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Studies of the Concentration of Free Amino Acids in the Tissues of *Blattella germanica* L. during Metamorphosis

Badania nad stężeniem poszczególnych wolnych aminokwasów w tkankach *Blattella germanica* L. podczas metamorfozy

In recent years the problem of amino acids metabolism in insects has been a subject of many studies. These investigations were concerned with the determination of the amino acid level in the insect tissues (2, 3, 9, 13) in the haemolymph (1, 2, 5, 8), in physiological and pathological conditions (11), and with the metabolism of amino acids during metamorphosis (2, 9, 13).

The subject of the present paper is the determination and comparison of the concentrations of free amino acids in the tissues of *Blattella germanica* L. at different life stages. For this purpose quantitative and qualitative determinations of 20 free amino acids were carried out in larval and adult tissues.

MATERIAL AND METHODS

Standard strain of *Blattella germanica* L. was obtained from the State Institute of Hygiene in Warsaw. The insects were kept in the laboratory from March to September 1967, at room temperature (22°C), on granulated feed. The development lasted six months, according to Sandner (12) — Table 1.

Table 1. The development of *Blattella germanica* L. at different larval stages, at 22°C

Larval stage	Development in days	Number of *proglottids antennae*	Number of *proglottids cerci*
I	9—14	21—26	3
II	14—22	29—32	5
III	28—56	34—38	7
IV	25—51	39—44	9
V	24—48	62—74	9—10
VI	22—41	75—87	10

Individual larval stages differed in the size of wings, the wing development, the number of *proglottids antennae* and *proglottids cerci.*

To ensure physiologically homogenous experimental material insects at different larval stages and *imagines* were fed 6% glucose solution for 24 hrs. prior to analysis. Each time 100 mg of material was tested. Ten analyses were made for each life stage. *Larvae* and *imagines* were washed three times with distilled water, and then homogenized in a glass homogenizer; the insoluble residue was removed by centrifugation. The supernatant was concentrated to a small volume and deproteinized with absolute ethanol. Protein precipitate was removed by filtration, and ethanol from filtrate was evaporated in a stream of hot air. Then 1 ml of distilled water was added to dilute a sample and 0.1 ml aliquot was applied on Whatman paper No. 3.

Whatman paper cut out in the T form was used for two dimensional electrochromatographic separation of amino acids (10). Electrophoresis, in the first direction, was performed in an adapted chamber at 20—22 V/cm and a current 0.7—0.8 mA. for 75 minutes in a formicate-acetate buffer, *pH* 2.2 (10).

The Whatman paper above the band reserved for electrophoresis was protected with octanol barrier which protects against the migration of buffer during electrophoresis. In the second direction, a descending chromatography in the mixture of butanol — acetic acid — water (4 : 1 : 5) was used. Amino acids were detected on paper by ninhydrin (0.2% acetone solution). After drying the spots were stabilized in a 0.5% copper nitrate solution in acetone and chromatogram was placed in a dark chamber, at a room temperature until dry. A qualitative determination of amino acids was performed using standard mixtures of amino acids obtained from The National Biochemical Corporation, Cleveland, Ohio.

Single spots of previously identified amino acids were cut out and eluted with 1 ml. of 70% methanol. The values showing the colour intensity of the eluates were read out, using the Pulfrich photometer with the Elpho attachment (500 μm wavelength, green filter) in the presence of a blank prepared by elution of the same filter paper in 70 μ methanol. The obtained extinctions of each amino acid were multiplied by calibration coefficient. The obtained levels of amino acids were used for statistical analyses.

The levels of 3 amino acids: cystine, α-amino-butyric acid, and tryptophan were Homitted from statistical analysis because of unsatisfactory separation on paper. For 13 amino acids and for total values of those 13 amino acids a mean arithmetic value was calculated according to the equation: $\bar{x} = \frac{\Sigma x}{n}$ where Σ means the total value of a given amino acid (x), n — the number of the analyses performed. The number of analyses was 10 for each of the 6 larval stages, 20 for adult stages, including 10 for females and 10 for males. The total number of analyses was 80.

The mean artithmetic error was calculated according to the equation $m = \sqrt{\frac{\Sigma (x - \bar{x})^2}{n(n-1)}}$ which helped to check significant differences between the comparable means. Significant differences between mean values were estimated, using the Student's T test for the comparison of amino acids concentrations only in males and females. The probability test (P) of the observed differences by random method was estimated from statistical tables.

