was of opinion that there was no use going outside for what might very well be obtained at home. I know that Captain Flower, director of the Zoological Gardens in Cairo, employed young "bulti" (Tilapia nilotica) in the tanks at the aquarium of Gezira and found them most efficient in keeping the water free from mosquito larvæ, and it was reasonable to suppose that many Nile fish were effective, especially as it is found that when fish are present in any pool left by the falling river mosquitoes do not breed out therein.

There were two points, however, requiring attention. If any water collection is stocked with fish these are apt to be speedily cleared out by natives or birds, such as kingfishers, which are very plentiful. Moreover, as is explained later, fish which attain any size are not suitable for use on irrigated land. Hence it was desirable to find a small and greedy fish which would offer no temptation to the native, which could be used in irrigation channels, and which, though not immune from the depredations of fish-loving birds, yet was so prolific or could be used in such numbers as to make these ravages of little account. The type of fish desired was that known in India as the chilwa, Chula argentea, which is said to be more efficient than "millions," as not only does it devour the larvæ, but, being a surface-feeder and an eager fly-taker, it is deadly to the adult mosquito, especially to the female intent on egg-laying.

Mr. Harold King, our entomologist, was going up the White Nile in the Floating Laboratory on a voyage of discovery and I asked him to take every opportunity of studying the question. Mr. King is an excellent field naturalist and admirably fitted to carry out such an investigation. His report, which I append, will be found of interest and value, and it would appear that in Cyprinodon dispar we have obtained the fish we require. This, as Mr. King remarks, remains to be proved, but the following letter, kindly sent me by the acting manager, Sudan Plantations Syndicate, in whose irrigation channels the fish are being tested, is at least promising:—

DEAR SIR,—In reply to your favour of the 19th inst. I have examined the small canal into which the fish have been introduced.

The canal is about 30 metres long and about half a metre deep, and the opening to the larger canal is closed with gauze wire netting to keep other fish out. Although the still water is now lying 25 days there are no signs of mosquito larvæ.

The fish are alive and seem to feed on flies on the surface of the water and are most active in the early morning.—Yours faithfully,

ALEX. MACINTYRE.

Like Mr. King, I have fed Ophiocephalus obscurus (*vide infra*) on the larvæ of Pyretophorus costalis and noted how the latter were devoured before they reached the bottom of the jar. The following is Mr. King's report:—

While on the White Nile, between the dates of April 17th and July 19th, I carried out some investigations with Nile fish with a view to ascertaining what species, if any, were likely to be of value in controlling mosquitoes by feeding on their larvæ. In most of the swamps where mosquito larvæ abounded shoals of small fish of various species also occurred, but from the fact that the two throve together it was evident that the fish were not likely to be of very much use. Numbers of these fish were captured, placed in jars, and offered mosquito larvæ, but with one exception they refused them until they had passed one or more days without food. The exception was a fish found in a khor between Gebel Ahmed Aga and the river. In this khor very few mosquito larvæ could be found—a search of nearly two hours resulted in less than a dozen specimens being taken—but there were present numbers of the young fry which has been identified by Mr. G. Boulenger of the British Museum as Ophiocephalus obscurus.

This fish feeds greedily on mosquito larvæ, thrives well in captivity and in stagnant water, and appears to be an ideal fish for the purpose for which it is wanted, except in one respect—viz., size. When full-grown it attains a length of 35 cms. As fry, inhabiting shallow waters, such as are found in swamps and river spills, this fish would no doubt prove of value, for it is in just such places that mosquitoes breed. On the other hand, though the fish would flourish in large irrigation canals and the fry could reach the smaller gadwals on irrigated land, the latter are frequently so constructed that the young fish, on increasing in size, could not regain the parent canals and would perish. Hence this species of fish is not likely to be an economical means of dealing with mosquito larvæ in such situations.

Some thirty specimens of O. obscurus are still living in a jar in the laboratories.

