POLSKA AKADEMIA NAUK
INSTYTUT ZOOLOGICZNY, ODDZIAŁ W KRAKOWIE

ACTA ZOOLOGICA CRACOVIENSIA

Tom I Kraków, dnia 20 lutego 1957 Nr 3

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Topografia centralnego systemu nerwowego gąsienic
Część I: Minujące gąsienice molowców (*Tineoidea*)

Топография центральной нервной системы гусениц
Часть I: Минирующие гусеницы из *Tineoidea*

The topography of the central nervous system of caterpillars
Part I: Leaf-mining caterpillars of the *Tineoidea*

[Pl. VI—IX and 2 text-figures]

1. INTRODUCTION

I understand by the central nervous system of insects — in accord with SNODGRASS (14) — the part of the nervous system composed of two ganglia (BRANDT'S „Nervenknoten"), the supraoesophagal ganglion and the suboesophagal one, as well as the central nerve cord, without the sympathetic nervous system.

The topography of the parts belonging to this system was known in the nineteenth century; most of the work was done by the Russian scientist E. BRANDT. Since his papers our knowledge on the histological structure of the central nervous system of insects has largely grown. Many papers have been written on the nervous system; they have, however, added nothing new to BRANDT'S chapter pertaining to the topography of the nervous system of the larvae of butterflies.

Hence my paper on the topography of the central nervous system of caterpillars is not begun by a survey of the newest opinions of zoologists on this matter, but by a short statement of the results of BRANDT'S work.

According to BRANDT (1), the central nervous system of caterpillars is composed of twelve nerve ganglia, every one of which was formed by the growing together of at least two primary nerve ganglia. The system comprises two cephalic ganglia, i. e. the supraoesophagal and suboesophagal ones, three thoracic ganglia, and seven abdominal ones. The thoracic and abdominal ganglia are single, as they formed by the union of one pair only of primary ganglia; only the seventh abdominal ganglion is compound — according to BRANDT — as it was formed by the union of two pairs embryonic nerve ganglia. This last ganglion has more functions than the preceding ones, as it innervates also the three last abdominal segments which have no special nerve ganglia.

The only exception of this rule, according to BRANDT, is the caterpillar of *Cossus cossus* L., which possesses only two thoracic ganglia and eight abdominal ganglia instead of seven. The reduction of the number of the thoracic ganglia from three to two is achieved by the growing together of the first thoracic ganglion into one with the suboesophagal ganglion. BRANDT adds here that in general the larvae of *Bombycidae*, *Noctuae*, *Geometridae*, have the first thoracic ganglion always lying close by the suboesophagal one, although not grown together with it. However, it is linked with it by short connectives.

This is the synthesis of BRANDT'S work which had a broad basis, as it took into account the topography of the central nervous system of 118 species of butterflies and 42 species of caterpillars. Its weak point was only this: among the caterpillars examined by BRANDT there was only one representative of the so-called *Microlepidoptera*, i. e. *Tinea pellionella* L.

In spite of this it seemed that the matter was presented exhaustively and that nothing new could be added. This explains why SPULER (15), REBEL (11), ZERNY (19), IMMS (8) gave descriptions of the location of nerve ganglia in the bodies of caterpillars in accord with BRANDT'S results. SNODGRASS (14) did not, it is true, include a separate chapter describing the central nervous system of caterpillars, as done by IMMS in his text-book of entomology, but drew a figure (fig. 196) showing a caterpillar with its internal organs. He showed a sketch of the central nervous system; it is easy to see two cephalic ganglia (the supraoesophagal and suboesophagal ones), three thoracic ganglia placed in the thorax, and eight ganglia placed in the abdomen; the eighth one is placed in this figure so near the seventh one, that they may be taken as grown into one.

I mention here, too, the paper of S. K. el SAWAF (16) on the moth *Galleria mellonella* L. The author gives a rather accurate description of the central nervous system of this moths caterpillar. This description in its topographical part agrees with the description of BRANDT, and differs from it only in this: SAWAF found in the abdomen of the caterpillar of *Galleria mellonella* L. not seven but eight nerve ganglia. According to BRANDT this number may be found only in the abdomen of the caterpillar of *Cossus cossus* L.

However, BRANDT did not examine the caterpillars of *Galleria mellonella* L., and — among all the so-called *Microlepidoptera* — he knew only the nervous system of the caterpillar of *Tinea pellionella* L. This is why I suppose that SAWAF is right in describing eight abdominal ganglia in the caterpillar of *Galleria mellonella* L. I am confirmed in this opinion by my own observations on the nervous system of the *Tineoidea* caterpillars mining the leaves of various plants.

2. TECHNIQUE AND OBJECT OF THE INVESTIGATIONS

My investigations of the nervous system of caterpillars differ from those of BRANDT and other authors, as in a vast majority of cases they were performed on live, not sectioned material, and without the use of chemicals to stain the nerve tissue. The use of such technique was possible, as I observed that the small caterpillars of the superfamily *Tineoidea* are unusually transparent and very well suited for microscopical examinations of the central nervous system, if the latter is naturally coloured.

It is interesting, and — as far as I know — hitherto unpublished, that the nerve ganglia of the caterpillars of some species of leaf-mining *Tineoidea* possess on their surface dark pigment cells or chromatophores. The pigment is brown or black. The chromatophores are usually so well visible through the transparent skin of the caterpillar, that they may be drawn and the changes of their shape may be observed in subsequent time intervals. However, it is indispensable to place the live caterpillar in a drop of water and to cover it with a cover glass. Thanks to the pigment cells the colourless nervous system is visible. The presence of he chromatophores makes it possible to observe in the body of the live caterpillar the form, size, and location of the nerve ganglia in a way that is faultless, not falsified by imperfections of the technique used.

I found such colouring of the nerve ganglia in caterpillars of the following species of moths: *Incurvaria oehlmanniella* Hb., *I. muscalella* F., in many caterpillars of the genus *Stigmella (Nepticula)*, in particular: *Stigmella myrtilella* Stt., *turicella* HS., *basalella* HS., *hemergyrella* Hein., *argentipedella* Z., *rhamnella* HS., *fragariella* Hyd,. *septembrella* Stt., *centifoliella* Z., *aucupariae* Frey; also *Bucculatrix frangulella* Goeze, *Leucoptera lustratella* HS., *L. wailesella* Stt., *Eupista (Coleophora) vacciniella* HS., *E. fuscedinella* Z., *Lophoptilus raschkiellus* Z., and *Scirtopoda herrichiella* HS. In all, in seven genera and nineteen species of *Tineoidea.*

Among the said *Tineoidea* some species have the chromatophores on the ganglia intensively coloured black or brown, and the fat-bodies disposed advantageously for observations of the nervous system. They are especially well suited for the establishing of the topography of the nervous system.

The first convenient object of my investigations were caterpillars of *Tineidae* of the genus *Incurvaria.* In the forest Las Wolski near Kraków (end of May — beginning of June) inhabited mines of *Incurvaria muscalella* F. may be found in leaves of the bilberry *(Vaccinium myrtillus).* I remark by the way that leaf-mining of the bilberry by *Incurvaria muscalella* F. has not yet been noted in the literature. Caterpillars of *Incurvaria oehlmanniella* Hb. were the second object of investigation; they also mined leaves of the bilberry and were found in July and August in Czerna ad Krzeszowice. The caterpillars of both species mine only in the life-stages I and II, and abandon the leaf in stage II. The caterpillar cuts a double-walled case out of the walls of the mine, and then descends with it to the ground, where it lives until pupation. For investigations of their nervous system I used caterpillars in the period of leaf-mining as well as in stages III do VII. I took the first from leaf-mines, the second from their cases.

Except the caterpillars of the genus *Incurvaria* I also examined caterpillars of other genera of the superfamily *Tineoidea*, and especially *Stigmella (Nepticula)*. *Stigmella myrtilella* STT. showed most convenient; except being transparent it has fat-bodies disposed advantageously (they do not obscure the nerve ganglia) and its nervous system is strongly coloured. Not only the ganglia, but also the connectives are partly coloured. I found the caterpillars in July and August in forests of the environs of Kraków in leaf-mines of *Vaccinium myrtillus*.

