

Effects of Larval Population Density on the Life Cycle of Flesh Fly, *Wohlfahrtia nuba* (Wiedemann) (Diptera: Sarcophagidae)

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Abstract. Different larval densities have revealed that growth is directly proportional to their numbers in their rearing jars. While developmental time for pupal stage have inverse relationship with larval population density of both sexes. Survival percentage of the larval and pupal stages were unchanged by the increase of larval population density. Larval population density had no effect on adult sex ratios. Puparial and adult weights responded inversely with the density for both sexes. Adult weight of males was less than those of females.

Key Words: Insecta, Sarcophagidae, *Wohlfahrtia nuba*, development, population

Introduction

The flesh fly, *Wohlfahrtia nuba* (Wiedemann) is largely distributed in Africa and Asia (Buttiker *et al.*, 1979 and Amoudi, 1993a). The genus *Wohlfahrtia* is known for causing severe intestinal and cutaneous myiasis in man and animals. Morsy and Soliman (1976) reported human traumatic myiasis due to this insect. El-Boulagui *et al.*, (1983) had reported 25 cases of aural myiasis from which 28% were belonging to this genus. Larvae of *W. nuba* were found to infest wounds of animals, particularly camels in northern Africa (Salem, 1938 and Lewis, 1955). At the same time, small number of larvae of this species have also been reported from a dead dog (Roubaud, 1914). Few studies have been conducted on the biology of *W. nuba* (Amoudi, 1993b; Khedre, 1998). Amoudi (1993b) described the effects of temperature on developmental time and weight of this species.

The larvae of flesh flies may breed in carrion, excrement or decaying organic matter (Amoudi *et al.*, 1992; Al-Misned, 2000; Al-Misned *et al.*, 2001). Some of them have been reported as parasites on snails, turtles and tortoises (Kripling, 1937; Nair, 1968). The natural history of carrion flies (Calliphoridae and Sarcophagidae) is thought to include an intense competition for larval food (Wells and Greenberg, 1992a). A carcass typically receives many eggs or larvae even more than the available food support (Holdaway, 1930; Salt, 1932; Fuller, 1934; Kneidel, 1984), and the resource is typically consumed within one generation time of the arthropods involved. The experimental exclusion of some species from carrion has resulted in an increase in competitor populations (Denno and Cothran, 1976; Wells and Greenberg, 1992b). Consequently, the food competition is a chief factor controlling populations.

The present study was carried out to examine the effect of larval population levels on the developmental time of the flesh fly *W. nuba* including its effect on larval and pupal survival.

Materials and Methods

Larvae of *W. nuba* were obtained from Wadi Haniffa, Riyadh City and the colony has also been maintained at 25 ± 1 °C, 65-70% RH, and a 15:9 (L: D) h photoperiod in the Department of Zoology, College of Science, King Saud University at Riyadh.

Hatched first instar larvae (0-2h old) were transferred individually to 15 g ground beef contained in 250ml jars to give levels of 20, 40, 60, 80, 100, 120, 180 and 200 larvae per jar. After 4 days the media were covered with 3-4 cm. deep sawdust which moistened by distilled water.

The rearing jars were covered by clothes allowing ventilation. Two replicates (jars) were used for each larval level. All larval sets were kept at the similar physical conditions.

Larvae were checked during wandering phase through the sawdust at 12 h intervals until pupation to determine the total larval developmental time. For each group, the fresh pupae were daily collected, isolated, counted and weighed using Ac-100 balance (Mettler Instrument, Zurich, Switzerland; accuracy, 0.1 mg) and kept in clean jars provided with moistened sawdust until the emergence of adult. The pupal developmental time was recorded upon the adult emergence, flies were etherized lightly, sexed and weighed.

Statistical analyses were conducted using the MINITAB computer program. Relationship between developmental time, survival and weight at one hand and different larval densities per jar on the

other hand were calculated using correlation coefficient. For univariate models significance of the correlation coefficient, r , was tested with analysis of variance (Edwards, 1985). Student's t test was also used to compare males and females for some biological parameters.

