WORLD HEALTH ORGANIZATION

REGIONAL OFFICE FOR THE EASTERN MEDITERRANEAN

ORGANISATION MONDIALE DE LA SANTÉ

BUREAU RÉGIONAL DE LA MÉDITERRANÉE ORIENTALE

WHO/FAO SEMINAR ON FOOD HYGIENE, ZOONOSES CONTROL AND VETERINARY PUBLIC HEALTH PRACTICE

Lahore, 29 October - 6 November
Teheran, 7 - 11 November 1964

EM/SEM.VPH/14
28 October 1964

ORIGINAL: ENGLISH

EPIDEMIOLOGICAL NOTES ON HUMAN INFECTIONS WITH PARASITES OF ANIMALS

by

Dr. M. Abdussalam*

---

* WHO,HQ

TABLE OF CONTENTS

I EPIDEMIOLOGICAL NOTES ON HUMAN INFECTIONS WITH PARASITES OF ANIMALS

A large majority of the animal parasites are host specific and are not interchangeable between animals and man. A few are, however, not so rigid in their physiological requirements and can parasitize more than one host species including man. This small group includes such important causes of human disease as Leishmania, blood flukes, intestinal flukes, tapeworms, trichinae, strongyloides and others. Some parasites of animals spend their larval period in human tissues and cause such serious diseases as hydatidosis and myiasis. In other cases, the larvae that enter human tissues fail to develop normally and perform erratic migrations causing serious damage as in creeping eruption, visceral larva migrans, etc. The ectoparasites acquired from animals not only cause annoyance and painful skin lesions but in many cases transmit pathogenic microörganisms. Many of the zoonoses caused by animal parasites are of considerable local importance in public health. Others are of relatively minor importance.

The bio-ecological and evolutionary aspects of the relationships involved have been reviewed by Garnham (1959a), Kozar (1959), Cameron (1958), Heisch (1956) and Wright (1947a). Beaver (1961) and Faust (1955) briefly surveyed the infections resulting from invasion by parasites of animals, and Shikhobalova (1955) published a popular account of the helminthic zoonoses of the Soviet Union. In the present article, the principal parasitic infections interchangeable between man and vertebrate animals have been listed and brief notes on important epidemiological features added. Emphasis is laid on recent work and on infections with pathogenic parasites reported from warm areas of the world.

II PROTOZOA

Most of the protozoan parasites of man, and of the animals in his environment, are so strictly host specific that interchanges of infection are infrequent even where close morphological similarity between the parasites of man and animals suggests such a possibility. It is mainly among the haemoflagellates that host specificity is not so rigid and animals assume the role of reservoirs of human infection.

Leishmaniasis All the three established species of Leishmania pathogenic for man (L. tropica L. donovani and L. braziliensis-complex*) have animal hosts in nature. Leishmania tropica, the cause of oriental sore, is widely but focally distributed in the dry zones of the tropics and sub-tropics. Endemic areas exist in Africa, the countries around the Mediteranean, Middle East, Indo-Pakistan, Central Asia and China. Dogs have been found naturally infected in many of the endemic areas but their exact role in the endemiology of the disease is not clear. Recent work in Central Asia (Hoare, 1955; Petrishcheva et al., 1963) has revealed the existence of two types of the disease. A "moist" ulcerating type occurs in the people of rural areas on the fringe of deserts and is contracted from gerbils (Rhombomys opimus, Pallasiomys erythrourus, P. meridianus and others) through the agency of sandflies. The other is a chronic "dry" type, characterized by late ulceration. It occurs in urban areas and represents man to man infection, through sandflies, of the Leishmania which is better adapted to the human subject. The two types are reported to be immunologically distinct. The "moist" variety has also been found in Iran in association with Rhombomys opimus (Ansari and Faghih, 1953). It is likely that natural enzootic foci in gerbils and other desert rodents exist in the other infected areas. This might also explain the endemicity of the disease in dry areas.

Visceral leishmaniasis (kala azar) is widely distributed in northern and western China, central Asia, Indo-Pakistan, the Middle East, countries around the Mediteranean, East Africa and in a few localities in West Africa and South America. Dogs have long been considered to be an important reservoir of the infection in China, the Middle East and the Mediteranean area, where the disease occurs more commonly in children. In India and Kenya, dogs have not been found to be infected though the epidemiological picture suggests the existence of an animal reservoir (Heisch, 1954) which may be a rodent. In recent attempts to clarify the position, Heisch et al. (1959) isolated a strain of Leishmania from gerbils

---

Garnham (1962) has pointed out that there are at least four forms of cutaneous leishmaniasis in the new world (espundia, uta, pian-bois and chicklerosular). Each has a different epidemiology and is due to a different species of Leishmania.

(Tatera nigricauda) in Kerio Valley, Kenya, where human cases had occurred in fair numbers. This strain produces heavy infections in hamsters but only transient local skin nodules in man. Volunteers challenged with L.donovani after their nodules had faded were found to be immune. The gerbil strain may be L. donovani or a related species. In China, recent studies (Li, 1957) indicate the possibility of the simultaneous existence of the Indian type disease in which adults are attacked more frequently and dogs do not appear to be implicated. Latyshev et al. (1951) reported the occurrence of Kala azar among reclamation workers in the previously uninhabited areas of the Vakhsh valley in Tajikistan. A search for local reservoirs revealed that jackals, Canis (Thos) aureus, were naturally infected. These authors suggest that in densely populated towns of central Asia, the dog has taken over the role of a reservoir from the jackal, and Hoare (1955, has postulated a similar transfer from the fox to the dog, in ancient times, in the Mediteranean area.

Muco-cutaneous leishmaniasis (espundia) caused by L. braziliensis is confined to central and south America. Dogs have been found naturally infected and have been considered to be reservoirs. No wild animal reservoir has been identified but the prevalence of the disease in forest workers suggests such a possibility (Davey and Lightbody, 1956).

African trypanosomiases (reviewed recently by Nash, 1960). The less acute Gambian trypanosomiasis (T. gambiense) is restricted to West Africa between latitudes 15° N. and 15° S. of the equator, the eastern limits being Lakes Victoria and Tanganyika. The more serious Rhodesian type (T. rhodesiense) is restricted to eastern Uganda, Tanganyika, Portuguese East Africa, the Rhodesias and the north-eastern portion of Mozambique. Until recently, there was no direct evidence that a reservoir of either of these trypanosomes existed in wild animals, although there was strong indirect and circumstantial evidence that such reservoirs did occur particularly for T. rhodesiense (Davey, 1958). The latter occurs in thinly populated bush country abounding in wild ruminants and is transmitted chiefly by the game tsetse fly, Glossina morsitans. Infection is contracted when the uninhabited areas abounding

in game are visited for hunting, fishing, gathering beeswax or travelling. Experimentally, it had been shown that T. rhodesiense, serially transmitted in sheep, with secondary lines in antelope and monkeys, had maintained its infectivity and virulence for man over 23 years (Willet and Fairbairn, 1955; Ashcroft, 1959). Heisch et al. (1958), however, proved directly that game acted as a reservoir for this trypanosome. They were successful in infecting a human volunteer with a strain isolated from a bush-buck (Tragelaphus scriptus) shot in an endemic area in Kenya.

The Gambian trypanosomiasis is less acute and has a greater tendency to invade the nervous system. It occurs in relatively well populated localities with few wild animals. The benignity of the early stages of the disease means that man himself can infect tsetse flies (G. palpalis and G. tachinoides) when going along shaded paths by the streams and across the fords. This man-to-man transmission through the fly may be the reason for the greater adaptation and consequent mildness of this infection. It has also been shown that T. gambiense is easily transmitted to the domestic pig, producing a sub-clinical infection which may persist for a year or more (Van Hoof, Henrard and Peel, 1942). Other domestic animals, such as cattle, sheep and goats may also carry this infection without apparent symptoms for long periods of time and probably act as reservoir hosts (Craig and Faust, 1955).

American trypanosomiases Chagas' disease, caused by Schizotrypanum cruzi is the better known of the two American infections of this group. It is prevalent in Mexico, Argentina and the Brazilian highlands, but smaller foci of infection are widespread in the rest of central America and nothern parts of South America. In the United States, the infection has been detected in wild hosts as far north as Maryland (Walton et al., 1958) but human cases are rare or absent. Trypanosomes closely related to S. cruzi have been found in monkeys exported from Malaya and Indonesia but human infection has not been recorded in these countries. The domestic reservoirs in America are dogs, cats and children. The wild reservoir hosts include monkeys, rodents, bats, armadillos and oppossums. The vectors are triatomid bugs in which the trypanosomes multiply, making them additional reservoirs.

In Venezuela, Colombia and Guatemala, there occurs another trypanosome (T. rangeli) in the blood of man, dog and opossum. It is apparently non-pathogenic or only mildly virulent for man. Triatomid bugs (Rhodnius prolixus) are natural vectors. Experimentally, the infection is transmissible to Cebus monkeys and mice (Pifano, 1954).

Piroplasmosis A few isolated reports of the finding of piroplasms in human beings have appeared in the literature but were generally regarded as misidentifications or findings of artefacts or Jolly bodies. Skrabalo and Deanovic (1957) reported a carefully investigated case of Babesia bovis infection in a splenectomized individual who had lived and tended cattle in an infected area. The illness in this 33-year-old patient was characterized by fever, anaemia, haemoglobinuria and chocolate discoloration of the skin. It ended fatally in eight days. Following this report, Garnham and Bray (1959) transmitted this piroplasm by intravenous inoculation of infected calf blood into splenectomized chimpanzees (Pan troglodytes verus) and the rhesus monkey, and produced a fulminating infection accompanied by blackwater as reported in the human patient. They suggest that latent piroplasmosis may exist on a large scale in rural populations in infected areas and should be considered when the operation of splenectomy is contemplated.

