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Pre-Imaginal Instars of Mallophaga and Application of Some Growth Principles

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The amount of growth achieved at each moult in most insects is governed by certain empirical laws. The practical utility of some of these laws in MALLOPHAGA is discussed. The head-width in the nymphal instars of *Lipeurus caponis* (Linn.), *Cuclotogaster heterographus* (Nitzsch), *Goniodes pavonis* (Linn.), *Bruelia atharae* Ansari, *Quadraceps testudinarea* (Children), and *Laemobothrion titan* Piaget has been shown to present a very constant ratio of growth. The Dyar's rule has been shown to corroborate the number of instars in the species studied. Prizibram-Magusars rule as modified by Bodenheimer was applied to the head-width, body-length and body-width of final instar nymphs of various Mallophaga. The calculated figures were found to correspond very closely to the observed measurements. A latent division was found to occur between the body-length of I and II instar nymphs in Ischnocera alone.

Introduction

ALMOST all monographic papers on Mallophaga give the salient characters of immature stages. The detailed description of three nymphal instars of *Columbicola columbae* (Linn.) was, however, first presented by Martin in 1934. The nymphs of biting-lice leave the egg in a relatively advanced condition of morphological development. In general structure and body form, they prefigure the adults.

We studied the nymphal instars of various species of Mallophaga, *viz.*, *Philopterus corvi* (Linn.), *Sturnidoceus ruficeps* (Nitzsch), *Bruelia atharae* Ansari, *Bruelia iliaci* (Denny), *Bruelia saleemi* Ansari, *Bruelia subtelis* (Nitzsch), *Columbicola columbae* (Linn.) *Cuclotogaster heterographus* (Nitzsch), *Goniodes pavonis* (Linn.). *Quadraceps testudinaria* (Children), *Menacanthur gonophoeus* (Burmeister), *Menopon gallinae* (Linn.) and *Laemobothrion titan* (Piaget). As far as the general features are concerned none of these warrant a separate treatment. The description of various instar nymphs of *Cuclotogaster heterographus* (Nitzsch) given below will serve as examples.

In many insects the amount of growth, which is achieved after each moult, is regulated in accordance with certain empirical laws. We applied some of these growth laws to the nymphal instars of Mallophaga. The results obtained are presented in this paper with a view to invite criticism.

Description of nymphal instars of *Cuclotogaster heterographus* (Nitzsch)

The young louse resembles the parents except in size, cuticular markings and genitalia. The chaetotaxy is also very variable in various instar nymphs. The mouth-parts exhibit the same general type of construction and hardness.

First stage nymph is small flat insect, body colour yellowish white ; integument delicate and leathery ; sclerotised abdominal plates entirely wanting. Segmentation of abdominal region obliterated. Dorsal chaetotaxy scarce, marginal hairs exceptionally long. Mouth-parts and buccal cavity well developed. Total body length 0.98-1.22 mm, breadth 0.35-0.41 mm.

The second instar nymph dirty yellow in colour, with well developed body markings, specific ornamentation still indistinct but in advance stage of colouration. In older individuals, however, transverse blotches and longitudinal bands slightly well developed and therefore feebly visible. Total body length 1.36-1.56 mm, breadth 0.44-0.49 mm.

In the third instar nymph degree of sclerotisation and formation of body plates, transverse blotches and longitudinal bands intensified, body pigmentation smoky with yellowish tinge. Head and cephalic hairs, thorax and thoracic chaetotaxy more or less as in adults. Abdominal chaetotaxy, however, still reduced. Genitalia present in incompletely developed condition. Secondary sexual characters well marked, antennal projection in male nymph well formed. Total body length 2.05-2.25 mm, breadth 0.68-0.88 mm.

The above descriptions are drawn from the nymphs bred in the laboratory. Different stages of other species were, however, collected from freshly killed, birds.

