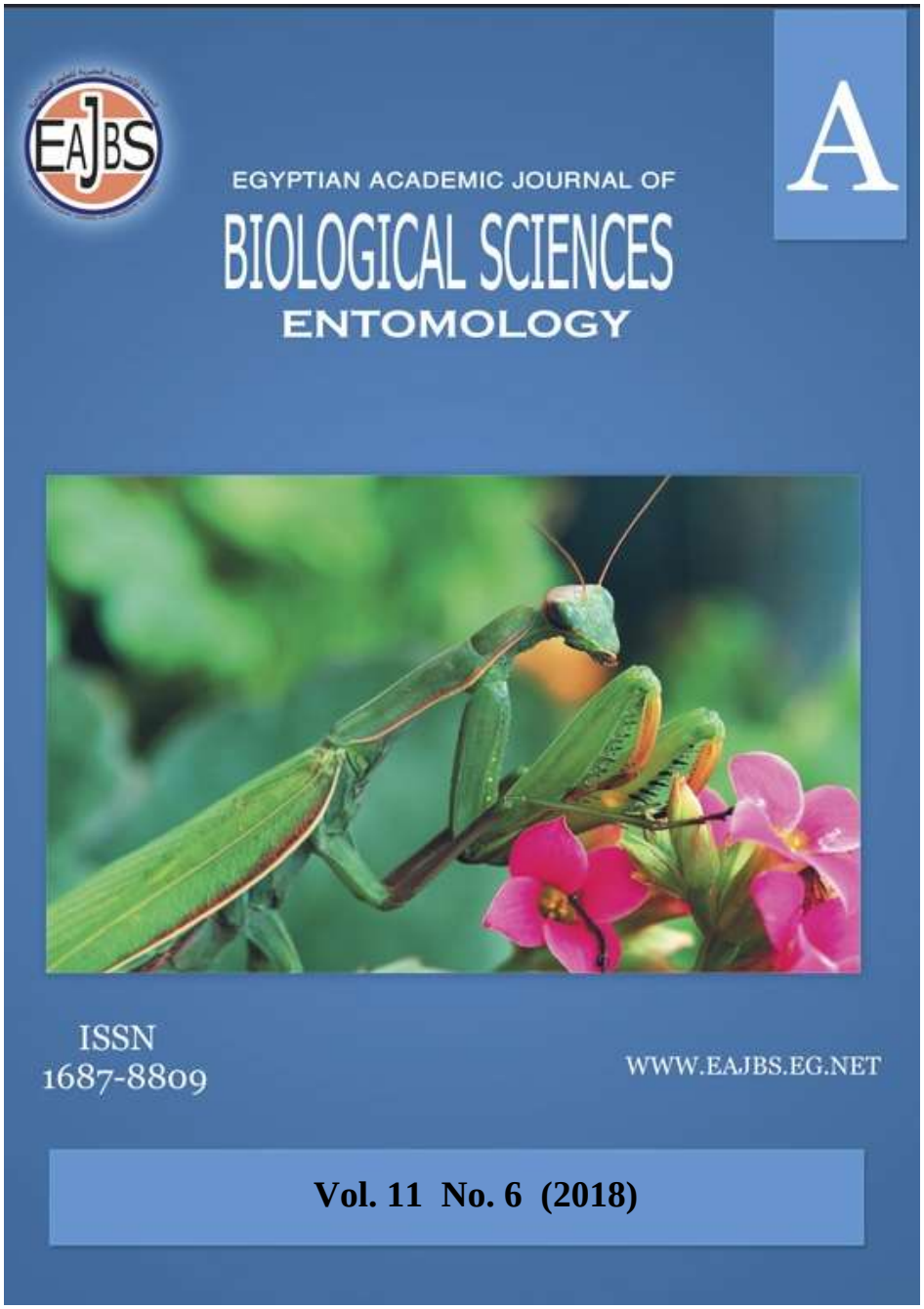

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Food Consumption and Growth Rates with Certain Biological Aspects of Red Palm Weevil, *Rhynchophorus ferrugineus* Olivier Rearing on Sugarcane Stems

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ABSTRACT

The rearing of red palm weevil, *Rhynchophorus ferrugineus* Olivier on sugarcane stems, as substitutive host, to study each of food consumption, growth rates and some biological aspects, detected that the larvae undergo ten instars from egg hatching until construction of cocoon, the total duration after hatching of these instars reached 66.1days, ranged between 58 to 74 days. The lengths of larvae at 10th instars were ranged 47 -56mm, with a mean of 52 ± 3.03mm. The weight of last larval instar reached 6.61 g (ranged 5.8-7.4 g).

