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Unerwienie i narządy zmysłowe skrzydeł pasikonika *Locusta cantans* Füssl. (*Orthoptera, Locustidae*)

The innervation and sense organs in the wings of the Grasshopper *Locusta cantans* Füssl. (*Orthoptera, Locustidae*)

napisała

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Introduction

The innervation and sense organs in the wings of *Orthoptera* are little known and have been till now the object of only scarce investigations (Erhardt, Zaćwilichowski). E. Erhardt studied on a transversal and longitudinal sections only the base of the anterior and of the posterior wing of *Pachytylus* Fieb., *Psophus* Fieb., *Meconema* Serv., *Locusta* Geer., *Orphania* Fisch., *Phaneroptera* Serv. and described the sense organs situated there. The innervation and sense organs in the wings of *Phyllodromia germanica* L. and *Stauroderus biguttulus* L. are very well known owing to the researches of J. Zaćwilichowski. *Phyllodromia* shows a primitive but rather rich innervation of the wings, while the innervation in the wings of *Stauroderus* Bol. is much simpler and is a secondary phenomenon. The same is observed in sense organs. The nerve and sense elements in other representatives of *Orthoptera* and especially in those who emit sounds by means of strongly chitinized wings seem to present interesting problem. For the object of my researches I have chosen therefore a species of the Grasshopper *Locusta cantans* Füssl. common in our country.

Methods

By means of a glass cannula I injected the collected specimens with a watery solution of methylene-blue in various concentrations obtained from the stock 2% concentration. After a few minutes the nerve and the nerve cells show a distinct blue colouring. I fixed the specimens in molybdate of ammonia, washed them out, and dehydrated in absolute alcohol. After having clearing in cedarwood oil I prepared the specimens and closed my preparations in Canada balsam on an objectglass. Because of the remarkable thickness of the wings — especially of the anterior wings — I treated a part of them in 10% KOH and then stained them with fuchsin to make the chitinous sense organs more clear.

Chitinous sense organs in the anterior wing and their nerve elements

On the anterior wing of *Locuta cantans* Füssl. the hairs (*sensillae trichoideae*) and pores (*sensillae campaniformes*) appear as chitinous sense organs. The sense organs called hairs in the examined Grasshopper are in the wings of many other insects distinctly differentiated into hairs and bristles which differ morphologically and which are innervated in a different manner. The lack of the above-mentioned differentiation points to same primitiveness of the Grasshopper and reminds us of the state prevailing in two other representatives of *Orthoptera*: *Phyllodromia germanica* L. and *Stauroderus biguttulatus* L. It seems, that the order *Orthoptera* shows more primitive relations in this connexion than other examined orders of insects as *Trichoptera*, *Lepidoptera*, *Homoptera*, *Panorpata* etc., in which one always observes the presence of sense hairs and bristles. All the hairs of the Grasshopper are placed in a chitinous cavity surrounded by a chitinous ring and are innervated by means of bipolar nerve cells. However the manner of innervation varies. A part of hairs is innervated by single nerve cells like all the proper hairs of other insects and another part of hairs is innervated by groups which consist of three or four bipolar nerve cells. The latter manner of innervation is typical for the sense bristles in the wings of other insects, and therefore these hairs can be considered as primitive hairs analogously to these in *Phyllodromia germanica* L. and *Stauroderus biguttulus* L.

The hairs in the anterior wing differ from each other morphologically as regards their length and sometimes their breadth, especially at their base, so that in the anterior wing one can distinguish several kinds of hairs: 1) short hairs, and intermediate hairs, the latter being divided into: 2) the shorter and 3) longer hairs and long hairs among which one can distinguish: 4) thinner and 5) thicker hairs (fig. 2).

The short hairs, 8-10μ long are very faintly visible and very often break off, so that there remains only a cavity, which testifies to the presence of the hair. The hairs of this type are very abundantly represented on the wing membrane in the proximal portion of the wing, on the stridulatory veinlet and on those of the vibrating area in the right wing (fig. 5) and are innervated mostly by means of single bipolar nerve cells. One finds only sometimes a group composed of three or four nerve cells which send their peripheral processes fused into a bundle to the base of a short hair.

The hairs of the intermediate type show a considerable variation in size, and are therefore divided into the two following groups: the shorter and the longer hairs. The shorter hairs, about 50μ long bow-bent towards the upper surface of the wing always lie on the veinlets, while the longer hairs, 75-85μ long, also bow-bent or quite straight, are placed as well on the veinlets as on the anterior margin of the wing and on the wing membrane. All the hairs of the intermediate type are at their base almost equal in breadth which varies from 7μ to 10μ, and more or less equal in the size of the basal cavity of 15-19μ in diameter including the ring. These hairs are most scarce on the anterior wing, und are innervated chiefly by groups of cells. Among this kind of hairs one should include the hairs which lie on the final portion of the veinlet *AI* in the right wing, but I must add that they are conic and never bow-bent (fig. 5).

The long hairs 95-115μ long are differentiated into thinner and thicker hairs. The thinner ones are slightly chitinized, quite transparent, bow-bent, 3,8-4μ thick at their base, with a diameter of the basal cavity of 15μ. They turn mostly towards the upper surface of the wing. Some of them, however, run distinctly in the opposite direction lying on the lower surface of the wing. They are very numerous on the anterior margin of the wing, on all the veinlets, especially on *v. Cu* and *v. A.* of the left wing, and less numerous on the wing membrane. It is characteristic that the posterior proximal portion of the left wing is much more chitinized than the right wing, which involves a difference in the quantity of chitinous sense organs and in the innervation. Thus the right wing shows rather a large number of short and intermediate hairs, while the left wing has a huge number of thin hairs, whose length is always greater (120μ) than that of all the long hairs of the anterior wing. Moreover, the left wing is covered with a larger number of hairs than the right one.

The long thicker hairs do not differ in their length from the thinner hairs but they are twice as thick, as they measure 7-10μ at their base. They are strongly chitinized, brown coloured, readily visible, and most often straight. They appear most abundantly in the distant portion of the wing, and are the only hairs on the circular veinlet in the distal portion of the wing. However, one finds them on nearly all the longitudinal veinlets, especially on *v. M*, but rarely on *v. Cu* and *v. A*, where the long thinner hairs and the intermediate hairs prevail. The position of the hairs present on the longitudinal veinlets is nearly perpendicular to the veinlet itself, and they are directed as well to the anterior as to the posterior margin of the wing; the hairs which appear on the oblique and transversal veinlets lie obliquely towards their veinlets at an angle of more or less 45°.

The long thicker hairs are always innervated by groups which consist of three or four nerve cells, every one of which sending off its peripheral process towards the base of the hair. All the processes unite into a collective nerve fibre which penetrates into the base of the hair. The nerve does not penetrate into the canal of the hair, which prooves the primitiveness of the hairs innervated by the groups of nerve cells. It is the made of innervation typical for the sense bristles in other insects. The bundle of the peripheral processes which innervate the bristles penetrates into the canal of the bristle, except in the bristles of very few insects, as for instance *Typhlocyba* Germ. (*Homoptera*), in which this phenomenon as a secondary one is the result of a more primitive development of the sense bristles; this remains in connexion with the feeble chitinization of the wing. The longer thicker hairs conform mostly to the typical sense bristles of other insects in appearance, arrangement on the wing and in the made of innervation.

The size of the cells innervating the sense hairs is rather diverse and varies from $11{,}4\mu$ to 19μ. The same is observed as well in the single cells which innervate the short hairs as in the cells which appear in groups.

Moreover, on the anterior wing appears a group of intermediate hairs 38μ long. This group consisits of ten to twelve sense hairs arranged in a bundle lying, at the very base of the wing on the posterior convex margin of *v.* $Sc+R+M+Cu$. The stipe of the hair, besides being always straight does not show considerable difference in comparison with the intermediate hairs scattered singly on the wing; on the other hand, the cavity of the hair increases in length in to a kind of canal which is rather long, and in which runs the peripheral process of the sensory-nerve cell; it does not penetrate into the stipe of the hair but ends in its cavity (fig. 10). The other hairs on the anterior wing of the Grasshopper do not show such a structure of the cavity. The group of hairs turning towards the upper surface of the wing is innervated by means of single nerve cells which in principle do not differ from those that innervate the other hairs.