Average measurements of 20-50 nymphs of some other species are given below :—

	L. titan	Bruelia atharae	Quadraceps testudinaria	Goniodes pavonis
I	4.45 × 1.16	1.14 × 0.54	1.13 × 0.41	1.56-1.67 × 0.67-1.20
II	5.90 × 1.35	1.43 × 0.62	1.91 × 0.61	2.15-2.35 × 1.16-1.25
III	7.06 × 1.67	2.24 × 0.84	2.56 × 0.83	2.77-3.19 × 1.45-1.80

Different instar nymphs of *Goniodes pavonis* (Linn.), *Bruelia atharae* Ansari *Quadraceps testudinaria* (Child), *Laemobothrion titan* Piaget are shown in the figure.

Growth of nymphal instar of Mallophaga and Dyar's Principle

It was shown by Dyar (1890) that head-width of successive larval instars in Lepidoptera follows a regular geometrical progression. This principle has since been found to hold in various other orders, *viz.*, Collembola, Hymenoptera, etc. (Imms, 1938).

This rule has been also found helpful in calculating the actual number of ecdysis from incomplete series of cast skins as in *Haematopota*: Tabanidae (Cameron, 1934). Qadri (1938) stated that the increase in the width of the head of *Blatta* follows a geometrical progression as envisaged under Dyar's law only up to third instar. In some exceptional cases such as *Heliothis*: Lepidoptera (Gaines and Campbell, 1935) and *Popillia*: Coleoptera (Abercrombie, 1936) however, the Dyar's principle cannot be used for corroborating the number of instars.

The result of applying the principle to the head-width in the nymphal instars of various Mallophagan species is presented in Table I. The factor for increase in head-width was obtained by dividing the average observed width in each instar by that of the previous one and an average of all factors so obtained for each instar was calculated. From the table below, it will be seen that the calculated head-widths using Dyar's principle approach the actual observed widths extremely closely. From this it is inferred that head-width is a safe indication of the instar of Mallophagan nymph and the Dyar's principle is of practical value to preclude the chance of an ecdysis being overlooked. By the application of this rule to the cast skins, the actual number of ecdysis can also be correctly calculated.

Growth of nymphal instars of Mallophaga and Przibram-Megusar's Principle as Modified by Bodenheimer

Przibram and Megusar (1912) established that all-linear dimensions increases at each ecdysis by a constant equal to $\sqrt[3]{2} = 1.26$. This rule was deduced from measurements on *Sphodromantis*: Orthoptera. It has also been found to hold good in various other insects, *viz.*, *Dixippus*: Orthoptera (Eidmann 1924), *Notonecta*: Hemiptera (Teissier, 1931) and Hymenoptera (Glover, 1939). This rule has been shown to be of no practical

Table I.—Observed and calculated head-width of nymphal instars of Mallophaga

Instar	Observed head-width (mm.) :— average in parenthesis.	Calculated head-width (mm.)	Difference between calculated and observed widths, expressed as percentage of observed width
1. *Lipeurus caponis* (Linn.) after Wilson, 1939.			
I	0.223-0.262 (0.242)	...	...
II	0.251-0 277 (0.264)	0 242 × 1.09 = 0.264	0.0
III	0.277-0.303 (0.290)	0.264 × 1 09 = 0.288	- 0 7
2. *Cuclotogaster heterographus* (Nitzsch).			
I	0.32-0.38	...	...
II	0.36-0.41	0.320 × 1.34 = 0.428	+4.8
III	0.48-0.58	0.428 × 1 34 = 0.575	−0.87
3. *Goniodes pavonis* (Linn.).			
I	0.50-0.69 (0.69)	...	..
II	0.75-0.87 (0.87)	0 690 × 1.24 = 0 858	- 1.9
III	1.00-1.06 (1.06)	0.858 × 1.24 = 1.063	+ 0.28
4. *Bruelia atharae* Ansari.			
I	0.383	...	...
II	0.486	0 383 × 1.27 = 4.86	...
III	0.617	0.486 × 1.27 = 6 17	...
5. *Quadraceps testudinaria* (Children).			
I	0.43	...	...
II	0.53	0.43 × 1.24 = 0.53	...
III	0.66	0.53 × 1.24 = 0.66	...
6. *Laemobothorion titan* Piaget.			
I	0.967	...	...
II	1.03	0.967 × 1.11 = 1.073	+4.17
III	1.20	1.073 × 1.11 = 1.191	−0.73

value in *Lymantria* : Lepidoptera (Goldschmidt, 1933) *Melanoplus* : Orthoptera (Hodge, 1933), *Locusta* : Orthoptera (Key, 1936) *Tenodera* : Mantidae (Przibram and Brecher 1930) and *Popillia* Coleoptera (Ludwig, 1939). It is of doubtful value in those insects where the increase in weight at each moult is very great. In Muscidae and other flies where the larva grows in size but the cells do not divide after embryonic period, this rule has to be abandoned.

