The Kinetic responses and foraging behavior of *Drosophila melanogaster* larvae

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Date of acceptance 23/4/2007

Abstract:

Adaptive responses in larval behavior may be of two kinds:
Taxis: This involves a change in direction relative to source of a stimulus. Kinesis: Kinesis has no directional component, but involves change in the rate of performance in response to a stimulus. ***Drosophila*** larvae exhibited flexible behavioral responses associated with food acquisition and selection for different environmental conditions. In this investigation, we are concerned explosively with kinetic responses to food viability. Third instar larvae were subjected to test for thirty minutes in each of the following conditions i) in distilled water, ii) in Ringer's solution, iii) in glucose solution and on live yeast suspension. In each case the larva was in a thin layer of solution, or suspension over agar gel. On non – nutritive substrates, such as distilled water the predominant behavior is locomotion accompanied by exploratory movements foraging for food. When food is encountered the predominant behavior shifts from locomotion to feeding by sustained rhythmic scooping with the mouth hooks. Locomotore activity remains constant on yeast but immediately rises on transfer to Ringer's solution over the observation period. This is orthokinesis. On transfer to glucose solution larvae again show the instant rise in locomotion, but remains at a constant level with no evidence of an orthokinetic response. Feeding activity rate remains constant on yeast whereas in Ringer's solution we observe another kinetic response, for which we propose the term fagokinesis. This response is not observed when larvae were transferred to glucose solution.

Introduction

By looking into the scientific reviews, there are a few studies concerned with the behaviors or ecology of ***Drosophila*** which give detailed description of larval behavior (1,2). The larvae of different species can discriminate between various odors. Larvae also are able to discriminate between different varieties of yeasts on which they feed (3,4). They respond to different humidity levels, sugars and ethanol (5, 6, 7, 8, and 9). However, these experiments were generally confined to the scoring of the position of larvae within an apparatus and neither the mechanisms of orientation nor any responses other than movement of larvae were recorded. A more detailed concerned with behavior of ***Drosophila*** larvae was made by (Green et al 1993) in which they described: 1- feeding behavior looking to the cephalopharyngeal scooping movements .2- Locomotor behavior , consisting of a wave contraction originating at the posterior end of the larvae and traveling interiorly along the body segments towards the head (10) . They observed that the structure of behavior is different on whether larvae were observed in the presence or absence of food. Feeding behavior plays an important role in larval development and survival. (Bakkler 1969) concluded that early or late pupation time was dependent on the rate of feeding, but he did not observe feeding behavior directly (11). He argued that the feeding rate might have effects on larvae competitive ability.

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Two feeding strains were selectively established (Sewell et al 1975) termed as fast and slow differing in their cephalopharyngeal retraction rate, the slow feeding larvae showed a correlated reduction in locomotion but this was not observed in the fast feeding larvae (12). Other investigators (13) found that there are differences in growth rate between their fast and slow strains. They also emphasized that larval feeding activity is affected by genes located on all three major chromosomes. Larvae can make a visible trail during its movement in the substrate and this trail was considered as a measure of locomotor behavior and the trail was measured and termed "path length "(14). The same investigator recognized two distinct larval foraging strategies in ***D. melanogaster*** "rover" and "sitter". Rover larvae have long path length whereas sitter larvae have a significantly shorter path length(15).A complicate comparison of mean locomotor activity scores between larvae at different stages of development were measured (16). Other study reported that ***D. melanogaster*** larvae showed greater differences in locomotion and feeding scores than did ***D. simulans*** (17). Different components of larval behavior may vary according to environmental factors. In food absence larvae show high locomotor activity but low when feeding accrued on suitable food source also found that the mean of feeding rates varies with the stage of larval development (12). Study in this area was based upon relatively short periods of observation of 60 seconds duration with which they were conserved, which could not provide information on the stability of expression of larval behavior over long time intervals.

