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

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Abstract
The development and growth of two forensically important flies namely, the house fly *Musca domestica vicina* Macquart and the blow fly *Lucilia sericata* Meigen were studied in the laboratory under different constant temperatures. Temperature caused a significant change in the duration of the developmental stages as well as the total durations of the two flies. The developmental threshold temperature varied among and between the developmental stages of both species. Again, the developmental threshold temperature was much higher for *M. domestica* than *L. sericata*. The fresh and/or dry weights of the feeding larval instars of both species increased with age at all tested temperatures. Also, the fresh and/or dry weights of the immature stages of both species increased with a heightening of temperature. The duration and growth of *M. domestica* and *L. sericata* are age makers of the immature stages of these flies and can be used easily in the accurate estimation of the postmortem interval.

Introduction
The larvae of cyclorrhaphous flies occupy diverse habitats and are well adapted to develop in rapidly decaying media such as carrions. Several modifications enhance the adaptive success of these larvae, including a short feeding period, rapid growth rate, modified digestive enzymes, high metabolic rate and a few number of larval instars (Roback, 1951; Zdarek and Slama, 1972).

It was recorded that the developmental rate of the larvae of Musca vetustissima, Lucilia cuprina, *L. sericata* and Protophormia terrae-novae was linear with temperature (Greenham, 1972; Vogt and Woodburn, 1980; Wall *et al.*, 1992 and Greenberg and Tantawi, 1993). Greenberg and Szyska (1984) observed that eggs and feeding larval stages, of three species of blow flies and one species of phorid fly, developed faster than the post feeding larval and pupal stages. It was also noted that the weight of the larvae increased rapidly during the feeding period. While, during the wandering stage, the weight slowly decreased until pupariation (Hanski, 1976; Roberts, 1976; Levot *et al.*, 1979 and Duodu and Biney, 1981).

The present study was carried out to describe in quantitative terms the duration and growth of each of the immature stages from egg deposition to adult eclosion of two forensically important flies; *Musca domestica* and *Lucilia sericata* and to indicate how these factors are affected by changes in temperature.

Materials and Methods
Cultures of *M. domestica* and *L. sericata* were established in the laboratory of the Zoology Department, Faculty of Science, Alexandria University, and were maintained at 27°C and relative humidity of 70%. Larvae of *M. domestica* were fed on chicken's mash whereas those of *L. sericata* were fed on fresh liver. Fifty eggs for each species were placed in 20 gm of larval medium. Ten replicates were reared under five constant temperatures (15, 20, 25, 30 and 35°C). The developmental threshold temperatures were estimated, between 15 and 35°C, by using the equation $t = T-(K/b)$ where b is the slope of the regression line and K is the developmental rate at the given temperature T. Thermal requirements for each of the developmental stages were calculated from the equation: $DD = y\ (d-t)$ where y = developmental time (days), d = temperature, and t = the lower threshold temperature (Andrewartha and Birch 1954). The duration of each stage was recorded daily at each studied temperature. Also, individuals of the same age were chosen randomly and weighed daily. The dry weight of these individuals was recorded after drying at 100°C for about 24 hrs till constant weight.

Results
It is clear from the data cited in Table 1 that durations of the different immature stages of both species as well as the total duration are controlled by temperature. The total duration of the immature stages of *M. domestica* raised under a temperature of 35 and 15°C was 8.30 and 30.0 days respectively, whereas that of *L. sericata* was 9.66 and 28.30 days, respectively.

It is also remarkable that the pupal stage of both species occupies the major part of the total duration. The mean developmental rate (1/developmental time) at each of the studied temperatures was plotted against temperature. The regression lines for the developmental rate of each of the immature stages of *M. domestica* and *L. sericata* are presented in Table 2 and illustrated graphically in fig. 1 and 2. The values of the correlation coefficient (r) clearly indicate a significant positive relationship between the developmental rate of the different immature stages of both species and the rearing temperature.

It is clear from the data cited in Table 3 that the developmental threshold temperatures vary among and between the developmental stages of both species. The developmental threshold temperatures of the total e 1: Duration of the different immature stages of *M. domestica* and *L. sericata*, raised at five different constant temperatures.

