LIFE-FERTILITY TABLES FOR *Euborellia annulipes* (LUCAS) (DERMAPTERA: ANISOLABIDIDAE) A COTTON BOLL WEEVIL PREDATOR

W.P. Lemos¹, F.S. Ramalho¹, and J.C. Zanuncio². (1) Unidade de Controle Biológico (UCB)/Embrapa Algodão, Caixa Postal 174, 58107-720, Campina Grande, Paraíba. Bolsista do CNPq. E-mail: framalho@cnpa.embrapa.br, (2) Departamento de Biologia Animal, Universidade Federal de Viçosa, Minas Gerais.

ABSTRACT

Life tables are of great importance to understand the population dynamics of an insect. They allow us to condense the essential biological data in a population into definable terms of mortality rate, survival, longevity, reproduction, and life expectancy. This research was designed to estimate life-fertility tables and growth rates of *Euborellia annulipes* (Lucas) (Anisolabididae) under laboratory conditions using an artificial diet, at 25 and 30°C.

The research was conducted at the Unidade de Controle Biológico (UCB) - Embrapa Algodão, Campina Grande, Paraíba, Brazil. The predator was maintained in growth chambers, type BOD, at 25 and 30°C, relative humidity of 60 ± 10%, and photoperiod of 14:10 (L:D) h. The *E. annulipes* studied were from a colony (12th generation) maintained at UCB. Fecundity began to decline at the 84th d at 25°C and 74th d at 30°C of adult age and ended with the death of the females at both temperatures. The gross reproductive rates were 89.2 at 25°C and 91.4 at 30°C; the net reproductive rates were 65.3 at 25°C and 40.3 at 30°C; the generation time were 195.2 d at 25°C and 142.9 d at 30°C; the doubling time was 33.0 d at 25°C and 26.7 d at 30°C; the intrinsic rates of increase were 0.02 at 25°C and 0.03 at 30°C, and the finite rates of increase were 1.02 at 25°C and 1.03 at 30°C. The predator population increased by 52.2 at 25°C and 20.5 at 30°C adult progeny per female per generation in the laboratory. The best age for inoculative releases of *E. annulipes* against cotton boll weevil populations is the age with the highest age-specific reproductive values, that is, newly emerged females at 25 or 30°C.

INTRODUCTION

Dermapterans are voracious, have high attack capacity and have been important in the control of several insect pests, particularly, immature lepidopterans (Klostermeyer 1942), homopterans (Madge and Buxton 1976), coleopterans (Klostermeyer 1942, Ramalho and Wanderley 1996, Lemos et al. 1998), and dipterans (Mourier 1986).

The diversity of species and habitats of dermapterans, their generalist habits, and various reports in the literature (Klostermeyer 1942, Madge and Buxton 1976, Mourier 1986, Ramalho and Wanderley 1996, Lemos et al. 1998) show the importance and potential of these predators in programs of integrated pest management.

The ring-legged earwig *Euborellia annulipes* (Lucas) has been reported as an efficient natural enemy of *Cosmopolites sordidus* German (Curculionidae) and some pest insects of stored grains (Klostermeyer 1942), as well as lepidopterous pests in sugar-cane ecosystems in the United States and Japan (Klostermeyer 1942, Gould 1948, Hensley 1971).

Recently, studies conducted by Ramalho and Wanderley (1996), and Lemos et al. (1998 and 1999) reported the possibility of use *E. annulipes* as predator of larvae and pupae of the cotton boll weevil in the northeast region of Brazil.

Life tables are of great importance to understand the population dynamics of an insect. They allow us to condense the essential biological data in a population into definable terms of mortality rate, survival, longevity, reproduction and life expectancy (Coppel and Mertins 1977).
This research was designed to estimate life-fertility tables and growth rates of *E. annulipes* under laboratory conditions using an artificial diet, at 25 and 30°C.

**MATERIAL AND METHODS**

The research was conducted at the Unidade de Controle Biológico (UCB) - Embrapa Algodão, Campina Grande, Paraíba, Brazil.

