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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences, 2 (2): 472-477, 1999

Research Article

The Bioenergetics of the House Fly *Musca domestica vicina* and the Blowfly *Lucilia sericata*

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Abstract

Temperature caused a significant change in the bioenergetics of the two forensically important flies namely, the houseft *Musca domestica vicina Macquart* and the blow fly *Lucilia sericata* Meigen in the laboratory under different constan temperatures. The oxygen consumption of both species increased with an increase in the larval weight at all teste temperatures. Conversely, as the weights of both species increased, the oxygen consumed per mg fresh or dry weight decreased. The pupal respiration followed the U-shaped curve. The calculated temperature coefficient (Q_{10}) values were n very high for all stages of both species at lower temperature. The instantaneous rate of assimilation of the feeding larva of both species increased with increasing weight and age. The instantaneous growth efficiency and the cumulative growt efficiency values at all tested temperatures were higher for *L. sericata* than *M. domestica*. The oxygen consumption an food assimilation are age markers of the immature stages of these two forensically important flies and can be used easi in the accurate estimation of the postmortem interval.

Introduction

Tropic-dynamic aspect of ecology has resulted in a number of studies on the bioenergetics of consumer species, usually in the laboratory where metabolic parameters may be precisely measured. Such information can then be extrapolated to field situations, not only for the species in question, but also for ecologically similar groups (Welch, 1968). In bioenergetics studies, the metabolism can be measured in considerable detail as a function of the most significant factors, both internal; such as age, size, physiological state etc. and external; such as temperature, relative humidity, the nature and availability of food etc.

The relationship between oxygen consumption and weight of larvae or unit weight were previously studied by Drummond and Chamberlain (1961), Healey (1967), Guerra and Cochran (1970), Tilbrook and Block (1972), Otto (1974), Block and Tilbrook (1975), Swift (1976), Putman (1977) Ziser and Nettles (1979) and Martin (1991). The oxygen consumption of the pupal stage always forms a U-shaped curve like that of most other metamorphosing insects (Keister, 1953; Park and Buck, 1960; Guerra and Cochran, 1970; Shishin'ova, 1986; and Shaurub, 1993).

Waldbauer (1968) stated that the highest value of the instantaneous growth efficiency (K_2) was coincide with the most intense production phase.

Whereas, the cumulative growth efficiency was varied with temperature, developmental stage, or the weight of the larvae (Hanski, 1976).

Therefore, the present study deals with the energetics of two forensically important species, Musca domestica and Lucilia sericata. From such studies, information about the species' potentialities under different conditions can be provided, and the possibilities of using these factors to determine the age of the larvae can be established.

Materials and Methods

Cultures of *M. domestica* and *L. sericata* were establishe in the laboratory of the Zoology Department, Faculty Science, Alexandria University, and were maintained 27°C and relative humidity of 70%. Larvae of *M. domesti* were fed on chicken's mash whereas those of *L. serica* were fed on fresh liver. Fifty eggs for each species w placed in 20 gm of larval medium. Ten replicates w reared under five constant temperatures (15,20,25,30 a 35°C). Oxygen consumption was measured with conventional Warburg respirometer (Dixon, 1951), by direct manometric method outlined by Umbreit et (1957). All the experiments were carried out during same hour each day and the tested specimens were u only for once. The data were presented in the forms:

1. μlO_2 consumed/individual/hr.
2. μlO_2 consumed/mg fresh weight/hr.
3. μlO_2 consumed/mg dry weight/hr.

The temperature coefficient (Q_{10}) was calculated for e 5°C increment in temperature (Cairns, 1978) using formula:

$$\text{Log } Q_{10} = \frac{10(\log K_1 - \log K_2)}{t_1 - t_2}$$

where K_1 and K_2 are the oxygen consumption rates and t_2 °C respectively (Hoar, 1966).

For the estimation of larval assimilation; ten replicates each species, at each of the experimental temperatu were prepared as previously mentioned. Replicates were undisturbed till the end of the feeding period. Accordin Hanski (1976); assimilation was measured according t equation $A_i = P_i + R_i$ where A_i is the instantaneous ra assimilation, P_i is the instantaneous rate of productio

R_i is the instantaneous rate of respiration, or $A_c = 0.98 (B_{t1}-B_{t2})$ where A_c is the cumulative food assimilation, B_{t1} and B_{t2} were the weights of the larval medium at the beginning and the end of the experiment, respectively.