Materials and Methods:

A- Fly collection and population cage: Adult ***Drosophila melanogaster*** wild type, were collected from Baghdad city and its vicinity. The flies were captured, using the attractive ordinary simple method depending upon some decaying vegetables and fruits, such as banana, orange and apples with a few amount of glacial acetic acid, put randomly inside glass bottles. The bottles containing flies were labeled into many lines according to the site where the flies were captured as follows: 1- The flies collected from city center were put into two groups, Bc_1 which denotes to the flies collected from AL- Baya area, Bc_2 denotes to the flies collected from Jamila area. 2- Five groups of flies were captured from surrounding area of Baghdad; these are Mahamodia, Abu-ghraib, Al – hussainia, Beni – saad and Hour-rejab. The population cage was established from seven separate isofemales in breed lines, each derived from a different wild type female captured at a single site in a transitional habitat of Baghdad and its surrounding area. A week later, seven inbred cultures of wild type flies were obtained. The progeny of these cultures were allowed to meet at random, and then ten pairs of flies (male and female) from each of the seven cultures (70 pairs in all) were used as the founder generation for the main population cage.

B- Culture media: Different media and substrates are used in this investigation: 1- Oatmeal medium for stock cultures: All flies were brought to the lab room for breeding and cultured in glass bottles (11.5 cm. height and 5.5 cm. diameter) containing oatmeal medium with yeast, also a large plastic can (22 cm. height and 16 cm. diameter) used for population cage. 2- Plain agar (3 %) for Petri dish plates . 3- watch glass containing plain agar mixed with ethanol and glacial acetic acid , for egg collection .4- ***Drosophila*** Ringer's solution (Roberts, 1986) (18) . 5- Glucose solution (the concentration was chosen to have the same osmolarity as the Ringer's solution (18). 6- Live yeast suspension 20%.

C- Egg collection and larval growth: The watch glasses containing agar with a blob of thick yeast suspension were placed directly inside the population cage. The yeast together with the alcohol, acetic acid, enhanced the attractiveness of the agar surface as an egg-laying substrate for female flies. After two hours, the watch glasses were removed out from the cage and maintained in lab. room. Next day the larvae which have been collected transferred on to a plain agar in watch glasses and overlaid with yeast suspension only. The purpose of this is to prevent the exposure of newly hatched larvae to the alcohol and acetic acid in the agar of the watch glasses used for egg collection. The watch glasses used for larval growth were placed individually inside covered Petri dishes to protect the larvae from desiccation.

D- Observation and scoring of foraging activity (feeding and locomotor rate): Experimental observations were made by transferring a single third instar larva (50 – 52 hours old) to a plastic Petri dish containing agar over layered with required medium. The dish lid was kept on as long as the test lasted to maintain constant conditions within the dish after transferring and before scoring began. Each larva was allowed to settle and acclimatize to the new conditions, for two minutes . Feeding activity score was based on a count the number of scoops with the mouth hooks per minute. Larval locomotore activity rate was recorded by counting the number of waves of segmental contraction passing along the larvae during a one minute period , (Green et.al. 1993).Larvae were observed at a magnification of X25 and using heat filtered illumination. For scoring digital counter and digital timer were used. To examine the effects of the physical conditions provided by different substrates on larval behavior , three experiments were designed in order to score feeding and locomotor activities as follows: In the first and the second experiment , a thin layer of 20% of live yeast suspension was used , and this represents food present environment . While a thin layer of distilled water and ***Drosophila*** Ringer's solution, in the first and second experiments, respectively, and these represent, liquid no food environments. Whereas the third experiment was more complex than the previous two experiments and designed as follows: substrate (A): 20% of live yeast suspension, and this represents food presents environment. Substrate (B): ***Drosophila*** Ringer solution and this represents liquid no food environment. Substrate (C): 20% of live yeast suspension again, also this represents food present environment. Substrate (D): Glucose solution and this represents liquid with dissolve food environment. Fifteen larvae were tested individually over thirty minutes period in each condition, scoring feeding activity for one minute and locomotor rate for one minute alternately. All experiments of this study were achieved within approximately three months started from beginning of February to the end of April (2004), under ordinary lab conditions and temperature range approximately between 24-28 C^{o}. Stock cultures were turned over to fresh media every two weeks.

The investigation to be described in this study focuses particularly upon feeding and locomotion behavior of ***D. melanogaster*** wild type in Baghdad city and its vicinity depended on the experimental designs established by (Mohammed-Ali 1990). We are hoping to answer the principle question being asked: Do the rate of foraging (concerned with feeding and locomotion) activity varies with the varied of food?

