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Disease of Domestic Animals and Human Welfare ¹.

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(Received December 1949.)

Introduction.

From the time when man began to domesticate animals, his welfare and his progress have depended to a very considerable degree on these animals for food and clothing, as beasts of burden, in the production of crops, and even for his physical protection. In temperate climates animals have been bred towards particular objectives, as, for example, horses for draught or racing, cattle for maximum meat or milk production, sheep and goats for meat, milk or wool, and poultry for egg-production or for their flesh. Although animal husbandry has encountered many difficulties, those of a genetical nature have been largely overcome. On the other hand, infectious and parasitic diseases of many kinds have become enzoötic and too frequently have developed into epizootics that have threatened to exterminate certain breeds of animals and to destroy entire industries. Moreover, a considerable number of these diseases are transmissible to man himself and from time to time have caused his death or at least have endangered his health. In addition, undesirable domestic animals like the black rat have capitalized on man's carelessness and have brought disease into his own abode.

Man's welfare is affected wherever there is loss of production in crops intended for human or animal consumption, wherever there is reduced productivity of domestic animals as a result of malnutrition or disease, and wherever there is a lowering of human standards due to famine and disease.

The problems encountered in human welfare in warm climates are frequently much more complicated than they are in temperate regions of the earth. In moist tropical areas vegetation is luxuriant, but it often lacks adequate amounts of vitamins and other consti-

¹ Read before the Division of Anthropology of the Seventh Pacific Science Congress held in New Zealand, February 1949.

tments essential for proper nutrition. In dry hot climates grains and forage crops cannot be grown except during brief periods of rainfall or in areas where irrigation is developed. Native breeds of domestic animals are able to subsist on a minimum of food, but they are relatively inefficient and uneconomical compared with temperate zone standards.

Because of the continued increase in the human population, because of the immediate need for supplementing the amount of available food for human consumption, and because of the importance of raising the standards of living and of health for a large portion of mankind, it may be useful to survey briefly the relationship between disease in domestic animals and human welfare, with the hope of obtaining information which will suggest improvement in the situation.

Disease in Domestic Animals and Food Loss.

In reviewing this extensive subject, it is necessary first of all to define the term "disease". The word literally means "lack of ease or comfort". Thus, disease may be considered as any state which departs from the optimum functioning of the organism, whether it be from structural deformity, organic disease, malnutrition, infectious processes or any combination of these causative factors. To these one may add poor breeding or inexperienced selection of stock, and failure of introduced races or strains to become acclimatized to new environments. In nature the survival of a species depends on its ability to compete; in animals under domestication man imposes artificial barriers which may improve the stock or may allow it to deteriorate.

Departments of Animal Husbandry in Agricultural Experiment Stations or Veterinary Research Institutes in practically every country on the earth have as their main objectives the development of domestic animals best adapted to the needs of each country, their maximum usefulness to man, and, with practical experimental evidence, the instruction of farmers of the region as to how they can produce and utilize these animals profitably. Native breeds are frequently inferior in many respects to highly bred strains which are imported, but the former are usually more resistant to heat, excessive humidity or drought and restricted pasturage, as well as to infectious and parasitic diseases of the region. If superior breeds are introduced at the most favorable time of the year and are bred with native stock, by careful selection, by storing an adequate amount of fodder for the period when no grazing is available and by intelligent care of the animals, many of the desirable characteristics of both parent stocks may be

preserved. Thus, the interbreeding of Brahman and Holstein cattle has developed a hardy stock which is adapted both to dry and moist hot climates and produces meat and milk of high quality.

Nevertheless, domestic animals which otherwise are well adapted to man's needs frequently constitute an economic burden, because they are infected with a legion of pathogenic organisms. Doctor WILLIAM A. HAGAN, Dean of the Cornell University College of Agriculture, Ithaca, New York, has estimated (1947) that there is at least a one-billion-dollar loss each year in the United States in the output of meat, poultry and dairy products due to diseases of domestic animals. In Great Britain and Ireland it has been calculated (1944) that a 10 per cent loss in animals and animal products is sustained from this same cause. In other countries where exposure to disease is greater and control measures are less satisfactorily developed, the loss is proportionately greater. Yet it is these latter countries which urgently need more abundant supplies of animal proteins. The generalizations which have thus far been stated will become more apparent with a consideration of some of the more important specific types of disease caused by infectious and parasitic agents and of their effects on animal hosts.