During May I met Mr. Butler, Superintendent of Game Preservation, who told me of a small fish—Cyprinodon dispar—which lives in Khor Arbat, about twenty-two miles from Port Sudan. He very kindly furnished me with some notes on its habits, and recommended that it should be given a trial, as it appeared to him to be likely to give good results. He further said that while no mosquitoes are noticeable in the vicinity of that khor they are plentiful near other similar khors where C. dispar does not exist.

Accordingly, on Sept. 6th, I left for Khor Arbat, and having spent three days there returned to Khartoum on Sept. 12th. There were myriads of the fish in the khor, but at first I had considerable difficulty in persuading them to live in captivity. Eventually I found that while if placed in jars nearly full of water most of them died within twelve hours, yet if given only about two inches of water over a layer of sand they could be transported fairly easily. One hundred and one living specimens reached Khartoum and were there offered mosquito larvæ which they took readily. This, however, is not conclusive proof that C. dispar feeds on mosquito larvæ in its wild state as the specimens had been unfed for two days when the larvæ were given them, none being obtainable at Khor Arbat.

As these fish did not thrive in jars I wrote to Mr. MacIntyre, acting manager of the estate at Zeidab, belonging to the Sudan Plantation Syndicate, Ltd., asking him if he would allow them to be placed in a gadwal on the Company's estate for purposes of experiment. This he readily agreed to, so on Sept. 19th I took those that were still alive—about seventy in number—to Zeidab and the following morning liberated them in a short length of gadwal, which Mr. MacIntyre very kindly had filled with water. This gadwal is not used at present for agricultural purposes, and the pipe connecting it with the canal has been netted to prevent other fish gaining access. This was done in order that the C. dispar might be given every chance of establishing themselves before being subjected to the possible ravages of other and larger fish.

The specimens liberated at Zeidab were all immature, as it was found that partially grown fish withstood captivity better than did adults.

When full grown C. dispar attains a length of 8 cms., and in all stages appears to prefer shallow water.

Should the gadwal in which these fish were liberated remain free from mosquito larvæ during the coming year, while similar gadwals in the immediate vicinity serve as breeding places for these pests, I think sufficient proof of their value will have been obtained to justify an effort being made on a larger scale to establish C. dispar throughout all the gadwals on the Sudan Plantation Syndicate Ltd.'s estate and on other similar farms where great difficulty is experienced in controlling mosquitoes.

Attached is the account of Cyprinodon dispar given by Boulenger in his monumental work on "The Fishes of the Nile":—

This species has not actually been found in fresh water in any part of the Nile Basin, but as it seems to be widely distributed along both coasts of the Red Sea, in tidal pools and at the mouth of the rivers, and as it is known to occur in hot springs in Arabia and Persia and in fresh water in Cutch, it will probably be found in inland waters in Egypt in the neighbourhood of the Red Sea. It is included here on this supposition.

C. dispar is very closely allied to, and difficult to distinguish from, C. fasciatus, but it grows to a larger size, it has only 9 to 10 rays in the dorsal fin, and 10 or 11 in the anal, and the caudal fin, which is truncate, is marked in the male with two or three crescentic black bands; the dark and light crossbars on the body, which are more or less distinct in the female, are replaced in the adult male by numerous round light (in life blue) spots. 16 to 20 teeth in each jaw. 26 to 28 scales in the lateral line, 22 or 24 round the body. Grows to a length of 80 millimetres.

In describing this species, Rüppell observed that it is found all round the Red Sea, in salt water, but that it occurs also in the thermal fresh-water of Hadjer Elme near Tor. Mr. Lort Phillips also found it in a hot spring at Makulla, Persian Gulf, and the type specimens of C. stoliczkanus, Day, were obtained in a small nearly quite freshwater stream at the village of Joorun, in Cutch.

It would seem that this fish could be also utilised for dealing with Culex salus in the latter's aquatic stages which are passed in salt or very brackish water.

Khartoum.

RECENT RESEARCHES ON THE ANATOMY OF THE HEART.

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AND
IVY MACKENZIE, M.A., B.SC., M.B. GLASG.,
CARNEGIE RESEARCH FELLOW.