The other kind of the chitinous sense organs is a spheric chitinous formation which appears singly and scattered scarcely, and moreover assembled in groups in the basal portion of the wing. These organs may be called pores because they appear as round spaces surrounded by a chitinous ring; nevertheless in their inside there is distinctly visible a channel-like or funnelled protraction which runs deeply from the round pore that lies on the surface into the chitin or — if the pore lies on the margin of the veinlet — towards the middle of the veinlet. In the typical pores of other insects there is no such protraction, nevertheless the above-mentioned detail of structure seems not to speak against their being sense pores, and especially so, as the size (7,5-10μ) and the outline of the pore and of its chitinous ring resembles completely the sense pores of other insects. Similar chitinous sense organs have been described in the elytra of some *Coleoptera* as for inst. *Cantharis livida* L. and of some *Hymenoptera* (*Allantus arcuatus* Forst. and *Rhogogaster viridis* L.) and oving to their small size (2-3,5μ) were named by Zaćwilichowski chitinous canals or pore-like formations. Moreover, I am inclined to accept that they are sense pores owing to the fact, that: 1) not all of them show a channel-like protraction, notwithstanding their identical appearance and their presence in common group, 2) the few pores scattered singly in the slightly chitinized partion of the wing have no channel-like protraction, 3) all are innervated by means of single elongated bipolar nerve cells of the size: 13-15μ in the shorter diameter and 17-20μ in the longer diameter, with big nuclei. Their centripetal processes are always longer than the peripheral ones and those of the pores which lie in groups often unite into some small bunches branching off from the longitudinal nerve.

The single pores appear very scarcely (hardly a few) on the membrane of the anterior wing. They are very feebly chitinized and therefore difficult to perceive. Assembled in groups (fig. 3) the pores are present exclusively in the basal portion of the wing namely on the upper and lower side of the collective veinlet $Sc+R+M$. On the anterior margin of the mentioned veinlet on the lower surface of the wing, lies the first subcostal group, which consists of six pores arranged in a row bent forward; it is innervated by bipolar nerve cells whose centripetal processes form a bundle of fibres which branches off from the costal nerve and runs proximally. To the second subcostal group correspond the pores arranged in an uneven row, which extends along the anterior margin of the collective veinlet $Sc+R+M$ and further on, when it divides into three separate veinlets; *Sc*, *R* and *M*, along the veinlet *Sc* on the lower surface of the wing. The distance between the individual pores whose number varies from 30 to 35 is very unequal, so that in one rather elongated group one can distinguish several smaller accumulations and separately lying pores; moreover, in the distal portion of the row the distance between the pores increases distinctly. The cells innervating this row are characterized by very long centripetal processes curved rather strongly; several of them blend into a collective fibre which runs off from the subcostal nerve; moreover, one can observe, that their length increases as they draw nearer to the distal portion of the row. On the upper surface of the wing lie two other groups of pores. The first of these forms a compact accumulation of ten pores which lie on the posterior basal portion of the veinlet $Sc+R+M$, and are innervated by nerve cells which also adhere closely to each other, and whose short centripetal processes split off singly from the radial nerve just behind the point where the short branchlet innervating the basal group of hairs runs off from the above-mentioned nerve.

The second radial group of pores consists of eight pores arranged in an uneven row; it lies near the first radial group of pores. The nerve cells which supply the pores of the second radial group with peripheral fibres have very short centripetal processes which branch off separately from the maternal radial nerve.

At a small distance from the second radial group of pores on the upper side of the radial veinlet there lie also several — most often three — pores, which can be considered to be single owing to their irregular distribution and to the considerable distance that separates them. The centripetal fibres of the cells which innervate these pores split off separately from the radial nerve and are distinctly longer than the peripheral processes which go to the pores.

I did not observe any chordotonal organ in the wings of the Grasshopper which confirms the state of things in the majority of *Orthoptera* (E. Erhardt), except *Phyllodromia*, whose two chordotonal organs have been described by J. Zaćwilichowski.

Distribution of nerve branches in the anterior wing

Even before penetrating into basal portion of the wing the alar nerve (*n. alaris*) divides itself into two rather large nerve branches (fig. 1). The anterior branch may be called the costo-subcostal nerve (*n. costo-subcostalis*), and the posterior branch — the radio-medio-cubito-anal nerve (*n. radio-medio-cubito-analis*). The costo-subcostal nerve runs for a rather long distance, and before penetrating into the base of the wing splits off into two nerves: the costal nerve (*n. costalis*) and the subcostal nerve (*n. subcostalis*).

The costal nerve, distinctly thinner than the subcostal one, forms with it an angle somewhat higher than 45°, and runs as an uniform nerve for a very short distance, as it sends off soon successively very numerous, shorter or longer, branchlets which turn towards the forepart of the wing. They run in the oblique veinlets which run off from the costal veinlet (*v. costalis*) towards the anterior margin of the wing. These branchlets, which can be called *ramuli anteriores*, bifurcate further on, innervating in this way a large area, which lies between the costal veinlet and the circular veinlet, which runs along the anterior margin. The smallest branchlets innervate the very numerous hairs of various types and the scarce pores. The largest anterior branches or their ramifications enter into the circular veinlet and run in it for a short distance, or split into two oppositely directed branchlets. Only the last anterior branches sent off by the costal nerve innervate a portion of the circular veinlet and the chitinous sense organs which are present on it. Besides the anterior branches directed towards the forepart of the wing, the costal nerve sends off on its entire length numerous branchlets, first smaller and then gradually increasing in size, which turne beyond the costal nerve and embrace a small area lying beyond the corresponding veinlet. At the point where it splits off its first branchlet (*ramulus anterior*) the costal nerve itself penetrates into the costal veinlet at the base of the wing und runs in it parallel to the anterior margin of the wing. At the distance of more or less $^1/_2$ of the length of the wing it turns in a way that corresponds to the course of the costal veinlet towards the anterior margin of the wing running nearly parallel to the anterior branchlets. At last it enters into the circular veinlet and runs in for a rather long distance innervating the chitinous hairs present there.

The subcostal nerve (*n. subcostalis*), shortly after getting separated from the costal nerve, penetrates into the collective subcosto-radio-medial veinlet (*v.* $Sc+R+M$) and at its very base gives off short nerves which innervate, at first the first subcostal group of pores, and then the row of pores which corresponds to the second subcostal group of pores (fig. 3). The nerves which innervate the first group of pores are very short and form a rather compact bundle of fibres, but the numerous branchlets which innervate the subcostal row of pores are more loosely distributed and their centripetal fibres are distinctly longer than the peripheral fibres. Moreover, on all its length, the subcostal nerve gives off very numerous branchlets which innervate the hairs abundantly represented on the subcostal veinlet and especially behind the row of pores; one should note, however, that in the distal portion of the wing the number of the branchlets decreases in connexion with the smaller number of the chitinous sense organs. The subcostal nerve itself runs as a thick nerve trunk on all its length in the subcostal veinlet, giving off on its way at first shorter and then longer nerve branches towards the anterior margin of the wing (fig. 1). The former innervate the final portion of the space between the *v. C.* and *v. Sc*, the next indeed very few branches (one or two) join the costal nerve or its branches and the more distant branches, up to the apex of the wing, play the role of the anterior branchlets (*ramuli anteriores*) that run in the oblique veinlets which go off from *v. Sc* to the anterior margin of the wing and run nearly parallel to the above-mentioned anterior branchlets. Nearly all of them penetrate into the circular veinlet which extends along the posterior margin of the wing and innervate with their peripheral processes the hairs there present (fig. 4). In its final course, the subcostal nerve gives off backwards very few branchlets which join the following nerve (*n. radialis*) and then it penetrates into the circular veinlet in which it runs to the very apex of the wing innervating the long thicker hairs by means of a group of sensory-nerve cells; these hairs closely resemble the bristles in other insects.