Piroplasmiasis, babesiosis and heart-water fever in cattle, sheep and goats produce anemia and jaundice, resulting in loss of weight, in poor quality meat, in diminished milk production and greatly reduced fertility. Brucellosis in cattle causes an uncounted amount of abortion. Hoof-and-mouth disease in cattle in the Western Hemisphere from Argentina to the Rio Grande renders meat unsuitable for human consumption. Bovine tuberculosis is responsible for heavy losses in the quantity and quality of milk and beef. Surra in horses and mules throughout the warm countries of the world has greatly reduced the economic usefulness of these animals as beasts of burden. Coccidiosis in young poultry is responsible for a 12 to 20 per cent mortality.

When one considers the helminthic infections, he is confronted with a very large number of species of worms which parasitize domestic animals. Probably the most cosmopolitan are the roundworms. In the Federally-inspected slaughter houses in the United States one per cent of all swine are condemned because of icterus due to *Ascaris* invading and blocking the biliary passages. Another species of *Ascaris* (*Ascaridia galli*) causes 25 to 35 per cent mortality in young chickens. The deadly lancet hookworm of sheep (*Haemonchus contortus*), the hookworms, heartworms and *Spirocerca* of dogs, several genera of strongylate worms which infect horses, mules and burros, several species of *Trichostrongylus* which parasitize sheep, goats, cattle, pigs and camels, tapeworms (*Syngamus* spp.) of goats and chickens, and the trichina worm

(*Trichinella spiralis*) of hogs— all these are a tremendous drain on the health of domestic animals, and thus on their value to man.

Perhaps the most notorious helminth parasitizing sheep and goats is the liver fluke, *Fasciola hepatica*. This fluke occurs in practically all regions where sheep are raised. It causes extensive necrosis of the liver, the so-called "liver rot", with high mortality and serious loss in meat and wool production. Related flukes in cattle and caribao (*Fasciola gigantica*, *F. aegyptiaca* and *Fascioloides magna*), are responsible for great waste in meat, milk and hide production. In the United States, where liver fluke infections are much less serious than in China, Africa and Australia, the annual loss in dressed meats amounts to millions of pounds.

Tapeworms, likewise, take a heavy toll of domestic animals. In infected chickens 50 per cent extra food consumption is required compared with parasite-free chickens for each pound of added weight (i.e., 4.5 lbs. vs. 3.1 lbs. of grain). In horses, sheep and cattle tapeworms are a common nutritional burden, causing weakness, emaciation and inferior quality of the meat. Moreover, hydatid cyst in sheep, cattle and hogs is a major cause of death in enzoötic regions, while coenurosis, or "gid", in sheep is almost invariably fatal. Finally, cysticercosis in cattle and hogs damages the tenderest portions of the meat, greatly reducing its nutritional value and frequently rendering it unfit for human consumption.

Although the internal parasites of domestic animals are responsible for an estimated 25 per cent reduction in animal food available for man, an even greater array of external parasites preys on these animals.

In many tropical countries with rain forests, as, for example, Burma, Malaya, Ceylon, the Philippines, Borneo, Celebes, New Guinea, Java and Sumatra, omnipresent blood-sucking leeches attack domestic mammals and may even exsanguinate them.

There are many groups of arthropods which infest domestic animals. Myiasis-producing flies cause serious damage to the flesh and hides of horses, cattle and sheep. These include: the horse bots (*Gasterophilus* spp.); the cattle bots (*Hypoderma bovis* and *H. lineatum*); the sheep nasal bots (*Oestrus ovis* and *Rhinoestrus purpureus*); *Dermatobia hominis* of cattle in tropical regions of the Western Hemisphere, *Cochliomyia hominivorax* and *C. macellaria*, *Wohlfahrtia magnifica* and *W. vigil*, *Sarcophaga haemorrhoidalis* and several other species.