SOME three years ago Dr. Martin Flack and one of the writers published a paper[1] on the muscular connexions between the various parts of the heart and summed up the results of other researches which had been published at that time. In that paper a small mass of peculiar muscle and nerves was described—a mass a little bigger than a grain of wheat—which was constantly found at the termination of the superior vena cava in the right auricle and to which we gave the name of sino-auricular node. Because of its intimate connexion with nerves and the peculiar structure of its muscle fibres—similar to those of the auriculo-ventricular node described by Aschoff and Tawara at the commencement of the bundle passing from auricles to ventricles—we supposed that the sino-auricular node might prove to be the starting point of the heart's contraction.

Dr. Walter Koch,[2] working in the laboratory of Professor Aschoff, has fully verified and also extended our description of the sino-auricular node. He found also, as Keith and

1 A. Keith and M. Flack: Journal of Anatomy and Physiology, 1907, vol. xli., p. 172. See also THE LANCET, April 11th, 1906.

2 W. Koch: Deutsche Medicinische Wochenschrift, 1909, No. 10; Munchener Medicinische Wochenschrift, 1909, No. 46.

Flack stated, that the sino-auricular node had no special muscular connexion with the auriculo-ventricular node except through the general musculature of the auricle. Dr. Ch. Thorel[3] has reached a different conclusion; he found by serial sections of the human right auricle that these two nodes were connected by a differentiated strand of tissue. We have been unable to find such a connexion in the hearts of smaller mammals in our series of sections. We are still of opinion, not only that these nodes are devoid of a special connexion, but that they represent two quite different autogenetic systems in the heart. Professor Aschoff,[4] in a recent excellent summary of recent work on the pathological anatomy of the heart, cites the experiments by Hering, Langendorff, and Lehmann as favouring the theory that the sino-auricular node is the point of origin of the heart's contraction.

We have recently cut and examined a series of hearts of the eel, frog, tortoise, lizard, pigeon, sparrow, and of many mammals, with the view of throwing more light on the nature of the sino-auricular node of the human heart. The result of our investigations has been to show that all those areas of specialised or primitive musculature—such as have been described as nodes—are really areas where the musculature of the heart comes into an extremely intimate contact with the nervous system, that nodes are really neuro-muscular contacts. We found that those areas of the heart of the tortoise which Gaskell found to have the greatest power of originating the heart's impulse, and those of the eel which MacWilliam found were the most automatic, were areas made up of a mixture of nerve and muscle fibres. The appearances led to the belief that in these areas the nerve fibres become actually continuous with the muscle fibres, and that there are nucleated fibres which, from their structure and staining reaction, appear to be intermediate between nerve and muscle fibre. To the cardiac areas which we regard as made up of nerve and muscle fibres we propose to give the non-committal name of "nodal tissue."

The wall of the sinus venosus of the eel, in which the great veins end, is made up of nodal tissue, but this is accumulated and the nerve element is more abundant at the bases of the venous valves which mark the junction of sinus and auricle. In the frog this tissue is massed mostly in the left auricle, at the termination of the pulmonary vein, but it extends also on to the right auricle. We were able to verify the fact that the part of the left auricle (vestibule) in which the pulmonary veins end is a derivative of the sinus venosus. The nodal tissue of the frog occurs at the sino-auricular junction, but instead of being continuous round the whole extent of that junction, as in the eel, it is concentrated in one part.

As one ascends the scale of animals the concentration becomes more marked. The nodal tissue is in intimate connexion in the frog with Remak's ganglion, which it would be more convenient to name, as it really is, the sino-auricular ganglion of the heart. The condition in the tortoise and lizard is very similar to that in the frog; the nodal tissue, however, is now more directly connected with the right auricle, although, as in the frog, the chief centre of its distribution is at the termination of the pulmonary vein (vestibule) in the left auricle, where it has a close connexion with the sino-auricular (Remak's) ganglion. The nodal tissue forms almost a complete circle round the junction of sinus and auricle, its chief distribution, as already mentioned, lying at the termination of the pulmonary vein. In the bird's heart the sino-auricular tissue is not in evidence in the form in which it is present in the heart of other vertebrates. The sino-auricular node is represented by small neuromuscular stations scattered along the sino-auricular junction. The sino-auricular ganglion, still in relationship with the vestibule of the left auricle, is also reduced in extent.

