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EFFECT OF STARVATION AND DIFFERENT DIETS ON THE LIPID CONTENTS OF THE THORACIC MUSCLES OF *LUCILIA CUPRINA* (WIED.) (CALLIPHORIDAE : DIPTERA)

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Abstract : The quantitative analysis of the lipid contents of the thoracic muscles of starved and differently fed female blowflies, *Lucilia cuprina* was carried out at 4 hourly intervals starting frcm 4-hour old flies. The maximum lipid contents were observed in the beef extract-fed flies (9.90 mg/100 mg) while the minimum were observed in the starved flies (9.85 mg/100 mg). Except for minor fluctuations a consistant decrease was observed in all the categories of the flies. At the end of the experimental period the minimum amount was observed in the starved while the maximum amount was noted in the mixed-fed flies.

INTRODUCTION

Apart from carbohydrates, one of the other sources of energy provision for muscular activity is the fat. The utilization of lipids as major source of energy during flight was reported as early as 1940 in *Eutteix tenellus* by Fulton and Romney but Krogh and weis-Fogh (1951) working on the desert locust, *Schistocerca* described it in detail. Lipid is an ideal substrate for flight, since hydration of glycogen would make isocloric quantities eight times heavier than lipid, thus resulting in a very heavy insect (Weis-Fogh, 1952). Later on, utilization of lipids by flight muscles of insects was further substantiated by various workers like Domroese and Gilbert (1964), Bode and Klingenberg (1965), Beenakkers (1966), Thompson and Bennet (1971), and many others.

Metabolism of lipids in Diptera has not received the same attention as they do not appear to utilize fat in flight (Wigglesworth, 1949 ; Gilbert, 1967 ; Sacktor, 1974). Most of the work about this important energy substrate has been confined to those species which either use fat as a fuel during flight like locusts (Bode and Klingenberg, 1964 : Candy, 1970 ; Mwangi and Golds worthy, 1977) or store fat during their development like beetles, moths and cockroaches (Casida *et al*, 1957 ; Gilmour, 1961 ; Domroese and Gilmour, 1964). During the present investigation different types of diets were given to different groups of *Lucilia cuprina* while one group was starved. The lipid contents of their thoracic muscles were estimated regularly so that variations, whether diet dependent or otherwise, could be studied. Any possible preference for this important metabolite under stress conditions like starvation was also observed.

MATERIALS AND METHODS

The Australian blowflies *Lucilia cuprina* used during the present work were taken from a colony maintained in the laboratory at 28±C°, relative humidity ranging from 70 to 75% and 12 hours photoperiod. Only females were used to avoid discrepency in the results. The newly emerged females were divided into 4 groups, each group containing several batches. 20 female flies were put in each batch and kept in separate glass jars covered with muslin. To the first group belonged the flies which were starved throughout. The remainder three groups were given the following diets respectively :

Group 1 : Beef extract (1 gm+10 ml H_2O)

Group 2 : Glucose (1 gm+10 ml H_2O)

Group 3 : Mixed diet (Beef extract+glucose).

(0.5 gm+0.5 gm+10 ml H_2O)

To determine the lipid contents the flies were first chilled and than their thoracic muscles were dissected out at 4 hourly intervals, starting from the newly emerged and upto the 40th hour of their life. Total lipids were estimated according to the method of woodman and Price (1971). Three replicates were used for each test and the results were statistically analysed.

RESULTS

The lipid contents of the thoracic muscles of the starved adult females of *L. cuprina* as well as reared on different diets upto the 40th hour of their laboratory life were as follows :

Starved Insects (Tables-1, 2), :

The lipid content of the thoracic muscles of the starved females was 9.85 m8/100mg after the 4th hour of their laboratory life. It decreased about 9% at 8 hours and was estimated to be 9.00 mg/100 mg. A further decrease

TABLE 1 : THE CHANGES IN THE LIPID CONTENTS OF THE THORACIC MUSCLES OF STARVED AND DIFFERENTLY REARED *LUCILIA CUPRINA.*

Time (in hours)	Diets			
	Starved	Beef extract-fed	Glucose-fed	Mixed diet-fed
4	9.85±0.41	9.90±0.35	9.80±0.30	9.70±0.20
8	9.00±0.31	9.35±0.30	9.15±0.35	9.20±0.35
12	8.70±0.30	8.80±0.29	8.60±0.32	8.40±0.25
16	9.10±0.20	8.95±0.25	8.90±0.21	8.61±0.15
20	8.15±0.19	8.40±0.09	8.20±0.15	8.45±0.20
24	7.54±0.50	7.62±0.09	8.20±0.15	8.00±0.16
28	7.41±0.38	7.43±0.15	8.40±0.16	8.20±0.10
32	7.21±0.15	7.40±0.20	7.60±0.10	7.90±0.09
36	6.90±0.10	7.18±0.05	7.42±0.05	7.65±0.10
40	6.75±0.05	7.00±0.06	7.35±0.10	7.43±0.05

TABLE 2 : DETAILED STATISTICAL ANALYSIS BASED ON THE DATA GIVEN IN TABLE-1. THE COMPARISON HAS BEEN MADE BETWEEN THE SAMPLES OF STARVED *LUCILIA CUPRINA* FOR DIFFERENT PERIODS OF TIME.

