

**DIFFERENCES IN THE HAEMOLYMPH FREE AMINO ACID OF THE  
DRAGONFLY *MESOGOMPHUS LINEATUS* (SELYS)  
(ANISOPTERA: GOMPHIDAE)**

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The total free amino acid concentration in the haemolymph was almost similar in both sexes of *M. lineatus*. Arginine, glutamic acid, isoleucine, leucine and methionine were found in higher quantities in the females whereas males had more alanine and lysine. Proline, even though present in the highest concentration, decreased markedly after a prolonged flight.

**INTRODUCTION**

Many authors have shown differences between sexes in the amount of haemolymph free amino acids of various insects (DUFFY, 1958; KAPLAN et al., 1958; FOX et al., 1959; PRICE, 1961). Even though the total and differential estimation of the haemolymph free amino acids was carried out by VARADARAJ & SUNDARA RAJULU (1977) and VARADARAJ (1978) in adult dragonflies, no data are available regarding sexual dimorphism. THAKARE et al. (1975) have qualitatively investigated the haemolymph free amino acids and sex differences in the adult *Pantala flavescens*.

The primary aim of the present investigation is to estimate quantitatively the haemolymph free amino acids of adult *Mesogomphus lineatus* in relation to sex, and their variation, if any, after prolonged flight.

**MATERIAL AND METHODS**

Adult individuals, obtained locally around Erode, Tamil Nadu, India, were used. The method of obtaining the samples of haemolymph from both sexes and the procedure for the estimation of free amino acids given by VARADARAJ & SUNDARA RAJULU (1977) were followed. The

individuals selected for estimations were kept isolated and unfed for 24 hrs to avoid variations in the free amino acid content due to differential feeding.

## RESULTS

The results are shown in Table I. There was no obvious qualitative difference in the total haemolymph free amino acids of the sexes and both contained alanine, aspartic acid, arginine, cystine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tyrosine and valine. Of these, proline and, to a somewhat lesser extent, glycine were the most concentrated, while the sulphur-containing amino acids were in very low concentrations. This applies to both sexes.

However, there were differences between the sexes in the concentration of some of the amino acids. Thus, the males had high concentrations of alanine and lysine, which were, respectively, three times and twice that found in females, whereas females contained twice the amounts of arginine, glutamic acid, leucine and isoleucine found in males.

Another interesting feature noticed was that the proline concentration decreased markedly following a 15-30 min flight period in both sexes, suggesting the possibility that proline serves as an energy source for the flight of this species.

Table I  
Differential concentration of free amino acids in the haemolymph of adult *Mesogomphus lineatus* (mg/100ml). Each value is mean  $\pm$  SD of 5 observations

Amino acids	Before flight		After a continued flight	
	Male	Female	Male	Female
Alanine	30.5 $\pm$ 2.0	12.0 $\pm$ 0.8	30.2 $\pm$ 1.5	13.0 $\pm$ 0.5
Aspartic acid	14.9 $\pm$ 0.4	15.3 $\pm$ 0.3	14.7 $\pm$ 0.5	14.1 $\pm$ 0.5
Arginine	8.0 $\pm$ 1.0	15.5 $\pm$ 1.1	8.9 $\pm$ 0.9	16.9 $\pm$ 1.9
Cystine	0.3 $\pm$ 0.1	0.9 $\pm$ 0.4	0.4 $\pm$ 0.2	1.3 $\pm$ 0.6
Glutamic acid	9.8 $\pm$ 0.4	20.0 $\pm$ 0.8	8.5 $\pm$ 0.5	20.9 $\pm$ 1.1
Glycine	46.8 $\pm$ 2.7	46.1 $\pm$ 2.5	46.1 $\pm$ 2.5	46.9 $\pm$ 2.0
Histidine	23.4 $\pm$ 1.5	23.8 $\pm$ 1.7	22.7 $\pm$ 1.3	23.5 $\pm$ 1.0
Isoleucine	9.8 $\pm$ 0.8	20.1 $\pm$ 1.0	11.2 $\pm$ 1.1	21.0 $\pm$ 0.7
Leucine	11.4 $\pm$ 0.7	21.9 $\pm$ 1.4	11.9 $\pm$ 0.8	24.3 $\pm$ 1.6
Lysine	57.0 $\pm$ 3.1	28.1 $\pm$ 2.5	55.9 $\pm$ 1.2	27.6 $\pm$ 1.8
Methionine	0.2 $\pm$ 0.1	2.6 $\pm$ 0.3	0.3 $\pm$ 0.1	1.5 $\pm$ 0.2
Phenylalanine	15.1 $\pm$ 2.0	14.0 $\pm$ 1.7	15.9 $\pm$ 1.5	16.7 $\pm$ 1.8
Proline	65.2 $\pm$ 3.5	63.9 $\pm$ 4.1	30.1 $\pm$ 2.0	31.9 $\pm$ 2.5
Serine	13.5 $\pm$ 0.9	14.8 $\pm$ 0.8	12.8 $\pm$ 1.0	14.0 $\pm$ 1.1
Threonine	25.0 $\pm$ 1.1	24.1 $\pm$ 1.7	24.3 $\pm$ 1.4	24.7 $\pm$ 1.7
Tyrosine	20.0 $\pm$ 1.2	21.1 $\pm$ 1.1	20.4 $\pm$ 0.8	20.7 $\pm$ 1.5
Valine	14.8 $\pm$ 1.6	13.9 $\pm$ 1.0	14.0 $\pm$ 0.5	14.2 $\pm$ 0.9
Total	365.7	377.2	328.3	333.2

