

Citation:

S. de Boer, The Structure and Overlap of the dermatomes of the hindleg with the cat, in:
KNAW, Proceedings, 19 I, 1917, Amsterdam, 1917, pp. 321-333

Physiology. — “*The Structure and Overlap of the dermatomes of the hindleg with the cat*”. By Dr. S. DE BOER. (Communicated by Prof. G. VAN RIJNBEEK).

(Communicated in the meeting of May 27, 1916)

I applied the same method that I made use of for the determination of succeeding dermatomes in the thoracic-lumbar region, for fixing the lines of demarcation of the dermatomes of the hindleg.

If we want to apply this method to the lower part of the spinal cord, we have to overcome a difficulty.

From the 5th lumbar root in a distal direction the succeeding roots are closely connected. At their origin from the spinal cord these roots are consequently not separated from each other, as is the case with all roots originating higher.

Consequently I acted as follows: The lumbar-sacral part of the spinal-cord was laid bare under ether-chloroform narcosis, the dura was split lengthwise. Then I sought the 4th lumbar root. I moistened then the spinal cord round the place of entrance of this hind-root with a solution of sulphate strychnini (1 %) coloured by methylene-blue. Sometimes the 3^d lumbarroot had previously been cut. When the cat had then awaked from the narcosis, the hyperreflectory field of lumb. IV was indicated on the skin with water-colour. Then this hindroot was cut under narcosis and at the place of egress of the following hindroot (lumb. V) the spinal cord was moistened with a solution of strychnine. Special care was taken, that in a distal direction the spinal cord was not moistened past the last radicularis of lumbalis V. Then the line of demarcation of this field was determined and marked on the skin. Every time different colours were made use of for the different fields. The succeeding root was then treated in the same way, till all following dermatomes of the hindleg, as far as sacralis 1 or 2 included, had been obtained. When I determined in this way the dermatomes, it is certain that the proximal limits could be obtained more accurately than the distal ones. The spinal cord round the proximal radicularia of each root can always be sufficiently moistened with a solution of strychnine, because the preceding root had been cut. In a proximal direction I never ran the risk of moistening too much or too little. I was not so certain however with regard to the distal radicularia. Though I moistened here as carefully as possible with a tapered piece of cottonwool the spinal cord to just behind the place of entrance of the last radicularis of each root, the uncertainty always remained

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here, that I moistened the spinal cord either too far or not far enough in a distal direction. If the last radicularis of a root is not likewise poisoned, then the field is a narrow zone too small in a distal direction, if, on the contrary, the proximal radicularis of the next following root is likewise poisoned, then the field is a narrow zone too large. We must consequently be mindful of these possible errors, when judging of our dermatomes. When now the dermatomes of the hindleg had been marked with different colours on the skin, then the cat was killed. On a plastermould I indicated then the dermatomes again with paints of different colours and then the skin of the hindleg was finally prepared. The skin was then tanned and deposited. An exact description of the course of the limits of the dermatomes I had obtained, was made by me immediately after the expiration of the experiment. Thereupon I proceeded to the section.

For this purpose the entire spinal cord, as far as the skull, was laid bare. The number of cervical, dorsal and lumbar vertebrae was counted. Counting from the skull I traced which hindroots had every time be experimented. If I found deviations in the situation of the fields pointing to prefixion or postfixion of the hindleg, or if the number of the different sorts of vertebrae deviated from the normal number, the plexus was laid bare and examined. Deviations of the plexus were marked, a scheme of the plexus was drawn, and usually the plexus was then extirpated, pinned to a waxplate and fixed in a solution of formol.

In this way I obtained a representation on a plastermould of all the dermatomes I had determined, in such a way that the dermatomes determined on one hindleg, were transferred to a plastermould, then I had the skins of the hindlegs on which the dermatomes were indicated, and at last an extensive description of the dermatomes. In this way I have determined the dermatomes of the left hindleg for 19 cats (I constantly took the left hindleg, as I had a plastermould of that hindleg, and it was of no consequence for my purpose on which hindleg I made my experiments).

