VI. *Some observations and experiments made on the Torpedo of the Cape of Good Hope in the year* 1812. *By* John T. Todd, *late surgeon of His Majesty's ship Lion. Communicated by Sir* Everard Home, *Bart. V. P. R. S.*

Read February 15, 1816.

WHILST the Lion was stationed at the Cape of Good Hope, the seine, as is the custom throughout the navy, was frequently employed in procuring fish for the use of the ship's company, and besides the more edible kinds, many of the Torpedo were caught. In this manner the opportunity was afforded me of making the following observations, some of the imperfections of which I must be allowed to attribute to the "*manus nuda*" of my situation. The fish were generally caught early in the morning, and examined as soon after as possible. When this could not be done, they were placed in buckets of sea-water, where they sometimes remained alive for three, and in one instance for five days.

The torpedo is seldom met with to the eastward of the Cape of Good Hope. Hence, whilst I rarely failed in procuring them in Table Bay, I never but once succeeded in doing so in Simon's Bay, although the opportunities were the same in both places. It was never caught but by the seine, although the hook and line, with bait of every variety, were as often made use of exactly in the same situations. It differs in no respect, as far as I have been able to observe, from the same fish of the northern hemisphere, except that it was never

found so large; being never more than eight, nor less than five inches in length, and never more than five, nor less than three inches and a half in breadth. The colour of the animal is various; the upper surface being generally hazel grey, reddish brown, or purple; the under surface greyish white, yellowish white, or white with black patches.

The columns of the electrical organs were larger, and less numerous in proportion, than those described by Mr. HUNTER, in the torpedo caught at La Rochelle. When separate and uninfluenced by external pressure, they appear to be of the form of cylinders, as is shown as nearly as possible by suspending them by one of their extremities. The different forms which they exhibit in a horizontal section of the whole organ, are produced by their unequal attachment to one another by the intermediate reticular substance.

The electrical organs are so placed within the curvature of the semilunar cartilages of the large lateral fins, as to be entirely under the influence of the muscles, which are inserted into these cartilages. So that in any lateral motions of these cartilages towards the trunk, or in any increase of curvature of these cartilages, the electrical organs must be compressed. There appears also to be a muscular structure, which connects the anterior part of these cartilages to a process projecting from the anterior part of the cranium, the action of which must tend to increase this effect.

The inferior and posterior terminations of the small lateral fins are covered with laminæ of osseous matter, which are enveloped in the epidermis.

A much larger proportion of nerves is supplied to the electrical than to any other organs. This has appeared to others so

important an observation, that it may be repeated with propriety.

The shocks received from the torpedos which I examined, were never sensible above the shoulder, and seldom above the elbow-joint. The intensity of the shock bore no relation to the size of the animal (sensation being the only measure of intensity), but an evident relation to the liveliness of the animal, and *vice versâ*. The shocks generally followed simple contact, or such irritation as pressing, pricking, or squeezing, sometimes immediately, and sometimes not until after frequent repetition. Not unfrequently, however, animals apparently perfectly vivacious suffered this irritation without discharging any shock. There appeared no regularity of interval between the shocks. Sometimes they were so frequent as not to be counted; at other times, not more than one or two have been received from one animal; and, in a few instances, it has been impossible by any irritation to elicit shocks from some of them. When caught by the hand, they sometimes writhed and twisted about, endeavouring to extricate themselves by muscular exertion, and did not, until they found these means unavailing, discharge the shock. In many instances, however, they had recourse to their electrical power immediately.

The electrical discharge was, in general, accompanied by an evident muscular action. This was marked by an apparent swelling of the superior surface of the electrical organs, particularly towards the anterior part, opposite to the cranium, and by a retraction of the eyes. It was so evident, that when the animal was held in the hand of another person, I was often able to point out when he received the shock. In this,

however, I was also sometimes deceived; and I think I have received shocks (particularly when the animal has been debilitated, and the shocks weak,) without having been able to observe this muscular action.

