

COMPARATIVE HELMINTHOLOGY AS AN AID IN THE  
SOLUTION OF ETHNOLOGICAL PROBLEMS<sup>1</sup>

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I regret that unavoidable absence in Europe on duty prevents me from addressing you in person and taking part in the deliberations of the Society today.

This message to you is being written on shipboard as we make our way towards the Immortal City, the civilization of which played so great a part in the past in the dissemination of culture and of infectious diseases throughout Western Europe.

We have just passed "Flores in the Azores where Sir Richard Grenville lay," one of the outposts of that great little country, Portugal, which led the van in maritime exploration and discovery before the day of Columbus.

Before us lie Cape St. Vincent and Cape Trafalgar, scene of the great battle between the English and the combined fleets of France and Spain, an event which has played a part in the distribution of races in the tropics and in the development of tropical medicine. Here we may see the field in which were trained the seamen of that Portuguese Prince, Henry the Navigator, grandson of John of Gaunt, "Time-honored Lancaster." It was due to this Portuguese Prince that explorations of the West Coast of Africa were made, eventually resulting in the rounding of the Cape by Vasco da Gama. In Prince Henry's time mariners were afraid to go very far out of sight of land beyond the Straits of Gibraltar. Along the west coast of Africa some capes appeared too stormy to be rounded, but Henry exhorted his mariners and urged them to further effort until they finally explored the entire coast. Por-

<sup>1</sup> Presidential address, read in part by Dr. V. G. Heiser at twenty-first annual meeting of American Society of Tropical Medicine, May 5 and 6, 1925, Washington, D. C.

tugal was a very great country during this period. Cabral discovered Brazil; an empire was founded by Portuguese in India; Australia was discovered by them; Magellan's men circumnavigated the world; colonies were founded in Indonesia—all of which is celebrated in Camoes's great epic *The Lusiad*.

The Portuguese fell before the more numerous arms of stronger peoples, and little remains of that Indian empire now, beyond Macao and a portion of one of the Indian isles. But a great maritime trail was blazed by the Portuguese and for a time their star of empire shown with a brilliancy of the first magnitude.

The era of maritime adventure and exploration inaugurated by the Portuguese, and extended by the Spanish, Dutch, and English, has led to the migration of vast numbers of peoples to the tropics and to other parts of the globe. Diseases of civilized peoples of Europe and diseases of the natives of the tropics have been mutually exchanged and disseminated. And the study of these diseases encountered in tropical lands gives this Society its reason for existence.

The movements of people during historical times may be traced with some exactness, and the diseases carried during these migrations may in general be inferred and in some instances ascertained.

Tuberculosis and pneumococcus infections are known to have been disseminated amongst the natives of Africa by Europeans. There are reasons for believing that tuberculosis first made its appearance in civilized lands on the Eastern shores of the Mediterranean, and Stewart very plausibly concludes that contact with Roman civilization spread the disease throughout Western Europe.

There is today wide interest in the subject of man's origin and his migrations and distributions over various parts of the earth. One can hardly pick up a journal devoted to a popular discussion of general topics without encountering an article on these subjects. During the past month articles have appeared on the life of primitive man discussed from the viewpoint of one familiar with the skeletal remains and remains of implements used by primitive man in Europe and England. Osborne has recently discussed the likelihood of our finding in Asia the location of the ancient

home of man. Dart's recent discovery in South Africa of the remains of a manlike creature found deep in a limestone formation in Bechuanaland, South Africa, together with his comments and those of other anthropologists on the place probably occupied by this creature in nature were broadcasted but a few days ago in the public press.

It will be recalled that three years ago another skull of primitive man was found at Broken Hill, Northern Rhodesia, South Africa. Most anthropologists, including Osborne, have believed that primitive man arose in Asia, but these two specimens in three years from South Africa lead one to suspect that Africa also must be included in the speculations as to the home of primitive man.