E- The results were statistically analyzed using: 1) Linear regression test for regression slop and intercept 2)

Bartlett's test for homogeneity of variance

Results:

In figures (1) and (2). Fifteen of 3rd instar larvae were tested. Each larva was observed for thirty minutes in each environment and feeding and locomotion activities were scored in alternate 1-minute intervals as described in material and methods. The results are shown in Table (1) for feeding and locomotion activity. In yeast suspension larval feeding rate slowly declines from 170.8 scoops initially to 153 scoops per minute at 29 minutes. In liquid food absence condition (distilled water), scooping rate of the larvae slowly increased over the period of observation from 163 per minute initially to 207 per minute. Table (1A) represents the linear regression analysis for larval feeding rate in yeast suspension and in distilled water. The regression slope was highly significant. Locomotion activity in yeast was unstable but showed no consistent trained throughout the 30 minutes observation period. While in distilled water the locomtor rate was increased steadily from 32 to 52.8 contractions per minute. The regression slope of locomotion rate showed no significant activity in yeast suspension, while it was highly significant in water environment (Table 1A). The significant decline in larval feeding rate observed in yeast suspension appears to be associated with the change in cephalopharyngeal scooping might therefore reflect change in the density or viscosity of the substrate throughout the test period , since locomotion may require less effort and consequently may be less readily influenced by viscous substrate in food absence environments . Larvae showed a significant increase in their rate of locomotor activities and cephalopharyngeal scooping. This rise in the rate of locomotor activity is evidently an example of "ORTHOKINESIS" in ***Drosophila*** larvae. Both these kinetic responses might be a direct consequence of food deprivation. Another possibility is that the observed rise in the rates of performance of the two behaviors may be driven by osmotic stress caused by immersion in distilled water. The results which are illustrated in Figures (3) and (4) respectively explain the feeding and locomotion behavior in yeast suspension and ***Drosophila*** Ringer' solution. On yeast, throughout the 30 minute observation period , the mean larval feeding rate remains virtually constant. On transfer to Ringer's solution, the initial feeding rate was higher than in yeast. This was followed by significant increase throughout the prior period of observation. Mean larval locomotor activity also remained constant throughout the test period, Table (2) and Table (2A). In Ringer's solution larvae showed an initial increase in mean rate of locomotion similar to that observed for feeding rate. This was followed by a significant linear increase in locomotor rate up to minute 30 . Results of these experiments reveal that the mean rates of locomotion and cephalopharyngeal scooping of larvae from random mating population on a uniform suspension of live yeast remain constant over a 30 minutes observation period .On no food liquid environment larvae showed two distinct kinetic responses: Orthokinesis , and an increased rate of cephalopharyngeal scooping . The kinetic response of these movements associated with feeding behavior has been previously described by (Muhammed-Ali 1990) in ***Drosophila*** larvae who have suggested an appropriate term for this is "phagokinesis". The possibility that both orthokinesis and phagokinesis observed in distilled water might be driven by osmotic stress rather than absence of food can be ignored because they are the same in Ringer's solution, which is

isotonic with ***Drosophila*** tissue .For more detailed investigation of the effects of food absence on locomotion and feeding activity was made using 3rd. instar larvae from cage population ; the experimental procedure was described in the methods . Figure (5) and Table (3) show that on yeast suspension, the larval feeding rate showed a very small but statistically significant rise over the 30 minutes observation period . After transfer to Ringer's solution, larval feeding rate rose and exhibited a significant linear increase throughout the observation period (between minutes 31 and 60). At the end of this period, each larva was returned to live yeast suspension again (yeast 2). The rate of feeding was virtually remained constant from minutes 61-90.After that time, larvae were transferred to glucose solution. This transfer resulted in a step up in the initial feeding rate to 185 retractions per minute, representing a rise of some 27 retractions per minute over the mean rate observed during the preceding 30 minute period in yeast (2). Feeding rate showed no significant change during the period larvae were observed in glucose solution. The larvae do not exhibit phagokinesis response , Table(3A) (minutes 91-120). Figure (6) and Table (3) show the locomotor activity of larvae tended to respond to different environmental conditions in a similar manner to the feeding activity described above .Locomotor rate showed no significant change on yeast suspension (1), whereas in Ringer's solution there was a significant rise in locomotore rate (Table 3A). In yeast suspension (2), the rate fell to a level similar to the previously observed level in yeast 1, which remained without significant change for thirty minutes. There was a small consistent difference between the rates of locomotion in yeast (1) and yeast (2), this may indicate that the least some of the induced increase in the absence of food has persisted after locomotion on food .On being transfer to glucose solution, the locomotor was again attended by a step up in rate, but there was no significant change in locomotion in glucose solution, Table (3A).