Lice infest hogs, cattle, caribao, sheep, camels and horses. The chigoe flea (*Tunga penetrans*) invades the feet of hogs and dogs. Mange mites (*Sarcoptes*, *Psoroptes*, *Otodectes*, *Notoedres*, etc.) invade the skin of many domestic animals, causing weeping granulating lesions.

Other mites infest chickens, causing loss of weight and egg production. Ticks of many species suck the blood of horses, cattle, hogs and dogs, and greatly reduce their health and economic value.

Horses, mules, cattle, sheep, hogs and dogs are the victims of blood-sucking flies, including many species of horse flies, the biting stable fly (*Stomoxys*), species of *Chrysops*, of *Glossina* in Africa, hippoboscids, *Simulium*, *Culicoides* and mosquitoes. Aside from the blood which is withdrawn, the welts produced, the irritating salivary secretions introduced into their victims and pyogenic infection which gain entrance into the wounds, these blood suckers frequently cause sufficient annoyance, so that the animals do not feed properly, become emaciated and may die of exhaustion.

A considerable number of blood-sucking arthropods are also the biological vectors to domestic animals of disease-producing viruses, spirochetes, bacteria, protozoa and helminths. Ticks transmit the virus of heart-water fever, the organism of fowl spirochaetosis, of Q fever, piroplasmosis, babesiosis and tularemia. Trombiculid mites transmit scrub typhus. Species of "biting" flies transmit several trypanosomes pathogenic to domestic animals. Mosquitoes and other blood-sucking gnats transmit filaria worms of domestic animals and the virus of equine encephalomyelitis.

Thus, the economic loss due to infectious and parasitic diseases in domestic animals is, indeed, very great. In many countries the effective control of these diseases would add 25 to 50 per cent to the value of these animals and their products. This increase would probably be sufficient to provide poorly nourished populations with enough animal power and animal food to guarantee nutritional balance.

Domestic Animals as a Reservoir of Disease for Man.

Not only do poor stocks of domestic animals, heavily parasitized with practically every kind of pathogenic organism, constitute a liability rather than an asset to man's progress; these animals likewise frequently serve as reservoirs of pathogenic micro-organisms which cause human sickness and death. One might list hundreds of species of such organisms common to domestic animals and occasionally found in man, but such examples lie outside the purpose of the present discussion. On the other hand, there are many instances in which man's health and even his life are endangered by pathogens originating in domestic animals. A few of these will now be considered.

Among the rickettsia infections transmitted from animal re-

servoirs to man are murine typhus, primarily through the intermediary of the flea *Xenopsylla cheopis*, and Q fever, transmitted from cattle by several species of ticks. Among the bacterial diseases contracted by man from animal sources are bovine and avian tuberculosis, hemolytic streptococcosis, bovine and caprine brucellosis, tularemia, anthrax and tetanus, all contracted from direct human contact with infected animals, their products or excretions. In addition, millions of human deaths have been caused by plague transmitted by fleas that have fed on domestic rodents.

Several protozoan diseases of man have animal reservoirs. Most conspicuous today is American trypanosomiasis, usually referred to as Chagas' disease. From Argentina and Chile to the southern United States, rodents, armadillos, squirrels, opossums and monkeys, and in South America cats and dogs are the natural hosts of this widespread human disease which is transmitted by triatomid bugs. *Trypanosoma brucei* in game mammals in Africa is probably the parent species from which the agent of African trypanosomiasis in man was derived, but the human strain has been modified and man is today rarely, if ever, infectible with the original animal strain. Nevertheless, domestic mammals in endemic areas frequently harbor *T. gambiense* and game animals are reservoirs of *T. rhodesiense*, which cause human "sleeping sickness". In China and Mediterranean countries dogs are common reservoirs of *Leishmania donovani*, which produces visceral leishmaniasis in man. The plasmodia of human malaria most probably originated in simian hosts and these animals today maintain malaria parasites closely related to quartan and vivax types in man. The pig and the monkey are sources of *Balantidium coli* which parasitizes man in warm climates.

