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EFFECT OF STARVATION ON SOME LIFE HISTORY PARAMETERS OF THE MOSQUITO PREDATOR *SPHAERODEMA URINATOR* (HEMIPTERA - BELOSTOMATIDAE)

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Key words: Starvation-development-survival-reproductive potential-Mosquito predators-Life history-*Sphaerodema urinator*

ABSTRACT

The influence of partial and total starvation on some life history parameters of the mosquito predator *Sphaerodema urinator* was investigated. Newly hatched nymphs starved for 1 or 2 days had longer duration than unstarved nymphs. Nymphs starved for 2 days produced adults with significantly heavier weights than those produced from the check, unstarved, nymphs. The sex ratio of adults deviated towards males when the nymphs were starved for 1 or 2 days. Total starvation gradually reduced the survival potential of nymphs. No nymphs could tolerate starvation for more than 5 days. Starvation of adults for 1 or 2 weeks had no significant effect on their longevity. Adult females starved for 1 or 2 weeks and males starved for 2 weeks had significantly heavier weights than those of

unstarved adults. Starved females had longer preoviposition and postoviposition periods, shorter oviposition period and higher fecundity than unstarved females. Adults were able to tolerate a total starvation for 16 days and without a significant effect on their survival and no males or females were able to tolerate starvation for more than 42 and 37 days, respectively.

INTRODUCTION

Both nymphs and adults of the family Belostomatidae have been reported to feed on a variety of aquatic insects as well as on tadpoles, small snails and fishes (Imms, 1963; Usinger, 1965; Bay, 1967 and Tawfik *et al.*, 1979). The belostomatid water bug *Sphaerodema urinator* is abundant in water pools and canals in Egypt all the year round (Priesner and Alfieri, 1953). High abundance of this bug was observed in many aquatic habitats containing mosquitoes especially those rich at edges with Bermuda grass, that serve as shelter and resting sites for bugs especially juveniles (Abou-Baker, 1984) and it represented the highest population of dominant belostomatid species in many rearing and nursing ponds in Abbasa fish farms, Sharkiya Governorate (Habashy, 1993). It can tolerate higher degree of water pollution and can live in relatively shallow collections of water bodies (Abou-Baker, 1984).

The present work aims at studying the effect of nutrient stress on some life history parameters of nymphs and adults of this predator and to explore the capacity of this promising mosquito control agent to withstand partial or complete starvation when their preys are absent.

MATERIAL AND METHODS

I. Collection and maintenance of the predator (*Sphaerodema urinator*):

Different stages of *S. urinator* (Hemiptera-Belostomatidae) were collected from the field using metallic strainer (20

cm. in diameter), with an aluminum handle (150 cm. long), and reared in glass aquaria under laboratory conditions using the method described by Tawfik *et al.* (1979) and Abou-Baker (1984) with the following modifications. Each aquarium (50 X 35 X 35 cm.) was provided with tap water to a depth of only 10 cm.. Electric wires and floating foam rubber pieces were placed in water for resting and crawling of insects instead of aquatic grasses and plants, used by other investigators, to avoid fermentation of plants and keep water quality. Each aquarium was covered with a perforated plastic cover to prevent insect escape.

II. Maintenance of the prey (*Culex pipiens* mosquito)

A colony of *Culex pipiens* mosquito, taken from a natural breeding place in Benha city was maintained for more than one year in a walk-in insectary at a constant temperature of 27±3°C and 50±5% relative humidity following the method of Abou-Baker (1984) and Ibrahim (1993). Fourth instar larvae from this colony were used as preys for nymphs and adults of *S. urinator*.

1. Effect of partial starvation on the development of the immature stages of the hemipteran predator:

Newly hatched nymphs, were placed in plastic cups (3.5 cm. in diameter and 7 cm. height), containing water to a depth of about 2 cm, and starved for 1 or 2 days, then groups, each of 10 starved nymphs, were transported into plastic cups (12 cm. in diameter and 7 cm. height). A sufficient number of 4th instar *Culex pipiens* larvae was daily provided to each cup. Groups, each of 10 nymphs were treated as previously described, but without starvation and were used as check groups. Each treatment was replicated 5 times. All cups were supplied with pieces of electric wires and floating foam rubber for the insect to crawl on, covered and maintained in temperature controlled cabinets at 25±2°C and 16:8 (Light/dark) photo period/24 hours, provided by 5 watt electric lamps controlled by time switches. All cups were observed daily at the same time until adult emergence. Duration and mortality of each nymphal instar, as well as the sex ratio and weight of emerged adults were recorded.