The caterpillars of *Stigmella septembrella* STT. mining the leaves of *Hypericum* sp. also showed to be convenient material. Their nervous system is distinctly coloured and they are not rare.

In September *Stigmella argentipedella* Z. showed to be a species convenient for examination; it mines the leaves of the birch and is rather common near Krzeszowice. Again, in October we have *St. hemargyrella* HEIN., found in the forest Las Wolski near Kraków in fallen, brown beech leaves.

I also examined caterpillars of other species of the genus *Stigmella* and ascertained that they all possess a central nervous system coloured better or worse; some as strongly as *St. myrtilella* STT., in others only the supraoesophagal ganglion is well visible. Some caterpillars of *Stigmella* sp. which I found in the first half of July in leaf-mines in *Corylus avellana* and *Salix caprea* (they could not be determined more exactly) also had a strongly coloured nervous system.

A rather good species to investigate, although quite difficult to find, was *Eupista (Coleophora) vacciniella* HS. mining the leaves of the bilberry and *E. fuscedinella* Z. from birch leaf-mines. The caterpillars of the first appear in their bilberry mines at the beginning of July, the second ones at the end of August in their birch mines. Both stay in the mines for a short time, in life-stage I only. After the first moulting they abandon the inconspicuous leaf-mine and spend the remaining life-stages in a case on the outer side of the leaves of the food plant.

Leucoptera lustratella HS. showed to be very grateful material. I found its inhabited mines in leaves of *Hypericum acutum* at the end of July and in August near Tenczynek ad Krzeszowice by the road to the ruins, and under the summit of Mount Boża Męka near Czerna ad Krzeszowice.

The best object for investigation, however, was the caterpillar of *Bucculatrix frangulella* Goeze in the period of mining the leaves of *Frangula alnus* or *Rhamnus cathartica*. It is especially well suited for examination as it is very common. The only inconvenience is the necessity to take it out from a narrow corridor-mine. It is comparatively the easiest to take out in an intact state from the corridor terminating the leaf-mine, i. e. in life-stage III. Mines recently made must be sought to obtain younger caterpillars. Such a mine has the form of a minute spiral and is a black opaque spot on the upper side of the leaf. The minute caterpillar lives in such a mine in which it may be seen only with difficulty. Seeking those youngest caterpillars of *Bucculatrix* I found that the record of M. Hering in his „Blattminen" (*Bucculatrix frangulella* should abandon its leaf-mine already after the first moulting) does not apply to the Kraków material. I ascertained without all doubt that the mine is abandoned after the second moulting, that is in life-stage III. In life-stage I, i. e. after leaving the egg-shell, the transverse axis of its head-moult — according to my measurements — amounts to 89,6 microns, in life-stage II-124,4 to 134,4 microns, in the third (when abandoning the leaf inside) as much as 160 to 192 microns. I found in the abandoned mines not one, but two moults of the head, derived from life-stages I and II.

It is most difficult to take out the intact caterpillar in its first life-stage, as its body-lenght is less than 1 mm, and it must be sought for in a hardly transparent mine space.

After leaving the mine the caterpillars of *Bucculatrix* feed freely on the under-side of the leaves. However, excellently suited for observations of their nervous system in their first three life-stages, the caterpillars have no greater value in life-stages IV and V, being too little transparent.

Except the leaf-miners possessing a coloured nervous system, numerous species of these possess quite colourless ones. Yet some of them are sufficiently transparent to make visible at least the boundaries of the supraoesophagal ganglion. The latter, however, must be taken out of the body to be seen, more often than not; this is not difficult, as a simple pulling off of the head with a needle-point in a drop of physiological solution causes also the supraoesophagal ganglion to slip out of the body in an intact state. This simple operation allows to evaluate the form, size, and position of the caterpillar's supraoesophagal ganglion.

In this way I could examine caterpillars of the following species of mothflies: *Lyonetia clerkella* L. from *Betula*; *Antispila petryi* MART. and *A. pfeifferella* HBN. from *Cornus sanguinea*; *Rösslerstammia erxlebella* F. from *Tilia* sp.; *Euspilapteryx auroguttella* STPH. from *Hypericum* sp.; *Xanthospilapteryx syringella* F. from *Syringa* sp.; *Lithocolletis sorbi* FREY from *Sorbus aucuparia* and *maestingella* Z. from *Fagus silvatica*; and *Tischeria complanella* HBN. from *Quercus* sp.

In all, my investigations comprised 14 genera with 28 species of moths. They all belong to the suborder *Frenatae*, superfamily *Tineoidea*, and families *Tineidae*, *Stigmellidae*, *Lyonetiidae*, *Gracillariidae*, and *Elachistidae*.

Lastly I began work on the topography of the colourless nervous system of the caterpillars of the species *Eriocrania*. *Eriocraniidae* belong to suborder *Jugatae*, i. e. to a more primitive suborder than *Frenatae*, and deserved examination if only for this reason. However, these investigations are not taken into account in this paper, as they are only begun.

The drawing were made with the help of a drawing apparatus of REICHERT from Vienna. They take into account not only the disposition of the nerve ganglia in the body of the caterpillars, but also their form, proportions, and natural distances.

3. RESULTS OF OBSERVATIONS

a. The brain

It is enough to examine against the light by an eightfold magnifying glass the caterpillar of *Incurvaria oehlmanniella*

Tr. or *I. muscalella* F. (fig. 1) feeding in its mine, or *Bucculatrix frangulella* Goeze when it approaches the end of its leaf-mining stage (fig. 2), or else *Stigmella myrtilella* Stt. in its bilberry leaf-mine — to see that they all possess two dark baglets in the dorsal part of the thorax, lying close to each other.

When observing the fore part of the body of mining caterpillars through the microscope, it is easy to ascertain that these dark baglets move backwards and forwards in accord with the movements of the head of the feeding caterpillar. When the caterpillar moves its head towards the leaf parenchym away from the thorax, the baglets move forwards after it, and when the head recedes after cutting off the bit, they recede after it, too. It is infallibly a sign of connection with the head and of the possibility of easy translocation in the body (without resistance of other internal organs). The movements of the baglets are slight, they do not move into the head, neither do they touch the abdomen when receding. They perform no independent movements, but repeat those of the head. They are placed in the thorax and belong to it doubtlessly.

These baglets form together the ganglion supraoesophageum of the central nervous system which Deegener (3) and also Snodgrass (14) call the caterpillar's brain. Besides the term „supraoesophagal ganglion" I also use the name „brain" for shortnes's sake.

The figures 1, 3, 6, 14, 16 and 17 showing the anterior part of the bodies of various species of Tineids — are included to show the brain as well as its form and size in relation to the head. It is easy to ascertain that they all contain the brain in the thorax, but not in the head. Similarly, it lies in the thorax of all other caterpillars of Tineids mentioned before.

The brain consists of two parts, which Brandt calls hemispheres. An hemisphere is most often pear-shaped and always smooths-walled, without lobus opticus on the outer side. On figures 3, 4, 6 and 14 the commissure linking both hemispheres may be seen. It consists of nerve fibres which — I suppose — here, too, link the left-side brain centres with the right-side ones. The commissure keeps both hemispheres rather close

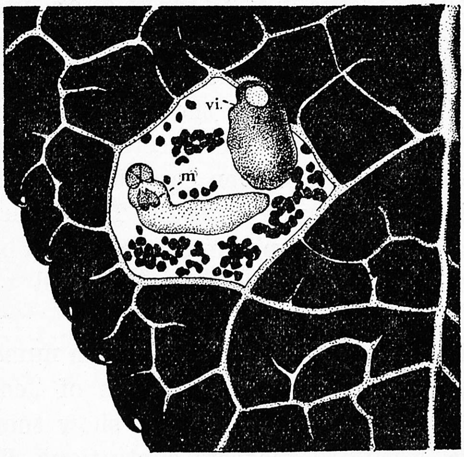

Fig. 1. Fragment of leaf of *Vaccinium myrtillus* with a mine occupied by the caterpillar of *Incurvaria muscalella* F. The caterpillar is in life-stage I, found in the forest Las Wolski, June 9th, 1952. Enlarged. vi — incubation vesicula; m — brain or supraoesophagal ganglion. Faeces is visible in the mine.