Malaria Bruce-Chwatt (1960) has summarized the present position of the relationship between the malaria of man and anthropoid apes as follows: "The malarial parasites of anthropoid apes are morphologically indistinguishable from the three species parasitic in man. In order to determine the mutual relationships between the human and anthropoid parasites, cross-infection experiments have been carried out. In the case of the falciparum-reichenovi parasite, attempts to infect chimpanzee from man have been more successful if the animal was splenectomized. In the case of the vivax-schwetzi parasite, the human strain produced in the chimpanzee a subclinical infection which could only be demonstrated by the subsequent inoculation of man from the ape; on the other hand, man appears to be more tolerant of the chimpanzee strain, which produces in him only a mild and transient infection. Man proved to be most susceptible to the infection with the malariae-rodhaini parasite of the chimpanzee, which produced in the human host

febrile symptoms with quartan periodicity and was carried through several human passages; the infection of chimpanzees with the human strain was symptomless with scanty parasites. The situation with regard to the human ovale malaria is similar to that of the vivax-schwetzi." Malaria of anthropoid apes is, however, limited to a relatively small part of west Africa and the Congo even though the distribution of these animals is more extensive in Africa (Garnham, 1954). Further, the anthropoid apes are rare animals and live at a distance from human habitations. They are therefore a relatively unimportant reservoir of human malaria.

The malarial parasites of monkeys were generally regarded as specific to these animals and not transmissible through mosquitos to man. Recently, however, a strain of Plasmodium cynomolgi isolated from Macaca irus in Malaya (Hawking et al., 1957) and considered to be a new subspecies, P. cynomolgi bastianellii, by Garnham (1959b) has been found to be readily transmissible to man through the agency of anopheline mosquitoes (Eyles et al., 1960). This parasite causes typical malarial paroxysms with tertiary periodicity and appears in the blood as vivax-type forms with enlarged erythrocytes and Schüffner's dots. The monkeys exist in relatively large numbers, often in close proximity to man, in many malarial localities. It is therefore important to assess the exact role of this malarial parasite in the epidemiology of the human disease by intensive parasitological and ecological studies.

Intestinal protozoa Entamoeba histolytica is the principal parasite of this group with a cosmopolitan distribution. Its pathogenic effects are commonly observed in the tropical and sub-tropical countries and are generally associated with the large race of the parasite. Amoebae identical with or morphologically resembling E.histolytica have been observed in a variety of mammals including dogs, cats, cattle, pigs, rats and monkeys (Hoare, 1959). In the latter, it is usually non-pathogenic and saprozoic but in South American monkeys, it causes severe morbidity. It is generally believed that the animal hosts do not play an important part in the epidemiology of this infection in man, with the possible exception of monkeys in South-East Asia. These animals

live near human habitations and probably constitute an important reservoir of human infection (Cameron, 1958). It has been shown that the human and simian strains are readily interchangeable between monkeys and man (Dobell, 1931; Knowles and Das Gupta, 1934).

Walkiers (1930) has reported an unusual outbreak of dysentry in cattle in Isangi, Congo, in which numerous E. histolytica were seen in the faeces of some of the affected animals. Since this outbreak was preceded by an epidemic of amoebiasis in human beings in the same locality, it was thought that the cattle got infected when grazing on pastures polluted with human faeces. In Dakar, E. histolytica was found in the lungs of zebu cattle suffering from brochopneumonia and streptothricosis (Thiery and Morel, 1956). How infective bovine amoebiasis can be for man, is still problematic.

The ciliate parasite Balantidium is also a univeral and common parasite of pigs. In man and monkeys it produces prominent ulceration of the large bowel. Human infection is generally believed to have been derived from pigs as most patients give a history of association with these animals. The relatively low incidence of human infection compared with the amount of exposure suggests that man is quite resistant (Faust, 1933). Highly resistant cystic forms, which are produced in the bowel of the pig, are not always formed in the human host. Man is obviously an abnormal host for this parasite (Cameron, 1956). Even so, large epidemics are not unknown, e.g. one occurred not long ago in Georgia (Kozar, 1959).

Toxoplasmosis Toxoplasma gondii infects a large number of species of mammals and birds besides man. It has a very wide geographical distribution and occurs equally frequently in tropical and temperate countries. Serological surveys indicate that one quarterto three quarters of the adult population of various countries have been infected (Beattie, 1960). Because of the high prevalence of infection in domestic animals, particularly food animals, it is believed that human infection is derived from animals. Infected meat, brain, faeces, urine, saliva and nasal secretions have been suggested as possible vehicles of spread. Infection by mouth and nasal instillation can be produced in laboratory

animals and it has been suggested that in man the main portal of entry may be through the tonsillopharyngeal region.

Transplacental infection from the mother to the foetus and accidental infection through wounds is known. The mode of infection in animals, except through the placenta, is not known. Arthropods do not appear to play any role in its spread. Avirulent strains can be rendered virulent by passage in the miltimammate mouse, Rattus coucha (Lainson, 1955).

Pneumocystis carinii which, like Toxoplasma, is a protozoan of undetermined relationships, is associated with cases of interstitial non-syphlitic pneumonia espécially in children in Europe, Asia (China), North and South America and is probably cosmopolitan. Several species of domestic and wild animals are known to carry the parasites in their lungs as a latent infection and are believed to be sources of the human infection. In dogs pneumonia associated with this parasite has been recorded. Man to man transmission is known to occur (Jirovec, 1959).

III TREMATODA

Trematode infections of man are quite important in warm climates especially in the Oriental region. This is because of the vast areas suitable for the propagation of mollusc intermediate hosts and the existence of certain socio-cultural factors (food habits and occupations) which expose man to infection. Because of certain specific requirements of the snail intermediate hosts, the trematode infections remain endemic in well defined areas, often with recognizable topographic characters. Some trematodes use a second intermediate host, which may be a food animal (fish, crustacean, etc.) or the infective cercaria may encyst on a food plant (water chestnut, water-cress, water caltrops). Such infections are limited to populations eating these animals or plants raw or undercooked. The following infections may be mentioned:

Gastrodiscoides hominis is a common parasite of man in Assam and also occurs in Indo-China. It causes mild colitis and diarrhoea. In Assam and other parts of eastern India, it is common in domestic pigs and has been recorded from the Napu mouse-deer in Malaya (Khalil, 1923). It does not appear to be an important parasite of man except in eastern India.

Schistomomiasis. The blood-flukes are among the most important parasites of man which infect nearly one-fifth of the whole human race (Cameron, 1958). In the western Pacific region, Schistosoma japonicum is easily the most important parasitic disease and is considered to attack over 46 million people (Stoll, 1947). (Wright, 1950, estimated the number of infected persons to be over 33 million). The infection is widely distributed in China, Japan, Taiwan, Philippines and the Celebes. The infected localities have been listed by Wright (1947b and 1950) and more are being added by recent workers (Pesigan et al., 1958; Okoshi, 1958, and others). Four or more species of the amphibious snail genus Oncomelania act as intermediate hosts. It has been known for a long time that a number of domestic and wild mammals in the endemic areas are infected with S. japonicum and are capable of passing viable eggs which can infect clean snails. These animals include cattle, buffaloes, goats, horses, dogs, rats, moles and weasels. Although the true relative importance of the various hosts in maintaining infection is not fully known, it is clear that it varies from one locality to the other. It has been suggested (McMullen and Harry, 1958) that in Japan and China, cattle are more important than man in maintaining the infection, while in Taiwan

a strain of purely zoophilic type shows an incidence in snails comparable to that found in other areas. It has been shown experimentally by Hsü and Hsü (1956) that this strain has become so specialized for animals that in man it develops in the viscera for a time but does not attain maturity. In the Philippines, recent studies on egg production, hatchability of eggs produced in different hosts, and the population densities of the various hosts indicate that, in Leyete, man is probably the greatest contributor to the infection in snails. As the Oncomelania snails which are amphibious discharge cercariae only when in water, it is the vertebrate hosts which go into water that are more commonly infected. Thus, cattle which work in rice fields and dogs which roam about unleashed are frequently infected (Okoshi, 1958). Adult water buffaloes are resistant, though the young ones are easily infected. In general, it may be stated that vertebrate reservoir hosts other than man appear to play an important role in the epidemiology of S. japonicum infection, though the relative importance of different species in maintaining the infection remains to be studied in many localities.

There are occasional reports of the occurrence of S. japonicum infection in man in various parts of Africa, (Causton, 1930; Maclean et al., 1958). Walkiers (1928) described an allied form S. faradjei from five Congolese. It has been suggested that all these were spurious or real infections with S. margrebowei which is common in antelopes in Southern Rhodesia (Nelson, 1960).

Schistosoma mansoni infection is widely distributed over Africa and South America. Until recently, the infection was considered to be largely confined to man, the only recorded animal hosts being two African monkeys, Cercopithecus sabaeus and C. aethiops. In recent years, a number of wild mammals of the order Rodentia and some of Insectivora and Marsupialia have been found to be infected in Africa and South America (Kuntz, 1955; Martins, 1958; Pitchford, 1959). More recently, Miller (1959; 1960), Nelson (1960) and Strong et al., (1961) have demonstrated natural infections in a large percentage of baboons (Papio doguera) in endemic areas in Kenya. Nelson believes that these animals derived their infections from man and may, under certain conditions, act as a source of increased transmission to man. It appears that many animal hosts might play an important part as reservoirs of S. mansoni infection, but further work is needed to elucidate their precise epidemiological significance.

Schistosoma haematobium of Africa and the Middle East, with isolated small foci in Portugal and western India, appears to be rather highly specialized for parasitism in man. An early record of a wild mammal being naturally infected is that of Cercocebus torquatus atys by Cobbold in 1869. As pointed out by Martins (1958), the identification of the parasite in this record is doubtful as, at that early date, no other species of the haematobium - complex were known, and so a mis-identification was possible. A few species of this complex are described from animals in Africa and Asia (S. bovis, S. mattheei and S. indicum) and are common among domestic ruminants. In Africa, human infections with all these species, except S. indicum, have been recorded on the basis of eggs detected in the faeces. Of these S. mattheei is fairly common in man in parts of South Africa (Nelson, 1960). S. rodhaini which is a common parasite of wild rodents in Africa and is now known to occur in man in the Congo (Report, 1960). Le Roux (1949) and Varma (1955) have both suspected that the autochthonous cases of human schistosomiasis in Indo-Pakistan may be due to S. indicum which is widely prevalent among ruminants and equines in this sub-continent. Further studies are needed to elucidate the role of these species in human infection and their biological relationship to the morphologically similar S. haematobium.