Results and Discussion

Developmental time. The time required for the development of *W. nuba* larvae and pupae at different levels of larval population density are shown in Table (1). The total larval developmental time increased as a function of increasing larval population density. There were significant correlations between total larval developmental time among the different levels of larval population density applied in the present study ($r=0.91$, $p<0.01$) for males and ($r=0.85$, $p<0.01$) for females. These results agreed with those obtained by Ulliyet (1950) for sheep blowfly and Kamal (1958) for many species of calliphorid and sarcophagid flies. They demonstrated that a critical food shortage tended to increase the duration of the larval stage. Sullivan and Sokal (1963) examined house fly and Omar (1992) tested *Chrysomya albiceps* and they found that the duration of larval development was extended as larval population density increased. In Mediterranean fruit fly, population ranging in density from 1-15 eggs per cm^2 , the duration of the larval development is extended from 24 to 29 days as population density increased (Martinez- Beringola, 1966). In case of *Drosophila* larvae, Singh (1940) for *Drosophila melanogaster* and Amoudi *et al.* (1993) for *Zaprionus indianus* indicated that the time spent in larval instars is prolonged by increasing levels. While in *Chrysomya megacephala* and *Chrysomya rufifacies* Goodbrod and Goff (1990), observed that the larval develop-

Table 1. Developmental time (days) of *W. nuba* immature life stages at different larval densities and $25 \pm 1^\circ\text{C}$, 65-70% RH and 15:9 (L:D) h photoperiod.

Larval densities (n)	Stages, Mean \pm SE							
	Larva		Pupa		Total		$\delta + \text{♀}$	
	δ	♀	δ	♀	δ	♀		
20	7.4 \pm 0.27	7.2 \pm 0.17	14.0 \pm 0.00	14.2 \pm 0.09	21.4 \pm 0.27	21.4 \pm 0.23	21.4 \pm 0.17	
40	7.2 \pm 0.09	7.5 \pm 0.19	14.0 \pm 0.00	14.4 \pm 0.17	21.2 \pm 0.09	21.9 \pm 0.25	21.6 \pm 0.16	
60	7.2 \pm 0.18	7.4 \pm 0.11	14.5 \pm 0.14	14.5 \pm 0.11	21.6 \pm 0.22	22.0 \pm 0.09	21.8 \pm 0.11	
80	7.7 \pm 0.19	7.2 \pm 0.10	14.5 \pm 0.08	14.4 \pm 0.07	22.1 \pm 0.21	21.6 \pm 0.13	21.8 \pm 0.12	
100	7.5 \pm 0.10	7.5 \pm 0.10	13.6 \pm 0.17	13.3 \pm 0.14	21.3 \pm 0.26	20.7 \pm 0.22	21.0 \pm 0.17	
120	8.3 \pm 0.13	8.5 \pm 0.10	13.4 \pm 0.10	13.0 \pm 0.09	21.8 \pm 0.18	21.6 \pm 0.13	21.6 \pm 0.11	
180	8.5 \pm 0.09	8.5 \pm 0.07	12.5 \pm 0.06	12.6 \pm 0.05	21.0 \pm 0.10	21.1 \pm 0.08	21.1 \pm 0.06	
200	8.5 \pm 0.09	8.4 \pm 0.08	12.0 \pm 0.10	12.1 \pm 0.08	20.5 \pm 0.16	20.5 \pm 0.13	20.5 \pm 0.10	
Overall Mean \pm SE	7.8 \pm 0.20	7.8 \pm 0.21	13.6 \pm 0.32	13.6 \pm 0.33	21.4 \pm 0.17	21.4 \pm 0.19	21.4 \pm 0.16	

mental period is shortened by increasing density. Ping -Man and Dudgean (1989) reported that the duration of larval development of *Hemipyrellia ligurriens* declined when competition was intense at high larval densities. In flesh fly, *Bercaea cruentata* (Al-Misned *et al.*, 1999) and *Parasarcophaga ruficornis* (Al-Misned, 2002), the larval developmental time decreased with decreased larval food weights.

The present data showed the pupal developmental time decreased with increasing population density. This may due to the increase in competition of food. A significant inverse correlation between the larval density and the pupal developmental time ($r=-0.89$, $p<0.01$) for males and ($r=-0.93$, $p<0.01$) for females. Mean total larval and pupal developmental time (combined sexes) was decreased with increasing larval population ($r=-0.72$, $p<0.05$). Such data are in agreement with

those of Al- Misned *et al.* (1999) and Al-Misned (2002), they found in *Bercaea cruentata* and *Parasar-cophaga ruficornis*, that the pupal and the total developmental time decreased with the decrease of larval food weights. On the other hand, Scheiring *et al.* (1984) found that the increase in crowding of *D. melanogaster* larvae delayed the emergence of flies and expanded the emergence period. In case of mosquito larvae, Terzian and Stahler (1949) for *Anopheles sp.* and Ikeshoji (1965) and Ikeshoji and Mulla (1970a and b) for *Culex sp.* found that overcrowding conditions generally result in retarded growth.

In the present study no significant differences ($p>0.05$) between the overall mean larval, pupal and total developmental time of both sexes were observed.

Larval duration was 34.1, 34.3, 33.5, 33.9, 35.7, 38.9, 40.3 and 41.0% and for pupae was 65.9, 65.7, 66.5, 66.1, 64.3, 61.1,

Table 2. Survival percentages of the immature stages of *W. nuba* at different larval densities.

