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normal substances, so that neither the mercury halides, nor those of Sb exhibit any association. The molecular formulae for these latter compounds will, therefore, no doubt be $SbCl_3$ etc., and not Sb_2Cl_6 etc.

After these somewhat lengthy expositions I can be a good deal shorter in future, now that the Methods for the further calculation have been sufficiently set forth and elucidated by the examples of mercury and also of antimonium.

In the determination of the values of b_k and $\sqrt{a_k}$ for the different metals and the remaining elements of the periodic system we shall, therefore, have to refer continually to this second Paper.

Aluminium, Borium, Arsenicum, Bismuth, Tellurium, Silicium etc. will be treated first.

Clarens, March 1916.

Zoology. — "*On the Setal Pattern of Caterpillars.*" By A. SCHIERBEEK. (Communicated by Prof. J. F. VAN BEMMELEN.)

(Communicated in the meeting of March 25, 1916).

In 1876 WEISMANN proved the ontogeny of the peculiar colour-patterns occurring in many Sphingide-caterpillars to be a further differentiation of the linear ornamentation. From this he concluded that the ocellar and annular markings had also phylogenetically taken origin from longitudinal stripes, and he could back this inference by the fact, that the intermediate stages, which in some genera and species were passed through during their growth, acted as terminal stages in other forms. From that time onwards many investigators have occupied themselves with the study of the external appearance of caterpillars. Independently of each other WILH. MULLER and DYAR called attention to the regular arrangement of the setae in different families; O. HOFMANN, PACKARD, QUAIL, TSOU [1]) and others followed them in their track.

J. F. VAN BEMMELEN (1913) pointed out the connections between the colour-pattern of caterpillars, pupae and imagines, which indeed had been remarked by other students, e.g. POULTON, but had not been considered of real importance. VAN BEMMELEN's views therefore introduced a new aspect into the discussions, as he defended the homology of pigmentspots with tubercula and setae. This connection

[1]) Tsou's paper only came into my hands, after the writing of the present communication.

had been overlooked by FRACKER, who in 1915 made a careful study of the setal pattern of a great many caterpillars.

The majority of investigators have introduced their own nomenclature for the arrangement of the setae, refusing to accept that of their predecessors, as it repeatedly became evident that each enlargement of our knowledge claimed new indications for the details of the pattern. Hoping to evade the difficulties, several authors, following the example of DYAR, took refuge in ciphers. But this only aggravated the confusion, as DYAR himself was obliged after a few years to propose a new numbering, which others again tried to emendate. So FRACKER preferred the notations of the greek alphabet, thinking that as their succession was less familiar to our modern minds, it would not lead so easily to false conclusions about homologies.

He designs "one single generalized segment (fig. 1) by plotting, one segment over the other, the setae of the prothorax, metathorax, and abdomen of the generalized members of the different genera, families and suborders of Lepidoptera, as if they all were on the same segment." (p. 17). To this generalized type he ascribes a great value, as he believes he has reconstructed by this method the ancestral pattern. In those cases where the number of setae is less than it should be according to this hypothesis, he explains their absence by retrogression (he supposes the absent ones to have remained undeveloped). The nearest approach to this generalized type he sees in the arrangement of the setae on the prothorax of *Hepialus, instar I.* Yet it must at once be stated that FRACKER did not observe this species himself, but only judged by a drawing (without accompanying description) of DYAR after *Hepialus mustelinus.* The notation of the setae after FRACKER's system may be seen in Fig. 1.

In August 1914 Prof. J. F. VAN BEMMELEN called my attention to the question of the arrangement of the setae, and from that date onward I have been occupied in investigating the transformation of the setal pattern during the larval period of Lepidoptera. The paper in full, containing detailed descriptions of the successive instars and exact non-schematic figures, will before long be published in: *Onderzoekingen verricht in het Zoologisch Laboratorium der Rijks-Universiteit te Groningen.* The bibliography will also be given. Here may follow only the chief results of my investigations; they were obtained before FRACKER's paper came into my hands, and they are often in contradiction with his observations. Moreover they specially deal with the youngest instars of the larvae, which FRACKER disregarded in most cases.

