

EPIDEMIOLOGY OF BRUCELLOSIS IN THE UNITED STATES OF NORTH AMERICA

JAMES H. STEELE, DVM, MPH*

David Bruce studied the etiology of undulant fever and isolated a gram negative organism which he called *Micrococcus melitensis*. This finding is the basis of our knowledge of this disease. Zamit contributed the basic epidemiological fact that milk is the source of undulant fever in Malta. The discovery that presumably normal goats had some antibodies against Bruce's organism and that the milk contained the organism led to the military order that all milk consumed by military personnel should be boiled. The incidence of infection was materially reduced in the military population in sharp contrast to the continued high incidence among natives who continued to consume raw milk.

Bang and Stribolt described the cause of infectious abortion among cows as *B. abortus* but the relation of this organism to *Micrococcus melitensis* was not suspected until the classical studies of Evans in which she demonstrated the relation of the two and suggested that *B. abortus* might produce human infection. Kennedy in 1914 had obtained evidence that undulant fever occurred in persons who had not been out of the British Isles. Traum had previously discovered the cause of infectious abortion among swine which he termed *B. suis*.

Thus the fundamental knowledge available to workers at the termination of Miss Evans' work included an understanding of the relation of the organism involved in the general problem. The relation of milk to infectivity, and the suspicion that *B. abortus* and *B. suis* might cause human infection. When Keefer (1924) described the first case of known infection in the U. S., the former suspicion became a known fact. With increasing awareness of the disease, the reported cases in the U. S. have increased from 60 in 1927 to over 6,000 in 1947.

To eliminate some of the confusion in the nomenclature of the organism involved in this disease, K. F. Meyer suggested that these organisms be classed as *Brucella* (in honor of David Bruce). This system of nomenclature has been universally adopted. The three organisms with which we deal most frequently are *Brucella melitensis*, *Brucella suis* and *Brucella abortus*.

Now that the historical background of the disease has been indicated, let us return to the experience of the United States with the disease. Generalizing from the British experience, it was thought that undulant fever spreads through the ingestion of milk contaminated with virulent *Brucella*. Therefore, one of the methods to control the disease was to make sure that all the milk consumed be properly pasteurized.

* Chief, Veterinary Public Health Division, Communicable Disease Center, Public Health Service, Atlanta, Georgia.

The State Department of Health of Iowa became interested in the problem of brucellosis and it made special efforts to study the individual cases that were reported. The study began in 1927 and has continued to the present day. This represents the most complete study undertaken in the United States. The first report issued by Jordan, Borts and Hardy in 1931 revealed some serious flaws in the old theory which postulates that brucellosis is only a milk-borne disease.

In considering the occupation of people suffering with brucellosis, it was found that packing-house workers had the highest rate of infection. Second, came the male farm workers with a rate only one-tenth as great. Then came the female farm workers with a rate only one-fortieth of the packing house workers. In other sections of the population taken as a whole, the rate is one forty-fifth of the highest rate.

Before proceeding any further into an analysis of these rates, it must be pointed out that in the cities of the United States, the greater portion of the population drinks milk which has been pasteurized and has been rendered harmless as far as brucellosis is concerned. Also it must be noted that most of the packing-houses in the United States are located in cities. Therefore, it is obvious that the packing-house workers in Iowa who were sick with brucellosis got their illness not from milk but from some other source.

The only other known common source of human infection is the infected farm animal. Some people are inclined to dismiss this as a special source and therefore one on which epidemiological conclusions should not be made. To answer them one may simply point to the difference in disease rates between male and female farm workers. The rate among male farm workers is four times as great as the rate among female farm workers. Since the majority of farm workers both male and female drink raw milk one would expect that the brucellosis morbidity rates in both sexes would be the same, but they are not. The only explanation of this discrepancy is the fact that in Iowa, it is the male farm worker who takes care of the animals while the female farm worker does other tasks.

From this pioneer study, the belief that brucellosis may be a disease resulting from contact with infected animals and infected carcasses originated. Workers in other areas in the United States took different approaches to the same problem. In Indiana, agglutination surveys among different groups of people revealed different percentages of reactors depending on the occupation of the group. Among veterinarians, 50% were reactors. In rendering plants (fertilizer plants) 30% were reactors; slaughter-house workers showed 15%.

It is from such data that one is forced to the conclusion that direct physical contact with infectious material is a more dangerous health hazard than the ingestion of raw milk.

There are some workers in this field of epidemiology who insist that

each species of *Brucella* gives rise to peculiar problems. They maintain that a predominance of *Brucella abortus* infection among animals will result in an excessive number of milk-borne cases and that a predominance of *Brucella suis* among animals will give rise to the majority of contact cases.

An analysis of experience in different sections of the United States with different types of animal husbandry lends some support to this thesis.