The skin of every hindleg I had experimented on, was always finally prepared in the same way. The sections of the skin that I executed for this purpose followed the same lines in every hindleg as much as was possible. I proceeded for this purpose in the following way: First I applied a circular section through the trunk skin, beginning from the 4th lumbar vertebra perpendicular to the vertebral column towards the ventral medianline. A second section follows from the place where the former section passes the ventral medianline, along

the ventral medianline in a caudal direction to a short way on the tail. Then I applied a third section, beginning from the interdigital fold between the 2nd and the 3rd toe, over the middle of the planta pedis and the calcaneus; then this section is continued over the middle of the bellies of the calf muscles, through the fossa poplitea. Then the posterior rim of the upperleg is followed towards the symphysis in the direction behind the scrotum. A fourth section follows the dorsal medianline from the 4th lumbar vertebra to a little way on the tail. This section is united on the tail by a little transversal section, so that the ventral tailsection is hit at about 1 cm. distance from the spot where it begins at the insertion of the tail. The toes are successively peeled out by uniting the tops of the toes by means of sections following the middle of the webs. I shall begin by describing the dermatomes of the hindlegs of those cats with which I found no deviations at the plexus or the vertebral column.

Without constantly mentioning the fact, we have, in the first row to do with the dermatomes of the hindleg of cats that were in possession of 7 cervical vertebrae, 13 thoracal and 7 lumbar vertebrae, whilst there was no deviation in the plexus (median-class according to LANGLEY).

I shall begin by a description of the dermatomes of those cats with which the situation of the dermatomes does not deviate much from the average one. I use here expressively the word average and not normal, because it is my experience that there are not two cats to be found, with which the overlap of the dermatomes of the hindleg corresponds. The shape and situation of the dermatomes depends upon many factors, among which the level of the spinal cord on the spot where the hindleg develops itself, occupies a prominent place. This level of development oscillates round an average and so does likewise the shape and the extension of the dermatomes. A deviation from this average of an entire segment can even exist.

Cat 34 (4 Febr. (1916).

The spinal cord in the lumbar-sacral region is laid bare under ether-chloroform-narcosis, the dura is split lengthwise. The hindroot of lumbalis 3 is cut and the spinal cord moistened round the place of entrance of the hindroot of lumbalis 4 with sulphate strychnini 1% (coloured with methyleneblue). When the cat has awaked from the narcosis, the line of demarcation of the hyperflexory field is marked on the skin.

Lumbalis IV. Anterior boundary. This proceeds from the dorsal medianline and runs 1 cm. behind the crista ilei in a somewhat caudal-distal direction to the groinfold, which is reached about the boundary between the posterior and the

central third part. Then the frontal boundary passes over on the ventral side of the body to reach the ventral medianline nearly in front of the symphysis.

Posterior boundary. This proceeds from the dorsal medianline, runs over the trochanter and reaches the frontal side of the lower leg 2 cm. below the patella, then passes upon the median plane of the leg and reaches the ventral medianline nearly in the middle of the symphysis. This root is cut under narcosis, and the spinal cord is moistened with sulphate strychnini 1% round the place of entrance of lumbalis V. The hyperreflectory field is marked on the skin.

Lumbalis V. Anterior boundary. The most proximal point of it lies nearly in the boundary between the central and the lower third part on the lateral plane of the upperleg. From here the frontal boundary extends with a curve to the centre of the patella, and then passes over to the interior of the lower leg. Directed with a slight convexity towards the posterior rim the boundary-line continues then in a distal direction between the malleolus internus and the calcaneus. Then the boundaryline passes over to the planta pedis, runs at a short distance from the medial footrim and follows this as far as the middle of the first toe. There the boundaryline turns with an acute angle in a proximal direction to the dorsal side of the foot. Over the latter the boundaryline continues in a proximal direction, passes the joint of the foot in the centre between the two malleoli, and proceeds first at 3 and afterwards at 1½ cm. distance from the posterior rim of the leg, till the point of issue is reached. This root is now cut under narcosis, and the spinal cord is moistened with a solution of strychnine round the place of entrance of the succeeding root.