Schistosome dermatitis. The blood flukes of several vertebrates such as birds, rodents, monkeys and other mammals (Trichobilharzia, Pseudobilharzia, Schistosomatium, Schistosoma, etc.) are capable of penetrating the human skin as cercariae but fail to attain maturity in this host. After first exposure to such cercariae, there is little observable reaction and Olivier (1953), on the basis of experiments in monkeys, believes that they reach the lungs and produce small haemorrhages but are killed within five days. After repeated exposures, however, the human skin shows an allergic response and the cercariae are killed and retained in the epidermis. They cause severe itching, oedema and haemorrhages. Schistosome dermatitis (swimmers' itch, cercaria dermatitis, etc.) has been observed in several countries including South Africa (de Meillon and Staffberg, 1954). In Malaya, Buckley (1938) found that the cercariae of S. spindale, a blood fluke of domestic ruminants, produces an itching dermatitis on the feet and hands of rice field workers. A similar condition exists in India (Anantaraman, 1958) and Burma. It is probable that schistosome dermatitis is cosmopolitan in distribution. In any case, it is much more widely distributed than the blood flukes which attain maturity in man.

Clonorchiasis. The Chinese liverfluke Clonorchis sinensis, like other members of the family Opisthorchidae and the closely allied Heterophidae, uses fish as the second intermediate host. The infective metacercariae are encysted in the flesh, gills and the skin of the fish. The adult fluke therefore occurs in the fish eating mammals, such as dog, cat, pig, wild cat, martin, badger and mink. Human beings get infected through eating raw or undercooked fish. The infection is endemic in Japan, China (except the north-west), Korea, Taiwan and Indo-China. It has also been detected in Chinese immigrants to other countries (USA, Cuba, India) and in native Hawaiians who are believed to have been infected through eating fish imported from China or Japan. However, the infection does not appear to have gained a foothold in these countries. The fish intermediate hosts consist of 40 or more fresh-water species of the family Cyprinidae. In South China, the ide (Ctenopharyngodon idellus) is the most common source of infection.

Opisthorchiasis. Three species of Opisthorchis (O. felineus, O. viverrini and O. noverca) occur in the bile ducts of man, and, like Clonorchis, use fishes as second intermediate hosts. O. felineus is highly endemic in certain areas of East Prussia, Poland and the USSR. It has also been reported from Japan, Indo-China, Philippines and Indo-Pakistan, but is not endemic in localities where clonorchiasis is prevalent. Stoll (1947) has estimated that 1.1 million persons are infected, mainly in eastern Europe and the USSR. O. viverrini, first described from the civet cat (Felis viverrini) is an important parasite of man in north-east Thailand (Sadun, 1957) and western Viet Minh (Bedier and Chesneau, 1924). Sadun has estimated that at least one-fourth of the total population of north-east Thailand (1,500,000 people) are infected, thus creating a serious public health problem. Dogs and cats are the reservoir hosts. Opisthorchis noverca is a rare parasite of man in India, though it is fairly common in dogs and pigs (Bhalerao, 1931).

Other opisthorchid flukes, which are rare parasites of man and are likewise acquired through eating raw fish are as follows: Pseudamphistomun truncatum occurs in Siberia, the reservoir hosts being the seal, cat, dog, fox and wolverine (Gulo borealis). Metorchis orientalis is contracted from eating the fish Pseudorasbora parva in Japan. Metorchis conjunctus infection is contracted in the north-eastern part of North America from eating the common sucker (Catostomus commersonii). An allied species, Metorchis felis occurs in China but does not appear to have been recorded from man.

Heterophyiasis. The heterophyids are small flukes inhabiting the intestine of man, fish-eating mammals and birds. Their life-cycle involves snails and fresh-water fishes as intermediate hosts. They are particularly prevalent in the Nile delta and the humid regions of the Far East. Practically all species are potential parasites of man, but fourteen have so far been found in this host. Two of these, Heterophyes heterophyes and Metagonimus yokogawai, are the most important. Heterophyes heterophyes is fairly common in Egypt, Palestine, Japan, Korea, central and southern China, Taiwan and the Philippines. The fish hosts are the mullet (Mugil japonicus) and Acanthogobius in Japan and M. cephalus* as well as Tilapia nilotica in Egypt. The snails involved live in brackish waters. Cats, dogs, foxes and other fish-eating mammals are reservoir hosts.

Metagonimus yokogawai is common in Japan, Korea, Taiwan, China, Siberia, and Indonesia. It has also been encountered in Palestine, Russia, Rumania and Spain. The reservoir hosts are dog, cat, pig, the pelican and other piscivorous birds. The fish hosts are the salmonoid, Plectoglossus altivelis, and the cyprinoids, Richardsonium hakuensis and Odontobutis obscurus.

Other heterophyids of man, having a limited distribution in the Far East, are as follows: Heterophyes katsuradai occurs in Japan and uses the mullet as its fish host. H. brevicaeca has been found in man in the Philippines. Haplorchis taichui and H. pumilo occur in Taiwan and the Philippines. Their fish hosts are Cyprinidae, Siluridae and Colitidae. Centrocestus formosanus occurs in Taiwan, the Philippines and Hawaii. There are a few other rare species described mainly from Taiwan.

In their intestinal habitat, the heterophyid flukes hardly cause any symptoms unless present in large numbers. In the Philippines, however, a general secondary invasion of the heart, spinal cord, brain and other organs has been reported in patients harbouring adult heterophyids. Apparently the ova gain access to the general circulation and invade the capillaries of various organs particularly the heart and brain. In these locations they set up serious cardiac and cerebral lesions, chiefly haemorrhages and oedema. Watson (1960) mentions the finding of a cyst containing adult Heterophyes removed from the brain of a man with epileptic symptoms. He had apparently acquired the infection while serving in the Far East.

---

*Salted mullet (fessikh) is often eaten raw in the Near East. Metacercariae remain infective in it for ten days but not for two weeks.

Echinostomatid infections. These flukes are small and of low pathogenicity for men. Twelve species belonging to the genera Echinostoma, Himastha, Paryphostomum and Echinochasmus have been recorded from man, mostly in the Far East. Some of them may be mentioned here. Echinostoma ilocanum occurs in the Philippines, Celebes, Java and China, in man, dog and rat. The first intermediate host is the small snail Gyraulus convexiusculus. The second intermediate host may be any fresh-water snail but human infection is derived chiefly from Pyla. This snail is eaten raw by the inhabitants of Luzon, either directly from the shell in the field or with salt or vinegar in the home. Echinostoma revolutum is a cosmopolitan parasite of ducks and geese but human infection has been recorded in Taiwan (2.8 to 6.5 per thousand) and Indonesia. Snails are the second intermediate hosts also. Echinostoma malayanum infects man in Malaysia, Indonesia and China and uses Indoplanorbis exustus and other freshwater snails as intermediate hosts (Joe and Virik, 1963).

Paryphostomum sufrartyfex is a parasite of pigs in eastern India (Bhalerao, 1931) and is known to occur in association with dropsy and anaemia in children in Assam.

Fascioliasis. The ruminant liverflukes Fasciola hepatica and F. gigantica are capable of infecting man accidentally. The former is generally prevalent in Europe, America and the temperate parts of Asia. F. gigantica is widespread in the warmer parts of Asia, Africa, the Pacific Islands and possibly Central America. Snails belonging to the family Lymnaeidae are the most important intermediate hosts. Domestic herbivora and wild rabbits are important reservoir hosts. Human infection takes place through ingestion of infected water plants, e.g. water-cress (Alicata and Bonnet, 1955; Coudret and Triozon, 1957), lotus stems and flowers. Rarely, children are infected through eating windfall fruits picked up from snail infested ground. Only sporadic cases occur in man but in a few areas (France, USSR, Cuba) substantial local foci have been detected. Since ova of these flukes may be passed in the faeces of uninfected persons after eating infected sheep livers, care is necessary in interpreting results of faecal examination. In Africa, human fascioliasis is known from Congo, Moçambique and South Africa (Louw & Wilkie, 1956).

In some Eastern Mediterranean countries, sheep and goat livers are habitually consumed raw. It is believed that if livers contain immature Fasciola they get lodged in folds and crypts of the buccal and pharyngeal mucous membranes, tonsils, and sometimes in the Eustachian tubes. They cause inflammation of these organs which may be severe and may rarely end in death. The syndrome is well known to the people of these areas and is locally called halzoun (Watson and Kerim, 1956). It is not caused by the adult flukes (Azar, 1964). An intestinal fluke, Clinostomum complanatum, normally parasitic in fish-eating birds has been found in the pharynx of man in Israel and Japan but it does not cause halzoun. Linguatula larvae have been considered to cause this condition.

Dicrocoeliasis. The small liverfluke of sheep and other herbivora, Dicrocoelium dendriticum is almost cosmopolitan in its distribution. Sporadic infections of human beings have been reported from several countries including North Africa, Congo and Nigeria. Curran and Feng (1930) demonstrated eggs of this fluke in the faeces of many persons in Shensi Province, China, but believed that most of them were cases of spurious parasitism. The life history of this fluke has been worked out by Krull and Mapes (1951, et seq.) in the New York area. They found the first intermediate host to be a land snail, Cionella lubrica, and the second host to be an ant, Formica fusca. Animals are infected by swallowing ants carrying the metacercariae. The mode of infection of human beings is not known but it is likely to be similar to that for animals.

Eurytrema pancreaticum, a dicrocoeliid parasite of the pancreatic and bile ducts of swine, cattle and buffaloes in the Orient, has been reported once from man in China. The life history of this fluke and the mode of infection are similar to those of D. dendriticum. In Mauritius, the land snail Macrochlamys indica and the ant Technomyrmex deterquens are probably employed as intermediate hosts (Le Roux and Darnes, 1955).

