

possible of attainment, mounts made in this way would probably keep indefinitely. Diaphane has not been tried as a substitute for balsam.

The advantages of the method may be summed up as follows:

- (1) Substitution of the stain mixture for 75 per cent. alcohol-xylol is hardly to be considered as an extra effort.
- (2) The red objects, no matter how small, are readily visible, even in the hardened paraffin block.
- (3) Accuracy of cutting is facilitated.
- (4) The cut sections are quite visible in the ribbon and material may be examined superficially for accuracy of cutting, stages desired, etc.
- (5) Unfit material is eliminated without further waste of time, and sections of value are not inadvertently thrown away.
- (6) Critical examination of material may be made in the stage of removing the paraffin.
- (7) Finished mounts may be made at once, without the necessity of going through tedious processes, and especially the individual staining of slides.
- (8) Slides so made are fairly permanent.
- (9) Slides not intended for quick mounting may be destained and subsequently treated to any other staining technique.

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A STUDY ON THE LIFE HISTORY OF THE BROAD FISH TAPEWORM IN NORTH AMERICA

RECENTLY the committee on scientific research of the American Medical Association made a grant to the writer in support of a field study on the life history of the broad fish tapeworm, *Diphyllobothrium latum*. This species is a well-known and somewhat serious parasite of man in various regions of the Old World. It was first reported in the United States by Leidy, who studied in 1879 a specimen taken from an immigrant. Other cases which certainly were introduced have been reported from time to time and these records have increased rapidly in frequency within recent years.

The first case in the human host unquestionably infected by larvae bred in this country was reported by Nickerson in 1906 from the clinic of Dr. Parker, of Ely, Minn. The patient was a boy only two years old who had never been out of the state and had never eaten imported fish. In 1911 Nickerson published data on 65 cases from Minnesota, including another record of local infection. Other indigenous cases have been reported by Warthin from Michigan, by Becker from Chicago, by Magath and by Riley from

Minnesota, and by Lyon from Indiana. In some districts this species has come to be the most abundant and important human cestode, and this abundance is of very recent origin.

The European form has been introduced into North America many times as more than one hundred cases in man were recorded up to 1922; the list has grown since then though many cases are still unpublished. In fact in certain regions such instances have become too frequent to justify publication. The ova of the parasites were disseminated by sewage systems and thus fishes in connecting rivers and lakes are infected. The history of the parasite at Lake Geneva (Switzerland) is a striking illustration of the way in which the condition is caused and also corrected. No one has as yet shown that the parasite can find here intermediate hosts and the particular small crustacea functioning as such in Europe are rare or unknown here. Moreover, since no accurate examination has been made of the adult tapeworms taken from man here, it may be that the hosts which were infected on this continent really sheltered a new, similar and yet unrecognized species and not the well-known type found in the Old World.

Closely related if not identical species have been reported from other hosts than man in this country, thus by Warthin from the gray fox in northern Michigan, and by Hall and Wigdor from the dog in Detroit. The latter authors regarded the form they described as a new species and named it *D. americanum*. I have myself seen such a tapeworm taken from a dog at Ely, Minn., by Dr. J. E. Thompson. I have also adult tapeworms of this type collected from bears in the northwestern United States and in Alaska. The adult specimens from this continent have not been studied sufficiently precisely to justify a positive statement concerning their specific identity with the Old World species.

The last larval stage, *i.e.*, the form by which the final host is infected, is known as a plerocercoid and occurs in various fish. These plerocercoid larvae are so simple in structure and so imperfectly known that as yet no one can pass upon their relation to definite adult species. I have often found such larval stages of bothriocephalid tapeworms in fish studied in various regions from the Great Lakes to Alaska. Nickerson also records finding such larvae but states distinctly that in the present state of knowledge it is impossible to determine the species to which they belong.

