FOOT AND MOUTH DISEASE WITH SPECIAL
REFERENCE TO ITS COMMUNICABILITY
TO MAN

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The subject of foot-and-mouth disease would ordinarily not receive a
place on the program of a meeting of your Association, but with the
introduction of the disease into the cattle of Mexico last winter it is only
natural that officials, physicians and others concerned with public health
should desire to discuss foot-and-mouth disease, especially as it relates
to the health of man.

The press and the radio have carried stories concerning the presence
of foot-and-mouth disease in Mexico, the probable mode of its intro-
duction, the areas involved, and the methods agreed upon by officials
and advisers from both countries to be used in combating this outbreak.
In general, these reports have been in accordance with the known facts
at that time. I do not know whether or not any reference to these
phases will be made by other speakers at this meeting, but your Chair-
man felt it would be desirable that I should briefly present this back-
ground.

From official sources, it is learned that the disease made its appear-
ance in the Mexican State of Veracruz on or about November 1, 1946,
on a ranch where a second shipment of Brazilian Zebu bulls had landed.
The Brazilian animals in an earlier shipment of October, 1945 to Mexico
apparently were not affected with the disease.

At present, there is an embargo against the transportation of cattle,
other ruminants and swine from Mexico into the United States. Foot-
and-mouth disease has spread to the west and south and involves fourteen
states, also the Federal district, but is still 300 miles from the United
States border, as was officially reported from Washington on April 11.
This report also stated that, because of spread of the disease, a moderate
enlargement of the quarantined areas set forth in the Washington News
Release of March 11 had been deemed necessary.

Upon the recommendation of the Mexican-United States Agriculture
Commission an administrative board was appointed by the Secretaries
of Agriculture of the two countries. This board is headed by a director
(Mexican), co-director (American) and six other members, three from
each country. The board has been determining the policies and pro-
cedures on the foot-and-mouth disease campaign in Mexico. In general,
the plan agreed upon is a modified "stamping out" method, consisting
of slaughter and burial or burning of animals in any new infected herds,
cleaning and disinfection, and the orderly and gradual slaughter for food of all the animals in herds which have apparently recovered.

There is now available 9 million dollars, as the United States’ share in the cost for the remainder of fiscal year, ending June 30, 1947. This sum is being matched by the Mexican government with a similar amount. It is planned to have about a hundred American veterinarians and inspectors in the field.

In the United States and a few other countries where foot-and-mouth disease is not endemic, it is feared as a very serious livestock malady. In the United States especially, extreme precautions are taken to prevent its introduction, and rigid measures are used to eradicate it in the event of outbreaks. These procedures, which include the so-called “Stamping out or Slaughter method,” are accepted as necessary by the officials entrusted with the control and eradication of infectious diseases of animals, and they receive the full support of most livestock owners and the public in general. As a result the United States has enjoyed long intervals of freedom from this malady. There is no indication at present that such stand will be abandoned. In cooperation with the Mexican Government, similar methods will be used. Every effort will be made to prevent further spread, and to eventually stamp out the disease in that country.

Characteristics.—Foot-and-mouth disease, also known as aphthous fever, is an acute febrile and highly contagious disease. Practically all cloven-footed animals, especially cattle, hogs, sheep and goats, are susceptible to this disease. Deer were affected in California in 1924 and 1925, and other wild cloven-footed animals have been found in other countries to be affected at times. Other animals and man very rarely contract the disease.

This disease is caused, as you know, by a filtrable virus and is characterized in animals by the formation of vesicles on the mucous membranes covering the tongue, lips, gums, palate or other lining membranes of the mouth; on the skin between and above the claws of the feet, and on the teats and udder. Any one or several of these locations may be involved. In hogs, lesions may also occur on and above the snout and, in rare cases, the muzzles of cattle are affected. In sheep, goats, and deer, the feet are the most common site of the vesicle formation. As a rule, the vesicles rupture shortly, leaving the raw, eroded surfaces. Foot lesions cause severe lameness, mouth lesions, profuse salivation, especially in cattle. In none of these lesions is there a pustular stage.

The lesions of foot-and-mouth disease heal rather rapidly, but, in some instances, those on the feet may give rise to serious secondary bacterial infections. Before, during, and for a short time after the appearance of lesions, there is a striking rise in temperature, consider-
able loss of flesh and, in cows, a severe reduction in the milk flow. The mortality, as a rule, is low and is mostly from secondary infections. There may be abortions and the loss in calves is sometimes very high. The deterioration of the animals causes far greater loss than the actual mortality.

In man the disease is also characterized as an acute febrile malady, with vesicle formation principally on the hands and the feet, and more rarely in the mouth. This phase will be discussed in more detail.