Lumbalis VI. The most proximal point of this field falls just in the inferior part of the lateral plane of the upperleg, but more caudally and distally than that of the former field. From here the foremost boundaryline runs with a convex frontal curve in a distal direction, and passes the crista tibiae a little above the middle of the tibiae. The boundaryline is then continued on the medialplane of the lowerleg, and runs over the malleolus internus, then along the medial rim of the foot, in front of the ball of the foot and passes then between the 3rd and the 4th toe to reach the dorsal side of the foot. The boundaryline proceeds over the latter nearly parallel to the exterior rim of the foot, behind the malleolus lateralis, and then nearly parallel to the posterior rim of the leg to the point of issue. After this root has been cut under narcosis, the spinal cord round the place of entrance of the succeeding root is moistened with a solution of strychnine. After the awakening from the narcosis the hyperreflectoric field is determined and marked on the skin.

Lumbalis VII. The most proximal point of this lumbalis falls on the posterior rim of the lowerleg a little above the place where the calf muscles end and the tendon of Achilles begins. From here the boundaryline proceeds frontally with a convex curve and crosses the fibula a little above the malleolus lateralis, continues in front of this malleolus, in a slanting distal medial direction over the back of the foot and farther over the middle of the dorsal side of the 2nd toe, so that the medial side of the toe falls outside the field, passes over the end of the toe to the plantary side and proceeds then medially from the ball of the foot in a proximal direction. The boundaryline proceeds then along the medial rim of the foot over the posterior side of the malleolus medialis with an upward convexity to the point of issue. Now this root is cut, and the spinal cord round the place of entrance of the succeeding root is moistened with strychnine.

Sacralis I. Anterior boundary This field has at the dorsal and at the ventral side again contact with the medianline. The anterior boundaryline issues from the dorsal medianline, proceeds over the trochanter, coinciding with the posterior boundary of the field of lumbalis IV. On the middle of the upperleg these 2 boundarylines diverge. The anterior boundaryline proceeds then nearly parallel to the posterior rim of the leg to the malleolus lateralis, continues about $1\frac{1}{2}$ cm. past this malleolus, and turns then with an acute angle to the calcaneus. The inner-side of the leg is then reached over the calcaneus; then about the middle of the lower and the upperleg is followed towards the posterior boundary of the field of lumbalis IV; this is then farther followed to the ventral medianline.

Posterior boundary. This issues from the dorsal medianline near the root of the tail, proceeds over the tubel ossis Ischii with a curve under along the scrotum to the ventral medianline, which is reached at about the centre between the posterior rim of the symphysis and the opening of the anus. This root is now cut, and the spinal cord round the place of entrance of the succeeding root is moistened with a solution of strychnine. The hyperflexory field is determined.

Sacralis II. Anterior boundary. This issues from the dorsal medianline at about the centre of the former field, proceeds along the anterior side of the tubel ossis Ischii and reaches the ventral medianline behind the symphysis.

Posterior boundary. This issues from the dorsal medianline in the beginning of the root of the tail, proceeds frontally round the opening of the anus and reaches the ventral medianline between the scrotum and the opening of the anus. The scrotum falls consequently inside this field, and the anus outside it.

After these fields had been determined and marked on the skin of the cat with watercolour of different hues, these fields were transmitted to a plastermould, likewise in different colours. The skin is finally prepared in the way I described before, and tanned.

At the section it is ascertained that the cat had 7 cervical, 13 thoracal, and 7 lumbar vertebrae. As was presumed, the hindroots of lumbalis 4, 5, 6, 7 and sacralis 1 and 2 have been experimented on. Sketches were made of the arrangement of these fields on the skin of the hindleg, which I reproduce here in fig. 1 and 2¹⁾.

Fig. 1 represents the outside of the hindleg, fig. 2 the inside. A first glance teaches us already, that likewise on the hindleg the mutual overlap of the rootfields is considerable.

The overlap at the toes is likewise rather important. The skin of the toes is innervated from 3 hindroots (5, 6 and 7).

In the same way as I described above, I determined the dermatomes of the left hindleg with 19 cats.

From these determinations it appeared to me, that, also in this series of experiments, in which we had to do with cats showing no deviations, either of the vertebral column or at the plexus, the situation of the separate dermatomes is very inconstant.

¹⁾ The figures of this communication were drawn by Prof. WILLEM, to whom I pay my sincere thanks.

