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Autor: Hoeppli, R.
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F Arthropod Infections

I

Bloodsucking Diptera

General Statements

A connection between flies and diseases was widely assumed since ancient times; examples are found in the chapters on malaria, sleeping sickness and uta.

In ancient Mesopotamia the god of disease and death was Nergal, whose emblem was a fly symbol, such as is shown on a cylinder seal in the Pierpont Morgan collection in New York (teste GARRISON, 1929, p. 64)¹.

Baal-zebub, the god of flies, corresponded according to Flavius Josephus to the Greek Zeus Apomuios, the averter of flies (GARRISON, 1929, p. 67).

The connection of certain gods with flies and the fly amulets of the Egyptians indicate that already in antiquity people suspected flies as carriers of diseases.

Mosquitoes

Africa

In many parts of Africa the natives tried to protect themselves against mosquitoes by smoke, produced usually by a fire inside the hut, or as LIVINGSTONE (1857, p. 81) described of the Banagoa tribe, living on the borders of a marsh of the Mababe, north of the Kalahari desert: "Their huts were built on poles and a fire was made beneath by night, in order that the smoke may drive away the mosquitoes which abound on the Mababe and Tamunak'le more than in any other part of the country."

Regarding *Aedes aegypti*, many references are given by CARTER, 1931.

¹ See also: O. KELLER, Die Antike Tierwelt, Leipzig 1909, 1913, vol. II, pp. 448-449.

America

Several early Spanish chroniclers dealing with the Conquest mention mosquitoes; the first is OVIEDO in his *Sumario*, 1526, cap. XLIX.

BERNAL DIAZ DEL CASTILLO (1492–1580), who accompanied Cortés on many of his campaigns, pointed out the great number of mosquitoes, gnats and ticks which attacked the Spaniards, *Historia verdadera de la Conquista de la Nueva España*.

Among the arthropod designs on pottery made by the Pueblo people in the Mimbres Valley, New Mexico, about A.D. 1200, there is a swarm of mosquitoes (H. G. RODECK, 1932).

PISO, 1658, gave two early illustrations of mosquitoes from Brazil. The first illustration of a mosquito-net is probably that by OLAUS MAGNUS, 1555².

Sandflies – *Phlebotomus* sp.

In the chapter on cutaneous leishmaniasis it has been mentioned already that, according to Hipólito Ruiz, who visited Peru from 1777–1788, the native population assumed that the disease was caused by the bite of very small and almost imperceptible insects, called uta (sandflies).

Surret flies – *Tabanidae* (gad flies or horse flies)

D. J. LEWIS, 1952, has given a comprehensive review *Early Travellers's Accounts of Surret flies (Tabanidae) in the Anglo-Egyptian Sudan* with numerous quotations from the writings of travellers between 1790 and 1900.

The biting flies mentioned by the authors are according to LEWIS chiefly *Tabanidae*. So far some 70 species of *Tabanidae* have been found in the Sudan. Several of them are very destructive to camels and cattle by their biting, some transmit diseases such as the 'Guffer' disease (trypanosomiasis) of camels. In the Sudan these flies are the cause of the annual migration of the Arabs and their animals. The name 'surreta' (plural surret) is used by the nomadic Arab tribes in the Sudan for various species of *Tabanidae*.

The first report on surret flies was given by JAMES BRUCE³, 1790, from his observations made in 1772 when he entered the Sudan from Ethiopia. His publication *Travels to discover the*

² OLAUS MAGNUS 1490–1557.

³ JAMES BRUCE 1730–1794.

Source of the Nile (first edition 1790) was strongly criticized as many of his statements seemed incredible and his report on the destructive effect of the surret flies greatly exaggerated.

The fly (*Pangonia magretti*) was called *Tsaltalya* in Ethiopia and *Zimb*⁴ in modern Arabic.

J. BRUCE speaking of the Cushite in his work (vol. II, Chapter II, p. 314, second edition) writes:

"His mountains, and the cities he built afterwards, were situated upon a loamy black earth, so that as the tropical rains began to fall, a wonderful phenomenon deprived him of his cattle.

Large swarms of flies appeared wherever that loamy earth was . . . As soon as this plague appears, and its buzzing is heard, all the cattle forsake their food and run wildly about the plain, till they die, worn out with fatigue, fright and hunger. No remedy remains but to leave the black earth and to hasten down to the sands of Atbara; and there they remain while the rains last, this cruel enemy never daring to pursue them farther."

J. BRUCE gave a description of the fly and a rather crude figure of the insect is found in the 4th edition (1813), vol. VII (VIII) no. 39. He was criticized as a travel liar who perhaps had never been to Abyssinia, but gradually it was found that although inexact in numerous details, his statements were essentially true.

The report of Sir SAMUEL BAKER⁵, 1867, one of the great travellers in Africa, confirmed BRUCE's statements concerning the effect of surret flies.

BAKER gave an account of the attacks of the 'seroot' and other flies on man, camels and wild animals. "When this fly attacks an animal or man, it pierces the skin instantaneously, like the prick of a red hot needle driven deep into the flesh, at the same time the insect (p. 185) exerts every muscle of its body by buzzing with its wings as it buries the instrument to its greatest depth. The blood starts from the wound immediately and continues to flow for a considerable time . . ." "It was said that of domestic animals only the goat could survive the bites of the fly and that donkeys did not graze when attacked" (quoted from LEWIS, 1952), who adds several vivid excerpts from BAKER's publication.

Tsetse flies – *Glossina* sp.

E. E. AUSTEN, in his *Monograph of the Tsetse-Flies*, 1903, has given in chapter II an extensive historical survey with valuable

⁴ Zimb corresponds to Zebub in Hebrew.

⁵ Sir SAMUEL BAKER 1821–1893.

comments and in chapter IV a bibliography up to 1899. In order to avoid repetition, only a few points in the medical history of tsetse flies will be discussed.

Africa

The name 'Tsetse' has been explained in various manners. Some authors, e.g. EDMONDS and WALKER, 1929, believe that it is a Zulu word, supposed to resemble the noise made by the fly. BUXTON, 1955, assumes that the word was used in Bechuanaland and signifies a fly destructive to cattle.

The word Tsetse was first used in England in 1849 and soon was found in books on travel in Africa, e.g. by GORDON CUMMING, 1850; LIVINGSTONE, 1857; KIRK, 1865 (see W. E. F. THOMSON, 1960).