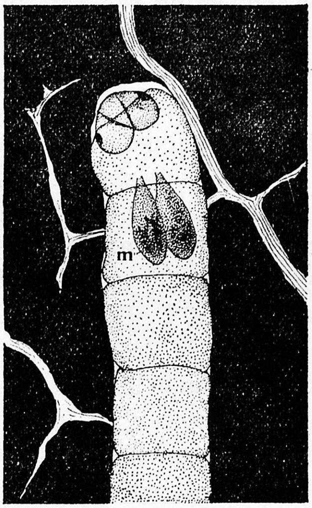

Fig. 2. Fragment of leaf of *Frangula alnus* with part of mine inhabited by the caterpillar of *Bucculatrix frangulella* Goeze. Caterpillar in life-stage III; mine found on Mount Buczyna ad Tenczynek, Aug. 22nd, 1952.

together. I could observe in the thorax of an intact caterpillar of *Incurvaria oehlmanniella* Tr. in life-stage I side-way movements of both hemispheres. Namely, both hemispheres are pushed away by the beating of the heart, one to the left, the other to the right, and then the connecting commissure appears. However, the commissure is seen easiest when the caterpillar's head is pulled off its body by a needle. The brain is then found behind the head; both hemispheres are separated by the distance allowed by the connecting commissure, well visible at this moment.

On the surface of both hemispheres often numerous chromatophores may be seen in various states of „contraction" or „dilatation". Figures 1, 3, 6, 14 and 17 show them in the „dilatation" state, fig. 16 in that of „contration". The chromatophores of the nerve ganglia of *Bucculatrix frangulella* Goeze are apt to strong „contractions". As long as this species of caterpillar remains in the mine they are „dilatated". Since the moment when the caterpillar abandons the leaf (i. e. in the second half of the third life-stage as well as the fourth and fifth) they are always „contracted".

The head nerves connecting the hemispheres with the sense organs of the head have no chromatophores. Only *Stigmella myrtilella* Stt. shows traces of pigment there (fig. 14).

Also connectiva circumoesophagalis is colourless; it connects the brain with the suboesophagal ganglion. It is not drawn in fig. 9, 10 and 12 as it was invisible. To show it, the anterior part of the nervous system must be taken out of the body, and this is no easy task as the superfamily *Tineoidea* caterpillars are very small. I succeeded in this in the caterpillars of *Incurvaria muscalella* F. (fig. 2) and *Bucculatrix frangulella* Goeze (fig. 4).

Thanks to a different build and position of the head (see pages 18 to 20 for details) non-mining caterpillars have a somewhat different position of the brain. The non-mining caterpillars have their brain directed with its protocerebral part towards the ceiling of the head-case. In the mining ones, again — as the back of the head is „inserted" into the thorax and disposed in a quasi-horizontal plane (fig. 9, 11 and 12) — its protocerebral part is directed towards the abdomen.

Together with the translocation of the brain to the thorax there may be seen also a lengthening of the nerves connecting the brain with the sense organs of the head, as well as a lengthening of the oesophagus which reaches into the prothorax (fig. 9, 11 and 12).

The size of the brain in comparison with the size of the head should be discussed in particular. It may be said in general what follows:

1) the brain in comparison with the head is large, sometimes very large,

2) in comparison with the size of the head the brain is so much the larger as the caterpillar is younger,

3) the cause of this difference in relative size is the quicker development of the head, quicker than the growth of the brain.

Table I

Measurements of the breadth of the brain and head of caterpillars in various life-stages

Species of caterpillar	Measurements in microns	Life-stages						
		I	II	III	IV	V	VI	VII
Incurvaria oehlmanniella Tr.	Breadth of head	223	295			574	679	850
	Breadth of brain	160	226			273	280	350
	Difference	63	69			301	399	500
Incurvaria muscalella F.	Breadth of head		284	400	540		701	(last stage)
	Breadth of brain		197	214	273		318	"
	Difference		87	186	267		383	
Leucoptera lustratella HS.	Breadth of head	96	164	220	329			
	Breadth of brain	90	107	146	172			
	Difference	6	57	74	157			

I came to these generalisations on the base of numerous observations of which only a small part has been illustrated here. I was convinced of their rightness by micrometric measurements of the breadth of the head and brain (in its broadest part). Both measurements were always made on the same caterpillar. However, measurements in different life-stages of the caterpillars could be made only on different specimens. This is not without objection, but the measurements cannot be made on one specimen, as the caterpillar must be first taken out of the mine and placed in a drop of water — this causes its death after some time. Therefore the measurements were necessarily made on different specimens in various life-stages.

However, small the number of measured specimens and large the gaps in the measurements — the results are not meaningless. Table I ascertains that really the breadth of the brain as compared to that of the head is very large in leaf-mining caterpillars; table I also shows that the difference in breadth of the head and brain — at first rather small — increases with every moulting. It is the smallest in the life-stage I, and largest in the last. This is also illustrated by fig. 1 (Pl. VII) where the outlines of the head and brain of *Incurvaria oehlmanniella* Tr. are given in the same scale in life-stage I and VII. In life-stage I the brain is so large, that it could in no way be contained in the head; in life-stage VII it would get in quite easily.

Table II

B — breadth of head
D — interstadial difference in breadth of the head of caterpillars (in microns)

Species of the caterpillar	Stage I		Stage II		Stage III		Stage IV		Stage V
	B	D	B	D	B	D	B	D	B
Bucculatrix frangulella Goeze	89	29	118—124	42	160—192	80	240—282	95	335—400
Antispila stachjanella A. Dz.	135	55	190—215	95	285—320	115	400—455	0	400—455

The cause of this state of things should be sought for in a different tempo of growth of the head and the brain. The head of caterpillars develops in „leaps", the brain grows normally. There are as many „leaps" in the development of the head as there are prepupal moultings; these „leaps" — according to my calculations — for caterpillars moulting only four or five times, are larger with every moulting.

Table II illustrates the changes in head-size for *Bucculatrix frangulella* Goeze and *Antispila stachjanella* A. Dz. (Dziurzyński, 4). The caterpillar of *Bucculatrix* has five normal larval stages, *Antispila* also five, but only four may be said normal, as the fifth stage of the *Antispila* caterpillars is a prepupal stage, when they feed and grow no more. Of course, the breadth of the head is the same in stage IV and V; only four stages may be used when calculating interstadial differences.

Table II allows to ascertain that in both species of caterpillars the interstadial differences of head sizes grow with each moulting. The differences 29—42—80—95 given for *Bucculatrix*, and 55—95—115 for *Antispila* were computed from the minimal dimensions. When comparing the maximal dimensions, following interstadial differences are obtained: for *Bucculatrix* 35—68—90—118, for *Antispila* 80—105—135. In both cases the results are in accord with the generalisation given on page 11.

The measurements of the brain breadth given in table I witness the slow rate of growth of this organ in comparison with the „leap-wise" growth of the head.

The central nervous system of the caterpillar of *Bucculatrix frangulella* Goeze deserves a separate discussion. Fig. 16 shows the fore part of its body dorsally in lifestage I. The measurements gave following dimensions:

body length	780 microns	head length	64 microns
breadth of head ...	89 microns	approximate brain	
breadth of brain ...	112 microns	length	144 microns

Compared to the minute head, the brain was unusually large. Moreover, its form was different from the normal one. The hemispheres could not be discerned. Only an incision in the back end of the ganglion tells of a certain tendency to divide it.

Unfortunately, I discovered this first life-stage of *Bucculatrix* too late, i. e. at a time when in this region *Bucculatrix frangulella* Goeze passed its first life-stage, and therefore I could not find a second specimen. I had to repeat these observations in July 1953 and came to the same conclusions.

Fig. 10, 11 and 17 show the fore part of the body of *Bucculatrix* in life-stage II dorsally and laterally.