In my opinion the setae must be homologized according to their arrangement in regard not only to each other, but also to other organs occurring on the external surface of the larval body, of which the stigma undoubtedly is the most important. Yet the place of this opening is not always the same. For on the prothorax it is situated near to its caudal border, the segments of the abdomen on the contrary bear their stigmata in their oral half. A dislocation of the stigma therefore probably has taken place. Without deciding which position of the stigma should be considered the most primitive [1]), one thing may be safely accepted as an incontestable fact, i. e. that such a dislocation will exercise a certain influence on the setae in its neighbourhood.

FRACKER however, judging by his fig. 1 (ϑ and x), seems to suppose that the stigma might be able to dive, as it were, beneath a seta and so pass it without in the least disturbing its position. I am sorry to say that I cannot possibly agree with such an opinion, as I am convinced that a seta on the oral side of the stigma will always maintain its anterior position. For this reason I prefer for the setae a system of names instead of ciphers or letters, because in that way the situation of the setae is indicated at the same time. Moreover by adopting names, I can remain in harmony with the nomenclature of WEISMANN, W. MULLER and J. F. VAN BEMMELEN, and so act according to the rules of priority, which should be observed also in cases like these. For the sake of clearness the use of names is by far to be preferred to that of ciphers or letters.

My observations led me to the conclusion that a far going correspondence exists between the arrangements of the *setae* (hairs), *tubercles* (eminences usually bearing one or more setae), *verrucae* (warts with many setae), *scoli* (prominent spines), and *pigmental spots*. I therefore consider all these dermal products to be homologous. A homogeneous dispersion of setae or their total absence are both secondary modifications.

Different types of pattern may be distinguished, but they can be deduced from each other.

Type I. The most widely spread, as it occurs on the abdominal segments of almost all caterpillars, when newly hatched (Instar I), and in many species is retained during the whole larval period. Moreover, the pattern on the prothorax of these caterpillars corresponds in its main features with the abdominal one. In the following list the setae marked with an asterisk usually occur on the prothorax

[1]) In a following paper I hope to give some information in this question.

only. Whenever they are also present on the abdomen, this will be mentioned in the description. But where *type I* is given for a certain family, this has no relation to the *setae. The type therefore consists of:

Seta (etc.) *dorsalis*, oral and at the same time dorsal.

S. subdorsalis superior, more caudal and in some cases also somewhat ventral to the foregoing.

**S. subdorsalis inferior*, ventral to the preceding.

**S. dorsolateralis*, on the oral border of the segment between s. dorsalis and s. suprastigmalis.

S. suprastigmalis, above the stigma in a vertical line with s. dorsalis and s. dorsolateralis.

**S. prostigmalis*, anterior to the stigma.

S. poststigmalis, caudal and usually a little ventral to the stigma.

S. infrastigmalis, beneath the stigma.

S. basalis anterior, and

S. basalis posterior, between s. infrastigmalis and the insertion of the leg, or where this is absent, between s. infrastigmalis and s. pedalis.

S. pedalis, on the base of the leg, or when the leg is obsolete, on the corresponding spot. I consider this seta as a proof of the secondary reduction of prolegs on the abdominal segments 1,2,7,8,9. The legs of the thorax and sometimes those of the abdomen are generally well provided with hairs. To these I did not give names, as they nearly always differ in shape and size from the above named primary ones, and so may be fairly considered of secondary nature.

**S. propedalis*, on the ventral side, before the anterior margin of the leg.

S. ventralis, between the inner side of the leg and the ventral, median-line.

The reductions, occurring within the limits of this type, generally are traceable in the ontogeny of one and the same species, or by comparison between the different species of one and the same family. The hinder abdominal segments usually differ a little from the type. The simplifications, corresponding with this deviation may be considered as secondary modifications, though they often lead to pseudo-primitive arrangements.

Type Ia. A simplification of very frequent occurrence is caused by the vanishing of the *setae dorsales*, the *seta poststigmalis* at the same time coalescing with the *seta infrastigmalis*. The result is a single series, in which the stigma also takes its place. This pattern, which at first sight seems to possess a primitive character, occurs

e.g. in *Saturnia pavonia*. The original tubercles are here, even in the newly hatched larva, changed into verrucae and in the later instars into scoli. The only exception is seta dorsalis on the prothorax, which remains a single seta (fig. 3).