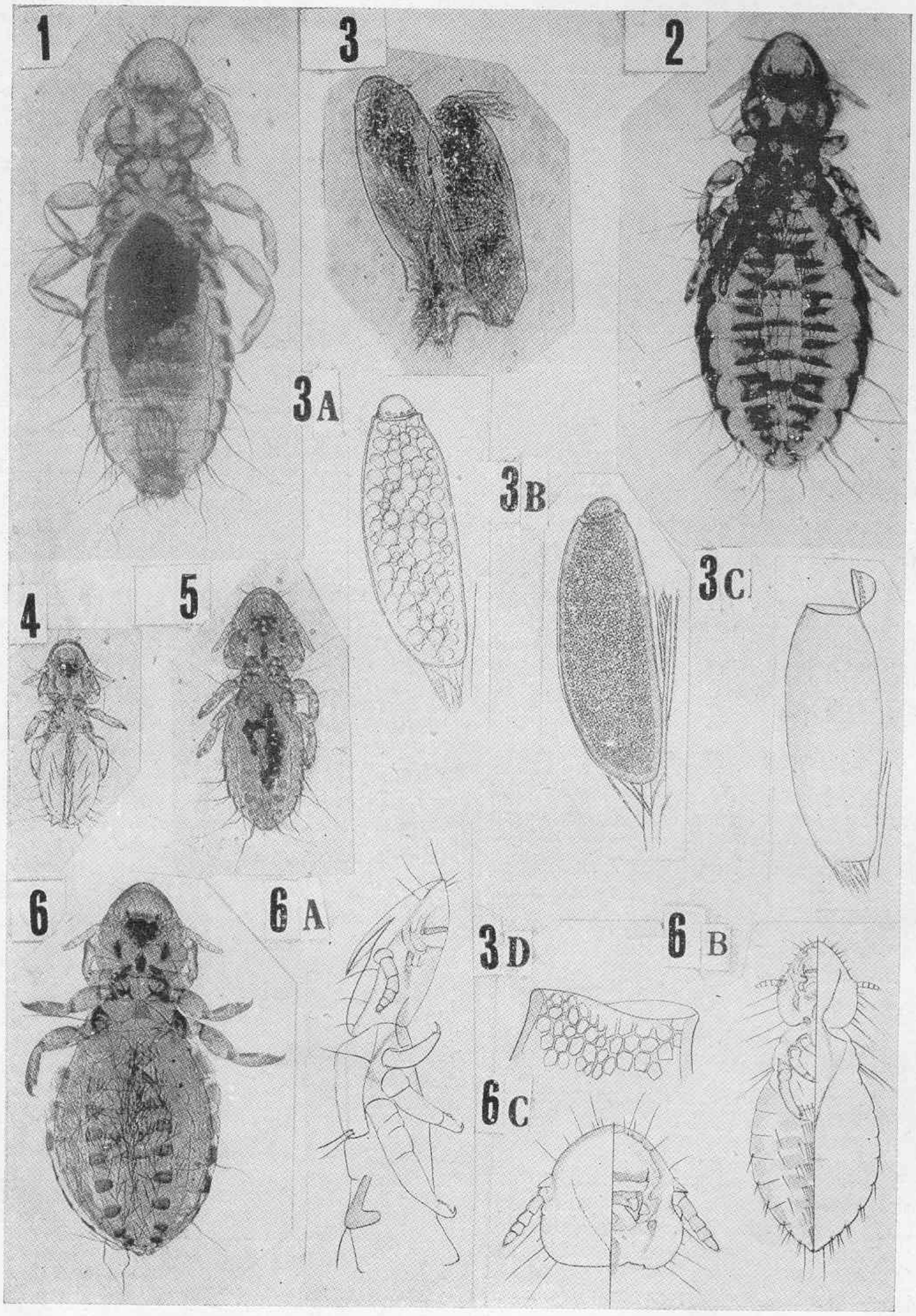
Bodenheimer (1933) while commenting on the growth principles has amplified certain important interpretations. He has shown that in certain insects, the rate of increase exceeds the standard coefficient, because the cell division may have occurred more than once in the same stage. He has called these extra divisions as *Latent divisions* and presented a modified definition of the Przibram-Megusars principle. He has stated that "Insect growth'' follows a progressive rule factor of $\sqrt[3]{2} = 1.26$ or $n \times 1.26$ for linear dimensions.