The rapid increase in the number of cases of human infection reported in the United States, the consequent increasing contamination of our streams with probable like increase in infection of fish, and the severe anemia incident to the parasitization of the

species in the Old World, no less than the general hygienic and biological interest associated with the problem, make it important to study the situation promptly and in such fashion as to secure exact information on the various aspects of the question.

The American parasite in man may be identical with the European species, but, if not, two very similar species are now found side by side in certain regions. At least one of them affects man and either one or both of them also occur in other hosts in these regions. On the abundance and distribution of the parasites in other hosts as well as in man depends the frequency of human cases.

The life cycle of the tapeworms in this country must be precisely determined, whether a new species is involved or not, since this life cycle need not necessarily be identical with that reported for Europe. Evidently on the exact history of its varied relations to seasons and hosts depends both the manner and facility with which man is infected, and per contra the methods by which such infection may be regulated. In this connection it is essential to consider not only the last larval host but also the earlier phases of the life cycle as well. This is especially important since the species (*Cyclops leuckarti*) which in Europe serves as the first larval host is either rare or wanting on this continent.

Nickerson first showed that the source of human infection could be traced to a definite lake and Magath later demonstrated the occurrence of infected fish and thus of necessity infected intermediate hosts in a lake in the same general region. It is important to confirm these observations and to extend them to other waters for the purpose of determining the range and frequency of the parasite as well as the number and degree of infection of the intermediate hosts. Field studies are essential in securing the facts in the case and thus in furnishing a safe basis for views as to the probable future history of the parasite and possible means for its control and ultimate eradication.

With the purpose of studying the problem on the ground a field party has been organized and will carry on work this summer in northern Minnesota where the parasite has been so frequently reported. This party is directly in charge of the writer. Dr. T. B. Magath, of Rochester, Minn., will collaborate in the investigation and have control of the clinical experiments in particular. Dr. H. E. Essex of the University of Illinois will study the early development of the parasite and carry on the experiments in the field. Helpers will be secured as needed. The U. S. Bureau of Fisheries has undertaken to cooperate by sending an apprentice fish culturist to collect fish and maintain the aquaria. The Mayo Foundation has

made a substantial contribution to the enterprise by furnishing reagents, apparatus and other help.

The problem will be attacked at once from several different angles. One line of work involves securing eggs of the adult tapeworm, developing them in cultures and employing them in feeding experiments to determine the species of crustacea or other small aquatic organisms which can function as first intermediate hosts. It may also be possible to collect naturally infected crustacea. The second stage in the life history will be sought by feeding such infected crustacea to small fish. While the time may not suffice to allow of full development in such first intermediate hosts, undoubtedly the plerocercoid larvae can be obtained as they have been previously from various fish, large and small. Among such specimens some will probably be sufficiently advanced in development to use in experiments with final hosts. In any event such material when carefully preserved and studied may show characters adequate to differentiate the plerocercoids of one bothriocephaloid tapeworm from those of another species. Here again the conclusions can be tested by feeding experiments with various hosts.

The problem can hardly be completely solved in a single summer, even with the varied attack planned. But preserved specimens will afford opportunity for continuing the study in my laboratory during the winter. Efforts will also be made to secure and transport living material so that feeding experiments can be continued there.

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SPECIAL ARTICLES

THE TOXICOLOGY OF CARBON MONOXIDE

THE toxicology of carbon monoxide gas always raises the mooted question as to whether carbon monoxide is poisonous *per se* or produces all its toxic effects from interference with proper oxygenation of tissues. In all higher animals it has been the general opinion of most pharmacologists that carbon monoxide is poisonous by virtue of its combining with hemoglobin to form CO hemoglobin and thus preventing the hemoglobin from combining with oxygen. The affinity of carbon monoxide for hemoglobin has been found to be some two hundred times greater than its affinity for oxygen. Carbon monoxide gas of itself is commonly regarded as being physiologically inert. Some recent work however seems to indicate that carbon monoxide is not as innocuous *per se* as it has been supposed to be. Thus Warburg (*Biochem. Zeit.*, 177, pp. 471, 1926) has shown that car-