ANOVA LIPID TABLE

Items	Sum of square	df (n — 1)	Mean Square	F. Value
Rations	21.87	9	2.43	5.73***
Error	8.40	20	0.424	
Total	30.36	29		

TABLE - 3—DETAILED STATISTICAL ANALYSIS BASED ON THE DATA GIVEN IN TABLE-1. THE COMPARISON HAS BEEN MADE BETWEEN THE SAMPLES ON FED BEEF EXTRACT FOR DIFFERENT PERIODS OF TIME.

ANOVA LIPID TABLE

Items	Sum of square	df (n — 1)	Mean Square	F. Value
Rations	20.23	9	2.247	5.94*
Error	7.56	20	0.378	
Total	27.79	29		

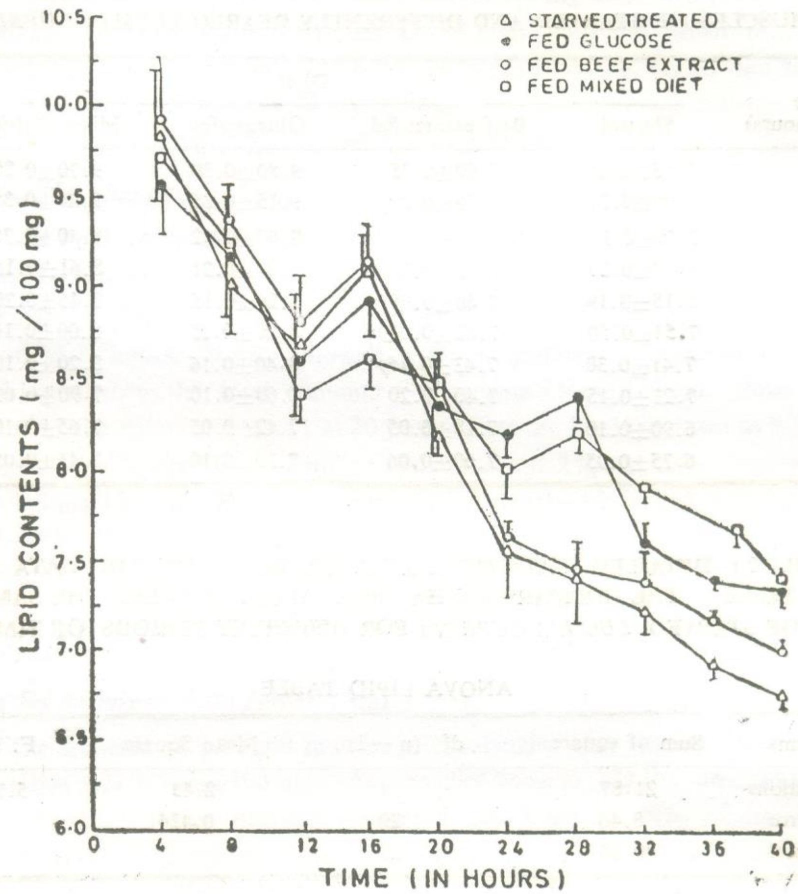

FIG. 1 : CHANGES IN THE LIPID CONTENTS IN THE THORACIC MUSCLES OF *Lucilia cuprina* AT DIFFERENT TIME INTERVALS REARED ON DIFFERENT DIETS.

TABLE 4 : DETAILED STATISTICAL ANALYSIS BASED ON THE DATA GIVEN IN TABLE-1. THE COMPARISON HAS BEEN MADE BETWEEN THE SAMPLES ON FED GLUCOSE FOR DIFFERENT PERIODS OF TIME.

ANOVA LIPID TABLE

Items	Sum of square	df (n — 1)	Mean Square	F. Value
Rations	8.54	9	0.948	2.30
Error	8.23	20	0.411	
Total	16.77	29		

TABLE - 5 –DETAILED STATISTICAL ANALYSIS BASED ON THE DATA GIVEN IN TABLE - I. THE COMPARISON HAS BEEN MADE BETWEEN THE SAMPLES FED ON A MIXED DIET FOR DIFFERENT PERIODS OF TIME.

ANOVA LIPID TABLE

Items	Sum of square	df (n — 1)	Mean Square	F. Value
Rations	3.89	9	0.43	0.94
Error	9.12	20	0.46	
Total	13.01	29		

occured and the level fell down to 8.7 mg/100 mg at 12 hours. A slight increase of 4% as compared to 12 hours occured at 16 hours and the observed amount became 9·1 mg/100 mg. It was followed by a gradual decrease and at 20 hours a 10% decline as compared to 16 hours was observed and the lipid contents became 8.15 mg/100 mg. This downward trend was maintained throughout the experimental time and the lipid contents at 24, 28, 32, 36 and 40 hours were 7.51 mg/100 mg (3% less), 7.41 mg/100 (3% less), 7.21 mg/100 mg (2% less) 6.9 mg/100 mg (2% less) and 6.75 mg/100 mg (2% less) respectively.

