the caprine type), Brucella abortus (the bovine type), and Brucella suis (the porcine type). The three species are very closely related. Man is infected directly through the skin by contact with diseased animals or their tissues and discharges, or indirectly through the consumption of raw milk and milk derivatives from certain infected animals. The disease in man is often referred to as undulant fever; at one time it was commonly called Malta fever. The number of recognized cases have increased rapidly as physicians have become familiar with the disease and more adequate diagnostic procedures have been developed.

Classification of human cases of brucellosis. The cases of human brucellosis can be divided into three groups. (a) Cases that occur in cities among persons who do not come in contact with livestock. The usual source of infection is raw milk and cream, and products made from them. These cases are about equally distributed between the sexes. (b) Cases that occur on farms having livestock. The infection may be due to the consumption of raw milk or derivatives of it, and also to direct infection from farm animals. The cases on farms involve men much more commonly than women, presumably because the men have more contact with livestock. (c) Cases in cities among persons who come in contact with livestock. A relatively large number of cases of brucellosis have occurred in cities among persons in contact with livestock, especially hogs. Commonly, these cases involve employees of meat-packing plants. The primary sources of the infections are tissues of the animals killed.

Brucellosis from goats. Brucellosis has existed for an indefinite period among the inhabitants of the island of Malta and at one time it was designated Malta fever. A causative organism was discovered by Bruce[45] in 1887, and named Micrococcus melitensis in 1893.[46] Because of the prevalence of the fever among the British soldiers and sailors stationed on the island, the British government, in 1904, appointed a commission to investigate the sources of infection and advise methods of control. As early as 1905, the commission considered that the milk from goats was an important factor in the spread of the disease among persons. Subsequent studies indicated that goats were easily infected, that about 50 per cent of them acquired the disease naturally, and that the causative organism was eliminated in the milk and urine. Ten per cent of the goats in Malta were found to be eliminating the organism in the milk, and this was highly infectious for monkeys, in which it produced attacks similar to the fever in man. It appears the elimination of the organism in the urine of goats is a late phenomenon and that this occurs in gushes for short intervals. Goats are evidently infected by consuming contaminated feed, and since the urine of infected goats may contain the organism there is abundant opportunity for this.

45. Practitioner 39, 161, 1887.
46. Ann. Inst. Past. 7, 289, 1893.

In 1911, Ferenbaugh and later Gentry and Ferenbaugh[47] established through agglutination tests and blood cultures that brucellosis existed endemically in the goat-raising sections of Texas. All the human cases reported by them gave a history of association with the goat industry, and some had consumed goats' milk. In an examination of 151 goats these investigators found that about 20 per cent gave a positive agglutination test in a dilution of 1 to 20, whereas 3 agglutinated in a dilution of 1 to 40. A large number of goats in the section studies were direct descendants of goats imported from districts in which brucellosis was known to exist. Mohler and Eichhorn[48] substantiated the existence of the disease in Texas and proved its presence in New Mexico by agglutination and complement fixation tests on goats from these states. Furthermore, careful investigations seem to show that the disease has existed for many years in Texas and New Mexico among people connected with goat raising, under such names as mountain fever and slow typhoid fever. Holt and Reynolds[49] reported that they believe brucellosis is endemic along the entire Mexican border of Texas, New Mexico, and Arizona. Mohler and Hart[50] fed cultures of the causative organism to a normal American goat and obtained an infection, which was evident from a pronounced increase in the agglutinating power of the blood.

The importance of goats' milk in spreading the disease has been shown in various ways. When the fresh milk supplied the soldiers at Malta was pasteurized, the disease among them was reduced 90 per cent. The disease did not occur among the convicts of the civil prison at Malta who were not allowed milk. It was practically eliminated among British soldiers stationed at Gibraltar by prohibiting the consumption of raw goats' milk. Mexican goat herders are only infrequently infected; this may be due to the fact that they boil milk before drinking it.

History of a shipment of goats to the United States. The history of a shipment of goats to the United States[51] affords proof of the role played by milk from infected goats in causing brucellosis in man. A herd of 61 nannies and 4 billy goats was shipped from Malta, on the steamer Joshua Nicholson for the United States, via Antwerp. On reaching Antwerp the goats remained in quarantine 5 days and then went on the steamship St. Andrew to New York. The goats were transferred to a quarantine station where they remained under observation. Bacteriological examinations resulted in the recovery of the Brucella organism, first from the milk of 2 goats and later from that of several more.