Epidemiological investigations conducted in Utah in 1947 suggested that of the three species, *Brucella abortus* was the chief cause of human brucellosis. Through a serological survey it was determined that 2.3 percent of the population carried serum agglutinins for *Brucella*. The incidence of agglutinins was significantly higher in rural than in urban communities and in most instances was related to the amount of infection in cattle. The incidence of agglutinins was 2.5 percent in males and 2.1 percent in females. When the sex ratio of actually reported cases in this state was examined, this narrow male to female ratio was substantiated. It appears as though infected raw dairy products play a more significant role in the epidemiology of brucellosis in this state than in other states, as the incidence of infection in both sexes is almost equal.

The epidemiology of brucellosis in Arizona and the southwest has changed considerably with the development of a dairy industry needed to serve a growing human population. Thirty years ago the only occurrence of brucellosis reported was an occasional case among persons attending goat herds. With the increase of goat herd infection, the health hazard to people working with these animals increased. This became a widely known fact among agriculture workers and eventually it became very difficult to employ goat herd shepherds. The goat industry has declined in some areas due to the difficulty in attracting men to supervise the herds. The incidence of melitensis infection has declined accordingly, but the rate of brucellosis has remained at a high level due to the growth of the dairy industry and the number of family cows.

A recent survey of human brucellosis by the Arizona State Board of Health revealed a rate of 2.9% of agglutination reactors in the general population in Maricopa County and 0.5% in Pima County. The respective cattle reactor rates were 4.6% in Maricopa County and 2.3% in Pima County. The human rate is almost six times higher in Maricopa County than in Pima County while the cattle rate is only two times higher. A partial explanation is the number of family cows in Maricopa County which are infected and the close contact with such animals and consumption of their milk, cream, and cheese in a raw state.

The local physicians reported 118 cases between May 1945 and May 1947. Most of these cases are attributed to raw milk. An epidemiological study of these cases would be of real interest.

The contention that contact infections are important only where

there is a predominance of *B. suis* in the animal reservoir is refuted by the experience in Iowa. In the past two years more *Brucella abortus* has been isolated from human cases than *Brucella suis* and still the occupational rates reveal that handling animals appears to be more dangerous than ingesting raw milk. In Indiana where the dairy and swine industries are well balanced, the predominant organism is *Brucella abortus*. The incidence of disease in occupational groups (farmers, veterinarians, packing house workers) remains the same. In Connecticut there are almost no swine and *Brucella abortus* accounts for 96% of the human cases of brucellosis. Still the occupational differentials remain the same as previously noted.

It is important to point out that *Brucella melitensis* has been isolated from swine in Iowa and from cattle in Indiana, and that in both these states this organism is responsible for 8% of the human brucellosis. Public health authorities are closely watching the spread of *Brucella melitensis* in animals other than goats. Such spread would aggravate a situation that is already serious.

A study of the epidemiological data available on the 6,000 cases of brucellosis, reported in the U. S. in 1947, attributes the source of infection almost equally to ingestion of raw milk and dairy products, animal contact on the farm, and industrial exposure to animals and animal products. These figures cannot be accepted as completely accurate because of the irregularity in reporting cases which prevails in some areas. Available data point out very clearly that the control of human brucellosis is directly dependent on the eradication of the disease in animals.

This brings up the question of control of human brucellosis. It is well to speak of disease problems but our ultimate aim should be control and eradication. Since we know that cattle, swine, goats and sheep and possibly horses are reservoirs of infection, we must direct our attention to the control and eradication of the disease in these animals.

Man gets the disease either by the ingestion of contaminated milk and dairy products or by contact with infected animals. Hence methods of control must be applied at the point where we can readily interrupt the cycle of infection.

One obvious method that suggests itself is the proper pasteurization of all milk that is consumed as such or that is put into dairy products. To accomplish this end, some states such as Utah, Colorado and Michigan have laws which require that all milk, which is sold for drinking purposes, must be pasteurized. California requires the pasteurization of all cheese. All other states are striving toward this desirable goal. Individual farm families are urged to pasteurize their milk before using it. More and more families are availing themselves of simple techniques to make their milk supply safe.

Even though all the milk were pasteurized, it would still leave a large

source of brucellosis as an uncontrolled occupational hazard. To stamp out this hazard it is necessary to control the disease in the animal reservoir. In the U. S., there is a cooperative control program for bovine brucellosis, administered by the federal and state governments. Under this program which was put into practice in 1936, the percentage of infection has been cut in half. There is one state, North Carolina, which has reduced its cattle infection to less than one per cent and is considered free of the bovine disease. In all, about 20% of the area of the U. S. is thought to be free of brucellosis in cattle. For this achievement and for the continued leadership in this good work, credit must be given to the Bureau of Animal Industry of the U. S. Department of Agriculture.

At present there is no official program for the control of brucellosis in other animals. However, various agriculture experiment stations are suggesting methods by which brucellosis in swine may be controlled.

It is generally agreed that so long as brucellosis occurs in animals, it will occur in man, and the surest way to eliminate this disease as a public health problem is to eradicate the disease in animals.

In the U. S. it is felt that the double attack offers great possibilities to rapid success. The public health authorities promote the use of properly pasteurized milk and milk products while the veterinary authorities attack the disease in its animal reservoir. By such concerted effort on the part of all concerned, including the animal owners, we are very hopeful that we will rid ourselves of brucellosis.