In the mammalian heart the sino-auricular nodal tissue is concentrated on the right auricle, chiefly along the sino-auricular junction and in front and on each side of the termination of the superior vena cava. In the heart of the mole this tissue is peculiarly abundant at the sites just mentioned, as Keith and Flack[5] have described. We have now found that in the lowest type of mammalian heart—that of the Monotreme Echidna[6]—the nodal tissue is abundant and peculiar; it lies superficially along the junction of sinus and auricle, especially in that part of the junction known in human anatomy as the sulcus terminalis. The tissue is seen as leashes of superficial nucleated fibres passing downwards on the surface of the auricle where they become continuous with the ordinary muscular fibres. In the hearts of rodents the nodal tissue has an extensive distribution along the sino-auricular junction, but in the higher mammals, as in man, it tends to become concentrated at the termination of the superior vena cava.

Thus it will be seen that the sino-auricular nodal tissue becomes less in amount and more concentrated in position as one passes from the lower and more automatic to the higher and less automatic type of hearts. As the animal becomes more specialised the heart loses its independence and becomes more a part of the general organisation. The nodal tissue becomes less in amount; the cerebro-spinal nerves enter into a more direct relationship with the cardiac musculature.

We come now to deal with the auriculo-ventricular nodal tissue. In the mammalian heart this tissue is represented by the reticulum or node in which the auriculo-ventricular bundle commences. On its discovery Aschoff was inclined to regard this node as the automatic centre of the heart. The node is situated in the septal wall of the right auricle near the orifice of the coronary sinus. Aschoff's original hypothesis as to the nature of the node was supported by the investigations of his pupil Dr. Walter Koch,[7] who observed that the tissue of the nodal region contracted in the dying heart when all the other parts had ceased. Professor H. E. Hering's experiments support the view that the highest automatic centre of the heart is the sino-auricular. On anatomical evidence the auriculo-ventricular node must be regarded as a lower centre.

In the evolution of the heart the nodal tissue at the auriculo-ventricular junction has, like that at the sino-auricular junction, undergone reduction and concentration. In the heart of the eel the auriculo-ventricular nodal tissue forms a complete ring. It is composed of reticulated fibres situated at the inner margin of the auriculo-ventricular orifice. It receives numerous nerve fibres from the plexus of nerves surrounding this orifice. The nodal tissue is inserted between the annular fibres of the auricular canal and the inner longitudinal fibres of the ventricle. In the frog's heart, although the ring of tissue is complete, there is evidence of concentration, for it is more abundant at certain points, and this concentration becomes more marked in the reptilian heart. In the bird's heart the auriculo-ventricular nodal tissue is reduced in amount; it is represented by scattered points situated chiefly near the base of the inter-auricular septum, where the nerves and muscle form small nodes. In the mammalian heart the ring becomes reduced to the auriculo-ventricular node at the commencement of the bundle distributed to the ventricles.

It is very probable, as Dr. James Mackenzie[8] has supposed, that in cases of continued irregularity of the heart the inception of the rhythm of the heart has been taken on by the auriculo-ventricular node, owing perhaps to a lesion of the sino-auricular node. In some of Dr. Mackenzie's cases of continued irregularity one of us found that the sino-auricular node was more isolated than normal, with signs of fibrosis, but the appearances varied in different cases, and the technique employed in their examination was too crude to allow definite inferences to be drawn.