On the Joshua Nicholson there were 23 officers and men in addition to the persons in charge of the goats, and goats' milk was freely consumed. Eleven of the crew left the ship at Antwerp and, with the exception of one who was in the hospital because of a hernia, their movements could not be traced. Eight of the twelve remaining officers and crew fell sick at intervals varying from 18 to 34 days from the embarkation of the goats, and in five of the eight blood reactions showed that brucellosis was the cause of the illness. Of the four who were not sick, two drank very little milk and the other two appear to have boiled their supplies. The St. Andrew carried

47. Jr. Am. Med. Assn. 57, 730, 889, 1045, 1127. 1911.
48. U.S.D.A. B.A.I. 28th An. Rpt. 119. 1911.
49. Mil. Surg. 56, 414. 1925.
50. U.S.D.A. B.A.I. 25th An. Rpt. 279. 1908.
51. U. S. Pub. Health Mar.-Hosp. Serv. Hyg. Lab. Bul. 56, 201. 1909.

30 cattlemen, a crew of 30, and the 4 persons in charge of the goats. Although many of these drank milk there was no evidence of illness. After the arrival of the goats in the United States a number of persons tasted the milk but only two drank any quantity. One of these doubted the idea of brucellosis being conveyed by goats' milk, and continued to drink the milk at frequent intervals. He died suddenly from pneumonia and the agglutinating power of his blood against Br. melitensis was never tested. The other person developed a typical case of brucellosis.

Epidemic of brucellosis due to goats' milk. Lake[52] reported an epidemic of brucellosis which occurred in Phoenix, Ariz., as a result of the consumption of goats' milk. More than 30 cases were positively diagnosed and undoubtedly many others occurred. In all but three of the cases goats' milk from the same dairy was known to have been used and in the three it could not be excluded. A Brucella organism was recovered from two of the cases. Agglutination tests were made on 115 goats in the herd responsible for the epidemic, and 18.3 per cent was positive.

Significance of brucellosis among goats in the United States. Although only a comparatively small amount of goats' milk is consumed in the United States, an increase will undoubtedly occur, and in the development of the goat industry the possibility of spreading brucellosis to both goats and man must be considered. Apparently the goats in certain areas are free of the disease. Learmonth and Hall[53] studied blood samples from 70 goats in 8 herds and milk samples from 128 animals, and found no evidence that goats harbor Br. melitensis in or near Denver.

Brucellosis from cattle. Contagious abortion in cattle has been known in England and continental Europe for many years. In 1897, Bang[54] ascribed it to an organism which produced the disease on artificial inoculation and could be recovered from the infected animals. The organism is now designated Br. abortus and is the common cause of abortion in cattle. In 1918, Evans[55] noted the close relationship between Br. abortus and the organism originally described by Bruce as M. melitensis. This led to the conclusion that the latter organism is not a Micrococcus and suggested the possible relationship of Br. abortus to disease in man.

By blood culture Duncan,[56] in 1925, isolated an organism from a case of undulant fever that resembled Br. abortus more closely than Br. melitensis. Duncan concluded that the evidence pointed to Br. abortus as the cause of undulant fever in Rhodesia and to cows as the source. Since this original isolation, Br. abortus has been obtained from many cases of human brucellosis in various parts of the world and it is now regarded as the important organism causing this disease in many countries.

Brucella organisms in milk. Various investigators have observed that guinea pigs inoculated with cows' milk for the purpose of detecting M. tuberculosis and autopsied after extended periods showed lesions which could easily be mistaken for tuberculosis but in which no acid-fast organisms could be

52. Pub. Health Rpts. 37, 2895. 1922.
53. Jr. Am. Vet. Med. Assn. 84, 915. 1934.
54. Ztschr. Tiermed. 1, 241. 1897.
55. Jr. Inf. Dis. 22, 580. 1918.
56. Brit. Med. Jr. 1, 554. 1925.

demonstrated. Schroeder and Cotton[57] noted this condition in a series of tests and found it transmissible from one guinea pig to another by subcutaneous inoculation of affected tissue. Their interest in the nature of the disease was continued when they found that the milk of a tuberculous cow caused it, even when the milk was obtained so as to exclude contamination from any source but the interior of the udder. The responsible organism was eventually cultivated and its similarity to the organism of contagious abortion led Mohler and Traum[58] to suspect that the two were identical; this suspicion was strengthened by the fact that much of the milk studied by Schroeder and Cotton came from the sources which supplied Mohler and Traum with material for their work on contagious abortion. A comparison of the organisms showed no detectable difference, either cultural or morphologic, and the use of the Schroeder and Cotton organism as an antigen in applying the complement fixation test to animals infected with abortion established the identity beyond a doubt. By inoculating the abortion organism Mohler and Traum produced the typical lesions in guinea pigs. Smith and Fabyan[59] also found that the udders of infected cows are reservoirs for Brucella organisms.

