Again and again it has been discovered that animals in nature and those subsequently domesticated are a potent source of human illness and death. Ever since man's existence, he has been brought into intimate relationship with the "living" environment. In all probability, the majority of specifically human infectious diseases have evolved during the past 10,000 years through progressive adaptation of parasites abundant in animal or arthropod species. In many of the standard human diseases, the dynamic inter-relationship has advanced so far that the origin of the parasite cannot be traced to the previous host. On the other hand, at least 75 diseases of domestic and wild animals are known to be of potential public health significance. Certain facts deserve some consideration:

(1) Infections and diseases of highly organized mammals not only affect the health of man, but through their serious economic effects, they injure his welfare. Financial investment in animals is large; millions of citizens depend upon the breeding and raising of farm animals as their means of livelihood. These citizens are profoundly affected by the toll of animals taken by disease. Human health is greatly influenced by such foods as meat, milk, butter and cheese, and a considerable part of the cost of these relatively expensive foods is related to disease losses. Some progress has been made through education of the farmer concerning the economic losses, but he remains unaware of the health hazards of having infected livestock on his premises. In nearly every communicable disease, public health efforts have lowered morbidity and mortality. The only diseases in which a noteworthy record has not been achieved are those of animal origin. Every health worker has a share in the economic and educational problems created by the diseases of domesticated animals.

(2) A generous majority of infections of mammals are chronic, and exhibit an outstanding tendency to remain latent or subclinical. The apparently healthy, though infected animal—a carrier or shedder—bears an epidemiologic relationship with the single or group infections of man. Early acute, but mild, and atypical stages of the animal disease may be equally dangerous.

(3) Human infections may serve as sentinels or indicators of an extra-human reservoir. In recent years, far-reaching surveys of the animal kingdom involving the ecology of mammalian, avian or arthropod carriers and vectors have either disclosed or at least suggested totally...
unexpected situations. On the other hand, a human disease may be identified after the animal reservoir is discovered.

(4) When man becomes the host of an animal infective agent, the infection chain usually ends blindly and human-to-human infections, are rare, but not impossible. They have occurred, for instance, in psittacosis and bovine tuberculosis, but this is not the rule.

(5) The clinical and anatomical character of the disease in man is quite similar to that in animals. A change in host apparently fails to alter the principal diagnostic signs, provided the portal of entry of the infective agent is the same.

(6) The control by eradication appears to be easy in some, is more difficult in others, and when wild rodents, monkeys and birds act as reservoirs, it is impossible. By destroying the infected animal, noteworthy successes have been achieved. Whenever the principle of destroying the animal host is impractical and too costly, regular immunization of exposed livestock may prove effective. Diminution of dense rodent and flea populations with newer rodenticides and insecticides may eliminate endemic typhus and plague. Measures directed against the arthropod vector and the use of protective vaccines for the exposed human population give some assurance that serious epidemics may be averted. In the face of vast reservoirs of disease, the hope of wiping them out completely becomes untenable, but the means of controlling their epidemic spread have been vastly improved.

It would be profitable to review several of the infections listed in the lantern slides, but since the time is limited, it has been suggested that the problem of caprine brucellosis and its control be considered.

**Brucellosis Due to Brucella Melitensis**

Since the infections caused by one representative of the *Brucella* group—*Brucella melitensis*—are relatively common in the United States-Mexico border states, it is only proper to attempt a brief summary of the present-day knowledge. This is particularly indicated in view of the fact that plans for the control and eradication of brucellosis in goats has received little critical appraisal. Reports from Mexico City indicate that at least 95 per cent of the cases of brucellosis in Mexico City are of caprine origin, most likely due to cheese and butter prepared with goats' milk imported from neighboring states (Castañeda et al., 1942). In order to determine the epidemiology of human brucellosis, the natural history or the ecology of the infection in the animal reservoir must be understood.