R. GORDON CUMMING, 1850, gave the earliest detailed description of the effect of the bite of tsetse flies on horses.

DAVID LIVINGSTONE in his '*Missionary Travels and Researches in South Africa*', 1857, discusses in some detail tsetse (*Glossina morsitans* Westwood 1850) and its destructive effect on domestic animals. He gave a figure of *Glossina* copied from WESTWOOD on the title page of his book and on page 571 the same picture accompanied by a copy of WESTWOOD's figure of the mouth parts and a rough original woodcut made from a drawing by I. E. Gray of the British Museum, representing the fly in nearly natural size.

LIVINGSTONE assumed the existence of a venom which the fly injected by its bite. He writes that "it is well known that the bite of this poisonous insect is certain death to the ox, horse and dog" (p. 80). On the other hand, he found the bite of the tsetse perfectly harmless for man and wild animals; "our children were frequently bitten, yet suffered no harm (p. 82). In LIVINGSTONE's opinion the mule, ass and goat enjoy the same immunity from the tsetse as man and the game (p. 82).

It was very fortunate for LIVINGSTONE that his travelling did not take him into an area with endemic sleeping sickness, as he might have had to revise his opinion that tsetse are perfectly harmless for man.

America

In dealing with sleeping sickness in a previous chapter, it has been pointed out that occasionally negro slaves in an unrecognized early stage of the infection were shipped to the New World, where they developed the typical symptoms and died. In the absence of tsetse flies the infection could not spread. It may be mentioned that fossil tsetse flies (*Glossina*) have been found in Miocene deposit in Colorado (T. D. A. COCKERELL, 1919).

The work on Nagana and on tsetse flies as transmitters by DAVID BRUCE, as well as the work of BRUCE and other investigators on human trypanosomiasis, is well known, and as it has been carried out at the closing of the 19th and in the early years of the 20th century, it is comparatively recent and is not discussed here.

II

Fly larvae — maggots

General Statements

The knowledge of parasitic fly larvae and their destructive effect on host tissue increased considerably both in Africa and the Western Hemisphere in the second half of the nineteenth century (GEDOELST, 1905).

Non-parasitic fly larvae, which develop from eggs of flies deposited in wounds and ulcerations, are only briefly mentioned as not belonging to the subject of our study.

These maggots are known since ancient times and are mentioned already in the nineteenth book of Homer's *Iliad*, when Achilles refers to the wounds of the dead Patroclos and the danger that flies would there produce maggots which would disfigure the body.

In the past, surgeons had sometimes observed a beneficial effect of maggots, as they feed on necrotic tissue and in this way clean the wounds. D. J. LARREY, 1766–1842, Napoleon's famous head of the Army Medical Service, made such observations (note 1).

Since 1930 maggot therapy attracted for a number of years considerable interest as a means of treating badly healing wounds, especially in osteomyelitis (W. S. BAER, 1931). Nowadays treatment by living maggots has been replaced by more convenient and safer methods.

Some early Spanish and Portuguese chroniclers refer to myiasis. SOARES DE SOUSA, 1587, mentions myiasis from Brazil; FRANCISCO ANTONIO DE FUENTES Y GUZMÁN in his *Recordación Florida* (written between 1675–1699) points out the suffering of the Spanish soldiers caused by cutaneous and especially nasal myiasis, and Fray BERNABÉ COBO (1653) knew the 'mosquito-worm', the larva of *Dermatobia cyaniventris*.

There was no transmission by the slave trade.

Only three parasitic fly larvae, known for centuries, will be briefly discussed.

Blood sucking fly larva

Congo floor maggot — Larva of *Auchmeromyia luteola**Africa*

The Congo floor maggot (larve des planchers du Congo) — larva of *Auchmeromyia luteola* (Fam. *Calliphoridae*) is a well known blood sucking fly larva which occurs in Africa south of the Sahara, including the Cape Verde Islands.

The natives were very familiar with it and gave correct information about the habits of the maggots to DUTTON, TODD, and CHRISTY, who published in 1904 the first detailed description from the Congo.

The natives make a clear distinction between the Congo floor maggot and the larva of the Tumbu fly *Cordylobia anthropophaga*. They know that the first one only sucks blood but never enters the skin as the second always does. They also know that it is easy to find the floor maggot even in greater numbers in the huts within the cracks of the mud floor beneath the mats on which people have slept. The larvae only feed at night. The fly deposits its eggs on the ground in the huts, especially where formerly urine has been voided.

Myiasis

Myiasis due to the larva of the Tumbu fly, *Cordylobia anthropophaga*, Grünberg*Africa*

Cordylobia anthropophaga (Fam. *Calliphoridae*) is widespread in Africa, south of the Sahara. In Southern Africa, it has been found as far southwards as the Orange Free State, Swaziland and Natal (ZUMPT, 1959).

The native population knew the Tumbu fly for centuries. In the Senegal it was called 'ver du Cayor'; the Mendi name for the fly is 'Boyeh'; 'Tumbu' is a Negro-Creole word according to F. SMITH, 1908.

The first publication dealing with the infection is by COQUEREL and MONDIÈRE, 1862. In the Senegal these authors studied the successive changes of the skin from the time of infection until the larva leaves through the small opening in the furuncle-like inflammatory swelling.

The native population held the view that the maggots were the product of a small fly which laid its eggs in the moist sand where they developed, and the larvae entered the skin of a person

stretched out on the sand. COQUEREL and MONDIÈRE disregarded the correct opinion of the natives and assumed that the fly deposited its eggs directly on the skin.

Subsequently the fly and the larvae have been studied in detail regarding their morphology and biology, especially their way of infection by many authors. Among these publications the one by BLACKLOCK and THOMSEN, 1923, is particularly valuable.

The result of their work showed that the infection takes place exactly as the natives had stated.

Myiasis due to the larva of *Dermatobia cyaniventris*

America

Dermatobia cyaniventris Marquart (Fam. *Cuterebridae*) occurs in tropical and subtropical America from the border of the United States to Argentina. For many centuries the larva and the skin lesions were well known to the local population of different regions. They also knew to some extent about the unusual way of infection as seen from various local names, e.g. Berne or Verme in Brazil; Beef-worm in Honduras; Nuche or Gusano de mosquito, or Gusano de Zancudo (mosquito worm) in Colombia and Venezuela; Gusano macaco or ver macaque in Cayenne; Saglacuru in the Maya language; Moyocuil in Mexico.