The work of the early investigators indicated that Br. abortus was often present in milk. In a series of 77 samples of market milk from 31 dairies, Schroeder and Cotton[57] found that 8 samples from 6 dairies were infected. In another series of 140 samples from 4 dairies they obtained the following results: dairy A, 35 samples, 11 infected; dairy B, 33 samples, 7 infected; dairy C, 34 samples, 2 infected; dairy D, 38 samples, 2 infected. With a single examination of milk from individual animals, these investigators found that 19 of 140 cows in a large herd in the District of Columbia and 11 of 36 cows at the Bureau of Animal Industry Exp. Sta. at Bethesda, Md., yielded the organism; a considerable percentage of the cows in the latter group was tuberculous. Cooledge[60] noted that 27 per cent of the cattle studied on seven farms had Br. abortus infected udders, and that once the infection is established in the udder the milk becomes a carrier of the organism and a possible source of infection for years. The rear quarters were usually the first to show Br. abortus infections indicating that genital discharges and switching of the tail are its sources; the infection may then be carried to the front quarters. Fleischner and Myers[61], in 1917, reported that the abortion organism "is for practical purposes, always present in the certified milk produced in the San Francisco Bay regions."

The more recent studies also emphasize the common presence of Br. abortus in milk. In 1930, Hasley[62] detected Br. abortus in certified milk by plating. It was grown from 10 of 230 samples examined and the 10 samples came from 3 of the 5 dairies studied. The highest number of organisms was 8 per ml. and the average for the 10 positive samples was 2 per ml. Fitch and Bishop[63] examined 18 samples of milk from commercial distributors in a city requiring that all milk sold raw come from cows negative to the agglutination test. None of the samples were positive although results on one sample

57. U.S.D.A. B.A.I. 28th An. Rpt. 139. 1911.
58. U.S.D.A. B.A.I. 28th An. Rpt. 147. 1911.
59. Centbl. Bakt. 1 Abt. 61, 549. 1912.
60. Mich. Agr. Exp. Sta. Tech. Bul. 33. 1916.
61. Am. Jr. Dis. Child. 14, 157. 1917
62. Jr. Inf. Dis. 46, 430. 1930.
63. Proc. Soc. Exp. Biol. Med. 30, 1205. 1933.

were unsatisfactory because of the early death of the inoculated animal. Of 18 samples obtained from distributors in a city having no requirements with reference to the cows, 6 samples were positive, 6 were negative, and the results on 6 were unsatisfactory; the 6 positive samples represented five dairies since duplicate samples were obtained from one dairy. Thompson[64] studied the milk from 10 high-producing cows which never manifested symptoms of contagious abortion but whose blood serum showed agglutinins for Br. abortus in relatively high dilution. The milk was examined for Br. abortus at intervals of 30 days over an entire lactation period by both direct plating and the inoculation of guinea pigs; the latter method was slightly more efficient. Results showed Br. abortus may be eliminated in the milk of cows classed as "healthy carriers." Actually 6 cows were positive.

The raw milk in Great Britain also frequently contains Br. abortus. Minett and Pullinger[65] found Br. abortus in 17 of 26 samples of certified milk, in 31 of 39 samples of other high-grade milk, and in 27 of 43 samples of milk each representing a 3,000-gallon tank. Smith[66] examined milk from 183 cows and found 17 were positive to Br. abortus. Barratt[67] studied 157 samples of milk, most of which was ordinary milk. Thirty-four contained Br. abortus; an additional infected sample was found among 16 inoculated animals that died prematurely. Br. abortus was not obtained from 5 samples of pasteurized milk. The only sample of certified milk examined contained it. Pullinger[25] reported that 11 of 31 samples of raw cream contained Br. abortus.

Gwatkin[68] examined 102 milk samples from cows known to be infected with contagious abortion; 52 contained Br. abortus.

Brucella organisms in other dairy products. With Br. abortus in milk, its presence in other dairy products would be expected unless pasteurization is used. Fitch and Bishop[63] collected cream from cows shedding Br. abortus and churned it without pasteurization. Half of the butter was salted and half unsalted. Br. abortus was isolated from both the salted and unsalted butter and from the buttermilk. The organism was also recovered from ice cream made from cream known to be naturally infected.

In general, samples of market butter have failed to show Br. abortus, presumably because such butter is practically always made from pasteurized cream. It appears that Br. abortus does not survive very long in cheeses in which there is a rather rapid acid development.