**Brucella Infection in Goats.**—Knowledge concerning caprine brucellosis is largely based on observations collected in the century-old endemic foci on the Island of Malta, in North Africa and in France (Taylor et al., 1938) and to a minor extent in the Southwest of the United States (Meyer and Eddie, 1935) and Colorado (Stiles, 1945). In sample surveys of herds of goats in Arizona, as high as 16 per cent of the animals
gave positive agglutination reactions in a dilution of 1:80 and higher. In 2 (8 per cent) of 25 blood specimens from a large herd in the Guadalupe Mountains, the complement-fixation titers were 1:160+++ to 1:320+++; similar ratios prevail in southwest Utah. In Colorado, the sera of 14,339 goats from 131 herds were tested and the titers of 1,220 (8.5 per cent) were 125+++ and higher.

These facts deserve consideration in view of the newly created interest in Brucella melitensis infection in regions remote from goat-breeding areas. The extent of the infection may not be reflected even in these reported incidences, because it is not unlikely that the agglutination test fails to detect all the infections among the tested goats.

Irrespective of the many epoch-making observations and studies on the nature of the Brucella infections of goats, knowledge of its ecology and pathogenesis is based on information concerning less than 50 animals (Basset-Smith, 1923; Eyre, 1925; Burnet and Anderson, 1924). Although the Report of the Commission for the Investigation of Mediterranean Fever (1906, part IV, p. 47) states: "Pregnancy goes on uninterrupted in infected goats; miscarriage was reported only in one instance," it is now recognized that in the highly susceptible Maltese goat, the most apparent clinical symptom of Brucella melitensis infection is abortion.

In acute infection, which can be readily induced by injection, through the conjunctival sac or by the oral route, pyrexia occurs, the animal loses weight, his head droops and his coat becomes rough and in some cases there is diarrhea (Polding, 1939). Bacteremia is usually present for a month or more, although the serum may give no agglutination reactions. Goats discharging Brucella can infect exposed goats one week after inoculation. The serum response of nonpregnant goats infected by contact is slight and lasts for only a short period. While the majority of goats cease to be dangerous spreaders within 5 months of the termination of the pregnancy, localization of Brucella melitensis in the regional lymph nodes of the genital and mammary tracts continues for years. In bucks, localization in the form of orchitis has been reported. Second pregnancies may cause no exacerbation of the disease, but Brucella melitensis may be discovered in vaginal secretions and in milk (Meyer and Eddie, 1935).

During the acute phase of the infection, Brucella melitensis may be isolated from the blood continuously or intermittently from the milk. According to recent studies, elimination of the organism in the urine plays a very subordinate role (Taylor and Hazemann, 1932; Polding, 1939). Large numbers of Brucella melitensis may be discharged in milk; infected goat's milk may contain as many as 500,000 bacilli per milliliter. As a rule, the number of colonies exceeds 600 per milliliter during the first few months after infection, but as the specific mastitis begins to alter the secretion, the colonies drop to less than 10. It is generally recog-
nized that apparently healthy chronic carriers may shed irregularly and with frequent intermission an enormous number of these organisms. Kidding, particularly during the cold season, favors dissemination of highly infected genital discharges. Goat kids are highly resistant for at least 2 months after birth, despite the ingestion or contact with an enormous number of *Brucella melitensis*. The ability to recover from an infection is directly linked with the age of the goat; the younger the animal, the greater the likelihood of complete recovery. Scattered observations concerning brucellosis in goat herds indicate that mild, abortive autosterilizing infections are not infrequent, and explain the peculiar stationary percentage of *Brucella* infections in the goats of Tunis, Island of Malta, which varies between 5 and 12 per cent.

**Veterinary control measures based on agglutination tests alone are inadequate.**—Repeated blood cultures, when agglutination and the allergic skin test have been recommended, but not evaluated on a large scale (Dubois and Sollier, 1931; Meyer and Eddie, 1935).

Goats are readily infected with *Brucella abortus* and *Br. suis* (Doyle, 1939); experiments have shown that the ingestion or injection of these strains fails to protect the goat against abortion, specific endometritis or metastatic localization in the lymph nodes when the animals are reinfected with *Brucella melitensis* (Meyer and Eddie, 1941).