Table-1- Mean feeding and locomotion activity of third instar larvae of Drosophila melanogaster wild type from population cage in yeast and indistilled water

	Feeding rate			Locomotion rate	
	in yeast	in water		in yeast	in water
Time	means	means	Time	means	means
0	170.8	163.5	2	30.1	32.1
3	170.7	170.9	4	31.9	34.9
5	170.6	177.85	6	32.5	38.95
7	171.9	181.9	8	31	39.1
9	171.99	182.8	10	32.55	39.55
11	172	187.95	12	34.9	43.1
13	168.1	191.1	14	33.1	43.99
15	168.68	194.9	16	30.5	46.1
17	164.8	197.5	18	31.21	45.22
19	165.8	200.9	20	32.9	50.1
21	163.5	203.5	22	32.5	50.02
23	161.8	203.9	24	34.9	49.5
25	160.1	204.1	26	32.95	48.1
27	157.8	207.4	28	33.8	50.12
29	153.42	207.22	30	31.5	52.8

Table-1-A-Regression slope (b) and intercept (I) for change in feeding and locomotion of 3rd instar larvae in yeast suspension and in distilled water over a 30 – minute observation period. 15 larvae were scored.

Activities	Slopee			Intercept		
Feeding	b	S.E	P	I	S.E	P
In yeast	-0.611	0.072	<0.001	174.8	1.21	<0.001
In water	1.399	0.891	< 0.001	171.32	1.64	< 0.001
Locomotion						
In yeast	0.053	0.045	n.s	31.5	0.82	< 0.001
In water	0.649	0.057	< 0.001	32.9	1.01	< 0.001

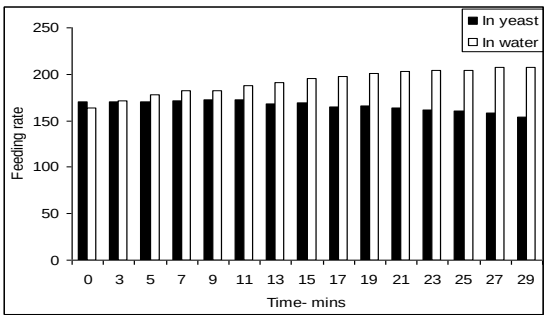

Figure-1- Feeding activity in 3rd. instar larvae of D. melanogaster , wild type , in yeast (food presence) and in distilled water (food absence) , over a 30 – minute observation period . 15 larvae were observed in each condition.

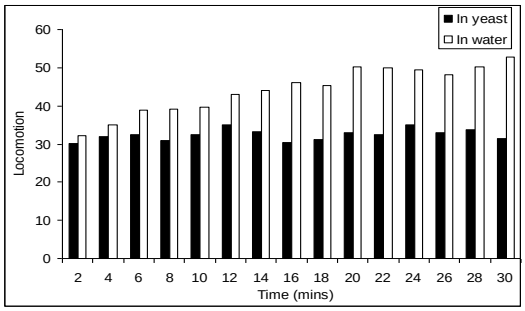

Figure-2- Locomotor activity of third instar larvae of Drosophila melanogaster , wild type, in yeast (food presences) and distilled water (food absence) , over a 30 – minute observation period . 15 larvae were observed in each condition.

Table-2-Mean feeding and locomotion activity of third instar larvae of D. melanogaster , wild type , in yeast suspension and in Ringer's solution , over a 30- minute of observation period in each condition . 15 larvae were scored in each of 15 alternate one minute intervals .

Feeding rate			Locomotion rate		
	in yeast	Ringer's		in yeast	Ringer's
Time	means	means	Time	means	means
1	167.75	180.8	2	24.02	29.9
3	166.9	183.3	4	24.45	33
5	167.9	186.45	6	24.9	34.82
7	168.5	189.8	8	24.8	34.9
9	168.7	193.2	10	23.9	35.75
11	168.5	194.9	12	24.5	37.2
13	168.8	198.9	14	24.35	37.9
15	168.2	201.1	16	24.42	39.24
17	168.9	206.5	18	24.1	41.05
19	167.9	209.5	20	24.9	41.5
21	168.2	211.9	22	23.9	42.42
23	168.2	215.8	24	24.4	43.35
25	168.3	220.9	26	24.3	44.5
27	168.5	224.9	28	24.15	45.32
29	168.65	228.8	30	24.32	45.55

Table2-A: Regression slopee (b) and intercept (I) for chang in feeding and locomotion of third instar larvae over a 30. -minute observation period , in yeast suspension and in Ringer's solution . 15 larvae were scored.