The posterior branch (*n. radio-medio-cubito-analis*) is distinctly shorter than the anterior branch (*n. costo-subcostalis*) as in $^1/_4$ of its length and far before the base of the wing it divides itself into two nerves: the radio-medial nerve (*n. radio-medialis*) and the cubito-anal nerve (*n. cubito-analis*).

The thick radio-medial nerve penetrates at the base of the wing into the *v.* $Sc+R+M$ (fig. 1) giving off — nearly at the height of the separation of the costal and subcostal nerves — a short nerve branchlet which provides with its sensory-nerve cells a group of hairs which lies at the very base of the wing, on the posterior convex margin of *v.* $Sc+R+M$ (fig. 3). That group corresponds to the groups of hairs described by J. Zaćwilichowski in *Panorpata*, *Trichoptera* and *Blattoidea*. In its further course, the radio-medial nerve innervates the two radial groups of pores sending off separately short centripetal processes of nerve cells which emit their peripheral processes to the pores. The last centripetal fibres of the nerve cells do not belong to the complex of fibres which innervate the second radial group of pores but they provide the singly scattered pores of *v. R* with nerve cells. Besides the pores, the radio-medial nerve innervates the hairs which lie on *v. R* or in the space between *v. Sc* and *v. R* and between *v. R.* and *v. M*, and it even gives longer branchlets which provide with their peripheral processes the hairs which lie on *v. M.* so that the initial portion of *v. M* is very abundantly innervated, though it has no particular medial nerve, which runs in fusion with the radial nerve in *v. R* (fig. 3). In its further course the radio-medial nerve gives off thicker and thinner nerve branches which tend beyond their nerve of origin, and penetrate into the medial veinlet, where they innervate the chitinous sense organs in the shape of numerous hairs. At last, the radio-medial nerve splits into two nerves, which run at first parallel to each other in *v. R*: the radial nerve (*n. radialis*) and the medial nerve which — on account of its course and its lack in the medial veinlet — cannot be homologized with the proper medial nerve in other insects. It ought be named therefore separately as the transverso-medial nerve (*n. transverso-medialis*).

The radial nerve gives off in its further course a rather thin branchlet; this branchlet runs in that of the transversal veinlets in the space between *v. Sc* and *v. R* which penetrates into *v. Sc* and turning at a right angle towards the apex of the wing runs in the subcostal veinlet for a rather long distance. Soon afterwards, the described main nerve gives off something like a second branch of the medial nerve which runs in a transversal veinlet in the space between *v. R* and *v. M* and joins the first branch of the radial nerve. This however is repeated several times as the radial nerve gives off in its further course quite a number of nerve branchlets which run in all the transversal veinlets that connect *v. R* with *v. M*, but these branchlets are considerably thinner, and not all of them enter into a strict connexion with the radial nerve thus formed. Some of them end just when they penetrate into *v. M*, dividing dichotomously (fig. 1). Therefore, it is perhaps right to call the first ramification that separates off from the collective radio-medial nerve the anterior transverso-medial nerve (*n. transverso-medialis anterior*) and the following ramification — the posterior transverso-medial nerve (*n. transverso-medialis posterior*). Here I ought to note, that in the course and also in the appearance of the aforesaid transverso-medial nerves and of the branches of the radio-medial and radial nerves such an advanced variations appear in the left and right wings, that I could hardly decide myself to give names to the above-mentioned nerves. In its further course the radial nerve together with the radial veinlet splits and gives off the anterior radial nerve (*n. radialis I*) which runs in the veinlet *RI*, and the sectoral nerve (*n. sectoralis)* which gives off three following branchlets; these run in the posterior distal branches of the veinlet *Rs*. All the branchlets as well as the final fibres of the sectoral nerve penetrate into the circular veinlet at the very apex of the wing and then divide — every one of them into two final nerves which run into opposite directions — and innervate by means of groups of sensory-nerve cells the long hairs present in great numbers on the distal veinlets and on the circular veinlet.

The *nervus radialis I* runnig in conformity with the radial veinlet towards the apex of the wing gives off towards *v. Rs* most often three short nerve branchlets, and it ends at the point where *v. R* passes into the circular veinlet.

In all the insects examined up to now the medial nerve (*n. medialis*) is the next longitudinal nerve branch. In the Grasshopper *Locusta cantans* Füssl. there is no proper medial nerve, and the chitinous sense organs which lie on the veinlet *M* and in the space between *v. R* and *v. M* are innervated in the proximal portion by the ramifications of the radio-medial nerve, and in the distal portion by the above-mentioned nerves: *n. transverso-medialis anterior* and *posterior*. These nerves unite into a nerve trunk which runs for a very short distance, and soon splits in conformity with the veinlets at first into two and then into a greater number of branchlets. The first of the two initial ramifications running in the veinlet $M_{1+2+3+4}$ is increased in its course by numerous nerve fibres sent off by the radial nerve, so that it does not lose its thickness, although it gives off a great number of fibres with sensory-nerve cells which innervate the hairs abundantly scattered there. This ramification gives off successively and in conformity with the course of the veinlets three branches towards the posterior margin of the wing, so that four nerves arise (*n. transverso-medialis*$_{1,2,3,4}$) which run in the corresponding veinlets (*v.* M_1, M_2, M_3, M_4). The fourth transverso-medial nerve splits once more into two nerves (tm_4, tm_{1a}). All the above-mentioned nerves, except tm_{4a}, reach the circular veinlet in which they end, innervating partly its chitinous sense elements. The second ramification of the transverso-medial nerve which can be named tm_5 runs in the veinlet M_5 and ends in the place where *v.* M_5 joins *v.* M_4. The nerve tm_5 gives off several branchlets directed towards the veinlet $M_{1+2+3+4}$ (some of them join the nerve which runs in this veinlet) and several big, most often bifurcated nerves turned towards the posterior margin of the wing. These ramifications bifurcate further on into smaller and smaller fibres, which embrace the whole of the richly and intricately veined space which lies over the vibrating area, between *v.* M_5 and the posterior margin of the wing; they innervate with sensory-nerve cells the sense hairs which lie here. In comparison with the anterior and apical circular veinlets the posterior circular veinlet is much poorer in chitinous sense organs and thus more feebly innervated. The first branchlet of the nerve m_5 innervates partly the middle veinlet of the vibrating area, and together with the fibres of the following branchlet also the upper portion of the veinlet of the vibrating area.

Before proceeding to describe the innervation of the lower portion of the vibrating area and of the portion of the wing which lies under it, I must point out that the course of the nerves as well as the number and quality of the chitinous sense organs differs in the left and right wings; this is certainly in connexion with a rather strong difference in the chitinization of the left and right wing, conditioned by their different role in emitting sounds in *Locusta* Geer. Therefore I will describe at first the right wing (fig. 5) and then I will point out the differences in the left wing (fig. 6).

Far from the base of the wing the cubito-anal nerve (*n. cubito-analis*) forms with the radio-medial nerve (*n. radio-medialis*) an angle of 45° and at a little distance in its course divides itself into the cubital nerve (*n. cubitalis*) and the anal nerve (*n. analis*).

The cubital nerve bends towards the base of the wing, and running nearly parallel to the radio-medial nerve penetrates into the basal portion of the cubito-anal veinlet (*v.* $Cu+A$). It divides itself soon into the first and second cubital nerves (*n. cubitalis* 1 *and cubitalis* 2) which run in the cubital veinlet. The very thin first cubital nerve runs in conformity with corresponding veinlet, at first obliquely, forming with the longer axis of the wing an angle of 45°, and then penetrating into the veinlet Cu_1 it splits into two branchlets. One of them penetrates into the middle veinlet of the vibrating area, innervating its hairs and also these of the transversal veinlet; the other branchlet as the stridulatory nerve (*n. stridens*) innervates the stridulatory veinlet, which arose from an embranchment of the cubital veinlet and is covered with a row of small chitinous spindle-shaped ribs. This nerve innervates with single cells the scarce intermediate shorter hairs on the stridulatory veinlet. Having left the above-mentioned veinlet it runs further on in the posterior circular veinlet of the vibrating area, ending at the point, where the posterior veinlet passes into the upper veinlet. It gives off on its way a short branchlet which provides with nerve cells several hairs that lie on the transversal veinlet of the vibrating area.

