ON THE INFLUENCE OF METAMORPHOSIS ON THE VORACITY OF BUPALUS PINIARIUS L. (Lep.)

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ON THE INFLUENCE OF METAMORPHOSIS ON THE VORACITY OF *BUPALUS PINIARIUS* L. (Lep.)

by J. KLEINHOUT

We confine ourselves to a phenomenon given in figure 1, which relates the production of feces and the devoured quantity of food measured in larvae of holometabolic species of Insecta (*Bupalus piniarius* L.; see : Pl. I). The schematic diagram is based on the data given in table I. The phenomenon shows a slow increase, after that a rapid decrease, followed by a short interval. There after exactly the same happens again.

It is still undecided as to how far this phenomenon, also found by BLUNCK (1924) in *Dytiscus*, may be generalized, relative to the different subdivisions of Insecta. A similar diagram can not be composed e.g. for the food of a ladybug consisting of plant-lice (JÖHNSSEN, 1930). Even once it was observed that the insect devoured a prey while shedding its old hide. From various papers it is clear (TITSCHACK, 1924; GEBLING, 1925), that the voracity shows a decline connected with shedding. Here too this decline does not come to zero, but the verifications were not made daily or refer to a population (1). And concerning my own figures, I have no much evidence, because there is only a small number of observations and I lack any support in literature.

a. We can prove that the phenomenon exists in this few figures.

(1) Experiments, where the larvae did not kept separately (e.g. JANDA, 1961, *Act. Soc. Zool. Bohem.*, XXV (4) : 306-317), show a wrong figure, because of the asynchronic development (see table I).

b. We can prove by which the phenomenon is not caused.

c. We can make probable by which the phenomenon is caused indeed.

A calculation of the relation to temperature is superfluous of course, but in this case of special interest. We assume that the species concerned is subject to phenomenon X, which causes a special picture of the production of fecal material and (in this case needle-) attack. We figure out the trend as for the ascent of this picture, and that by means of the method of least squares. Now it appears, that the positive and negative deviations of the trend are correlated positively with the temperature measured close to the site of experiment (correlation coefficient for the maximum and minimum temperatures the day before and the minimum temperature of the very day resp. 0.36, 0.42 and 0.44; see : fig. 2). This proves the typical picture X to exist.

It is obvious to presume that another environmental factor is cause of the phenomenon. We can however easily explain why this is not true. We know that environmental factors fluctuate within a short interval of time. From which follows, it appears now that in case of non-synchronous metamorphosis the phenomenon does not come into existence, 1) if we measure the diurnal collected quantities (see : table I), 2) if we collect the looper-feces in the fir-wood (SCHWERDTFEGER, 1930).

The cause of the interruption in the attack of the needles has to be found in shedding of the skin as is suggested. The skin-shedding is characterized by tumefaction of the head-capsule. In *Bupalus* this lasts about a week, therefore much longer than is stated by ENGEL (1939). It has to be noticed however, that the figures of the table are few and show a great standard-deviation. After the casting of the head-capsule, which is shed to the front, as contrasted with the other external parts (ENGEL, 1939; see : Pl. II), the diameter of the head shows a sudden increase (according to DYAR's method). During the period of shedding the mouth-parts are blockaded (although this item needs further investigation).

The beginning of an instar is not marked by the discarding of the old cuticula, though in life history studies the length of a developmental stage is usually measured from the time the exuviae are cast. Physiologically, however, it should be reckoned from the time the old cuticula is loosened from the epidermis, which more approximately marks the beginning of the short period of development that is to give the increased size and the characteristics of the following instar (SNODGRASS, 1935; cf. ENGEL, 1939). Note this critical point in figure 1. The voracity shows a criterion for the time of shedding.