**Juvenile Development and Mortality.** Twenty-four hours before the initiation of the experiment, clutches of eggs of *E. annulipes*, in an advanced development stage were separated. Egg masses of *E. annulipes* were maintained in Petri dishes (9.0 cm x 1.5 cm) with a piece of absorbent paper in its interior (11.5 x 10.0 cm). This paper was folded in four similar parts for protection of the predator. One ml of water was put on this piece of paper in the first day and 0.3 ml each day in the following days per Petri dish aiming to maintain constant humidity inside these recipients. Each Petri dish was completely sealed with 19 mm wide adhesive tape to reduce humidity losses. After this, Petri dishes with biological material were put and maintained in growth chambers at 25 and 30°C.

The number of instars of *E. annulipes* was measured by observing and registering the occurrence of ecdysis or change in nymph coloration. Newly-emerged nymphs of *E. annulipes* show a brilliant black coloration.

**Oviposition Periods and Fecundity.** A total of 20 (at 25°C) and 18 (at 30°C) newly-emerged pairs of adult *E. annulipes* were selected for each temperature and confined in Petri dishes (9.0 x 1.5 cm) until the death of females. A male which died before its female partner were replaced. Each Petri dish had a container (3.5 x 0.5 cm) with 460 mg of artificial diet (Lemos *et al.* 1998) which was changed every 2 d.

Number of dead adults were daily observed, as were number of clutches deposited per each female, number of eggs per clutch per female, and number of eggs per female of *E. annulipes*. The following biological parameters were analyzed: interval between clutches, pre-oviposition, oviposition and post-oviposition periods; longevity of females, sex ratio of emerging adults and percentage of egg hatch. Each clutch stayed with the respective female until nymphs hatched, because eggs of this predator require care by the females to prevent infestation by mites or fungi (Lemos *et al.* 1998).

**Life and Fertility Tables.** Life and fertility table parameters were calculated for adult predators using data obtained from the study described above. The death and survival rates (*q_x* and *s_x*) observed each day were recorded for all immature stages and adult ages. The probability of surviving from birth to age *x* (*l_x*) for every immature stage and adult age was also calculated. From these data the following statistics were calculated: intrinsic rate of population increase (*r_m*), gross reproductive rate (GRR), net reproductive rate (*R_0*), finite rate of increase (*λ*), rate of increase (*λ*), mean generation time (GT), doubling time (DT), and age-specific reproductive values (*RV_x*).

**RESULTS AND DISCUSSION**

The highest cohort fecundity (*m_x*) was observed when the adult predators were 84 d of adult age (at 25°C) and 21 d of adult age (at 30°C), with *m_x* values of 19.3 and 15.9, respectively. Therefore, it was verified in this research that at both temperatures studied, females of *E. annulipes* produce the highest number of eggs and of female progeny per female in the same age classes, suggesting that the higher number of female progeny generated per females of *E. annulipes* will happen at the age at which they deposit the highest number of eggs, that is, 84 and 21 d of adult age, at 25 and 30°C, respectively. These findings will be useful in determining the impact of age on fecundity of *E. annulipes* and in determining the best age to release the predators in cotton fields. Studies of this nature correlating the number of eggs per female, number of female progeny per female and adult age are nonexistent in the literature with insects of the order Dermaptera. These rates declined with age of females of *E. annulipes* from this time on. Duration of reproductive period (*m_x*) of *E. annulipes* at 25°C was longer (335 d) than that observed at 30°C (251 d).
Highest egg production per female of *E. annulipes* was registered at 30°C in the 3rd week of their adult life what demonstrates that this ambiental factor significativelly influences fecundity of this predator. Neiswander (1944) reported that the fecundity of this predator was higher in the first clutches and tended to decrease with each succeeding one. These results corroborate the findings of Knabke and Grigarick (1971) which revealed that successive clutches of *E. cincticollis* gradually declined in number of eggs.