RESULTS

Using the mehod of electrochromatography, identification and separation of 20 amino acids in the larval tissues and the identical number of amino acids in the *imago* were performed. The following amino acids were identified: cystine, lysine, histidine, arginine, glutamine, aspartic acid, serine, glycine, threonine, glutamic acid, alanine, tyrosine, α-aminobutyric acid, tryptophan, valine, arginine, methionine, phenylalanine, leucine, iso-leucine and proline. A spot was identified in the composition, of which proline was found. The spot increased in size and intensity with larval development. This amino acid was omitted from quantitative estimations because of technical difficulties. Quantitative values were estimated in the following pairs: threonine and glutamic acid, valine and methionine, leucine and iso-leucine, because of close values of the R_f coefficients of those pairs.

The concentrations of free amino acids at different life stages of *Blattella germanica* L. are presented in Table 2. For comparative purposes the concentrations of separate amino acids at different life stages are given in relative values (see Fig. 1). The concentration of each amino acid at the first larval stage is taken as 100%.

The quantitative value of cystine at the first larval stage ranged from 0.26 to 0.58 mg%. At later life stages the concentration of this amino acid was low. In the *imago* the concentration ranged from 0.17 to 0.51 mg%.

The concentration of lysine at the first larval stage was 1.67 to 2.23 mg%, on the average 2.011 ± 0.0592 mg%. The highest concentration of this amino acid was observed at the second life stage; it was 2.51—2.86 mg%, on the average 2.760—0.0305 mg%. Between the third and the sixth larval stages a gradual decrease in the lysine concentration was observed, which at the sixth stage was 1.88—2.02 mg%, on the average 1.960 ± 0.0176 mg% (Table 2).

In the *imago* the concentration of lysine was 1.61—2.37 mg%, on the average 1.827 ± 0.0455 mg%. In males the level of lysine ranged from 1.85 to 2.76 mg%, on the average 1.97 ± 0.0500 mg%. In females the corresponding values were 1.61—2.37 mg%, on the average 1.685 ± 0.515 mg%. Student's test showed a significant, statistically higher level of lysine in males. In females the concentration of lysine was lower by 0.285 mg% ($t = 4.385$; $P < 0.01$) (Table 3).

The level of histidine at the first larval stage was 2.21—2.78 mg%, on the average 2.378 ± 0.0620 mg%. At the second larval stage these values increased from 2.82 to 3.18 mg%, on the average 3.060 ± 0.0349 mg%. Beginning with the third larval stage a decrease in the concentration of histidine was observed to continue up to the sixth stage. At the