The larva lives in the subcutaneous tissue in a small hole which communicates with the outside by a minute opening. The tissue around the opening is infiltrated, forming a slight wall. The larva inside the hole has a position that its posterior extremity with the stigmata turns toward the opening. With the increase of the larva the skin forms a small boil.

The local population in various parts of South America believed that the larvae were due to mosquitoes which introduced their eggs into the canal which they had made in the human skin when they sucked blood. Already in 1653 the Jesuit Fray BERNARBÉ COBO mentioned the 'mosquito-worm' infection.

The work of NEIVA and GOMEZ, 1917, contributed greatly to the understanding of the way of infection. These investigators observed that the fly catches bloodsucking mosquitoes, e.g. *Janthinosoma lutzi* and flies, holds them for a short time and deposits a number of eggs on their abdomen, which are fastened by a sticky substance (for a good illustration, see GEIGY and HERBIG, 1955). Within 5–10 days the larvae are developed; they open the egg on one pole and wait until the mosquito or fly rests on the skin of a victim to suck blood. The larva then tries to reach the skin and, if successful, enters the skin, causing the lesions mentioned before.

When after several weeks the larva is fully developed, it leaves the skin through the small opening of the boil and drops to the ground to bury itself there; it pupates and becomes a fly.

Just as we have found in the case of the Tumbu fly that COQUEREL and MONDIÈRE disregarded the correct observations and beliefs of the natives concerning the way of infection, the opinion that mosquitoes were connected with *Dermatobia* infection held by the local population in South America was for some time likewise disbelieved by modern investigators, some of whom, for example in Brazil, regarded it as a popular error widely spread among the peasants.

Besides the just discussed three parasitic fly larvae there are many others in Africa and the Western Hemisphere which are here omitted as they are not of historical interest.

Note

Pendant le travail de la suppuration, les blessés furent seulement incommodés des vers ou larves de la mouche bleue, commune en Syrie.

La présence de ces vers dans les plaies paraissait en accélérer la suppuration, causait des démangeaisons inconfortables aux blessés, et nous forçait de les panser trois et quatre fois le jour.

(Footnote p. 311) Malgré l'importunité de ces insectes, ils ont accéléré la cicatrisation des plaies, en abrégant le travail de la nature et en provoquant la chute des escarres celluleuses qu'ils dévoraient. *Mémoires de Chirurgie militaire et campagnes de D. J. LARREY*. Tome I, p. 310. Paris 1812 (Campagne en Syrie).

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III

Scabies – Sarcoptes scabiei

General Statements

For a very long time scabies was not clearly differentiated from various skin diseases of different aetiology which were accompanied by itching. Scabies was known from ancient times and was very common among many races but was apparently rare or absent in some countries. In Japan, for example, it was according to MASAO OTA, 1937, only comparatively recently introduced by foreigners. On the other hand, it was widespread in China since early times. In ancient Egypt it was apparently present. The Smith and Ebers papyri give many remedies for a great variety of skin diseases which, to judge from their well defined clinical concepts, included scabies.

The causative organism, the itch mite, *Sarcoptes scabiei*, was evidently known to the common people from antiquity long before it attracted the attention of physicians and scientists.

The earliest descriptions of the itch mite were given by CH'AO YUAN-FANG, c. A.D. 610, and by the Persian-Arabic physicians AHMAD AL-TABARĪ, second half of the tenth century (note 1), and by AVENZOAR (Abū Marvān ibn Zuhr), c. 1091–1162 (note 2).

Africa

In Africa scabies was frequently called 'craw craw', although this name includes a variety of skin diseases unrelated to scabies. W. F. DANIELL, 1849, reports from the Bight of Biafra about skin diseases: "The one of most prevalency is that denominated by the Bonnians Kraw-Kraw, which is an aggravated form of scabies, attended with much irritation."

It is certain that true scabies due to *Sarcoptes scabiei* was very frequent among negro slaves, as it was pointed out by numerous contemporary writers for example by BRYSON, 1847, dealing with diseases of slaves on slave ships: "Diseases most prevalent amongst captured slaves: crawl-craws (sic) is generally found rife in every cargo of slaves and is frequently communicated to the price crew in the course of the voyage; it principally infects the outer part of the arms from the wrists up to the elbow, but also spreads over the whole of the body if neglected."

French authors also emphasized the frequency of scabies among the negroes on the African West coast. Among early French writers on scabies are CHASSANIOL, 1865; REY, 1880; BORIUS, 1882.

America

Scabies was carried by negro slaves to the New World, where, however, it was most probably already present in pre-Columbian times.

According to a manuscript of the Peruvian Indian Felipe HUAMAN POMA DE AYALA *El primer nueva coronica y buen gobierno*, c. 1613, scabies of man and mange of lamas *sara oncoy or sara papa acuya* were well known in Peru at his time (DIETSCHY, 1938)¹. FRIEDMAN, 1947, p. 52, on the other hand, is inclined to assume that scabies was introduced from Europe into the American continent by the Spaniards and later immigrants.

Notes

1. AḤMAD AL-TABARĪ, the Persian Abu'l-Hasan Aḥmad bin Muḥammad al-Tabarī. A few extracts of the *Kitāb al-Mu'ālaja al-buqrātīya* have been translated by MOHAMED RIHAB (Arch. Gesch. Med. 19, 123–168, 1927; ref. to the itch mite will be found on p. 134, Isis 10, 119, teste SARTON, *Introduction to the Hist. of Science*, vol. 2, 1950, p. 233).

2. AVENZOAR. Statement regarding Soab (itch mite): "Syrones sunt pedicilli subter manuum crurumque et pedum cutem serpentes, et pustulas ibidem excitantes, aqua plenas, tam parva animalcula, ut vix visu perspicaci discerni queant." Quoted from KÜCHENMEISTER, F., and ZÜRN, F. A., 1878–81. *Die Parasiten des Menschen*, 2nd edition, Leipzig, p. 515.

¹ DIETSCHY, 1938, reproduces eleven pictures from the manuscript.

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IV

Ticks

General Statements

Some authors of early historical time have already mentioned ticks and discussed their origin, feeding habits and supposed qualities as remedies. In China, for example, baked cattle ticks were recommended to be taken by children as a remedy and also as a prophylactic for smallpox.

Among Graeco-Roman and later authors dealing with ticks are Aristotle, M. Porcius Cato, Varro, Columella, Pliny, Dioscurides, Galen and Avicenna. Pliny mentions that ticks have no anus. Several writers point out that certain animals are usually heavily infested with ticks, whereas others, such as mules and asses, are not attacked.