The variations of the sensitive field of lumbalis IV are not strong. I found this field always in connection both with the dorsal and

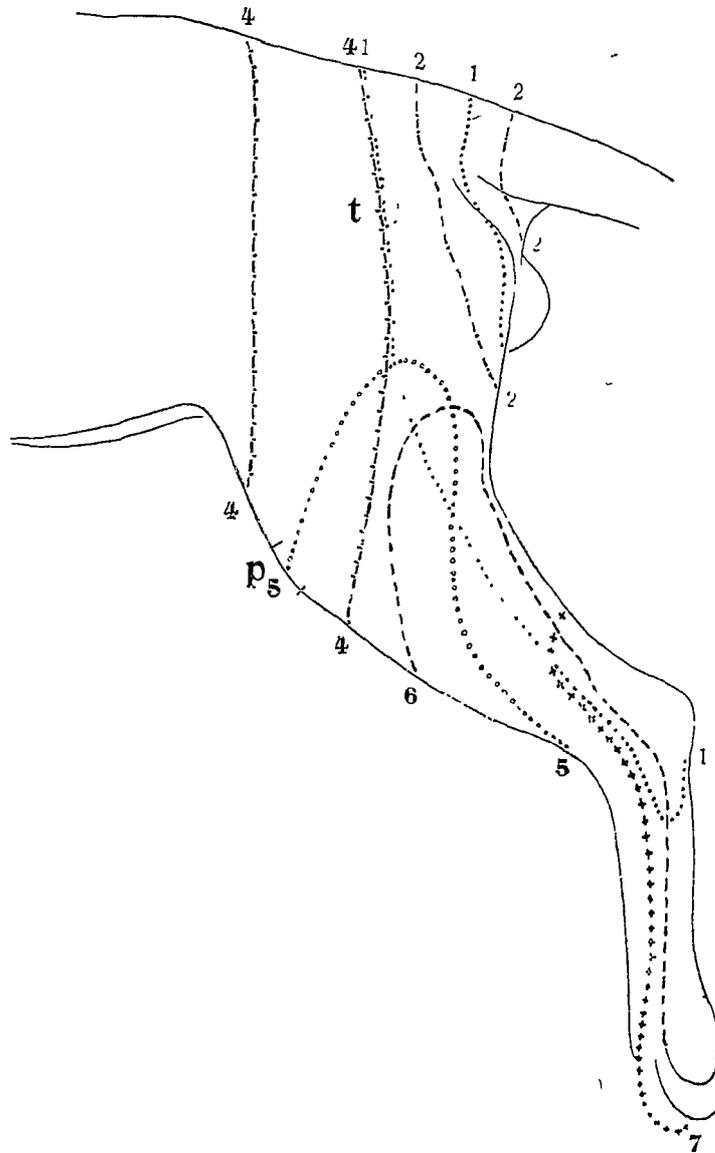


Fig. 1.

Left hindleg of a cat at the exterior side. The heavy figures indicate the ordernumber of the lumbar dermatomes. The thinner figures are placed at the boundaries of the sacralis. *t* = trochanter *p* = patella. For the innerside vide Fig. 2.

with the ventral medianline. Only with one cat a lap was extant at the innerside of the leg to the middle of the bellies of the calf-muscles. For the rest I always found deviations of the plexus,

when this lap was found at the field, and then it was also larger.
 On the contrary the sensitive fields of lumbalis V, VI and VII