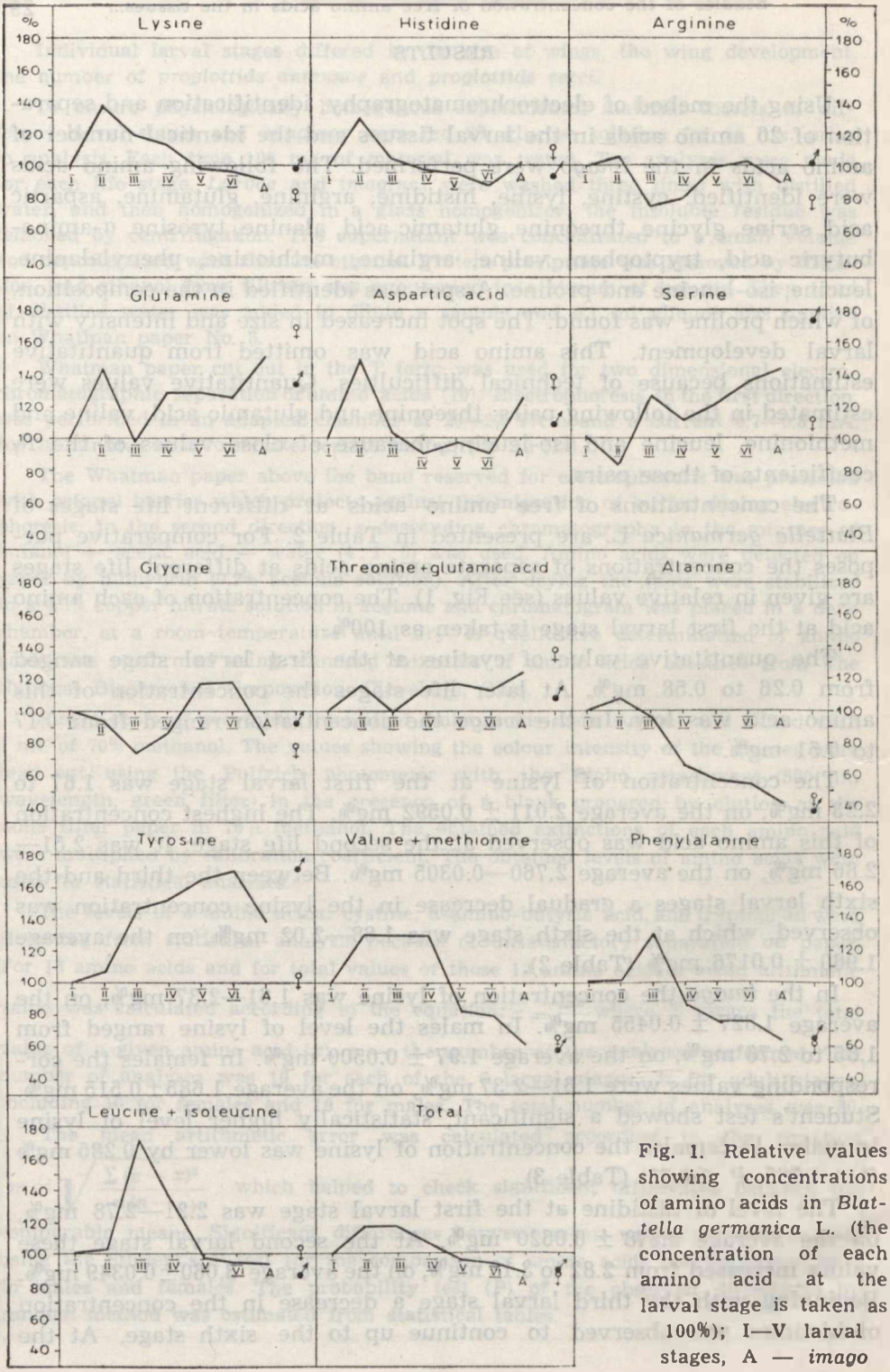

Fig. 1. Relative values showing concentrations of amino acids in *Blattella germanica* L. (the concentration of each amino acid at the larval stage is taken as 100%); I—V larval stages, A — *imago*

Table 2. Concentrations of the amino acids at different life stages of *Blattella germanica* L. (the concentration of each amino acid at the first larval stage is taken as 100%)

Life stage	Values in mg % from	Values in mg % to	Per cent	Life stage	Values in mg % from	Values in mg % to	Per cent
	Lysine				Histidine		
I	1.67	2.23	100	I	2.21	2.78	100
II	2.51	2.86	137	II	2.82	3.18	129
III	2.21	2.53	119	III	2.25	2.93	104
IV	2.18	2.45	113	IV	2.14	2.82	98
V	1.74	2.10	98	V	2.04	2.46	95
VI	1.88	2.02	97	VI	1.89	2.25	88
Imago	1.61	2.37	91	*Imago*	1.96	2.38	102
♀	1.61	2.04	84	♀	2.34	2.83	111
♂	1.85	2.37	98	♂	1.96	2.38	93
	Arginine				Glutamine		
I	1.50	2.98	100	I	0.23	0.55	100
II	1.37	2.99	106	II	0.40	0.70	143
III	1.29	1.81	75	III	0.30	0.45	98
IV	1.52	2.20	80	IV	0.33	0.60	128
V	1.99	2.35	100	V	0.44	0.62	128
VI	2.18	2.50	103	VI	0.44	0.67	125
Imago	1.62	2.47	90	*Imago*	0.46	0.84	151
♀	1.62	2.04	80	♀	0.60	0.84	169
♂	1.95	2.47	101	♂	0.46	0.65	134
	Aspartic acid				Serine		
I	0.76	1.14	100	I	0.47	0.70	100
II	1.33	1.60	148	II	0.34	0.58	83
III	0.92	1.17	102	III	0.61	1.04	126
IV	0.86	1.00	90	IV	0.58	0.86	111
V	0.69	1.14	97	V	0.57	0.84	121
VI	0.72	1.04	91	VI	0.70	1.18	135
Imago	0.88	1.50	124	*Imago*	0.58	1.20	143
♀	1.20	1.50	138	♀	0.58	0.80	112
♂	0.88	1.26	109	♂	0.86	1.20	174
	Glycine				Threonine + Glutamic Acid		
I	0.69	1.13	100	I	1.00	1.40	100
II	0.56	0.98	93	II	1.27	1.54	115
III	0.58	0.78	74	III	1.08	1.56	99
IV	0.55	0.85	86	IV	1.24	1.72	114
V	0.81	1.10	116	V	1.28	1.83	116
VI	0.92	1.09	117	VI	1.24	1.72	112
Imago	0.59	1.09	85	*Imago*	1.11	1.94	123
♀	0.62	0.79	78	♀	1.45	1.94	138
♂	0.59	1.09	92	♂	1.11	1.53	108