The caterpillar drawn on fig. 17 had following dimensions:

breadth of head ... 124 microns
breadth of brain ... 102 microns
length of head .... 92 microns
approximate length of brain .... 128 microns

The caterpillar drawn on fig. 10 and 11 had following dimensions:

breadth of head ... 118 microns
breadth of brain ... 102 microns
lateral height of head 73 microns
height of prothorax 153 microns
length of head .... 96 microns
approximate length of brain .... 137 microns
lateral height of brain .... 74 microns
height of suboesophagal ganglion .... 60 microns
height of both ganglia .... 135 microns

In comparison to the head size the supraoesophagal ganglion is very large in the caterpillar's life-stage II as well as in life-stage I, although somewhat shorter. In life-stage I it is broader than the head and about twice longer. Instead, in life-stage II, in the described specimens its breadth was somewhat smaller than the breadth of the head, and its lenght was approximately one and a half times that of the head. It may be said in general that the brain of the caterpillar of *Bucculatrix frangulella* Goeze in its two first life-stages, in the described caterpillars as well as in others examined by me, was so large that even all by itself, without the suboesophagal ganglion, it could not find room in the head.

Measurements in later life-stages of the caterpillar of *Bucculatrix* gave following results (I give measurements of four specimens in life stage III and four in life-stage V):

Life stage III: specimen	1	2	3	4
breadth of head	166	160	169	192
breadth of brain	128	131	153	192

Life-stage V: specimen	1	2	3	4
breadth of head	292	318	335	342
breadth of brain	290	318	275	278

Basing on these measurements we could say, that there is only a minimal difference between the breadth of the brain and that of the head until the last life-stage of the caterpillar. These results differ from those obtained for *Incurvaria oehlmanniella* Tr., *I. muscalella* F., and *Leucoptera lustratella* HS. We could even think that the growth of the brain equals the „leap-wise“ growth of the head. In reality it is not so, to be sure, the breadth of the brain until the last life-stage is nearly equal to the breadth of the head, but the lenght of the brain of the caterpillar of *Bucculatrix frangulella* Goeze lessens distinctly. Therefore the generalisations on page 11 are valid for it, too.

On the dorsal side of the head, just under the triangular surface of clypeus of the caterpillar of *Incurvaria oehlmanniella* Tr. (fig. 1, 3) and *I. muscalella* F. there may be seen a minute globular body coloured similarly to the ganglia of the central nervous system. This body in the live caterpillar sometimes shows vibrations, which I ascribe to the current of blood flowing from the aorta to the head. I think this could be the ganglion frontale as this body has the colouring of the central nervous system and lies on the median line of the head where it could be expected.

b. The ventral cord

On the ventral side in prothorax under the oesophagus and below the brain lies the ganglion suboesophageum (fig. 9, 11 and 12). Its position, size, relations to the thoracal ganglia, as well as the disposition of chromatophores on its surface may be seen on the figures showing the central nervous system from the ventral side, i. e. figures 4, 7, 8, 13 and 18.

It may be said generally that:

1) the suboesophagal ganglion is translocated from the head to the thorax as well as the brain and lies in the prothorax under the brain,

2) it is a large ganglion in comparison to the head, especially in young caterpillars, in which it could not find room together with the brain in a head too small and flattened;

3) it lies very near the first thoracal ganglion; sometimes so near that a pair of short connectives linking it with the first thoracal ganglion is invisible (fig. 11 and 18); again, it is never grown into one with the latter. In this case the conditions are similar to those observed by Brandt in caterpillars of the *Macrolepidoptera* as I mentioned on page 2.

In mesothorax and metathorax there are three thoracal ganglia, the first and second in mesothorax, the third in metathorax (fig. 7, 8, 9, 10, 12, 13 and 18). In non-mining caterpillars which have the brain and the suboesophagal ganglion in the head the first thoracal ganglion lies in prothorax; in mining caterpillars I always found it in mesothorax or on the boundary of prothorax and mesothorax. Therefore it may be said that it was transplaced, too, in consequence of the translocation of the head ganglia to prothorax.

The thoracal ganglia are linked between themselves and with the suboesophagal ganglion by widely distant, paired connectives (fig. 7, 8 and 13). Usually the connectives, although colourless, are easily discernible. However, in *Bucculatrix frangulella* Goeze in life-stage I and partly in II (fig. 18) the thoracal ganglia lie so near each other that the connectives are invisible. The reason of this is the shortness of the body while the ganglia are comparatively very long.

Table III

Width and length of the ganglia of the ventral nerve cord of the caterpillar of *Bucculatrix frangulella* Goeze

in life-stage I

Ganglion	suboe-sophag.	thoracal			abdominal							
		I	II	III	1	2	3	4	5	6	7	8
width	70,4	64	64	57,6	40,6	37,4	47	47	37,4	37,4	47	47
length	70,4	40,6	43,8	64	47	54,4	57,6	54,4	64	64	51,4	76,8

The body length of the measured caterpillar (table III) was 748 microns without the head, and somewhat less than 700 microns without the last abdominal segments 9 and 10 which have no nerve ganglia. The summed length of the ventral cord ganglia is 691,4 microns, i. e. barely some microns less.

The thoracal ganglia are of various length and various form. The breadth of the thoracal ganglia is rather variable and does not allow generalisations; however, the length of the ganglia most often increases from the first to the third (as given by the measurements of table IV).

The form of the thoracal ganglia is varied and characteristical for the genus of the moth. E. g. for *Stigmella* the thoracal

Table IV
Length of the foremost nerve ganglia in microns

No.	Name and date of measurement	Breadth. of head	Ganglion. suboes.	Thoracal ganglia		
				I	II	III
1.	*Incurvaria oehlmanniella* Tr. 22 VII 1952	223	105	57	73	76
2.	*Stigmella septembrella* Stt. 27 VIII 1951	204	128	86	91	108
3.	*Stigmella septembrella* Stt. 20 VII 1952	214	102	80	99	121
4.	*Stigmella myrtilella* Stt. 16 VII 1952	261	67	96	115	118
5.	*Stigmella myrtilella* Stt. IX 1951	284	113	67	93	112
6.	*Stigmella* sp. (from *Salix*) 16 VII 1952	297	112	92	121	128
7.	*Leucoptera lustratella* HS. 23 VII 1953 Stage I	96	54	32	34	40
8.	*Leucoptera lustratella* HS. 21 VIII 1951 Stage II	166	94	57	76	89
9.	*Leucoptera lustratella* HS. 21 VIII 1951 Stage III	220	128	89	96	128
10.	*Leucoptera lustratella* HS. 10 VIII 1951 Stage IV	329	128	91	121	144

ganglia I and II (seen ventrally) always have the form of a triangle, whereas the third one as well as the abdominal ones are approximately diamond-like. In *Bucculatrix frangulella* in the earlier life-stages the thoracal ganglia are of quadrangular outline. In others they are most often round or oval.

The abdominal ganglia are connected with the thoracal ones. There are always eight abdominal ganglia in caterpillars with a coloured nervous system, thus as many as Brandt found in the abdomen of the *Cossus cossus* L. caterpillar, and Sawaf in *Galleria mellonella* L. We may suppose that also the *Tineoidea* caterpillars with a colourless nervous system possess eight abdominal ganglia.

The abdominal ganglia of the described caterpillars were somewhat smaller than the thoracal ones, but the difference in size is slight (fig. 10 and 13).

The last ganglion is always much larger than the penultimate. In young caterpillars of *Incurvaria oehlmanniella* Tr., *I. muscalella* F., *Eupista vacciniella* HS., and *Bucculatrix frangulella* Goeze ganglion 8 lies near ganglion 7; in older specimens of *Incurvaria* sp. they are distant. The largest distance could be found in *Stigmella myrtilella* Stt.

Ganglion 8 lies nearly always in segment 7; therefore not only segments 9 and 10, but also 8, have usually no ganglia.

The connectives linking the abdominal ganglia are single in their foremost part, they are double in their hind part. In this bifurcation lies the so-called median nerve — Snodgrass (14) — belonging to the sympathetic system. This nerve could not be perceived on live, unstained material.