Fasciolopsiasis. Fasciolopsis buski, the large intestinal fluke occurs in pigs in China, Taiwan, Indo-China, Thailand, Indonesia, Burma and India. It has also been found in wild boars (Sus cristatus) in West Pakistan (Abdussalam and Amin, 1955). Human infection has been reported from all these countries except West Pakistan, but the incidence is particularly heavy in Chekiang and Kiangsi Provinces of China (Hsü and Li, 1953) and in certain districts of Assam.

Stoll (1947) estimated 10 million infections in the Far East, half of which are in Chekiang area only. It is highly probable that undetected foci of human infection exist in other countries where the infection is known from pigs, and water plants growing in the habitat of snail intermediate hosts are peeled with teeth or eaten raw. Such a focus was recently found in central Thailand, where epidemiological investigations were carried out following the death of a 15-year-old girl who carried over 500 adult F. buski in her bowels (Sadun, 1957). Thirteen per cent. of 1563 persons examined in areas where water caltrop (Trapa and Eichhornia sp.) was common were found infected. The prevalence rate was highest among children 5 to 14 years old. The infected children admitted that they often picked up and ate fresh water caltrops on their way to and from school. In heavily infected endemic areas, fasciolopsiasis is an important cause of disease and death. Animals other than pigs and ~~wild boars are~~ not important as reservoirs of the parasite, though dogs ~~are occasionally infected~~.

Paragonimiasis. The lung fluke Paragonimus westermani is widely but focally distributed in several countries. In the western Pacific and S.E. Asia, it occurs in Siberia, Japan, Korea, Manchuria, China, Taiwan, Indo-China, the Philippines, Thailand, Malaya, Indonesia, India, New Guinea, Samoa and the Solomon Islands. It is also known from a few areas in Africa (Congo, Nigeria, Cameroons) and Central and South America, but it is not known if the infection is endemically established here except in the Cameroons where 4 per cent. of the population are said to be infected. Records based on the recovery of eggs alone without identification of the worms may be misleading. Yarwood and Elmes (1943) reported the finding of Paragonimus ~~eggs in a sub-cutaneous~~ cyst behind the ear of a patient in Nigeria. Fain and Vandepitte (1957) found similar cysts with eggs in people in Kasi, Congo. One of the cysts contained also an adult fluke which they described as representing a new genus and species, Poikilorchis congolensis. Apart from a snail, the lung fluke uses a ~~second~~ intermediate host which may be a crab or a crayfish. In the western Pacific region, crabs of the genera Eliocheir, Potamon and Sesarma and the crayfish A. similis are infected. Human infection results from eating infected crabs or crayfishes particularly after ~~soaking them~~ raw in vinegar, brine or wine. While the crabs are killed by this treatment, the metacercariae survive for several hours and may be viable when ingested. Certain aborigines in Asia eat the infected crustacea raw. Stoll (1947) has estimated about 3 million cases

of lung fluke infection in Asia. The animal hosts of the lung fluke include dog, cat cat, wild cat, tiger, fox, marten, badger, mink, rat, muskrat, weasel, opossum, wolf, goat, pig, crab-eating mongoose (Herpestes urva) and the Indian mongoose (H. edwardsi). In man, the fluke generally lives in cystic cavities in the lungs but, at times, it has a more generalized distribution in various organs of the body. Serious symptoms are produced by the parasites located in the brain, particularly in children. For a comprehensive review of paragonimiasis, see Yokogawa, Cort and Yokogawa (1960).

IV CESTODA

Cestodes or tapeworms are highly specialized parasites and use two or more hosts for their development. Species which develop as adults in man spend their larval stages in food animals (and some tapeworms of carnivora infect man during their larval stages). They are, therefore, important as meat-borne infections and their prevalence in any population is connected with their food habits. A few others generally occur in monkeys, rodents, dogs and other animals and accidentally infect man. With the exception of a species of Hymenolepis they cause sporadic infections. The following infections may be mentioned.

Taeniasis. The pork tapeworm, Taenia solium, is cosmopolitan in distribution and is particularly prevalent where insufficiently cooked or processed pork is eaten by man, It does not usually occur in Muslim and Jewish communities who do not eat pork. Stoll (1947) has estimated the number of infected persons in the world to be less than three million, half of them being in Asia. Faust (1949), however, considers this estimate to be "ultraconservative". The larval worm eaten with pork develops into an adult in about three months and may live in the intestine for as long as 25 years. Human beings can also be infected with cysticercus if they swallow eggs of the worm harboured by themselves or by someone else. The cysticerci occur most frequently under the skin and in the brain. They may also occur in the muscles, the heart, the liver, lungs, orbit or the abdomen. When in the brain, the cysts cause symptoms of epilepsy and other nervous disorders (Bickerstaff, 1955).

The beef tapeworm, Taenia saginata, is considerably more prevalent than the pork tapeworm, Stoll's (1947) estimate of its incidence being 39 million persons, mostly in Africa* and the USSR. The Muslim populations of Asia are also fairly

*See Merle (1959), Biche and Thienport (1959), Marsboom et al. (1960),

heavily infected and in the Far East it is much commoner than T. solium. The incidence is markedly high where people eat beef cooked in lumps on open fires and pollution of pasture with human excreta is frequent (e.g. in Tibet and Abyssinia). Cattle acquire the infection from grazing on ground polluted by human faeces containing eggs of the tapeworm. Eggs may remain viable on grass for eight weeks or more. Infection in water buffaloes is said to be much less than in cattle. Adult cattle and even calves 1 1/2 to 3 months of age have been found to be highly resistant to experimental infection in East Africa (Urquhart, 1959; Froyd and Round, 1960).

Hydatidosis. The dog tapeworm, Echinococcus granulosus, uses sheep and other herbivorous animals in which the larvae (hydatid cysts) develop from eggs swallowed with grass and forage polluted with infected dog faeces. Man can get infected with hydatid cysts by swallowing eggs of this tapeworm. The high resistance of eggs to environmental influences is an important factor in the epidemiology of the disease. People who regard the dog as an unclean animal and do not fondle it are less commonly affected than others in the same area who have no such inhibition (Schwabe et al., 1960). Infection generally takes place during childhood but symptoms caused by the hydatid appear several years afterwards in adult life. The infection is cosmopolitan but more frequent in some areas than in the others, e.g. in South America, Australia and New Zealand, the Mediterranean region and parts of Africa. Stoll (1947) has estimated 100,000 infections mainly in South America. Recent studies in Wales and South Eastern United States have revealed important foci of hydatidosis. In the temperate parts of Eurasia, Japan (Rausch and Yamashita, 1957) and in St. Lawrence Island, Alaska, another closely allied tapeworm (E. multilocularis) of dogs and foxes is prevalent. It utilizes microtine rodents as its intermediate hosts in addition to herbivora and man. It has been suggested that besides the primary sylvatic cycle involving foxes and voles a domiciliated cycle cat-mouse cat may

develop (Vogel, 1960). In addition to the two typical species mentioned above special races or subspecies adapted to dog-equine cycle have been found in Europe and the Eastern Mediterranean region.

Other larval cestodes occasionally parasitic in man include Coenurus cerebralis which has been found in the cranial cavity and bladder-worms of Multiceps which occur in the sub-cutaneous tissue or muscles. M. glomeratus and M. brauni infections are not uncommon in some parts of Africa (Fain, 1956).

Diphyllobothriasis. The broad fish tapeworm Diphyllobothrium latum and related species are prevalent in the human populations of the northern temperate zones of America, Europe and Asia, where fishes from fresh-water lakes form an integral part of the diet. In the western Pacific, the infection occurs in Siberia, northern Manchuria and Japan. In the warmer countries of this region, it is extremely rare. Several fish-eating mammals including dogs, cats, bears, seals, foxes, etc., are reservoir hosts. The ciliated embryophore, which hatches from the egg in water, develops in crustaceans to form a procercoid larva. In fishes, which feed on infected crustacea, the larva develops to form a sparganum or "plerocercoid larva". This is ingested by man and other mammalian hosts in the flesh of raw or undercooked fish. The fishes involved are the pikes, eels, salmons, trout, sauber and burbot. In Japan, the rainbow trout and several other Salmonidae act as second intermediate hosts. Pollution of lakes with untreated sewage and faeces of fish-eating mammals are important factors in maintaining infection in an endemic area. Sporadic cases outside endemic areas may be caused by the importation of infected fish.

Sparganosis. The plerocercoid larvae (spargana) of several species of diphyllobothriid tapeworms have been found in man. The adults are parasites of mammals or are unknown. Most cases of human sparganosis have

been recorded in the Far East, but it is known to occur in other parts of the world including USA, Australia, Africa, British Guiana and Italy (Huang & Kirk, 1962). The adults of Spirometra erinacei and related species are found in dogs, cats and wild carnivora. Only the larva occurs in man. Other animals, parasitized by the larva are monkeys, pigs, weasels, hedgehogs, rats, chickens, snakes and frogs. Man and these animals commonly become infected through ingestion of Cyclops containing the procercoid in raw water. Human infection also results from eating raw flesh of the second intermediate hosts (frogs, snakes etc.) which, according to Weinstein et al. (1954), is not uncommon in Korea. Infection may also be acquired by applying infected meat from the second intermediate hosts as poultices on inflamed skin or mucous membrane particularly the conjunctiva (Houdemer, 1926; Botero and Gomez, 1958).

Hymenolepiasis. The dwarf tapeworm, Hymenolepis nana, is cosmopolitan in its distribution but appears to be commoner in warm climates. Heavily infected foci have been found in parts of USSR (Samarkand) and Indo-Pakistan. Stoll (1947) estimates 20 million infected persons, two-third of them in Asia. Children between the ages of four and nine years are more commonly infected than other age groups. Rats and mice are commonly infected with the same species or a closely allied variety (H. nana var. fraterna) but opinions differ as to the extent to which rodents act as sources of human infection. Experimentally, children can be infected with the murine species and vice versa but certain differences in the facility of development in the reciprocal host have been observed. It appears that man is the chief source of his own infection, though there is epidemiological evidence that infection of murine origin also takes place.