Table 2 continued

Life stage	Values in mg% from	Values in mg% to	Per cent	Life stage	Values in mg% from	Values in mg% to	Per cent
Alanine				Tyrosine			
I	2.30	2.53	100	I	0.88	1.26	100
II	2.34	3.34	108	II	0.86	1.41	107
III	1.91	2.43	96	III	1.34	1.57	146
IV	1.29	1.70	66	IV	1.41	1.65	152
V	1.18	1.44	57	V	1.55	1.84	164
VI	1.10	1.40	56	VI	1.56	1.80	167
Imago	1.07	1.38	55	*Imago*	1.57	1.91	169
♀	0.76	0.99	38	♀	0.86	1.41	104
♂	1.00	1.20	48	♂	1.59	1.99	171
Valine + Methionine				Phenyloalanine			
I	3.48	3.91	100	I	1.52	1.75	100
II	4.63	5.02	129	II	1.18	2.27	101
III	4.46	5.82	129	III	1.74	2.27	130
IV	4.52	5.63	129	IV	1.30	1.46	86
V	2.98	3.27	82	V	0.98	1.33	75
VI	2.89	3.10	79	VI	1.15	1.27	76
Imago	1.90	3.90	62	*Imago*	0.86	1.30	64
♀	2.06	3.90	66	♀	0.86	1.30	64
♂	1.90	2.41	58	♂	0.94	1.15	65
Leucine+Iso-leucine				Total			
I	2.66	3.22	100	I	21.54	23.78	100
II	2.63	3.28	104	II	24.66	27.87	117
III	4.10	5.35	171	III	24.52	27.95	117
IV	3.73	4.21	133	IV	22.97	25.36	106
V	2.72	2.94	97	V	20.49	21.76	95
VI	2.51	2.81	94	VI	20.21	21.71	93
Imago	2.44	3.01	94	*Imago*	18.82	21.27	88
♀	2.89	3.01	102	♀	19.41	21.27	89
♂	2.44	2.57	87	♂	18.82	20.87	88

sixth larval stage the concentration of lysine ranged from 1.89 to 2.25 mg%, on the average 2.099 ± 0.0477 mg%; in the adult form the level of histidine ranged from 1.96 to 2.38 mg%, on the average 2.433 ± 0.0562 mg%. The concentration of histidine in the *imago* did not differ significantly when compared with that of the first larval stage. Some differences were observed in the levels of histidine in males and females ($t = 7.487$; $P < 0.001$) (Table 3). In males the concentration of histidine (2.200 mg%) was lower by 0.426 mg% in comparison with that found in females (2.646 mg%).

Table 3. Concentrations of amino acids in *Blattella germanica* L. with regard to sex