The growth efficiency was calculated as a cumulative index K_{2c} (Klekowski *et al.*, 1967), where $K_{2c} = P_c / A_c . 100$ and as an instantaneous index $K_{2i} = P_i / A_i . 100$. Both indices were calculated for each of the cited temperature.

Results

The daily oxygen consumption of the developing embryos inside eggs, feeding and post feeding larvae, and pupal stage of both flies raised at five different constant temperatures, are illustrated graphically in Fig. 1-6. The results showed that oxygen consumption of the various immature stages of both species increased with increasing temperature. Person correlation coefficient displayed a significant correlation (r = 0.97, 0.97, 0.95 and 0.87 for the developing embryos inside eggs, feeding larvae, post feeding larvae and pupae of *M. domestica* and r=0.99, 0.97, 0.94 and 0.91 for similar stages of *L. sericata*).

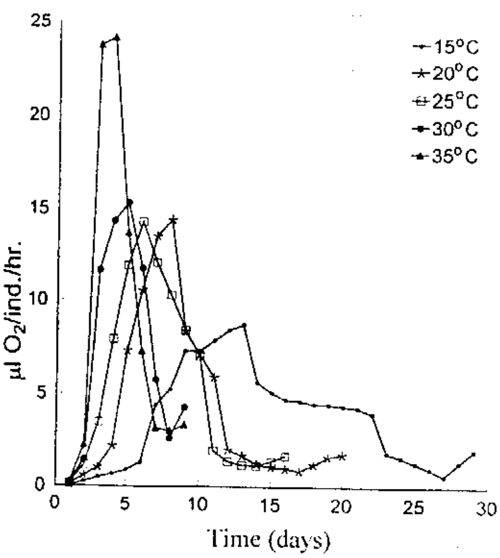

Fig. 1: The daily oxygen consumption (μlO_2/ind./hr.) of the different immature stages of *M. domestica*, raised at five different constant temperatures.

At all tested temperatures, for the two species, the developing embryos inside eggs had the lowest consumption value. The oxygen consumption increased at the onset of the feeding larval stage and reached its maximum value at the end of this stage then it started to decrease at the beginning and during the post feeding period. This is followed by a decrease during the pupal stage. The daily oxygen consumption of the various immature stages at all tested temperatures is higher for *L. sericata* than *M. domestica*.

The calculated temperature coefficient values (Q_{10}) of the oxygen consumption for the different stages of both species are given in Table 1. It can be seen from this table that, at low temperatures (15-20°C), the Q_{10} values of all stages of both species were generally higher than at the higher temperatures (30-35°C).

Table 1: Temperature coefficient (Q_{10}) calculated for each increment in the temperature range from the oxygen consumption rates of different immature stages of *Musca domestica* and *Lucilia sericata*.

Stage	Temp. (°C) Coefficient (Q_{10})			
	15-20	20-25	25-30	30-35
Eggs				
M. domestica	2.08	2.16	2.59	1.05
L. sericata	1.72	1.94	1.92	1.33
Larvae				
M. domestica	2.56	1.20	1.39	2.02
L. sericata	1.78	4.19	1.19	1.46
Post-feeding larvae				
M. domestica	2.39	1.74	2.04	1.96
L. sericata	1.43	1.96	1.12	1.03
Pupae				
M. domestica	1.01	1.11	8.54	0.99
L. sericata	0.99	1.35	5.99	1.25

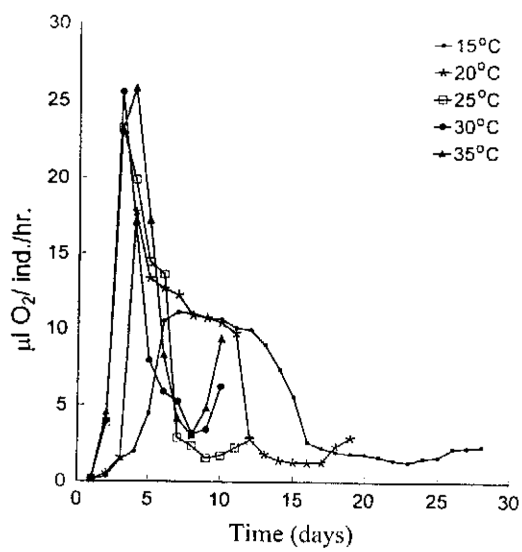

Fig. 2: The daily oxygen consumption (μlO_2/ind./hr.) of the different immature stages of *L. sericata*, raised at five different constant temperatures.

