

Physiology. — *On the Segmental Innervation of the Skin of Rays*¹⁾. By Dr. J. TEN CATE. (Communicated by Prof. G. VAN RIJNBERK).

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The innervation of the skin of fish by the posterior roots of the spinal cord has thus far received little attention. Direct indications of a segmental innervation of the chromatophores of the skin by the sympathetic system in Pleuronectides are to be found in the researches by POUCHET²⁾. VAN RIJNBERK³⁾ has established the segmental innervation of the skin by the pigmento-motor nerve fibres in Solea-, and Rhomboidichthys-species. VAN RIJNBERK⁴⁾ also demonstrated in sharks, in scillium catulus, and scillium canicula the segmental innervation of the skin by the posterior roots. This, to my knowledge, is about all that the literature contains concerning this problem.

I have conducted a series of experiments with rays (*raja clavata*), trying to make out how the skin of this fish is innervated by the posterior roots, and I applied principally the method of the so-called "remaining sensibility", suggested by SHERRINGTON for the determination of the boundaries of the dermatomata. As known, this method consists in isolating one dorsal root, or a group of them, by severing from two to four roots cranial or caudal to the first-named. Thus a sensible field is obtained, bounded by two insensible fields. By means of this demarcation of the sensible and insensible fields the location as well as the extent of the dermatomata can be established.

The spinal cord of rays, extending all along the vertebral column as far as the end of the tail, distributes a large number of dorsal and ventral roots to either side, which unite outside the vertebral column.

FÜRBRINGER⁵⁾ was the first to show that the first two or three spinal nerves are formed only by the ventral roots. In fair agreement with the observations by BRAUS⁶⁾ I could establish in most rays, examined by me, that already the third spinal nerve is formed as well by the ventral as by the dorsal root; but in a few cases the third spinal nerve was supplied only by the ventral root. In rays the first 17 or 18 spinal nerves form the

1) After the experiments made in the aquarium of the K. Zoöl. Genootschap N. A. M. at Amsterdam and the Zoöl. Station at Den Helder.

2) cit. after v. RIJNBERK, *Ergebnisse der Physiologie*, Bd. V, 1906.

3) *Archivio di Fisiologia*, Vol. III, 1906.

4) PETRUS CAMPER, *Nederl. Bijdragen tot de Anat.*, D. III, Afl. 1, 1904.

5) *Ueber die spino-occip. Nerven der Selachier*, Festschrift f. L. GEGENBAUER, III, Leipzig 1897.

6) *Jenaische Zeitschr. f. Naturwiss.*, Bd. 31, N. F. 24, 1898.

plexus cervico-ptyergialis, which in conjunction with the 18th to the 21st spinal nerve is located between the skull and the shoulder-girdle, and innervates the skin of the trunk before and above the shoulder-girdle, and of the anterior half of the pectoral as well. The spinal nerves emanating from the spinal cord behind the shoulder-girdle innervate directly the skin of the trunk and the hindermost half of the pectorals, without forming a plexus.

Generally the pectorals are innervated by the rami ptyergialis of the 3^d to the 40th spinal nerves. But I observed that also the 41st spinal nerve not infrequently participates in the innervation of the pectorals. Here, as well as in the formation of the plexus cervico-ptyergialis, I could differentiate several variations.

Interptyergial nerves, such as in Squalides, do not occur in rays. The 41st or the 42^d pair of the spinal nerves participates already in the innervation of the ventral fins. The last pair of the spinal nerves that innervates the ventral fins is the 56th; the next-following innervate the tail and form, as established by ROBIN, a plexus on either side, reaching as far as the end of the tail.

The boundary-lines and the location of the various dermatomata, identified by me after SHERRINGTON's method, I have indicated in a series of schemata. As, however the location as well as the boundaries of the dermatomata of the ventral side differ comparatively little from those of the dorsal side, I may be allowed to confine myself to reproducing only a general diagram of the boundaries of the dermatomata, and that of the dorsal side (Fig. 2).

It will be seen from this diagram that the course of the boundaries of the dermatomata differs. Nevertheless a prototype can easily be identified. The dermatomata lying on the level of the shoulder-girdle are most typical. They (from the 20th to the 22^d) run fanlike from the diameter of the trunk to the margin of the pectoral fin and are broadening towards the periphery. More anteriorly and posteriorly this shape has more or less altered, because the part of the dermatoma that overlaps the fin has turned forward or backward.