Our investigations have made certain that the single strand of muscular communication now known as the auriculo-ventricular bundle is peculiar to the mammalian heart. In the fish, frog, and reptile this bundle is represented by the inner vertical fibres of the ventricle which issue from the auriculo-ventricular ring of nodal tissue; as the nodal tissue becomes concentrated the inner vertical fibres also become reduced until only the strand connected with the remnant of the nodal ring remains in the mammalian heart. We see in the reduction of the ring and

[3] Ch. Thorel: Munchener Medicinische Wochenschrift, 1909, p. 2195.
[4] L. Aschoff: Medizinische Klinik, 1909, Nos. 8 and 9. Professor Hering's latest results have just appeared in the Münchener Medizinischen Wochenschrift, No. 17, 1909.
[5] A. Keith and M. Flack: Journal of Anatomy and Physiology, 1907, vol. xii., p. 172.
[6] For the heart of this animal we were indebted to Professor J. P. Hill. A consecutive series of excellent sections was prepared for us by Wm. Chesterman, Oxford.
[7] W. Koch: Ueber das Ultimum moriens des Menschlichen Herzens. Inaugural Dissertation, Freiburg-im-Breisgau, 1907.
[8] J. Mackenzie, Quarterly Journal of Medicine, 1907, vol. i., p. 39.

of its ventricular strand the same process at work as in the rest of the heart—viz., a reduction in the automatic power of the ventricle and its greater subjection to the central nervous system.

The condition in the bird's heart puzzled us greatly. There was no bundle to be found, although certain muscular connexions between the right auricle and ventricle were found. We hoped to get a clue to the condition in the bird's heart in that of the Echidna, but there we found a large and typical bundle with many points of resemblance to the form found in the hearts of ungulates, but we also found considerable remnants of the extensive auriculo-ventricular connexion which prevails in lower vertebrate hearts, especially round the right auriculo-ventricular orifice. One of these remnants demands mention because it throws light on the nature of the auriculo-ventricular node. In the heart of Echidna we found that this node gave off not only the bundle but also a leash of fibres which descended at once to the septal wall of the right ventricle, independently of the bundle, a connexion which we also noted in the heart of the rat. This direct connexion we regard as a remnant of the complete circle of inner ventricular fibres. On the left side of the heart of the Echidna there was an auriculo-ventricular connexion consisting of ordinary muscle fibres. In the bird's heart the muscle connexion between the auricles and ventricle is found on the lateral and mesial side of the right auriculo-ventricular orifice, but these connecting fibres are not of a markedly specialised type.

Two recent papers demand mention. Dr. E. J. Curran[9] has drawn attention to the bursa or lymphatic space that surrounds the bundle, a circumstance that leads him to infer that the bundle is passive during contraction of the heart. He traces the connexions of the auriculo-ventricular node to both auricles; our sections show that the closest connexion of the node is with the septal fibres of the left auricle and with the annular fibres of the right. Dr. R. Retzer[10] has inferred, from an investigation of developing hearts, that the auriculo-ventricular bundle is a special downgrowth of musculature of the sinus venosus within the ventricles—an interpretation with which we totally disagree. On the other hand, we think there is much to be said in favour of Dr. Retzer's hypothesis that the bundle may have much in common with the spindles of voluntary muscles, although the analogy is denied by Dr. Gordon Wilson.[11] Sherrington showed that these spindles are the points from which the sensory nerves of muscles commence—points at which coördinating impulses arise. These muscle spindles persist after section of all the nerves of a muscle; Keith and Miller have shown that the ventricular ramifications of the bundle persisted years after the bundle in the human heart had been severed by a gumma. We are of opinion that experiments will show that the bundle is not only for the conduction of impulses from auricle to ventricle, but that through the bundle the condition of the ventricle is continually affecting the condition of excitability of the auricle. The bundle appears from its nature to be not only a conducting but a coördinating mechanism.

Professor Aschoff[12] and his pupil Dr. Nagayo have shown that the transparent appearance and large size of the Purkinje (bundle) fibres of the ungulate heart is due to the presence of glycogen. Of great significance in unravelling the method in which the impulse is conducted from one chamber of the heart to another is Professor Wenckelbach's[13] discovery that a sino-ventricular rhythm may occur in the human heart, a rhythm which MacWilliam observed in the eel's heart many years ago.