It is of special interest that D. R. ARTHUR (1965) published and illustrated what is possibly the oldest record and the oldest figure of ticks. It concerns a fragment of the head of a hyaena-like animal from an Egyptian tomb (tomb No. 155, Dra Abn el-Nago, Western Thebes, dating from the time of Hatshepsut-Thuthmosis III (eighteenth Dynasty about 1500 B.C.). ARTHUR pointed out three excres-

cences on the inside of the ear which had not been mentioned in previous publications dealing with the tomb and the fragment. The reasons for considering the possibility of these excrescences representing ticks are their shape resembling a partially or fully fed condition, their size relative to the pinna of the host and their feeding location on its inner side.

Africa

Ornithodoros sp. In dealing with 'tick-fever' (African relapsing fever) we have mentioned already that it was well known among the indigenous population and also among foreign residents that tick bites are occasionally followed by fever and sickness. Ticks were therefore feared. LIVINGSTONE, 1857, describes the effect of a tick bite from his own experience at Ambaca (pp. 382-383).

A very simplified pottery tick of the Nok period (c. 500 B.C.—c. A.D. 200) is kept in the museum at Jos, Nigeria (plate XX).

America

In the Western Hemisphere the Spanish conquistadores found ticks widespread in the West Indies and on the American mainland.

OVIEDO reports from Espaniola tick infestation of cattle in the fields and of the bullocks drawing carts.

Concerning human tick infestation, OVIEDO states that in certain places ticks are numerous and attach themselves to the skin in such a way that they can only be removed with great difficulty. The Spaniards used acid and the Indians sometimes killed them with fire. The result was always that especially the legs were covered with wounds and ulcerations (OVIEDO, Sumario, 1526, cap. LXXXI).

Note

The papyrus Ebers mentions a plant *qaga* and, in connection with it, refers to a pathogenic agent. VON OEFELE (1901, p. 509) regarded the plant as *Ricinus* and the pathogenic agent as either a tick, *Ixodes* or a louse, *Pediculus*, because their form somewhat resembles that of the fruit of the *Ricinus* plant.

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V

*The Sandflea — Tunga penetrans**A. The early knowledge of Tunga penetrans in America and the West Indies*

The original home of the sandflea are the tropical and subtropical parts of the American continent between about 30° N and about 30° S, and the West Indies. The infection existed long before the arrival of Columbus, as it is represented in pre-Inca Peruvian anthropomorphic pottery vessels, 'huacos' (plate XVI) ¹.

The sandflea became known to the Spaniards soon after Columbus had landed at Guanahani on 12th October 1492. The earliest published report is by OVIEDO in his *Sumario de la natural historia de las Indias*, 1526, chapter VIII (nigua).

In his complete work (1535) OVIEDO gives a more detailed description of the infection. He believed that the sandflea could pass its entire life-cycle on a person, as either the eggs or the larvae were deposited in the tissue and in this way the infection could spread on the same person, an error which was repeated by several later writers.

The parasite is known in different countries under different names. In Brazil it is called 'pulga de areia'; 'bicho do pé'; 'bicho de porco'; 'jatecuba'; in the Spanish parts of South America and Mexico 'nigua' or 'pique', or 'piqui', in the French possessions 'chique'. In the British territories and the United States *Tunga* is called 'jigger'; 'chigoe'; 'sandflea'.

Following OVIEDO, quite a number of writers have mentioned sandflea infection from tropical and subtropical America and the West Indies.

Among the early authors is Gonzalo Ximénez de Quesada (1538), whose manuscripts, as far as the present writer could ascertain, have not yet been printed but have been quoted by Piedrahita, Bishop of Panama, one of the early historians of New Grenada (ROULIN, 1870). In 1558 THEVET (1502–1590) reported sandflea infection from tropical America (see SINGER, 1912, and HOEPPLI, 1959, pp. 214–215).

HANS STADEN, 1557, reported sandflea infection from Brazil and SOARES DE SOUSA, 1587, gave a good description of the effects of *Tunga* from the same country.

¹ MOODIE, 1923, and TELLO, 1924, have likewise illustrated huacos, representing sandflea infection.

BERNABÉ COBO described in detail the infection from Peru and the treatment used by the local Indians. ALEIXO DE ABREU, 1623, likewise mentioned the sandflea from Brazil.

G. PISO (Willem Pies, 1611–1678), who had lived like G. MARCGRAVE (Georg Markgraf, 1610–1644) in Pernambuco during the Dutch occupation of Brazil (ca. 1630–1654), published in 1648 with MARCGRAVE *Historia Naturalis Brasiliae* in twelve books². The first part is by PISO: *De Medicina Brasiliensi libri quatuor*, the second by MARCGRAVE: *Historia Rerum Naturalium Brasiliae libri octo*. Leiden and Amsterdam³.

In part I, cap. XXII *De Externis Malis quorundam Insectorum*, PISO describes sandflea infection: “Minutissimos vermiculos Lusitanis *Bicho*, Brasilianis *Tunga* haec terra nutrit.” They are especially frequent in people who walk barefoot on dry sandy soil. — They have nothing to do with the Guinea-worm. “Nihil cum Guineensibus vermiculis commune habent, qui longi, lati & albicantes chordarum speciem referunt.” If one removes them, it is necessary that the little sac should be taken out intact, as otherwise the infection may spread. For protection Acaju oil is used; it is applied to the soles of the feet and on the toes.

In the seventeenth century DU TERTRE described sandflea infection from the West Indies. He recommended the wearing of shoes for protection.

Among eighteenth century authors are LABAT, 1722 (West Indies), SLOANE, vol. II, 1725 (West Indies), CATESBY, vol. II, 1743, who gave one of the early illustrations of *Tunga* (West Indies and southern part of North America), JUAN & ULLOA, 1748, BAJON, 1777, 1778 (Cayenne and French Guiana), MOSELEY, 1792 (West Indies), CHAPPE D’ANTEROCHE, 1772 (Mexico), GUMILLA, 1745 (Orinoco).

Among writers of the early nineteenth century who refer to sandflea infection is A. von Humboldt, who mentions it in a letter to the Capitán General de Caracas, Manuel de Guevara Vasconcelos, written from Nueva Barcelona 20th August 1800 (teste ARGUMOSA, 1959). Others are WINTERBOTTOM, 1803 (West Indies), and RENGGER, 1832, 1835 (Paraguay).

