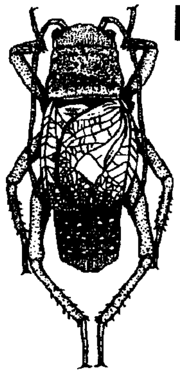

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THE ALLOMETRIC LARVAL GROWTH OF SOME SPECIES OF RHEOPHILOUS CADDISFLIES (TRICHOPTERA) IN KEDROVAYA RIVER (RUSSIAN FAR EAST)

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The correlation between body weight of caddis larvae and their length, and also body weight and width (or length) of head capsule of 7 rheophilous species (*Stenopsyche marmorata, Arctopsyche palpata, Hydropsyche orientalis, Apsilochorema sutshanum, Rhyacophila impar, Rh. narvae* and *Neophylax ussuriensis*) is studied. Based on correlation of larval body weight and body lenght two types of allometric growth are found, i. e. isometry and negative allometry. Isometrical growth pointed out in the larvae of *A. sutshanum* only. The body form of other species changed during growth. Three types of equations of the correlation between body weight and width (or length) of the head capsule of larvae were obtained.

KEY WORDS: Trichoptera, larvae, wet weight, linear sizes, allometric growth.

С.Л. Кочарина. Аллометрический рост личинок некоторых реофильных видов ручейников (Trichoptera) реки Кедровой (Дальний Восток) // Дальневосточный энтомолог. 1997. N 39. С. 1-8.

Изучена зависимость массы тела от его длины, а также от ширины (или длины) головной капсулы у 7 видов реофильных ручейников:

Stenopsyche marmorata, Arctopsyche palpata, Hydropsyche orientalis, Apsilochorema sutshanum, Rhyacophila impar, Rh. narvae и *Neophylax ussuriensis*. На основании зависимости массы тела от его длины у личинок отмечено 2 типа аллометрического роста: изометрия и отрицательная аллометрия. Изометрический рост тела отмечен только для *A. sutshanum*. Форма тела других видов изменялась в процессе роста. Выявлено три типа уравнений зависимости между массой тела и шириной (или длиной) головной капсулы личинок изучаемых видов.

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INTRODUCTION

The order Trichoptera is the most important in both biomass and density in the fauna of mountainous and foothill streams. The aquatic stages of caddisflies serve as a food for the young of Pacific salmons: *Salvelinus alpinus malma*, *Onchorhynchus masu* and other benthic fishes.

Recently this order has increasingly attracted the attention of the investigators. However, many aspects of the ecology and biology of some species are not studied yet. There is practically no information on the larval growth of stream caddisflies, correlations between weight and linear dimensions, conformities of production processes and the influence of the main environmental factors on these processes.

We have attempted to elucidate the relationship between body wet weight and body length and width (or length) of the head capsule in some rheophilous species in the Kedrovaya River.

MATERIALS AND METHODS

A detailed description of Kedrovaya River and its tributaries has been given previously (Levanidov, 1977; Levanidova et al., 1977; Kocharina, 1989).

Quantitative samples were taken from July 1979 to November 1980 using a benthometer designed by V.Ya. Levanidov (Levanidov, 1976; Levanidova, 1982; Kocharina, 1989); two samples were taken monthly from each station (Fig. 1).

The larvae of 7 species were studied: *Stenopsyche marmorata* Navas (Stenopsychidae), *Arctopsyche palpata* Mart. (Arctopsychidae), *Hydropsyche orientalis* Mart. (Hydropsychidae), *Rhyacophila impar* Mart. and *Rh. narvae* Navas (Rhyacophilidae), *Apsilochorema sutshanum* Mart. (Hydrobiosidae) and *Neophylax ussuriensis* (Mart.) (Uenoidae).

The larvae were fixed in 4%-formaldehyde just after collection.