Larval densities (n)	Survival %		Adult sex ratio	
	Larva	Pupa	Total	♂:♀
20	95.0	73.3	65.0	1:1.8
40	92.5	62.2	57.5	1:1.3
60	90.3	73.7	70.0	1:1.2
80	91.3	65.8	60.0	1:1.4
100	97.0	64.9	63.0	1:1.4
120	92.1	68.3	62.9	1:1.4
180	86.1	69.7	60.0	1:1.5
200	94.8	70.4	66.8	1:1.3
Overall Mean ± SE	92.4±1.19	68.5±1.43	63.2±1.44	1:1.4

Table 3. Weights of pupal and adult stages (Mean±SE) of *W. nuba* at different larval densities.

Larvae/jar (n)	Pupal wt. (mg)		Adult wt. (mg)		Total biomass /jar (g)
	♂+♀	♂	♀	♂+♀	
20	90.2±0.68	40.8±1.95	60.4±1.27	53.4±2.09	0.748
40	81.3±0.39	36.6±0.22	54.1±0.52	46.5±1.33	1.070
60	82.4±0.73	36.1±0.55	51.4±0.46	44.5±0.91	1.869
80	73.1±0.14	33.3±0.20	42.4±0.16	38.6±0.48	1.853
100	69.2±0.07	33.4±0.41	39.9±1.26	37.2±0.81	2.344
120	55.8±1.03	28.5±1.47	36.1±0.46	32.9±0.74	2.468
180	39.6±0.38	19.4±0.29	27.3±0.35	24.1±0.36	2.603
200	34.0±0.95	16.2±0.86	21.2±0.68	19.0±0.56	2.527
Overall Mean ± SE	65.7±7.29	30.5±3.05	41.6±4.74	37.0±4.06	1.935±0.247

59.7 and 59.0% of the total developmental time (combined sexes) for eight different population densities (20, 40, 60, 80, 100, 120, 180, and 200 larvae per jar/15 g ground beef), respectively. The percentage duration of total developmental time for larvae was increased ($r=0.94$, $p<0.01$) and for pupae was decreased ($r=-0.93$, $p<0.01$) with increasing larval population.

Larval and pupal survival. Data obtained in the present study revealed that larval survival of eight larval densities (Table 2) ranged between 86.1% and 97%. This result did not reflect any decisive effect of larval densities on the percentage of larval survival. Statistical analysis of data in Table (2) revealed that no significant correlation was found between all eight tested levels of larval densities and larval survival percentage ($r=-0.25$, $p>0.05$). Findings of the present study are in agreement with those of Al-Misned *et al.* (1999) and Al-Misned (2002). They found that no significant correlation between larval food weights and larval survival percentage of *B. cruentata* and *P. ruficornis*, respectively.

The percentage of pupal and total survival were not significantly correlated

with population density, ($r=0.06$, $p>0.05$) for pupae and ($r=0.05$, $p>0.05$) for total survival.

The percentage of pupation (Table 2) showed in general a similar trend as that of the larval survival mentioned above. This may show that once the larvae reach their maturity, the rate of pupation is not affected. Data presented in Table (2) showed clearly that larvae which successfully survive produced pupae. Such data are in agreement with those of Al-Misned *et al.* (1999). They found that no significant correlation between larval food weights and pupal and total survival percentage of *B. cruentata*, which was observed by Wells and Greenberg (1992a), who found that the survivorship from egg to adult according to egg density for *C. rufifacies* and *Cochliomyia macellaria* in pure culture revealed no significant effect of density. Also the present findings here are in general agreement and somehow coincident with those of Kelany *et al.* (1989). They found that all tested density levels of *Parasarcophaga argyrostoma* and *C. albiceps* showed no effect on the pupation percentages, and they also added that once

mental period is shortened by increasing density. Ping -Man and Dudgean (1989) reported that the duration of larval development of *Hemipyrellia ligurriens* declined when competition was intense at high larval densities. In flesh fly, *Bercaea cruentata* (Al-Misned *et al.*, 1999) and *Parasarcophaga ruficornis* (Al-Misned, 2002), the larval developmental time decreased with decreased larval food weights.

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Overall Mean ± SE	92.4±1.19	68.5±1.43	63.2±1.44	1:1.4

the larvae reach the pupal stage, the rate of emergence is not strongly affected.

Sex ratio. Data obtained in the present study were examined for any possible relations between larval density and sex ratio. No significant correlation was detected ($r=-0.25$, $p>0.05$) (Table 2). This finding was similar to that observed in house flies (Boggild and Keiding, 1958; Sullivan and Sokal, 1963), blowfly *Calliphora erythrocephala* (Shahein, 1986) and fleshfly *P. ruficornis* (Al-Misned, 2002).