The earliest discoveries of man's remains were made in Europe, in England, Germany, and France, or in the zoogeographical zone known as the Holarctic Zone. Later some primitive remains were found in Java in the Oriental Zone. These were found by a Dutch scientist, Eugene Dubois, and the species from which they were derived has been named *Pithecanthropus erectus*. In the discoveries made in South Africa we have to consider also remains of primitive man from the Ethiopian Zone. The Dart skull (*Australopithecus*) is from an immature child about four years of age, and is "anthropoid-ape-child-like" in type. According to Hrdlicka it appears to have belonged to a race of anthropoids which emerged just before the dawn of man.

Prof. G. Elliot Smith of the University of London believes that Professor Dart's discovery tends to give support to Darwin's contention that Africa, where the chimpanzee and gorilla now live, was probably the home of the human family. On the other hand, however manlike the chimpanzee may be and in spite of "Mr. Crowley and Kitty Murphy," there is something very human in the orang-utan of Indonesia where Dubois's discovery was made. I remember seeing in the Garden of the Sultan at Deli, Sumatra, a family of orangs. The father had a fiery red beard and mustachios and was delighted to receive copper coins which he sucked: his consort, with her baby held in maternal fashion, covered her head with a piece of jute bagging in a

manner exactly like that in which Malay women in the kampongs nearby wore their slendangs or scarfs. The group presented altogether a very human appearance.

Of course this is mere suggestive testimony and not evidence that the orangs are as high in the zoological scale as the gorilla and chimpanzee. For besides the testimony with regard to the intelligence of the brutes in question an appeal must be made to the evidence of comparative anatomy.

Osborn believes that the links in the ascent of man from anthropoid may be traced backward from Cro-Magnon man, the last of the cave men found in Western Europe, to Neanderthal man, who, it is believed, was the first of the cave-dwelling men of Western Europe, thence back to Heidelberg man, who lived in Germany during the midst of the riverdrift period. Before him was the Piltdown man whose remains have been found in Sussex, England, in deposits of the beginning of the riverdrift period. The man of Trinil, Java, dates also from the riverdrift period at its beginning.

Osborn suggests that the succession of the races in Western Europe begins with the Nordic race which dates back about 15,000 years, having appeared at the front of the retreating ice sheet. The Cro-Magnons lived in Western Europe some twenty thousand years before the advent of Nordics. The Neanderthal race lived in Europe about 40,000 years before our time, while Heidelberg man is believed to have lived in Western Europe 400,000 years ago. Piltdown man lived 500,000 years ago, while Foxhall man, known only by his flints and fireplaces, is thought to have lived as long ago as 600,000 years.

Dart's new African man-ape, according to Dr. Hrdlicka, is more closely related to the old African stem of the American monkeys than it is to the types of monkey now living in the old world. The old African stem of monkeys referred to came to the new world from Africa by way of a land bridge which connected the two continents in the tertiary period.

These speculations have resulted from the researches of paleontologists and comparative anatomists. It would be interesting if other lines of investigation might be opened up in connection

with this subject, and it seems possible that comparative helminthology, one of the handmaidens of tropical medicine, might be brought in to add its quota to the testimony needed in the elucidation of the problem. The affinities of divers types of animals in some instances have been determined by parasitologists through a study of the parasites which the hosts have harbored.

It was Wallace, of course, who was one of the first naturalists to trace the distribution and dispersion of birds and other animals. He showed in the Islands of India that there were certain peculiar distributions of animals and birds which could only be explained on the ground that land communications formerly existed connecting the islands with the continent of Asia. Later these islands became separated one from the other and from the continental land mass.

Johnston of Australia investigated the distribution of the hosts of various trematods, and he used the doctrine of the land bridge in arriving at certain of his conclusions.

Metcalf by a study of *Opalina* parasites of frogs has shown that there was probably a continental land bridge connecting Australia with the southern part of South America.

Kellogg by a study of *Mallophaga* of birds has shown that these parasites are highly specific for certain hosts. And he has pointed out on this basis that certain groups of birds possess relationships which systematists in ornithology had suspected but which they had been unable to prove by reference to morphological and anatomical features.

By a study of the species of hookworms harbored by mankind in divers places it has been possible to suggest the origin and migrations of the people in question. I have discussed this subject elsewhere and reached certain conclusions.<sup>2</sup> Since the publication of these papers there have come to my hands additional data which have a bearing on the general subject, and which confirm these conclusions.