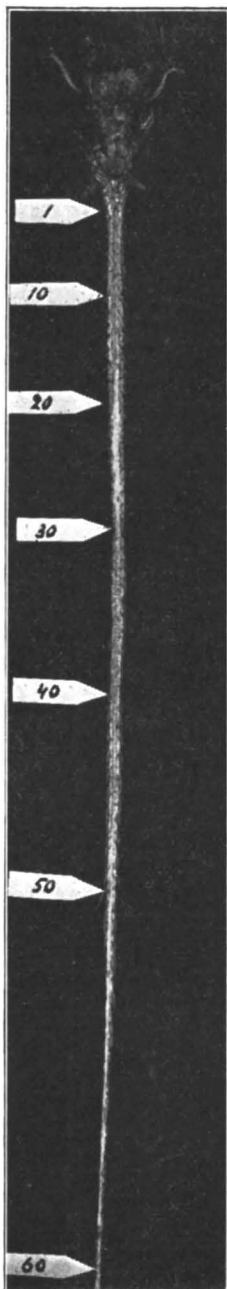


Fig. 1.

When measuring the breadth of these dermatomata at the dorsal and

the ventral diameter, and at the lateral line of the trunk, where the skin of the trunk passes on to the fin, it is easy to convince oneself that the breadth of the dermatoma of the dorsal diameter gradually increases towards the lateral line. Near the ventral diameter the dermatoma is always broader

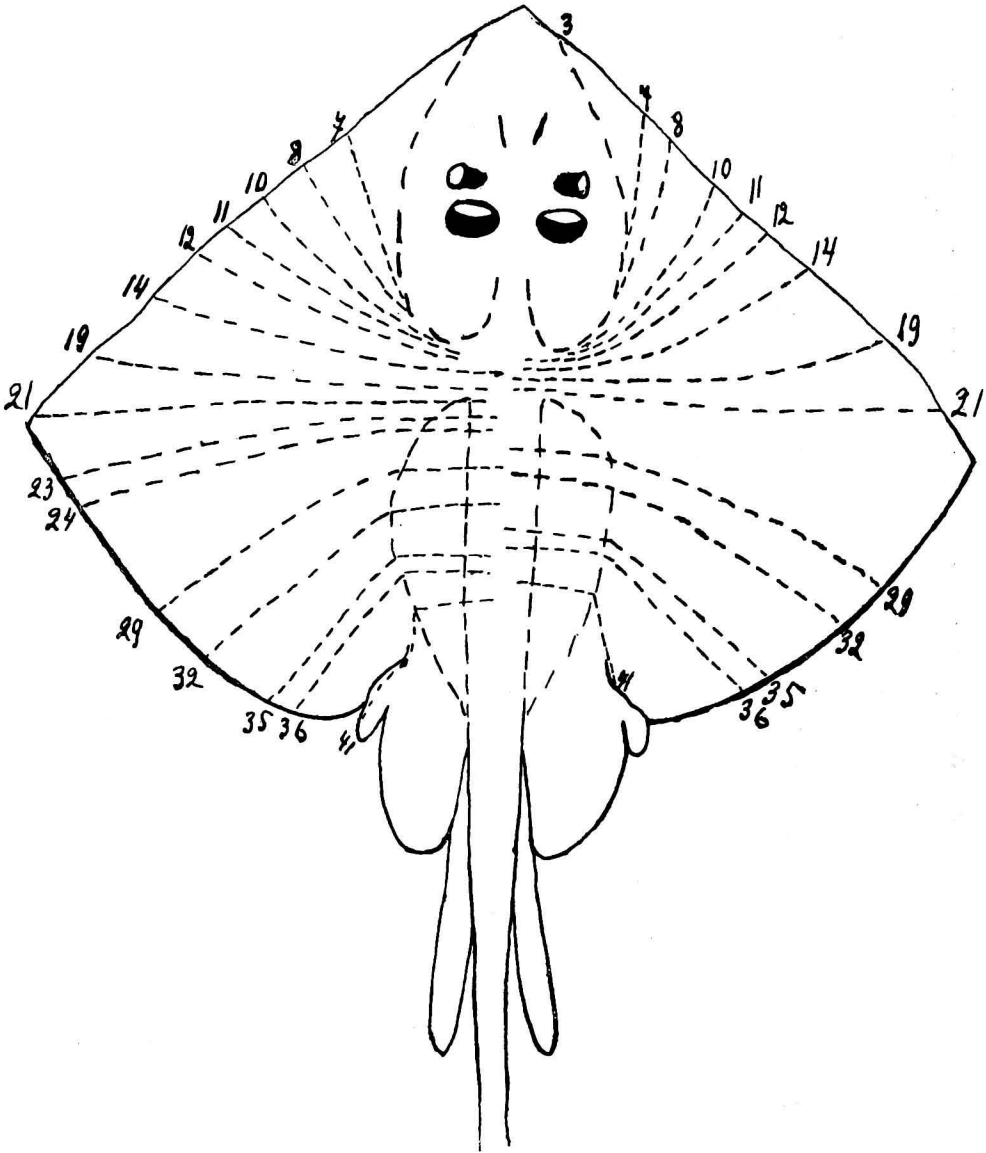


Fig. 2.