Type Ib. A final stage, almost identical with the former is found in *Lymantridae = Liparidae*. But here it is not the subdorsal seta or verruca which disappears, but the *dorsal* one. The *poststigmal verruca* associates with the *suprastigmal* one, but not completely, as even in full grown caterpillars the original duplicity remains perfectly visible, the two halves being divided by a furrow (fig. 4).

Type II. At first sight meso- and metathorax seem to possess a setal pattern different from that on the segments of the abdomen (fig. 5).

If we draw a line over these thoracic segments which crosses the stigmata of prothorax and abdomen, three setae on each of these segments are found above it, arranged in a vertical series. This group of setae is near the oral border of the segments. I consider them to be the *dorsal, dorsolateral* and *suprastigmal seta.*

Nearly in the same series the *seta prostigmalis* is found, as is clearly proved in those cases where a vestige of the stigma is present.[1]) Then the rudiment lies near the caudal border of the segment in the same position as the stigma of the prothorax. Sometimes it is represented by a pigmented spot (Porthesia chrysorrhoea, Zeuzera pyrina) or by a verruca (Arctia caja, Sericina telamon) and in other cases the tracheal system is visible through the skin and shows a distinct inflation on the corresponding place (Pieris brassicae and P. napi). Beneath the prostigmal seta the *infrastigmal* one, and in some cases the *basal* ones are found. As all these setae are arranged in a row, the type of their arrangement seems to be exceedingly simple.

By the above mentioned writers these setae are homologized in very different ways, as is demonstrated by the tabulated survey, given by FRACKER on page 40.

In comparison with the abdominal, this *type II* in the first place shows a reduction, by the suppression of the *superior* and *inferior subdorsal setae.* The former however sometimes remains visible. (Pieris napi). Moreover the *poststigmal seta* is generally absent.

I explain this reduction as a consequence of the situation of the stigma near the caudal border of the thoracic segments, which hindered the complete development of the posterior row of setae. I hope to give full details in my next paper.

[1]) Even when this vestige is the wing "anlage" the seta s. prostigmalis remains.

On the other hand meso- and metathorax generally show the *dorsolateral seta,* which is missing so often on the abdomen. This seta I consider as a primary one, for it not only occurs on nearly all thoracal segments, but it is found also on the abdomen in widely diverging families (e.g. Phalera bucephala, Pieris napi, Hepialus spec.). In the two last cases I could not detect it in the first instar, but it did occur in the more advanced. Yet QUAIL mentions this seta in the first instar of Pieris brassicae, where I failed to see it. The most remarkable circumstance however in connection with this seta is the occurrence of a pigment-spot on the pupae and imagines of Pierids exactly in the position where one might look for the seta, being even present in those cases, where during the last larval instar the setae become irregularly spread over the segment and are not surrounded by a considerable amount of pigment. It is on account of these arguments that I feel justified in considering the dorsolateral seta as a primary one.

I could amplify the outcome of my investigations with the results obtained by the writers mentioned before. Though they sometimes appeared to be in contradiction with my conclusions, in my opinion they really support them.

In the following survey of the types occurring in different families of Lepidoptera, the latter ones are arranged according to SHARP's handbook.

Of Rhopalocera *Nymphalidae* I studied Vanessa urticae L. For this family WIL. MÜLLER gives a primitive design, consisting of setae in *instar I,* yielding their place later on to a pattern of spines which shows a corresponding arrangement. The species I studied possessed from the beginning, besides common setae, a number of spines. These according to my theory may be indicated as follows (on the abdomen): the dorsal, suprástigmal and infrastigmal scolus and besides these in the form of simple setae, the subdorsal and poststigmal. Where such a close similarity existed with the primitive pattern, a real homology might be anticipated. Yet, for a number of S.-American forms, W. MÜLLER observed that these scoli where the product of the transformation of secondary setae, spread amongst the primary ones. So the above mentioned similarity would be incidental; but in agreement with MÜLLER the original nomenclature may be maintained.