Larval growth rate recorded 0.096g/day, adult weevil remains stable through the 1st four weeks of feeding (mean, 1.244 g) and decreased afterward during the 5th and 6th weeks of feeding (mean, 1.128 and 0.956 g, respectively).

The acquired weight of larvae has differed with the variation in weight of larvae. The percentage of larval weight gain varied from 49.76 (for 2 g / larva) to 7.93% (for 5 g / larva).

Total weight of food consumption during successive growth periods (55days) recorded 83.18 g / larva. Daily consumption recorded 10.37 g during the feeding period, with a rate of 1.5 g / larva.

INTRODUCTION

Red palm weevil, *Rhynchophorus ferrugineus* (Olivier), is the most dangerous and important destructive borer to the palm trees cultivated in different Egyptian governorates.

This weevil is an invasive pest to palm trees in many countries. The origin of this pest was South East of Asia (Pakistan, India, Burma, Pengaladish and Indonesia) and spread later in the other countries (Iran, Iraq, Saudi Arabia, Emirates) and recorded for the first time in Egypt by Saleh (1992). The weevils attack the top, bottom or middle of the palm tree in any stages of growth Brand,(1917), Batt and Girgis (1996) found this pest in Sharkyia, Ismailia and Qaluobuia governorates (Egypt), also Batt (2004) found that the infestation was observed on different heights of palm trunk, however, most infestation were noticed on the lower part of about 2m. and few were apical, larvae bore tunnels in all directions, but the most run with the

inner fibers of palm and upward.

The red palm weevil occurred in banana and palm trees and its larvae were occasionally found stems of sugar cane (Muir and Swezey, 1916). This weevil was commonly found damaging coconuts trees in Ceylon (Henery, 1917) in Java and Sumatra (Leefmans, 1920); in Philippines (Hernandez, 1921); in Ceylon (Huston, 1922), (De Mel, 1928), (Jepson, 1932); in India (venKatsubba Iyer, 1940), (Nirula, 1956); in Thailand (Vestal, 1956). Rahalkar et al.(1972) in India found that sugarcane stems were a good substitute for pieces of raw coconut fruit for mass rearing of the coconut pest *R. ferrugineus* (Olivier), also Rahalkar et al.(1978) developed on artificial diet for mass rearing of the red palm weevil *R. ferrugineus* pest of coconut and other palms and also of sugarcane in India, also Rahalkar et al.(1985) reared this pest on sugarcane and artificial diet. Rananavare et al. (1975) used freshly shredded sugarcane stem tissue backed in perforated boxes as a site for oviposition and a source of food for adults and larvae of *R. ferrugineus* weevil.

Kaakeh, (2005), in United Arab Emirates, carried out mass rearing of RPW on both the natural diet and artificial diets, these diets were based on each of sugarcane, palm heart, palm leaf base, oat, potato, pineapple, oat-palm fiber sheath, oat-potato and oat-pineapple.

In Egypt, some attempts were executed to rear RPW on other non- host plants, these plants were sugarcane stems, corn stems, sweet potato tubers, carrot roots, apple fruits, dasheen, banana stems, cabbage stems, turnip tubers, table beet, potato tubers, squash fruits, colocasia and kaki fruits, the insect could complete its life cycle and produced new generations on five former plants (Hussein, 1998). The same author found that the sugarcane stems gave the shortest larval period and produced the highest number of eggs/female and highest emergence percentages, while carrot roots showed the longest larval period and gave the minimum emergence percentages, whereas the carrot roots produced the minimum number of eggs/ female.

Also, Abd-EL-Azim et al.(2009)(a&b) carried out certain studies and influence of feeding with various concentrations of cane sugar on some biological aspects of red palm weevil *R. ferrugineus*.

The current work was carried to study certain biological aspects of RPW, *R. ferrugineus,* the effect of feeding with sugarcane stems on weights of adults and rate of larval growth as well as food consumption of larvae during various periods of developmental stages on sugarcane stems.