An allied tapeworm, H. diminuta occurs in rats, mice and other rodents but accidentally infects man and dog. This tapeworm uses several species

of arthropods as its intermediate hosts. These include rat fleas, cockroaches and the meal-worm beetle which are liable to contaminate human food. Human cases have been observed in Japan, the Philippines, Indo-Pakistan, USSR and several other countries.

Dipylidiasis and other tapeworm infections. The dog tapeworm Dipylidium caninum is a cosmopolitan parasite of dogs, cats and wild carnivora. Human beings, particularly children, are accidentally infected through contact with dogs and cats. It is generally assumed that if an infected dog licks the face of a child shortly after crushing an infected flea, the cysticercoid may be deposited on the face or hand resulting in the ingestion of this infective stage by the child (Moore, 1962).

Bertiella studeri is a parasite of primates but has been found in man in Africa, South America, India, Indonesia and the Philippines. Human infection is accidental and results from swallowing infected oribatid mites which act as intermediate hosts. Raillietina madagascariensis, a parasite of rats, has been occasionally found as an accidental parasite of man in the Philippines, Thailand and Mauritius. It is common in rats in northern Taiwan. Cockroaches are believed to serve as intermediate hosts. Inermicapsifer cubensis, another parasite of rats, has been found in man in Kenya and is endemic in Cuba. The majority of human infections are in children one to three years of age.

V NEMATODA

Most of the large number of nematode species parasitic in man and animals are so host specific that they are not interchanged in spite of frequent opportunities of doing so. Only a few (Trichinella, Dracunculus, Strongyloides, etc.), occur in many host species including man. Some

species produce disease in man as erratic larvae though they are incapable of attaining maturity in this host.

Strongyloidiasis. Strongyloides stercoralis is a cosmopolitan parasite of man, particularly in warm and moist areas with poor hygiene. Its distribution generally parallels that of hookworms but it is rare in certain areas in China where hookworms are highly prevalent. Stoll (1947) estimates about 35 million human infections in the world, of which 21 million are in Asia. Man is believed to be the chief source of his own infection. Where conditions of moisture and warmth are suitable, the worm can multiply in the soil, thus producing enormous numbers of larvae capable of penetrating the human skin. One of the extraordinary features of skin infection with Strongyloides larvae is the amazingly rapid speed with which the burrows advance. Another interesting feature is the so-called auto-infection produced by larvae which apparently mature in the mucus-faeces medium at the anus and penetrate directly into the skin of that area producing urticarial swellings which often take the advancing linear character of 'creeping eruption' (Weiner, 1960). Certain primates and dogs are found infected in the endemic areas but they are considered to have acquired infection from human reservoirs. Related species of Strongyloides occur in domestic animals but they are not capable of establishing themselves permanently in the human intestine.

Trichostrongyliasis. The small bursate worm Trichostrongylus orientalis is a common parasite of the rural populations in Iran and the Far East and probably remains confined to man. Other species (T. colubriformis, T. probulurus, T. virtinus, T. axei, etc.), have been found in man and herbivorous animals in various parts of the world and are being encountered with increasing frequency in surveys of helminth parasites of man. Stoll (1947) estimated the world incidence of trichostrongyliasis at 5.5 million human cases. Watson (1953) has raised this estimate to

58 millions on the ~~basis of his own experience and that~~ of others since Stoll's estimate. He himself found 25.4 per cent of 335 persons infected in Basrah, Iraq. In Iran, Biocca et al. (1960) detected trichostrongyliasis in 7% of the ~~persons examined in some areas~~. Human infection is apparently acquired by ingestion of greenstuffs and water polluted with infective larvae derived from the faeces of herbivora which are the natural hosts. Infective-stage larvae can survive on greenstuffs for as long as 15 months and withstand severe aridity. Herbivora are also readily infected with strains of human origin. Infections in man are generally light and symptomless.

Other trichostrongylid parasites of ruminants which have been rarely found as accidental parasites of man are Ostertagia ostertagi, O. circumcincta, Haemonchus contortus and Mecistocirrus digitatus. The last named species is a fairly common parasite of cattle, buffaloes, sheep and pigs in China, Japan, Malaya, Burma and India, but has been seen once in human faeces in Hongkong.

Ancylostomiasis. The two principal hookworms of man, Ancylostoma duodenale and Necator americanus, have both been identified from dogs, cats, pigs, gorillas and other animals. Even if all these identifications are correct, animals do not appear to play any important part in the epidemiology of these infections in man. Three species of animal hookworms A. braziliense, A. caninum and Uncinaria stenocephala are infrequent or rare parasites of the human intestine but frequently cause local cutaneous reactions at the site of larval penetration. The larvae of A. braziliense cause indurated reddish papules at the point of penetration into human skin. In two or three days, narrow, linear, wavy, red tunnels, 1 to 2 mm in diameter, apparently produced by migrations of the larvae become prominent ("creeping eruption"). The lesions itch, especially at night, and scratching may lead to secondary infection. The most common location of these lesions is on the hands and feet, but they may occur on any part of the body. They persist for weeks. Beaver (1957) has however opined that the assumption that A. braziliense causes creeping eruption is to be regarded as faulty unless further experimental proof is forthcoming. These larvae do not cause creeping eruption in the skin of dogs, cats, rats, guinea-pigs or monkeys, although nodular lesions are produced on the skin of monkeys. Creeping eruption has been recorded frequently in the gulf states in USA and probably occurs in the Far East and South America where A. braziliense occurs. Human infection is usually contracted, during contact of exposed parts of the body with moist earth or sand to which infected dogs and cats have access.

The larvae of A. caninum and Uncinaria stenocephala generally set up a transient inflammation of the skin with itching, induration and urticaria in 48 hours. The lesions do not show the linear tunnels of the creeping eruption and disappear within a few days to two weeks. Ancylostoma malayanum, a parasite of the Himalayan and Malayan bears has been recorded as occurring in man.

Ascariasis. Ascaris lumbricoides of man and of the pig are morphologically identical and similar forms have been recorded from the muskrat (Tiner and Chin, 1948), squirrels and monkeys. There is experimental evidence to show that the human and porcine parasites are host specific races and the human parasite does not attain maturity in the pig. Cameron (1958), however, considers that in the temperate northern regions, where swine infections are heavy, the infrequent human infections are of porcine origin.

Toxocarosis. The dog ascarid, Toxocara canis is a cosmopolitan parasite of dogs and the adult worm has once been recorded from the human intestine in Egypt. It is, however, more important as a human pathogen in the larval stage as the so-called "visceral larva migrans". A very large number of eggs are passed out in the faeces of infected puppies three weeks to six months old. Counts as high as 15,000 ova per gram of faeces have been recorded (Sprent and English, 1958). The eggs are highly resistant and may survive in the soil for years; they are sticky and adhere to any objects that may come in contact with them. Thus, in a short time, the surroundings of infected puppies (which may also be the human environment) become heavily infected. The embryo in the egg moults and becomes the second-stage larva. At this time, the egg is infective and may be swallowed by dogs or human beings (children of dirt-eating age). The larvae hatch in the small intestine of the child and enter the blood stream thus reaching the liver, lungs, brain and other viscera. In the tissues through which they migrate, they cause large linear necrotic lesions. Ultimately, they become encapsulated in dense connective tissue but remain alive for many years. Beaver (1958) has studied in Singapore, a typical case of a syndrome known for a long time as "tropical eosinophilia" and considers it to be identical with visceral larva migrans. This condition is not confined to children. Chaudhuri and Saha (1959) have experimentally set up "tropical eosinophilia" in a volunteer who received 100 embryonated eggs of T. canis by mouth. However, tropical eosinophilia appears to be a condition with multiple etiology and some other

helminthic infections may also be implicated in its causation.

Another syndrome ascribable to visceral larva migrans is an eosinophilic granulima of the eye which has been suspected of being retinoblastoma (Wilder, 1950; Ashton, 1960) and this suspicion has often resulted in unnecessary enucleation of the eyeball.

Other species of Toxocara (T. cati and T. leonina) are probably also capable of causing the foregoing lesions in man (Gibson, 1960). T. canis larvae are potentially pathogenic for the pig in the same way as for man (Done et al., 1960).

It may be added that human infections with Toxocara spp. of animals are not erratic parasitism but "paratenesis". This phenomenon is seen in helminth parasites of predators which pass the larval stage in one or more animals preyed on (Beaver, 1962).

Gnathostomiasis. Gnathostoma spinigerum occurs in the stomach of cats, dogs and wild felines in Japan, Korea, China, Indo-China, Malaya, Thailand, Burma, Indo-Pakistan and Australia. Several cases of human infection with immature worms are known from the western Pacific, Indo-China, India and Australia. In the course of its development, the worm utilizes two intermediate hosts, a Cyclops and a fish, frog or snake. The definitive animal hosts acquire infection by eating the second intermediate host. Man is probably infected in the same manner but the worm fails to develop to maturity. Human infection is also possible through accidental ingestion of infected Cyclops. Gnathostoma hispidum, a parasite of swine and cattle, has been recorded as a parasite of the sub-cutis of man in Japan (Morishita, 1924), and China (Chen, 1949). For a comprehensive review of gnathostomiasis see Miyazaki (1960).

Dracunculosis. The guinea-worm Dracunculus medinensis is a widespread parasite of man in Africa, western Asia and South America. Rare human infection has been reported from Korea and a case in a dog is known from China. Several species of Cyclops act as intermediate hosts and human infection takes place through ingesting these crustaceans with raw water. Tanks and step wells are liable to get infected as affected humans and animals can wade through them or wash themselves on the banks.

Filariases. Filarioid worms have been generally regarded as specific to one or two closely allied host species, but recent work has revealed that certain species (e.g. Brugia malayi) are adapted to living in several host species. This makes filarial infections, actually or potentially important zoonoses.