According to Wegener and to Joly there was during the Car-

<sup>2</sup> Observations on the geographical and ethnological distribution of hookworms. *Parasitology*, 1920, xii, no. 3.

The distribution of hookworms in the zoological regions. *Science*, 1921, lii.

boniferous period but one sole continental land mass. This was made up of the areas now known as the Old and New Worlds. The mass was in a state of extraordinary fluidity and, under astronomical forces, became separated into continents as we now know them. But this hypothesis was based largely on superficial and complementary outlines of the continental masses now existing, and is not generally accepted.

Other paleontologists and zoogeographers have traced the land masses as they probably existed in the different geological periods and have recognized certain zones which may be given as follows:

- Neotropical Zone
  - South America
  - Central America
  - Lowlands of Mexico
  - Antilles and southern tip of Florida
- Sonoran Zone
  - Highlands of Mexico
- Holarctic Zone
  - The rest of North America
  - Europe
  - Africa north of the Sahara
  - Asia north of the Himalayas
- Oriental Zone
  - Asia south of the Himalayas
  - Indonesia
- Ethiopian Zone
  - Africa south of the Sahara

While these are the areas above sea-level at the present time, it is certain that in former geological times there were communications by land which have enabled birds and animals to migrate to areas now separated by impassable barriers of water.

Osborn believes that man was a great traveller, but it is evident that he only began to travel after he had developed a high degree of intelligence; before that he probably wandered no farther than the animals upon whom he preyed. There are no evidences of his presence on the American continent until the appearance of the

mongoloids, who probably came from Asia in rather recent times. Man's travels and migrations to Polynesia have probably occurred almost within historic times.

Some ethnologists would have us believe that certain remains found in the caves of Southern Europe are of negroids, but there is no helminthological evidence that this is true.

In certain of the limestone caves in the south of France, in Spain, and in the Canary Islands, the remains of the bones of animals and of man have been found, together with drawings on the walls of the caverns made with pigments containing black oxide of manganese and red ochre. In South Africa similar drawings or paintings are to be found on the granite boulders on the High Veldt.

While it is believed by some that the cavern wall-drawings in France were made by the artistic and splendidly developed Cro-Magnon race, the drawings in South Africa were undoubtedly made by the little Bushman representatives of an undersized negroid race considered very low down in the ethnic scale.

One of the most interesting of these Bushman drawings is still to be seen near Salisbury, Southern Rhodesia, where I had the pleasure of searching for it with the late Dr. Maynard of Johannesburg. These Preraphaelite Brethren of the Veldt confined their efforts to depicting in the simplest way the animals and men with whom they were familiar. No decorative effect was produced. Apparently they used an ore composed of ferric oxide which was mixed with a vegetable drying oil. On the dry, almost rainless veldt the paintings had survived the elements in places where it is said the Bushmen have not ranged in 500 years. While no effort at decorative effect was aimed at by the Bushman artists, the painting at Salisbury shows that a distinctly artistic effort was produced in the selection of the site for the drawing.

Granite the world over seems to weather in somewhat similar fashion. Great boulders break up into two or three or sometimes four smaller boulders often resting one on top of the other. Sometimes a large boulder will split vertically. In the atelier or gallery chosen by the Bushman there was one large boulder sunk in the earth which made a floor measuring about 20 by 20 feet. On top

of this was another boulder of granite nearly as large, but a great fragment had broken off the lower fourth. The fragment constituted the canvas, while the remainder of the upper and mother boulder gave the canvas protection on three sides and curved up and over it forming a canopy of massive granite rock. The "canvas" was about six or eight feet across its smooth surface and was nearly square. There was ample room on the floor for the artist to stand at his work.

The figures in the drawing were those of ostriches, antelopes, a snake, and men. It would have been difficult to have found such another peculiarly weathered rock and workshop in the country round, but the little negroid Bushman had not only found the rock but had put it to use in a supremely artistic way.