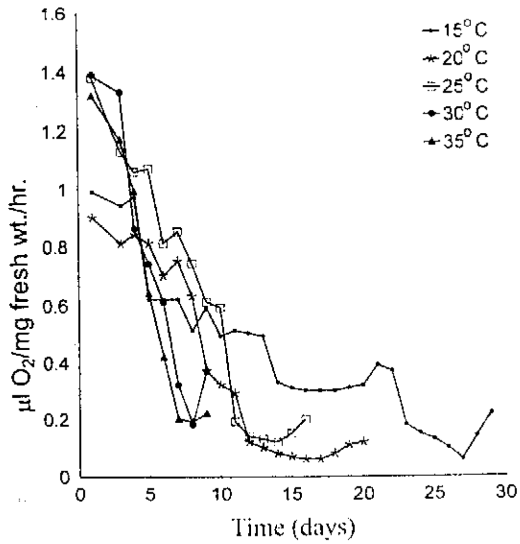

Fig. 3: The daily oxygen consumption (μlO_2/mg fresh wt./hr.) of the different immature stages of *M. domestica*, raised at five different constant temperatures.

It can be seen from figures 3-6 that when oxygen consumption is expressed on a unit weight basis, the rate of consumption at all tested temperatures decreases in the series feeding larvae-post feeding larvae-pupae.

In the present study the instantaneous and cumulative foo assimilation as well as the instantaneous and cumulativ growth efficiency for the feeding larval stage of *M domestica* and *L. sericata* raised at different five consta temperatures are presented in Tables 2-6. It can b observed from the data cited in tables 2 & 3, that th instantaneous rate of assimilation (A_i) increased with th increase of weight and age of the feeding larva Furthermore, A_i of both species increases with temperatur Person correlation coefficient indicated significa correlation (r = 0.95, 0.96 for *M. domestica* and *L. serica* respectively).

From the present data, it can recorded that 25 and 30 represent an optimum production in *M. domestica* and *sericata* respectively. Also, it can be observed that foo assimilation at all tested temperatures is higher for *sericata* than *M. domestica*.

Discussion

The results presented clearly show that oxyg consumption rates of the various stages of the test species are temperature dependent; the rate increases wi temperature. These results add support to similar studies b other workers on a variety of insects (Keister and Buc 1961; Tribe and Bowler, 1968; and Cairns, 1978) and wide variety of poikilotherms (Dawson and Bartholome 1956; Grainger, 1956; Kanugo and Prosser, 195 Beamish, 1964; Edney, 1964; McFarland and Picken 1965 and Davies, 1966).

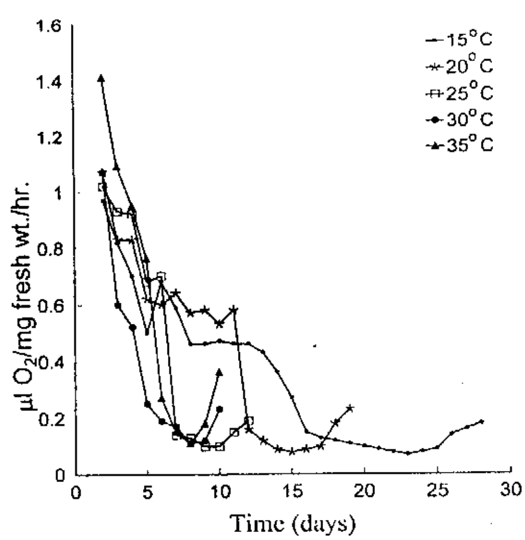

Fig. 4: The daily oxygen consumption (μlO_2/mg fresh wt./hr.) of the different immature stages of *L. sericata*, raised at five different constant temperatures.