After getting separated from the first cubital nerve the second cubital nerve extends obliquely and nearly parallel at first to the first cubital nerve and then — with the veinlet Cu_2 it bends at an obtuse angle towards the posterior margin of the wing, then it takes again its previous oblique direction. This nerve splits into several branchlets which innervate the circular veinlet of the vibrating area, the adjacent veinlets which lie over the vibrating area, and a portion of the posterior circular veinlet. Previously, the cubital nerve gives off smaller or bigger branches which provide with sensory-nerve cells all the chitinous sense organs which lie on *v. Cu*, Cu_1, Cu_2, and a part of them scattered in the space between *v.* Cu_1 or *v. Str.* and *v.* Cu_2, and between Cu_2 and *v. A.* One of the branches (*ramus recurrens n. cubitalis*) penetrates into the *v. stridens*, where at $^1/_4$ of its length it splits into two branchlets. One of them innervates several hairs on this veinlet and the other, turning downwards to the wing membrane, innervates several hairs.

The anal nerve (*n. analis*) after having separated from the collective cubito-anal nerve even before penetrating into the wing splits into two branches which can be named *n. analis anterior* and *n. analis posterior. N. analis anterior* penetrates into *v. A. II*, beneath the thickened margin of the wing and not into *v. A I*, this being probably in connexion with the fact, that the two above-mentioned veinlets join each other. The biggest branch of the *n. analis anterior* penetrates into the veinlet *A I*, and runs in it almost to the posterior margin of the wing. *N. analis anterior*, running on all its length almost parallel to the posterior margin of the wing, gives off very many and very long bifurcated branchlets towards the veinlets: *Cu*, *A I* and *A III*, thus attending as well to the numerous hairs of various types which lie on the veinlets, on the wing membrane, and also on the strongly chitinized margin of the wing, as to the very few pores on the veinlet *A II* (fig. 5).

N. analis posterior, distinctly thinner than the *n. analis anterior*, penetrates beneath the thickened margin of the wing into the veinlet *A III*, which forms almost the posterior margin of the wing; together with it this nerve quickly disappears giving off a few nerve fibres, which provide the very few hairs with sensory-nerve cells.

In the left wing (fig. 6) the stridulatory nerve does not run through all the length of the *v. stridens* but ends splitting into some branchlets just by the entrance into this veinlet. The second cubital nerve runs generally in conformity to the analogous nerve in the right wing, but it is considerably thinner and shorter as it ends just beneath *v. Str.* which crosses *v. Cu.* The anal nerve of the left wing divides itself like the corresponding nerve of the right wing into two nerves: *n. analis anterior* and *n. analis posterior*, both separately penetrating at different points beneath the thickened margin of the wing into the posterior portion of the wing, independently of the course of the anal veinlet; towards it the *n. analis anterior* directs itself in a semicircular line and runs in it for a short distance splitting then into two nearly identically thick branches. The first of those leaves the anal veinlet, penetrates into the cubital veinlet at the point where it almost touches *v. A* and runs in it at first together with the cubital nerve; then crossing the *v. stridens* it penetrates into the posterior circular veinlet of the vibrating area and leaves it just behind $^1/_2$ of the vibrating area turning nearly at right angle towards the posterior margin of the wing, where it ends, giving off some small branchlets. After having penetrated into the cubital veinlet and in its further course this branch sends off on both sides fairly numerous nerve branchlets, two of which directed towards the anterior margin of the wing, deserve special mention. One of them is a bifurcating branch which innervates nearly $^3/_4$ of the stridulatory veinlet, the other is a branch which at first runs in the transversal veinlet of the vibrating area parallel to *v. stridens* and then, after having turned at an acute angle towards the apex of the wing, runs in the middle circular veinlet of the vibrating area. These ramifications innervate some scarce hairs which lie on the above-mentioned veinlets and partly on the small veinlets directed towards the middle of the vibrating area. The presence of the ramification of the anal nerve which innervates the chitinous sense elements of the stridulatory veinlet, is probably connected with the considerable shortening of the stridulatory nerve in the left wing, whose location and functions were taken over by the above-mentioned ramification. The final portion of the stridulatory veinlet is also innervated by one of the branchlets of *n. analis anterior*, but this branchlet turns towards *v. A.* The second branch of the anal nerve runs up to the end in the first veinlet, and giving off a great number of branchlets directed towards the posterior margin of the wing, innervates a considerable part of the hairs scattered richly on the first anal veinlet, on the circular veinlet of the posterior margin of the wing, on the transversal veinlets which connect the two last veinlets and at last on the wing membrane. This branch ends in the posterior portion of the circular veinlet of the wing giving off before its end a short branchlet which innervates the scarce hairs on the posterior circular veinlet of the vibrating area.

N. analis posterior, considerably thinner than the *n. analis anterior*, after having penetrated into the wing membrane runs in it at first without connection with any veinlet and then splitting into two branches, which run into opposite directions. The first of them turns towards the first anal veinlet in which it runs alongside of the *n. analis anterior*, and ends in one (usually in the second) of the transversal veinlets which connect *v. A I* with the posterior circular veinlet of the wing. The second branch turns towards the posterior margin of the wing, penetrates into the circular veinlet in which it runs for a rather long distance, and ends more or less at the height of the transversal veinlet which resembles a protraction of the stridulatory veinlet. As well the anal posterior nerve as its two branches give off a very great number of ramifications of different size, which innervate and embrace the area of the chitinous sense organs placed on the wing membrane, on the veinlet *A I*, on the posterior circular veinlet and on all the transversal veinlets; they form thus together with the ramifications of the *n. analis anterior* a dense net-work.

The above-described innervation of the portion which lies beneath the vibrating area in the left wing does not appear in all my preparations. Nearly 1/2 of my preparations (about twenty, of the left wing shows considerable divergences from the above-described innervation; These differences consist in the presence of the thick and long cubital nerve which crosses the *v. stridens* together with the corresponding veinlet and which runs in the posterior circular veinlet of the vibrating area likewise as the first branch of *n. analis anterior* in other preparations (fig. 7). The *n. cubitalis* separates very often in such cases already from the collective nerve trunk (*n. cu* + *a*) in the wing, and not before penetrating into it. Further, the first cubital nerve is completely lacking and its function is taken over by the second cubital nerve which, by means of one or two branchlets turned in opposite directions, provides all the chitinous sense organs rather abundantly scattered on *v. stridens* with nerve cells. Moreover, that ramification of the second cubital nerve which penetrates into the stridulatory veinlet is never as long as to reach the veinlet Cu_1. It always ends in the inusually strongly chitinized stridulatory veinlet. The appearance and the course of the thick and long second cubital nerve involves the subsequent divergences in the anal nerve which does not split then into two branches that are always present in the preceding case, but always runs on all its length in the corresponding anal veinlet. Very often in that case there is a single anal nerve, while in the former case one always observes the *n. analis anterior* and *posterior*; each of them splits into two branches, so that in consequence there appear four branches of the anal nerve. In the latter case, there is most often only one single anal nerve which embraces with its very numerous ramifications the whole space between *v. Cu* and the posterior margin of the wing. Sometimes, however, one can observe a very thin and short posterior anal nerve which branches off already in the wing but does not show any ramifications. The quantitative as well as the qualitative supply of nerve elements for chitinous sense organs in the portion located under the vibrating area in the left wing is generally similar in both cases but differs rather from the right wing, which being generally more feebly chitinized, shows remarkably fewer chitinous sense organs in comparison with the left wing although their absolute number is very considerable.

One can easily observe that the *n. stridens*, the *n. cubitalis* and the *n. analis* show the greatest diversity in the distribution of the nerve branches although the remaining main nerve trunks or rather their branches show sometimes also rather marked.