The width of the head capsule was determined for 6 species, and the length for *S. marmorata*, being measured from the front edge of the frontoclypeus to the foramen occipitale. Measurements were made under a binocular microscope MBS-

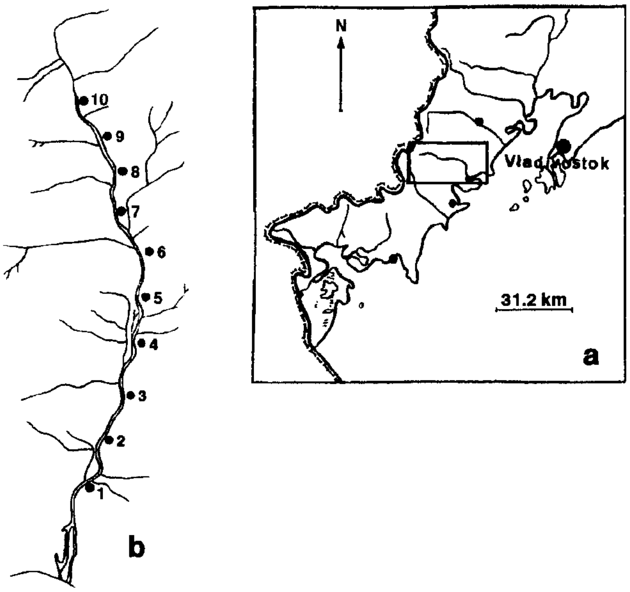

Fig. 1. Position of Kedrovaya River in the southern part of Primorye (a) and schema of location of regular stations (b).

1 with an ocular micrometer at magnification of 2x8 and 4x8. Larval length was measured from the front edge of the labrum up to the end of the IX abdominal segment, using millimeter paper for larger individuals and an ocular micrometer for smaller ones. The larvae were uncurled before measurements with dissecting needles so that head capsule, abdomen and thorax were in line.

Wet weight was determined for larvae dried on filter paper, using torsion balances WT-50, WT-250 and WT-1000 with accuracies of 0.01, 0.1 and 1.0 mg.

Parameters of equations correlation were obtained using the method of least squares and their confidence limits by the method proposed by A.A.Umnov (1976).

RESULTS AND DISCUSSION

The relationship of body wet weight and body length

The relationship between length (L) of the growing organism and its wet weight (W) can be given using the equation (Winberg, 1967):

$$W = aL^b \quad (1),$$

where W - wet weight of animal, mg; L - length of body, mm; "a" and "b" - constants of equation; a - constant, equal to W, when L=1.

If the animal keeps the same body form during growth, b=3 (this is isometrical growth). If the ratio W/L decreases during growth, then b<3 and there is negative allometric growth; when b>3 one has positive allometric growth.

In recent years equation (1) has been used in hydrobiological investigations by Russian scientists for animals of several systematic groups, for example chironomid larvae (Pankratova & Balushkina, 1981; Balushkina, 1982, 1987; Toderash, 1984), larvae of rheophilous mayflies (Tiunova, 1987) and stoneflies (Teslenko, 1992). A.F. Alimov and V.G. Vlasova (1980) investigated the relationship between wet weight and body length in caddisflies larvae of 17 species from Onega Lake and reservoirs near St-Petersburg (Old Petergof, Pesochnaya River and others). This investigation showed that between wet weight and body length for caddisflies larvae, as for the other amphibiotic insects, there is strong dependence, which is approximated by the equation:

$$W = (0.0156 \pm 0.003)\, L^{2.922 \pm 0.052} \qquad (2).$$

The value of "b" indicates that isometric growth is characteristic of the caddisflies larvae studied by A.F. Alimov and V.G. Vlasova, and in the course of development the body form remains unchanged until pupation.

Our investigation gave the coefficients for equations of wet weight and body length for 7 species as shown in Table 1. These coefficients for three net-spinning species and the lines of regression have been published previously (Kocharina, 1989). Those for the other species are shown in Fig. 2.

Table 1 shows that the value of the parameter "b" varies from 2.288 (for *S. marmorata*) to 3.059 (for *A. sutshanum*), and that parameter "a" ranges from 0.004 (for *A. sutshanum*) to 0.079 (for *N. ussuriensis*). The relative errors of coefficient "a" varied from 11.9% (for *A. palpata*) to 28.0% (for *A. sutshanum*). The relative errors of parameter "b" did not exceed 5.0%.