MATERIALS AND METHODS

Cocoons of red palm weevil *R. ferrugineus* were collected from severely infested palm trees cultivated of Tenth of Ramadan district, Sharkyia governorate during April 2018. The cocoons were placed in plastic containers and transferred to the laboratory at wood boring research department, Plant Protection Research Institute, Dokki district, Giza governorate.

The containers were covered with a muslin cloth (or perforated plastic covers) and left under laboratory conditions closed observations and daily extermination was made until the weevil emerged from cocoons. The emerged weevil was collected and sexed.

Each one couple of RPW (30 replicates) was placed on cutting (internodes) of sugarcane stem in a plastic box covered netting wire under laboratory conditions. The boxes were continuously observed and examined until egg oviposition and larvae hatched. The hatching larvae used to make laboratory rearing on sugarcane stalks (stem) to determine some aspects of larval growth such are, duration of larval instars, length and weight of larvae during different instars and amount of food

consumption during the developmental stage of larvae. The continued inspection was made, the number and duration larval instars estimated by the number of exuviae and date of moulting until beginning the construction of cocoons.

To determine the amount of consumed food, 30 larvae were weighted and each larva was planted in one sugarcane cutting (about2.5cm diameter), its weight was estimated before the cultivation of larva. Sugarcane cutting was longitudinal divided in half and gathered by elastic bands to facilitate the internal examination for larvae. The larvae were weighted at the end of each instar, the increase in larval weight was estimated of each instar.

The weight of sugarcane cutting was calculated before the cultivation of larva and at feeding end, the weight of consumed food was determined. Fifteen intact sugarcane cuttings were left under laboratory condition during the different periods of larval breeding and deficiency in moisture content was estimated. The corrected weight of food consumption was determined.

The effect of feeding on weight of adult weevil during various periods was studied, thus 25 weevils were weighed and fed on peeled sugarcane cuttings placed in plastic containers covered with perforated plastic covers, the weevils were weighed after different periods of feeding, the obtained weights of weevils at different periods were compared with the other primitive weights to determine the increase in weighted of adult weevils.

To study the acquired weight of larvae resulting from feeding, the larvae with different weights were fed on sugarcane cuttings for various periods and larvae were weighted after feeding periods, the acquired weights were estimated. The daily growth rate and percentage larval again were studied. The statistical analysis for obtained data carried out by SAS program (2001).

The following equations were used to determine some relationships between different aspects of larvae growth and food consumption, these are:

- **Lost weight of Moisture content** (LWMC)
  = weight of intact sugarcane cuttings at beginning experiment – weight of sugarcane at the end of experiment. (for instar duration) = g
- **Daily rate of Lost moisture content**= $\frac{\text{LWMC}}{\text{No. feeding days}}$ = g/day
- **The larval acquired weight (LAW) = (increasing in larval weight)** = Weight of larva after feeding - Weight of larva before feeding = g
- **The larval acquired weight (LAW) %** = $\frac{\text{Increasing weight (LAW)}}{\text{Primitive weight}} \times 100$
- **Daily growth rate (DGR**) = $\frac{\text{The larval weight again (LWG)}}{\text{Days number of feeding period}}$ = (g/day)
- **Weight of food consumption =**
  Weight of sugarcane cutting before feeding (Introduced food) – the weight after feeding = g
- **Correct weight of food consumption (CWC) =**
  Weight of food consumption - Lost weight of Moisture content (LWMC) = g
- **Daily consumption Rate (DCR) =**
  $\frac{\text{Corrected weight of food consumption (CWC)}}{\text{Days number of feeding period}}$ = (g/day)
- **Consumption % =** $\frac{\text{Corrected weight of food consumption (CWC)}}{\text{Introduced food}} \times 100$ =

RESULTS AND DISCUSSION

Certain Biological Aspects of RPW, *R. ferrugineus* rearing on Sugarcane Stems:

Data concerning the duration of larval instars, length and weight of larvae as well as weight gain and larval growth rate for *R. ferrugineus* weevil reared on sugarcane cuttings are illustrated in Table (1).

Ten larval instars were observed for RPW, reared on sugarcane stems, the larval duration until the last instar (10^{th} instar) was ranged 58-74 days, with a mean of 66.1 +4.60 days, the larval length of this instar ranged between 47 to 56mm, with a mean of 52 +3.03mm.