Amino acid	*Imagines* Sex	Mean value	Difference	*t*	*P*
Lysine	♂	1.970	+ 0.285	4.385	< 0.01
	♀	1.685	0.0650		
Histidine	♂	2.220	− 0.426	7.487	< 0.001
	♀	2.646	0.0569		
Arginine	♂	2.233	+ 0.447	6.478	< 0.001
	♀	1.786	0.0690		
Glutamine	♂	541	− 0.141	4.111	< 0.01
	♀	682	0.0343		
Aspartic acid	♂	1.106	− 0.287	6.552	< 0.001
	♀	1.393	0.0438		
Serine	♂	1.041	+ 0.369	9.000	< 0.001
	♀	672	0.0410		
Glycine	♂	792	+ 0.124	2.145	> 0.05
	♀	668	0.0578		
Threonine + Glutamic acid	♂	1.366	− 0.364	5.215	< 0.001
	♀	1.730	0.0698		
Alanine	♂	903	− 0.231	8.400	< 0.001
	♀	1.134	0.0275		
Tyrosine	♂	1.739	+ 0.690	10.192	< 0.001
	♀	1.049	0.0677		
Valine + Methionine	♂	2.179	− 0.341	1.703	> 0.10
	♀	2.520	0.2002		
Phenylalanine	♂	1.032	+ 0.019	0.354	> 0.70
	♀	1.013	0.0537		
Leucine + Iso-leucine	♂	2.507	− 0.448	24.216	< 0.0001
	♀	2.955	0.0185		
Total	♂	19.629	0.304	1.100	> 0.25
	♀	19.933	0.2763		

The quantitative value of arginine at the first larval stage was 1.50 to 2.98 mg%, on the average 2.221 ± 0.1798 mg%. An increased average value i.e. 2.366 ± 0.2014 mg% at the second larval stage was random. At the next life stage the level of arginine increased from 2.18 to 2.50 mg%, on the average 2.285 ± 0.0286 mg% (IV larval stage). In the *imago* the concentration of arginine ranged from 1.62 to 2.47 mg%, on the average 2.010 ± 0.0613 mg%. Statistical test showed a significantly higher level

of arginine in males (2.223 ± 0.0576 mg%) than in females (1.786 ± ± 0.0380 mg%) ($t = 6.478$; $P < 0.001$).

The concentration of glutamine at the first larval stage was 0.23—0.55 mg%, on the average 0.404 ± 0.0295 mg%; at the second larval stage the increase of this amino acid ranged between 0.46 and 0.70 mg%, on the average 0.598 ± 0.0208 mg%. At the third larval stage the level of arginine diminished to 0.30—0.45 mg%, on the average 0.394 ± 0.151 mg%. The concentration of glutamine increased with the development of the larval stage, its highest values ranging from 0.56 to 0.84 mg%, on the average 0.612 ± 0.0233 mg%. The concentration of glutamine in females was significantly higher than that in males (on the average by 0.0141 mg%; $t = 4.111$; $P < 0.01$).

The level of aspartic acid at the first larval stage ranged between 0.76 and 1.14 mg%, on the average 1.011 ± 0.0380 mg%. At the next stage the concentration of aspartic acid increased and ranged from 1.33 to 1.60 mg%, on the average 1.496 ± 0.0263 mg%. At the third larval stage the level of aspartic acid was lower, 0.92—1.17 mg%, on the average 1.029 ± 0.0283 mg%. At later larval stages the concentration of aspartic acid diminished. At the sixth larval stage it slightly increased. In adult individuals the concentration of aspartic acid increased. The increase was observed to be higher in females (1.20—1.50 mg%) than in males (0.88—1.26 mg%). The average values in females and males were 1.393 ± 0.0280 mg% and 1.606 ± 0.0337 mg%, respectively. These differences were significant ($t = 6.552$; $P < 0.001$).

The variations in the concentration of serine during metamorphosis are interesting. At the first and second larval stages the obtained values were the lowest: 0.34—0.58 mg%, on the average 0.499 ± 0.0220 mg%. During later development the increase in the concentration of serine ranged from 0.70 to 1.18 mg%, on the average 0.810 ± 0.0451 mg% (VI larval stage). Differences between the concentrations of serine in males and females ranged within the limits of + 0.369 mg%. The difference was statistically significant.

Quantitative values of glycine at the first larval stage were 0.69—1.13 mg%; on the average 0.862 ± 0.0457 mg%. During later development a slight decrease of this amino acid was observed at the second larval stage (0.56—0.98 mg%, on the average 0.800 ± 0.0422 mg%). At later life stages an increase in the concentration of glycine was observed. At the sixth larval stage the concentration of glycine was 0.92—1.09 mg%, on the average 1.007 ± 0.0220 mg%, in the *imago* — 0.59—1.09 mg%, on the average 0.730 ± 0.0315 mg%. T test showed no significant differences between the concentration of glycine in males and females; the probability test (P) exceeded 0.55 mg%.