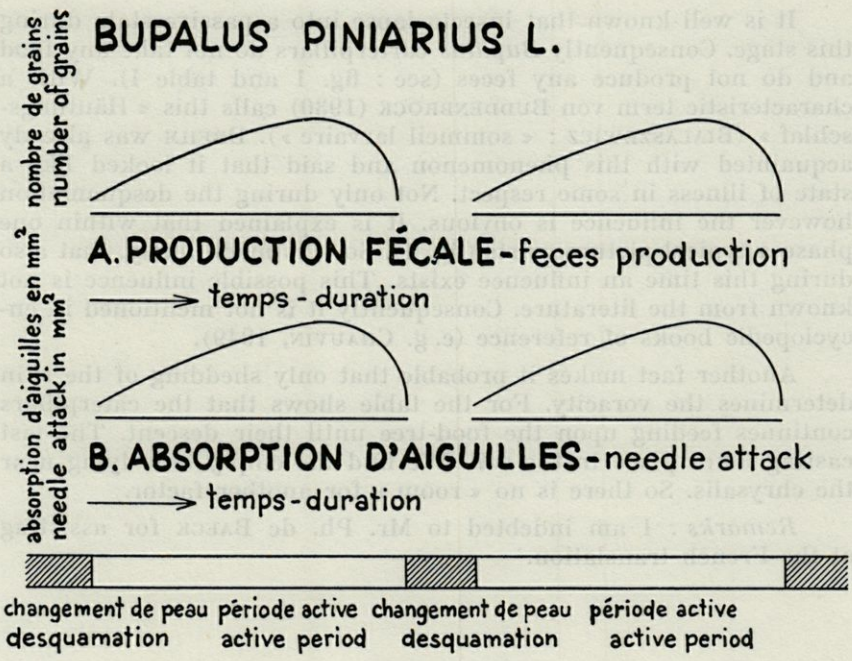

FIG. 1. — Schematic figure. The figure is made after a series of non schematic figures (table I). More-eating during the successive stages is not expressed. With shedding of the skin is meant the bullous state of the head-capsule. The caterpillars are bred outside separately in an airy case. For further information, see table.

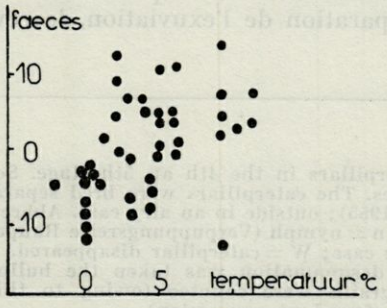

FIG. 2. — Correlation of the minimum temperature and the feces-production of the very day after eliminating the trend. Correlation coefficient 0.44. If the data cover more days they are not expressed in the diagram. Temperature measured at Schaarsbergen (Nederland) at a distance of about 500 meters just above the ground. A temperature-case was used to reduce the error of radiation.

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It is well known that insecta lapse into a passive state during this stage. Consequently *Bupalus* carterpillars do not take any food and do not produce any feces (see : fig. 1 and table I). With a characteristic term von BUDDENBROCK (1930) calls this « Häutungsschlaf » (BIALASZEWICZ : « sommeil larvaire »). BREHM was already acquainted with this phenomenon and said that it looked like a state of illness in some respect. Not only during the desquamation however the influence is obvious. It is explained that within one phase a typical picture exists (fig. 1). So it is made likely, that also during this time an influence exists. This possible influence is not known from the literature. Consequently it is not mentioned in encyclopedic books of reference (e. g. CHAUVIN, 1949).

Another fact makes it probable that only shedding of the skin determines the voracity. For the table shows that the caterpillars continues feeding upon the food-tree until their descent. The last casting takes place in the soil. We find the empty hide lying near the chrysalis. So there is no « room » for another factor.

Remarks : I am indebted to Mr. Ph. de BAECK for assisting at the French translation.

RÉSUMÉ

La production fécale aussi bien que l'absorption d'aiguilles de *Pinus silvestris* L. par les chenilles de l'espèce *Bupalus piniarius* L. (Lép., Géom.) (Pl. I) offrent un aspect typique (fig. 1 et Tableau I), probablement causé par l'état de leur peau. Le phénomène n'est pas signalé dans la littérature (voir par ex. CHAUVIN, 1949). Pendant la période de préparation de l'exuviation, le revêtement de la tête

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Table I. — Caterpillars in the 4th an 5th stage. Source of the material : shaken from the trees. The caterpillars were bred separately (KLEINHOUT, 1960, compare with LONG, 1955) ; outside in an airy case. Abbreviations : V = shedding of the head-capsule; n = nymph (Verpuppungsreife Raupe : ENGEL, 1939, Abb. 7) on the bottom of the case; W = caterpillar disappeared.

As criterion of desquamation was taken the bullous state of the head-capsule. The fecal grains were counted (owing to this, more-eating in the successive stages has found no expression).

Measuring the attack was done as follows. The breadth of the needle was fixed at 1 mm. Then the breadth of the attack has been estimated. The length of the attacked piece was measured. The attacked needles were eliminated. A dual attack of a needle did not occur, since the caterpillars show a little move after attacking a needle (KLEINHOUT, 1960). Checks made early in the morning.