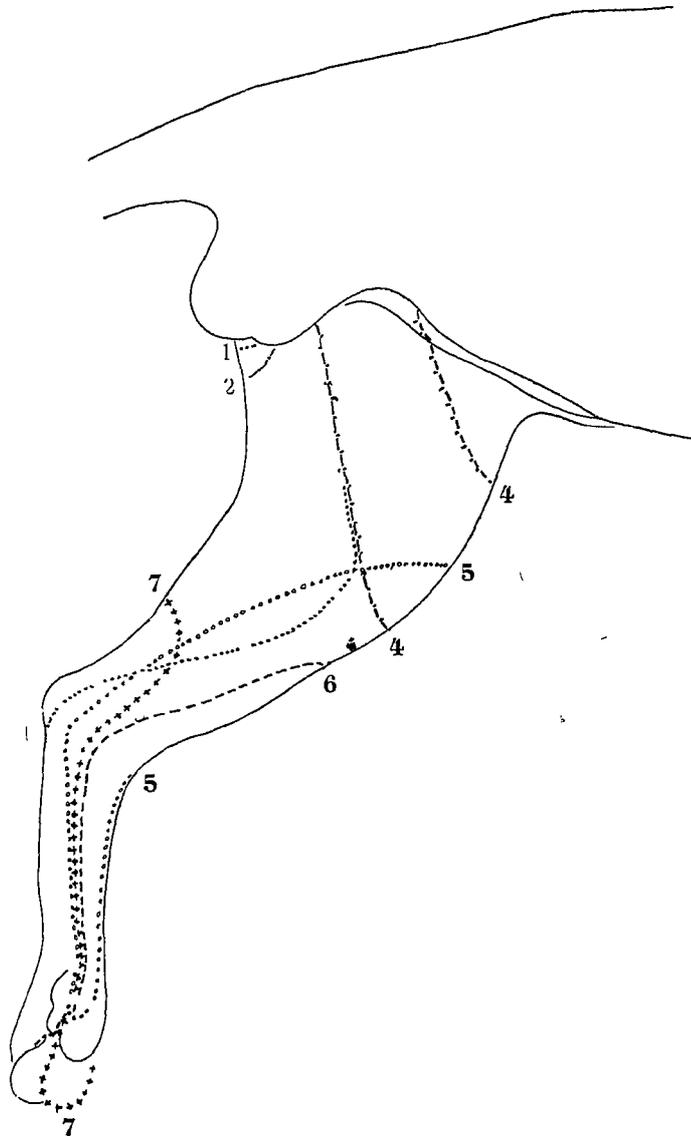


Fig. 2.

Left hindleg of the cat of Fig. 1 at the inner side. The heavy figures indicate the order-number of the lumbar dermatomes. The thinner figures are placed at the boundaries of the sacral segments.

had always lost every contact both with the ventral and with the dorsal medianline.

The situation and the dimension of these 3 topfields are subject to considerable fluctuations. So the proximal or, as WINKLER and

VAN RIJNBEEK call it, the top part of the field of lumbalis V now extends as far as half way the upper leg, now as far as above the trochanter. The height to which the sensitive field of lumbalis VI rises, varies likewise but not so much as with lumbalis V. These two dermatomes extend in their proximal parts almost entirely over the lateral side of the leg. Much less so on the innerside, as WINKLER and VAN RIJNBEEK found with the dog. These fields are, it is true, likewise with the cat turned inwardly. These distal slips into which these two fields are extended vary likewise very considerably. Now this slip extends with lumbalis V as far as the region between the malleolus internus and the calcaneus, now as far as half way the interior rim of the foot or the metatarsophalangeal joint. The most distal slips of this field extend as far as the first toe, even the entire first toe can fall inside this field. Lumbalis VI includes here the first, the first two or the first three toes.

The 3^d topfield offers likewise rather important variations in situation and extent. Usually the field reaches proximally as far as a few cm. above the calcaneus, but it can likewise here extend as far as the fossa poplitea. The field encloses then the foot laterally and plantary. Sometimes only the lateral toe falls inside this field, another time the 2 or the 3 lateral toes. Incidentally all the toes are innervated from this root. In this latter case this field encloses the foot as a low shoe with an opening at the dorsal side increasing from the first toe as far as the lower leg. These 3 topdermatomes present rather strong variations in shape and situation. Apparently these variations are strongest distally near the foot. We saw that the number of toes, falling inside each of these fields varies constantly. I must however point out that suchlike variations are not caused by important variations of extent. A slight variation in the extent of a sensitive field is already sufficient to bring one toe more or less within this field. An equal variation in the extent of a more proximal part of the field would make little impression. A slight shifting in the level of design before the extremity is most felt exactly at the most peripheric part of the extremity. The strongly pronounced differentiation of the shape of the extremities at the terminations is the cause of this fact.

Sacralis 1 and 2 are both again in touch with the dorsal and likewise with the ventral medianline. Sacralis 1 is especially in the distal parts very variable. The tongue that projects here at the lateral side of the extremity, can reach now as far as the calve-muscles, now as far as the calcaneum or halfway along the lateral rim of the foot, and at last even enclose the little toe. In the cases

in which I found the 4th toe inside this field, there were always variations in the plexus extant pointing to the fact that the extremity was designed postfixally. The foremost boundaryline of this field first coincided dorsally and ventrally from the medianlines for some distance with the posterior boundary of the 4th lumbarsegment. I found likewise in different cases here an overlap of about $\frac{1}{2}$ cm. These will certainly be the experiments that succeeded best. Caricature formation is, after all, likewise with segments of strychnine by no means rare.