The concentration of threonine was examined together with that of glutamic acid. At the first larval stage the concentration of threonine was 1.00—0.40 mg%, on the average 1.258 ± 0.0430 mg%. At the next stage the concentration increased from 1.27 to 1.54 mg%, on the average 1.445 ± 0.0283 mg%. At the third larval stage a decrease in the concentration of serine was observed. It was 1.08—1.56 mg%, on the average 1.249 ± 0.0576 mg%. During later development a gradual increase in the concentration of those amino acids was observed. The highest concentration level was observed at the fifth larval stage and was 1.28—1.83 mg%, on the average 1.463 ± 0.0552 mg%. In adult specimens the average amino acids concentration was 1.548 ± 0.0538 mg%. It was distinctly lower ($P < 0.01$) in males than in females. In males it was on the average 1.366 ± 0.0369 mg%, while in females — 1.730 ± 0.0592 mg%. No considerable variations were found between the concentrations of tryptophan in the separate larval stages and those in the *imago*. The concentration of tryptophan varied from 0.02 to 0.09 mg%. Equally low values were also found in α-aminobutyric acid; its concentration during metamorphosis ranged from 0.9 to 0.15 mg%.

At the first larval stage the level of alanine was 2.30—2.53 mg%, on the average 2.386 ± 0.0222 mg%. An increase in the level of alanine was observed at the second larval stage. This increase varied from 2.34 to 3.34 mg%, on the average 2.583 ± 0.1060 mg%. At the third larval stage the decrease of alanine was 1.91—2.43 mg%, on the average 2.297 ± 0.0618 mg%. In the next larval stage (IV—V) the concentration of alanine continued to decrease; its values in the *imago* were the lowest (0.76—1.20 mg%, on the average 1.018 ± 0.0297 mg%. The average concentration values in males and females were 0.903 ± 0.0218 mg% and 1.134 ± 0.0168 mg%, respectively. The difference was statistically significant ($P < 0.001$).

Quantitative values in the concentration of tyrosine were observed with the beginning of the second larval stage. At the sixth larval stage the highest values of tyrosine were 1.57—1.91 mg%, on the average 1.717 ± 0.0342 mg%. The level of tyrosine was found to be higher by 0.690 mg% in males when compared with that of females.

The difference was statistically significant ($t = 10.192$; $P < 0.0001$. Table 3).

The level of valine and methionine was 3.48—3.91 mg% at the first larval stage, on the average 3.786 ± 0.0543 mg%. A considerable increase in the concentration of those amino acids, at the second larval stage, was 4.63—5.02 mg%, on the average 4.872 ± 0.0416 mg%. It was observed to maintain the same level at the third and fourth larval stages. At the fifth larval stage a considerable increase in the concentration of valine

and methionine was observed; it was 2.98—3.27 mg%, on the average 3.119 ± 0.0279 mg%. A further decrease in the concentration of those amino acids occurred in the *imago*. It ranged from 1.90 to 3.90 mg%, on the average 2.350 ± 0.105 mg%. T test does not show a difference in the concentration of valine and methionine between males and females.

The concentration of phenylalanine at the first larval stage ranged from 1.52 to 1.75 mg%, on the average 1.594 ± 0.0288 mg%. It maintained the same level at the second larval stage (on the average 1.616 ± ± 0.1268 mg%). At the third larval stage a considerable increase in the level of phenyalanine occurred (2.065 ± 0.0586 mg%). At later life stages the level of phenylalanine continued to decrease. In the *imago* its values ranged from 0.86 to 1.30 mg%, on the average 1.022 ± 0.0262 mg%. The concentration of phenylalanine was almost identical in males and females (1.012 ± 0.0206 mg% in males, 1.013 ± 0.0496 mg% in females; $t = 0.354$; $P < 0.7$). It averaged 1.022 ± mg%.

The concentration of leucine was estimated with iso-leucine. At the first larval stage the concentration of those amino acids was 2.66—3.22 mg%, on the average 2.892 ± .0785 mg%. At the third larval stage the highest values of leucine and iso-leucine were 4.10—5.33 mg%, on the average 4.941 ± 0.1436 mg%. At the fourth larval stage a slight decrease in the concentration of these amino acids occurred and at later stages it maintained almost the same level. In males the concentration of leucine and iso-leucine was much lower than in males; ($t = 24.216$; $P<0.0001$). A statistically significant correlation was found between the levels of those amino acids in males and females.