Activities	Slopee			ntercept		
Feeding	b	S.E	P	I	S.E	P
In yeast	0.0179	0.149	n.s	167.2	0.37	<0.001
In ringer	1.56	0.034	< 0.001	178.9	0.054	< 0.001
Locomotion						
In yeast	0.162	0.01	n.s	23.82	0.21	< 0.001
In Ringer's	0.472	0.24	< 0.001	32.1	0.39	< 0.001

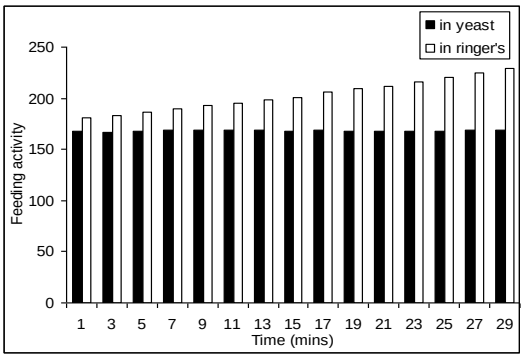

Figure-3- Feeding activity of third instar larvae of ***D.melanogaster*** , wild type , in yeast suspension (food presence) and in Ringer's solution (food absence) .15 larvae were observed in each condition , over a 30 minute observation period .

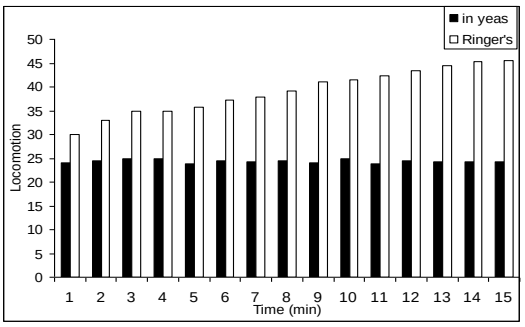

Figure-4- Locomotor activity of third instar larvae of ***D.melanogaster*** , wild type , in yeast suspension (food presence) and in Ringer's solution (food absence) .15 larvae were observed in each condition , over a 30 minute observation .

Table-3- Mean locomotion and feeding activity of 3rd instar larvae of ***Drosophila*** wild type, in yeast(1) , Ringer's solution, yeast again (2) and Glucose solution .15 larvae were scored in each condition over a 30 minute observation period . Larvae were scored in each 15 alternate one minute intervals.

Feeding activity					Locomotion activity				
	yeast(1)	Ringer's	yeast(2)	Glucose		yeast(1)	Ringer's	yeast(2)	Glucose
Time	mean	mean	mean	mean	Time	mean	mean	mean	mean
1	166.9	180.15	157.9	184.65	2	22.95	33.85	27.01	34.65
3	166.8	185.3	158.55	184.52	4	23.6	35.01	26.95	34.01
5	166.95	188.9	159.8	185.92	6	24.5	36.02	26.92	34.95
7	166.2	191.5	160	186	8	23.95	36.8	26.25	34.65
9	166.8	197.95	158.9	185.5	10	24	37	26	34.75
11	167.5	200.5	158.01	186.5	12	24.5	38.9	25.95	34.2
13	167	199.1	159.2	186.56	14	24.7	39.2	26.5	35.02
15	166.51	201.85	160.22	186.33	16	23.85	39.75	26.98	34.8
17	166.8	205.8	159.8	186.99	18	24.01	39.5	27.88	34.7
19	167.1	206.9	159.75	187.8	20	24.5	41.95	27.01	34.52
21	167.9	211.2	158.95	187.1	22	24.9	42.95	28.02	35
23	166.2	217.82	159	186.5	24	24.22	45.92	27.33	34.8
25	167.95	223.4	158.99	186.25	26	25.2	45.5	27.02	35.31
27	168.1	227.9	159.1	185.9	28	25.7	46.2	28.01	34.5
29	167.8	232.5	158.92	185.5	30	24.8	47.95	27.95	34.66

Table3-A- The regression slope (b) and intercept (I) for change in feeding and locomotion of third instar larvae of ***D. melanogaster*** wild types , in yeast (1) Ringer's solution , yeast again (2) and in glucose solution, over a 30 – minute of observation period . 15 larvae were scored.