4. PROBABLE REASONS OF THE TRANSPOSITION OF THE NERVE GANGLIA FROM THE HEAD TO THE THORAX

All the information gathered in the previous chapters, pertaining to the shifting of the capital nerve ganglia into the thorax in caterpillars, relate exclusively to caterpillars of Tineids which mine the leaves of various plants. In caterpillars living not inside, but outside the plant's body, i. e. non-mining ones, such translocations have not yet been observed. Therefore we must ask whether the function of mining has any nearer connexion with the described translocations in their nervous system.

The question of the influence of plant-mining on the external appearance of caterpillars is not new. It has been synthetically approached by HERING in his work „Biologie der Schmetterlinge“ in 1926. It has also been discussed by RIPPER (13) in his lecture in 1929.

While describing the topography of the central nervous system, I must shortly discuss here the influence of leaf-mining on the position and form of the head of the caterpillars of butterflies.

We can ascertain very easily that the caterpillars which live on the surface of plants have their head posed perpendicularly or nearly perpendicularly to the long axis of their body. Such a head is called orthognathic (WEBER, 18).

In the head-case of such caterpillars we can always discern two large hemispheres separated on the dorsal side of the head by a suture. This suture bifurcates towards the bottom and forms two arms comprising a large triangular area, called *clypeus* by SNODGRASS (14) and frons by older authors (e. g. KUZNECOV (9), FORBES (5), RIPPER (13), and others). These sutures remind of a capital letter Y upside-down. The upper, odd end of this suture is called sutura metopica by KUZNECOV (9), sutura epicranialis by RIPPER (13), sutura coronalis by WEBER (18), and SNODGRASS (14). In this paper I use SNODGRASS's term as the most recent.

The ratio of the height of the triangular clypeus to the length of sutura *coronalis* is variable and depends on the mode of living of the caterpillar. This ratio is called index epicranialis by RIPPER (based on a paper of RIPPLEY (12) unknown to me). On an orthognathic type of head, characteristical for caterpillars living free, sutura *coronalis* is of considerable length; hence the epicranial index is a fraction or approaches one. Moreover, in an orthognathic type of head there is a considerable difference in the size of the anterior surface of the head as compared with the posterior one. The anterior surface is much larger than the posterior surface.

Such a head is said advantageous in position for the caterpillars, as it facilitates the eating of food which lies underneath the head, on the level of their legs.

The leaf-mining caterpillars are in different conditions of food-gathering. They remain inside the leaf, where the food is before the head on a level with the long axis of their body, not underneath it. This forces them to hold their head differently; from a vertical position it goes over into a horizontal one. This change of the mode of gestion of the head during the feeding in the mine is the cause, according to many authors, of the horizontal position of the head of leaf-mining caterpillars.

According to these authors, this new position of the head came to be in two ways:

1) In caterpillars feeding on the leaf parenchyma, or those called tissuefeeders by TRÄGARDH (17), the back of the head was indented into the prothorax and this caused its horizontal position. Together with this the occipital area of the head was reduced, namely the sutura *coronalis* and its neighbourhood disappeared as well as the connexion between both hemispheres. Figures 16 and 17 witness the lack of sutura *coronalis* on heads of this type. A still stronger shortening of the head in the occipital area took place, in my opinion, in the genera *Leucoptera* and *Stigmella*, in which the clypeus confines broadly with the back end of the head (fig. 6, 14).

2) in the second group, in caterpillars feeding on the sap of the epidermis cells, or those called sapfeeders by TRÄGARDH, represented in Poland above all by the genera *Lithocolletis* and *Phyllocnistis*, the occipital part of the head was similarly reduced as in the first group. However, the head did not „indent" into the prothorax, although it took an horizontal position, as its ventral side was lengthened. Here, too, the epicranial index cannot be computed, as there is no sutura *coronalis*.

Both groups of caterpillars possess a prognathic type of head. In short — according to many authors — the primarily orthognathic caterpillars became prognathic by leaf-mining [1].

Leaf-mining, moreover, exerted a weaker or stronger influence on the flattening of the head. In the first group there is a strong

[1] A prognathic type of head — its epicranial index may, however, be computed and exceeds one — is found also in non-mining caterpillars which somewhat weakens the assertion of these authors.

flattening of the head in the genera *Tischeria* and *Stigmella*, in the second group all caterpillars possess a strongly flattened head. The mining caused also a straightening of the oesophagus and reduced the number of eyes; e. g. in *Stigmella* there is only one ocellus on each side instead of six. Moreover, it influenced some changes in the number, size, and the equipment of the locomotive organs. In extreme cases even the thoracal legs and abdominal prolegs disappear completely, as e. g. in the genera *Antispila* and *Stigmella*.

In my opinion quite good proofs of a strict connexion between the mining and the exterior build of the caterpillar are given by *Bucculatrix frangulella* GOEZE, which passess its two first life-stages and a part of the third in its mine, and the rest of the third as well as the last two on the under-surface of the leaves of *Frangula alnus* or *Rhamnus cathartica*. Thus its life is passed in two different environments.

The caterpillar of this moth in life-stage I and II cuts out a very narrow spiral mine-channel, barely broad enough to enable the entomologist to take it out of its mine in an undamaged state with difficulty (fig. 15). In its first two life-stages it has no hairs or thoracal legs and abdominal prolegs. It can move slowly in the mine supporting the sides of its body against irregularities of the mine walls. It may be said with some right that in such conditions of life it would be of no import for the caterpillar to possess hairs or legs.

After the second moulting the caterpillar makes its last mine-channel, this time somewhat broader. This channel extends sideways from the spiral part of the mine (fig. 15k). Then comes the moment when the caterpillar bites through the under-side cutis of the leaf and comes out of the mine. In this third life-stage it has hairs as well as three pairs of thoracal legs and five pairs of prolegs. They are all still weakly developed; e. g. the prolegs are very short and each has only two claws on its hind edge. It may be said that they are fit for use in the larger end part of the mine, and when the caterpillar leaves the mine they enable it to move on the surface of the leaf.

In both first life-stages the caterpillar's head has a prognathic build; it is horizontal in a way characteristic for mining caterpillars. When the caterpillar leaves the mine and lives on the under-side of the leaf, it finds its food not before its head, but underneath, level with its legs. This compels it to hold its head in a new way, vertically. In accord with this its head in life-stage III is somewhat differently built than in life-stages I and II. In both first life-stages it lacks the sutura *coronalis*, so that the epicranial index cannot be computed. In stage III a short suture appears, the index amounts to about two. I see here the beginning of a likening of the back of its head to the heads of non-mining caterpillars.

In life-stage IV, i. e. after the third moulting, the caterpillar possesses a head with a somewhat smaller epicranial index; the prolegs on its abdomen are normally long and are armed with many claws. In life-stage V its head is distinctly similar to the orthognathic type. Fig. 5 shows the anterior part of this caterpillars body in life-stage I (fig. „a") and V, i. e. the last (fig. „b"). On fig. „a" the head is deeply let in into the thorax and has its characteristical a horizontal position. The head on fig. „b" was directed downwards and I had to change its position on purpose — to be able to draw it in the position shown on the figure. The head on fig. „a" is more enlarged than that on fig. „b". This was done so to give both heads approximately the same width on the drawings. In reality caterpillar „a" had a head 89,6 microns wide, caterpillar „b" — 380 microns. Both were drawn together for comparison. Fig. 5 illustrates the deep change undergone by the head of the caterpillar of *Bucculatrix frangulella* Goeze, during its development. It is easy to see that in the last (fifth) stage of larval life its head is no more let in into prothorax, and the clypeus is nearly as long as sutura *coronalis*, so that the epicranial index amounts to one in this stage. Again, such an index characterises heads of an orthognathic type. The unusual contrast between complete hairlessness of the caterpillar in life-stage I and strong hairyness in life-stage V is striking. To finalise, we may say that the caterpillar of *Bucculatrix frangulella* Goeze in the first half of its life (which it spends in a mine) has a prognathic head as all mining caterpillars have. On the other hand, in the second half of its larval life, and especially in life-stages IV and V (spent outside the mine on the leaf) its head is orthognathic, similar to the heads of non-mining caterpillars living freely on the surface of plants.