Infection of milk with Brucella organisms. When Br. abortus is present in milk it commonly comes from the interior of the udder. This species apparently becomes established there and grows much as do the common udder organisms. The results of Cameron[69] indicate that the organism survives for extended periods under a variety of conditions so that infection from the stable surroundings is also possible. Br. abortus lived 4.5 hours exposed to direct sunlight, 121 days (the maximum period studied) when dried in the presence

64. Jr. Inf. Dis. 55, 7. 1934.
65. Brit. Med. Jr. 2, 1080. 1933.
66. Jr. Hyg. 34, 242. 1934.
67. Jr. Comp. Path. Ther. 48, 43. 1935.
68. Can. Pub. Health Jr. 25, 5. 1934.
69. Cornell Vet. 22, 212. 1932.

of nutrient material, 72 days when dried in the absence of nutrient material, 66 days (the maximum period studied) in wet soil in an unheated cellar, 4 days in normal bovine urine at room temperature, 120 days in bovine feces in a test tube in the laboratory and dried very slowly, and 100 days in bovine feces kept in an unheated cellar and not dried.

Dangers from infected milk. A number of cases of brucellosis in man occur each year in the United States and a portion of these is due to infected milk; but the number of cases is small when the wide distribution of the disease among cattle and the frequency with which infected cows eliminate the causative organism in the milk are considered. Hardy et al.[70] suggested that dairy products which serve to disseminate the infection either carry large numbers of organisms or strains of unusual virulence, and noted that relative human immunity must also be operative. Many human cases of brucellosis are isolated or in small groups, and it is evident that an extremely small percentage of persons consuming an infected milk supply develops the disease.

Information on the spread of brucellosis from cattle to man has emphasized the desirability of establishing herds that are free of the disease, and progress along this line has been rapid, especially in herds supplying milk that is to be consumed in a raw condition. The economic importance of brucellosis in cattle is another factor in the elimination program.

Examination of milk for Brucella organisms.[71] The inoculation of guinea pigs is a satisfactory method of examining milk for Brucella organisms. Cream is obtained from the milk by gravity or centrifuging and a small amount, for example 2 ml., inoculated subcutaneously or intraperitoneally. After 6 to 10 weeks the animals are killed; the tissues are examined for characteristic lesions and also cultured. Blood serum from the animals can be tested for agglutinins.

Cream can be examined by making direct cultures on the surface of a suitable medium in plates. Liver agar[72] is satisfactory and the addition of gentian violet to a final dilution of 1 to 200,000 inhibits the growth of many gram-positive organisms. The plates should be held in a closed container in which about 10 per cent of the air has been replaced by carbon dioxide. Cultures considered to be Brucella organisms must be properly identified. This general procedure is more difficult to use with cream containing many organisms than with low-count cream because of the interference of various species.

Milk[71] is sometimes studied for Brucella agglutinins by obtaining the serum with rennet and testing the agglutinating power of it. A high content of agglutinins indicates an udder infection, but various investigators have noted that there is no close correlation between the agglutinin content of milk and the presence of Br. abortus. Gilman[73] recovered Br. abortus from the milk with one or more quarters of 78 per cent of the cows showing a 1 to

70. Pub. Health Rpts. 45, 2433. 1930.
71. See ref. 26, 130.
72. Jr. Inf. Dis. 40, 352. 1927.
73. Cornell Vet. 21, 243. 1931.

80 milk titre, which was the titre considered positive; in five instances he also obtained it from milk showing a milk titre less than 1 to 80.

Brucellosis from hogs. Br. suis was apparently first isolated in 1914 from premature fetuses from sows. The hog appears to be the true host. Like the other Brucella species it is capable of causing disease in man. Br. suis is apparently more virulent for man than Br. melitensis or Br. abortus.

The primary danger of human infections with Br. suis is contact with infected hogs or tissues from them on farms or in meat-packing plants. McNutt[74] tested 1,547 hogs in a packing plant and blood from 2.3 per cent reacted in dilutions of 1 to 50 or higher. Cultures from tissues of such reacting hogs yielded the Brucella organism in about 41 per cent of the cases.

Various investigators have obtained Br. suis from bovine sources. Gilman and Milks[75] typed 117 strains of Brucella organisms recovered from milk and found 113 were bovine and 4 porcine; the 4 porcine strains came from three herds.

Beattie and Rice[76] studied an outbreak of milk-borne undulant fever that was caused by Br. suis. It involved 30 persons of whom 27 obtained milk from one dairy. This dairy had 20 cows and supplied about 80 households; in 18 of these, undulant fever occurred. The last case appeared 13 days after the sale of milk from the dairy was stopped. Br. suis was obtained in blood cultures from 6 of 14 patients and from the milk of 1 of the cows in the herd.