The larval weight was increasing with the increase of acquired weigh, at the last larval instar, the weight acquired recorded 0 82 g and the weight of larva was ranged 5.8 -7.4, with a mean 6.61 + 0.8 g the total increase in weight of larva recorded 6.37 g during the total growth period, which indicates that larval growth rate was 0.096 g/day.

Hussein (1998) found that the mean period of larval development was 47.17days on sugarcane stems, he showed that the duration of larvae fed on trunk piece of palm varieties from 23days on Zaghlol variety to 47.88 days on ornamental dates, while the development of larvae recorded 51.50 days (on sweet potato medium), 72.17 days (on data palm medium), 85.50days (on apple medium) and 117.17 days (on carrot medium). In this respect, Rahalkar et al., (1985) mentioned that the duration from egg to prepupa of RPW was 51 -75 days when the insects reared on sugarcane stems and recorded also that the larval period lasts from 35 to 80days.

Highly significant correlations were recorded between certain biological aspects of RPW, *R. ferrugineus* larvae, Table (2). Values of correlation coefficient "r" were 0.987, 0.999, and 0.837 between duration of larval instars and each of length, weight and larval gain, respectively. A value of "r" was 0.973 between length and weight of larvae.

Table (1) Duration of larval instars, length and weight of larvae of RPW, *Rhynchophorus ferrugineus* reared on sugarcane stems, under laboratory conditions of 28.6-32.2°C and 52.3-72.1 RH.

Larval instars	Items	Duration after Hatching	Larval length (mm)	Larval weight (g)	Feeding period	(LAW)	(DGR)
1^{st}	Range	2-3	4-6	0.17 - 0.26	2.8	0.24	0.086
	M. + SD	2.8 ± 0.42	4.8 ± 0.75	0.24 ± 0.36			
2^{nd}	Range	5-6	6-10	0.44 - 0.53	3.1	0.28	0.090
	M. + SD	5.9 ± 0.32	7.8 ±1.33	0.52 ± 0.04			
3^{rd}	Range	6-9	9-16	0.62 -0.80	2.6	0.24	0.092
	M. + SD	8.5 ± 0.067	12.6 ± 3.01	0.76 ± 0.07			
4^{th}	Range	11-13	17-23	1.06 -1.25	4	0.44	0.11
	M. + SD	12.5 ± 0.61	19.8 ± 1.94	1.20 ± 0.08			
5^{th}	Range	14-21	21-33	1.34 -2.02	6.2	0.65	0.105
	M. + SD	18.7 ± 2.28	27 ±4.15	1.85 ± 0.29			
6^{th}	Range	22-29	28-35	2.13 -2.81	7.9	0.69	0.087
	M. + SD	26.6 ±2.60	31 ± 2.61	2.54 ± 0.33			
7^{th}	Range	30-42	35-40	2.94 -4.12	11.7	1.11	0.095
	M. + SD	38.3 ± 3.80	38 ± 2.10	3.65 ± 0.58			
8^{th}	Range	42-52	38-48	2.16 – 5.15	10.2	1.16	0.114
	M. + SD	48.5 ± 3.19	41 ± 3.79	4.81 ± 0.94			
9^{th}	Range	51 - 63	45 -51	5.1 -6.3	9.3	0.98	0.105
	M. + SD	57.8 ± 3.82	48 ± 2.0	5.79 ± 0.59			
10^{th}	Range	58- 74	47 -56	5.8 - 7.4	8.3	0.82	0.099
	M. + SD	66.1 ± 4.60	52 ± 3.03	6.61 ± 0.8			

Table (2): Correlation values between the duration of larval instars and some biological aspects of RPW *R.ferrugineus* larvae.