Lympatic filariasis caused by B. malayi has a widespread but patchy distribution in South-east Asia from Korea to New Guinea and extends westward to India and Ceylon. The incidence is highest in water-logged rural areas where the mosquito vectors find suitable breeding places. Recent work in Malaya (Laing et al., 1960) has shown that the dusky leaf-monkey (Presbytis obscurus), the long-tailed macaque monkey (Macaca irus), the pangolin (Manis javanica), the wild cat (Felis bengalensis) and the domestic cat are all infected in nature. Because of the high infection rate in leaf-monkeys they have been regarded as important reservoir hosts while the infection in the domestic cat is believed to be incidental to man. Experimental transmission of the human infection to several animal species has been affected (Edeson and Wharton, 1958). B. pahangi a closely allied species of filarial worm occurs in a wide range of animals in Malaya but human infections have not been encountered in nature. Experimentally, this worm can be transmitted to human beings (Edeson & Wilson, 1964). Three other species (B. patei, B. buckleyi and B. ceylonensis) are as yet unreported from man. A microfilaria of man described from Madagascar under the name Wuchereria bancrofti var. vauceli is morphologically allied to B. malayi (Galliard, 1959) and may occur in animals.

Loa loa of man has been reported from African primates and there are other species of Loa occurring in several African monkeys. Recent work on the possibilities of cross infections between man and monkeys tends to show that under natural conditions such cross infection must be rare. There are separate host-vector complexes, the human infection involving man and the vector flies Chrysops silacea and C. dimidiata. The simian infection involves the various monkey hosts and the vector flies Chrysops langi and C. centurionis (Watson, 1960).

Acanthocheilonema perstans and A. streptocerca occur in several areas of tropical Africa, the former extending also to South America. Chimpanzees in Africa have been found infected but they do not appear to play any important role in the epidemiology of the human infection.

Trichinosis. Trichinella spiralis is a small nematode parasite of the muscles and intestine which is able to occur as larva and adult in the same individual. It has a wide host range and occurs in more than 25 mammalian species. Human infection is generally contracted from pork. The infection is cosmopolitan and particularly common in North America, the Arctic Regions and

Europe. Stoll (1947) estimated 27 million infected persons. The infection is relatively unimportant in the tropics and in the orient though small epidemics have been recorded in Kenya and Thailand. Recent work in Alaska (Rausch, 1953) has revealed the presence of Trichinella larvae in the flesh of several species of boreal carnivorous mammals including bears (Ursus and Thalarctos) which are eaten by the Eskimos. The larvae were also detected in white whale and seals but these animals are not likely to be important as sources of human infection.

Trichuriasis. The whipworm, Trichuris trichiura, is a cosmopolitan parasite of man which is particularly abundant in warm regions with high rainfall. Its incidence generally coincides with that of Ascaris, like which it flourishes in areas where untreated nightsoil is used as fertilizer. Trichuris trichiura has been reported from monkeys, lemurs and swine but there is no evidence that these animals play any part in the epidemiology of the infection in man. On the other hand, T. vulpis the whipworm of dogs has occasionally been found in children.

Angiostrongylosis. Recently Angiostrongylus cantonensis, a lungworm of rats has been found in the cerebrospinal fluid, brain and eyes of persons suffering from eosinophilia meningo-encephalitis in Hawaii, Tahiti, Thailand and other countries in the western Pacific. Human infection takes place from eating raw carrier hosts like slugs, land planarians and prawns. A dish consisting of grated coco-nut and prawn juice ("taioro") is popular in Tahiti and other Pacific islands. Infection through the skin in persons walking barefoot on infected ground has also been suspected (Alicata and Brown, 1962).

Other nematode infections. Capillaria (Hepaticola) hepatica, a parasite of the liver of rats, mice, hares, beavers, muskrats, peccaries and monkeys has been reported from man in India and South Africa. Probably, the infection is not uncommon in rat infected localities but is not easily detectable except on postmortem examination.

The kidney worm of dogs and other animals, Dioctophyme renale, occurs in China, America and Europe. A few cases of human infection are known but the infection is necessarily rare. (This worm is the largest nematode known and may attain a length of one metre). Syphacia obvelata, an oxyurid parasite of the large bowel of rats and mice is cosmopolitan in distribution and has been recorded once from a child in the Philippines. Gongylonema pulchrum is a parasite of the oesophagus of ruminants and has been found a few times under the oral mucosa in man in China, USA (Georgia) and Italy. Dung beetles and cockroaches act as

intermediate hosts. Thelazia callipaeca, the eye-worm of dogs, cats and monkeys has been found in human eyes in China, Korea and India (Friedmann, 1948). A related species, T. californiensis has been reported from man twice in the United States. Raillietina cuneata is a parasite of African monkeys and has been recorded from man in Africa, Caucasia, Israel and South America. An acute abdominal syndrome in persons eating insufficiently-cooked herrings has been described from the Netherlands. Larvae of a fish parasite Eustoma rotundatum were found piercing the wall of the small intestine (van Thiel et al., 1960).

VI ARTHROPODA

Quite a large number of parasitic mites, ticks and insects are interchangeable between vertebrate animals and man. Very often, these parasites attack man when he enters endemic areas or when the original host in the human environment is absent or dead. In some cases, larval stages only attack man (chiggers, maggots, etc). Very often, the arthropod parasites acquired from animals not only cause tissue damage and annoyance but also transmit pathogenic micro-organisms. Evidently, such a vast field cannot be adequately covered in the present review. Only the barest outlines are given below:

Harvest mites or chiggers. Of more than 700 or more species of trombiculid larval mites known, only 46 attack man or domestic animals. Many of the latter occur in the orient and a few transmit tsutsugamushi fever or scrub typhus. The principlal species is Trombicula akamushi and its variant which had been named T. deliensis. It is widespread from Japan to New Guinea and westward to Indo-Pakistan. The recorded hosts include dog, cat, cattle, insectivores, marsupials and birds but the principal hosts in nature are rodents. In the river valleys of north-western Honshu, Japan, species of Microtus and Apodemus are important but further south, rats are the most important hosts. In Japan, the trombiculids are abundant in July and August and disappear with the onset of cold in October. In Taiwan they are active for a longer period (April to November) and further south, nearer the equator, they are active throughout the year, their numbers decreasing only in the dry season. In Indo-Pakistan and other parts of southern Asia, they are abundant in grassy areas at the edge of forests and in abandoned cultivable land where rodents are numerous. Man picks up infection while passing through infested grass or when resting on it.

An allied species, T. scutellaris, is believed to be the vector of Schichito fever which has been considered to be the mild winter form of scrub typhus on Izu Islands, Japan. Natural hosts of this mite are rodents and birds. In northern Japan, the larvae appear from September to November but in the Izu Islands its season extends from September to May (Sasa, 1954).

Other important species which attack man in the oriental region are: Trombicula wichmanni, T. hirsti, Schöngastia vandersandei, S. schüffneri, and Neoschöngastia americana. They cause dermatitis but have not so far been proved to transmit any disease. Trombicula autmunalis and T. alfreddugesi, the two well known pest chiggers of Europe and America do not seem to occur in the orient. For further information on chiggers reference may be made to Womersley (1952) and Wharton and Fuller (1952).

Blood sucking mites. Several species of mesostigmatic (gamasid) mites parasitic on domestic birds and house-dwelling (domiciliated) birds and rodents, attack man causing painful bites and localized dermatitis. Some of the more common species are: Dermanyssus gallinae of wild and domestic birds, Ornithonyssus bacoti (tropical rat mite) of rats and other rodents, O. bursa (tropical fowl mite) of domestic and wild birds, Laelaps jettmari of wild rodents in Manchuria, Korea and Japan, Haemogamasus pontiger of rodents in Asia, Africa and Europe, and Haemolaelaps glasgowi of rats and mice in the Far East and America. The species occurring on birds have been reported to harbour the viruses of arbor encephalitides and those parasitic on rodents have been found to carry infections of murine typhus, plague, tularaemia and haemorrhagic fever. The exact role of these mites in transmitting infections to man needs further elucidation. The mouse mite (Allodermanyssus sanguineus), however, transmits rickettsial pox to man in USA and the USSR. It occurs in North Africa and has also been found on the black rat (Rattus rattus) in India and West Pakistan (Abdussalam, 1958).

Itch mites or Sarcoptidae. Species of Sarcoptes closely allied to human S. scabiei cause mange in domestic animals. They may be physiological races of a single species or closely allied varieties of it. Human beings develop transient scabies after contact with infected animals particularly camels and dogs. The infection disappears automatically after some time. Experimental transmission of the goat Sarcoptes to a human volunteer has shown that gravid females burrow in soft human skin, lay eggs and cause localized scabies. The larvae that hatch are, however, unable to establish themselves on human skin and the lesions

disappear in about three weeks when the adult mites originally transferred have died. A similarly transient lesion occurs on human skin infected with Notoedres cati. The itch mites of man and animals have been reviewed by Dubinin (1954).

Ticks. Except for Ornithodoros moubata (species complex) which infests human habitations in parts of Africa, all ticks are primarily parasites of domestic and wild animals. They are only accidental parasites of man, who is attacked when he visits various biotopes like forest, bushlands, grasslands, banks of rivers and animal habitations. Some species (Argasidae) live in cracks and crevices of houses and come out at night to suck the blood of man and animals. They are vectors of such important diseases as relapsing fevers, tick typhus, Q fever, tick-borne encephalitides, haemorrhagic fevers, Colorado fever, tularaemia, brucellosis and possibly anthrax. Their bites cause local dermatitis and sometimes toxaemia (tick paralysis).

Several species belonging to the following genera are known to attack man: Argas, Ornithodoros, Ixodes, Hyalomma, Boophilus, Dermacentor, Amblyomma and Haemaphysalis.