## DISCUSSION

In *M. lineatus*, 16 amino acids were identified in the haemolymph. This resembles the findings of VARADARAJ & SUNDARA RAJULU (1977) in *Orthetrum sabina* and VARADARAJ (1978) in *Anax immaculifrons*.

The similarity between sexes of total free amino acid concentrations had also been noticed by COLES (1963) and BARRETT & FRIEND (1975) in *Rhodnius prolixus*. Proline is the predominant haemolymph free amino acid also in *Glossina morsitans* (BURSELL, 1963), *Aedes aegypti* (THAYER & TERZIAN, 1970), *Leptinotarsa decemlineata* (DE KORT et al., 1973) and *R. prolixus* (BARRETT & FRIEND, 1975).

The higher concentration of alanine in males has also been observed in *Culex pipiens* (CHEN, 1958) and *Pantala flavescens* (THAKARE et al., 1975) while lysine was found in a greater quantity in males of *P. flavescens* (THAKARE et al., 1975). On the other hand, arginine, glutamic acid, isoleucine, leucine and methionine were dominant in females of *P. flavescens* (THAKARE et al., 1975). A higher concentration of methionine was also recorded by KAPLAN et al., (1958) in female *Drosophila melanogaster* and by BARRETT & FRIEND (1975) in *Rhodnius prolixus* females. In *M. lineatus* methionine was practically nil (0.2 mg/100 ml) in the haemolymph of males. In *Orthetrum sabina* and *Anax immaculifrons* it was totally absent (VARADARAJ & SUNDARA RAJULU, 1977; VARADARAJ, 1978). The total basic amino acids (arginine, histidine and lysine) were higher in males whereas females had larger quantities of acidic amino acids (aspartic acid and glutamic acid) and sulphur-containing ones when compared to males. It is presumed that basic amino acids may accelerate testicular development, while acidic and sulphur-containing ones speed up ovarian development. This agrees with the findings of SIDHU & KUMAR (1980) in the beetle, *Chilomenes sexmaculata*.

A reduction in proline following flight has been observed, and proline has been implicated as an energy source in the flight of tsetse flies (BURSELL, 1963), of locusts (BROSEMER & VEERABHADRAPPA, 1965; MAYER & CANDY, 1969), of *Apis mellifera* (BARKER & LEHNER, 1972), of *Leptinotarsa decemlineata* (DE KORT et al., 1973) and of *Rhodnius prolixus* (BARRETT & FRIEND, 1975). CRABTREE & NEWSHOLME (1975) have reported oxidation of proline by flight muscle preparations for all major orders of insects. In the adult hexapods, haemolymph amino acids may provide a soluble and readily available substrate reserve for the tricarboxylic acid cycle, since many amino acids are quickly degraded to acetylCoA, pyruvate or tricarboxylic acid cycle intermediates (CHEFURKA, 1965). As proline was the major amino acid in the haemolymph of the dragonfly before flight and as it decreased immediately after flight, it is reasonable to infer that proline may serve as an energy source for the flight of this species too.