In the examples given below, the observed head width of III instar nymphs of Mallophagan species were divided by 1.26 until a figure very near the observed head width of the I instar nymph of the same species was obtained. The results so obtained are presented in Table II.

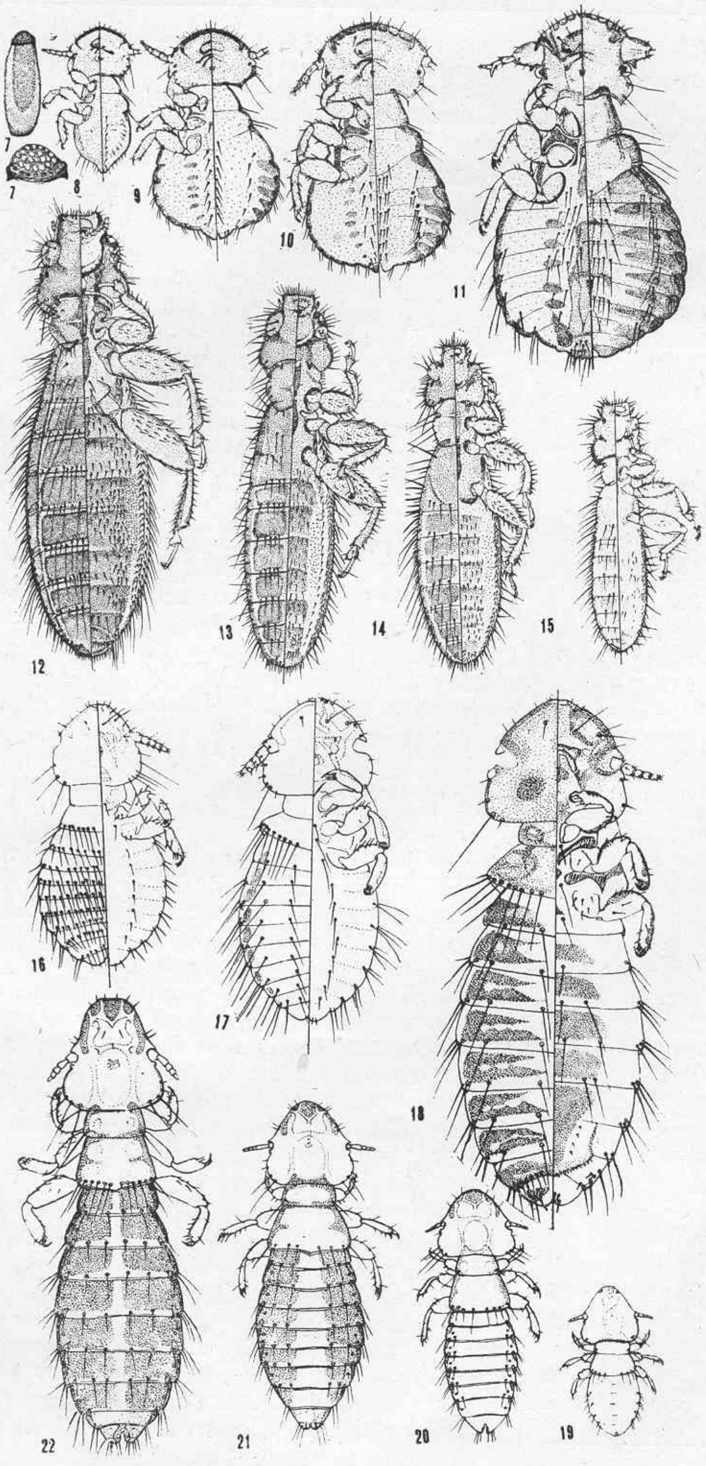
Table II —Results of applying Przibram Megusar's principle as modified by Bodenheimer to the head-width of nymphal instars of certain Mallophaga