Differences found on *E. annulipes* fecundity are associated with different factors, among them temperature, that affect population growth of predators (Southwood 1978) and food quality that may also affect the progeny and survival of *E. annulipes*. Conflicting results among studies in the literature using the same temperature or diet may reflect differences of the studied strains or in their adaptation to the diet in laboratory environment. According to Rankin *et al.* (1995) descriptions of clutch size and number of clutches (lifetime fecundity) vary widely among studies and may be caused in part by diet quality, varying temperatures and photoperiods, or differences among experimental populations.

Studies demonstrating the effects of temperature on fecundity of dermapteran species are rare in the literature. Bharadwaj (1966) found that most of the eggs of ring-legged earwig were laid in approximately 165 d in laboratory conditions between the middle of September and the end of February; after that, oviposition declined and was sporadic. When reared at 25°C, females of *E. annulipes* laid 1.68 eggs per female per day (Koppenhöfer 1995), which approximates the values obtained in the present study. Melamed-Madjar (1971) reported that the highest number of eggs was laid by *Anisolabis annulipes* (Lucas (=*E. annulipes*) at 24 to 30°C, at 14°C few eggs were laid, and none were laid at 10°C.

The number of hatched nymphs was almost 1 1/2 times higher at 30°C (243.3) than at 25°C (172.7). Studies on impacts of temperature on egg mortality of *E. annulipes* are few in the literature. Melamed-Madjar (1971) showed that there was a significant effect of temperature on egg hatching of *E. annulipes*. According to this author, eggs do not develop at 10 and 14°C; however, a high proportion of egg hatch at 20°C (73.6%) and 32°C (85.4%). Lemos *et al.* (1998) reported that this predator had egg survival of 85.5% (at 25°C) and 78.1% (at 30°C) which are similar to the survival rates obtained in this research. These rates varied greatly as a function of the age of females at both temperatures.

As the data on *E. annulipes* survival and reproduction become available, a population growth model can be constructed. A simulation model developed in such a manner can be coupled with prey population dynamic models to develop boll weevil management strategies involving biological control programs in cotton crop.

**Life and Fertility Tables.** Mean generation times (GT) were 195.2 and 142.9 d, gross reproductive rates (GRR) were 89.2 and 91.4 eggs per female, and the net reproductive rates (R₀) were 65.3 and 40.3 female progeny per adult female, at 25 and 30°C, respectively. The values obtained for generation time indicate that 1.9 and 2.6 generations of *E. annulipes* per year can be obtained at 25 and 30°C, respectively. The positive values of R₀ indicate population growth of *E. annulipes* at the two studied temperatures. When reared at 25°C, the population of *E. annulipes* increased 1.4 times of a generation for another as compared to 30°C. The intrinsic rate of population increase (rₚ), mean generation (GT), and doubling time (DT) are useful indices of population growth under a given set of growing conditions (Tsai 1998). The rₚ and λ values, at 25°C, were respectively, 0.02 per day and 1.02. However, when reared at 30°C, these values were of 0.03 per day and 1.03, respectively. The doubling times were 33.0 d, at 25°C, and 26.7 d at 30°C. The proportions of individuals surviving all immature stages and reaching adulthood (λₖ) were 0.8 (at 25°C) and 0.5 (at 30°C). Thus, under optimal conditions, an increase of 52.2 (at 25°C) and 20.5 (at 30°C) adult progeny per female per generation (λₖ x R₀) could be expected. *E. annulipes* reared at 30°C showed higher intrinsic rate of increase resulting from faster development, higher survival, and higher reproductive rate.

The age-specific reproductive values (RVₙ) provide information that can be useful in determining the best age for releasing *E. annulipes* in the cotton ecosystems to reduce the cotton boll weevil populations. The higher value of RVₙ (81.6) at 25°C corresponds to newly-emerged adults. However, the maximum value of RVₙ (78.3) at 30°C also corresponds to newly-emerged adults. Therefore, the ideal age of release for inoculative releases of *E. annulipes* would be the age with the highest RVₙ values, that is, newly-
emerged females at 25°C (RV6= 81.6) and 30°C (RV4= 78.3). In programs of biological control of cotton boll weevil by propagation and release of predators, the major strategy that can be followed is inoculative releases.

REFERENCES BIBLIOGRAPHY