TABLE 1

Date	Nombre de grains					Absorption d'aiguilles en mm²					Changement de peau				
Date	Number of grains					Needle-attack in mm²					State of desquamation				
number caterpillar →	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
11/9	4	14	1	4	3	0	0	0	0	0	—	—	v	—	—
12/9	0	16	0	5	6	0	0	0	0	0	—	—	v	—	—
13/9	2	30	0	17	6	0	14	0	4	3	—	—	v	—	—
14/9	0	32	0	7	13	0	7	0	0	0	v	—	v	—	—
15/9	0	21	14	6	2	0	8	0	1	0	v	—	—	—	—
16/9	0	28	23	10	22	0	6	8	6	4	v	—	—	—	—
17/9	0	23	19	10	15	0	5	6	5	9	—	—	—	—	—
18/9	3	27	32	14	27	3	0	14	7	6	—	—	—	—	—
19/9	4	26	25	7	17	0	2	0	0	4	—	—	—	—	—
20/9	3	22	16	5	17	0	8	8	1	30	—	—	—	—	—
23/9	22	87	112	45	103	7	21	39	12	48	—	—	—	—	—
24/9	17	4	47	23	36	0	0	28	13	27	—	v	—	—	—
25/9	23	0	56	29	43	13	0	28	15	0	—	v	—	—	—
26/9	22	0	56	26	4	9	0	0	6	0	—	v	—	—	—
27/9	19	0	47	29	3	10	0	64	22	0	—	v	—	—	v
30/9	90	0	156	39	0	19	0	18	16	0	—	v	—	—	v
1/10	26	7	55	20	0	22	0	0	11	0	—	—	—	—	v
2/10	31	23	45	24	0	16	16	16	5	0	—	—	—	—	v
3/10	30	26	60	21	0	18	17	121	12	0	—	—	—	—	—
4/10	19	21	40	5	0	5	8	40	0	0	—	—	—	—	—
6/10	54	52	96	0	20	17	15	50	0	22	—	—	—	v	—
7/10	40	30	45	0	22	0	5	78	0	14	—	—	—	v	—
8/10	35	28	36	0	24	22	4	65	0	18	—	—	—	v	—
9/10	29	30	33	0	22	9	37	20	0	32	—	—	—	v	—
10/10	17	36		0	32	7	3		0	0	—	—	n	v	—
11/10	5	28		0	23	0	4		0	23	—	—	—	v	—
13/10	2	42		0	30	0	44		0	43	v	—	—	v	—
14/10	0	24		0	13	0	0		0	5	v	—	—	v	—
15/10	0	20		0	16	0	5		0	25	v	—		—	—
16/10	0	31		0	27	0	36		0	48	v	—		—	—
17/10	0	27		0	23	0	42		0	30	v	—		—	—
18/10	0	37		3	21	0	31		4	15	v	—		—	—
20/10	0	65		14	54	0	87		8	35	v	—		—	—
21/10	0	33		5	23	0	25		3	40	v	—		—	—
22/10	0	32		6	25	0	15		10	60	v	—		—	—
23/10	0	44		10	34	0	48		7	34	v	—		—	—
24/10	0	43		10	36	0	59		5	47	v	—		—	—
25/10		51		13	42		65		11	86	w	—		—	—
29/10		171		78	188		186		76	196		—		—	—
30/10				29	49				34	147	n			—	—
31/10				27	43				30	67				—	—
1/11				15	26				28	70				—	—
3/11				68	43				49	18				—	—
4/11				19	17				13	30				—	—
5/11				23	3				30	0				—	—
6/11				21					22					—	n

se détache et se soulève. Ce phénomène dure environ une semaine; pendant cette période, les chenilles ne mangent pas et ne produisent pas de boulettes fécales (fig. 1, Tableau I). L'influence de l'état de la cuticule est alors claire et peut-être expliquée par un blocage des pièces buccales, ce qui suggère que peut-être toute l'absorption d'aiguilles de pin subit l'influence de l'exuviation.

Les données numériques fournissent un résumé de la consommation journalière [1. d'après le nombre de boulettes fécales récoltées (SCHWERDTFEGER, 1930); 2. qui peut être calculée dans le Tableau I], mais ne représentent pas le phénomène par suite du développement non synchrone des différentes chenilles. Ce phénomène, produit par des facteurs internes en rapport avec la préparation de l'exuviation, apparaît nettement sur la figure 1.

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PLATE I. — *Bupalus piniarius* L., shedding of the skin, instar 3 to 4.

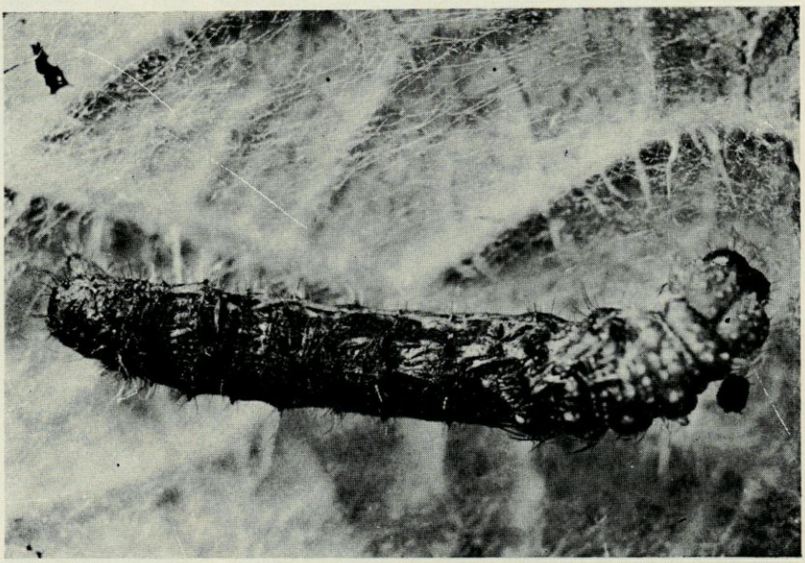

PLATE II. — *Vanessa urticae* (Lep.), shedding of the skin.