	Duration (in days)							
	Eggs	Larvae		Post-feeding larvae		Pupae		
perature (°C)	Mean	Mean ± S.E.	% of	Mean ± S.E.	% of	Mean ± S.E.	% of	Total duration Mean ± S.E.
M. domestica	> 1	11.66 ± 0.33	38.44	8.33 ± 0.33	27.46	9.33 ± 0.57	30.76	30.30 ± 0.33
L. sericata	> 1	6.33 ± 0.33	22.34	7.33 ± 0.33	25.87	14.33 ± 0.33	50.58	28.30 ± 0.33
M. domestica	± 1	6.33 ± 0.33	32.74	4.33 ± 0.33	22.40	9.00 ± 0.57	46.56	19.30 ± 0.33
L. sericata	± 1	4.33 ± 0.88	22.40	6.33 ± 0.33	32.75	8.66 ± 0.33	44.80	19.32 ± 0.33
M. domestica	< 1	4.33 ± 0.33	32.48	3.33 ± 0.33	24.98	6.33 ± 0.33	47.49	13.30 ± 0.66
L. sericata	< 1	2.66 ± 0.33	21.01	3.33 ± 0.33	24.98	6.33 ± 0.33	47.49	13.30 ± 0.66
M. domestica	< 1	3.33 ± 0.33	35.69	3.33 ± 0.33	35.69	3.66 ± 0.66	39.23	9.30 ± 0.33
L. sericata	< 1	2.33 ± 0.33	22.56	1.33 ± 0.33	12.87	7.33 ± 0.33	70.95	10.30 ± 0.66
M. domestica	< 1	2.33 ± 0.33	27.97	2.33 ± 0.33	27.97	3.66 ± 0.33	43.94	8.30 ± 0.33
L. sericata	< 1	2.00 ± 0.01	20.70	1.66 ± 0.33	17.18	6.00 ± 0.547	62.11	9.66 ± 0.33

e 2: The regression equation for the developmental rate (y), at rearing temperature (X), of the different immature stages of *Musca domestica* and *Lucilia sericata*.

e	r	r2 (%)	Regression equation
ae			
M. domestica	0.99	98.00	y = -0.1732 + 0.0166x
L. sericata	0.99	98.00	y = -0.1022 + 0.0176x
feeding larvae			
M. domestica	0.96	92.20	y = -0.0675 + 0.0137x
L. sericata	0.88	77.40	y = -0.3734 + 0.0305x
e			
M. domestica	0.93	86.50	y = 0.0631 + 0.0099x
L. sericata	0.95	90.30	y = 0.0371 + 0.0046x
l			
M. domestica	0.99	98.00	y = -0.0371 + 0.0046x
L. sericata	0.98	96.00	y = 0.0175 + 0.0036x

e 3: The developmental threshold temperature (t), and the termal constant (K), for the different immature stages of *Musca domestica* and *Lucilia sericata*.

e	Mean ± S.E. of threshold temp.	Value of t-test	Mean ± S.E. of thermal constant	Value of t-test
ae				
M. domestica	10.45 ± 0.48*	6.25	60.41 ± 0.04*	9.02
L. sericata	5.79 ± 0.57		56.69 ± 0.01	
feeding larvae				
M. domestica	4.91 ± 0.99*	3.37	72.74 ± 0.02*	14.14
L. sericata	12.23 ± 1.39		32.75 ± 0.02	
ae				
M. domestica	-3.71 ± 1.19	5.67	100.86 ± 0.19*	24.48
L. sericata	8.10 ± 0.41*		229.51 ± 0.49	
l	4.82 ± 0.65		275.31 ± 0.06	

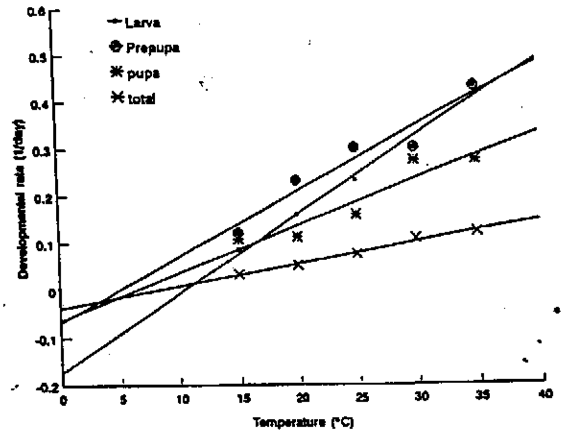

Fig. 1: The developmental rate (1/day) of the different immature stages of *M. domestica*, raised at different constant temperatures.