Flies fed on beef extract (Tables-1,3)

The lipid contents of the thoracic muscles after the 4th hour of their laboratory life were 9.90 mg/100 mg. The contents decreased about 6% at 8 hours the and values/became 9.35 mg 100/mg. They further decreased about 6% as compared to 8 hours and at 12 hours were 8.8 mg/100 mg. Upto 20 hours the values were almost static (8.95 and 8.40 mg/100 mg at 16 and 20 hours respectively), but then the values decreased at 24 hours and fell down to 7.62 mg/100 mg (20% decrease as compared to 20 hours). At 28, 32, 36 and 40 hours this level was noted to be 7.43 mg/100 mg (2% less), 7.4 mg/100 mg (0.89% less), 7.18 mg/100 mg (3% less) and 7.00 mg/100 mg (3% less) respectively.

Glucose-fed flies (Tables 1,4)

The lipid contents of the thoracic muscles of the glucose-fed flies were 9.8 mg/100 mg after 4 hours of emergence. These decreased to 9.15 mg/100 mg. after 8 hours, the values fell down further 6% and the contents were 8.6 mg/100 mg at 12 hours. It was followed by an insignificant increase of about 3% at 16 hours when the total contents had became 8.9 mg/100 gm. After this a decline in the values was noted at 20 hours when the level fell down to 8. 35 mg/100 gm. At 24 hours also a slight decrease of about 2% was noted and contents were 8.2 mg/100 mg. But at 28 hours a 2% increase was noted with the level reaching to 8.4 mg/100 mg. A decline in the values occurred thereafter and at 32 hours the lipid contents became 7.6 mg/100 mg (3% less) and 7.42 mg/100 mg at 36 hours. The level further fell down to 7.35 mg/100 mg at 40 hours (0.94% decreased).

Flies fed on mixed diet (Tables : 1,5)

The contents of the flight muscles of the females after the 4th hour of their emergence was 9.7 mg/100 mg. As the flies became old the amount of lipid declined although this decrease was small. At 8 hours it was 9.2 mg/100 mg (5% less) and at 12 hours it was measured to be 8.4 mg/100 mg (9% less). It was followed by a slight increase of 2% at 16 hours with the lipid level becoming 8.6 mg/100 mg. But again a decline in the value was observed and at 20 hours their level had dropped to 8.45 mg/100 mg (2% les) followed by a further decrease of about 5% at 24 hours, when the lipid level became 8.00 mg/100 mg. An insignificant increase followed (2%) at 28 hours and the values became 8. 2 mg/100 mg. The value than gradually decreased and at 32 hours it was estimated to be 7.9 mg/100 mg (4% less as compared to 28 hours state), 7.65 mg/100 mg at 36 hours (3% less) but the lowest amont 7.43 mg/100 mg was noted at 40 hours (3% less as compared to 36 hours).

The maximum amount of lipids was noted in 4-hour old flies of all the categories. After that the values decreased gradually upto 12 hours (12% decrease in starved, 11% in beef extract-fed, 12% in glucose-fed and 13% in mixed diet-fed as compared to 4 hours old). A slight increase occurred in the four groups at 16 hours. Afterwards in the starved and beef extract-fed flies lipid contents started to decrease gradually and a total decrease of 36% in the latter had occurred upto 40 hours as compared to 4 hours. But this level slightly increased at 24 hours in the glucose-and mixed diet-fed, followed by a decrease upto 40 hours. A total depletion of 25% in the glucose and 23% in the mixed diet-fed had taken place upto 40th hour as compared to the 4th hour. The values were compared and can be seen in fig. 1.

DISCUSSION

In *L. cuprina* females lipid was found to be an important metabolite of the flight muscles, since a steady decrease, except for minor fluctuations, was observed in all the categories of the flies. It appears that like many insects where fat is an important energy substrate (Cilmour, 1961 ; Cilbert, 1967 ; Sacktor, 1974), in *L. cuprina* also it is a useful fuel. The maximum drop in the contents was observed in the starved insects where the depletion was 36% as compared to the initial amount. The minimum drop was observed in the mixed diet-fed flies where the decrease was 23 %. Beef extract-fed showed a 29% while glucose-fed flies showed a 25% decrease in the contents at the end. It shows that when there is no dietry source of energy lipids are the main metabolites to be used, glucose-fed flies also used it to a very large extent, thus showing that glucose in not a very impoıtant source of energy for flight muscles. In the beef extract-fed insects consumption rate comes in between the two extremes, thus showing that although lipids are used to a large extent but they are not the sole source of energy. The present work shows that whether there is a dietry source or not, lipids in this blowfly are one of the important metabolites for the flight muscles. Since it gives more calories for an equivalent amount of any other metabolite it is a major energy source for insects which have prolonged flights, as it helps to keep the weight of the body in a profitable range (Beenakkers, 1965).

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