Sacralis 2 can also send a smaller or larger slip to the upperleg.

A single word about the axile lines of SHERRINGTON called by BOLK differentiation-boundaries.

We know for certain that originally the 4th lumbarsegment and the 1st sacralsegment, have not verged to each other. The experiment taught me however, that the overlap is much stronger than was originally supposed, but the mutual overlap of succeeding segments is not so strong, that the 4th lumbarsegment and the 1st sacralsegment, between which 3 segments are lying, can originally have verged on each other.

With the thoracic lumbarsegments I found in the dorsal region overlap of every two segments that were separated in succession by another, and in the ventral region there was still overlap of 2 segments that were separated in succession by 2 other segments. Nowhere did I see 2 segments verge on each other that were separated in succession by three other segments. We know consequently for certain, that the 4th lumbarsegment and the 1st sacralsegment originally have not overlapped each other and have not verged on each other, but that there has existed between the caudal boundary of the 4th lumbarsegment and the cranial boundary of the 1st sacralsegment a zone of a certain width. After the development of the extremity these 2 boundaries of dermatomes have approached each other, and the two dermatomes between which there was originally a distance, have even for a narrow zone overlapped each other. This fact was already known from SHERRINGTON's experiments. SHERRINGTON points to the fact that the overlap at the axile lines has much resemblance to the dorsal and the ventral "crossed-overlap". About as far as the boundary between the inferior and the central part of the upperleg these two dermatome-boundaries coincide; afterwards the anterior boundary of sacralis 1 assumes a more slanting posterior direction. The superior part of the 5th lumbar dermatome reaches nearly this height, so that then the length of the axial line corresponds with the distance, along which these two dermatome boundaries coincide.

In those cases however in which the 5th lumbar segment extends farther in the direction of the vertebral column, and even crosses the region of the trochanter, the length of the dorsal axile line is thereby considerably shortened. As we saw already above, the 5th and the 6th lumbar segment at the innerside of the leg extend less far than is the case with dogs. Consequently the ventral axile-line is here longer with cats. The distinctness of the determination of the dermatones at the innerside of the upperleg according to the strychnine-method leaves here however something to be desired. A greater extension of the tops of the 5th and the 6th lumbar segment would of course here shorten the axile-line.

In connection with this discussion of the axile-lines I want to fix here the attention to another fact that, in my opinion, is connected with the origin of the axile-lines.

The top of the 5th lumbar segment namely penetrates with a rather wide margin into the sensitive field of sacralis 1. Now it seems to me, that originally this overlap did not exist there, because 2 dermatomes that are separated by two others; do not show such an overlap in the dorsal region. Therefore it seems to me, that during the development of the extremities this overlap has come into existence secondarily; the anterior rim of the field of sacralis 1 has thereupon approached the field of lumbalis IV, and in this way a fringe of the top of the 5th lumbar dermatome has likewise been overlapped.

Shifting of the design of the hindleg.

In my material of experiments I have three times observed a postfixed design of the hindleg. In one of these cases I supposed that I found indications that would make a widening of the design of the extremities admissible.

In Fig. 3 a representation is given of the arrangement of the dermatomes of the hindleg from the dorsal side, in Fig. 4 from the ventral side (cat 32). At the boundaries of the dermatomes the order-figure of the dermatomes is given (at the lumbar segments by thick figures and at the sacral segments by thin figures). From these pictures it appears distinctly, that the 5th lumbar skin-segment takes here the place of the 4th of the average cases, the 6th that of the 5th etc. On the hindleg every dermatome has consequently shifted about the width of a segment in a frontal direction. From the investigation of the plexus Ischio-lumbalis it appeared, that here the N. Ischiadicus had originated in the 7th lumbar and the 1st sacral root, and received moreover bundles from lumbalis 6 and

sacralis 2; that further the N. Obduratorius originated from lumbalis 6 and received moreover bundles from lumbalis 5; that the N. Femoralis originated from lumbalis 5, and received moreover bundles from lumbalis 4 and 6. The 1st sacral root was a little thinner than the 7th lumbalis and thicker than the 6th lumbalis. Here we have consequently to do with a nerveplexus, as occurs at postfixure