Thus it is doubless that there is a strict dependency between the external build of the caterpillar of *Bucculatrix frangulella* Goeze and the two environments where it spends its life.

Therefore it should be discussed whether the said translocation of the nerve ganglia in mining caterpillars of the *Tineoidea* has any connexion with their mode od life inside the leaf.

For a long time I supposed that such a connexion really exists. However, in the last months of my work on these problems I came to the conclusion that the cause is not so much the mode of life in the mine as the prognathism of the head. Again, the prognathism is not necessarily connected with mining. Many caterpillars may be found which possess a prognathic type of head and do not mine at all.

E. g. the caterpillar of *Ephestia kühniella* Z. of the *Pyralidae*, breadth of head 452 microns, had an epicranial index equal to 2,1; thus its head was of a prognathic type. The caterpillar of *Talaeporia tubulosa* Retz, family *Talaeporidae* (placed in the system near the *Tineidae*), had a head 480 microns broad with an epicranial index 3; another specimen of the same species had a head 1032 microns broad with an epicranial index 2, 2. Thus all three possessed a prognathic type of head, although none of these species mine channels in plant tissues, as *Ephestia kühniella* Z. lives in flour, and *Talaeporia tubulosa* lives on the trunks of trees hidden in a bag as the caterpillars of the bag-worm moths are.

It is interesting to note that in both these species there may be ascertained a similar transposition of the nerve ganglia into the thorax as in mining caterpillars.

We could thus conclude upon a near dependency between a prognathic type of the head and the transposition of the nerve ganglia from the head into the thorax. Is such a generalisation sufficiently motivated? I think that only further investigations on the topography of the central nervous system of caterpillars of butterflies belonging to other families of the „Micro- and Macrolepidoptera“ may answer the question of the real appearance of this dependency. As yet it is too early to emit valid generalisations.

I suppose on the contrary that the size of the brain, as connected with the life-stage of the caterpillar (in the meaning of page 11), has nothing in common with the prognathism of the head. I think, too, that there is no nearer relation between the prognathism of the head and the separation of the eighth abdominal ganglion from the seventh. The question whether the caterpillars of moths possess seven abdominal ganglia should rather be considered again. It may be that eight independent ganglia will be found not only in caterpillars mining plant tissues, not only in *Cossus cossus* L. and *Galleria mellonella* L., but also in many other non-mining caterpillars.

In the end I must mention the matter of a transposition of nerve ganglia in insects belonging to other orders. Some examples may be cited. Thus Brandt (2) ascertained that a mature *Rhizotrogus solstitialis*, L. *Stylops* and *Hydrometra* have only the brain in their heads, whereas the suboesophagal ganglion lies in the thorax and is grown into one with the thoracal ganglia. Moreover, Brandt found in the larva of the dipteran *Stratiomys chamaeleon* L. the translocation of both head ganglia and all abdominal ganglia into the thorax. Finally Meixner (10, p. 1052) noted that a resting larva of the beetle *Lampyris noctiluca* L. pulls its head deep into the prothorax and then both the nerve ganglia of the head move into the mesothorax.

These examples of a transpositions of nerve ganglia from the head into the thorax demonstrate that the leaf-mining caterpillars of the Tineids are no exceptions in this respect.

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STRESZCZENIE

Dotychczasowe badania nad topografią centralnego systemu nerwowego gąsienic motyli uwzględniały prawie wyłącznie gąsienice tzw. *Macrolepidoptera*. Gąsienice molowców minujące w liściach, jako zbyt drobne, nie budziły pod tym względem zainteresowania badaczy.

W pracy nad topografią centralnego systemu nerwowego uwzględniłem jedynie gąsienice naszych molowców, minujące w liściach różnych roślin. Są one wprawdzie bardzo drobne, jednakże przy tym tak przejrzyste, że ich system nerwowy, pokryty w węzłach zazwyczaj chromatoforami, może być badany *in vivo*. Przedstawia to znaczną korzyść w badaniach, odpada bowiem konieczność sekcjonowania zwierząt.

Przebadanych zostało 28 gatunków, w tym 14 rodzajów motyli z plemienia molowców *Tineoidea*. Szczegółowy wykaz gatunków znaleźć można na stronie 4 i 7 niniejszej pracy.

Badania wykazały, że u wszystkich minujących gąsienic molowców mózg, tzw. ganglion supraoesophageum: 1. tkwi nie w głowie, ale w tułowiu (ryc. 1. 3, 6, 14, 16, 17 Pl. VII—X),

2. w porównaniu z wielkością głowy jest duży, niekiedy bardzo duży (Pl. X 16), 3. w stosunku do wielkości głowy jest tym większy, im młodsze jest stadium życia gąsienicy. Przyczyną tej ostatniej różnicy jest szybszy od wzrostu mózgu rozwój głowy.

Nie tylko mózg, lecz również zwój podprzełykowy, tzw. ganglion suboesophageum nie znajduje się w głowie, lecz tkwi w tułowiu, poniżej mózgu (ryc. 7, 8, 11, 12, 13, 18 Pl. VII—X). W stosunku do głowy jest to duży zwój, zwłaszcza u młodych gąsienic, u których wraz z mózgiem nie mógłby się pomieścić w zbyt małej i spłaszczonej głowie. Leży on bardzo blisko pierwszego zwoju tułowiowego, lecz nie jest z nim zrośnięty. Pierwszy zwój tułowiowy uległ również przesunięciu ku tyłowi i leży wraz z drugim tułowiowym w mesothorax, a nie w prothorax, jak to jest stale u nieminujących gąsienic.

W odwłoku wymienionych gąsienic znajduje się stale nie 7, jak podaje Brandt dla przebadanych przez siebie gąsienic z *Macrolepidoptera*, lecz stale 8 węzłów nerwowych, przy czym ósmy jest zazwyczaj całkowicie oddzielony od siódmego.

Wymienione powyżej przesunięcia zwojów nerwowych stoją zapewne w związku z prognatyczną budową głowy gąsienic minujących, a w nieznacznym tylko stopniu ze sposobem ich odżywiania się, które polega na minowaniu liści.

РЕЗЮМЕ

Проводившиеся до сих пор исследования топографии центральной нервной системы гусениц бабочек касались почти исключительно гусениц *Macrolepidoptera*. Гусеницы молей минирующие в листьях, как слишком мелкие не возбуждали в этом отношении интереса исследователей.

В работе над топографией центральной нервной системы автор исследовал лишь гусеницы встречающихся в Польше молей, минирующих в листьях различных растений. Хотя эти гусеницы очень мелки, однако они приэтом так прозрачны, что их нервная система покрытая обыкновенно на ганглиях хроматофорами, может быть исследуема in vivo. Это представляет большое удобство при ис-

следованиях так как отпадает необходимость секционировать материал.

Исследовано 28 видов, принадлежащих к 14 родам бабочек из племени *Tineoidea*. Подробный список видов находится на стр. 4 и 7 настоящей работы.

Исследования показали, что у всех минирующих гусениц молей мозг, т. е. надглоточный ганглий (ganglion supraoesophageum: во первых находится не в голове, а в груди (рис. 1, 3, 6, 14, 17 Pl. VII—X), во вторых, по сравнению с величиной он велик, иногда очень велик (P. X 16), в третьих, по отношению к величине головы, он тем больше, чем моложе стадия гусеницы. Причиной этой последней разницы является более быстрый рост головы, чем мозга.

Не только мозг, но и подглоточный ганглий (ganglion suboesophageum) не находится в голове, а в груди, ниже мозга (рис. 7, 8, 11, 12, 13, 18 Pl. VII—X. По сравнению с головой, это большой ганглий, особенно у молодых гусениц, у которых он вместе с мозгом не мог бы поместится в слишком малой и сплющенной голове. Он лежит очень близко к первому грудному ганглию, но не срастается с ним. Первый грудной ганглий подвергся тоже смещению кзади и лежит вместе со вторым грудным ганглием в мезотораксе, как это всегда имеет место у минирующих гусениц.