From the similarity of the stone monuments and buildings of Egypt to those found in other lands it has been inferred that migrations of Egyptians, or transference of Egyptian influence to the Soloman Islands and elsewhere in the South Seas, and also to Yucatan, had occurred. But we possess no helminthological testimony that the hookworms peculiar to Egyptians have ever been found in the countries where Egyptian migration is alleged to have taken place. Besides, de Morgan as well as others hoped that the idea of constructing stone monuments of similar type might have occurred independently to several people in different parts of the globe.

Life is an unfolding, or a tendency, as Bergson put it, and we may expect to see certain type tendencies revealed wherever man has lived. One of the pronounced tendencies is the graphic impulse which, as we have seen, occurred not only among the Cro-Magnons in Europe but also among the lowly and far removed African Bushman.

How can helminthology aid in the elucidation of these ethnological problems? The question would require in the first place some consideration of the nature of parasitism and of nematode infections.

Without going into the nature of parasitism it may be sufficient to say that certain parasites appear to be able to infest or infect a large variety of living animals. Certain microorganisms for



example can live in and on the tissues of animals of numerous types. Others are not able to maintain themselves so well on a large variety of hosts. Plague is primarily a disease of rats; tularemia, a disease of rabbits; typhoid fever and cholera, of man. Other protozoa higher up in the scale as, for example, the malarial plasmodium, are parasitic only in certain insects and in man. While *Plasmodium falciparum* is an obligate parasite in man and certain anopheline mosquitoes, it is not capable of taking on a parasitic existence in culicines, and is immediately digested or destroyed in some other way in the stomach of a culex mosquito when ingested in the ordinary way. *Ancylostoma caninum* is a nematode which has never been found to infect man although the soil which barefooted man walks upon and which is infested by dogs contains enough larvae to maintain these animals in a highly infected condition. *A. brazilense* is a species of nematode which is found in dogs and cats as well as in a few other mammals, generally carnivora of the genus *Felis*. Man occasionally becomes infected with this worm. *Ancylostoma duodenale* is a nematode which is found almost exclusively in man and only in certain parts of the world. *Necator americanus* is a nematode which is also found almost exclusively in man, although a worm which resembles it very closely has been found in swine. These worms not only are highly specific for certain hosts, that is to say are found only in certain hosts, but they seem to require the blood or tissue juices which these hosts supply, for when they are transferred to other hosts they often fail to reach complete development. These obligate parasites must have been long associated with their peculiar hosts and must have come down through the ages with them. Wherever the host has migrated there the obligate parasite has migrated also. And if the hosts have become differentiated into several species along the way, the same thing may have happened to the parasites. Certain types of hosts then, may have the same, or zoologically closely related parasites.

Only three species of hookworms have been found in man *A. duodenale*, *Necator americanus*, and *A. braziliense*.

The first two named are obligate parasites of man for they have

been found but rarely in any of the lower animals and then in very small numbers only. *Necator Americanus* may suffer slight morphological changes in the swine and correspond to what has been described as *Necator suillus*. *A. braziliense* is an example of a nematode which normally lives in the dog and cat but which is able to take on to a very limited extent a parasitic existence in man. *Ancylostoma duodenale* and *Necator americanus* not only appear to be equally able to infect man with ease but either species may become implanted on any soil that is suitable to the other. This is true in temperate and subtropical climates as well as in tropical regions. For both worms are found infesting the soil and man in Southern Brazil, Mid-Java, Paraguay, and Jamaica. While *A. duodenale* is found in Europe in temperate climates, *Necator americanus* is distributed in the temperate climate of the southern states of America. There can hardly be any question but that the distribution of the two species of hookworms does not depend on climate and soil, but is due to the migration of the hosts which harbor the worms.

In the analysis of the worm counts made by my colleagues Barber and Hacker, and by myself in the Orient and by various persons elsewhere, it was found that pure cultures of one species would tend to be found in certain ethnic stocks. Mixed cultures tended to be found where there was known to have been mixtures of two or more ethnic stocks. Moreover pure cultures tended to be found in certain geographical areas as well as in ethnic stocks.