Chitinous sense organs in the posterior wing and their nerve elements

In the posterior wing of the Grasshopper the number of the chitinous sense organs is smaller than in the anterior wing. This certainly is in connection with the lesser degree of chitinization in the posterior wing. The chitinous sense organs in the posterior wing consist of hairs (*sensillae trichoideae*) and pores (*sensillae campaniformes*).

The hairs of the posterior wing show various length and consequently one can distinguish among them: 1) short hairs and intermediate hairs, the latter being divided into: 2) longer and 3) shorter hairs, and 4) long hairs. All these kinds of hairs are somewhat shorter and thinner than the corresponding hairs in the anterior wing and besides they seem more transparent. The short hairs appear only in one group in the basal portion of the wing on the strongly convex posterior margin of the veinlet *Sc*, on the upper surface of the wing. This group consits of about fifteen hairs and is innervated by single nerve cells whose not very long centripetal processes separate from the subcostal nerve, singly or by means of small branchlets which split soon into separate fibres. The diameter of the nerve cells which innervate the group of short hairs reaches 11,4μ, so it corresponds to the smallest cells which supply the hairs of the anterior wing. The intermediate (shorter and longer) and the long hairs appear on the upper and lower surfaces of almost all the veinlets and on the wing membrane, but I must notice that a larger accumulation of hairs is seen on the anterior margin of the wing and on the proximal part of the wing, especially in the space between the veinlets: $R + M$ and A. Advancing towards the distal portion of the wing the hairs on the wing membrane disappear, and their number on the veinlets distinctly decreases, especially in the posterior portion of the wing. Only the anterior margin of the wing shows a relatively larger number of intermediate and also of long hairs on all its length; moreover, in the final portion of the wing these hairs like those in the anterior wing are less transparent, assume a yellowish hue and are somewhat thicker. The intermediate and long hairs are innervated by means of groups which consist of three or four nerve cells similar to the cells which innervate the hairs in the anterior wing. The manner of innervation of these hairs points to some primitiveness of the intermediate and long hairs like of those in the anterior wing.

The sense pores of the posterior wing appear scattered singly or accumulated in groups. Groups of pores are present only on the lower side of the veinlet *Sc* lying nearly on its margin. The first subcostal group of pores, the most proximally situated, lies at the very base of the veinlet *Sc* on its anterior convex margin, and consists of six to eight pores arranged rather loosely. This group is innervated by means of bipolar elliptic nerve cells which correspond in their appearance and in their size to the cells which innervate the pores in the anterior wing. The centripetal processes of these cells are branchlets of the subcostal nerve.

The following (second) subcostal group of pores, situated just behind the first one on the anterior margin of the corresponding veinlet, consists of eight or nine pores which lie close to each other. The centripetal processes of the nerve cells which supply the second group of pores separate from the main subcostal trunk almost at a single point, spreading radially towards their cells.

The third subcostal group of pores forms a long row composed of thirteen pores rather distant from each other; the first of these pores is considerably remote from the others. The sensory-nerve cells of this group have very long centripetal processes which do not separate directly from the subcostal nerve but by means of a long branch which runs together with the subcostal nerve in the corresponding veinlet. This branch splits off nerve fibres which are formed by two centripetal processes of the sensory-nerve cells; afterwards these two processes separate. Only the processes of the first and the last cell split off singly from their intermediate branch. Behind the third subcostal group of pores there appear further sense pores which can still be considered as single, the more so since the distance between them is rather large, and their number swiftly decreases as they get near $1/4$ of the length of the wing. The sense pores appear also on the radial veinlet, though they do not accumulate into groups, but are scattered on the upper side of the wing singly. Their number is small as it does not exceed ten, and they are situated in the proximal portion of the veinlet $R + M$. Their sensory-nerve cells have long centripetal processes and short centrifugal ones.

One ought to note here, that E. Erhardt described in the posterior wing of *Locusta* Geer the pores which appear on the upper side of the radial veinlet and on the lower side of the subcostal veinlet; they appear in the shape of rows which consist of ten to twelve pores. However, she neither mentions the subcostal groups in the posterior wing nor the numerous pores which appear in groups or singly in the anterior wing.

Distribution of the nerve branches in the posterior wing

The innervation of the posterior wing is generally rich especially in its anterior portion, but in comparison with the anterior wing it shows a rather large reduction. Above all the decrease of the number of the smaller ramifications which provide the chitinous sense organs with sensory-nerve cells is evident.

The alar nerve (fig. 8) at a long distance before penetrating into the base of the wing divides similarly as in the anterior wing into two nearly identically thick branches which can be called the costo-subcostal nerve (*n. costo-subcostalis*) and the radio-medio-anal nerve (*n. radio-medio-analis*). Before penetrating into the base of the wing the costo-subcostal nerve splits into two nerves: the thinner costal nerve (*n. costalis*) and the thicker subcostal nerve (*n. subcostalis*). The costal nerve, forming with the subcostal nerve an angle not much smaller than a right angle tends towards the anterior margin of the wing, then turns at an obtuse angle towards the apex of the wing, and penetrates at the base of the wing into the faintly traced costal veinlet which nearly constitutes the very margin of the wing. This nerve is relatively short as it ends usually in more or less one third of the length of the wing and only exceptionally reaches $^1/_2$ of the length of the wing. At first, the costal nerve does not innervate any chitinous sense organs but at the height of the second subcostal group of pores it begins to send off nerve fibres which innervate the sense hairs situated on the very margin of the wing, on the costal veinlet and on the wing membrane between *v. C* and *v. Sc* by means of single nerve cells or nerve cells arranged in groups and by means of peripheral fibres (fig. 9).

The subcostal nerve penetrates into the corresponding veinlet at the base of the wing and runs in it on all its length, except in the final portion, because in its apical course it penetrates into the one but last transversal veinlet which connects *v. C* with *v. Sc*, and soon afterwards it ends in the costal veinlet. This nerve, which can be considered as innervating most abundantly the chitinous sense organs, gives off in all its length very many smaller or bigger branchlets which turn chiefly towards the anterior margin of the wing and towards the costal veinlet and which innervate the sense hairs, and some shorter nerve fibres which innervate the pores or the hairs. In the basal portion of the wing it sends off bundles of centripetal fibres of the nerve cells which innervate the first and the second subcostal groups of pores by means of their centripetal fibres. At the height of the first subcostal group of pores, but towards the opposite side the subcostal nerve sends off a bundle of fibres which innervate the group of hairs situated on the posterior convex margin of *v. Sc.* Soon afterwards the *n. subcostalis* gives off a rather large branch which divides at first innervating the few hairs which lie on the wing membrane between *v. Sc* and *v. R.* and then runs together with its nerve of origin in the subcostal veinlet providing with sensory-nerve cells the third subcostal group of pores arranged in a row. Towards the anterior margin of the wing the subcostal nerve sends off some branchlets which run in the transversal veinlets; these veinlets connect the subcostal veinlet with the costal veinlet which constitutes the margin of the wing. All the ramifications, which correspond to the *ramuli anteriores* in the anterior wing, penetrate into the costal veinlet and as it were assume the functions of the disappearing costal nerve, as they innervate the hairs of the costal veinlet. Some of them split into two branchlets which turn into opposite directions. The strongest is the first ramification sent off by the original nerve in the neighbourhood of the third subcostal group of pores; it is remarkably thicker than the costal nerve. Just a little smaller is the last ramification which runs in the costal veinlet that passes here into the circular veinlet far behind the point where its original subcostal nerve disappears.

The posterior branch (*n. radio-medio-analis*) is shorter than the anterior branch (*n. costo-subcostalis*), because in more or less $^{1}/_{2}$ of its length it begins to send off successive longitudinal nerve trunks.