2. Effect of total starvation on the survival potential of nymphs:

Twenty, newly hatched, nymphs were kept individually in plastic cups (3.5 cm in diameter and 7 cm height) containing water to a depth of about 2 cm, without any food until death of all insects. Another group of twenty nymphs were treated as previously described but nymphs were provided with a sufficient number of 4th instar *Culex pipiens* larvae (10 larvae/day/cup). Mortality was daily recorded in both groups at the same time. All cups were maintained as described viz.1.

3. Effect of partial starvation on some biological aspects of the adult stage:

To study the effect of partial starvation on the development and sexual maturation of *S. urinator* adults, newly emerged adults were sexed and placed individually in plastic cups (3.5 cm in diameter and 7 cm height) half filled with tap water and starved for 1 or 2 weeks, then one male and one female were paired together and were daily provided with sufficient number of 4th instar *Culex pipiens* larvae. Another group of sexed and paired adults was similarly treated, but without starvation and was used as a check group. Each treatment was replicated 20 times. All cups were maintained as described viz.1. The weights of males and females were recorded after 15 days of initiation of the experiment.

4. Effect of total starvation on the survival potential of adults:

To study the effect of total starvation on the survival potential of *S. urinator* adults, an experiment was designed in the same manner made for nymphs except that newly hatched adults of both males and females were used instead of nymphs. Twenty, newly emerged adults, were kept individually in plastic cups (3.5 cm in diameter and 7 cm height) half filled with tap water, without any food until death of all insects. Another group (20 insects from each sex) was daily provided with sufficient number of 4th instar *Culex pipiens* larvae (30 larvae/

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day/cup). Mortality was daily recorded at the same time for all groups. All cups were maintained as described viz.1.

RESULTS AND DISCUSSION

1. Effect of partial starvation on growth and development of nymphs

The mean duration for the unstarved nymphs, was significantly shorter than those starved for one ($P < 0.05$) or two days ($P < 0.01$) (Table, 1). This increase in duration, as a result of starvation, occurred actually in the 1st nymphal instar, as the duration of the 2nd, 3rd, 4th and 5th nymphal instars was relatively similar in all treatments. The 1st nymphal instar starved for one or two days takes more time to reach the 2nd instar, but when food was provided, normal growth and development was initiated after a short recovery period. An increase in the duration of starved insects was observed in the homopterous *Panolis flammea* by Leather (1983).

Our results (Fig. 1) also showed that the 1st nymphal instar could tolerate starvation for 2 days without a significant effect on the survival of the nymph stage. This may be due to the presence of metabolic reserves in newly hatched nymphs.

The weight of females emerging from nymphs starved for two days was significantly ($P<0.05$) greater than the weight of females emerging from unstarved nymphs whereas, the recorded increase in weight of males starved for 2 days as well as males and females starved for 1 day was not significant. Starvation of nymphs for 2 days may stimulate or activate some metabolic pathways in females only, so when food was provided with a sufficient amount, food consumption, utilization and reservation may be better in prestarved individuals. This explanation can be supported by our results (Abou El-Ela *et al.*, 1996) which indicated that after starvation, nymphs consumed significantly more preys specially during the 1st and 2nd days of feeding.

The sex ratio of adults (Table, 1) deviated towards males when newly hatched nymphs were starved for 1 or 2 days. This difference in sex ratio may be a consequence of difference in sex related

mortality rather than the result of direct selection for a deviated sex ratio.

2. Effect of total starvation on the survival potential of the nymphal stage:

The survival potential of *S. urinator* nymphs gradually decreased during the 1st and 2nd days of starvation (Fig, 2). Mortality greatly increased during the 3rd day to reach 58.6% and no nymphs could tolerate starvation for more than 5 days. The ability of nymphs to tolerate starvation during the first 2 days of their life may be due to the presence of metabolic reserves at hatching. Later on, these metabolic reserves greatly decrease and mortality increase to reach the peak during the 3rd day of starvation. Few nymphs were able to tolerate starvation for 4 or 5 days after which all nymphs died.

3. Effect of starvation on some biological aspects of adult stage

Our results (Table, 2) revealed that adults of *S. urinator* could tolerate starvation, without a significant effect on their longevity, for a period of one or two weeks. This could be attributed to the presence of metabolic reserves accumulated during the nymphal stage.