Just as the Spanish conquistadores in the sixteenth century, the French troops which by order of Napoleon III invaded Mexico in the sixties of the nineteenth century, suffered severely from sandfleas (GUYON, 1870).

Besides the few authors mentioned, there are many others who refer to the sandflea in America and the West Indies. From all

² For biographical data see E. G. JACOB, 1965.

³ PISO published in 1658 a second edition under the title: *De Indiae Utriusque Re Naturali et Medica libri XIV*. Amsterdam.

these publications one may draw the conclusion that *Tunga penetrans* was widely established and known as a pest in tropical and subtropical America and the West Indies when the first Spaniards arrived.

B. The early knowledge of sandflea infection in Tropical Africa

Whereas we have from the first half of the sixteenth century numerous references to *Tunga penetrans* infection from tropical America and the West Indies, where the local population knew how to deal with the infection, corresponding reports from Africa are rare and more recent.

There existed the widespread erroneous belief expressed in numerous publications that the sandflea did not occur in Africa prior to 1872 when it was (re-)introduced by a British ship, the 'Thomas Mitchell', sailing from Rio de Janeiro to Ambriz (Angola). There are, however, a few reports which indicate that in all probability sandflea infection existed in Africa much earlier.

The first report concerns the famous pilgrimage to Mecca in 1324 by Mansa Musa, sultan of Mali. In the chronicles it is stated that the caravan proceeded from Walata by the westerly route northward to Twat and there suffered a considerable diminution by an affection of the feet which involved a large part of the caravan. There is no description of the sickness given and no statement that it was caused by sandfleas. It was anyway a major disaster which incapacitated about one half of the caravan so that it was recorded in the chronicles. There is no proof but a certain probability that the event was due to sandflea infection, SHAW, 1906. (See also TROUSSAINT, 1902.)

HENNING, 1904, has drawn attention to an early publication which in his opinion refers to *Tunga penetrans* infection. SAMUEL BRAUN, a physician of Basle, published in his *Schiffahrten*⁴, Basle, 1624 (Report on his first voyage to West Africa in 1611–13), a description of cases with minute 'worms' under the nails of hands and feet which might have been sandfleas. Other symptoms such as deep tissue destruction near the anus had in all probability nothing to do with *Tunga* infection. BRAUN may have observed patients with a mixture of different unconnected pathological conditions including *Tunga penetrans* infection and myiasis.

⁴ BRAUN made altogether five voyages between 1611 and 1621; three times he went to the West Coast of Africa and twice to the Mediterranean (see HENNING, 1904).

FALKENSTEIN, 1877, stated that *Tunga penetrans* had been observed by ADANSON already in 1759 in Senegal. ADANSON, 1759, p. 298, points out the very large number of sandfleas in the huts of the local inhabitants and the irritation caused by them. Strangely enough he does not mention the burrowing in the skin but points out that the sandflea does not jump higher than 3–4 inches. As he did not speak of the burrowing in the skin, some writers, e.g. KARSTEN, 1865, and HESSE, 1899, expressed the view that the flea observed by ADANSON, cannot have been *Tunga penetrans*.

One has to admit that it is surprising that ADANSON did not speak of the burrowing in the skin. On the other hand, he mentions that the sandfleas were of such a small size that one could hardly see them, that their attack caused a very strong itching and that they could not jump higher than 2–3 inches, which is characteristic for *Tunga*.

Regarding another eighteenth century author, BARBOT, there can be no doubt that he referred to *Tunga*. BARBOT designated himself as Agent-General of the Royal Company of Africa and Islands of America in Paris. His publication *A description of the Coasts of North and South Guinea and of Ethiopia Inferior vulgarly Angola, etc.* was published in an English translation in London in 1732. In Book I, Chapter II, p. 32, he writes:

“Men are here plagued with a sort of handworms which in the Caribee islands in America are called Chiques, and work themselves into the soles of the feet, and the heels, becoming the more troublesome and insupportable, in that they are not to be sorted out, if they have once time given them to lay their eggs there.”

HIRSCH, in his Handbook of Geographical and Historical Pathology, vol. II, p. 364, 1885, refers to a statement by a Russian physician that the sandflea had existed in Africa for a long time. HIRSCH doubted this statement as he could not find any supporting data.

The present author has checked the statement, which is found in *Grum's Gesundheitsfreund*⁵ (Friend of Health) no. 19, pp. 145–147, 1838 (Mittheilung des Staabsarztes SKRIPITZIN, derzeit ältesten Chirurgen des Seehospitals in Cronstadt – Zeitschrift für die gesamte Medizin Bd. 13, Auszüge p. 77, 1840). SKRIPITZIN reports regarding the sandflea:

“Sein Vaterland ist nicht ausschliesslich America, wie bisher ein grosser Teil der Naturforscher glaubt, und ihn deswegen *Pulex americanus* nennt.

⁵ A Russian journal of popular medicine which was apparently well-known in the middle of the 19th century, as it is mentioned in Turgenev's *Fathers and Sons* by the nihilist Bazarov.

Dieser Floh findet sich auch schon bei Negern auf ihrer Überfahrt von Africa nach America vor. Daher findet sich dies Insect in Mozambique, Congo and anderen Gegenden Africa's, mit welchen Negerhandel getrieben wird."

A new development in the history of *Tunga penetrans* infection in Africa begins in 1872 with the arrival of the British ship 'Thomas Mitchell', a sailing vessel of 499 tons, built at Dumbarton on the Clyde in 1851⁶. The ship, which had brought coal from England to Rio de Janeiro, went in ballast from Rio to Ambriz (Angola) where it arrived in September, 1872. The crew suffered from sandfleas, which also infected visitors to the ship. The sandfleas were carried to the shore by the infected persons and also in old coffee sacks (PECHUEL-LOESCHE, 1882, teste HESSE, 1899, p. 523).

Within a short time the local population suffered terribly from *Tunga* infection, especially as the cause of the suffering was at first unknown.

Before the end of 1872, the sandflea had been carried southward to São Paulo de Loanda and northward to the Congo. The rapid spread was due to coastal vessels which called at larger ports along the coast.