Biological aspects Larvae	Duration after hatching	
	Simple correlation (r)	Simple regression (b)
Larval length	0.987	0.703
Larval weight	0.999	0.099
Weight gain	0.837	0.014
Larval length x Larval weight	0.973	0.134

Effect of Feeding with Sugarcane Stems on Weights of Adult Insects of RPW, *R. ferrugineus:*

Data on weights of red palm weevil adults fed on sugarcane stems are clarified in Table (3), these data indicated that all weights of adult weevils weights remain stable through the first four weeks of feeding, also the light weights of weevil (0.7-1.1g) were about stable through its life period , while the heavy weight weevils (1.2 -1.6g) appeared different changes in weevil weights, where the weights were decreased throughout the feeding period (6weeks) from 1.6g to 1.1g, 1.5-0.7 and 1.4-0.8g.The range of primitive weight varied between 0.7 to 1.6g with a mean of 1.24 $\pm$ 0.266, while the last weight (after 6 weeks) were ranged 0.7 -1.3g,with a mean of 0.956 $\pm$ 0.217g.

Table (3): Weight of adult insects of RPW, *R.ferrugineus* feeding on sugarcane stems for different periods

No.	Primitive weight up to (g) 4th week	Replicate	Weight after feeding	
			5weeks	6weeks
1	1.6	2	1.2	1.1
2	1.5	3	1.3	0.7
3	1.4	3	0.9	0.8
4	1.3	5	1.3	1.3
5	1.2	5	1.2	0.8
6	1.1	3	1.1	1.1
7	1	1	1	1
8	0.9	1	0.9	0.9
9	0.8	1	0.8	0.8
10	0.7	1	0.7	0.7
Range	0.7 -1.6	25	0.7 -1.3	0.7 -1.3
Mean $\pm$ SD	1.24 $\pm$ 0.226		1.128 $\pm$ 0.178	0.956 $\pm$ 0.217

Acquired Weight for RPW, *R. ferrugineus* Larvae with Different Weights Various Feeding Periods:

The acquired weights of RPW larvae with various weights rearing on sugarcane cuttings for different periods are illustrated in Table (4)

The acquired weights of RPW larvae have differed with variations in larval weights and feeding periods. The means of acquired weights for larva recorded 1.14, 0.56, 0.58 and 0.4 g at larva weights of 2, 3, 4 and 5 g levels, respectively. At the same weight levels, the means of daily growth rates were 0.045, 0.028, 0.020 and 0.021g / larva, while the percentages of larval acquired weight were 49.76, 15.65, 13.28 and 7.93% respectively. These percentages were gradually decreased with increasing of larval weight from 2 g to 5 g.

Table (4):The acquired weight and daily growth rate of RPW, *Rhynchophorus ferrugineus* larvae at different weights for various feeding on sugarcane stems.

Larval weight levels (g)	Items	Feeding period (days)	Larvae acquired weight (LAW)	Daily growth rate (DGR)	Larval acquired weight (LAW %)
2	Range	19 - 37	0.6 -1.6	0.032 - 0.068	28.57 - 66.67
	M ± SD	26.2 ± 8.82	1.14± 0.33	0.045± 0.014	49.76± 13.76
3	Range	10 - 32	0.4 - 0.9	0.014 – 0.028	11.11 -25.71
	M ± SD	25.4± 7.86	0.56 + 0.185	0.028 ± 0.0009	15.65 ± 5.27
4	Range	25 - 29	0.3 + 0.8	0.012 -0.028	6.97 -17.02
	M ± SD	27.6 ±1.74	0.58 ± 0.172	0.020 ±0.0006	13.28 ±3.51
5	Range	8 -27	0.1 -0.8	0.013 -0.030	1.85 -16
	M ± SD	18 ± 7.87	0.4 ± 0.24	0.021 ±0.0005	7.93 ± 4.97

Lost Moisture Content from Sugarcane Cuttings:

The lost moisture content of intact sugarcane cuttings which used as a control with the other which used for feeding to determinate the correct weight of food consumption (CWC).

Data in Table (5) showed the rate and weight of lost moisture content from sugarcane cuttings during rearing periods for different larval instars under laboratory conditions at the mean of 32.2°C and 58.7% RH.

Data indicated that lost moisture content from 15 cuttings was 69. 6 g during 4days, while it reached 174 g during 10 days. The daily rate of lost moisture content ranged 0.35 -2.25 g (4-10days), with a mean 1.158 g for 55days with 15 sugarcane cuttings. The data also detected that the total weight of moisture content was 63.69 g during 55days while it recorded 17.37g for 15 sugarcane cuttings

Table (5): Rate and weight of lost moisture content of sugarcane cuttings during different periods under laboratory condition of 32.2°C and 58.7% RH.