Females starved for 1 or 2 weeks and males starved for 2 weeks had significantly ($P<0.05$) greater weights than unstarved females and males. The reason for this is unknown but it may be due to stimulation or activation of some metabolic pathways which may lead to a corresponding increase in food consumption and body weight. Again, this explanation may be supported by the finding of Abou El-Ela *et al.* (1996), that the number of *Culex pipiens* larvae consumed during a period of 10 days by adults prestarved for 2 weeks was greater than the number consumed by unstarved adults. The weight increase in prestarved adults was more apparent in case of females. This might be a sex related factor.

Females starved for 2 weeks had significantly ($P<0.001$) longer preoviposition period than

those starved for 1 week and unstarved females (Table, 2). In the mean time, the oviposition period of females starved for 2 weeks was significantly ($P<0.01$) shorter than that of the check, unstarved, females. Consequently the post oviposition period of females starved for 2 weeks was significantly ($P<0.05$) longer than that of the unstarved females. The difference in oviposition or postoviposition periods between females starved for 1 or 2 weeks was insignificant.

The relatively long preoviposition period of starved females may indicate that gonadal development is lagged behind somatic development. Ward *et al.* (1983) suggested that species with high reproductive investment have low resistance to starvation. Consequently, starved *S. urinator* should allocate the available resources mainly to maintenance at the expense of reproduction. A strategy that favors the maintenance enables nutritionally stressed insects to adjust their activities to the resources available at a given time (Clements and Boockock, 1984).

The number of egg rafts produced/female and the total number of eggs produced/female significantly decreased in case of starved females. In most insect species starvation of adult females suppresses their fecundity and often the primary cause is not a nutritive deficiency but a hormonal one involving the Corpora allata (Johansson, 1955 and Engelmann, 1970). In adult *Shistocerca gregaria* direct evidence was presented showing that starvation suppresses the Corpora allata activity (Tobe and Chapman, 1979).

Females starved for 1 weak produced significantly ($P<0.001$) more eggs/raft than unstarved females. No significant difference was found in the incubation period or egg hatchability of the starved and unstarved females. It may be concluded that the effect of starvation on sexual maturation, fecundity and fertility of females is interacting and additive but the most apparent effect of starvation is a retardation in sexual maturation and a decrease in fecundity whereas fertility and incubation period of eggs were not greatly affected.

4. Effect of total starvation on the survival potential of adults.

Males and females of *S. urinator* were able to tolerate complete starvation for about 16 days, without a significant effect on their survival (Fig. 3), then, the survival potential of starved males and females gradually decreased with the increase of starvation period. No males or females could tolerate starvation for more than 42 and 37 days respectively. The ability of adult *S. urinator* to tolerate starvation for a long period is important, if this predator is to be used in a biological control program against mosquitoes. The difference in survival between males and females may be attributed to an increase in the amount of energy required by females or to other sex related factors. It can be concluded that, the ability of adult *S. urinator* to tolerate starvation for this relatively long time (16 days), may be of great value in the field of biological control of mosquitoes since adults can be stored and/or transported safely until released in the breeding places of mosquitoes where they can tolerate starvation if the prey is scarce or absent.

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Table (I) Duration of nymphal instars, sex ratio and weight of adults of *S. mahatar* emerged from nymphs prestarved for one or two days (at 25 ± 2 °C and 16 L: 8 D photoperiod).

Days of starvation	Duration of nymphal instars (in days) Mean* ± S.E.						Adult weight (in grams) Mean* ± S.E		Sex ratio
	1 st	2 nd	3 rd	4 th	5 th	Total average	Male	Female	Female : Male
0	4 ± 0.27	4 ± 0.46	3.4 ± 0.18	4.5 ± 0.36	9 ± 0-.39	25.8 ± 0.8	0.1318 ± 0.0033	0.1451 ± 0.0032	1 :1.5
1	4.81a ± 0.33	4.06 ± 0.18	3.5 ± 0.18	4.6 ± 0.28	9.2 ± 0.12	27.5a ± 0.8	0.1332 ± 0.0072	0.1479 ± 0.0023	1 : 1.62
2	5.7c ± 0.24	4.5 ± 0.33	3.5 ± 0.27	4.7 ± 0.25	9.8 ± 0.15	30.2b ± 0.41	0.1366 ± 0.0021	0.1503a ± 0.009	1 : 1.95

* Each treatment was replicated 5 times.
Significant a:(P> 0.05) b: (P> 0.01) c: (P> 0.001)

Table (1): Duration of nymphal instars, sex ratio and weight of adults of *S. littoralis* emerged from nymphs prestarved for one or two days at 25±2 °C and 16 L: 8 D photoperiod).