In the kind of Vanessa which I studied, primary setae were almost completely absent.

As to the question, whether the pupal pattern must be reckoned to the primary or to the secondary design, I have not as yet arrived

at a definite conclusion. Judging from the pupal design of other Rhopalocera, a return to the primitive pattern of the first instar seems highly probable. With each following ecdysis the form of the scoli becomes more complicated, as MULLER has already observed. On the pupa of Vanessa (figured by J. F. v. BEMMELEN in 1912) a small spine occupies the place of the dorsal scolus, while the positions of the dorsolateral, suprastigmal, infrastigmal, basal and pedal scolus are indicated by pigment-spots. It deserves attention that in the larval stage the dorsolateral scolus is not present on the abdomen.

The *Pierids* in their first instar show the primitive pattern very completely. In the course of larval development great secondary changes take place by the multiplication of the number of setae and the formation of larger and smaller chitinous plates (called chalazae by FRACKER), which often bear a great number of setae. FRACKER denies their correspondence with primary setae, but in this he is mistaken. I have convinced myself that as far as the 3rd, and sometimes even the 4th ecdysis, the primary setae can be sharply distinguished from the secondary. The correspondence of these larval setae with the pattern of pupa and imago has been pointed out by J. F. v. BEMMELEN. Over and above these pigment-spots which can be brought in connection with primary setae, a spot is also found, corresponding to the dorsolateral seta.

Papilionid-larvae in their first instar were not at my disposal. The drawings of GRUBER (1884) however teach us, that amongst others in Papilio philenor, *instar I*, simple setae occur arranged according to *type I*. In succeeding instars, they are converted into scoli, growing more complicated with each ecdysis; in other species this change occurs during the first instar. P. ajax shows setae which bifurcate at their top, the same is mentioned by W. MULLER for different Vanessids, by SHARP for a few Pierids. In the ontogeny the dorsal setae disappear first, all the remaining setae follow this example successively.

Unpublished drawings of J. F. VAN BEMMELEN from specimens of Papilio podalirius in the collection KALLENBACH (now in the Groninger Zoological Laboratory), showed me, that the pigment-spots of the fullgrown caterpillar are arranged in a well characterized pattern. As far as I can judge they correspond with the dorsal, suprastigmal, superior and inferior subdorsal, pro-, post- and infrastigmal seta. Especially remarkable is the presence of the inferior subdorsal and prostigmal spot, which I did not perceive in the illustrations of the first instar. On the pupa of Papilio machaon (drawn by VAN BEMMELEN 1912), a tubercle marks the position of

he dorsal verruca. Between the stigma and the said tubercle two spots occur, representing the dorsolateral and suprastigmal verruca. Thus here again we find a dorsolateral on the pupa, which is absent on the abdomen of the caterpillar. For the rest, spots are found on the pupa agreeing with the prostigmal, poststigmal, anterior and posterior basal and often with the pedal verruca.

Summarising I may say, that in Rhopalocera during the first instar, *type I* is found on the abdomen. Afterwards three different changes may take place. Either the pattern gets complicated by the formation of verrucae, scoli or chalazae, or the setae, growing more numerous, spread over the surface of the segment in a homogeneous manner, or they disappear altogether. In all cases the primitive pattern comes back with the pupal stage, amplified by a dorsolateral spot on the abdomen as well as on the thorax. (cf p. 32).

Of *Heterocera* I studied the following families:

Saturniidae (fig. 3). As early as *instar I* Saturnia pavonia L. shows pattern *Ia* and this remains unaltered in sequence. The verrucae, which are present in the beginning, later on develop into scoli. On the prothorax the subdorsalis only remains a seta, but by its presence it justifies the supposition that the corresponding setae on the remaining segments have secondarily vanished.

Bombycidae. Instar III of Bombyx rubi shows a distinct arrangement of verrucae according to *type I*, but later on this pattern is quite wiped out by the great increase of the number of verrucae, which at the same time become irregularly dispersed.