While *Tunga penetrans* spread rapidly along the West Coast, its transportation deeper inland needed more time. It took place mainly on the old caravan routes but also by expeditions (e.g. by Stanley's Emin Pasha Relief Expedition of 1887). HESSE, 1899, traced in considerable detail the spread of the sandflea across tropical Africa from the West- to the East Coast, where it was first noticed in 1895. In the same year Senegalese soldiers carried the sandflea to Madagascar (BLANCHARD, 1899); in 1898 it had reached Zanzibar.

It was found not only on the plains but also in the Usambara mountains at an altitude of 1600–1700 meters⁷. Towards the end of the century Indian troops and labourers returning from Africa brought the sandflea to Bombay and later to Karachi.

It has long been known and reported that besides man various domestic and wild animals may be infected by the sandflea. Dogs, cats, mice, rats and especially pigs are important reservoir hosts for the infection of human beings. Future work is needed to find out how many species of sandfleas are involved.

⁶ The writer wishes to thank the National Maritime Museum in Greenwich for the information.

⁷ The altitude at which *Tunga penetrans* is able to exist, depends on the distance of the locality from the Equator.

The question arises why the sandflea did not spread in Africa during the centuries before its reintroduction by the British ship 'Thomas Mitchell' in 1872. The explanation is that there was, apart from traffic on the old caravan routes, not very much communication between the different parts of Africa.

The various tribes had as a rule little contact with each other, except when they were at war or made slave raids.

The rapid spread of *Tunga* across the tropical and subtropical parts of the African continent from the West to the East Coast within about twenty-five years after its reintroduction in 1872 is remarkable.

On the other hand, it is interesting to observe the influence of improved living conditions and of the knowledge of how to remove the parasite from the skin on the prevalence of the infection. BÜTTIKOFER, 1890, on his second visit to Liberia, 1886–1887, found in Monrovia so many people infected with sandfleas that everywhere in the streets one saw persons walking painfully, often with bandaged feet. Nowadays with most people wearing shoes and with improved streets it is very hard as the present writer noticed to find a *Tunga*-infected person in Monrovia.

In summarizing the following may be stated: *Tunga penetrans* infection existed in South America (Peru) in pre-Inca times as proved by its representation in Mochica pottery.

The first published reference to the sandflea in tropical America is by OVIEDO, 1526; in Africa, on the other hand, the first report which undoubtedly refers to *Tunga* is that by BARBOT, 1732. There are even reports from the 14th and the 17th century which may refer to *Tunga* infection in Africa. It is in any case certain that sandflea infection on the West Coast of Africa existed in the eighteenth century and probably much earlier but only in restricted areas. Comparatively few communications, such as existed at that period, are the most likely cause for the limitation of the infection.

It is highly probable that *Tunga penetrans* was introduced many centuries ago from tropical America into Africa. This is indicated by the name 'chique' used in Senegal, which had already been employed for a long time in French Guiana and the West Indies. 'Chique' apparently derived originally from 'Sika', an American Indian word.

The reintroduction of *Tunga penetrans* in 1872 by the British ship 'Thomas Mitchell' was followed by a rapid spread of the sandflea along the African West Coast and subsequently along the old caravan routes across the tropical part of the whole continent.

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VI

Fleas

Africa

In Egypt fleas were known since antiquity. The papyrus Ebers (c. 1555–1335 B.C.) gives several prescriptions to expel fleas from a house, for example sprinkling the walls with natron water (EBBELL, 1937, p. 113).

Fleas existed in tropical Africa and South- and Central America when the first Europeans arrived (notes 1 and 2)¹.

¹ The fleas were probably the cosmopolitan human flea, *Pulex irritans* Linnaeus, 1758, very numerous in North Africa, furthermore the fleas of dogs and cats and *Xenopsylla cheopis* Rothschild, 1903, the common flea on rats in the tropics, also *X. braziliensis* Baker, 1904, in tropical South America.

America

Fleas will have been carried by negro slaves to Central- and South America where they existed already since ancient times as proved by the representation of fleas in terracotta and stone in pre-Columbian art (plate XVII, figs. a & b).

There are references to fleas from the Western Hemisphere in the early Spanish literature.

OVIEDO's statement are given in note 2.

HERNÁNDEZ in his *Historia de los Insectos de Nueva España* states that the Mexicans used a decoction of tobacco which they spread over the walls in order to kill the fleas in a house (personal information by Dr. Somolinos d'Ardois, Mexico D.F.). The method is similar to that used by the Egyptians mentioned before.

FELIPE HUAMAN POMA DE AYALA, 1584–1614, refers to fleas.

BERNABÉ COBO reports that the moderately warm regions of the New World are heavily infested by both the common flea and the nigua (sandflea).

JORGE JUAN and ANTONIO DE ULLOA, 1748, vol. III, gave a similar report from Lima.

It may be mentioned that the Eskimoes apparently did not know fleas before the arrival of the white man (note 3)².

Notes

1. "The people of this island are flea-ridden and the negroes have lice; but the white people do not suffer from them, except for finding an occasional bed-bug in the beds where they sleep." Quoted from *Descriptions of a voyage from Lisbon to the island of São Thomé*, written by an anonymous Portuguese Pilot, c. 1540, p. 165; in "Europeans in West Africa 1450–1560. Documents to illustrate the nature and scope of Portuguese enterprise in West Africa etc." Translated and edited by JOHN WILLIAM BLAKE, vol. I and II, London. Printed for the Hakluyt Society, 1942, vol. I, pp. 145–166.

2. "Pulgas hay, pero pocas, é no en todos tiempos; é son mucho menores por la major parte que las de Castilla; pero pican mucho mas é son péores." (There are fleas but not many and not in all seasons; they are much smaller in their majority than those of

² The earliest fleas hitherto known are *Palaeopsylla klebsiana*, Dampf, 1911, and *Palaeopsylla dissimilis*, Peus, 1968, found in Baltic amber. They belong to the same genus but represent two very different species. They are about 50–60 million years old as proved by their inclusion in amber (DAMPF, 1911; PEUS, 1968).

Spain; but they bite much more and are worse). — OVIEDO, *Historia General* etc. Edit. R. Acad. de la Historia 1851, first part, lib. XV, cap. III, p. 455.

3. The Eskimoes, according to Nansen (see BODENHEIMER 1951, p. 281), did not know fleas before the arrival of the white man. They call them European's lice and eat them as delicacies. They even use special traps which are put between the clothes and the skin. (Regarding the use of flea-traps in Europe and China see HOEPPLI, 1959, p. 209.)