A milk-borne outbreak of undulant fever due to Br. suis occurred in a home for elderly persons in Connecticut.[77] It involved 14 cases with 3 deaths out of a population of 305 inmates and 81 employees. The evidence indicates the fever was due to drinking raw milk from cows infected with Br. suis. The organism was isolated from the blood of 2 patients and an abscess in a third. Out of the herd of 37 animals the blood of 2 cows was positive for Brucella infection and that from another was suggestive. There was an opportunity for the infection of the cattle from a herd of infected swine.

74. Jr. Am. Vet. Med. Assn. 86, 183. 1935.
75. Cornell Vet. 23, 150. 1933.
76. Jr. Am. Med. Assn. 102, 1670. 1934.
77. Conn. State Dept. Health 50th Rpt. 170. 1935.

From: "The Market-Milk Industry," by C. L. Roadhouse and J. L. Henderson, 1941. P. 61-64. Published by McGraw Hill Book Co.

BRUCELLOSIS.--Brucellosis (Brucelliasis) is the name recently given to a disease formerly called "Malta," "Mediterranean," or "undulant" fever. Three species of the genus Brucella infect man: B. melitensis, the goat (Caprine) strain; B. suis, the pig (Porcine) strain; B. abortus, the cow (bovine) strain. In human beings the disease is contracted by contact with animals infected with one or more species of Brucella or by consuming the milk of infected cows or goats. The most constant symptoms are intermittent fever, weakness, and profuse perspiration. General aching and headache are frequent; and pain may be localized in the back, neck, joints, and abdomen. The symptoms may continue for 1 to 3 months. At times the disease completely incapacitates the sufferer; and 2 to 3 per cent of reported cases terminate fatally. The symptoms are not sufficiently uniform to permit diagnosis without serological confirmation.

The first record of a Brucella infection was reported by Marston in 1859. He called the disease "Mediterranean" or "gastric" fever. In 1886, David Bruce isolated the organism causing the fever from the spleen of a victim of the disease and later named it Micrococcus melitensis. These first two reported infections were due to the goat strain and were referred to as "Malta" fever because their source was goats on the island of Malta.

Ten years after Bruce isolated the causative agent of Malta fever, Bang in Denmark discovered the cause of infectious abortion in cattle. He named the organism Bacillus abortus, and the disease induced in cattle by B. abortus infection is known as "Bang's disease." Traum noted a similar infection in swine in 1914. The pig, or porcine, strain differs in some characteristics and is now called Brucella suis.

Evans in 1917 found that Bang's bacillus resembled in cultural and serological characteristics the micrococcus discovered by Bruce. She remarked in her report that since Bruce's organism caused Malta fever in man one might logically expect to find similar infections from the bovine strain.

Man has proved susceptible to all three Brucella species, and the other two types are more virulent than the bovine. Aborting cows may harbor any of the three abortion organisms; but the susceptibility of human beings varies greatly, particularly with respect to the bovine type.

Prevalence of Brucellosis.—Brucellosis in man resulting from the caprine infection is widespread in subtropical regions and presents an important health problem in the countries bordering on the Mediterranean, in South Africa, in India, in China, and in the Philippines. It has also been reported as occurring in the State of Arizona.

Brucella suis is prevalent in the United States in the swine-producing areas, also in Denmark and Hungary, and probably in many other countries.

Table 25.--Incidence of Brucellosis in Various Regions of the United States, with Factors, Possibly Accounting for Variation. (Hardy, Jordan, and Borts)

Region	Cases of Brucellosis per 100,000 population, 3-year average*	Rural population percent+	Examination of Cattle		Percentage distribution of hogs.
			Percentage positive for Brucella infection	Percentage in herds with one or more reactors	
West N. Central	3.8	58.2	10.7	53.7	53.5
Pacific	2.3	32.5	7.9	43.2	2.1
Mountain	1.7	60.6	7.6	52.3	2.5
East N. Central	1.6	33.6	9.6	45.1	21.1
Mid-Atlantic	1.5	22.3	7.3	52.9	1.7
New England	1.5	22.7	10.7	58.5	0.4
South Atlantic	1.3	63.9	7.2	49.6	7.1
West S. Central	9.7	63.6	12.2	53.6	6.2
East S. Central	0.6	71.9	10.1	64.9	5.4
Total	1.6	43.8	9.5	52.6	100.0

* From 1929 to 1935.
\+ Those living on farms or in towns of less than 2,500 population.

As Table 25 indicates, the largest number of human cases of Brucellosis occur where the swine industry is intensively developed. Studying the sources of Brucella infections in man, Hardy and his associates found that 70 per cent were of the porcine variety out of 124 cases in which the organism was isolated from the blood stream or from local lesions.