		Slope			Intercept		
Activity	conditions	b	S.E	P	I	S.E	P
Locomotion	Yeast(1)	o.o57	± 0.019	< 0.01	23.5	± 0.32	<0.001
	Ringer's	0.462	± 0.034	<0.01	33.8	± 0.65	< 0.001
	yeast (2)	0.037	± 0.021	n.s	26.6	± 0.37	< 0.001
	Glucose	0.0052	± 0.0151	n.s	34.9	± 0.27	< 0.001
feeding	Yeast(1)	0.032	± 0.013	< 0.01	166.7	± 0.25	< 0.001
	Ringer's	1.81	± 0.092	< 0.001	179.9	± 1.58	< 0.001
	yeast (2)	0.018	± 0.028	n.s	159	± 0.49	< 0.001
	Glucose	0.051	± 0.035	n.s	185.8	± 0.54	< 0.001

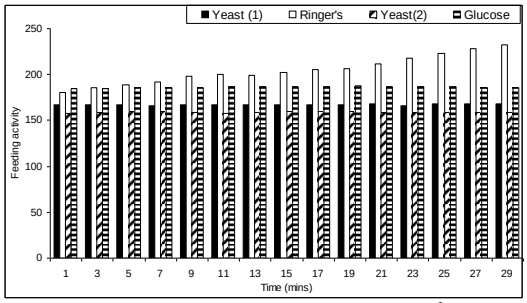

Figure-5- Feeding activity of 3rd instar larvae of ***D. melanogaster*** , wild type . 15 larvae were observed over a 30 minute period on yeast one (1) , Ringer's solution ,yeast again (2) and glucose solution. On each substrate, larvae were scored in each of 15 alternate on minute intervals (see Table three).

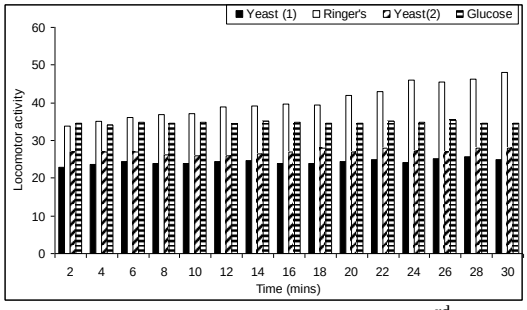

Figure-6- Locomotor activity of 3rd instar larvae of ***D. melanogaster*** , wild type . 15 larvae were observed over a 30 minute period on yeast one (1) , Ringer's solution ,yeast again (2) and glucose solution. On each substrate, larvae were scored in each of 15 alternate on minute intervals (see Table three).

Discussion:

Foraging behavior may be an important factor in determining success in exploiting different kinds of food recourses (17). Foraging pattern depends on different behavioral responses which are directed to maintain the larvae in optimal conditions with respect to food acquisition and growth (21). More recent study suggested that, the mouth hooks dentition play an important role in exploiting different kinds of food recourses and also direct the larvae to distinct environmental conditions with respect to food acquisition in order to maximize the rate of survival and development (1,19). The behavior of a larva in many situations depends on an interaction between external (ecological) and internal (physiological) stimuli. On a uniform substrate of yeast suspension, the larvae exhibit a relatively low level of locomotor activity .It feeds continuously and at a steady rate by scooping activated by cephalophyrangeal movements when larvae move into no food environment, larvae will exhibits an a progressive increase in locomotor activity rate.This behavior is termed as orthokinetic response which is evidently driven by lack of nutritional intake. These conclusions are in agreement with the previous finding of Franklen and Gun (1940), Godoy-herrera (1984), Muhammad-Ali (1990) and Green et al. (1993). When larvae contact with liquid irrespective , of whether this contains nutrients or not, instantly induces scooping movements associated with feeding. For further study, an interesting question , not , asked in this investigation , is :where are the sensors located which mediate the effect ?. Phagokinesis ,is expressed as progressive increase in the rate of feeding movements , it exhibited by larvae in a liquid substrate lacking in nutrients. This can be interpreted as an adaptive behavioral response. But when the larvae move into diluted medium, they will attempt to compensate by increasing their feeding activity, probably as part of "feeding back" mechanism directed to maintain a constant level of food intake. Mean feeding rate of this investigation showed no fixed in the populations but responds to directional selection towards both higher or lower mean feeding rate.This result agrees with Burnet et al. (1977) and Mohammed-Ali (1990). The ability of a larva to increase feeding rate when nutrient supply becomes diluted in order to maintain the rate of food acquisition of some optimum level may be described as a form of homeostasis and would be likely related with ability of larvae to adaptive behavior in fluctuated