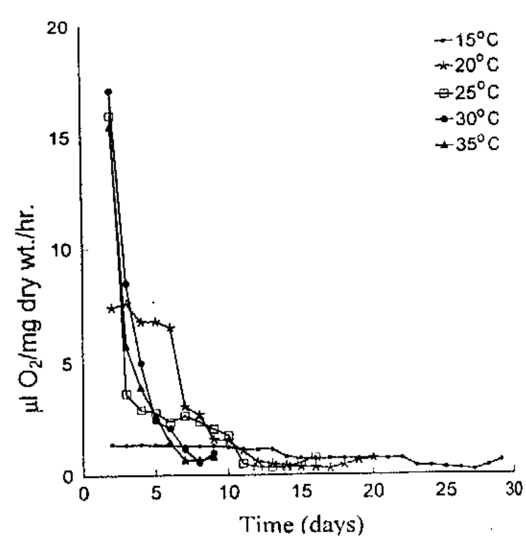

Fig. 5: The daily oxygen consumption (μlO_2/mg dry wt./h of the different immature stages of *M. domest* raised at five different constant temperatures.

Table 2: Mean ± SE of instantaneous rate of assimilation ($A_1 = P_1 + R_1$) of the feeding larval stage of *M. domestica*, raised at five different constant temperatures.

Day	15°C	20°C	25°C	30°C	35°C
1	0.39±0.03	0.63±0.07	1.19±0.05	1.49±0.12	2.38±0.08
2	0.62±0.02	1.07±0.10	4.35±0.17	12.91±0.85	27.68±1.19
3	0.79±0.02	2.37±0.05	9.76±0.43	15.84±0.94	28.15±2.10
4	1.04±0.08	8.09±0.15	13.40±0.22	18.71±1.91	
5	1.63±0.04	11.05±0.26	16.07±0.51		
6	7.10±0.47	16.29±0.28			
7	7.70±0.22				
8	8.93±0.13				
9	8.93±0.50				
10	8.94±0.41				
11	8.74±0.96				
12	8.90±0.15				
Mean±S.E.	5.31±0.11	7.97±0.10	8.95±0.13	12.25±0.81	19.40±0.39

Table 3: Mean ± SE of instantaneous rate of assimilation ($A_1 = P_1 + R_l$) of the feeding larval stage of *Lucilia sericata*, raised at five different temperatures.

Day	15°C	20°C	25°C	30°C	35°C
1	0.42±0.03	0.65±0.01	4.94±0.09	4.68±0.28	5.33±0.32
2	1.73±0.14	1.89±0.46	28.89±1.31	35.70±2.90	27.51±1.88
3	2.14±0.17	22.60±1.23			29.41±0.91
4	5.91±0.18				
5	12.28±0.66				
6	12.34±0.75				
7	12.78±0.26				
Mean±S.E.	6.80±0.08	8.38±0.40	16.92±0.67	20.19±1.47	20.75±0.64

Table 4: Mean ± SE of instantaneous growth efficiency ($K_{21} = P_1/A_1.100$) of the feeding larval stage of *Musca domestica*, raised at five different constant temperatures.

Day	15°C	20°C	25°C	30°C	35°C
1	33.59±2.74	11.11±1.41	5.04±0.21	4.69±0.37	5.88±0.43
2	25.81±0.78	4.67±0.51	20.23±1.19	9.99±0.56	14.38±0.59
3	17.72±0.41	8.02±0.11	18.34±0.89	9.47±0.58	7.80±0.56
4	16.35±2.33	9.27±0.03	11.27±0.02	18.33±2.16	
5	20.25±0.83	4.79±0.23	11.08±0.37		
6	18.03±1.26	17.19±0.31			
7	5.84±0.30	6.13±0.09			
8	7.92±0.16				
9	4.48±0.81				
10	4.52±0.52				
11	3.66±0.55				
12	2.02±0.03				
Mean±S.E.	12.26±0.38	8.74±0.23	13.19±0.16	10.62±0.67	9.35±0.14

Table 5: Mean ± SE of instantaneous growth efficiency ($K_{21} = P_1/A_1.100$) of the feeding larval stage of *Lucilia sericata*, raised at five different constant temperatures.