The first of them is the radial nerve (*n. radialis*), twofold at first and as such it penetrates into the basal portion of the radial veinlet, but then united into a single nerve runs in the above-mentioned veinlet to the very apex of the wing, where it ends. In the base of the wing this nerve gives off short branchlets which innervate with their sensory-nerve cells hairs of the radial veinlet and single radial pores, arranged in an uneven row; this nerve also sends off beyond the veinlet a comparatively large nerve which splits further on and whose smallest final fibres (the peripheral processes of the sensory-nerve cells) penetrate into the base of the hairs rather numerously scattered there. In its further course the radial nerve sends off very small or rather thick branchlets which penetrate into the transversal veinlets (which connect *v. R* with *v. Rs*) and turn afterwards at a right angle towards the apex of the wing running in the sectoral veinlet (*v. Rs*). Some of them are short and do not join the remaining branchlets, which successively separated, constitute a thick sectoral nerve (*n. sectoralis*) in the sectoral veinlet; each of these branchlets can be called therefore the first, the second, the third etc. transverso-sectoral nerve; in the anterior wing they have not been observed at all. Besides the above-desribed branchlets the radial nerve sends off also some nerve ramifications which always turn beyond *v. R* and running in the transversal veinlets do not join the ramified sectoral nerve but usually disappear after a very short course in one of the sectoral veinlets. The radial nerve and its branchlets innervate the hairs of various types and the very few pores rather scarcely distributed in the neighbourhood of the radial veinlet.

The sectoral nerve formed by the junction of several successively separated transverso-sectoral nerves splits like its veinlet at first into two and then into four branches. The first branch splits once more into two branches, one of which joins together with its veinlet the second branch of the sectoral nerve. All the ramifications of the sectoral nerve reach the circular veinlet where they end innervating the last hairs. The whole sectoral nerve provides with sensory-nerve elements the rather scarce hairs which lie within the reach of its ramifications. Consequently the sectoral nerve gives off two or three short nerve branchlets which can be called the transverso-medial nerve (*n. transverso-medialis*) as they penetrate into the first medial veinlet ($v.\ M_1 + M_2$) sending off short ramifications which turn towards the base of the wing (*rami recurrentes*). The last of the branchlets of the sectoral nerve runs in the veinlet M_{1+2} up to the junction of the veinlet *Rs* with the veinlet M_{1+2} where it joins the first ramification of the sectoral nerve, thus creating the sectoro-medial nerve (*n. sectoro-medialis*) which runs to the very apex of the wing.

In the anterior wing the analogous transverso-medial nerve is a thick nerve trunk which separates from the radial nerve and provides with sensory-nerve elements a huge number of the chitinous sense organs, while in the posterior wing this nerve shows a strong reduction. This is probably in connexion with the fact that it does not split off directly from the radial nerve; the latter gives off branches rich in nerve fibres to the sectoral nerve which subsequently sends off the feebly developed medial nerve.

The following nerve trunk separated from the posterior branch of the alar nerve is the anal nerve (*n. analis*) which splits off successively the separate anal nerves. The first of them (*n. analis I*) turns in a slightly bent line towards the veinlet *A I* penetrates into it and runs just up to the circular veinlet where it ends innervating the hairs that are situated there. Except very few nerve branchlets which turn towards *v. A II* this nerve does not show any other bigger ramifications. It gives off only short centripetal processes of sensory-nerve cells which appear in groups and innervate with their peripheral processes the sense hairs which lie on *v. I A*.

The following anal nerves penetrate at the base of the wing into a large anal cell and spread there nearly radially to the corresponding veinlets. At last, in the posterior wing there appear the seven anal nerves which run in their veinlets towards the posterior margin of the wing. In my preparations these nerves, except the first one, do not reach the posterior circular veinlet but disappear before however, one cannot maintain for certain on fhis ground that they end in fact sooner, the more so, as on the posterior circular veinlet where it joins the anal veinlets do appear hairs which correspond in appearance to the hairs of the circular veinlet innervated by the distal portions of other nerves. They too ought to be innervated. Perhaps the final portions of the nerves do not get stained owing to the difficulties which one meets when staining nerves in long and wide wings. The anal nerves innervate the hairs, especially these which lie in the basal portion of the corresponding veinlets.

Conclusions

My researches upon the sensory-nerve system in the wings of the Grasshopper *Locusta cantans* Füssl. lead me to state the following facts:

1. A rarely found abundance in the innervation of the anterior wing and a much poorer yet still rich innervation of the posterior wing, connected with a very high degree of chitinization in the anterior wing and a lesser one in the posterior wing.

2. The presence of a feebly developed costal nerve (*n. costalis*) in the posterior wing; its functions are assumed by the strongly developed subcostal nerve (*n. subcostalis*).

3. The lack of a separate medial nerve in the anterior as well as in the posterior wing.

4. The innervation of the medial veinlet (*v. M*) and of its branchlets by the transverso-medial nerves (*n. transverso-medialis anterior*, *n. transverso-medialis posterior*), which separate from the radial nerve (*n. radialis*) in the anterior wing and from the sectoral nerve (*n. sectoralis*) in the posterior wing. The transverso-medial nerve very strongly developed in the anterior wing shows a strong reduction in the posterior wing.

5. A strong modification of the cubital nerve (*n. cubitalis*) in the anterior wing in connection with the presence of a vibrating area and the total lack of this nerve in the posterior wing.

6. The presence of the stridulatory nerve (*n. stridens*) in the anterior wing.

7. The presence of one or two strongly developed anal nerves in the anterior wing and of seven not ramified anal nerves in the posterior wing.

8. A difference in the innervation of the part of the wing which lies under the vibrating area in the right and left wings.

9. The appearance of a great number of feebly developed hairs, innervated chiefly by groups of sensory-nerve cells.

10. The lack of sense bristles.

11. The presence of four groups of pores in the anterior wing and of three groups in the posterior wing; moreover, two groups in the anterior wing and one group in the posterior wing present themselves in the shape of long rows.

12. An insignificant number of single sense pores.

13. The lack of a chordotonal nerve.

Investigations described in the present paper were carried out in the Department of Zoology of the Agricultural Academy in Cracow.

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EXPLANATION OF THE FIGURES

Fig. 1. Anterior right wing.

Fig. 2. Fragment of the anterior wing. Proximal portion of the costal nerve (*n. costalis*) with sensory-nerve elements.

Fig. 3. Fragment of the anterior wing. Proximal portion of the subcostal nerve (*n. subcostalis*) and of the radial nerve (*n. radialis*) with sensory-nerve elements.

Fig. 4. Fragment of the innervation of the distal portion of the anterior margin in the anterior wing.

Fig. 5. Innervation and sense organs of the portion under the vibrating area and of a portion of the vibrating area in the right anterior wing.

Fig. 6. and 7. Innervation of the portion under the vibrating area in the left wing.

Fig. 8. Posterior wing.

Fig. 9. Base of the left posterior wing.

Fig. 10. Sense hair and sense pore with sensory-nerve cells, which innervate them.

EXPLANATION OF THE LETTERS

a I — first anal nerve (*n. analis anterior*)
a II — second anal nerve (*n. analis posterior*)
a I-a VII — *I-VII* anal nerves (*n. analis I-VII*)
c — pores
cu — cubital nerve (*n. cubitalis*)
cu_1-cu_2 — 1-2 cubital nerves (*n.* $cubitalis_{1-2}$)
na — anal nerve (*n. analis*)
nc — costal nerve (*n. costalis*)
nr — radial nerve (*n. radialis*)
rm — radio-medial nerve (*n. radio-medialis*)
rs — sectoral nerve (*n. sectoralis*)
r I — first radial nerve (*n. radialis I*)
sc — subcostalis nerve (*n. subcostalis*)
str — stridulatory nerve (*n. stridens*)
tm — transverso-medial nerve (*n. transverso-medialis*)
tma — first transverso-medial nerve (*n. transverso-medialis anterior*)
tmp — second transverso-medial nerve (*n. transverso-medialis posterior*)
tm_1-tm_5 — 1-5 transverso-medial nerves (*n.* $transverso\text{-}medialis_{1-5}$)
1 — short hairs
2 — intermediate shorter hairs
3 — intermediate longer hairs
4 — long thinner hairs
5 — long thicker hairs
I cr — first radial group of pores
II cr — second radial group of pores
I cs — first subcostal group of pores
II cs — second subcostal group of pores
III cs — third subcostal group of pores