*A. duodenale* was found in pure culture in Egypt and in Europe. *Necator americanus* was found in pure culture amongst Kaffirs in South Africa and in negroes in the Southern States and also amongst Solomon Islanders and Polynesians.

Mixed cultures of the two species of hookworm are more commonly found at present than are pure cultures of these worms, and this might be expected as a result of the migrations of peoples and the mixtures of races which have taken place even within historic times.

While mixed cultures are very common, it is found that one or the other species tends to predominate more or less markedly in certain areas or regions where we might expect to find mixtures of races in unequal proportion.

Mixed cultures have been found in Java where there are at least two ethnic stocks: one, the Malays who carry a marked predominance of *Necator* and in the remote mountain regions, a pure culture of this species; the other, a stock of North Indian origin, coming to the Island within historic times. The latter presumably brought large numbers of *A. duodenale* with it, for the population derived from it, now living in India, carries a high proportion of *A. duodenale*. In places in Java where there is a large proportion of this Indian stock there is a higher proportion of *A. duodenale* than in other parts of the island where this stock is absent.

The Malays on the Island not admixed with East Indian blood and not showing any evidences of Indian culture have as little as 2 per cent or less of *A. duodenale*. Where the proportion of Indian blood is larger the percentage of *A. duodenale* reaches 60 and even 85 per cent.

In India there has been a mixture of at least two ethnic stocks. In the north where there has been a larger proportion of white and mongoloid blood the percentage of *A. duodenale* reaches about 80, while in the south amongst the Tamils, where the white or other northern stocks, as compared with the dark colored natives, are least in evidence, the percentage of *A. duodenale* is only about 2.

In Fiji the autochthons harbor a pure culture of *Necator americanus* but the East Indian coolies who have been living on the island a few years under indenture from North India have a very high proportion of *A. duodenale*. After the Indian coolies have lived on the islands more than eight or nine years (the average life of a hookworm) they will have lost their complement of *A. duodenale* and have acquired sometimes a pure culture of *Necator americanus*, the worm which infests the soil and is derived from the native Fijians. Meanwhile Fijians who live in intimate contact with the East Indians acquire some *A. duodenale* from the soil which these people have infested with that species.

In parts of Brazil where negroes are predominant there is a preponderance of *Necator*, but where there is a large proportion

of Portuguese there has been added to the complement of worms harbored by the negroes a number of *A. duodenale* derived from Europe where this worm is the sole species encountered among the indigenous population.

In the Southern States the hookworm found among the negroes and whites is the *Necator*, derived from negroes. In Jamaica, however, where there were large numbers of East Indian coolies, introduced from North India after the slaves were liberated, the natives now harbor a mixed culture of *A. duodenale* and *Necator americanus*.

In spite of the many ethnic human stocks now existing and their wide distribution, only two species of hookworms are known to infect them. From the fact that the two species are not always found together and indeed are often found quite separately in divers stocks in great geographical areas, and from the additional fact that man is susceptible to infection by each species of worm, the absence of a species in any given area and ethnic group must be explained.

Primitive man must have been infected in the first instance and very early in his history, for the worm is an obligate parasite on man, and is absent from animals now living. Of course it is theoretically possible that man acquired the worm from animals now extinct. The most plausible explanation is that two races of anthropoids arose in geographical areas widely separated by water, where it was possible for hookworms to infest the soil, and that these races were in the first instance infested with a different species of hookworm.

One primitive race was infected with *A. duodenale*, and this race was distributed in the first instance in the area known as the Holarctic region. The other primitive race was infected with *Necator americanus* and was distributed in the first instance in the regions known as the Ethiopian and Oriental areas. These regions may have been, and in all probability were, connected by a land bridge in past times, the so-called Gondwana land.

The race infected with *A. duodenale* divided and wandered over the Holarctic zone of Eurasia, one branch, the Caucasians, towards the west; the other, the Mongoloids, towards the East.

The latter branch was infected to the greater extent. The Caucasian race may have been infected or reinfected by contact with the mongoloids. Another dark or black-skinned race was infected with *Necator americanus*, and this race has spread over the Ethiopian zone of Africa south of the Sahara to Melanesia and Australia. It has also spread over the Oriental zone of Southern India, Indonesia, and Polynesia.