Incidence.—The disease is endemic in animals, especially in cattle and swine, in most countries of the world. It is not endemic in North America, nor in Australia and New Zealand. Although it is now present in Mexico, it is hoped that it will soon be eradicated from there, and that country has been free from it since 1929. It has never been reported here in man.

Susceptibility of other animals.—In Europe this disease has been reported several times in the horse and mule, but no proven cases have thus far been recorded. Waldmann in Germany, Vallée in France, as well as The Foot-and-Mouth Disease Commission of the U. S. Department of Agriculture working in Europe and others were unsuccessful in 100 per cent of the attempts to infect horses with the disease. In the outbreaks of foot-and-mouth disease in the U. S. many horses were naturally exposed to the disease and in no instance was there evidence of infection. Many unproved and very few proved cases in dogs, cats, and rats have been reported, but experimental results on these animals have been erratic, and these animals are considered as not very susceptible. The guinea-pig is the most susceptible small laboratory experimental animal and is most suitable for inoculation. Natural infection has not been observed in them, and the disease is not ordinarily transmitted from guinea-pig to guinea-pig, even in very close confinement. Rabbits are much less susceptible. Hedgehogs have been experimentally infected with the disease, but unlike guinea-pigs, hedgehogs readily transmit the disease to each other by contact. They have contracted it when experimentally placed in contact with infected cattle, and experimentally cattle became infected when exposed by contact to diseased hedgehogs.

The virus.—Loeffler and Frosch in 1897 demonstrated the filtrability of the causative agent of the disease. The size of the virus has been
estimated to be between 8 and 20 milli-microns, which places it among
the most minute of these ultramicroscopic infective agents. The virus
is contained in the blood before and for a few days after the eruption of
vesicles, and is most concentrated and most easily accessible in the fluid
and coverings of the vesicles. It may also be found in the saliva, milk,
urine and other secretions.

The conditions under which the materials harboring the virus are
found outside the animal body determine its viability and its infectivity.
Such conditions are variable and at this time we can only speak in gen-
eral terms and on a few of them.

When kept at a temperature of 37° C., the virus loses its virulence in
from 24 to 48 hours, but at room temperature, it retains its virulence
somewhat longer. At 55° C., the virus in defibrinated blood is rendered
inactive in 20 minutes, and in vesicular contents in 5 minutes at 60° C.
In the ice box, at temperatures between 4° and 7° C., the virus has been
kept alive for many months, especially when contained in properly
buffered (pH 7.5–7.6) 50 per cent glycerin solution. When rapidly
dried, particularly at temperatures below the freezing point, 0° C., and
under vacuum (lyophilization), it remains active for several years.

That the virus does not always die rapidly after leaving an animal is
suggested by the fact that foot-and-mouth disease has appeared on
premises where re-stocking had not taken place until 30 to 60 days after
the slaughter of infected herds. Definite evidence is available to show
that in one instance in the United States, the virus persisted in the field
for 345 days. In the living animal, the infected tissues and fluids fre-
quently lose demonstrable infectivity within a week. However, vesicle
coverings were found by the British Foot-and-Mouth Disease Research
Committee to be infective for at least 15 weeks when placed in hay and
for 20 weeks in bran after removal from the animal. It was also found
that in carcasses of cattle and hogs that had been slaughtered in the
febrile stage of the disease and dressed, chilled, or frozen for market,
the virus was still active in the blood from 30 to 40 days, and in the bone-
marrow for 76 days and in one instance even as long as 100 days (end
point not reached).

It is of the utmost significance in the control of outbreaks, therefore,
to regard the virus as rather resistant. Furthermore, it is possible that
a portion of the covering of a freshly ruptured vesicle may become
detached, and if such a fragment finds suitable conditions outside the
animal, the virus in it may be active for a considerable time.

Ordinary chemical disinfectant agents, such as phenol, bichloride of
mercury, cresols, hydrogen peroxide, chlorine, iodine, chloroform, ace-
tone and alcohol in the concentrations generally recommended for de-
struction of bacteria, do not destroy this virus rapidly. In 1925, the
American Commission demonstrated that sodium hydroxide in a one per cent solution destroyed the virus within one minute. This agent, conveniently and cheaply available in the form of lye, has now been adopted by the United States and many European governments for use whenever disinfection is needed in combating foot-and-mouth or similar diseases. In practice, a two per cent solution is used.

There are three immunologically different types of virus (A, O, and C), which, however, produce experimental and natural disease pictures that are clinically indistinguishable. Intermediate types have been encountered, which especially at the time of recovery from animal isolation have not fitted into any of the three recognized types, but upon further experimentation most of these atypical types have usually been properly classified within these types.