В брюшке у названных гусениц находится всегда 8 нервных ганглиев, а не 7, как указывает Брандт для исследованных им гусениц из *Macrolepidoptera*. При этом восьмой ганглий обыкновенно совсем отделен от седьмого.

Указанные смещения нервных ганглиев находятся вероятно в связи с прогнатическим строением головы минирующих гусениц, а только в незначительной степени с их способом питания, каким является минирование листьев.

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Plate VI

Fig. 1. Head and prothorax of caterpillars of *Incurvaria oehlmanniella* Hb. Left downwards „a“ caterpillar in life-stage I, „b“ in life-stage VII. Enlarged about 60×
m — brain; g — ganglion frontale; f — sutura coronalis.

Fig. 2. Anterior part of central nervous system of caterpillar of *Incurvaria muscalella* F. taken out of its bag, July 17th, 1951, probably in life-stage V. Enlarged about 70×
m — brain, c — commissure connecting brain hemispheres; k — circumoesophagal connective; p — suboesophagal ganglion; t — first abdominal ganglion.

Fig. 3. Head and prothorax of caterpillar of *Incurvaria oehlmanniella* Hb. The caterpillar was taken out of its mine in life-stage II. The mine was found in a leaf of *Vaccinium myrtillus* in Czerna ad Krzeszowice, Aug. 18th, 1951. Enlarged about 160×
m — brain; c — commissura uniting the brain hemispheres; g — ganglion frontale; s — outline of scutum prothoracale dorsale.

Fig. 4. Anterior part of central nervous system taken out of body of caterpillar of *Bucculatrix frangulella* Goeze. The caterpillar was in life stage III and had made a mine in a leaf of *Rhamnus cathartica* on Mount Buczyna ad Tenczynek; mine found on Aug. 20th, 1951. Enlarged about 140×
m — brain; c — commissure connecting both brain hemispheres; p — suboesophagal ganglion; I — first thoracal ganglion. The circumoesophagal connective was broken on one side during preparation.

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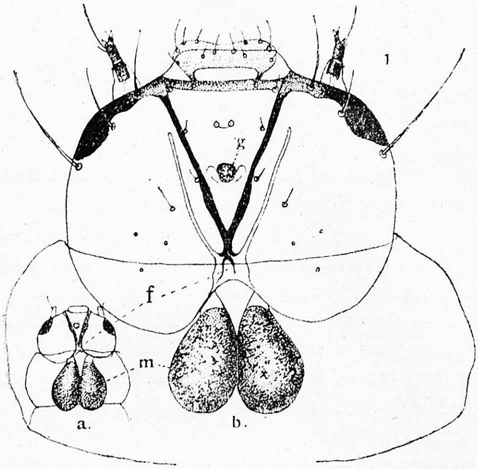

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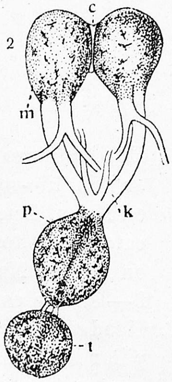

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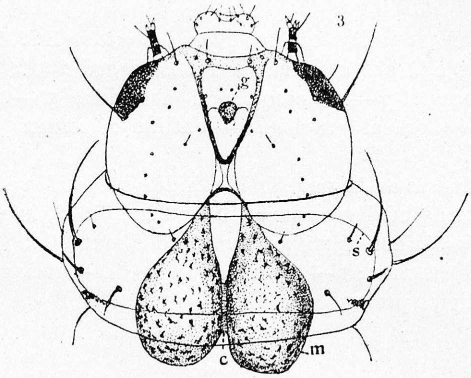

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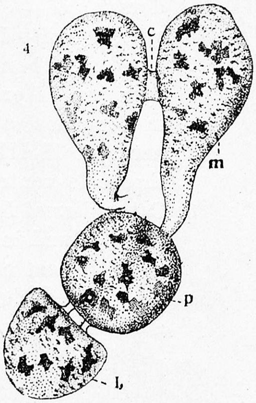

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Plate VII

Fig. 5. Head and prothorax of caterpillar of *Bucculatrix frangulella* Goeze: „a" in life-stage I, caterpillar found in mine, Aug. 22nd, 1952, on Mount Buczyna ad Tenczynek; „b" in life-stage V (i. e. the last), caterpillar found on leaf of *Frangula alnus*, Aug. 16th, 1952, on Mount Nawojowa Góra ad Tenczynek.
f — sutura coronalis; cl — clypeus; m — brain. Details in the text.

Fig. 6. Head and thorax of caterpillar of *Leucoptera lustratella* HS. Caterpillar in life-stage II, taken out of its mine made in leaf of *Hypericum acutum*; mine found in Czerna ad Krzeszowice, Aug. 18th, 1951. Dorsal view, enlarged 200×
m — brain; n — head nerve; s — outline of scutum prothoracale dorsale; cl — clypeus; ct — fat-bodies. Chaetotaxis and tracheal system omitted.

Fig. 7. Head and thorax of caterpillar of *Leucoptera lustratella* HS. Same specimen as on fig. 16, but seen ventrally. Enlarged 200×
m — outline of brain; p — suboesophagal ganglion; n — head nerve; I II IIIt — thoracal ganglia; s — outline of scutum prothoracale ventrale.

Fig. 8. Caterpillar of *Incurvaria oehlmanniella* Hb. in life-stage II, ventral view. Found in Czerna ad Krzeszowice, July 22nd, 1952, in mine made in leaf of *Vaccinium myrtillus*. Enlarged about 90×
p — suboesophagal ganglion; t — thoracal ganglia; c — abdominal ganglia; sp — vestigial proleg.

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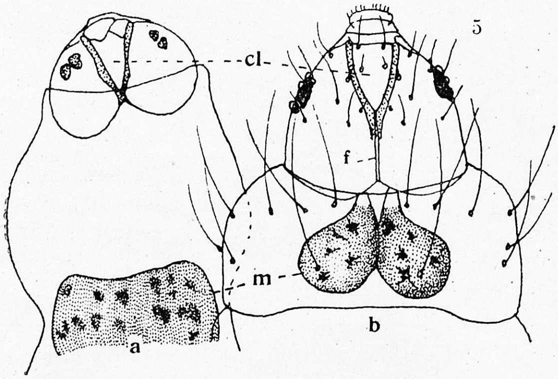

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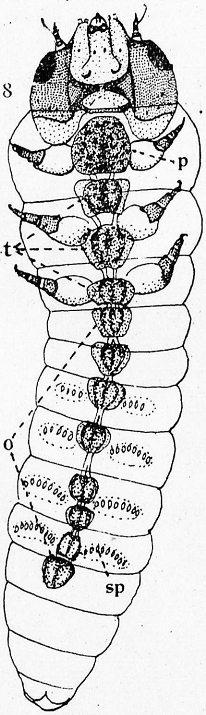

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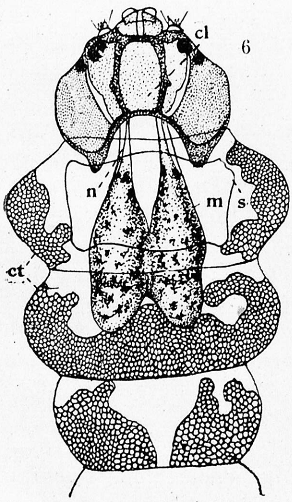

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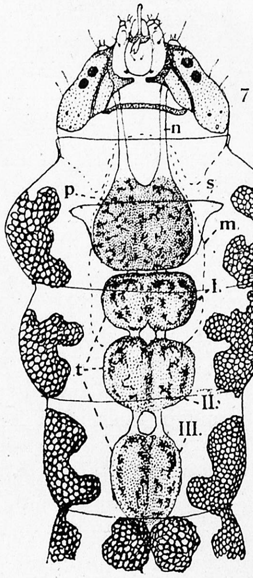

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Plate VIII

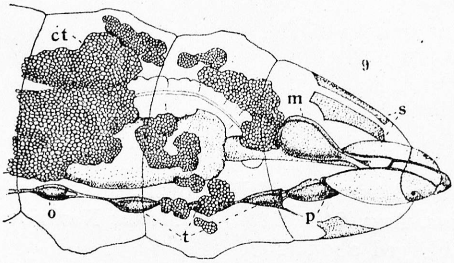
Fig. 9. Head and thorax of caterpillar of *Stigmella myrtilella* Stt. in lateral position. Caterpillar taken out of its mine made in leaf of *Vaccinium myrtillus*; mine found in Czerna ad Krzeszowice, July 21st, 1951. Enlarged about 40 ×
m — brain; p — suboesophagal ganglion; t — three thoracal ganglia; o — first abdominal ganglion; s — scutum prothoracale dorsale, opposite on dorsal side scutum prothoracale ventrale; ct — fat-body.

