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Survival rate from egg to adult was 349 days and this for egg rapidly decreased over 20 days. A peak of survival rate of larvae was obvious at 25 days after birth and then a gradual decline. S_{xj} curve of adults gradually increased and peaked on 274th day and 282th day for female and male respectively and gradual decrease with age. Survival rate was greater for female than male (about 5 days). (Fig. 1).

The intrinsic rate of increase (r_m) *O. elegans* was 0.002 d^{-1}. Finite rate of increase (λ), the gross reproductive rate (*GRR*), net reproductive rate (R_0), doubling time (*DT*) and mean generation time (*T*) were about, 1.002 d^{-1}, 71.6 and 42.3 offspring, 110.7 and 328.5 d respectively (Table 2).

Demographic information for *O. elegans* is currently unavailable. This information can be used to optimize monitoring methods for establishing Integrated Pest Management (IPM), and designing insect mass rearing programs. The r_m, *T* and *DT* are useful indices of population growth under a given set of growth conditions. It is generally presumed that short developmental time and high reproduction rate on a host reflect suitability of the plant tested (Van Lenteren& Noldus, 1996).

Table 2. Demographic parameters of *O. elegans* on date palm in the laboratory conditions.

Parameters	Unit	Mean ± SE
Intrinsic rate of increase (r_m)	day^{-1}	0.002±0.01
Finite rate of increase (λ)	day^{-1}	1.002± 0.01
Gross reproductive rate (*GRR*)	offspring	71.6±7.8
Net reproductive rate (R_0)	offspring	42.3±4.1
Doubling time (*DT*)	day	110.7±12.6
Mean generation time (*T*)	day	328.5±17.2

Age-Stage, Two-Sex Life Table Justifiation

Using on the female sex alone as in standard life table analysis may be to cause error in the preadult developmental time results, survival rate curve and population growth parameters. Most of life tables analyzed by assuming a 1:1 sex ratio and so, sex- specific developmental rates (Gu *et al*., 1992; Harvey & Strand, 2003; Bharathi *et al.*, 2004) and sex-dependent mortality risk (Isenhour & Yeargan, 1981; Berenbaum & Zangerl, 1991) violate this assumption (Amir Maafi & Chi, 2006). In this paper, data were analyzed based on an age-stage, two-sex life table to take both sexes into account as well as the variable developmental rate occurring among individuals. Chi (1988), Chi & Yang (2003), Yu *et al*., (2005) and Amir Maafi & Chi (2006) further discuss the problem of applying standard female age-specific life tables to two-sex populations with age- stage.

After laboratory studies, more attention should be devoted to semi field and field experiments to obtain more applicable results in field. There are, however, still problems that cannot be resolved by life tables alone. In addition, life table parameters often vary with different environmental variables. These data might be useful in pest management regimes of *O. elegans*.

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The stage durations of *O. elegans* in this study are within the range of these reports and sex ratio was determined 4:3 female: male. Among these 40 eggs, 5.2, 22.6 and 3.2% died in the egg, larval and pupal stage, respectively. The preadult survival rates are more than those reported by Hurprin & Fresneau (1969) and Soltani *et al*. (2008) and these variations may be due to species differences and differences in the substrates and rearing conditions.

Adult Parameters

Lifetime fecundities of *O. elegans* varied between 18 and 34 eggs/ female and these mean, was 26.5 eggs/ female (Table 1). The mean fecundity was obtained for *O. agamemnon*, 22.57 eggs/ female (Soltani *et al*., 2008), and range of this parameter was determined for *O. rhinoceros*, between 30 to 40 eggs/ female (Waterhouse & Norris, 1987). These variations principally were due to species differences. In laboratory breeding, mating females were heterogeneous in body size that influenced the numbers of laid eggs (Soltani *et al*., 2008). The smallest female in body size laid 18 eggs and normal females laid 28 to 34 eggs. The age of first reproduction has an important effect on population growth. The adult preoviposition period (APOP) as the time between adult emergence and first laid egg, was 9.2±0.05days and the total preoviposition period (TPOP) was 269.5±16.71days (Mean ± SE) (Table 1).