**Modes of Spread.**—The commonest agent in the spread of foot-and-mouth disease is, of course, the infected animal itself. As already stated, the virus is contained in the fluid and the coverings of the vesicles, as well as in the blood during the febrile stage of the disease. At this time, the saliva, urine, milk and probably other secretions and excretions are also infective.

The active virus leaving the infected animal contaminates its surroundings and can be carried mechanically by living beings—people, horses, and dogs, for example—or on litter, feed, stable, utensils and other objects, for considerable time. When contaminated material comes in contact with susceptible animals, the latter can readily become infected. Under conditions favoring the persistence of the virus outside the animal body, the danger of spreading infection is considerable. In view of experimental evidence, it is probable that infected animals spread the virus most actively in the early stages of the disease, and they may do so even before any lesions are observable.

Investigators and livestock sanitary officials, with only a few exceptions, believe that virus carriers exist, and that such animals may harbor the virus for a long time after recovery. The percentage of carriers, however, is believed to be small. The field evidence presented to support the existence of carriers is very strong, and numerous instances are reported in which the disease occurred in clean herds shortly after the addition to the herd of animals that had previously had foot-and-mouth disease; other sources of infection were satisfactorily eliminated. As long as eight months—and indeed in several instances more than a year—after recovery, animals were held responsible for causing outbreaks of the disease.

Where is this virus in animals that makes them carriers? It was thought that it is present in the hoof of recovered cases, or on the skin. This was only rarely experimentally proven. It is now believed as
indicated by experiments of Waldmann and his co-workers that the virus is present in low concentrations in blood and especially in the urine in a small percentage of recovered animals for variable periods of time—in one case as long as 246 days after onset of disease the virus was found in the urine of a cow.

Milk, meat, and the raw by-products of slaughter of infected animals may also be instrumental in distributing the virus. The British Foot-and-Mouth Disease Research Committee found that when the carcasses of experimentally inoculated guinea-pigs were bled out and kept at a temperature of 2° to 7° C. (slightly above freezing) the blood remaining in tissues around the throat was virulent after 21 days, while the bone marrow contained active virus for periods of 21 to 87 days. In another case the bone marrow was found to contain active virus for periods up to 96 days.

In experiments with hogs slaughtered during the febrile stage of the disease, active virus was found after 42 days in the bone marrow of carcasses whether they had been kept at chilling temperature or treated by dry or wet salt processes. In cattle and hog carcasses kept at freezing temperature, active virus was found in the bone marrow for 76 days.

The examples mentioned earlier explain how meat scraps, bone, and other parts from infected animals, when included in garbage or in butcher shop or slaughterhouse scraps, can be a source of infection in hogs. In fact, several foot-and-mouth disease outbreaks in the United States were traced to hogs which had been fed household, restaurant, institutional, or other garbage that could have contained meat from countries where the disease is endemic.

Human beings are next in importance to infected animals and animal products as agents responsible for the spread of the disease. It is generally believed that human beings convey the virus mechanically, on the clothing or person.

Immunization.—For many years, attempts have been made to develop an immunizing agent against foot-and-mouth disease that would be effective without producing the disease. A formalin-treated virus is now being manufactured and used in various parts of the world where the disease is endemic, and the vaccine appears to be of considerable aid in controlling the spread and in reducing the undesirable effect of the disease. However, in countries, like England, where the vaccine can readily be made, the slaughter method is still preferred, even though that country is constantly exposed to the disease. Apparently, for some adequately good reason, the American-Mexican Commission, studying the disease in Mexico at present, has thus far not included vaccination in the recommendations that have come to the writer's attention. In fact, a recent report item states that neither vaccine nor hyperimmune serum are to be used in Mexico at this time.
Methods of Control and Eradication.—Three methods are now in general use in the control and eradication of foot-and-mouth disease: (1) The stamping out, or slaughter method, which has been used in the United States and England and at various times in other countries; (2) the quarantine procedure, with or without vaccination, as used in most European countries; (3) slaughter and vaccination as now used to some extent in Switzerland. Which one of these methods is adopted depends upon prevailing conditions.

The slaughter method is no doubt economically more practicable in the United States than in some other countries. Many European countries, however, have laws and regulations providing for the slaughter of animals affected with foot-and-mouth disease. These regulations can be put into effect whenever those in control believe that this action will prevent the extension of the disease.

The effectiveness of the slaughter method depends upon three principal procedures.

(1) The slaughter and proper disposal of animals remove at once the greatest source of active virus and avoid the possibility of having carriers remain alive. The slaughter and burial are carried out as rapidly after diagnosis as possible. Frequently disposal has been accomplished within 18 hours after the report of infection.