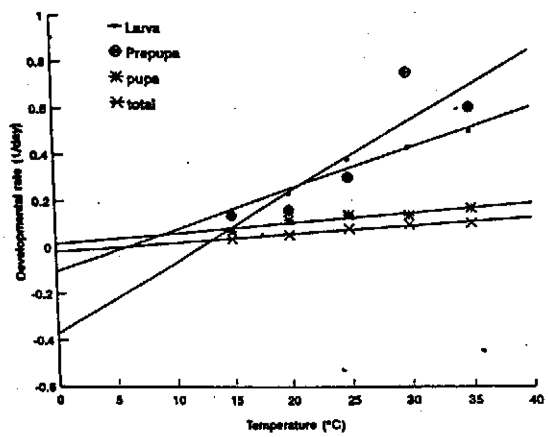

Fig. 2: The developmental rate (1/day) of the different immature stages of *L. sericata*, raised at different constant temperatures.

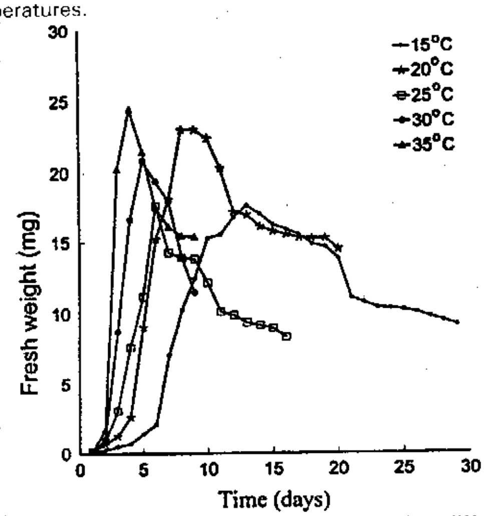

Fig. 3: Daily changes in fresh weight (mg) of the different immature stages of *M. domestica*, raised at different constant temperatures.

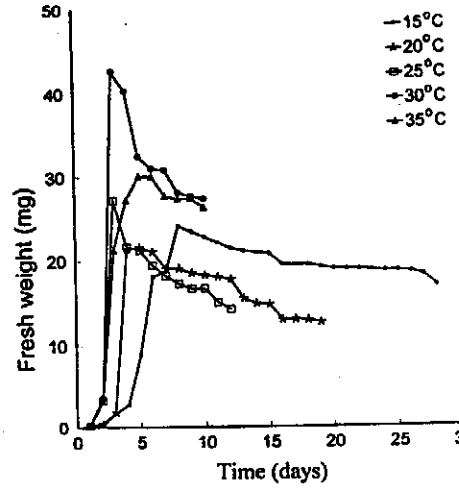

Fig. 4: Daily changes in fresh weight (mg) of the differen immature stages of *L. domestica*, raised at differen constant temperatures.

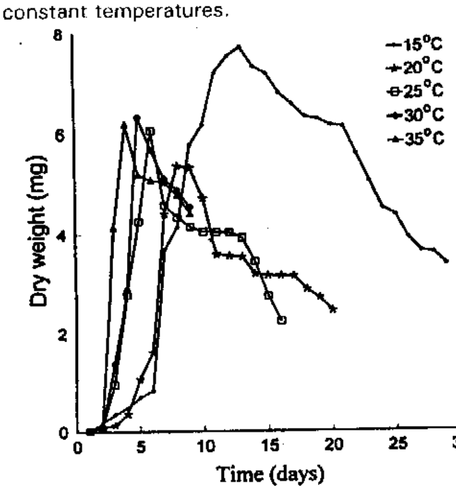

Fig. 5: Daily changes in dry weight (mg) of the different immatu stages of *M. domestica*, raised at different consta temperatures.