During the first instar Bombyx mori is exclusively ornamented according to *type I*, the subdorsal seta being simple. In the following ecdyses this pattern is rendered indistinct by a homogeneous dispersal of setae, but it may, though not without trouble, still be recognized up to the last larval instar, in contradiction with the inference of FRACKER (p. 102).

Sphingidae. Characteristic of this family during *instar I* is the absence of the poststigmal seta on the abdominal segments, a seta prostigmalis at the same time being present, while the dorsolateral seta only occurs on the thoracic segments. In Sphinx ligustri this design is very distinct, in Smerinthus tiliae only a few setae are missing, while at the same time a number of shorter setae are found dispersed in a homogeneous way amongst the primary ones. In Smerinthus populi during the first instar only a scanty rest of the primitive setae is present. In the latter genus the secondary setae show a highly remarkable shape. Their height is $\pm 50\,\mu$, and near the top they split up into a number of branches; the whole thus

producing the impression of an umbrella turned inside out by a storm. The Sphingid horn takes its origin beneath the dorsal seta of the eighth abdominal segment. WEISMANN, in his treatment of the colour pattern, gives only a few words to the setae and cites a species of Sphingidae which keeps them during the whole of its life. But, as he does not consider the setae as a part of the design, he does not give much attention to them. In the above-named species the setae disappear after the first ecdysis.

As long as I have not discovered intermediate stages, I cannot feel convinced by FRACKER's assertion (p. 126), that the prostigmal seta corresponds with his η, which is usually located beneath the stigma, the infrastigmal at the same time answering to *x*, which in other cases stands behind the stigma. In my opinion no proof whatever for such a rotation through an angle of 90° can be adduced.

Notodontidae. I carefully investigated all instars of Phalera bucephala. During the first instar a pattern of single or sometimes double setae was present, which accorded to *type I*. The double setae occupying the place of the dorsal might be supposed to be the result of a coalescence of this last with the dorsolateral. During following instars, up to the fourth, this pattern remains practically unmodified, but then the simple and double setae change into verrucae, which, however, maintain the same arrangement. Further the number of pigment spots increases after every ecdysis; especially along fore- and hind-margin of the segment. These spots unite with the accumulation of pigment in the verrucae and in this way horizontal lines are formed, running along the whole body. This is the only case in which I have been able to trace the origin of stripes, in all others they appear without any preliminary phenomena.

Cossidae. A full-grown larva of Zeuzera pyrina, a species which in the imaginal instar displays a highly primitive wing-design, showed on its abdomen *type I* but without a seta dorsolateralis on the anterior border of the stigma, a small seta is found only a little higher up than the usual position of seta prostigmalis (fig. 7). Yet I take it as such in contradistinction to FRACKER, who called it ε (my s. suprastigmalis). The seta above the stigma, which I call s. suprastigmalis is named by him ϱ. According to his system however seta ϱ belongs to the caudal series, i.e. beneath the subdorsal seta. Such an interpretation of the arrangement I can only regard as decidedly artificial. QUAIL found in Cossus a similar arrangement, he calls the seta prostigmalis III B.

Hepialidae. SHARP places this family after the Cossidae; many systematists, as is well known, unite it with *Micropterygidae* and

Eriocephalidae in the suborder of the *Jugatae*. I did not succeed in obtaining members of the two last mentioned families. As I said before, FRACKER was obliged to found his description of Hepialus *instar I* on a drawing by DYAR. The species which I was able to study, *H. hecta L.*, differs in important respects from DYAR's *H. mustelinus*. The prothorax especially, to which FRACKER ascribes extraordinary importance, is decorated in quite a different style. On the abdomen (fig. 8) I found the dorsal, suprastigmal (right above the stigma), superior and inferior subdorsal (both lying in one line parallel to the caudal border of the segment), the poststigmal, infrastigmal, anterior and posterior basal, propedal and ventral setae. On the prothorax moreover the dorsolateral and prostigmal, but not the poststigmal and inferior subdorsal seta. Thus the pattern agrees almost completely with *type I*.