The exact number of our cattle infected with Bang's disease is not known. Much blood testing has been done in a number of states, and the results indicate a widespread infection among dairy cattle throughout the country. In 1934 an extensive program for eradicating bovine infectious abortion was undertaken by the U. S. Department of Agriculture. This work has been continued, and 7,400,000 blood agglutination tests have been made of dairy cattle in nearly half a million herds. Table 25 shows the general distribution of infected cattle throughout the United States. The average number of reactors was 9.5 per cent of the animals tested, and 52.6 per cent of the herds tested showed one or more reacting animals. Where cows in individual herds have been examined, 20 to 50 per cent or more have reacted to the agglutination test for Bang's disease. Since the program in most states has been voluntary, probably the herds tested were not those that were more extensively infected, and the testing of all cows would have shown more than 9.5 per cent of reactors.

Table 26.--Reported Cases of Brucellosis 1925 to 1935, in the United States (Hardy and Others)

Year	Number of Cases	Number of states reporting cases
1925	24	5
1926	46	8
1927	217	21
1928	647	41
1929	952	44
1930	1,420	46
1931	1,351	40
1932	1,326	41
1933	1,659	45
1934	1,387	43
1935	1,897	45
Total	11,426	

Brucellosis in Man.--The first human case of Brucella infection of the B. suis type in the United States was diagnosed at Johns Hopkins University in Baltimore by Keifer in 1922 and reported by him in 1924. In 1925, Duncan isolated the first B. abortus organisms from man. In that year, 24 cases of human infections were reported in this country (Table 26).

The number of cases reported annually has increased markedly since 1925, the total for 1935 being 1,897. These cases, however, included the porcine, caprine, and bovine types; and cow's milk has not always been responsible. Many Brucellosis infections in man have developed from direct contact with swine and cattle without raw milk's being implicated. Data are not available to show the exact relation of raw-milk consumption to Brucellosis in man, although Hardy in 1932 reported 626 cases of Brucellosis in Iowa, of which 211 were attributed to the use of raw milk and milk products. Iowa is an important swine-producing state, and the porcine type of infection is more virulent to man than is the bovine. Because, however, cattle are susceptible to porcine infections, it would seem highly desirable to separate the dairy cows from swine and their environment. Apparently, a large amount of Brucellosis among consumers of raw milk in Iowa has resulted from porcine infections in dairy cattle, which carried the infection to man. This view is supported by a milk-borne epidemic of Brucellosis reported by Beattie and Rice in which 27 severe cases caused by the porcine strain occurred among 350 regular patrons of a raw-milk dairy during a period of 3 months. According to the information available, Brucella infections of man resulting from the bovine strain are less important than those from the porcine.

Data provided by the various state departments of health on the total amount of Brucellosis in this country in 1935 indicate an incidence of approximately 2 cases per 100,000 population.

BRUCELLOSIS A PUBLIC HEALTH PROBLEM
By Ward Giltner
Memoir No. 1
Agricultural Experiment Station
Michigan State College, East Lansing, Michigan. 1933

Pasteurization. From the public health standpoint pending the time when Bang's disease of cattle may be considered to have been eradicated in a given area, it is recommended that all milk coming from cows that react to the agglutination test for Brucella or from cows of unknown status in respect to brucellosis be effectively pasteurized. The usual legal requirements for milk pasteurization are adequate for protection against Brucella, but the factor of safety is probably less than in the case of other pathogens found in milk.

Experiments reported by Boak and Carpenter (1931) (197) indicated that the present requirements for pasteurization of milk (heating at 142°-145° F. for 20-30 min.) are adequate for destroying the most virulent strains of Br. abortus.

Recently, Murray et al. (1932) (198) reviewed the literature on pasteurization of milk containing Brucella and reported on their own experiments. They used a standard pasteurizing outfit and found that a temperature of 62°-63° C. (143.6°-145.4° F.), applied for three minutes, is sufficient to destroy both bovine and porcine varieties of Brucella. Thus they concluded that the usual procedure of 62°-63° C. for 30 minutes gives ample factor of safety, provided the pasteurizer is operated in the proper manner. With the lid of the pasteurizer open, viable Brucella were isolated even after 30 minutes. A flush gate valve is also necessary. In experiments in which an ordinary faucet outfit was used, live organisms were found after 30 minutes.