Days of starvation	Duration of nymphal instars (in days) Mean* ± S.E.						Adult weight (in grams) Mean* ± S.E		Sex ratio
	1st	2nd	3rd	4th	5th	Total average	Male	Female	Female : Male
0	4 ± 0.27	4 ± 0.46	3.4 ± 0.18	4.5 ± 0.36	9 ± 0-.39	25.8 ± 0.8	0.1318 ± 0.0033	0.1451 ± 0.0032	1 :1.5
1	4.8a ± 0.33	4.06 ± 0.18	3.5 ± 0.18	4.6 ± 0.28	9.2 ± 0.12	27.5a ± 0.8	0.1332 ± 0.0072	0.1479 ± 0.0023	1 : 1.62
2	5.2c ± 0.24	4.5 ± 0.33	3.5 ± 0.27	4.7 ± 0.25	9.8 ± 0.15	30.2b ± 0.41	0.1366 ± 0.0021	0.1503a ± 0.009	1 : 1.95

* Each treatment was replicated 5 times.

Significant a:(P> 0.05) b: (P> 0.01) c: (P> 0.001)

Table (2) Effect of adult* starvation on some biological aspects of *Sphaerodema urinator*

(at 25± 2 °C and 16 L : 8 D Photoperiod)

Weeks of starvation	Sexual maturation Mean• ± S.E. (In days)			Fecundity Mean• ± S.E.			Mean• ± S.E. of			Adult weight• (in grams) Mean• ± S.E.		Longevity (in days) Mean• ± S.E.	
	Pre ovi-posi-tion period	Ovi-posi-tion period	Post ovi-posi-tion period	No of egg rafts/ female	No of eggs/ raft	No of eggs/ female	Successive intervals between egg rafts (days)	Incu-bation period (in days)	Fert-lity %	Male	Female	Male	Female
0	7.4 ± 0.004	53.1 ± 6.33	8.7 ± 1.29	9 ± 0.55	47.16 ± 1.34	434.1 ± 24.12	6 ± 0.18	9.15 ± 0.4	88.01	0.1358 ± 0.008	0.165 ± 0.005	119.2 ± 10.24	69.2 ± 4.28
1	15.7c ± 0.9	49 ± 4.94	9.6 ± 1.65	7.1 ± 0.89	65.92c ± 3.3	460.3 ± 42.84	7.88a ± 0.77	8.77 ± 0.37	90.79	0.1345 ± 0.0015	0.177a ± 0.0031	108.4 ± 11.48	66.6 ± 6.19
2	20.16c ± 2.1	37b ± 2.2	10.4a ± 1.13	6.2c ± 0.51	50.36 ± 2.96	339.4c ± 18.8	6.16 ± 0.9	9.2 ± 0.34	87.17	0.1492a ± 0.002	0.184a ± 0.0085	112a ± 8.45	67.8 ± 7.87

* Newly emerged adults were used.

• Weight was measured after 15 days of feeding.

• Each treatment was replicated 5 times.

significant a: (P> 0.05) b: (P> 0.01) c: (P> 0.001)

Fig.(1) Mortality % among different nymphal instars of *S. avinoior* starved at the early time of stage for 1 or 2 days (at 25 ± 2 °C and 16 L: 8 D Photoperiod).