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VII

Lice

Africa

Lice existed in Africa since antiquity. Nits have been found on the hairs of an Egyptian mummy of the fourth century A.D. (EWING, 1924). PROSPERO ALPINI in *De Medicina Aegyptiorum*, Venice, 1591, mentions the frequency of lice in Egypt.

Louse infestation of negroes at São Tomé was mentioned about 1540 by the anonymous Portuguese pilot whom we have quoted in the previous chapter dealing with fleas.

A wooden statue of a kneeling woman holding on her left arm a child which is picking lice from the woman's head is kept in the Museum Rietberg in Zurich (plate XIX).

The eating of lice during delousing was rather common among certain African tribes (SIMMONDS, 1885). It was mentioned already regarding the Hottentots by P. KOLBEN, 1738, II, p. 179 (teste BODENHEIMER, 1951, p. 194). He reports their remark when asked how they could eat such vermin: "They suck our blood and we devour them in revenge."

The Pangwe of the Cameroons likewise had the habit of eating lice (G. TESSMANN, 1913-14, II, p. 187, 190, teste BODENHEIMER, 1951, p. 139).

There can be no doubt that negro slaves carried lice to the Western Hemisphere.

America

In the New World lice occurred from ancient times. EWING, 1924, found nits on the hairs of pre-Columbian Peruvian mummies and lice and nits on the hairs of prehistoric American Indian mummies from the southwestern United States. The earliest lice found are ca. 4000 years old (EWING, 1926).

PEDRO WEISS, 1932, described and illustrated nits of lice from the hairs of mummies of about 200 B.C. found in the Páracas caves, Peru.

A louse plays a rôle in the *Popol-Vuh*, the very old famous mythological book of the Maya-Quiché (note)¹.

A mochica huaco showing a woman delousing herself is kept in the Museo Nacional de Antropología y Arquelogía in Lima (plate XVIII).

Several of the early Spanish chroniclers describing the Conquest refer to lice. The best known report is probably that by ANTONIO DE HERRERA, 1554, who states that when the Spaniards entered the palace of Montezuma in search for treasures, they found sacs which they believed contained gold. However, on opening them, they discovered that they were filled with lice which had been given to Montezuma as tribute².

The custom of offering a tribute of lice as a sign of submission existed according to GARCILASO DE LA VEGA also in Peru. The Incas forced the Urus, who lived on the Lake Titicaca, to bring an annual tribute of lice.

TORQUEMADA mentions that Montezuma used old people who

¹ The author is obliged to Dr. H. Figueroa Marroquin, Guatemala, for having drawn his attention to the *Popol-Vuh*.

² It should be mentioned that some authors suspect that the sacs contained dried female cochenille insects (*coccus cacti*) which were erroneously taken for lice by the Spaniards.

were unable to do other work to visit the houses and to delouse people. They collected the lice in little bags (information by Dr. Somolinos d'Ardois, Mexico D.F.). Fray BARTOLOMÉ DE LAS CASAS states that the Indians of Española had lice.

JUAN DE VELASCO (1727–1819), 1789, speaking of lice in Ecuador, mentions that they are more frequent in a cool and cold climate than in a hot one.

A. VON HUMBOLDT, 1816–31, in his studies of the equinoctial Andes, mentions the occurrence of lice in high altitudes.

It is reported by various writers that similarly as in Africa, people in the Western Hemisphere had the habit of eating the lice during delousing.

OVIEDO, speaking of the household of Montezuma, mentions 'Sanctos religiosos', a kind of priests. They were wearing long hair full of lice which they were catching and eating while murmuring prayers.

PEDRO MÁRTIR DE ANGLERÍA, 1520–26, referring to the Indians of Cumaná, states: "Se comen sin asco las arañas, las ranas y cualquier gusano, hasta los piojos." (They eat without loathing spiders, frogs and any kind of worms, even lice." ALDROVANDI, 1638, repeats this statement regarding lice.

PEDRO CIEZA DE LEÓN, when he visited Pasto, found that the Indians there were eating their lice when delousing.

MOUFET, 1634, p. 304, mentions Spanish reports that lice were consumed by the Indians in the West Indies.

PURCHAS, 1625–26, vol. III, p. 975, states that when the Indians of the Province of Cuenca are infested with lice "they dress and cleanse one another and they that exercise this, are for the most part women who eat all they can take."

The habit of eating their own head-lice is reported from the Indians of the Isthmus of Panama (DAMPIER, 1697) and from the Indians of the Amazon river (WALLACE, 1852–53).

It should be pointed out that besides the few early authors just mentioned, there are numerous others who also refer to the existence of lice in the New World (regarding the eating of lice, see BODENHEIMER, 1951, and HOEPPLI, 1959, pp. 360–363).

In concluding we may mention an apparently rather widespread superstition. It is recorded not only by OVIEDO in his *Sumario* and his *Historia General*, but also by CERVANTES in *Don Quijote* and by ABRAHAM ORTELIO in his *Teatro del Orbe*.

According to this belief people on a voyage from Spain to the New World loose their lice when the ship passes the Azores so that they arrive in the Western Hemisphere with very few or no lice. On the return voyage, however, at about the region of the Azores

the lice gradually reappear so that on their arrival in Spain people have about just as many lice as on their departure.

OVIEDO stated that by personal experience during four voyages made from Spain to the New World and back he convinced himself of the correctness of this belief.

Note

The *Popol-Vuh* is a very old important document of Maya-Quiché literature. It combines mythology and history. The *Popol-Vuh* consists of four 'books'. In its present form it is a collection of manuscripts written at about 1530 by a christian Indian, DIEGO REYNOSO. The text is in the Indian language but in roman letters. It was found in the convent of St. Thomas of Chichicastenango by the Dominican monk Francisco Ximénez at the beginning of the eighteenth century; he translated it.

In the second part dealing with the twins Hunahpú and Ix-balamqué, who fight the forces of 'Evil', the *Popol-Vuh* tells the story of Ixmucané, a kind of goddess in the shape of an old woman who sends an important message by a louse to her grandsons.

The *Popol-Vuh* has been translated into several languages, a good translation is by RAPHAEL GIRARD, 1954, a Spanish edition is by VILLACORTA and RODAS, 1927.

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³ Quoted from LUIS A. LEÓN, 1951.

VIII

Bedbugs – Cimex lectularius – C. hemipterus (rotundatus)

Cimex lectularius likes the warm but not the tropical climate; in the tropics it is replaced by *C. hemipterus*.