EPIDEMIOLOGÍA DE LA BRUCELOSIS EN ESTADOS UNIDOS

(Sumario)

David Bruce estudia la etiología de la fiebre ondulante y aisló un organismo gram negativo que llamó *Micrococcus melitensis*, hallazgo que constituye la base de nuestros conocimientos sobre esa enfermedad. Zamit contribuyó el hecho básico epidemiológico, de que la fiebre ondulante en Malta procede de la leche; Bang y Stribolt describieron la causa del aborto infeccioso en las vacas como *B. abortus*, pero la relación de este microorganismo con el *Micrococcus melitensis* no fué sospechada hasta los estudios clásicos de Evans en que demostró la relación de los dos y sugirió que la *B. abortus* podría producir infección humana. Kennedy en 1914 había observado que la fiebre ondulante ocurría en personas que no habían salido de las Islas Británicas. Trauma había descubierto anteriormente la causa del aborto infeccioso en los cerdos, que denominó *B. suis*. De esta manera los trabajadores contaban con un conocimiento básico, después de los estudios clásicos de la Srta. Evans, sobre la relación de dicho organismo en el problema general; la relación de la leche con la infección, y la sospecha de que *B. abortus* y *B. suis* podrían causar infección humana. El descubrimiento de Keefer (1914) del primer caso de infección conocido en Estados Unidos confirmó lo que se sospechaba anteriormente. Con el conocimiento más amplio de la enfermedad, los casos denunciados en Estados Unidos han aumentado de 60 en 1927 a más de 6,000 en 1947. Para eliminar un tanto la confusión en la nomenclatura de dicho microorganismo en esta enfermedad,

K. F. Meyer sugirió que se clasificaran los mismos como *Brucela* (en honor a David Bruce). Este sistema de nomenclatura ha sido adoptado universalmente. Los tres microorganismos con los que tratamos más frecuentemente son *Brucela melitensis*, *Brucela suis* y *Brucela abortus*.

Habiendo establecido los antecedentes históricos de la enfermedad, el A. generaliza la experiencia obtenida. Desde el punto de vista británico se creyó que la fiebre ondulante se propaga por ingestión de leche contaminada de brucelas virulentas. El Departamento de Salubridad del Estado de Iowa interesó en el problema de la brucelosis y, en 1927, empezó un estudio de los casos individuales denunciados que continúa hasta la fecha, considerándose como uno de los más completos llevados a cabo en Estados Unidos. El primer informe presentado por Jordan, Borts y Hardy en 1931 reveló serias imperfecciones en la antigua teoría que postula que la brucelosis es sólo una enfermedad transmitida por la leche.

Trabajadores en otras regiones de Estados Unidos atacaron el mismo problema de diferentes maneras. En Indiana, estudios de aglutinación en diferentes grupos de personas revelaron diferentes porcentajes de reactivos, dependiendo de la ocupación específica del grupo. Entre los veterinarios, el 50% resultó positivo; en trabajadores en fábricas de abono, el 30%; y en los trabajadores en mataderos el 15%. Estos datos nos llevan a la conclusión de que el contacto físico directo con material infectado, es más peligroso que la ingestión de leche cruda. Algunos epidemiólogos insisten en que un aumento de la infección de *Brucela abortus* entre los animales resultará en una excesiva cantidad de casos originados por la leche y que un predominio de *Brucela suis* entre los animales dará origen a la mayor parte de los casos de contagio. Un análisis de la experiencia en diferentes secciones de Estados Unidos con diversos tipos de crianza de animales refuerza esta tesis. Investigaciones epidemiológicas llevadas a cabo en Utah en 1947, indicaron que de las tres especies, la *Brucela abortus* era la causa principal de la brucelosis humana. Mediante un estudio serológico se determinó que el 2.3% de la población poseía aglutininas para brucelas. La incidencia de aglutininas fué mucho más alta en las zonas rurales que en colectividades urbanas, y en la mayoría de los casos se relacionaba con la proporción de infección en el ganado.

La epidemiología de la brucelosis en Arizona y el suroeste ha cambiado considerablemente con el desarrollo de la industria lechera para abastecer el creciente número de habitantes. Hace treinta años los únicos casos de brucelosis denunciados eran entre los pastores que cuidaban de las cabras. La incidencia *melitensis* ha disminuído, pero el índice de brucelosis ha permanecido a un alto nivel debido al incremento de la industria lechera y a la cantidad de vacas de propiedad particular.

Un estudio de la información epidemiológica obtenida en 6,000 casos de brucelosis, denunciados en Estados Unidos en 1947, atribuye la causa de infección, casi por igual, a la ingestión de leche cruda y productos lácteos, al contacto con los animales en la granja, y a la exposición industrial a los animales y productos animales. Como toda esta información revela que los vacunos, cerdos, cabras y carneros, y posiblemente caballos, son reservorios de la infección, débese dedicar toda atención al control y erradicación de la enfermedad en estos animales.