The writer (1926) (199) participated in some experiments in which both Brucella and Mycobacterium tuberculosis were tested by the Electro-pure process.* The following conclusions from that work indicated that Brucella is slightly more resistant than the tuberculosis bacillus:

1. When artificially infected milk was subjected to the ELECTROPURE treatment, with the apparatus set to operate at 150° F., the treatment was ineffective in destroying the viability of Mycobacterium tuberculosis, Brucella abortus and Br. melitensis.

2. When artificially inoculated milk was passed through the ELECTROPURE apparatus, set to operate at 155° F., no viable Mycobacterium tuberculosis were found in the treated milk, but viable Br. abortus-melitensis were demonstrated to have been present, in three out of thirteen 3 cc. samples injected into guinea pigs.

3. When artificially inoculated milk passed through the ELECTROPURE apparatus, set to operate at 160° F., the milk was rendered free from living Mycobacterium tuberculosis, Br. abortus and Br. melitensis.

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* For a brief description of the apparatus used see pp. 114 and 212, Giltner's Textbook of General Microbiology. Blakiston's Son and Co., 1928.

Park, S. E., Graham, R., Prucha, M. J., and Brannon, J. M. (1932) (200) studied pasteurization of milk artificially infected with two strains of Brucella suis and summarized their results as follows:

"1. Two strains of Brucella suis, in hermetically sealed glass tubes of whole milk (500,000,000 organisms per cubic centimeter), were non-viable after twenty minutes at 140° F., after fifteen minutes at 142° F., and after seven minutes at 144° F.

"2. The same strains proved more resistant to heat in cotton-stoppered tubes of milk. Brucella suis survived for thirty minutes at 144° F. in milk containing 10,000,000 to 500,000,000 organisms per cubic centimeter, but the same period of time at the same temperature destroyed Brucella suis in milk containing 5,000 to 1,000,000 organisms per cubic centimeter. Therefore, it appears that the thermal death time is influenced by the degree of contamination."

In a foreword to this paper, Andy Hall, Director of Public Health of Illinois, Chairman of the State Undulant Fever Committee, made this comment:

"Undulant fever as a public health problem is unique in many ways. It has been recognized as such only recently. That the principal source of the disease is in domestic stock no well informed observer doubts. There is no uniformity of opinion concerning the relative importance of channels through which the infection may reach man from animals. No student of the subject denies that infected milk may result in spreading undulant fever among humans.

"A recent analysis of 155 cases of sickness that occurred during 1929 and 1930 in Illinois and which were clinically and serologically diagnosed as undulant fever cast a very strong suspicion on raw milk supplies as the agent of transmission in a significant percentage of the total incidence. Observers elsewhere have found evidence that infected milk may be an important means of transmitting the disease. Furthermore, undulant fever prevalence may be on the up curve, potentially at least. If nothing is done to control the disease a great endemic wave of this ailment among men in the not far distant future is a catastrophe which is well within the realm of the possible. On the other hand a relatively small amount of judicious energy spent now in research and control may offset that possibility.

"For these reasons, it seems of the greatest importance to bring to light all possible knowledge about the cause of undulant fever and means of controlling and spread of it. The accompanying report is a contribution to an important phase of this knowledge. Some controversy about the efficacy of pasteurization in destroying the causative organisms of undulant fever has arisen. Doubts created by this controversy will survive until the matter is settled by undisputable scientific experimentation. This report might be accepted as closing the chapter on one phase of the necessary experimentation."

Pasteurization should not be universally required for all market milk. The writer (1932) (201) has discussed this matter in a paper in defense of certified milk. Opposition was expressed to commending the pasteurization of a milk of low grade or to substituting pasteurization for more logical

methods of handling infectious diseases of cattle. There is just as great a source of danger due to the shortcomings of pasteurization as there is due to the remote possibilities of pathogens in a high-grade raw milk. Commercial pasteurization has become a highly technical process the benefits of which are available only to communities of considerable size. The crude heating of milk so that it is safe so far as Brucella is concerned is a technic that can readily be mastered by the housewife. Under circumstances that do not clearly safeguard the health of the family it is better to boil milk before using than to use it raw.

Recently, in Health News (v. IX, No. 31) of the New York State Department of Health, there was given a letter of a mother who protested against the rescinding of a pasteurization ordinance by a village board of health.

She wrote:

> "I am making this plea to save any mothers the anguish which I have just gone through and had it not been for some doctor on the job who knew his business enough to send a specimen of my little girl's blood to Albany and had it confirmed 'Undulant Fever,' I think that this summer would have found one little cot at the lake empty and through no carelessness in any way on a mother's part but only through ignorance for we had not been sufficiently warned of the danger lurking in raw milk."