**Epidemiology of human brucellosis due to Brucella melitensis.**—Every publication on brucellosis wrestles with the well-known fact that in the equation—man and *Brucella*—the reaction of the host to the infection is of variable severity. Latent or subclinical infection, natural resistance and such phrases are terms used in the description of the process in the host. Among the various factors which determine the establishment of the course of a *Brucella* infection in man, susceptibility or disposition to accept the parasite is an important factor. Although the ability of a *Brucella* organism to localize and to grow in the tissues of man depends on a multiplicity of complex as yet unknown factors, diverse observations during the years indicate that individual human beings accept the three species of *Brucella* to a variable degree. Some observations on *Brucella melitensis* are of interest in this connection:

Eight of a crew of 10 who drank goats' milk on the S. S. *Joshua Nicholson* fell ill with Malta fever. In a group of 15 collaborators, all equally exposed to a guinea pig breeding stock suffering from an extensive *Brucella melitensis* epidemic, 6 subclinical melitensis infections were recognized; culture of blood from one of the victims was positive and the agglutination titer was 1:10,000 (Zdrodowski et al., 1930). In Arizona, 400 to 500 people consumed goats' milk infected with *Brucella melitensis*, but only 35 manifested clinical infections (Lake, 1922). Five adults and a 9 year old boy consumed heavily infected goats' milk and 3 of the adults contracted clinical undulant fever; 7 of 14 men, continually ex-
posed during the kidding time to infected afterbirth of goats in a small town in Utah, yielded allergic and serologic reactions indicative of latent infection (Meyer and Eddie, 1935). In a group of 27 laboratory workers (16 males and 11 females) who came into intimate contact with melitensis cultures or infected tissue, 11 contracted clinical melitensis brucellosis, 3 had agglutinins in their blood, and 6 became strongly allergic to melitensis antigens. On a sheep farm in North Caucasus, 631 men and women were exposed to Brucella melitensis; 123 (19.5 per cent) gave serologic and allergic reactions indicative of infection; the infection rate was 77 per cent in veterinarians, 52.8 per cent in shepherders and 50 per cent in animal attendants (Popov, 1937). Finally, it has been reliably estimated that during 5 or 6 years, 14 per cent of the population over 15 years old in certain departments of France contracted undulant fever.

These observations indicate that the susceptibility or disposition of man to Brucella melitensis is around 50 to 85 per cent. Under severe exposure the infection index expressed in frank and abortive clinical attacks may be as high as 40 per cent, while the rate for latent infections may be slightly higher.

During the early part of 1930, the susceptibility of man to Brucella abortus was generally considered to be quite low, and the infection index was estimated at 1:100,000, while that for typhoid was given as between 1:13,000 and 1:20,000 (Fried, 1933; Zimmermann, 1935). Today it appears that Brucella abortus possesses a fairly high degree of infectivity, enabling at least temporary establishment in the tissues, but in only a small proportion of infected persons (3 to 5 per cent) are the conditions favorable for the production of clinically detectable disease. By contrast, Brucella melitensis and probably many strains of Brucella suis have not only a high infectivity (over 50 per cent), but also a high pathogenicity (as high as 40 per cent).

Control.—In view of these significant observations, preventive medicine and public health demand the ultimate eradication of the caprine Brucella infections. Specific requests for action became imperative during the Second World War when melitensis-infected goat cheese was widely distributed throughout the United States. Rather disconcerting is the association of hogs and cattle with Brucella melitensis strains (Balozet and Reynal, 1932; Parisot et al., 1932; Taylor and Hazemann, 1932; Meyer and Eddie, 1935; Damon and Fagan, 1947; Jordan and Borts, 1946; McCullough et al., 1949; Magoffin et al., 1949). Although the biology of these aberrant strains requires further intensive study, it is imperative that public health workers take cognizance of the important fact that highly infective strains of Brucella organisms may be disseminated in cows' milk.