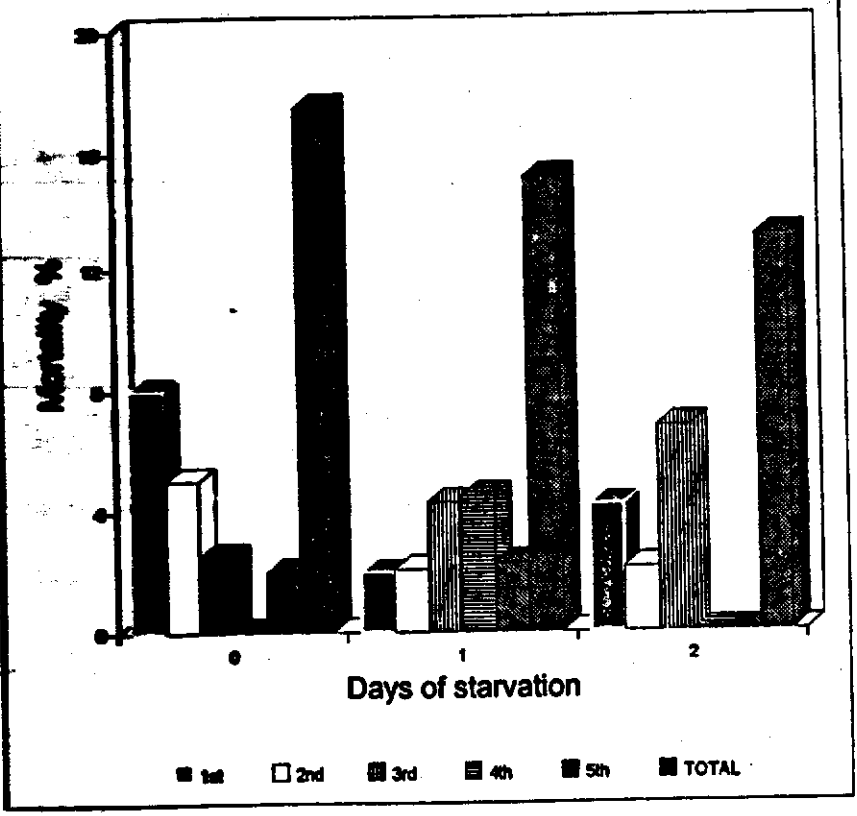


Fig.(1) Mortality % among different nymphal instars of *S. urinator* starved at the early time of stage for 1 **or 2 days** (at 25 ± 2 °C and 16 L: 8 D Photoperiod).

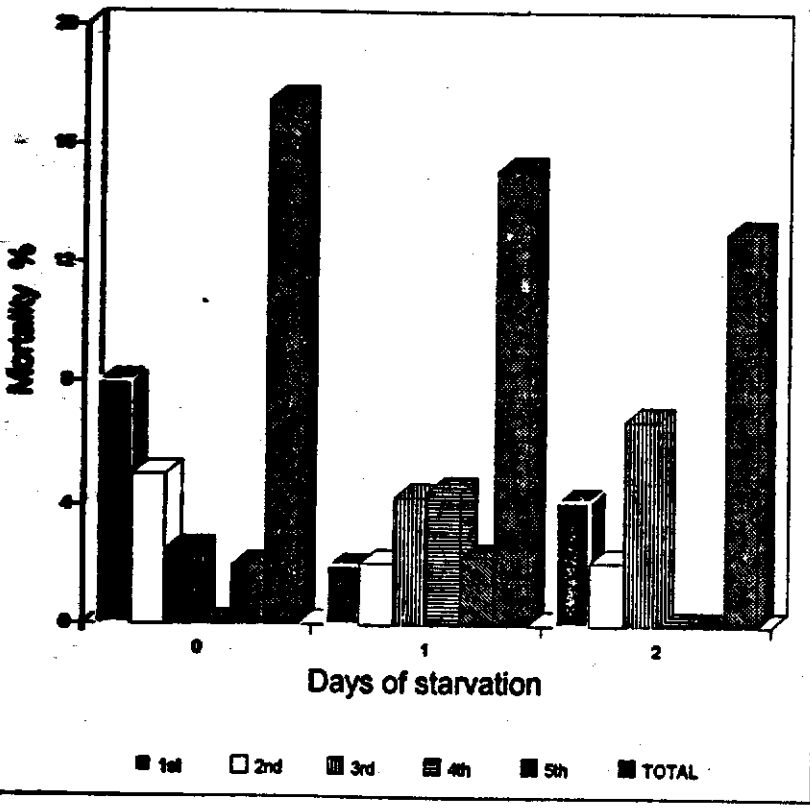


Fig. (2) Effect of total starvation on the survival potential of the 1st nymphal instar of *S. urinator* (at 25 ± 2 °C and 16 L: 8 D Photoperiod).