The total concentration of the above described amino acids at the first larval stage was 21.54—23.78 mg%, on the average 22.417 ± 0.2175 mg%. At the second larval stage an increase in the total concentration of all those amino acids reached the level of 26.158 ± 0.3199 mg%. There was also a high concentration of all those amino acids at the third larval stage i.e. 26.304 ± 0.3311 mg%. During later periods of metamorphosis a decrease in the concentration occurred. The lowest levels of the amino acids, taken totally, were observed at the sixth stage and averaged 20.942 ± 0.1352 mg%. In the *imago* the total concentration of the amino acids continued to decrease and averaged 19.781 ± 0.1399 mg%. No significant differences were found ($P < 0.25$) between the concentrations of the amino acids in males (19.269 ± 0.188 mg%) and those in females (19.33 ± 0.2023 mg%).

CONCLUSIONS

In the present paper considerable differences were found in the concentration of free amino acids between separate larval stages and the

imago stage of *Battella germanica* L. Twenty amino acids were identified in the tissues of the first larval stage and in those of the *imago*. They were: cystine, lysine, histidine, arginine, glutamine, alanine, tyrosine, α-aminobutyric acid, tryptophan, valine, methionine, phenylalanine, leucine, iso-leucine, proline, aspartic acid, glutamic acid, glycine, serine and threonine.

The highest concentrations of amino acids were found in the tissues of the second and third larval stages. At those stages the highest levels of lysine, histidine, glutamine, aspartic acid, leucine and iso-leucine were found. The highest levels are assumed to be related to the rate of metamorphosis processes which is highest at the beginning of metamorphosis.

The lowest values of all amino acids were observed at the sixth larval stage and in the *imago*. At those stages quantitative values of lysine, histidine, alanine, valine with methionine, phenylalanine, leucine, and iso-leucine were observed.

During metamophosis considerable variations in the proportions of individual amino were observed.

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Badania nad stężeniem poszczególnych wolnych aminokwasów w tkankach *Blattella germanica* L. podczas metamorfozy

Streszczenie

Metodą elektrochromatografii określono i porównano stężenie wolnych aminokwasów w tkankach *Blattella germanica* L. w poszczególnych stadiach rozwojowych. Wykonano jakościowe i ilościowe oznaczenie 20 wolnych aminokwasów w tkankach larw i w tkankach postaci dorosłej. Są to: cystyna, lizyna, histydyna, arginina, glutamina, kwas asparaginowy, seryna, glicyna, treonina, kwas glutaminowy, alanina, tyrozyna, kwas L-aminomasłowy, tryptofan, walina, metionina, fenyloalanina, leucyna, izoleucyna i prolina. W hydrolizatach drugiego i trzeciego stadium larwalnego wystąpiło najwyższe stężenie sumy aminokwasów. W tych stadiach rozwojowych stwierdzono najwyższy poziom lizyny, histydyny, glutaminy, kwasu asparaginowego, leucyny z izoleucyną. Najniższe stężenie wartości sumy aminokwasów obserwowano w szóstym stadium larwalnym i u postaci dorosłej. W tych stadiach zmniejszają się wartości ilościowe lizyny, histydyny, alaniny, waliny z metioniną, fenyloalaniny, leucyny z izoleucyną.

Исследования концентрации некоторых свободных аминокислот в тканях *Blatella germanica* L. во время метаморфоза

Резюме

Методом хроматографии определялась и сравнивалась концентрация свободных аминокислот в тканях *Blatella germanica* L. на отдельных стадиях развития. Проведено качественное и количественное определение 20 свободных аминокислот в тканях личинок и имаго: цистин, лизин, гистидин, аргинин, глютамин, аспаргиновая кислота, серин, глицин, треонин, глютаминовая кислота, аланин, тирозин, L-аминомасляная кислота, триптофан, валин, метионин, фенилаланин, лейцин, изолейцин и пролин. В гидролизатах второй

и третьей личиночных стадий установлена самая высокая концентрация суммы аминокислот. В этих стадиях развития установлен самый большой уровень лизина, гистидина, глютамина, аспарагиновой кислоты, лейцина и изолейцина. Самая низкая концентрация величин суммы аминокислот наблюдалась в шестой личиночной стадии и в имаго. В этих стадиях уменьшаются количественные величины лизина, гистидина, аланина, валина с метионином, фенилаланина, лейцина и изолейцина.

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