It is to be expected that the public health control measures be carried out in a manner not detrimental to the economy of livestock owners.
The program, furthermore, must be planned and executed in order to assure permanency of the contemplated goal. Success is only assured provided the technical procedures to be employed in the eradication program are dependable. Reliable observations have shown that negative reactions obtained with blood sera never preclude with certainty the possibility that the goat is not infected and a potential shedder (Zammit and Debono, 1930; Dubois and Sollier, 1931; Meyer and Eddie, 1935). The standard serum agglutination test is doubtless adequate as a herd diagnostic procedure, but not reliable in determining the infection status of an individual goat. On the other hand, a limited number of comparative studies (Meyer and Eddie, 1935) have shown that the allergic skin tests with suspensions of Brucella melitensis are more dependable than serologic tests in detecting inapparent latent infections.

Unfortunately, comparative studies have not progressed far enough to warrant recommending the combined application of the serologic and allergic tests. However, the public health authorities should demand that goat milk dairies consist of animals with negative blood and skin tests. Finally, the United States-Mexico Public Health Association should recommend that the ecology of caprine brucellosis be made the subject of detailed studies in the areas in which it is prevalent, and that control measures be planned and tested to determine the most effective procedures to assure freedom from Brucella melitensis of products prepared from goats’ milk. It is probably unwise to adopt measures which proved effective in the cattle industry, without careful investigation.

REFERENCES


CONSIDERACIONES EPIDEMIOLÓGICAS SOBRE ENFERMEDADES
DE ANIMALES CON REFERENCIA ESPECIAL A LA
BRUCELOSIS CAPRINA (Sumario)

Hace historia el A. respecto al papel de los animales domésticos como fuente de parásitos, y expresa que por lo menos 75 enfermedades de animales domésticos y salvajes tienen significación potencial en la salud pública, y opina que los siguientes hechos merecen consideración: (1) La infección y enfermedad en los mamíferos no solamente afectan la salud del hombre, sino que tienen graves efectos en su economía, dado que millones de ciudadanos invierten grandes sumas en el fomento y crianza de ganado, como medio de vida y por lo tanto la pérdida de dichos animales les ocasiona graves quebrantos; a la vez, el precio de productos tales como la carne, la leche, la mantequilla y el queso se hallan afectados por la pérdida en el ganado. Se ha adelantado bastante en la educación del campesino, con respecto a las pérdidas económicas, pero tiene aun mucho que aprender sobre los peligros que representa tener ganado infectado.

(2) Con excepción de la viruela, la glosopeda y el muermo, las infecciones en los mamíferos suelen ser crónicas y muestran tendencia a permanecer latentes o en forma subclínica; existe relación epidemiológica entre el animal aparentemente sano, aunque infectado, (portador) y las infecciones individuales o múltiples del hombre.

(3) Las infecciones humanas pueden servir de alarma o indicar la existencia de un reservorio extra humano.

(4) El ciclo de infección termina al ser infectado el hombre puesto que la transmisión de hombre a hombre es rara, a excepción de la psitacosis y la tuberculosis bovina.

(5) Los caracteres clínico y anatómico de la enfermedad son muy semejantes en el hombre y en los animales, sin que el cambio de huésped altere las principales indicaciones diagnósticas siempre que el portal de entrada del agente infectivo sea igual.

(6) A veces resulta difícil o imposible el control por medio de la extirpación como sucede en los casos de roedores silvestres, monos y pájaros. Cuando no se puede utilizar ese medio, resulta efectiva la inmunización regular del ganado expuesto. Aunque no es posible eliminar por completo vastos reservorios, los medios de control de diseminación epidémica han mejorado considerablemente.