(The average boundaries of the dermatomata: to the left the caudal, to the right the cranial).

than near the dorsal diameter, and about equal to, but frequently also a little broader than near the lateral line of the trunk. From the relations of the breadth of the dermatomata, just now referred to, it appears that in

rays they are trapezoidal, as it is the case in most animals, and as has been described by VAN RIJNBERK also for sharks. The following diagram (fig. 3) is a fairly correct representation of the dermatomata in rays.

As stated above, we find in the fore-part of the body of rays a number of anomalies and complications in the structure of the dermatomata. The part of the trunk that is bounded in front by the head and laterally by the gill-pouches, is covered with a comparatively narrow strip of skin, which is innervated by the dorsal roots forming the plexus servico pterygialis. In this part of the skin I could not establish a distinct dermatomere. In a ray, however, of which the posterior roots of the 4th to the 10th spinal nerve

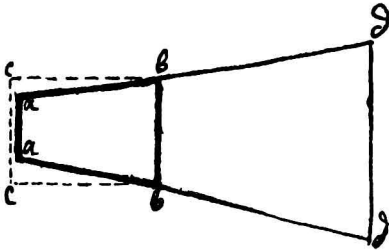


Fig. 3.

- a—a dorsal diameter
- b—b lateral line of the trunk
- c—c ventral diameter
- d—d margin of the fin

had been cut across, I detected complete insensibility. More backwards, between the posterior margin of the gill-pouches and the shoulder-blade, on the other hand, the course of the dermatomata could well be made out. These dermatomata, also innervated by the plexus cervico pterygialis, run from the dorsal and also from the ventral side by way of the trunk to the margin of the fins in the form of the ribs of a fan. The peripheral part of these ribs, that overlaps the pectoral fin, reveals a

larger deviation anteriorly the more cranially it is situated.

Quite a peculiar position is occupied by the 3rd to the 9th dermatomata. Their whole course coincides with the anterior part of the pectoral fin, no contact with the trunk can be identified. The form of these dermatomata is also most like that of the ribs of a fan. The pointed end of these ribs is situated just at the head-region, the broad part coincides with the fin-margin. Here, no doubt, we have to do with a forward displacement of

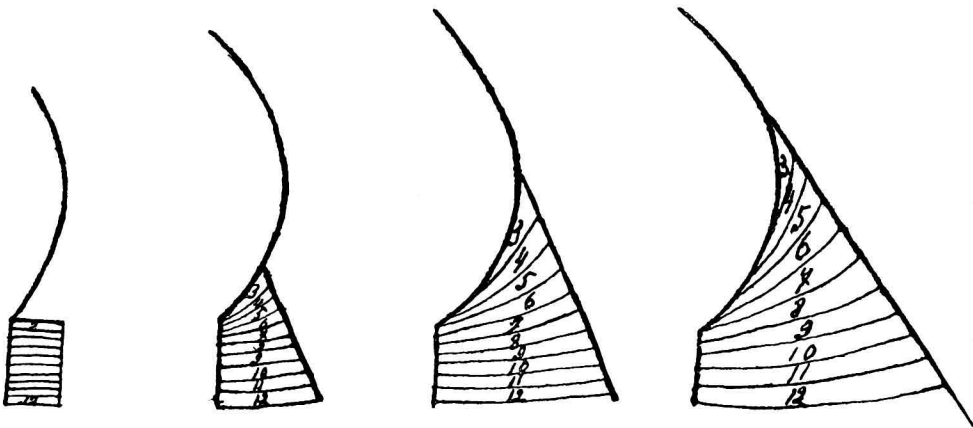


Fig. 4.

the dermatomata, which can be interpreted about in the same way as BOLK¹⁾ has suggested for the extremities of mammals. In rays, however, the displacement of the dermatomata is only a forward shifting, a fact that tallies quite well with FÜRBRINGER and BRAUS's theory concerning the forward extension of the pectoral fin. The shifting of the dermatomata may be imagined, as is represented in Fig. 4.