Africa

Bedbugs were known in different parts of the world from antiquity, but were introduced into some countries comparatively late. In the Alsace (Strasbourg) *Cimex lectularius* was first observed in the eleventh century, its occurrence in France was for the first time reported in the 13th century (KEMPER, 1928). In England *C. lectularius* was probably unknown before the sixteenth century (MOUFET, 1634, cap. XXV, pp. 269–271). It may be added that according to FALLÉN, bedbugs were still unknown in Sweden in 1807. In the mediterranean countries, on the other hand, bedbugs were widespread and mentioned by a number of Greek and Roman authors.

Bedbugs were discussed by Aristotle (384–322 B.C.) and by Pliny (c. A.D. 23–79). They were also referred to by non-medical and non scientific writers, for example by Aristophanes (c. 450–386 B.C.) in his *Clouds* and in the *Satyricon* of Petronius (died A.D. 66).

The anonymous Portuguese pilot (ca. 1540) whom we have mentioned in connection with his statements on fleas and lice in São Thomé also refers to bedbugs.

Bedbugs played a rôle in the treatment of a considerable number of diseases and pathological conditions from ancient times until the beginning of the nineteenth century. Dioscurides, Pliny, Galen, Marcellus Empiricus, Aetius, Actuarius and MOUFET, 1634, p. 270, recommended them for the treatment of malaria, a recommendation which is also found in Indian medical literature (HOEPPLI, 1959, p. 17, 155, 185).

America

As Italy and the Iberian Peninsula had close relations in Roman times and as bedbugs at the time of Petronius were apparently very common in Italy, they will have existed also in Spain, so that later, at the time of Columbus and the Conquest, Spaniards carried them to the New World.

BERNARDINO DE SAHAGÚN, 1569, states: “Hay chinches en esta tierra como las de Castilla, y llamanlas texcan” (there are bedbugs in this country as in Spain and they are called texcan).

It is possible that SAHAGÚN refers also to *Ornithodoros* species which in some parts of Central- and South America are called 'chinchés' (information by Dr. Luis A. León, Quito).

HERNÁNDEZ, in his *Historia de los Insectos de Nueva España*, cap. XXVI, describes the Hoeitexca, which he states is a large bedbug which sucks blood and has a bad smell. It is difficult to know whether HERNÁNDEZ refers to the common bedbug which we know to-day. He assures (lib. I, cap. 49) that the Ahoapatli destroys lice and drives away bedbugs and that the Zayolizcan (lib. VI, cap. 14) likewise kills the bedbugs (information by Dr. Somolinos d'Ardois, Mexico, D. F.). It seems that HERNÁNDEZ, like SAHAGÚN, uses 'chinche' not only for bedbugs but also for other arthropods.

Similarly as we have found in Europe that some countries were free from bedbugs for a long time, we notice from early reports the absence of bedbugs also in some parts of South America, for example in Peru.

BERNABÉ COBO, 1653, reports: "... en este reino tan extendido como este del Perú no los (bedbugs) hay, no los he visto en mas de cincuenta años, si bien es verdad que se hallan en otras provincias de Indias, particularmente en Nueva España." (In this large kingdom of Peru there are no bedbugs, I have not seen them in more than fifty years; on the other hand, it is certain that they are found in other provinces of the Indias, especially in Mexico.)

According to DOHRN, 1879, bedbugs were introduced into Chile by Europeans towards the middle of the 19th century.

In consequence of the greatly increased communications, bedbugs were gradually found everywhere, even in countries like Peru where formerly they had been absent. JORGE JUAN and ANTONIO DE ULLOA, 1748, who on their voyage to South America visited Peru, reported that the inhabitants of Lima, especially in summer, suffered greatly by fleas and bedbugs.

It can hardly be doubted that the Spaniards during their Conquest introduced bedbugs into the Americas. It remains, however, doubtful whether bedbugs existed in America before Columbus. A special difficulty is caused by the fact that the early Spanish authors used 'chinche' and the Aztec word 'texcan' not only for the common bedbugs, *Cimex lectularius* and *C. hemipterus*, but also for other arthropods.

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IX

*Porocephalus**Africa*

The African species *Porocephalus armillatus* lives as adult in the respiratory tract of snakes, pythons and puff-adders. The eggs are discharged either through the mouth of the snake or chiefly in the faeces. The eggs must reach the alimentary canal of a suitable animal, serving as intermediate host. The larval form has so far been found in a very wide range of mammals including man.

Within the intestine of the intermediate host, the eggs hatch, the larvae pierce the intestinal wall and reach the blood- and lymph-vessels. They are carried to various parts of the body and are found especially on the surface of the liver, in the lung, intestinal wall and on the mesentery. There they become enveloped by a capsule produced by the intermediate host.

The larval form has been found in negroes in different parts of Africa: Egypt, Senegal, Gambia, Sierra Leone, Gold Coast, Cameroons, Congo, furthermore in negroes of non-African countries who had previously been residents in Africa.

Besides *Porocephalus armillatus* other *Porocephalus* species have been described; L. W. SAMBON, 1910-1913, has given a critical review of all species described up to his publications.

The first record of *P. armillatus* was given by PRUNER, 1847. He found the parasite in Cairo at the autopsy of two negroes; one had died of peritonitis, the other of ulcerative colitis. The encapsulated larvae were situated on the surface of the liver, on the mucosa of the small intestine and on the mesentery. In the first negro, one parasite was found free in the duodenum.

In 1856 BILHARZ found three specimens encapsulated in the liver of a negro who had died of dysentery in Cairo. The parasites

had hooks which corresponded to those found previously in calcified cysts.

Early descriptions of *Porocephalus* infection were given by several other authors, among them by AITKEN, 1866, Jamaica; GIARD, 1896, Saint Louis, Senegal; CHALMERS, 1899, Accra, Gold Coast; BRODEN and RODHAIN, 1907, former Belgian Congo.

America

AITKEN's case is of special interest as it concerns a former negro slave who died in Jamaica in 1865 of peritonitis¹. He had been enlisted about eight months previously from the slave depôt at Rupert's Valley, St. Helena, where slaves captured in slave ships were kept until disposed of.

At autopsy two encapsulated *Porocephalus* larvae were found in the right lung and between 20-30 more on the anterior and posterior surface of the liver.

So far all cases of *Porocephalus armillatus* infection were diagnosed only at autopsy.

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¹ Details of AITKEN's case are given by SAMBON, 1910, pp. 214-215.