The value of the parameters in Table 1 show that 2 types of allometric growth - isometry and negative allometry - are characteristic for the species studied. Growth in which the body form does not change (b=3) occurs in *A. sutshanum* larvae. In the other species the body form becomes more elongated (b<3) during development, with the most distinct negative allometry being shown by *S. marmorata*.

All the equations have been calculated for a wide range of larval sizes and can therefore be considered as satisfactorily reflecting the weight/length relationship. Correlation coefficients were as high as 0.95 for all the species concerned.

The dependence of body wet weight upon width (or length) of head capsule

It is frequently necessary to calculate the wet weight of larvae of amphibiotic insects from their remains to determine the proportional roles of various species in the food of fishes or predator invertebrates. It is then advantageous to be able to use the relationship between body wet weight and width (or length) of head capsule. There have been no previous papers on this relationship in caddis larvae from foothill streams.

Table 1

Coefficients of the equations of the weight/length relationships for caddis larvae, $W = a L^b$

N	Species	n	Length range, mm	Weight range, mg	$a \pm m_a$	$b \pm m_b$	r_{xy}
1.	*Stenopsyche marmorata*	50	2.0-49.5	0.1-555.0	0.056±0.012	2.288±0.017	0.96
2.	*Arctopsyche palpata*	50	0.5-24.5	0.1-162.5	0.059±0.007	2.541±0.066	0.96
3.	*Hydropsyche orientalis*	50	1.0-14.5	0.1-27.0	0.039±0.006	2.416±0.104	0.96
4.	*Rhyacophila impar*	50	1.5-21.0	0.15-116.0	0.027±0.005	2.824±0.290	0.97
5.	*Rh. narvae*	50	2.0-12.0	0.1-17.2	0.028±0.005	2.455±0.102	0.96
6.	*Apsilochorema sutshanum*	50	2.0-15.0	0.1-15.8	0.004±0.001	3.059±0.152	0.95
7.	*Neophylax ussuriensis*	50	2.3-17.0	0.6-106.3	0.079±0.011	2.601±0.071	0.98

Table 2

Coefficients of the equations of the dependence of body wet weight of caddis larvae on width (or length) head capsule (d_k, l_k)

N	Species	n	Range of head capsule width (length), mm	Weight range, mg	$q \pm m_q$	$d_k(l_k) \pm m_{d,l}$	r_{xy}
1.	*Stenopsyche marmorata*	13	0.65-6.5	0.21-345.5	0.136±0.058	3.227±0.129	0.99
2.	*Arctopsyche palpata*	14	0.15-2.6	0.07-115.9	0.824±0.006	2.740±0.107	0.99
3.	*Hydropsyche orientalis*	17	0.30-1.3	0.19-19.5	0.925±0.012	3.078±0.108	0.99
4.	*Rhyacophila impar*	6	0.65-1.6	1.64-115.2	1.074±0.010	4.660±0.288	0.99
5.	*Rh. narvae*	6	0.30-1.0	0.2-14.9	1.044±0.062	3.088±0.271	0.99
6.	*Apsilochorema sutshanum*	9	0.25-0.9	0.1-8.25	0.931±0.097	3.465±0.369	0.96
7.	*Neophylax ussuriensis*	10	0.45-1.3	1.05-49.6	1.213±0.022	3.680±0.243	0.98

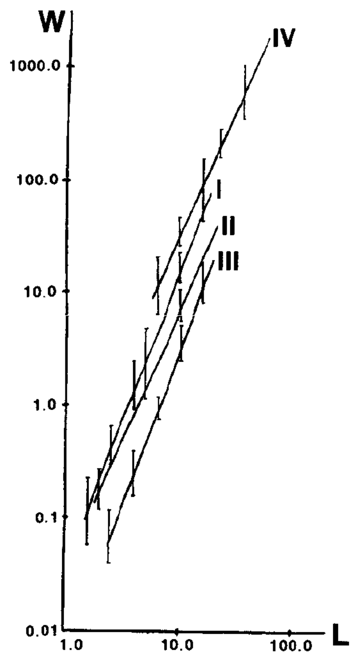

Fig.2. The relationship between the body wet weight (W, mg) and body length (L, mm) for caddis larvae: I - *Rhyacophila narvae*, II - *Rh. impar*, III - *Apsilochrema sutshanum*, IV - *Neophylax ussuriensis*. Vertical lines indicate confidence intervals at the 95% significance level.