Criteria	Range	Mean ± SD	Total weight o moisture	
			55days	15 cuttings
Daily rate of lost t moisture content g/day	0.35-2.25	1.158 ± 0.847	63.69	17.37
Lost weight of moisture content (7treats)	69. 6 -174	136.47 ± 32.79	955.35	

Food Consumption of RPW, Larvae Fed on Sugarcane Stems for Various Periods During Developmental Stages:

Larval feeding for RPW, *R. ferrugineus* on sugarcane stem during developmental stages from hatching until construction of adult cocoon detected the amount of sugarcane consumed by RPW larvae feeding for different periods.

Obtained data (Table, 6) indicated that consumed weight (CWC) of sugarcane stems recorded 1247.6g consumed by 15 larvae (83.18g/ larva), this consumed amount recorded 56.59% of consumption food, with rate 3.77% larva. Daily consumption during feeding period (55days) recorded 10.37 g with rate 1.5 g/ larva, the range of larval consumption / day varied from 0.987g (recorded at the first 4days of feeding) to 1.832 g (recorded at 6^{th} period, representing 8 days feeding, viz. 45 cumulative days).

Table (6): Food consumption of RPW, *Rhynchophorus ferrugineus* larvae fed on sugarcane during various periods of developmental stages

Feeding periods (in day)			Weight of sugarcane (g)			Daily consumption rate (DCR)		Consumption percentage	
			Consumed food	CWC					
P	D	Cu		15 larvae	Larva	15 larvae	Larva	15 larvae	Larva
1st	4	4	128.8	59.20	3.95	14.80	0.987	45.96	3.06
2nd	7	11	289.6	167.8	11.19	23.97	1.598	57.94	3.86
3rd	8	19	300.7	161.5	10.77	20.19	1.346	53.71	3.58
4th	8	27	346.5	207.3	13.82	25.91	1.727	59.83	3.98
5th	10	37	408.2	234.2	15.61	23.42	1.561	57.37	3.82
6th	8	45	359.0	219.8	14.65	27.48	1.832	61.23	4.08
7th	10	55	371.8	197.8	13.19	19.78	1.319	53.20	3.55
Total			2204.6	1247.6	83.18	155.55	10.37	56.59	3.77
M ± SD			314.9 ± 84.8	178.2± 54.3	11.88 ±3.62	22.22± 3.98	1.5 ±0.27		

P =Period - D= Days - Cu = cumulative - CWC = Correct weight of food consumption

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ARABIC SUMMERY

الأستهلاك الغذائى ومعدلات النمو وبعض السمات البيولوجية لسوسة النخيل الحمراء المرباه على سيقان قصب السكر

عبد الغنى محمد بط – محمد عبد الغنى بط – هدى رجب خليل على
معهد بحوث وقاية النباتات- مركز البحوث الزراعية- الدقى – الجيزة- مصر

تربية سوسة النخيل الحمراء على سيقان قصب السكر – كعائل استبدالى – لدراسة الأستهلاك الغذائى ومعدلات النمو وبعض الصفات البيولوجية بينت أن اليرقات تجتاز 10 أعمار من فقس البيض حتى بناء الشرنقة... وبلغت المدة الكلية لهذة الأعمار 66.1 يوم حيث تراوحت بين 58-74 يوم . تراوح طول يرقات العمر العاشر 47-56مم بمتوسط 52مم.. وقد تراوح الوزن اليرقى بين 5.8-7.4 جم بمتوسط 6.61 جم وسجل معدل النمو اليرقى 0.096جم / يوم.
تظل أوزان الحشرات الكاملة ثابتة خلال الأربعه أسابيع الأولى للتغذية (بمتوسط 1.244جم) ثم تتناقص خلال الأسبوع الخامس والسادس للتغذية (متوسط 1.128 ، 0.956 جم على التوالى).
الوزن اليرقى المكتسب يختلف باختلاف وزن اليرقة المغذاة. النسبة المئوية لزيادة الوزن اليرقى اختلف من 49.76% (لليرقات 2جم وزن) الى 7.93% (اليرقات 5جم وزن). الوزن الكلى للغذاء المستهلك خلال فترات النمو(55يوم) سجلت 83.18 جم / يرقة .الاستهلاك اليومى سجل 10.37جم خلال قترة التغذية بمعدل 1.5جم / يرقة.