Linguatulid infections. The adult parasites of this group which infect man live mainly in the respiratory passages of dogs and snakes. The eggs are voided with the nasal discharge and contaminate vegetation (salads, water-cress, grass, etc.). Man gets infected by eating or chewing raw infected plants. Rarely, infection results from eating raw or insufficiently cooked lymph nodes or livers of sheep or flesh of snakes containing the larvae.

Linguatula serrata, the adults of which normally occur in dogs and the larvae in herbivorous animals, occasionally infects man. It has been found in the anterior chamber of the human eye (Rendtorff et al., 1962) and in the tonsillar crypts. The adults of Porocephalus armillatus occur in pythons and vipers. Human infection is rather frequent in parts of Africa and occurs in Arabia. Post-mortem examinations have revealed an incidence of 23 per cent. in the Congo, 5 per cent. in West Africa and 7 per cent. in the Cameroons. A related form, P. moniliformis, occurs in China, Indonesia and the Philippines.

The bugs (Hemiptera). The family Cimicidae has about 40 known species of which two are commonly associated with man as bed bugs, Cimex lectularius and C. hemipterus. The former is the bed bug of temperate areas and the latter of the tropics. It is not uncommon to find both species in the same country but they seldom occur together in the same house. These bugs can easily get

established on colonies of laboratory animals such as guinea-pigs and rabbits. Other species of this family are parasitic on bats, and birds and some are potential feeders on man. Cameron (1958) has suggested that the bed bugs were also acquired by man from bats and birds.

The family Triatomidae has several species of the genera Triatoma, Eutriatoma, Rhodnius, Panstrongylus and Eratyrus which attack man. Ordinarily they infest burrows of rodents and armadillos, and chicken houses. In the absence of these animal hosts they enter houses and feed on man. They hide in cracks and crevices during the day and feed at night. They transmit Trypanosoma cruzi and T. rangeli to man. The bite of some species is painful. Nearly all occur in the Americas but on species (Triatoma rubrofasciata) is found in South China, Sumatra and Hawaii.

Fleas (Siphonaptera) are somewhat host specific even though they attach themselves temporarily to the skin of the host for feeding. They are generally numerous on nest building rodents. Certain species attack domestic mammals or house rats and mice and are cosmopolitan in distribution. Others are restricted to certain areas along with their hosts. Those which attack man in addition to animals are: Pulex irritans (cosmopolitan), Xenopsylla cheopis (tropics), X. astia (India, Burma, Ceylon), Nosopsyllus fasciatus (temperate zones, Mongolia, Asiatic parts of USSR) and Ctenocephalides canis (cosmopolitan). Tunga penetrans or the chigoe attacks man and other mammals in South America from where it was introduced to, and became established in Africa. The adult female burrows in the skin and lays her eggs there, causing painful sores and abscesses. The bites of other fleas are practically harmless for many persons but some are sensitive and suffer the formation of itchy, erythematous papules and even pustules. It is, of course, well known that fleas transmit certain micro-organisms and helminths to man. For a review of the transmission of diseases and infections by fleas, see Jellison (1959).

Myiasis. The invasion of living tissues of man or animals by fly larvae is called myiasis. Except for a single species, the Congo floor maggot (Auchmeromyia luteola) which is confined to man, all the others known to attack man also attack animals. Indeed, most of them are more commonly parasitic in animals, which may be regarded as reservoir hosts. The flies that cause myiasis in man belong to several families of Diptera and have been described in a monograph by James (1947). Some of the more common types of myiasis may be

mentioned here. The tropical warble fly (Dermatobia hominis) attacks human beings associated with animals. The female fly deposits its eggs on mosquitos, flies, ticks and other insects but particularly on the mosquito, Psorophora lutzii. On coming in contact with human (or animal) skin the larvae hatch out of eggs, penetrate the tissues and remain in the sub-cutaneous tissue for about 10 weeks or less. They cause small swellings which itch. If crushed in situ allergic reaction may result.

The ox warble larvae (Hypoderma bovis and H. lineatum) as well as horse bots (Gasterophilus intestinalis, G. nasalis and G. haemorrhoidalis) penetrate the human skin and migrate in the sub-cutaneous tissue, thus causing a creeping eruption. The larvae of the sheep and horse gad flies (Oestrus ovis and Rhinoestrus purpureus) mainly attack the eyes of shepherds and others associated with animals. The larvae burrow through the conjunctiva or the skin to reach the orbital fossa and sometimes even penetrate the eye-ball. Sometimes, the larvae are deposited in the nose and migrate to the naso-pharynx.

Chrysomyia bezziana is a calliphorine fly common in the Oriental and Ethiopian regions. In certain areas it is the commonest cause of blown wounds. It also lays its maggots in the nares, conjunctiva, ear or vagina. It will larviposit on living animals and man but not on carcasses. The Tumbu fly, Cordylobia anthropophaga of tropical Africa deposits its eggs on sand or clothes polluted with animal excrement. The larvae which hatch penetrate the intact skin of man (bare feet) and animals which comes in contact with the infested area.

VII CONCLUDING REMARKS

In spite of host specifity being the general rule among animal parasites, man is subject to attacks by a number of important parasites of animals. A large number of them are derived from domestic animals particularly the dog and the pig. Of the wild animals, rodents appear to be the most important sources of human infection. Quite a large number of zoonoses caused by animal parasites occur in Africa, the Oriental Region and the neighbouring areas of the Far East. Trematode infections, with schistosomiasis at the head of the list, appear to be quite prominent in the latter region.

In controlling these infections, the application of sanitary measures needs to be supplemented substantially by health education of the people. Many of the infections can be easily avoided by slight changes in food habits and socio-cultural or agricultural practices. In other cases, the wearing of shoes or certain type of dress may be enough to ward off infection. The development of cheaper and more effective anthelmintics, molluscicides, pesticides and insecticides will make the undertaking of mass control programmes possible. Furthermore, the development of simple but specific serological and other diagnostic tests will help not only in epidemiological investigation but also in control of the various infections.

REFERENCES

Abdussalam, M. (1958). Proc. X. Pak.Sci.Conf., 3, 11 (Reprint).

Abdussalam, M. and Amin, M. (1955). Proc. VII.Pak.Sci.Conf., 3, 8 (Reprint).

Alicata, J.E. and Bonnet, D.D. (1955). Proc. Helm.Soc.Wash., 23, 106 108

Alicata, J.E. and Brown, R.W. (1962). Canad.J.Zool., 40, 755-760

Anantaraman, M. (1958). Ind.J.Helm., 10, 46-52.

Ansari, N. and Faghih, M. (1953). Ann. Parasit., 28, 241-246

Ashcroft, M.T. (1959). Ann. Trop. Med. Parasit., 53, 137-146

Ashton, N. (1960). Brit.J. Ophthal., 44, 129

Azar, J.H. (1964). Amer.J. trop. Med. Hyg., 13, 582-583

Beattie, C.P. (1960). In Human Toxoplasmosis, pp. 175-183. Copenhagen.

Beaver, P.C. (1957). Amer. J. Trop. Med. Hyg., 6, 433-437

Beaver, P.C. (1961). Mimeographed document WHO/Helminth/2 Add.2, pp. 1-22

Beaver, P.C. (1962). Bull. Soc. Path. exot., 55, 555-576

Bedier, E. and Chesneau, P. (1924). Bull. Soc. Path. Exot., 22, 331-334

Bhalerao, G.D. (1931). Rec. Ind. Mus., 33, 475-482

Bickerstaff, E.E. (1955). Brit. Med. J., 1, 1055 1058

Biche, Y. and Thienpont, D. (1959). Ann. Med. Vet., 103, 27-35

Biocca, E., Paggi, L. and Grechia, P. (1960). Parassitologia, II, 345-352

Botero, D. and Gomez. J.J. (1958). Amer. J. Trop. Med. Hyg., 7, 597-599

Bruce-Chwatt, L.J. (1960). Simian Malaria in its Relationship to Malaria Eradication, pp. 1-25. Mal/Exp.Com.8/WP/32 (Mimeographed).

Buckley, J.C. (1938). J. Helm., 16, 117-120

Cameron, T.W.M. (1956). Parasites and Parasitism., London

Cameron, T.W.M. (1958). Ann. N.Y. Acad. Sci., 70, 564-573

Cawston, F.G. (1930). J. Trop. Med. Hyg., 33, 292

Chaudhury, R.N. and Saha, T.K. (1959). Lancet, II, 493-494

Chen, H.T. (1949). J. Parasitol., 35, 431-433

Cobbold, T.S. (1896). Entozoa, London

Coudret, J. and Triozon, F. (1957). Presse Medicale, 65, 1586-1588

Craig, C.F. and Faust, E.C. (1955). Clinical Parasitology, Philadelphia.

Curran, J.A. and Feng, S.T. (1930). China Med. J., 44, 891-904

Davey, D.G. (1958). Amer. J. Trop. Med. Hyg., 7, 546-553

Dobell, C. (1931). Parasitology, 23, 1

Done, J.T. Richardson, H.D., and Gibson, T.E. (1960). Res. Vet. Sci., 1, 133

Dubinin, V.B. (1954). Chestochniye Kleshchi (Range Mites), Moscow

Edeson, J.F.B. and Wharton, R.H. (1958). Trans. Roy. Soc. Trop. Med. Hyg., 52, 25-45

Edeson, J.F.B. and Wilson, T. (1964). Ann. Rev. Ent., 9, 245-268

Eyles, D.E., Coatney, G.R. and Getz, M.E. (1960). Science, 132, 17 June

Fain, A. (1956). Ann. Soc. belg. Med. Trop., 36, 679-688

Fain, A. and Vandepitte, J. (1957). Nature, 179, 740

Faust, E.C. (1949). Human Helminthology, Philadelphia

Faust, E.C. (1955). Infections produced by animal parasites, in Hull's Diseases Transmitted from Animals to Man, pp. 414-432. Springfield, Ill.