(2) The thorough cleaning and disinfection of the premises and of materials possibly contaminated with virus remove and destroy the greater portion of whatever virus may remain active after proper burial or burning of slaughtered carcasses.

(3) Test animals, including cattle and hogs, are allowed to feed and graze where they will come in contact with all parts of the premises and objects which might have been contaminated with foot-and-mouth virus. If any virus has escaped the cleaning and disinfecting processes, the test animals should reveal it by contracting the disease.

Foot-and-Mouth Disease in Man.—In man, the disease is extremely rare despite his close contact with infected animals in those countries where it appears and in the institutes where it is being studied. Actual attempts to infect man by direct injection of foot-and-mouth disease virus by Lebailly, Nicolle and Galozet, Kling and Hojor, Hernansson and Magnusson, Waldmann and others have been uniformly unsuccessful. Even in cases where man is infected, attempts to transmit the disease to other human beings have been unsuccessful, even by inoculation, as it was demonstrated in recent work in Sweden.

Motas of Roumania, and Thorshaug and Magnusson of Norway found no evidence of foot-and-mouth disease in many thousand children and adults who received smallpox vaccine which was proved by inoculation of cattle and swine to contain foot-and-mouth disease virus. In the
1908 outbreak of Foot-and-Mouth disease in the United States it was definitely proven that an imported Japanese strain of vaccinia was responsible for the introduction of the disease into this country, but no cases of foot-and-mouth disease in humans were reported despite the extensive use of the smallpox vaccine. The literature, however, reports many cases of foot-and-mouth disease in man, but, in most of them, this diagnosis can and should be questioned. The extremely high resistance of human beings to foot-and-mouth disease was impressed upon your speaker in the 1924 outbreak in California, when the disease was first discovered in a dairy of approximately 200 milking cows—teat and udder lesions were plentiful, and although the milk was consumed in the raw state for at least two days by patients and attendants in a children's hospital, no case of foot-and-mouth disease or foot-and-mouth like affection was found despite the explicit search for symptoms. There are, however, human cases of the disease as proved by guinea-pig and other animal inoculations and by the presence of immune bodies in serums of recovered human cases. Pancera, Gerlach, Trautwein, Flaum, Magnusson, and others have unquestionably established the existence of foot-and-mouth disease infection in man, although such cases are very few. Altogether the literature contains not more than twenty or twenty-five proven cases.

The period of incubation in man usually is from 2 to 5 days, but it may be longer. The disease may be ushered in by general ill feeling, fever, headache which is sometimes severe enough to put the patient to bed. Vesicles form on the skin of the palm of the hand, on the sole of the foot, on and between the fingers and toes and on the ungual folds around the nails. They are often preceded and accompanied by a burning sensation and by severe pain in the hands and feet. Vesicles on the mucous membranes of the mouth have been thus far less frequently reported. The localization of the lesions depends to a large extent upon the avenue of infection. The lesions may be found in one or more of these locations, and in cases reported from Sweden there was in some cases also a pharyngitis present, which manifested itself by soreness of the throat. Some observers of human cases have noted two phases of manifestation of the disease; first, eruption of the primary vesicle at point of entrance of infection, preceded and accompanied by fever, followed by the second phase in 24 or 48 hours or longer, a transient rise in temperature and the appearance of secondary vesicles. This is a characteristic of the disease observed in both naturally and experimentally infected animals.

The vesicles rupture and leave eroded surfaces which heal rapidly by scab formation, or dry up, and in either case are replaced by epithelium. As a rule, there is no scar formation if no secondary infection sets in. In man, as in animal, there is no pustular stage.
Histologically, there is a balloonization of the protoplasm of the epithelial cells, swelling and pycnosis of their nuclei, polymorphonuclear cell infiltration, some cell necrosis, separation of epithelial layers and an increase in sub-epithelial vascularity. The stratum germinativum and the stratum lucidum are involved. The former constitutes in part the base and the latter the most of the covering of the vesicle. Intranuclear inclusion bodies have been described, but further study is needed to establish the character and even the presence of abnormal intranuclear bodies in foot-and-mouth disease lesions.