Population Growth Parameters

Age-stage-specific survival rates (S_{xj}) of *O. elegans* represents the probability that an egg will survive to age x while in stage j (Amir Maafi & Chi, 2006). The survival rate (S_{xj}) for egg, larvae, pupa, female and male of *O. elegans* are showed in Fig. 1

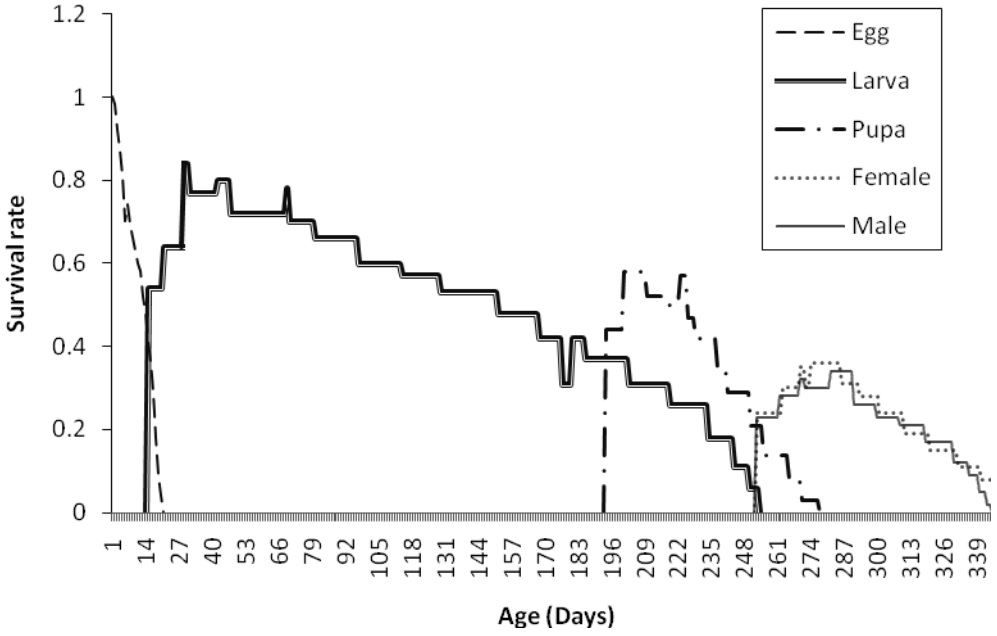

Figure 1. Age- specific survival (S_{xj}) curved for *O. elegans* on date palm in the laboratory conditions.

the age and j is the stage), the intrinsic rate of increase (r_m), the finite rate of increase (λ), the gross reproductive rate (GRR), the net reproductive rate (R_0), and the mean generation time (T).

Gross Reproductive Rate =GRR $$GRR=\sum_{\alpha}^{\beta} m_x$$

Net Reproductive Rate =NRR= R_0 $$NRR=\sum_{\alpha}^{\beta} l_x m_x$$

Intrinsic Rate of Increase =r_m $$1=\sum_{\alpha}^{\beta} e^{-rx} l_x m_x$$

Finite Rate of Increase =λ $$\lambda = e^{r}$$

Doubling Time=DT $$DT=\frac{\ln 2}{r}$$

T Mean Generation Time $$T=\frac{\ln R_0}{r}$$

Results and Discussion

Juvenile Parameters

Basic statistics of life stages of *O. elegans* were determined (Table 1). Developmental time mean for egg, larvae and pupa were obtained 16.4, 216.8 and 26.2 days respectively. The total preadult duration ranged from 235 to 266 days for female and from 228 to 259 days for male, and there was significant difference in total preadult duration between two sexes of *O. elegans*. Soltani *et al*. (2008) reported that the embryogenesis took for *O. agamemnon* under laboratory conditions were 14.3 day and the pupal period lasted 24.1 days. Hurprin & Fresneau (1969) showed that the developmental time of *O. elegans* reared on pieces of apple and other fresh vegetable matter, for egg, larval and pupal stages were 10 days, 3 months and 4 months, respectively.

Table 1. Basic statistics of different life stage of *O. elegans* on date palm in the laboratory conditions (n=40)

Statistics	Stage or Sex	Min	Max	Mean ± SE
Developmental time (d)	Egg	15	20	16.4± 1.32
	Larvae	194	228	216.8± 14.38
	Pupa	20	28	26.2±3.61
Total preadult duration (d)	Female	235	266	260.4±16.32
	Male	228	259	254.3±16.17
Adult longevity(d)	Female	63	89	77.5± 6.61
	Male	60	86	73.4± 6.21
APOP(d)	Female	8	10	9.2± 0.05
TPOP(d)	Female	243	276	269.5± 16.71
Fecundity(eggs)	Female	18	34	26.5± 4.52

O. elegans has one generation per year, lasting about 335±20 days and thus this pest is a univoltine species.

reach 80-90% in some places (Al-Khawaga 1999). The adult insects were the damaging stage feeding on the bases of fronds and bunches making long tunnels which are acting as a weakening and breaking factors for these parts. Larvae damages more than the adults, because they live the palm stalk and tunnels of the steam which the adults made at leaving it (Gharib, 1970; Al-Beker, 1972; Swayir *et al*., 1979;). The adult density of *O. elegans* obtained on some date palm varieties by solar light trap (Khalaf *et al*., 2010). The population dynamism of sympatric species of *O. agamemnon* Burmeister and *O. elegans* determined by solar light trap in Bushehr and the most of adult activity observed in June and July (Fasihi, 2011).