Friedmann, M. (1948). Antiseptic, 45, 620-626
Froyd, G. (1960). J. Parasit., 46, 491-496
Froyd, G. and Round, M.C. (1960). Res. Vet. Sci., 1, 275-282

Galliard, H. (1959). Bull. Soc. Path. exot., 52, 578-582

Garnham, P.C.C. (1954). Proc. Linn. Soc., London, 165, 61

Garnham, P.C.C. (1959a). Med. Press, 242, 251-256

Garnham, P.C.C. (1959b). Riv. Parasit., 220, 273

Garnham, P.C.C. (1962). Sci. Repts. Ist. Super. Sanita, 2 (1962), 76-82

Garnham, P.C.C. and Bray, R.S. (1959). J. Protozool., 6, 352-355

Gibson, T.E. (1960). Vet. Rec., 72, 772-774

Ginsberg, A., Cameron, J., Goddard, W.B. and Grieve, J.H. (1956). Bull. epiz. Dis. Afr., 4, 27-39

Hawking, F., Mellanby, H., Terry, R.J., and Webber, W.A.F. (1957). Trans. Roy. Soc. Trop. Med. Hyg., 51, 397

Heisch, R.B. (1954). Trans. R. Soc. Trop. Med. Hyg., 48, 449-464

Heisch, R.B. (1956). Brit. med. J., ii, 669-681

Heisch, R.B., McMahon, J.P., and Manson-Bahr, P.E.C. (1958). Brit. med. J., ii, 1203-1204

Heisch, R.B., Grainger, W.E. and Harvey, A.E.C. (1959). J. Trop. Med. Hyg., 62, 158-159

Hoare, C.A. (1955). Vet. Rev., 1, 62-68

Hoare, C.A. (1959). Ann. Rev. Ent., 4, 389-414

Houdemer, E. (1926). Bull. Soc. Path. Exot., 19, 802-804

Hsü, H.F. and Li, S.Y. (1953). Thapar Commemoration Volume, 133-138

Hsü, H.F. and Hsü, S.Y.L. (1956). Amer. J. Trop. Med. Hyg., 5, 521-528

Huang, C.T. and Kirk, R. (1962). J. trop. Med. Hyg., 65, 133-138

James, M.T. (1947). The Flies that cause Myiasis in Man. Washington, D.C. Dept. Agric. Misc. Publ. 631.

Jellison, W.L. (1959). Ann. Rev. Ent., 4, 389-414

Jirovec, O. (1959). J. Hyg. Epid. Microb. Immunol., Prague, 3, 28-59

Joe, Lie Kian and Virik, H.K. (1963). J. trop. Med. Hyg., 66, 77-82

Khalil, M. (1923). Proc. R. Soc. Med., 16, 1-6

Knowles, R. and Das-Gupta, B.M. (1934). Ind. med. Gaz., 69, 390

Kozar, Z. (1959). Wiadomosci Parazit., 5, 175-211

Kuntz, R.E. (1955). Amer. J. Trop. Med. Hyg., 4, 383-413

Laing, A.B.G., Edeson, J.F.B. and Wharton, R.H. (1960). Ann. Trop. Med. Parasit. 54, 92-99

Lainson, R. (1955). Ann. Trop. Med. Parasit., 49, 384

Latyshev, N.I., Kryukova, A.P., and Povalishina, T.P. (1951). Problems of Regional Gen. and Exp. Parasit. Med. Zool., 7, 35-62 (In Russian) Abst. in Trop. Dis. Bull., 51, 37-40

Le Roux, P.L. (1949). Cited by Craig and Faust (1953).

Le Roux, P.L. and Darne, A. (1955). Trans Roy. Soc. Trop. Med. Hyg., 49, 292

Li, C.H. (1957). Nat. Med. J. China, 43, 259-265. Abst. in Chin. Med. J., 75, 513, 1957

Louw, J.H. and Wilkie, M. (1956). S. Afr. Med. J., 30, 1157-1165

Maclean, G., Weble, G. and Msangi, A.S. (1958). E. Afr. Med. J., 35, 7.

Marsboom, R., van Parys, O., Drodsky, M. (1960). Ann. Med. Vet., 104, 191-196

Martins, A.V. (1958). Bull. Wld. Hlth. Org., 18, 931-944

Mapes, C.R. (1951). Cornell Vet., 41, 382-432. (See also several subsequent articles in the same journal by Mapes and Krull, and Krull and Mapes on the development Dicrocoelium dendriticum).

de Meillon, B. and Stoffberg, N. (1954). S. Afr. med. J., 28, 1062

Merle, A. (1958). Bull. Off. int. Epiz., 49, 483-500

Miller, J.H. (1959). E. Afr. med. J., 36, 56

Miller, J.H. (1960). Trans. Roy. Soc. Trop. Med. Hyg., 54, 44

Miyazaki, I. (1960). Exp Parasit., 9, 338-370

Moore, D.W. (1962). Southwestern Vet., 15, No. 4 (no pages marked on reprint)

Morishita, K. (1924). Ann. Trop. Med. Parasit., 18, 23-26

McMullen, D.B. and Harry, H.W. (1958). Bull. Wld. Hlth. Org., 18, 1037-1047

Nash, T.A.M. (1960) . Trop. Dis. Bull., 57, 973-1003

Nelson, G.S. (1960). Trans. Roy. Soc. Trop. Med. Hyg., 54, 301-324

Okoshi, S. (1958). Rep. Conf. Reg. Parasit. O.I.E. Alma-Ata. No. 25, 1-7

Oliver, L. (1953). J. Parasit., 39, 237-246

Pesigan, T.P., Farooq, M., Hairston, N.G., Jauregni, J.J., Garcia, E.G., Santos, A.T., Santos, B.C. and Besa, A.A. (1958). Bull. Wld. Hlth. Org., 18, 345-455

Petreshcheva, P.A., Zasukhin, D.N. and Safyanova, V.M. (1963). In Human Diseases with Natural Foci, pp. 282-346. Moscow Foreign Languages Publishing House.

Pifano, C.F. (1954). Arch. Venez. Patol. Trop. Parasit. Med., 2, 89-120. Abst. in Trop. Dis. Bull., 52, 881

Pitchford, R.D. (1959). Trans. Roy. Soc. Trop. Med. Hyg., 53, 213

Rausch, R. (1953). Proc. XV Int. Vet. Congr., 1, (2), 1165-71

Rausch, R. and Schiller, E.L. (1956). Parasitology, 46, 395-419

Rausch, R. and Morishita, J. (1957). Proc. Helm. Soc. Wash., 24, 128-133

Rendtorff, R.C., Deweese, H.W. and Murrah, W. (1962). Amer. J. trop. Med. Hyg., 11, 762-764

Report (1960). WHO/CCTA African Symposium on Bilharziasis. WHO/AFR/Bilharz/13, pp. 1-50 (mimeographed).

Sadun, E.H. (1957). Amer. J. Trop. Med. Parasit., 6, 416-422

Sasa, M. (1954). Jap. J. Sanit. Zool., 4, 233-251

Schwabe, C.W. and Daoud, K.A. (1960). Epidemiology of Echinococcosis in the Middle East. pp. 1-27, (mimeographed). Beirut.

Shikhobalova, N.P. (1955). Gelmintosi obshchiye chelaveku i zhivotnym (Helminthiases common to man and animals), Moscow.

Skrabalo, Z. and Deanovic, Z. (1957). Doc. Med. Geogr. Trop., 9, 11-16

Sprent, J.F.A. and English, P.B. (1958). Aust. Vet. J., 34, 168

Stoll, N.R. (1947). J. Parasit., 33, 1-18

Strong, J.P., McGill, H.C. and Miller, J.H. (1961). Amer. J. trop. Med. Hyg., 10, 25-32

Thiery, G. and Morel, P. (1956). Rev. Elev. 9, 343 (quoted by Hoare, 1959)

Tiner, J.D. and Chin, T.H. (1948). J. Parasit., 34, 253

Van Hoof, L., Henrard, C. and Peel, E. (1942). Rec. Trav. Sci. Med. Congo-Belge, 1, 53-68

van Thiel, P.H., Kuipers, F.C. and Roskam, R. Th. (1960). Trop. geogr. Med., 2, 97-113

Urquhart, G.M. (1958). Bull. epiz. Dis. Afr., 6, 381-388

Varma, A.K. (1955). J. Ind. Med. Ass., 25, 173-175

Vogel, H. (1960). Zeit. Tropenmed Parasit., 11, 36-42

Walkiers, J. (1928). Ann. Soc. belg. Med. trop., 8, 21

Walkiers, J. (1930). Ann. Soc. belg. Med. trop., 10, 379

Walton, B.B., Bauman, P.M., Diamond, L.S. and Herman, C.M. (1958). Amer. J. Trop. Med. Hyg., 7, 603-610

Watson, J.M. (1953). Parasitology, 43, 102-109

Watson, J.M. (1960). Medical Helminthology. London

Watson, J.M. and Kerim, R.A. (1956). J. trop. Med. Hyg., 59, 147-154

Weiner, D. (1960). Vet. Med., 55, 39-50

Weinstein, P.P., Krawczyk, H.J. and Peers, J.H. (1954). Amer. J. Trop. Med. Hyg. 3, 112-119

Wharton, G.W. and Fuller, H.S. (1952). A Manual of the Chiggers, Mem. Ent. Soc. Wash., No. 4, 185 pp.

Wilder, H.G. (1950). Trans. Amer. Acad. Ophthal, Otolaryng., 55, 99

Willet, K.C. and Fairbairn, H. (1955). Ann. Trop. Med. Parasit., 49, 278-292

Womersley, H. (1952). Rec. S. Austral. Mus., 10, 1-673

Wright, W.H. (1947a). Ann. N.Y. Acad. Sci., 48, 553-574

Wright, W.H. (1947b). Nat. Inst. Hlth. Bull., 189, 1

Wright, W.H. (1950). Bull. Wld. Hlth. Org., 2, 581-595

Yarwood, G.R. and Elmes, B.G. (1943). Trans. Roy. Soc. Trop. Med. Hyg., 36, 347

Yokogawa, S., Cort, W.C. and Yokagawa, M. (1960). Exptl. Parasit., 10, 81-137; 139-205