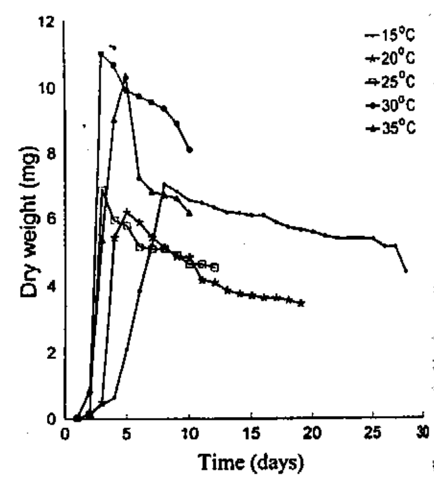

Fig. 6: Daily changes in dry weight (mg) of the different immat stages of *L. sericata*, raised at different const temperatures.

evelopment of the immature stages of *M. domestica* and . *sericata* were 8.1 and 4.82°C respectively and required 218.6 and 275.31 degree-days respectively, to complete heir development.

The fresh and dry weights of the various immature stages of *M. domestica* and *L. sericata* raised at the five tested emperatures are illustrated in Fig. 3-6. It is clear from these igures that growth of the larvae at each of the tested emperature is more or less sigmoid in form and can be livided into three categories: (1) a log phase where the arvae were adjusted to the environment; (2) an exponential phase where extremely rapid growth occurs and (3) a maximum stationary size. Therefore, the fresh weight of he feeding larvae of both species increased rapidly with ge till it reached its maximum value. After the larvae of oth species had stopped feeding and the wandering stage was reached, the weight was steadily decreased until they puparated. Also, the pupal weight of both species was lightly decreased till the emergence of adults. This trend in resh weight of both species has also been observed for dry weights of all stages of both species (Fig. 5 and 6).

Discussion

Temperature caused a significant change in the duration of the developmental stages as well as the total duration of the two flies, *M. domestica* and *L. sericata*. Immature stages raised at a high temperature had accelerated rate of development. Similar developmental pattern was recorded by Greenham (1972); Busvine (1980); Vogt and Woodburn (1980); Sukarsih (1988); and Wall *et al.* (1992). Nevertheless, Akey *et al.* (1978) found that the developmental rates of Culicoides variipennis were the same when reared at different temperatures. The present study pointed out that the pupal stage of both species occupied much longer time than the feeding and post feeding larval stages. This is in harmony with Greenberg and Szyska (1984) and Meyer and Mullens (1988). Also, the present data demonstrated a remarkable decrease in the developmental threshold temperature of the pupae of both species as compared to the feeding larval stages. These results are in accordance to those reported by Campbell *et al.* (1974); Vaughan and Turner (1987), Minkenberg and Helderman (1990), and Wall *et al.* (1992). The present work also revealed that the reduction in the developmental threshold temperature was always accompanied by an increase in the developmental time. This finding comes in agreement with those reported by Campbell *et al.* (1974) and Hailemichael and Smith (1994).

Regarding the effect of different temperatures on growth of the flies, the obtained data indicated that growth of the larvae under the five tested temperatures was more or less sigmoid in form. These findings were found to be in agreement with those obtained by Hanski (1976); Roberts (1976); Levot *et al.* (1979) and Duodu and Biney (1981). The pupal weight of both species was slightly decreased till the emergence of adults. Similar results were obtained by Otto (1974); Hagvar (1975) and Wightman (1978). There was a positive correlation between the fresh weights of the larvae of both species and the rearing temperatures, indicating an accelerated rate of growth with increasing temperatures. Similar findings were obtained by Hanna (1957); Otto (1974); Cairns (1978); Beckwith (1982); Sweeney and Vannote (1986) and Schroeder and Lawson (1992). However, Hammond *et al.* (1979) recorded that the weight of the clover worm, Platypena scabra decreased with increasing the rearing temperatures. While Beck (1983) noticed no changes in the weight of the corn barer larvae, Ostrinia nubilalis, reared at different temperatures.

Because sarcosaprophagous fly larvae are the initial and the most common entomologic inhabitants of human corpses, they are frequently encountered by the forensic investigators. In forensic practice, the age of the oldest actively feeding maggots recorded on a body can usually provide the most precise estimate of the postmortem interval (PMI). The age of the maggots is expressed by their length or weight (Wells and La Motte, 1995). The present study had revealed that the durations and growth of *M. domestica* and *L. sericata* are age markers of the immature stages of these flies and therefore they can be used easily in the accurate estimation of the postmortem interval (PMI).

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