Several helminthic infections of medical and public health importance occur or have occurred in domestic animals as reservoirs. Swine *Ascaris* was the parent stock of the human *Ascaris lumbricoides*, although today the two strains are biologically distinct. The hookworm *Ancylostoma braziliense* in cats and dogs is well known to the dermatologist of Florida, U.S.A., South Africa and Brazil as the causative agent of "creeping eruption" in man. *Strongyloides* of the chimpanzee readily infects man, as the writer can testify from his own experience and that of two of his former students. Man characteristically contracts trichinosis from eating infected raw pork.

Several of the flukes are common to man and domestic animals. *Fasciola hepatica* infection is a serious human disease in parts of France and along the north coast of Africa and is of increasing importance in human medicine in Latin America. *Clonorchis sinensis* is equally prevalent in man and domestic animals in

Japan, southern Korea, Formosa, South China and Indo-China. *Fasciolopsis buski* is common to man and the pig in parts of the same territory. *Schistosoma japonicum* occurs in man, dogs, cats, pigs, cattle, caribao and rodents in China, Japan and the Philippines.

Among the tapeworms of domestic animals there are three which are of serious concern to man, namely hydatid cyst, the beef tapeworm and the pork tapeworm. Hydatid cyst is the larval stage of *Echinococcus granulosus*, a minute tapeworm in the dog's small intestine. Many mammals serve as the host for the hydatid stage, including principally sheep, hogs and cattle. Man replaces these latter animals in the life cycle by accidentally swallowing eggs of the worm passed in the dog's excreta. Formerly hydatid cyst was a serious human disease in New Zealand, Australia and Iceland, but the scene has changed: today Argentina, Uruguay, Lebanon, Syria and Palestine are the hyperendemic centers. The beef tapeworm (*Taenia saginata*) occurs in most regions where raw beef is consumed. It is hyperendemic in Mohammedan countries. The pork tapeworm (*Taenia solium*) is particularly dangerous. In addition to harboring the mature worm, man frequently serves as host for the larval or cysticercus stage, replacing the pig. Cysticercosis in man is grave, since some of the larvae tend to localize in the brain, producing tumors which result in epileptiform seizures and other nervous manifestations. Today human cysticercosis constitutes a serious medical problem in parts of India and Mexico.

Many of the arthropods which infest domestic animals also produce lesions in man, or at least constitute serious human pests. Ticks which infest dogs, sheep, cattle and rabbits also take blood meals from man whenever opportunity is provided. Rat mites and chicken mites are annoying ectoparasites of man, and the cattle mange mite, *Sarcoptes scabiei* var. *bovis* is known to attack human beings in contact with infested cattle. The chigoe invades human skin as readily as it does that of the dog and the pig. All of the myiasis-producing flies attack man. These examples of arthropod infestation of man are particularly significant in this discussion, because they are correlated with the infestation of domestic animals which serve as their reservoirs.

Possible Ways of Improving the Situation.

There are many students of human welfare who assert that there is not enough fertile land to support the present human population on the earth and that with continued increase in population and the longer expectation of life due to the triumphs

of medicine the situation will become more and more intolerable. Some of these persons advocate birth control and this may provide a partial solution, if it is intelligently directed. The writer is convinced that the solution lies in better conservation of the soil, scientific development of agriculture in thus far unexploited vast regions of the tropics and breeding of stocks of more healthy animals throughout the world.

For most of the difficulties which today cause domestic animals to be inferior and economically unprofitable science has provided a pattern. Whether the need be for more sturdy beasts of burden, cattle producing better meat, milk and hides, sheep with better grades of meat and wool, more profitable hogs and goats, or poultry selected for increased flesh and egg production, these animals can be bred and can be acclimatized to most regions of the earth, thus ensuring an increased source of human nutrition. First of all this requires careful planning, with full knowledge of the climatic conditions of the country, the social, intellectual and psychological levels of the indigenous population, and the types of animals which will be most useful under such conditions. Moreover, the animals must have protection from heavy rains and snows, shade from intense tropical sunlight, clean surroundings and a supply of food and water when these are not available on the range. Caretakers must be properly trained and supervised until they understand and accept the rationale of efficient animal husbandry. Good stock poorly handled will provide no tangible profits.