On a half-grown specimen of Hepialus-larva from the Dutch village Boskoop, probably belonging to *Hepialus lupulinus*, the space above the prothoracic stigma was occupied by one seta only, which evidently was the superior subdorsal one, but the first abdominal segment carried the dorsal, dorsolateral and suprastigmal setae, all in one line above the stigma, and furthermore the superior and inferior subdorsal, the poststigmal, two infrastigmals, the anterior and posterior basal, the propedal and the ventral. If one wanted to derive the new second infrastigmal from the primitive pattern, it would be preferable to consider the anterior of the two as the real prostigmal. But before being able to give a solution of this question, it would be necessary to investigate the first instar of this species. FRACKER's explanation to regard the common poststigmal in this case as a typical subprimary seta ϑ, to call the posterior of the two substigmal setae χ, the inferior of the three suprastigmal ones ϱ (which latter designation he uses in other cases for the inferior subdorsal) is in my opinion not in harmony with the facts. Moreover the presence at the same time of an inferior subdorsalis in the usual place, is in opposition to FRACKER's views.

QUAIL in this case as in the others calls the suprastigmal seta III B. I cannot agree with this view, as I am of opinion that this index should be exclusively bestowed on the prostigmal seta, as QUAIL does in the case of other larvae.

In considering the case of the Hepialids it should never be forgotten that however primitive a family may be, it nevertheless may have suffered certain secondary changes. This argument is for instance supported by VAN BEMMELEN's investigations of the colour-pattern on the Hepialid wings (1914, 1915, 1916) where he certainly

met with a primitive pattern, but at the same time established profound secondary modifications. Such an example warns us against the premature belief in the generality of a pattern, which was only seen on a prothoracic segment in one single representative of the family during the first instar. Especially as this not only should give us the generalized type of all Jugatae, but moreover should enable us to derive from it the generalized type of all Frenatae.

Not being able to dispose of complete materials, I must to my regret refrain from the investigation of pupae in Hepialids, larvae and pupae in Eriocephalids and Micropterygids. Judging by illustrations in textbooks, they seem to show very interesting setae and verrucae.

Thyrididae. In the collection KALLENBACH, which served as the basis of my work, the full-grown larva of Thyris fenestrella is represented by a mounted specimen. The abdomen bears simple setae, arranged according to *type I*, the poststigmal seta only being absent. The thoracal segments possess moreover the dorsolateral and prostigmal setae.

Lymantridae (= *Liparidae*). Orgyia antiqua L. is a remarkable form of this family on account of its long, strongly plumose setae. In succeeding moults they constantly grow more complicated, as PACKARD already mentioned (1889). In the main my results agree with his notations, except that we differ in the number of moults after which certain features of the pattern begin to show themselves. In the first instar the verrucae on prothorax and abdomen are arranged according to *type I*, those on meso- and metathorax according to *type II*. In the beginning the setae are not plumose, afterwards they become strongly so. In the course of its development the subdorsal verruca of the abdomen disappears in two ways: on the anterior two segments it unites with the dorsal verruca, on the remaining ones it shrinks and becomes obliterated. (fig. 4).

Porthesia chrysorrhoea passes in the main through the same course of development.

On the verrucae of Ocneria dispar, but in the first instar only, small setae, which in their middle thicken into a little globular knob, are spread amongst the larger ones. Afterwards they disappear, and this we find also in Psilura monacha. (WACHTL and KORNAUTH 1893). The dorsal verruca sometimes remains visible during tho whole larval period as a single seta or as a small wart. In the three last named species the setae, just as in Orgyia are not plumose during the first instar, but become so later on.

The agglomeration of the suprastigmal with the poststigmal verruca

has already been mentioned, when speaking of *type Ib.* (p. 528). In contradiction with the inference of FRACKER I observed this coalescence not only in Ocneria (Porthetria) dispar, but also in Porthesia chrysorhoea.

The pupae of Ocneria dispar are provided with verrucae bearing short setae with microscopic ramifications. Among the verrucae the following can be clearly made out: the dorsal (bigger than on the larva), the subdorsal, the suprastigmal (quite near the poststigmal, yet separated from it more distinctly than on the caterpillar), the infrastigmal, the basal and lastly a very prominent pedal.