Pupal and adult weights. Data obtained showed generally that the increasing larval population density resulted in a decrease of pupal and adult weights (Table 3). The correlation between the level of crowding and the pupal weight was significant ($r=-0.99$, $p<0.001$). Such data are in agreement with those of Al-Misned *et al.* (1999), and Al-Misned (2002). They found that decrease in larval food weight of *B. cruentata* and *P. ruficornis* resulted in a decrease of pupal weight. Also Kelany *et al.* (1989) found that an increase in larval density of *P. argyrostoma* lead to the same result. They added also that distinguish differences were found between the mean weights of the control pupae of *C. albiceps* (10 larvae/50g fish) and the maximum density of 100 larvae/50 g fish. The present data was also in agreement with those of Zaher and Moussa (1961). They reported that the population density has a great influence of the weight of the pupae when the larval food is limited. Similar results were also found in house flies (Kitaok, 1957; Haupt and Busvine, 1968) and calliphorid flies (Shahein, 1986; Goodbrod and Goff, 1990; Omar, 1992).

The mean adult weights were significantly decreased with increasing population density ($r=-0.99$, $p<0.001$) for both sexes. Moreover, there was a significant differences ($p<0.001$) between adult weights of both sexes at all larval densities.

The mean adult weights of males were smaller than those of females.

From the results obtained in the present study, it is clear that the most favourable larval density ranged between 20 and 60 larvae per 15 g ground beef where the resulting weight of the combined sex were between 44-53 mg. Such data are in agreement in general with that found in *B. cruentata* (Al-Misned *et al.*, 1999), *P. ruficornis* (Al-Misned, 2002), *P. argyrostoma* and *C. albiceps* (Kelany *et al.*, 1989), house flies (Sullivan and Sokal, 1963) and *C. megacephala* and *C. rufifacies* (Goodbrod and Goff, 1990).

The results obtained in this study could be correlated with wild flies where the increase of weight of individual may reflect the decrease of population density.

Total biomass. The total biomass per jar obtained in the present study was significantly correlated with population density ($r=0.88$, $p<0.01$) (Table 3). The increase in total biomass of flies is not a crowding or food shortage effect. Those cultures with more larvae will produce a larger biomass of adults unless the adults are drastically reduced in size. As indicated in Table 3, the weight of flies was slightly decreased. Survival percentage of the larval and pupal stages were not affected by the increase of larval density. This will produce a large biomass of adults with increasing larval density.

Al-Misned *et al.* (1999) found in *B. cruentata* a positive correlation between the total biomass per beaker and larval food weights. Similar results were reported in *P. ruficornis* by Al-Misned (2002).

Concerning *W. nuba* examined in the present study it has been concluded the larval developmental time was increased, the pupal developmental time was decreased. At the same time, decrease in pupal and adult weights in response to larval population density was also detected,

while the survival percentage of the larval and pupal stages was not affected. In contrast, Collins (1980) found that all individuals of shore fly *Ephydra cinerea* surveyed were responded to larval food limitation by sacrificing adult body size, fecundity, and developmental time. In *Drosophila*, the crowding usually results in size reduction, increased development time and reduced fecundity is well known (Pearl, 1926; Miner *et al.*, 1927; Robertson, 1936; Annan, 1952; Birch, 1955; Grucci, 1955; Lints, 1963; Robertson, 1963). Andrewartha and Birch (1959) and Odum (1959) reported the well-known ecological fact that overcrowding of organisms produces adverse effects on their survival, rate of development and population growth.

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تأثير الكثافة العددية لليرقات على دورة حياة ذبابة *Wolfahrtia nuba* (Wiedemann) التابعة لعائلة ذباب اللحم من رتبة ثنائيات الاجنحة

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ملخص البحث : أظهرت الدراسة وجود علاقة طردية بين الكثافة العددية لليرقات في اوائى التغذية وفترات نمو اليرقات. وعلاقة عكسية بين فترات النمو في الطور العذري مع الكثافة العددية لليرقات في كلا الجنسين. كما وجد أن نسب معيشة كل من اليرقات والعذارى لم تتغير بزيادة الكثافة العددية لليرقات . كما أن الكثافة العددية لم تؤثر على نسبة الجنسين في الذباب المكتمل. كما أظهرت الدراسة وجود علاقة عكسية بين الكثافة العددية لليرقات وأوزان كل من العذارى والذباب المكتمل لكلا الجنسين . كما وجد أن وزن الذباب المكتمل في الذكور أقل منه في الإناث.