Equally important is the prevention of disease among animals which are introduced into new areas, together with the eradication or control of enzoötic and epizootic diseases. Although the latter are more dramatic in their consequences, the losses from widespread chronic infections are usually greater over a period of years. Many of these diseases are insect transmitted and can be eradicated by the application of commercially available insecticides such as DDT, Gammexane, and by the newer, even more potent chemicals which are being tested. While there are several good parasitocidal drugs effective in veterinary medicine, clean pastures and ranges will be more practical than mass medication. However, periodic de-worming of dogs will greatly reduce hydatid disease in sheep and cattle and de-worming of young poults will do much to control ascarids and tapeworms in chickens. In diseases like tuberculosis and hoof-and-mouth disease the sick animals must be sacrificed and their carcasses disposed of so that other members of the herd will not be exposed.

In diseases of domestic animals which are transmissible to man, as tuberculosis, brucellosis, Q fever, trichinosis and hydatid

disease, public health agencies must cooperate with animal industry to prevent human exposure. Frequently this will require education of the human population away from ancient customs and superstitions. Here the anthropologist and sociologist can render valued service.

The task which is suggested is herculean in its scope, but it is not impractical and it can be accomplished. The alternatives are human hunger and starvation, wars of aggression and the eventual destruction of human civilization.

Résumé.

L'homme dépend largement des animaux qu'il a domestiqués. L'élevage a produit des races qui sont très productives et qui, par une sélection appropriée, peuvent être acclimatées à des milieux même peu favorables. Une mauvaise sélection et le manque de soins donnent naissance à des animaux de qualité et de rendement inférieurs.

Les animaux domestiques sont sujets à beaucoup de maladies, parmi lesquelles celles de nature infectieuse et parasitaire sont très répandues et forment un véritable danger, affaiblissant leur vitalité et les rendant ainsi moins utiles. En outre un nombre considérable de ces maladies sont contagieuses pour l'homme et influencent la santé publique. Le contrôle des maladies des animaux domestiques en même temps qu'une amélioration des races et des soins plus consciencieux augmenteront la valeur de ceux-ci de 25 à 50 %. De cette façon ils contribueront à surmonter la sous-alimentation des peuples. La tâche est immense et demande la collaboration des éleveurs, des organes de la santé publique, des anthropologues et des sociologues, mais elle peut être accomplie. La solution s'appuie en premier lieu sur l'observation des règles sanitaires et sur l'éducation. L'alternative serait la famine, la guerre et même la destruction de la civilisation.

Zusammenfassung.

Der Mensch ist weitgehend von seinen Haustieren abhängig. Die Viehwirtschaft hat Rassen hervorgebracht, die sehr produktiv sind und durch passende Auswahl in verhältnismäßig ungünstiger Umgebung akklimatisiert werden können. Schlechte Wahl und mangelhafte Pflege erzeugen minderwertige Tiere, welche für den Besitzer unvorteilhaft sind.

Haustiere leiden an einer großen Zahl von Krankheiten. Diejenigen von ansteckendem und parasitärem Charakter sind besonders verbreitet und schwächen die Lebensfähigkeit der Tiere; dadurch werden diese auch für den Menschen von geringerem Nutzen. Außerdem ist ein beträchtlicher Teil dieser Krankheiten für den Menschen ansteckend und beeinträchtigt dessen Gesundheit. Durch dauernde Ueberwachung der Haustiere und zugleich bessere Zucht und Pflege wird deren Wert um 25 bis 50% erhöht. Auf diese Weise wird viel dazu beigetragen, das Ernährungsproblem der Menschheit zu lösen. Die Aufgabe ist riesengroß, aber sie kann gelöst werden. Sie verlangt die Zusammenarbeit von Züchtern, Gesundheitsämtern, Anthropologen und Soziologen. Die Lösung läßt sich durch Beachtung der Gesundheitsvorschriften und durch Erziehung erzielen. Die Alternative ist Hunger, Krieg und schließlich die Zerstörung der Zivilisation.