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## REFERENCES

- BARKER, R.J. & Y. LEHNER, 1972. Free amino acids in thoraces of flown honey bees, *Apis mellifera* L. (Hymenoptera: Apidae). *Comp. Biochem. Physiol.* (B) 43: 163-169.
- BARRETT, F.W. & W.G. FRIEND, 1975. Differences in the concentration of free amino acids in the haemolymph of adult male and female *Rhodnius prolixus*. *Comp. Biochem. Physiol.* (B) 52: 427-431.
- BROSEMER, R.W. & P.S. VEERABHADRAPPA, 1965. Pathway of proline oxidation in insect flight muscle. *Biochem. biophys. Acta* 110: 102-112.
- BURSELL, E., 1963. Aspects of the metabolism of amino acids in the tsetse fly, *Glossina* (Diptera). *Insect Physiol.* 9: 439-452.
- CHEFURKA, W., 1965. Intermediary metabolism of carbohydrates in insects. *In: The physiology of Insecta*, Vol. 2. Academic Press, New York.
- CHEN, P.S., 1958. Studies on the protein metabolism of *Culex pipiens* L. II. Quantitative differences in free amino acids between male and female adult mosquitoes. *Insect Physiol.* 2: 128-136.
- COLES, G.C., 1963. *Haemolymph and growth in Rhodnius prolixus* Stal. Ph.D. thesis, Univ. Cambridge.
- CRABTREE, B. & E.A. NEWSHOLME, 1975. Comparative aspects of fuel utilisation and metabolism by muscle. *In: Insect muscle*. Academic Press, London.
- DE KORT, C.A.D., A.K.N. BARTELINK & R.R. SCHUURMANS, 1973. The significance of L-proline for oxidative metabolism in the flight muscles of Colorado beetle, *Leptinotarsa decemlineata*. *Insect Biochem.* 3: 11-17.
- DUFFY, J.P., 1958. *Paper chromatography and paper electrophoretic studies of free amino acids and proteins of various mosquito species*. Ph.D. thesis, Rutgers Univ., New Brunswick, N.J.
- FOX, A.S., C.B. MEAD & I.L. MYNYON, 1959. Sex peptide of *Drosophila melanogaster*. *Z. indukt. Abstamm. - u. Vererb. Lehre* 87: 554-556.
- KAPLAN, W.D., B. HOCHMAN & J.T. KOLDEN, 1958. Occurrence of unequal amounts of free methionine in male and female *Drosophila melanogaster*. *Science, N.Y.* 127: 473-474.
- MAYER, R.J. & D.J. CANDY, 1969. Changes in energy reserves during flight of the desert locust, *Schistocerca gregaria*. *Comp. Biochem. Physiol.* 31: 409-418.
- PRICE, M., 1961. Some aspects of amino acids metabolism in the house-fly *Musca domestica*. *Biochem. J.* 78: 21-22.
- SIDHU, D.S. & NIRMAL KUMAR, 1980. Sex specific differences in the pool size of free amino acids concentration in *Chilomenes sexmaculata* Fabr., (Coleoptera: Coccinellidae). *J. scient. Res., Bhopal* 2: 1-3.
- THAYER, D.W. & L.A. TERZIAN, 1970. Free amino acids and related compounds in the tissues of ageing female *Aedes aegypti* mosquitoes. *J. Insect Physiol.* 16: 1-15.
- THAKARE, V.K., S.K. RAINA, S. RAVATKAR & V. RAGHUKUMAR, 1975. Qualitative studies on the free amino acids and sex differences in the haemolymph of the dragonfly, *Pantala flavescens*. (Odonata: Libellulidae). *Anim. Morphol. Physiol.* 22(1): 16-25.
- VARADARAJ, G., 1978. *Studies on the haemolymph and cuticle of a dragonfly, Anax immaculifrons* (Anisoptera: Aeshnidae) Ph.D. thesis, Univ. Madras.
- VARADARAJ, G. & G. SUNDARA RAJULU, 1977. Changes in the free amino acid concentrations of the haemolymph during development in *Orthetrum sabina* (Drury) (Anisoptera: Libellulidae). *Odonatologica* 8: 253-258.