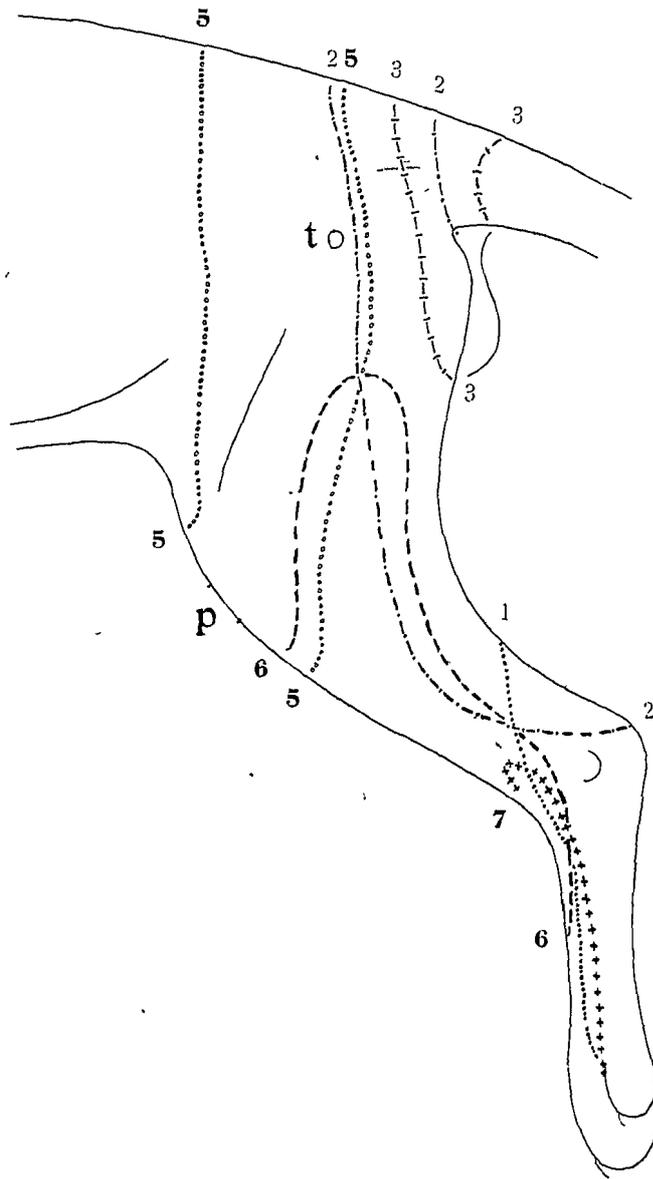


Fig. 3.

Strongly postfixally designed left hindleg of a cat. At the boundary of the lumbar segments the order-figure is indicated by a thick figure; at the sacral segments by a thin figure, *t* = trochanter, *P* = patella. For the innerside, vide fig. 4).

of the hindleg. This is entirely in conformity with the serial shifting of the dermatomes on the hindleg.

With cat 29 I found a postfixed design of the hindleg whilst a serial shifting of the dermatomes existed amounting to less than a segment. With this cat all fields have shifted in a cranial direction. The sensitive field of lumbalis 4 reaches less far than usually on the leg; the distal boundaryline crosses over the anterior rim of the leg $1\frac{1}{2}$ cm. above the patella. The top of the 5th lumbalis extends to above the trochanter, but does not reach the dorsal medianline. At the ventral side however this dermatome is in contact with the medianline. These two dermatomes point decidedly to a postfixed design of the hindleg. We see this a. o. also at the first