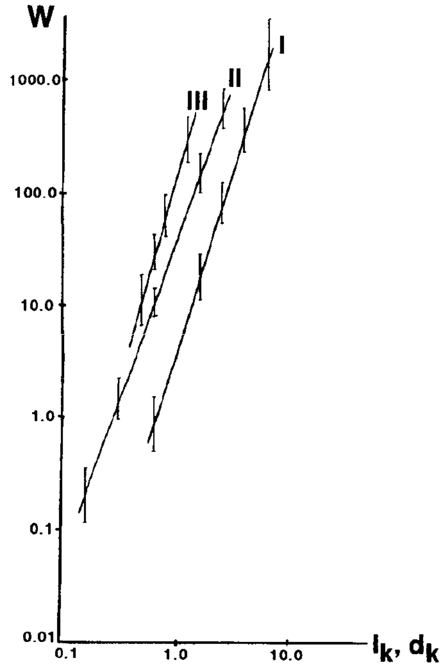

Fig.3. The relationship between the body wet weight (W, mg) and width (or lenght) of head capsule for caddis larvae: I - *Stenopsyche marmorata*, II - *Arctopsyche palpata, Hydropsyche orientalis, Rhyacophila narvae, Rh. impar, Apsilochorema sutshanum*, III - *Neophylax ussuriensis*. Vertical lines indicate confidence intervals at the 95% significance level.

R. Edwards (1958), T. Takeya (1958) and L. Smock (1980) showed that the relationship between mean wet weight and width of head capsule for each instar in several groups of insects may be described by the equation:

$$W' = q\, d_k^{\,a} \qquad (3),$$

where W' - the mean body wet weight of larvae of each instar; d - the width of head capsule; "a" and "q" - constants of equation; "q" - constant, equal to W, when d=1.

Similar studies were done by Ye.V. Balushkina (1987) on larvae of some species of Chironomidae. Based on her own and literature data, she derived equations for relationship between wet weight and width of head capsule for larvae of some species of subfamily Orthocladiinae.

The value of similar parameters for caddis larvae are given in Table 2 and Fig. 3 shows the lines of regression corresponding to these equations.

The relationship between wet weight and length of head capsule was obtained for *S. marmorata* larvae (Fig. 3-I). This dependence can be approximated by the equation:

$$W = (0.791 \pm 0.098)\, l_k^{3.227 \pm 0.129} \quad (4).$$

The error of the parameter "q" in eqiation (4) is 0.13% and the error of the parameter "l_k " is 4.0%. The statistical processing of the data on the relationship between wet weight and width of head capsule for *A. palpata, H. orientalis, Rh. impar* and *Rh. narvae* shows no significant differences between the equations for these species. So, based on the results of 53 measurements, a common equation of correlation W from d_k for these species was obtained:

$$W = (8.063 \pm 0.164)\, d_k^{3.001 \pm 0.098} \quad (5).$$

The error of parameter "q" is 2.05% and of parameter "a" is 3.3%. The line of regression corresponding to this equation is shown on Fig. 3-II.

The coefficients of a similar equation for *N. ussuriensis* larvae differ reliably from those for the other species. The regression line for larvae of this species (Fig. 3-III) corresponds to the equation:

$$W = (16.334 \pm 0.827)\, d_k^{3.681 \pm 0.245} \quad (6).$$

The errors of the parameters "q" and "a" are 5.0 and 6.6%, respectively.

CONCLUSION

The equations for the correlations between body wet weight and body length and width (or length) of head capsule for caddis larvae can aid hydrobiologists and ichthyologists who study the food of predator invertebrates and fishes. If we know one of the sizes we can rather accurately determine the body wet weight of caddis larvae of particular species under defined conditions. This allows us to obtain comparative data on these correlations for larvae inhabiting streams with different thermic and hydrologic regimes.

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