Two of these animals, as nearly alike in every circumstance as possible, being each placed in a separate bucket of sea-water, from one of them frequent shocks were elicited by irritation, *viz.* simple contact, or pricking, &c.; the other was allowed to remain undisturbed. The former became languid, the intensity of its shocks diminished, and it soon died; the last shocks being received in a continued succession, producing pricking sensations never extending above the hand. The latter continued vivacious, and lived until the third day. This experiment was frequently repeated with the same results; and it might be observed, in general, where there was no direct comparison made, that those which parted with the shocks most freely soonest became languid, and died; and those which parted with them most reluctantly, lived the longest.

Two torpedos being placed exactly in the same circumstances as the last-mentioned, from one shocks were elicited until it became debilitated. It was then allowed to remain until the following day. When they were both examined, it was found that the animal from which no shocks had been previously received, discharged them very freely; but it was with the greatest difficulty that they could be procured from the other.

Having made an incision on each side of the cranium and gills of a lively torpedo, I pushed aside the electrical organs, so as to expose and divide their nerves. The animal was then placed in a bucket of sea-water. On examining it in

about two hours afterwards, I found it impossible to elicit shocks from it by any irritation; but it seemed to possess as much activity and liveliness as before, and lived as long as those animals from which shocks had not been received, and which had not undergone this change.

Two of these animals being procured, the nerves of the electrical organs of one of them were divided after the manner above described. They were placed each in separate buckets of sea-water, and allowed to remain undisturbed. This was performed in the morning, and when examined in the evening, it was impossible to distinguish between the liveliness or activity of either.

Of two of these animals, the nerves of the electrical organs of one of them were divided. Being placed each in separate buckets of sea-water, they were both irritated as nearly alike as possible. From the perfect animal, shocks were received; after frequent repetition it became weak, and incapable of discharging the shock, and soon died. The last shocks were not perceptible above the second joint of the thumb, and so weak as to require much attention to observe them. From the other no shocks could be received; it appeared as vivacious as before, and lived until the second day. This experiment was frequently repeated with nearly the same results.

The nerves of one electrical organ only being divided in a lively torpedo, from which shocks had been previously received, on irritating the animal it was still found capable of communicating the shock. Whether there was any difference in the degree of intensity could not be distinctly observed. One electrical organ being altogether removed, the animal still continued capable of discharging the electrical shock.

Having divided one of the nerves of each electrical organ in a torpedo, from which shocks had been previously received, I still found the animal capable, after this change, of communicating the shock.

Having introduced a wire through the cranium of a torpedo, which had been communicating shocks very freely, all motion immediately ceased, and no irritation could excite the electrical shock.

I never received a shock from a torpedo, when held by the extremities of the lateral fins or tail.

The preceding account appears to me to afford grounds for the following conclusions.

1. That the electrical discharge of this animal is in every respect a vital action, being dependent on the life of the animal, and having a relation to the degree of life and to the degree of perfection of structure of the electrical organs.

2. That the action of the electrical organs is perfectly voluntary.

3. That frequent action of the electrical organs is injurious to the life of the animal; and, if continued, deprives the animal of it. Is this only an instance of a law common to all animals, that by long continued voluntary action they are deprived of life? Whence is the cause of the rapidity with which it takes place in this instance? Or is it owing to the re-action of the shock on the animal?

4. That those animals, in which the nerves of the electrical organs are intersected, lose the power of communicating the shock, but appear more vivacious, and live longer than those in which this change has not been produced, and in which this power is exerted. Is the loss of the power of commu-

nicating the shock to be attributed to the loss of voluntary power over the organ? Does this fact bear any analogy to the effects produced by castration in animals?

5. That the possession of one organ only is sufficient to produce the shock.

6. That the perfect state of all the nerves of the electrical organs, is not necessary to produce the shock.

And, 7. From the whole it may be concluded, that a more intimate relation exists between the nervous system and electrical organs of the torpedo, both as to structure and functions, than between the same and any organs of any animal with which we are acquainted. And this is particularly shown, 1st, By the large proportion of nerves supplied to the electrical organs: and, 2d, By the relation of the action of the electrical organs to the life of the animal, and *vice versâ*.