Fig. 10 and 11. Caterpillar of *Bucculatrix frangulella* Goeze in life-stage II, taken out of its mine made in leaf of *Rhamnus cathartica*. Mine found on Mount Buczyna ad Tenczynek, Aug. 22nd, 1952. Lateral view; fig. 10 enlarged 50 ×, fig. 11 enlarged 200 ×
m — brain; p — suboesophagal ganglion; I II — thoracal ganglia; 1—8 — abdominal ganglia; s — scutum thoracale dorsale; st — stigma.

Fig. 12. Head and thorax of caterpillar of *Incurvaria muscalella* F. seen sideways. Caterpillar in life-stage IV, taken out of its case. July 15th, 1952, the mine was found in a leaf of *Vaccinium myrtillus* in the forest Las Wolski, June 2nd, 1952. Enlarged 40 ×
m — brain; p — suboesophagal ganglion; t — thoracal ganglia; o — first abdominal ganglion. The anterior part of the alimentary canal is visible, the tracheal system was omitted on purpose.

Fig. 13. Head and thorax of caterpillar of *Stigmella myrtilella* Stt., ventral view. Caterpillar taken out of its mine made in leaf of *Vaccinium myrtillus*; mine found in Czerna ad Krzeszowice, July 21st, 1951. Enlarged 40 ×
m — outline of brain; p — suboesophagal ganglion; t I II III — thoracal ganglia; o 1 — first abdominal ganglion. Small tracheal branches and fat-bodies omitted.

Fig. 14. Head and prothorax of caterpillar of *Stigmella myrtilella* Stt. Taken out of its mine made in leaf of *Vaccinium myrtillus*; mine found in Czerna ad Krzeszowice, July 21st, 1951. Enlarged 40 ×
cl — clypeus; m — brain; n — head nerve; pr — oesophagus; g — silk gland; ct — fatbody.



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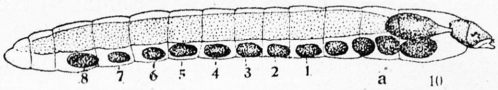

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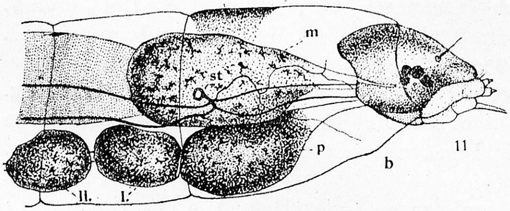

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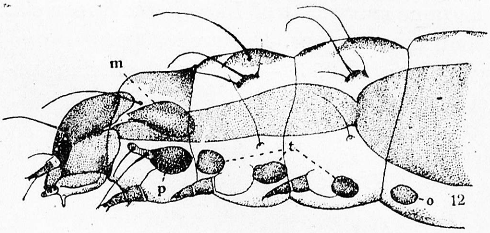

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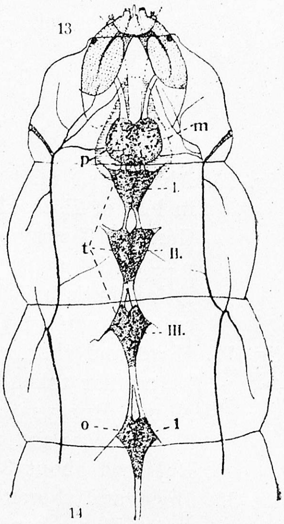

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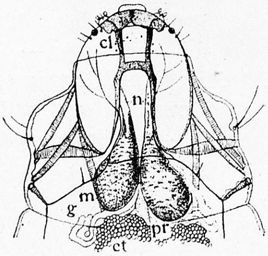

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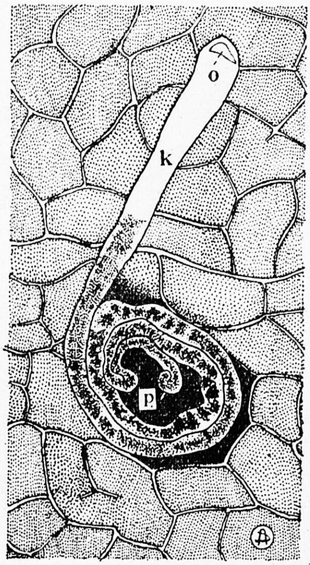
Plate IX

Fig. 15. Abandoned mine of *Bucculatrix frangulella* GOEZE. Mine found in leaf of *Frangula alnus*. Aug. 24th, 1952, on Mount Nawojowa Góra ad Tenczynek. Enlarged about 10×
p — initial spiral corridor; k — terminal corridor; o — opening in leaf cutis by which the caterpillar came out of the mine to the exterior part of the leaf.

Fig. 16. Head and thorax of caterpillar of *Bucculatrix frangulella* GOEZE. Caterpillar taken out of its mine in life-stage I. Mine found on Mount Buczyna ad Tenczynek, Aug. 22nd, 1952. Dorsal view. Head nerves and a tracheal system were invisible and are omitted. Enlarged about 300×

Fig. 17. Head and thorax of caterpillar of *Bucculatrix frangulella* GOEZE. Caterpillar taken out of its mine in life-stage II. Mine found on Mount Buczyna ad Tenczynek, Aug. 22nd, 1952. Dorsal view. Enlarged about 300×
m — brain; pr — oesophagus; t — tracheae; j — intestine.

Fig. 18. Head and thorax of the same caterpillar of *Bucculatrix frangulella* GOEZE as on fig. 17, but ventral view. Enlarged 300×
p — suboesophagal ganglion; 1, 2, 3 — thoracal ganglia; pr-ms-mt — pro-meso-meta-thorax.



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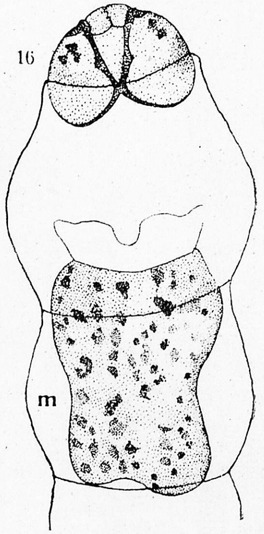

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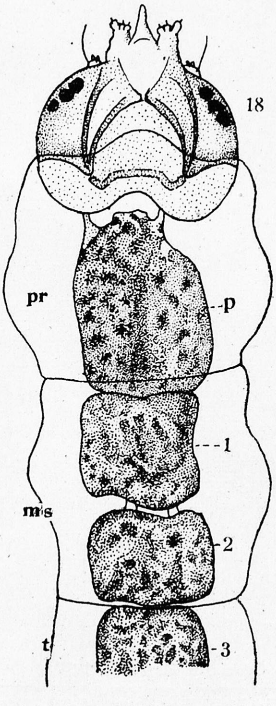

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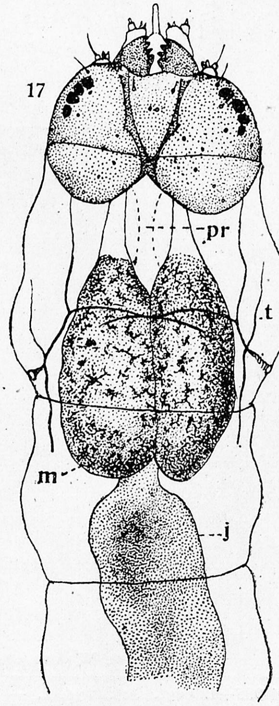

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