In the life tables (Lewis, 1942; Leslie, 1945, 1948; Birch, 1948), only female individuals are taken into consideration, and the means of the durations of developmental stages are used to construct age-specific survival rates and age-specific fecundity for the "female" population (Birch, 1948; Pinaka, 1994).

Hurpin & Fresneau (1969) studied bionomics of *O. elegans*, and they reared this pest under laboratory with substrate of pieces of apple and other fresh vegetable matter and at 28 to 30˚C. They reported that the egg, larval and pupal averaged 10 days, 3 months and 3 weeks, respectively. Soltani *et al.* (2008) studied the life cycle of *O. agamemnon*, under laboratory conditions and they obtained the embryogenesis took 14.3±1.42 days and the first, second and third larval instars were 33.1±26.9, 63.88±6.6 and 118.3±13.38 days respectively. Variation in developmental rates among individuals is commonly observed in most organisms, and ignoring such variation may result in errors in life table analysis (Chi, 1988; Chi & Yang, 2003). Ignoring the sex of individuals can also result in errors (Chi 1988). Chi & Liu (1985) and Chi (1988) developed an age-stage, two-sex life table model incorporating variable developmental rates and both sexes. In this study, we investigated demographic parameters of *O. elegans* reared on date palm under laboratory conditions. We also calculated a number of demographic parameters by used the age-stage, two-sex life table model.

Matherial and Methods

Biological material was collected by hand picking, in the Bam region (Iran). *O. elegans* were reared in the laboratory at 27±2ºC with a photoperiod of 16:8 (L: D) h and 65±5% RH. Ten rearing cages were including natural substrate collected from the natural breeding sites of larvae in date palm. Forty eggs of the insect (0 - 24 h old) were used in laboratory conditions to determine demographic parameters in the rearing cages. The developmental stage of each individual was recorded daily. As adult beetles emerged, males and females were paired in plastic cages (40 cm in diameter and 50 cm in height). Then, fecundity of each female and longevity of females and males determined.

Result data (age - stage and two - sex) were calculated using formula suggested by Chi & Liu (1985) and Chi (1988). Jackknife technique was used to calculate the population growth parameters (Sokal & Rohlf 1995). Data analysis was developed in a computer program TWOSEX – MSChart (Chi 2005) and this program is available at http://140.120.197.173/Ecology/prod02.htm (Chung Hsing University) and http://nhsbig.inhs.uiuc.edu.tw/wes/chi.html (Illinois Natural History Survey). TWOSEX-MSChart groups the raw data and calculates a number of life table parameters: age-stage specific survival rates (S_{xj}) (where x is

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Demography of date palm fruit stalk borer, *Oryctes elegans* (Col. : Scarabeaidae), on date palm under laboratory conditions

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Abstract

The date palm fruit stalk borer, *Oryctes elegans* Prell. (Col.: Scarabeaidae) is a serious pests of date palm in Bam region, Iran. In this research, demographic parameters *O. elegans* were studied under controlled conditions at 27±2ºC and 65±5% RH and 16:8 L: D. Data were analyzed based on an age-stage, two-sex life table, to take both sexes and variable development into consideration. Developmental time mean for egg, larvae and pupa were obtained 16.4, 216.8 and 26.2 respectively. In the laboratory, 5.2, 22.6 and 3.2% died in the egg, larval and pupal stage, respectively. The intrinsic rate of increase (r_m), finite rate of increase (λ), gross reproductive rate (*GRR*), net reproductive rate (R_0), doubling time (*DT*) and mean generation time (*T*) were $0.002d^{-1}$,$1.002d^{-1}$,71.6 offspring, 42.3 offspring, 110.7d and 328.5d respectively. These facts indicated that *O. elegans* is a univoltine species.

Key Words : demography, Fruit Stalk borer, *Oryctes elegans*, Bam, Life table

Introduction

The date palm fruit stalk borer, *Oryctes elegans* Prell. is considered as a key pest on date palm in many places of the world and a damaging level could be found in Iran: Fars, Bushehr, Khozestan, Ilam, Kerman (specially Bam region), Hormozgan, Sistan and Blochestan (Mohammadpour & Avand Faghih, 2007; Fasihi, 2011) and surrounding countries (Gharib, 1970; Hussain, 1974). This borer had been reported as a major pest on date palm in Qatar (Al-Azawi 1986), Oman (Elwan & Tameimi 1999), Egypt and Lybia (Dowson, 1982). *O. elegans* has one generation per year and adult emergence start during March and continued utill October (Gharib, 1970; Ali & Al-Sandouk, 2000) and infestation percentages may

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