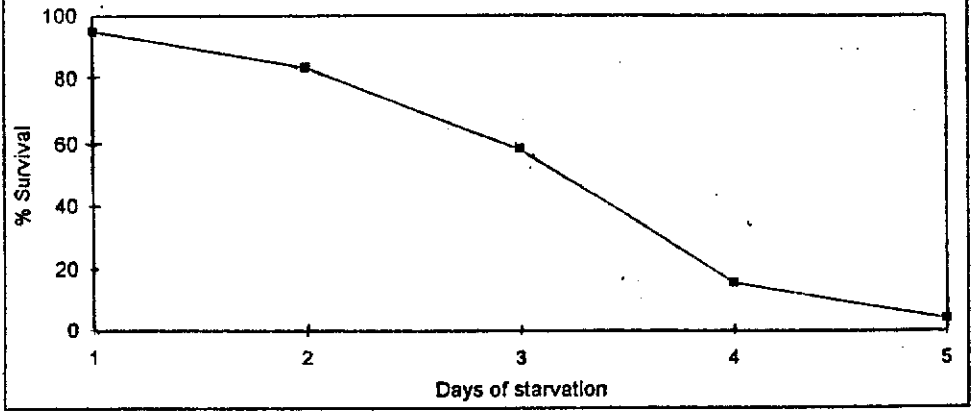
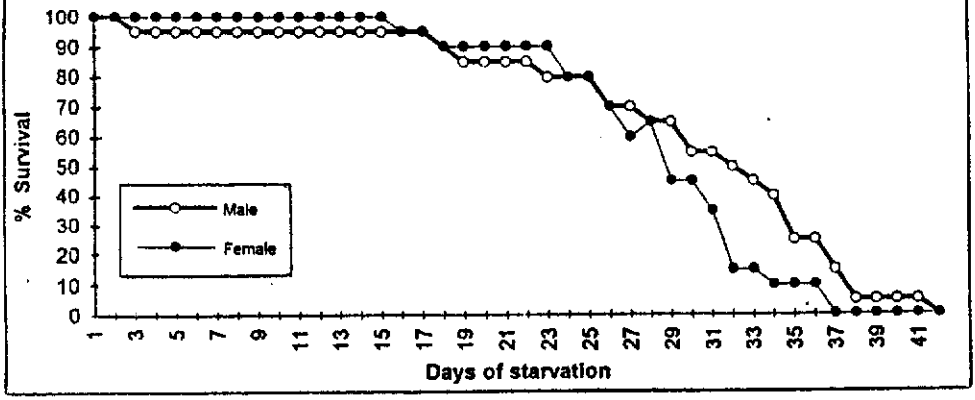


Fig. (3) Effect of total starvation on the survival potential of adult *S. urinator* (at 25 ± 2 °C and 16 L: 8 D Photoperiod).



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أثر التجويع على بعض مظاهر الحياة فى مفترس البعوض

سفيروديما يوريبنيتور (هيمبترا - بيلوستوماتيدى)

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تم دراسة أثرالتجويع الجزئى والكلى على بعض مظاهر الحياة فى حشرة *سفيروديما يوريبنيتور* المفترسة للبعوض . وتبين أن الحوريات التى تعرضت خلال طورها الحورى الأول للجوع ولمدة يوم أو يومين قد نمت أبطأ من الحوريات التى لم تتعرض للجوع . كما تبين زيادة أوزان الأفراد البالغة الناتجة من الحوريات التى تم تجويعها لمدة يومين خلال طورها الحورى الأول . وتبين أيضا زيادة نسبة الذكور عن الإناث فى الأفراد البالغة الناتجة من الحوريات التى تعرضت للجوع . وقد أدى التجويع الكامل للحوريات إلى الحد من قدرتها على الحياة ولم تتمكن أى من الحوريات تحمل الجوع لمدة تزيد على خمسة أيام . وبينت النتائج أن الأفراد البالغة تستطيع تحمل الجوع لمدة أسبوع أو أسبوعين وبدون أثر معنوى على طول فترة حياتها ، وقد تميزت هذه الأفراد بطول فترات ماقبل ومابعد وضع البيض وقصر فترة وضع البيض وزيادة الخصوبة مقارنة بالإناث التى لم تتعرض للجوع . وقد إستطاعت ذكور وإناث الحشرة تحمل الجوع التام لفترة بلغت ١٦ يوما وبدون أثر معنوى على فترة حياتها ثم قلت القدرة على تحمل الجوع تدريجيا بزيادة فترات التعرض للجوع ، وبلغت أقصى فترة تحمل للجوع فى الذكور ٤٢ يوما وفى الإناث ٣٧ يوما .