environment. Then, orthokinetic and phagokinetic responses of larvae appear to be driven by demand for food. Glucose which serves as an instantly available energy source prevents both kinetic responses. It is not presently known whether other sugars or other nutrients have this effect. This situation is more likely correlated with some physiological factors. One of many interpretations, is that peripheral sense organs, probably in the pharynx or anterior region of gut, which monitor the nutritional intake , are sensitive to depletion of cellular energy , reserves and provide feed back through the nervous system to the centers controlling feeding and locomotor movements . In addition, ***Drosophila*** larvae are thought to release salivary gland secretion onto the surrounding food medium, so that some predigestion of food takes place .Finally, an interesting area for further investigations, beyond the scope of this study are concerned with:

1. How the way in which phagokinetic and orthokinetic responses are coordinated?
2. How these two kinetic responses are genetically determined?

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الأستجابات الحركية وسلوك التغذي ليرقات ذبابة الفاكهة *Drosophila melanogaster*

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الخلاصة:

ربما تكون الاستجابات التكيفية لليرقات على نوعين Taxis-1 (الانجذاب): والذي يتضمن تغييراً في الأتجاه المرتبط مع مصدر الحافز او المنبه Kinesis-2 (التغير الحركي): والذي لا يمتلك عنصر الأتجاه ، لكنه يتضمن تغييرا في معدل الحركه في الأستجابة للحافز او المنبه . لقد ابدت يرقات ذبابة الفاكهة (***Drosophila melanogaster***) مرونة في استجاباتها السلوكية مرتبطا مع ما تستهلكه من غذاء واختيارها ظروف بيئية متباينة . في هذا البحث كان الاهتمام حصرا في الأستجابات الحركية لليرقات عند توفر الغذاء المتغاير . لقد خضعت يرقات الطور اليرقي الثالث للفحص ولمدة ثلاثين دقيقة في اوساط بيئية مختلفة وكما يلي : 1- في ماء مقطر .2- في محلول رنكير .3- في محلول سكر الكلوكوز .4- في عالق الخميرة .في كل حالة وضعت اليرقة في طبقة رقيقة من الماء او المحلول او العالق فوق الجل . في الوسط الخالي من الغذاء (الماء المقطر) ، كان السلوك الشائع لليرقات هو الحركة المرتبطة بحركات تمهيدية للبحث عن الغذاء . وعند توفر الغذاء يتحول السلوك من الحركة الى التغذي عن طريق اخذ الغذاء بصورة متوافقة مع حركة اجزاء الفم (الخطاطيف الفمية mouth hooks). يبقى النشاط الحركي ثابتا في الوسط العالق للخميرة لكنه يرتفع حالما تنقل اليرقات الى وسط فيه محلول رنكير خلال فترة الفحص وهذا مايطلق عليه بالأستجابة الحركية Orthokinesis . وقد ابدت اليرقات ارتفاعا ملحوظا في معدل النشاط الحركي عند نقلها الى وسط محلول سكر الكلوكوز وبقي بمستوى ثابت دونما زيادة تذكر في معدل الأستجابة الحركية . وقد كان معدل النشاط الغذائي ثابتا في وسط عالق الخميرة . في حين لاحظنا استجابة حركية اخرى عندما تكون اليرقات في وسط محلول رنكر والتي اطلقنا عليها المصطلح الأستجابة الغذائية الابتلاعية Phagokinesis . علما ان هذه الأستجابة لم تل حظ عند نقل اليرقات الى وسط محلول سكر الكلوكوز.