Day	15°C	20°C	25°C	30°C	35°C
1	26.19±2.33	21.54±0.13	22.67±0.07	16.67±1.02	15.95±1.03
2	18.49±0.45	17.46±2.06	19.76±0.99	28.58±2.43	16.24±1.15
3	8.41±0.96	21.64±0.44			12.48±0.42
4	25.04±0.74				
5	14.58±0.75				
6	10.45±0.76				
7	14.24±0.29				
Mean±S.E.	16.77±0.35	20.21±0.71	21.22±0.51	22.62±1.34	14.89±0.16

Table 6: The cumulative growth efficiency ($K_{2c} = P_c/A_c.100$) of feeding larval stage of Musca domestica and Lucilia sericata, raised at five different constant temperatures.

	Mean ± S.E. of cumulative growth efficiency	
Temp. (°C)	*M. domestica*	*L. sericata*
15	62.44±0.65	69.79±0.20
20	62.14±0.73	80.20±0.14
25	72.75±0.43	77.52±1.03
30	62.69±0.99	90.63±0.58
35	62.82±0.74	82.04±0.56

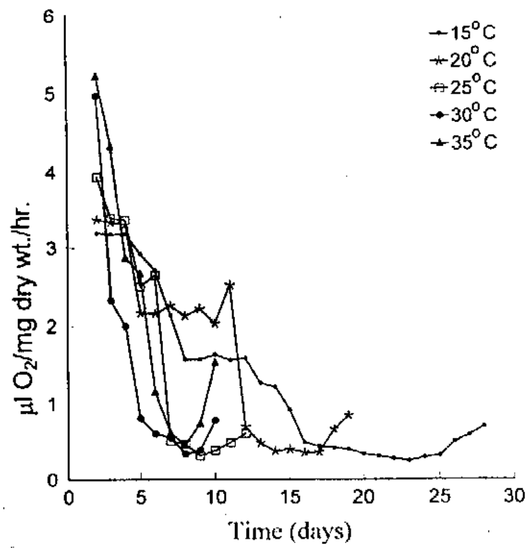

Fig. 6: The daily oxygen consumption (μlO_2/mg dry wt./hr.) of the different immature stages of *L. Sericata,* raised at five different constant temperatures.

It was recorded that as weights of feeding larvae increase there is a corresponding increase in oxygen consumed per individual. These results are in conformity with those obtained by Drummond and Chamberlain (1961), Gromysz-Kalkowska (1970), and Khalil (1994). The results also showed that the respiratory rates of the pupae follow a U-shaped curve. These results are similar to those reported by Needham (1950), Agrell (1953), Keister (1953), Roeder (1953); Park and Buck (1960), Guerra and Cochran (1970) and Jensen (1978). In this connection, Shaurub (1993) supposed that the descending and ascending arms of the U-shaped curve represent histolysis and histogenesis of tissues respectively.

The present study revealed values of Q_{10} not less tha unity for all stages of both species at higher temperature and not be very high at lower temperatures. This cou suggest that the two species under investigation a adapted to high temperatures.

Also, the present study adds support to the view "as th weights increase, the consumption per unit weigh decreases". Similar results have been reported b Drummond and Chamberlain, (1961); Guerra and Cochra (1970); Swift (1976); and Ziser and Nettles (1979).

It was reported that the instantaneous rate of assimilatio of he feeding larvae of both species increased wi increasing weight and age. These results may be explain according to the view of Hanski (1977) who stated th when the larvae are at the stage of the highest productio rate, their metabolism is channeled to the synthesis of ne tissues.

Also, it was recorded that larvae raised at hi temperatures had an increased rate of assimilation. Willian and Richardson, (1984) suggested that instantaneous ra of assimilation increases with temperature due in part increasing respiratory costs (R_i) and since production (also increases with temperature, consumption and digesti rates must increase.

Generally *L. sericata* exhibited high assimilation efficienci than *M. domestica*. This can be attributed to the Prote rich diet offered to *L. sericata* larvae. Also, Welch (196 stated that animals with high assimilation efficiencies te to be carnivorous, whereas those with lower assimilatio efficiencies tend to be herbivore/detritivores. The prese study supports the principle, that the detritivores *M. domestica* has a lower assimilation efficiencies than t carnivores L. sericata.

In addition, the present study revealed that the O consumption and assimilation rate of both *M. domesti* and *L. sericata* larvae are age and temperature depende Hence, these age-markers could be used for accura determination of postmortem interval in crimi investigations.

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