Arctiidae. The verrucae are arranged according to *type I*, with only one exception, viz. the poststigmal, which has removed a little beneath the stigma, thereby somewhat displacing the infrastigmal towards the ventral side. I investigated Arctia caja and Ocnogyna lubricipeda, both showing simple setae during the first instar and feathered ones in the later. In contrast with the foregoing family the dorsal seta remains very large.

Geometridae. Only full-grown larvae were at my disposal. The primitive pattern, *type I*, was amongst others well shown by Amphidasis betularia. The setae are not plumose, the suprastigmal is placed a little more caudally than in other forms.

Noctuidae. In this family I was able to compare my results with FRACKER'S schematic figures. We both came to the same conclusion: that in this extensive family the setae are transformed into verrucae, but sometimes return again to their primitive setose state. On the abdomen the primitive pattern seems to consist of the dorsal, suprastigmal (called by FRACKER in this case ϱ) the superior subdorsal, the post- and infrastigmal, one or two basals and the pedal. On the thoracic segments the prostigmal and dorsolateral are again added to them, the poststigmal is missing. Before and a little above the stigma a small prostigmal seta is found on the abdomen, which FRACKER takes to be ε (fig. 31 after Feltia glandaria) and QUAIL calls III B.

In Acronycta psi the fleshy prominence on the first abdominal segment has originated beneath the dorsal verruca, that on the sixth beneath the subdorsal one. In this species a prostigmal verruca is present, at least in the last instar.

In Depressaria nervosa (fullgrown specimen, coll. KALLENBACH) no setae are discernible except the dorsal seta on the mesothorax. On all segments however pigment-spots are seen in the same order as *type I* of the setal pattern. Here is therefore a new proof for the assumption, that *pigment spots may be homologized to setae, tubercula, verrucae, scoli, which is of eminent importance for the pupal design.*

Pyralidae, Pterophoridae, Tortricidae, Tineidae are not represented, as to their larval stage, in the collection KALLENBACH, no more so are *Eriocephalidae* and *Micropterygidae.* Judging from the drawings of FRACKER, they show the common *type I,* to which the inferior subdorsal and sometimes the prostigmal are added.

For the *Pterophoridae* O. HOFFMANN proved that some species possess setae, others verrucae, arranged according to *type I.* The deviations occurring in a few species can be easily brought back to the typical form, which in this case also includes the prostigmal seta. I am occupied with an investigation of this family, the results hitherto obtained harmonize with the above conclusions.

Taking all this together I feel justified in asserting that my *type I* can everywhere be recognized as the fundamental plan of the larval design. Up to the present time I have not succeeded in harmonizing this pattern with that occurring in other Insect-orders. The following groups would chiefly come into consideration in this instance. Blattidae (Spuler), Tenthredinidae, Trichoptera (Dyar), Panorpata (Handlirsch). Perhaps TOWER's excellent figures of Leptinotarsa may prove useful, but as yet these comparisons have not led to any satisfactory result.

Originally the pigment-accumulations agree with *type I.* Perhaps the linear markings are the result of spots, accidentally arranged in horizontal lines and meeting so as to coalesce, just as was actually observed in Phalera bucephala. As I could not obtain certain proof for this assumption, I prefer to reserve it until special investigations have brought the solution, and in the meantime to consider the *longitudinal stripes* as a new and independent element in the colour-markings, *acquired after the spots*, which for their part are bound to the setal pattern.

It is not surprising that the setal pattern in its primitivity or only inconsiderably modified is repeated on all segments of the body, with the exception of the two hinder ones, which also in other instances show great deviations from the general type. We consider it as a consequence of the strong homoiomery (= homonomy) governing the whole larval body. But an uninterrupted stripe, running in a longitudinal direction over a definite part of the segment, which part has become modified in consequence, is quite a different feature. Possibly those stripes which during the phylogeny have arisen step by step, as in Phalera bucephala, recede in the ontogeny to younger and younger instars. (WEISMANN). Yet it might fairly be expected, that when the stripe appears during the second instar for instance, it would be preceded during the first one by a series of isolated spots. This I could never detect. So the idea of mutations, by which

the stripy markings arose suddenly, remains open. The hypothesis of EIMER that stripes are more primitive than spots I feel compelled to reject.