La brucelosis por Brucella melitensis es relativamente común en los estados fronterizos de México-Estados Unidos. Los informes de Ciudad México indican que por lo menos el 95% de los casos son de origen caprino, probablemente debido a queso y mantequilla preparados con leche de cabra importada de estados vecinos. En los estudios realizados en rebaños de cabras de Arizona hasta el 16% de los animales registraron reacción positiva de aglutinación en una dilución de 1:80 y más. En 2 de 25 especímenes de sangre de un rebaño en las montañas de Guadalupe, los títulos de fijación del complemento fueron 1:160 a 1:320; el mismo promedio prevaleció en el sudoeste de Utah; en Colorado, los sueros de 14,339 cabras de 131 rebaños los títulos de 1,220 fueron 1:25 y más. Aparte de los importantes estudios y observaciones sobre la brucelosis en las cabras, los conocimientos de su ecología y de su patogénesis están basados en información sobre menos de 50 animales. El informe de la Comisión para la investiga-
ción de la Fiebre Mediterránea expresa: "La preñez sigue sin interrupción en las cabras infectadas, registrándose sólo un caso de aborto", sin embargo ahora se reconoce que el síntoma más aparente de la infección de la Brucella melitensis es el aborto. La mayoría de las cabras cesan de ser portadores peligrosos cinco meses después de terminada la preñez, pero la localización de la Brucella melitensis en los nódulos linfáticos de los tractores genitales y mamarios continúa por años; en los machos se ha observado la localización en forma de orquitis. La leche caprina infectada puede tener hasta 500,000 bacilos, excediendo de 600 número de colonias por mililitro durante los primeros meses después de la infección.

Las medidas veterinarias de control basadas sólo en las pruebas de aglutinación son inadecuadas; se ha demostrado que la ingestión o la inyección con Brucella abortus o Brucella suis no protege a la cabra contra el aborto ni contra la endometritis específica ni contra la localización metastática en los nódulos linfáticos cuando el animal se reinfecta con Brucella melitensis.

Todas las publicaciones sobre brucelosis luchan con el hecho de que en la ecuación hombre-Brucella, la reacción del huésped a la infección es de gravedad variable, siendo factor importante en el establecimiento del curso de una infección con Brucella en el hombre, la susceptibilidad o inclinación para aceptar el parasito, habiéndose observado que el hombre acepta las tres especies de Brucella en grado variable.

Resulta interesante notar que ocho hombres de una tripulación de diez bebieron leche de cabra en el vapor SS. Joshua Nicholson, enfermando con fiebre de Malta; en un grupo de 15 colaboradores, todos igualmente expuestos a una estirpe de cobayos de cría que sufrieran una epidemia extensiva de Brucella melitensis, se reconocieron seis infecciones subclínicas de melitensis, el cultivo de sangre de una de las víctimas fué positivo y el título de aglutinación fué 1:10,000; en Arizona manifestaron infecciones clínicas 35 personas en un total de unas 400 que habían consumido leche de cabra infectada con Brucella melitensis; de un grupo de 27 asistentes en el laboratorio que llegaron a un contacto íntimo con los cultivos de melitensis o con tejido infectado, once contrajeron Brucelosis melitensis clínica, tres tenían aglutininas en la sangre y seis llegaron a ser sumamente alérgicos a los antígenos de la melitensis. A principios de 1930 se consideró bastante baja la susceptibilidad del hombre a la Brucella abortus, estimándose el índice de infección a 1:100,000.

Observaciones dignas de confianza han demostrado que las reacciones negativas obtenidas de los sueros de sangre nunca excluyen con seguridad la posibilidad de que la cabra esté infectada y sea un portador potencial. La prueba de aglutinación del suero es adecuada como procedimiento de diagnóstico de un rebaño, pero no así para determinar el estado de infección individual de la cabra.

Sería de desear que la Asociación Fronteriza México-Estadounidense de Salubridad recomendara la ecología de la brucelosis caprina como materia de estudios detallados en las zonas donde prevalece y que las medidas de control sean planeadas y probadas para determinar los procedimientos más efectivos para asegurar que los productos preparados con leche de cabra se hallen libres de Brucella melitensis. Es necesario hacer una investigación cuidadosa antes de adoptar las medidas que resulte efectivas en el ganado vacuno.