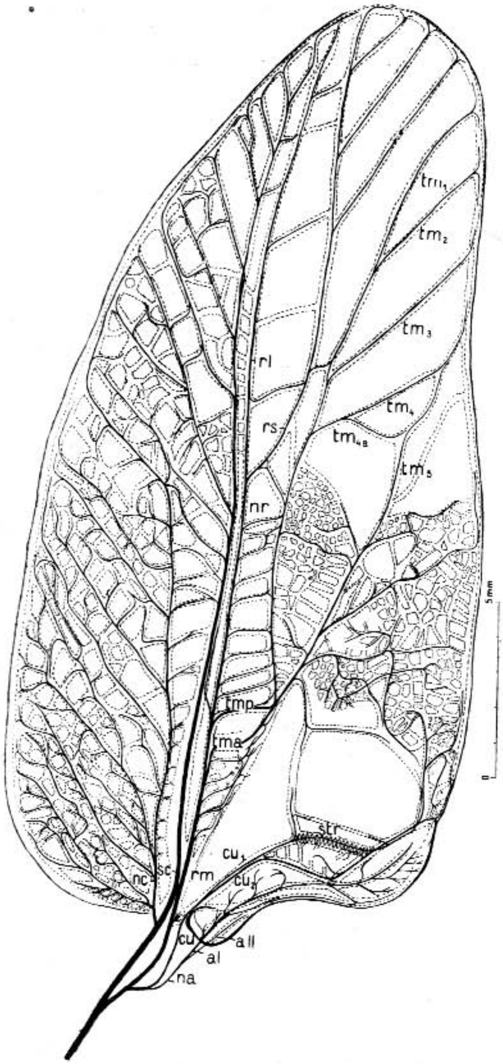

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Fig. 1

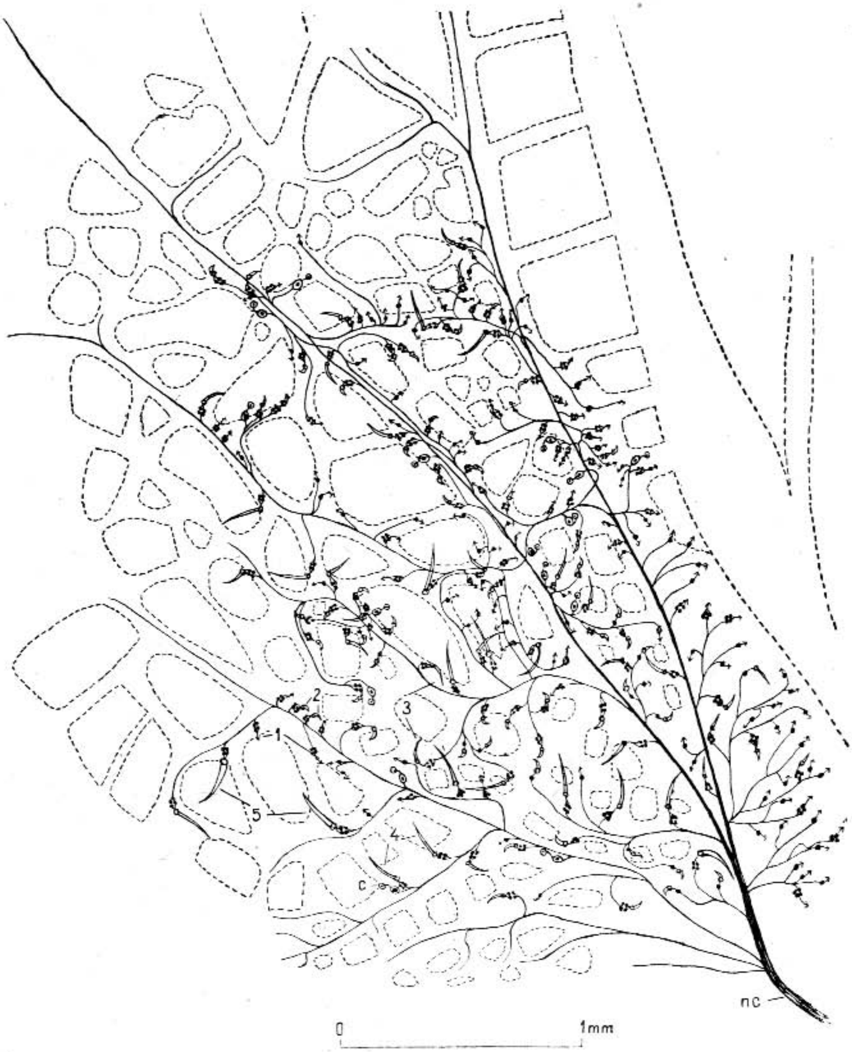


Fig. 2

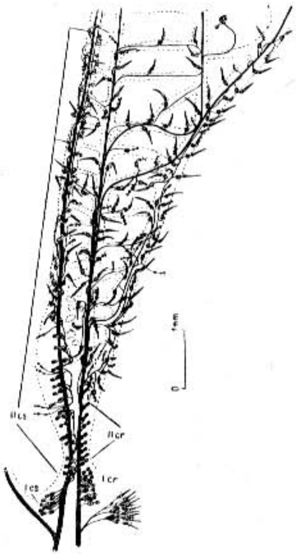


Fig. 3

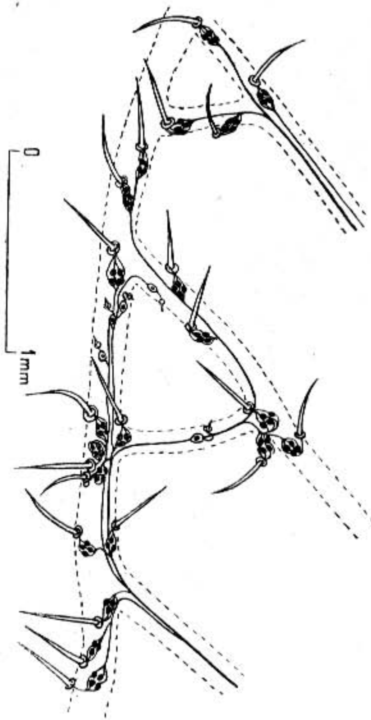
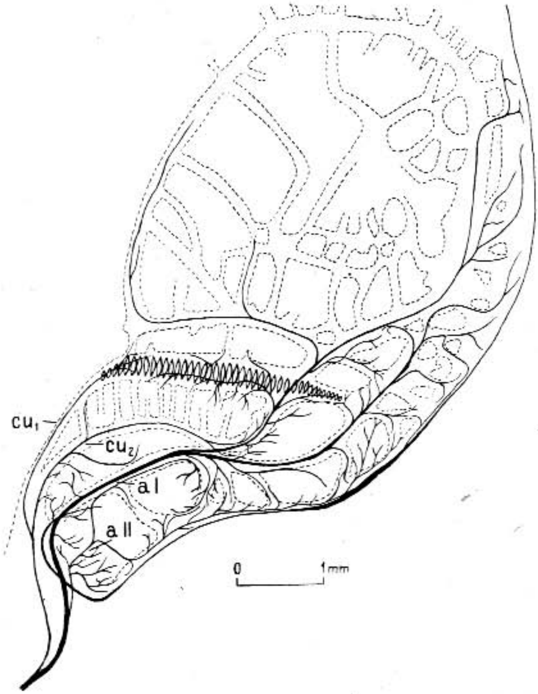


Fig. 4

Fig. 5



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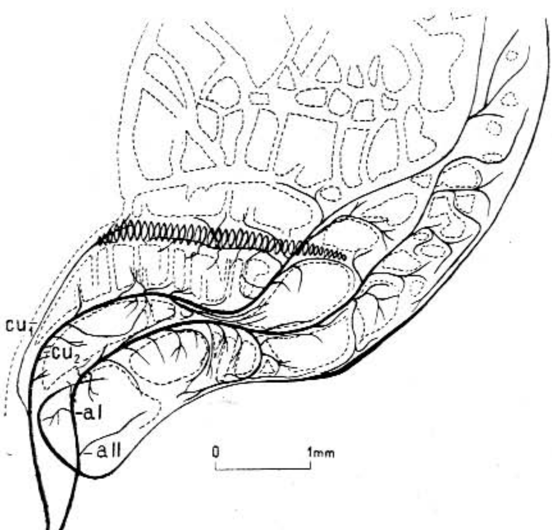