Verrucae must have originated independently in the most different families, e.g.: Vanessidae, Pieridae, Papilionidae, Saturnidae, Bombycidae, Notodontidae, Arctiidae, Lymantridae, Noctuidae, Pterophoridae, Eriocephalidae. Therefore no systematic value can be attributed to their presence.

In a few families, e.g. Arctiidae and Lymantridae, which without doubt are nearly related to each other, plumose setae have been differentiated out of simple ones.

Homogeneous dispersal of setae (Pieris napi, Bombyx mori) and baldness (Papilionidae, Sphingidae) are both of secondary origin.

The Sphingidae occupy a peculiar position, in so far as a prostigmal seta is found on their abdomen, the poststigmal one being at the same time absent. I doubt the systematic value of this phenomenon, the more so, as I believe that in other families I have traced my prostigmal seta in ε of FRACKER or III B of QUAIL.

Finally a few words on the connection between larval and pupal markings. Pieris napi and P. brassicae are two nearly related species living under exceedingly similar circumstances. The former is remarkable for its protective, the latter for its terrifying colouring, as well in the larval as in the pupal stage.

The egg, the first larval instar, the pupa and the imago, resemble each other almost completely as to their colour-design, but the older larval instars become more and more different. In Pieris brassicae not only the number of setae goes on increasing, but the tubercles from which they spring grow in bulk and are strongly pigmented. Yet the primary setae remain distinct unto the last larval instar.

In Pieris napi the setae also get more numerous and the primary ones remain distinct during a certain period, but the secondary do not combine with the primary into larger groups. The point of fixation of the seta in the skin is but faintly pigmented and the striae, so conspicuous in P. brassicae, are reduced in P. napi to small specks in the neighbourhood of the stigmata. Now in the pupae the same spots, which were shown by the first larval instar, suddenly reappear.

In the case of P. brassicae this means that the pupa shows fewer spots than the caterpillar, a reduction in pigment-development therefore taking place. In P. napi, on the contrary, where the larva shows hardly any pigment-accumulations and the primary pattern has totally disappeared, this pattern also returns on the pupa.

In both cases there can be no question of a simple printing-over as POULTON suggested. VAN BEMMELEN's figures of the pupae of P. brassicae and napi, as well as those of Euchloe cardamines and Aporia crataegi, which two last do not any more than the two former possess a primitive design during the last larval stage, give satisfactory evidence that the pupal pattern in all four is identical. He likewise proved that a similar system of markings was to be seen on the body of the imago during its development inside the pupal sheath

A remarkable fact in this connection is the occurrence of a pigmented spot on the abdomen, in the position where a dorsolateral seta might be looked for. This in my opinion, might be explained in two ways.

Either the *dorsolateral seta* is a primary one, which has usually vanished, but has remained on the thoracic segments and on the pupa.

Or, the dorsolateral seta is of a more recent origin than other primary setae and so manifests itself at a later stage on the abdominal segments than on the thoracic, as these latter are more advanced in their evolution. If this explanation is right, the pupa must be regarded as more highly developed than the first larval instar as regards the colour-markings.

The first assumption seems to me the more probable.

In any case the pupal markings are less complicated than those of the last larval instar and so provide us with an excellent example of convergent evolution.

The Hague, March 10, 1916.

Anatomy. — "*Some Observations on Periodic Nuclear Division in the Cat.*" By Mrs. C. E. DROOGLEEVER FORTUYN—VAN LEIJDEN. (Communicated by Prof. J. BOEKE)

(Communicated in the meeting of March 25, 1916.)

Introduction. After several authors had expressed their astonishment that so few mitoses occur in growing tissues, CHILD in 1904 [1]) and 1907 [2]) and PATTERSON in 1908 [3]) have tried to explain this by refuting, on account of their own observations, the generally accepted view that mitotic nuclear division would be the only normal one.

CHILD studied the most various tissues of animals of diverse

[1]) Anatomischer Anzeiger. XXV.
[2]) " " XXX.
[3]) " " XXXII.