During the course of time there has been some admixture of races and worms between these areas. We have been able to trace such admixture in Java, Jamaica, and Fiji.

The primitive race which arose in the Holarctic zone and which was infected with *A. duodenale* may be named *Homo ancylostensis* while the primitive dark-skinned race which arose in the Ethiopian-Oriental zone and which harbored a pure culture of *Necator americanus* may be named *Homo necatorensis*. From the fact that we find races which harbor one or the other of the two species exclusively while in other regions where there live races which are known to be mixed and in which the people harbor a mixture of the two species of hookworms, we can assume that the race which harbors a pure culture of hookworms probably represents an ethnic stock which had not been mixed with another stock harboring the other species of hookworm.

The white races of Europe present no helminthological evidence that they have ever been in contact with a negroid race harboring *Necator americanus*. If such contact ever took place it was at a time when cold prevented the development of the hookworm in the soil.

Polynesians harboring as they do a pure culture of *Necator americanus* present now no helminthological evidence that they ever sojourned on the continent of Asia where the hookworm formula of the people is now preponderatingly *A. duodenale*. The investigations of Lambert, Crichlow, and others within the past few years, have shown the hookworms of the people of Samoa, Funafuti, Mukalua, Ellice, Tonga, and the Solomon Islands to be exclusively *Necator americanus*, except where Chinese or North Indian coolies have added embryos of *A. duodenale* to the soil. In the mixing of the races one race may have lost all traces of the

primitive hookworm with which it was originally infested. Straits-born Chinese lose the *A. duodenale* which their parents brought from China and take on *Necator americanus* the worm which is chiefly found in the soil infested by the Malays with whom they work or play.

It is theoretically possible for a numerically small group to pass through a country and lose the worms with which they were originally infested, but we have no evidence that this has ever occurred. In Java where a small proportion of Indians probably mixed with a large proportion of Malays the numbers of *A. duodenale* are still very large.

The species formula, or proportion of *Ancylostoma* to *Necator*, amongst Malays of the Malay Peninsula, West Java, or Sumatra is like that of the Tamils of Southern India—2 per cent *A. duodenale*—and in view of the brachycephalic character of the Malay mongoloids and the dark-skinned dolichocephalic character of the Dravidian Tamils it is difficult to understand their having the same formula. Malays are great wanderers by sea and are known to mix freely with the negroid Semangs who may have contributed *Necator* to the *A. duodenale* content with which the Mongoloid Malayan may be assumed to have been originally infected. All negroids appear to have had a pure *Necator* content, for Kaffirs of South Africa, negroes of the southern United States, Australians (Bushfellow), Pygmies of Africa, Melanesians and their mixtures with Polynesians and Soloman Islanders now harbor exclusively *Necator americanus*.

The absence of the *Necator* from Egypt and Europe is an indication that there has been no intrusion of negroid stocks into these countries in spite of the Roman conquests and the influx of conquered peoples into Egypt, Greece, and Rome. The dark-skinned people of the Mediterranean basin are a distinct race not of negroid origin.

Osborn says that Cro-Magnon man spread over Europe in the west following the ice front as it retreated from the south. This occurred ten to twenty thousand years before the Nordics appeared in Western Europe. He believes that 40,000 years ago the Neanderthal race lived in Western Europe in caves because

the ice still covered large portions of the continent. Under such rigorous condition of climate, Neanderthal (anthropoid ape) man harbored no hookworms. Before and after cave life, man lived in the open and his remains are now to be found in river drift.

Osborn believes that the branches of primitive man are very old and that the Java (Trinil) man, and the English (Piltdown) and the German (Heidelberg) races are distant descendants of an earlier ancestral race. He speculates on the origin of man having taken place in Mongolia. Possibly one great branch, the mongoloids who harbored *A. duodenale* arose in Mongolia (Holarctic Zone). But there was another great branch which seems to predominate in the south (Oriental and Ethiopian zones) and this branch undoubtedly was infected with *Necator americanus*.