In the differential diagnosis in man all the vesicular exanthemata of the mouth, feet, and hands must be considered. As already described, a pustular stage is not present. The history can help or mislead in the diagnosis. There can be no foot-and-mouth disease in man in areas where it is not present in animals, and close contact with infected animals is essential, although, in Gerlach's case his daughter was reported to have developed the disease from eating whipped cream and butter. Because foot-and-mouth disease is present in animals in the locality all vesicular eruptions in man must not be considered as being caused by foot-and-mouth disease. The intracutaneous injection of fluid or coverings of the vesicles not more than two days old into the hind foot pads of guinea pigs should, in positive cases, induce primary vesicles at the site of inoculation within 24 or 48 hours; sometimes, however, it takes a little longer for these vesicles to develop. These are followed, as a rule within 24 to 48 hours, or longer, by secondary vesicles on hairless surfaces of one or both front feet and, in some instances, on the tongue.

The viruses of herpes simplex and variola also produce lesions in guinea pigs, by intradermal inoculations, but here the lesions are more diffuse and edematous and have a tendency to become purulent and do not show secondary involvement. Some herpes viruses are neurotropic for guinea pigs, but foot-and-mouth disease virus is not so.

Even though one or more human cases may develop in a locality, from the public health point of view, this disease is of no great importance, even in those countries where it is endemic in animals. Transference of the disease from person to person has not been reported. Whenever a case is suspected, it should be referred to the health authorities, who, in turn would no doubt notify the proper livestock sanitary official. Working with foot-and-mouth disease in the United States is prohibited by federal law.

When one considers that thousands of people have been in contact with infected animals in various outbreaks in the many herds in the various countries and when many more thousands have consumed milk from such animals—and the number of proven cases are so few—we are bound to
come to the conclusion that man rarely becomes infected with foot-and-mouth disease despite the fact that his exposure to the virus of the disease is great in many countries.

LA FIEBRE AFTOSA Y SU TRANSMISIÓN AL HOMBRE (Sumario)

Esta enfermedad apareció en el Estado de Veracruz, México, hacia el 1° de noviembre de 1946, fecha en que se efectuó el desembarco de una partida de toros cebú, brasileños. En la actualidad los Estados Unidos han prohibido la importación en los Estados Unidos de ganado y rumiantes procedentes de México. Una Comisión Agrícola Mexicana-Estadounidense, acordó adoptar un método de control "exterminador," esto es, sacrificar y enterrar o incinerar los animales de cualquier manada cercana que se halle infectada. Los Estados Unidos han asignado la suma de $9,000,000.00 como contribución a dicha campaña. Describense a continuación las características de la enfermedad: fiebre aguda, enfermedad sumamente contagiosa, caracterizada por la aparición de vesículas en la membrana mucosa que cubre la lengua, labios, encías, paladar, la piel entre los pezones y la de las tetas y ubres. La mortalidad generalmente es baja, siendo de mayor consideración los estragos que hace entre los animales que el índice de mortalidad. La enfermedad no es endémica de Norte América a pesar de que existe ahora en México y han ocurrido ocho epidemias en los Estados Unidos. El organismo causante es un virus filtrable, dependiendo de las condiciones externas la viabilidad e infectividad del virus. Para fines de control debe considerarse el virus más bien como resistente, y es destruído rápidamente por medio de una solución de hidróxido de sodio (1%). Se han comprobado tres tipos de virus inmunológicamente diferentes y que clínicamente producen la misma enfermedad. Los medios de diseminación que se consideran más corrientes son la dispersión de líquido y pústulas de las vesículas, creyéndose que existen portadores, pero en un porcentaje pequeño. En varias partes del mundo se ha empleado el virus tratado con formalina, y parece también que la vacunación ayuda a combatir la enfermedad, pero el autor no tiene conocimiento de que la vacuna haya sido incluida entre las medidas de control acordadas por la Comisión Mexicana-Estadounidense. El sacrificio y enterramiento y la limpieza de los locales, así como el empleo de "animales de prueba" en locales que habían estado infectados anteriormente, son los procedimientos principales del método de "exterminación." La enfermedad es sumamente rara en el hombre, habiendo fracasado los experimentos para infectarlo por medio de la inyección directa del virus. Admite el A. que existen muchos casos en la literatura de infección en el hombre, pero esos diagnósticos resultan problemáticos. Clínicamente la enfermedad en el hombre es semejante a la del ganado, excepto que las lesiones de las palmas de las manos y las plantas de los pies son mucho más corrientes que las de la boca. No se ha comunicado en la propagación de la enfermedad de persona a persona, llegándose a la conclusión de que aunque el hombre se halla repetidamente expuesto, rara vez adquiere la enfermedad.

Vacunación.—Según Bernardo Porzoneanski (Acción Sindical, 17, agto. 1947) en el Uruguay solamente 1,000 personas reciben toxoide tetánico anualmente. En cambio reciben antitoxina tetánica preventiva durante el mismo período más de 15,000. Recomienda el A. una campaña intensiva de inmunización antitetánica.