The dermatomata that are situated on the trunk behind the shoulder-girdle spread on the posterior half of the chest in the shape of a fan. This form, however, has become different in that the peripheral part, that covers the fin, deviates the more posteriorly, the more the dermatomata are

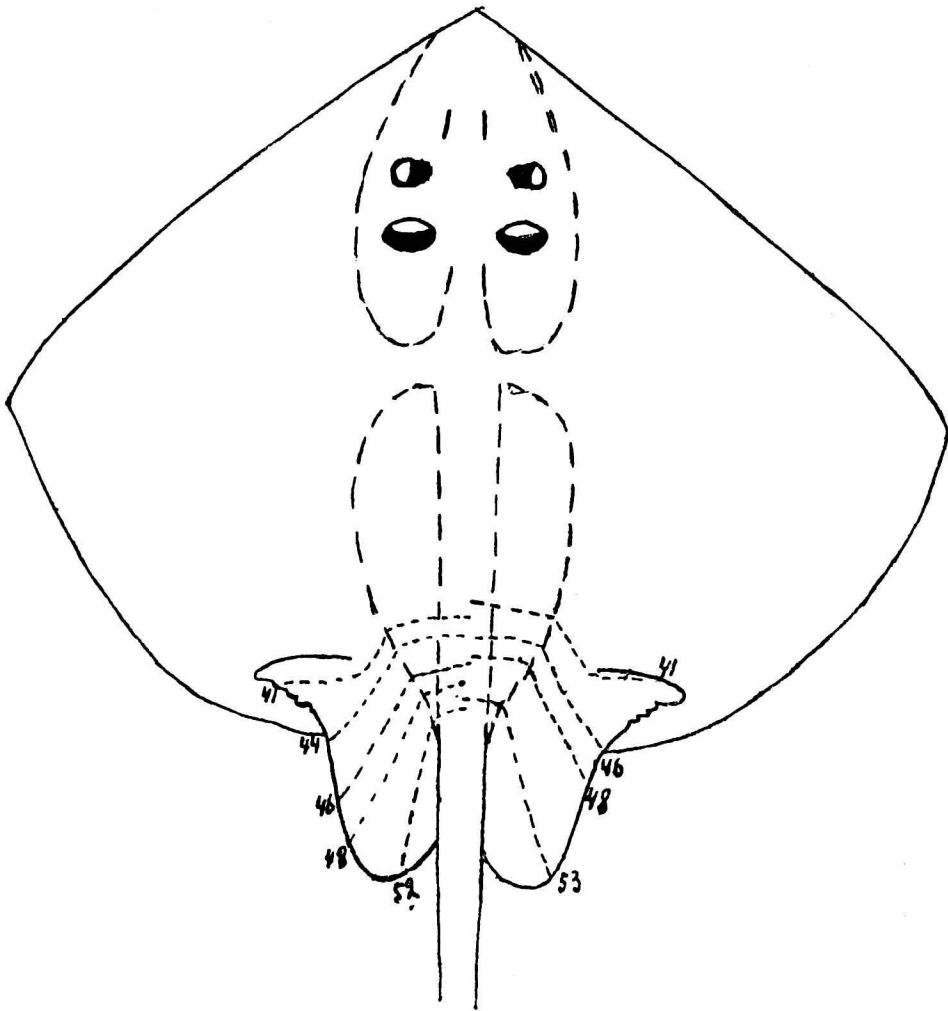


Fig. 5.

The average boundaries of the dermatomata: to the left caudal,
to the right the cranial.

¹⁾ De segmentale innervatie van romp en ledematen bij den mensch, Haarlem 1910.

disposed caudally, as may be seen in fig. 2. The more posterior the position of the dermatomata the smaller the angle becomes, at which the peripheral part of the dermatoma is inclined to the part of the trunk. The course of the dermatomata covering the trunk and the ventral fins is just the same. This is evident from fig. 5, in which I have given schematically the boundary lines of some of these dermatomata.

The innervation of the skin of the tail by the posterior roots happens in about the same way as on the trunk. In spite of the deviating configuration of the tail, the experiments after SHERRINGTON's isolation-method, and ROSSI's section-method, showed that the form of the dermatomata is the same here as on the trunk, namely a trapezium. This trapezoidal shape is here much more pronounced than on the trunk.

The overlapping of the dermatomata I have examined in some experiments after DE BOER's direct strychnine method¹⁾. As such experiments are comparatively difficult to perform with rays, I had to content myself in most cases with the indirect determination of the overlapping by the breadth of the sensible and insensible fields by the method suggested by WINKLER and VAN RIJNBERK²⁾.

These calculations have shown that in rays the overlapping in all parts of the body is larger than one third of the breadth of the dermatomata ; in most cases it is about one half of it. In some places, as e.g. on the ventral diameter the overlapping can be even more than the half of that breadth. The results obtained by the strychnine-method confirm the indirect measures found for the overlapping of the dermatomata.

1) Psychiatr. en Neurolog. bladen, 1918.

2) Versl. Kon. Ak. v. Wetensch., 1901.