Instar	Observed head-width (mm.) :— average in parenthesis	Calculated head-width (mm.)	Difference between calculated and observed widths expressed as percentage of observed width
Lipeurus caponis (Linn.) : after Wilson (1939).			
III	0.277-0.303 (0.290)	...	...
II	0.251-0.277 (0.260)	0.290 ÷ 1.26 = 0.230	−11.5
I	0.223-0.262 (0.242)	0.230 ÷ 1.26 = 0.182	−24.5
Cuclotagaster heterographus (Nitzsch).			
III	0.48-0.58 (0.53)	...	...
II	0.36-0.41 (0.38)	0.53 ÷ 1.26 = 0.42	+10.5
I	0.32-0.38 (0.35)	0.42 ÷ 1.26 = 0.383	− 5.7
Goniodes pavonis (Linn.).			
III	1.06	...	...
II	0.075	1.06 ÷ 1.26 = 0.840	+3.88
I	0.69	0.84 ÷ 1.26 = 0.667	−3.98
Bruelia atharae Ansari			
III	0.617	...	...
II	0.486	0.617 ÷ 1.26 = 0.489	+0.61
I	0.383	0.489 ÷ 1.26 = 0.388	+0.30
Quadraceps testudinaria (Children).			
III	0.66	...	...
II	0.53	0.66 ÷ 126 = 0.52	−1.9
I	0.43	0.43 ÷ 1.26 = 0.42	−2 3
Laemobothrion titan Piaget.			
III	1.200	...	...
II	1.030	1.200 ÷ 1.26 = 0.952	−7.57
I	0.967	0.952 ÷ 1.26 = 0.750	−22

It will be noted from the foregoing table that the calculated measurements



Figs. 1—5. *Cuclotogaster heterographs*, Nitzsch (Micro-photographs). 1. Adult male, 2. Adult female, 3. Eggs, 3A-D Eggs, 4. First stage nymph, 5. Second stage nymph, 6. Third stage nymph, 6A-C moulted skin



Figs. 6—11. *Goniodes pavonis*, Linn. 6-7 Eggs, 8. First stage nymph, 9. Second stage nymph, 10. Third stage nymph (male), 11. Adult male.

Figs. 12—15. *Laemobothrion titan* Piaget. 12. Adult female, 13. Third stage nymph, 14. Second stage nymph, 15. First stage nymph.

Figs. 16—18. *Bruelia atharae* Ansari. 16. Third stage nymph, 17. Second stage nymph, 18. First stage nymph.

Figs. 19—22. *Quadraceps testudinaria* (Children).
19. First stage.
20. Second stage.
21. Third stage nymph.
22. Adult.

are approximately near the observed measurements. When compared with the figures obtained by using the Dyar's principle, these figures, however, were not fairly close in all species.

We also applied this rule to the body-length and body width of the various species. As in the above case, the observed body-length (and body width) of the final instar nymph was divided by 1.26 until a figure approximately equal to the observed body-length (and body-width) of the first instar nymph of the same species was reached. The figures so obtained are presented in the Tables III and IV.

Table III — Results of applying Przibram-Megusar's Principle as modified by Bodenheimer to the total body-length of nympha_instars of Mallophaga