One of the chief results of our investigation has been to impress upon us the necessity of studying the special musculature of the heart in its relation to the extraordinary abundant nerve-supply of that organ. The excitable regions of the heart are those where the nerves come into a specially direct connexion with the specialised tissue which we have named nodal. We have not touched on the abundant nerve-supply to the sinuses of Valsalva at the commencement of the aorta and round the auriculo-ventricular orifices which we regard as end stations for sensory reflexes. The nerve plexuses at these regions are so close that zigzag experiments could not possibly sever all the nerve connexions between auricle and ventricle. We are also of opinion that an entirely fresh description of the nerves to the heart is necessary, and that the fundamental differentiation must be into those nerves which supply the venous base or commencement of the heart (derived from the lower cervical sympathetics) and those which supply the terminal end or arterial base of the heart. It is those nerves which end in the venous base which appear to exercise the inhibitory and accelerating effects on the heart through the specialised nodal system. Dr. Martin Flack[14] has given an excellent summary of the recent literature dealing with aspect of cardiac research.

[9] E. J. Curran: Anatomischer Anzeiger, 1909, Band xxxv., p. 89.

[10] R. Retzer: Anatomical Record, 1908, vol. ii., p. 149.

[11] J. G. Wilson: Proceedings of the Royal Society, 1909, vol. lxxxi., p. 151.

[12] Nagayo: Verhandlungen der Deutschen Pathologischen Gesellschaft, 1908 (Keil), p. 150.

[13] Wenckelbach, K. F.: Archiv Maladies du Cœur, 1908, No. 2.

A CASE OF SIMULTANEOUS SUPPURATIVE APPENDICITIS AND PERFORATED GASTRIC ULCER.

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THE patient, a female, aged 18 years, was sent in to hospital by Mr. J. Lewellyn of Kingswood on Oct. 17th, 1909, under the care of Mr. R. G. P. Lansdown. The previous history contained nothing of importance except that she had twice been under Mr. Lewellyn's care with symptoms of gastric ulcer, the last time six months before admission. She had also suffered from several attacks of pain and tenderness in the right iliac fossa, but not severe enough to lay her up. The present illness commenced on Oct. 16th. She had not felt well all day and had taken no solid food. At 8.30 P.M. she had a sudden attack of pain in the left side of the abdomen so severe that she fainted and was sick. The pain became less, but the sickness continued until 5.30 A.M. next day. The bowels acted after taking an aperient.

On admission at 9.30 P.M. on Oct. 17th the patient had a typical "abdominal" expression, with sunken eyes and dilated pupils. The pulse-rate was 136 and the quality poor; the temperature was 99·8° F. The abdomen moved very imperfectly, especially in the lower part, where the distension was also more marked than above. There was considerable rigidity all over, well-marked in the epigastrium, but perhaps more so in the right iliac fossa. There was nothing definite to be felt except a sense of thickening in the appendix region. There was distinct tenderness in the left loin, but none in the right, and rectal examination was negative. The right loin was dull, and the dulness did not shift. The rest of the abdomen was tympanitic, the stomach area was increased, and the liver dulness only just appreciable as a narrow zone of impaired resonance. The diagnosis lay between appendicitis and perforated gastric ulcer, and it was decided to explore the appendix first.

At 11.30 P.M., 27 hours after perforation, Mr. Lansdown operated. A small incision was made at the outer border of the right rectus. Much odourless peritoneal exudate escaped and the appendix was found covered with lymph, and swollen and congested, with a hard bulbous end. It was rapidly removed by crushing and inversion. As this could obviously not explain the whole of the symptoms a median incision was made above the umbilicus. On opening the peritoneum odourless gas in large quantity escaped, together with more fluid. A brief search revealed a perforation in the anterior wall of the stomach towards the cardiac end and nearer the lesser curvature. There was much surrounding induration, and the perforation was partially sealed by plastic lymph. It was closed with a purse-string suture and the fluid in the immediate vicinity mopped up; very little stomach contents escaped. The upper wound was closed in layers, and through the lower a cigarette-drain was passed into the pelvis. The appendix after removal was slit up, was found to contain pus, and the mucous membrane at the tip was ulcerated.

The patient bore the operation well. The Fowler position was adopted and a pint of hot saline solution was given by the rectum every four hours. The drain was removed, and

[14] Flack, M.: Further Researches in Physiology. Edited by L. Hill. London, 1909.