Fig. 7

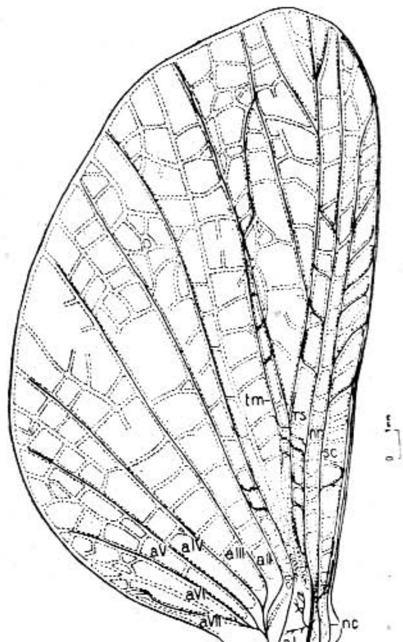

Fig. 8

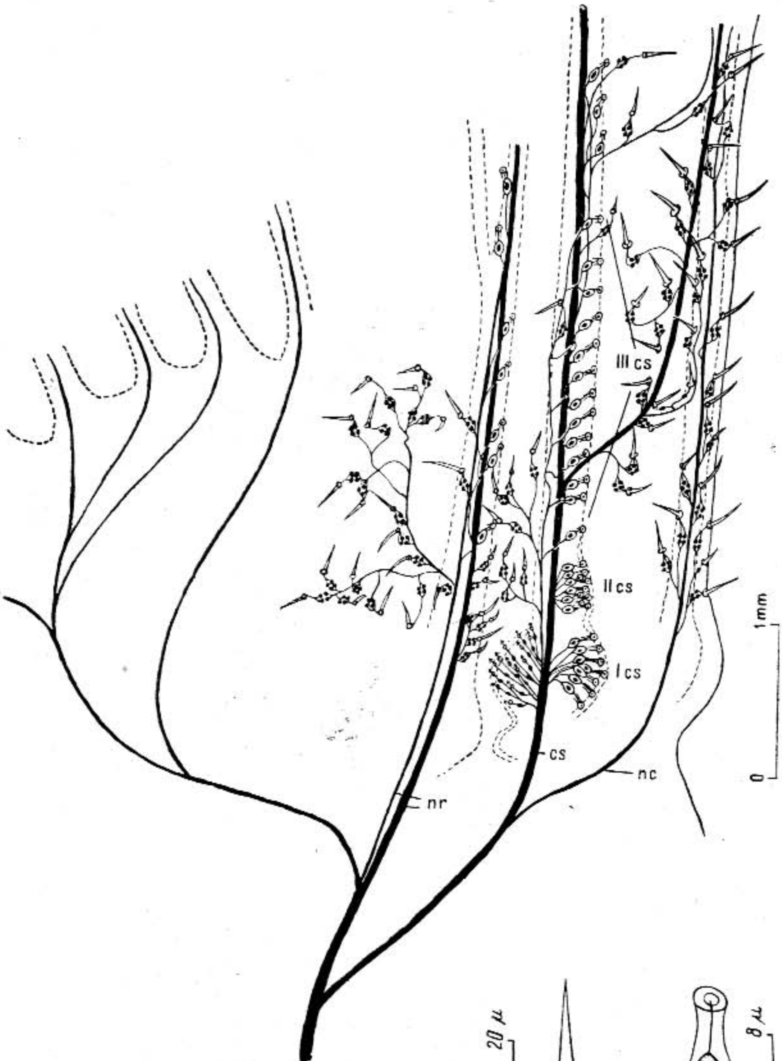

Fig. 9

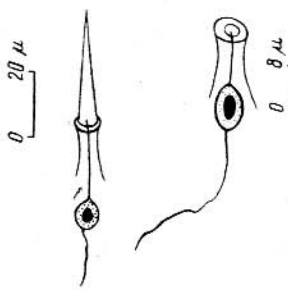

Fig. 10

STRESZCZENIE

Na skrzydłach pasikonika *Locusta cantans* Füssl. występują narządy zmysłowe w postaci różnego typu włosków i kopułek. Włoski unerwiane są przez oddzielne komórki nerwowe (typowy sposób unerwienia włosków) lub przez grupy złożone z 3-4 dwubiegunowych komórek nerwowych. Ten drugi sposób unerwienia jest charakterystyczny dla szczecinek zmysłowych skrzydeł większości owadów i z tego powodu włoski o tym typie unerwienia można uważać za prymitywne; od nich pochodzą włoski zmysłowe unerwiane przez jedną komórkę.

Skrzydło przednie jest wyposażone w liczne włoski pojedynczo rozsiane, nadto u jego nasady znajduje się grupa włosków. Kopułki zmysłowe występują pojedynczo (bardzo nielicznie) na błonie skrzydłowej lub też w czterech grupach u nasady skrzydła na zbiorowej żyłce $Sc + R + M$ (pierwsza i druga podbrzeżna grupa oraz pierwsza i druga promieniowa grupa kopułek). Wszystkie kopułki zmysłowe są unerwiane przez pojedyncze komórki nerwowe. Nerw skrzydłowy rozwidla się przed wniknięciem w nasadową część skrzydła przedniego na 2 gałęzie. Pierwsza z nich dzieli się na nerw brzeżny wnikający do żyłki *C* i oddający liczne gałązki w stronę przedniego brzegu skrzydła oraz na nerw podbrzeżny, który wnika do wspólnej żyłki $Sc + R + M$, unerwia obie podbrzeżne grupy kopułek i biegnie do samego wierzchołka skrzydła oddając w swej końcowej części gałązki nerwowe w stronę przedniego brzegu skrzydła. Gałąź druga dzieli się na nerw promieniowo-środkowy i nerw pachowo-tylny. Pierwszy z nich wnika do żyłki $Sc + R + M$, unerwia grupę włosków i 2 promieniowe grupy kopułek, dzieli się na nerw promieniowy (odszczepiający nerw sektoralny) i nerw poprzeczno-środkowy (dzielący się w swej końcowej części na 5 nerwów). Nerw pachowo-tylny rozszczepia się na nerw pachowy i tylny. Pierwszy z nich dzieli się na 2 gałęzie pachowe, z których jedna przechodzi w nerw stridulacyjny, drugi na 2 gałęzie tylne. Ostatnie 4 nerwy unerwiają dolną część okienka oraz część skrzydła leżącą przed nim i za nim. Przebieg ich, oraz ilość i jakość chitynowych narządów zmysłowych jest różna w skrzydle lewym i prawym, co pozostaje w związku z różną

budową obu skrzydeł. Wszystkie gałęzie nerwowe unerwiają chitynowe narządy zmysłowe swych żyłek oraz poszczególnych odcinków żyłki okrężnej skrzydła przedniego.

Skrzydło tylne ma mniej chitynowych narządów zmysłowych. Włoski są nieco mniejsze niż w skrzydle przednim, występują pojedynczo na błonie skrzydłowej i na żyłkach, lub skupiają się w grupę na żyłce *Sc* u nasady skrzydła. Kopułki występują pojedynczo na żyłce $R + M$, w skupieniach na żyłce Sc, tworząc pierwszą, drugą i trzecią podbrzeżną grupę kopułek. W skrzydle tylnym biegną następujące gałęzie nerwowe: nerw brzeżny, nerw podbrzeżny, nerw promieniowy (odszczepiający nerw sektoralny, który z kolei tworzy nerw poprzeczno-środkowy) i nerw tylny, dzielący się w samej nasadzie skrzydła na 7 gałęzi tylnych. Prawie wszystkie gałęzie nerwowe skrzydła tylnego dochodzą do żyłki okrężnej. Najbogaciej unerwiona jest nasada skrzydła oraz przedni jego brzeg.

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