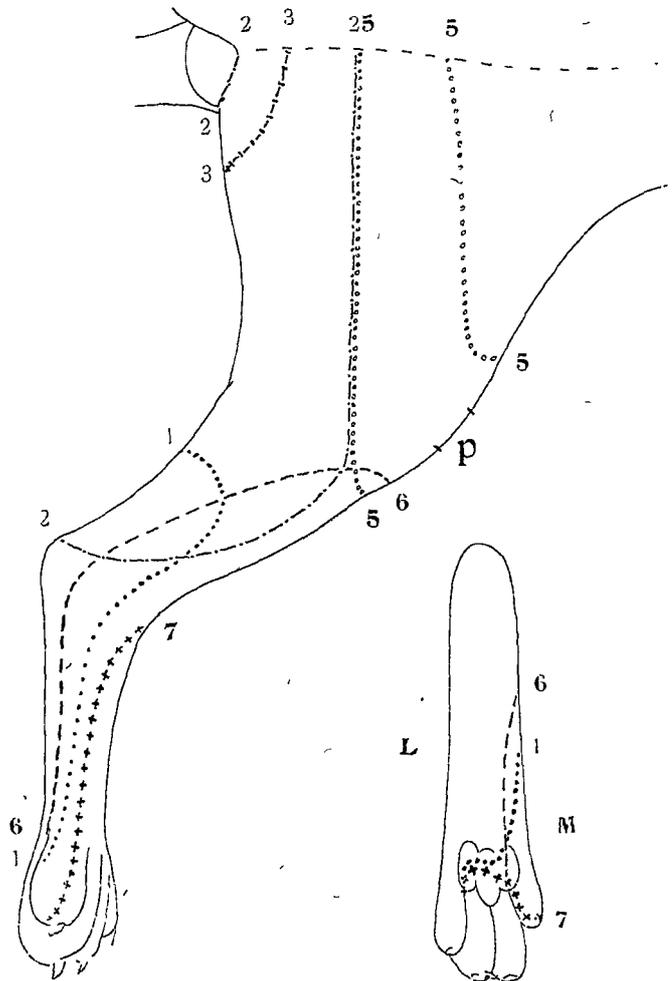


Fig. 4.

Innerside of the leg of fig. 3. Vide subscription of fig. 3. Separately is still given the planta pedis. *L* = lateral *M* = medial.

sacral dermatome, which covers the 4th toe entirely and the 3rd toe partially. We have here consequently a serial shifting of all the dermatomes, amounting to somewhat less than the width of one dermatome. The structure of the plexus pointed here likewise to a distinct, postfixed design of the extremities.

The sensitive fields of the skin of cat 35 furnished still a peculiarity which I wish to discuss here in a few words. The first sacral segment of this cat would point to a post-fixed design of the leg, whilst the 4th lumbar segment would suggest a prefixed design. The entire exterior rim of the foot and the 4th toe falls inside the field of sacralis 1. This points to a post-fixed design of the hindleg. The sensitive field of lumbalis 4 has a slip at the innerside of the leg reaching as far as the place, where the calf muscles end and the tendon of Achilles begins.

This field possesses consequently properties of the 5th lumbar segment and would point to a pre-fixed design of the extremities. The question rises, if we have here to do with a more widened design of the hindleg. With certainty I can, with the determination of these fields, exclude, that these deviations could have been caused by a not exact local moistening of the spinal cord with the solution of strychnine. I happened to determine the fields in this succession: lumb. V, VI, VII, sacralis 1 lumbalis IV. When I determined thus sacralis 1, the 3 preceding lumbar-roots had been cut, and the 1st sacral segment could consequently not obtain here the properties of the 7th lumbar-segment, because the spinal cord had not been locally moistened there. This is likewise the case with the field of lumbalis IV. When this was determined the 5th lumbarroot had been cut, and consequently the 4th lumbar segment could neither obtain properties of the 5th segment here, on account of the fact that the spinal cord had not been sufficiently locally moistened.

The 3 segments between these two fields offer few deviations.

The relations in the plexus are again of such a nature, as we find them at post-fixed design of the hindleg. The N. Ischiadicus originates again from the 7th lumbar root and the 1st sacral root, and receives likewise rootbundles from the 6th lumbalis and the 2nd sacralis. The 1st sacralroot is thicker than the 6th lumbarroot. I suppose I ought to describe this case as accurately as possible. It may be of use to continue to pay attention to the fact, that the possibility of a widened design of the extremities can exist.

WINKLER and VAN RIJNBEEK supposed likewise in 1910 in their investigations concerning the overlap of the dermatomes of the hindleg of dogs, that they had found indications of this fact.