The report of the Committee on Milk to the Conference of State and Provincial Health Authorities (June 2, 1932) attempted to answer the question: What practical methods can be devised and recommended to increase the percentage of pasteurized milk for sale in the smaller cities and towns of the country?

The committee believes that this is a very important problem, since the milk-borne outbreak reports of the (U.S.) Public Health Service and the American Child Health Association clearly indicate that the vast majority of milk-borne outbreaks of disease occur in small communities in connection with raw milk supplies. It is believed that the solution of this problem should be largely through educational means and that compulsory pasteurization ordinances should be passed only after the educational program has reached and convinced an unmistakable majority of the population. The local health officers of communities in which any considerable percentage of the market milk is still sold raw are urged to use an educational approach similar to that recommended in the Public Health Service Milk Sanitation Program under the chapter heading "What Policy Should the Health Officer Adopt with Reference to Pasteurization and with Reference to Increasing to the Optimum the Per Capita Consumption of Milk?" (Public Health Reports, Vol. 47, No. 33, August 12, 1932.)

At the 1932 meeting of the Society of American Bacteriologists, at Ann Arbor, Gilbert and Coleman (202) made a report on their study of undulant fever in New York State. They found that over 2,000,000 people in the State have a raw milk supply. While they located several hundred cases a year in the State, they believe that only one-tenth of the cases are recognized.

On this basis, there would have been several thousand cases a year in New York or more than are reported annually to the U.S. Public Health Service for the entire United States. They reported that nearly all of the New York cases are due to the bovine type of Brucella and that most of the cases had no contact with cattle; consequently, raw milk seemed to be the source of the trouble.

BIBLIOGRAPHIES
460 B.C. - 1897 A.D.

Hughes (1) 1897, page 29-34, to quote Eyre (see below) "included a comprehensive bibliography of Mediterranean Fever, ranging in point of time from the Epidemics of Hippocrates (460 to 357 B.C.) to the date of publication," 1897. "In the compilation of his list - a work in which he had the advantage of Professor Zammit's assistance - Hughes searched through rare and some unique volumes, both in manuscript and in type, lodged in the Bibliotheca of Valetta, and so secured many valuable references not elsewhere obtainable."

After the reference to Hippocrates, Hughes' next reference is 1709, Bates, 7, Naval Surgeon. An enchiridion of fevers incident to seamen in the Mediterranean, 2nd ed., London. A bare half-dozen references to the literature are attributed to the 18th century. From 1800 till the middle of the nineteenth century only a few over a dozen references could be found. From then on until 1897, the literature is rich in references to many aspects of the disease.

1897 - 1907

In the Report of the British Mediterranean Fever Commission, Part V, (pp. 67-75), Eyre presented a chronological list which is a continuation of Hughes' bibliography, and embraces the period from 1897 to January 1907. Eyre also (pp. 76-87) arranged his references by authors, alphabetically. While 112 authors are cited, 211 titles are listed, since some of the authors are credited with a considerable number of titles: Bruce, David, British, 6 titled; Craig, C. F., and Curry, J. J., Americans, 2 each; Dalton, F.J.A., British, 4; Eyre, J.W.H., and Gilmour, R. T., British, 5 each; Hayat, I. E., French, 2; Horrocks, W. H., and Kennedy, J. C., British, 10 and 13; Nicolle, C. H., French (Tunis), 6; Ross, E. H., British, 8; Shaw, E. A., and Smith, P. W. Bassett, British, 13 and 14; Wright, A. E., British, 4; and Zammit, Maltese, 6.

1903 - 1932

The writer has canvassed the Index Medicus and the Quarterly Cumulative Index Medicus from 1903 to date in an effort to study the development of investigations into undulant fever and cognate subjects with the following results:

Year	Malta Fever References	Eyre's List	Year	Malta Fever References	Year	Malta Fever References
1903	11	21	1908	46	1914	48
1904	16	16	1909	43	1915	19
1905	31	49	1910	79	1916	13
1906	40	47	1911	73	1917	9
1907	35	5	1912	48	1918	12
			1913	47	1919	10

Year	Malta Fever	Infectious Abortion	Abortus and Melitensis	Total
1920	12	--	--	12
1921	12	25	--	37
1922	16	29	--	45
1923	18	27	—	45
1924	33	29	--	62
1925	33	40	--	73
1926	46	40	6	92
1927	64	24	36	124
1928	69	29	42	140
1929	197	30	40	267
1930	207	33	45	285
1931	193	32	43	268
1932 - Part of	78	7	17	

Except for the decided slump during the world war period, there has been a steady increase in the output of literature on Brucella and brucellosis during the past three decades. Beginning with 1921 for a period of five years the references to abortus outnumbered the references to Malta fever.

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