Instar	Observed total body length (mm.) (average of 20—50 nymphs)	Calculated total body-length (mm.)	Difference between calculated and observed measurements expressed as percentage of observed length
1. *Bruelia atharae* Ansari.			
III	2.242	2.422÷1.26	...
II	1.429	1.922÷1.26 1.605÷1.26	+12.3%
I	1.140	1.274	+ 5.8%
2. *Columbicola columbae* (Linn.)			
III	1.633	1.633÷1.26	...
II	1.227	1.296÷1.26 1.030÷1.26	+ 5.62
I	0.824	0.817	− 0.85
3. *Cuclotogaster heterographus* (Nitzsch)			
III	1.94-2.2	1.94÷1.26	...
II	1.36-1.56	1.54÷1.26 1.22÷1.26	− 1.28
I	0.98-1.22	0.97	− 0.71
4. *Goniodes pavonis* (Linn.).			
III	2.77-3.19 (3.19)	3.19 ÷1.26	...
II	2.15-2.35 (2.28)	2.53 ÷1.26 2.009÷1.26	+10.9
I	1.56-1.67 (1.56)	1.594	+ 2.8
5. *Quadraceps testudinaria* (Children)			
III	2.56	2.56÷1.26	...
II	1.91	2.03÷1.26 1.61÷1.26	+ 6.2
I	1.13	1.27	+12.3
6. *Laemobothorion titan* Piaget.			
III	7.06	7.06 ÷1.26	...
II	5.90	5.603÷1.26	− 5.03
I	4.45	4.447	− 0.07

Table IV — Results of applying Frzibram-Magusar's principle as modified by Bodenheimer to the total body-width of nymphal instars of Mallophaga

Instar	Observed body-width (mm.) (Averages of 20—50 nymphs).	Calculated body-width (mm.)	Difference between calculated and observed measurements expressed as percentage of observed-width
Bruelia atharae Ansari.			
III	0.841	0.841÷1.26	...
II	0.617	0.666÷1.26	+8 %
I	0.542	0.529	−2.4%
Cuclotogaster heterographus (Nitzsch).			
III	0.64-0.86	0.64 ÷1.26	...
II	0.44-0.49	0.506÷1.26	+3.26
I	0.33-0.41	0.401	−2.19
Goniodes pavonis (Linn.).			
III	1.45-1.8 (1.7)	1.7 ÷1.26	...
II	1.16-1.25 (1.25)	1.35÷1.26 1.07÷1.26	+8.0
I	0.67-1.00 (0.80)	0.85	+6.25
Quadraceps testudinaria (Children).			
III	0.83	0.83÷1.26	...
II	0.61	0.66÷1.26 0.52÷1.26	+8.1
I	0.41	0.41	...
Laemobothorion titan Piaget.			
III	1.67	1.67 ÷1.26	
II	1.35	1.325÷1.26	−1.85
I	1.16	1.051	−9.40

It is obvious from these tables that in case of body-length, (*i*) there is always one latent division between I and II instars in Ischnocera Mallophaga while none at all in Amblycera ; (*ii*) in the case of breadth, there is frequently but not always, one latent division between I and II instars in Ischnocera but none at all in Amblycera. The chart on the next page presents the summary of the preceding tables.

From these observations, we deduce that in Mallophaga the body-length and breadth calculated, according to Bodenheimers' growth principle, corresponds very closely to the observed measurements and that this rule is in conformity with Przibram's rule, may be said to hold true for Mallophaga also. The absence or obscurity of "Latent divisions" in the

Amblycera does not invalidate the principle, rather it may throw some light on the relationship, origin or primitiveness of the sub-order.

Mallophaga	Latent Division between Length	Breadth
1. *Bruelia atharae* Ansari	I and II	...
2. *Columbicola columbae* (Linn.) ...	I and II	...
3. *Cuclotogaster heterographus* (Nitzsch) ...	I and II	...
4. *Goniodes pavonis* (Linn.)	I and II	I and II
6. *Quadraceps testudinaria* (Children) ...	I and II	I and II
6. *Laemobothorion titan* Piaget ...	...	...

Conclusions

The number of observations is too small to draw any reliable conclusion, but the following interesting facts that emerge out of the present study suggest to collect more evidence and elucidate it further :

(1) three instars of Mallophaga may be grouped according to head-width as in the case of Collembola, Hymenoptera and Lepidoptera larvæ.

(2) head-width of nymphal instars in Mallophaga is a safe indication of the instar. Width calculated on Dyar's principle, approximate sufficiently closely to the observed measurements as compared to calculated measurements obtained by Bodenheimer's Law and further preclude the chances of an instar being overlooked.

(3) Bodenheimer's Law can be applied to growth in body-length. In Ischnoceron Mallophaga, there occurs one "Latent division" between I and II instars while none in Amblyceron Mallophaga. The calculated lengths and breadth fall fairly closely to the actual measurements.

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