Article

The effect of photoperiod and temperature on hatching and egg development of *Bradyporus latipes* (Orthoptera: Tettigoniidae)

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Abstract

Two factors that affect egg diapause in *Bradyporus latipes* are photoperiod and temperature. In the current study the first instars of insect nymphs collected in fields at Dotu located in Shahre-Kord County, Iran. The samples werer reared in laboratory at 15 to 30°C and relative humidity of 40-60 percentages. The bottom of cages was filled with soil and with a 100-watt bulb day-length were controlled. Two photoperiod for adults, 16L:8D and 12L:12D were placed. Insect feeding plants during the breeding period were *Phlomis olivierii*, *Convolvulus* sp and *Bromus tomentellus* to adults emerged and mated in each photoperiod. The eggs were collected from soil weekly. Eggs maintained on moist filtere paper in petrdish and filterpaper moisted every week. For study the egg duration and egg hatching numbers, the eggs that were laid by females, incubated at 15°C, 20°C, 25°C and 30°C in incubators in two photoperiod inlaboratory. The eggs maintained in this situations for 30 weeks and egg hatching number were calculated. 80 eggs at 25°C were transferred to 5°C and 10°C for 30, 60 days in two maternal photoperiods to determine the effect of wintering on insect eggs diapuase and then return to primary situation. The experiments continued to next spring and 2nd next spring. Also 80 eggs from each maternal photoperiod were kept outdoor in field. The duration of egg periods and egg hatching number recorded and analysed by SAS software and the comparison of means were conducted by Tukey’s test. The results of current study demonsterated that the maternal photoperiod or photoperiod that effect females in oviposition time and temperature are more important in egg hatching number and egg duration.

Key words Orthoptera; *Bradyporus latipes*; photoperiod; temperature; egg diapause.

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1 Introduction

Insects overcomes bad environmental conditions and alives after unfavourable conditions by diapause process (Denlinger, 2002; Tougeron, 2019). This process may be occurred in all of stages, such as egg, larval, nymphal, pupal or adult stages and may be obligate or facultative (Renfree and Shaw, 2000). In each insect usually it occured in stages that which high adapted to bad environmental conditions (Bale and Hayward 2010; Duan and Larson, 2019). In orthoptera insect family almost diapause occurred in eggs named embryonic diapuase and rarely adult period, that egg diapause is dominant in orthoptera species (Tougeron, 2019). This kind of diapause named embryonic diapause that occurs in one or more stages of the embryonic development. Tettigonidae had different diapause pattern and may be have one, two or three year, one generation. The embryonic period of tettigonids occures in eight phases in 26 stages (Warne, 1972, Hartley, 1990). Diapause may be disrupting embryogenesis in very young embryo and final embryogenesis. Diapause occurred and disrupt the mature embryo (Ingrisch, 1986a). Initial and final diapause determine life cycle of tettigonidae (Ingrisch, 1986a). The life cycle of European tettigoniids classified into three classes based on the duration of egg diapause: (1) annual life cycle (2) annual or biennial life cycle (3) biennial and/or longer life cycle. In type (1), initial diapause does not occur. In type (2), eggs may enter initial diapause faculta- tively induced by low temperature and/or parental short photoperiod (Ingrisch, 1986a). In type (3), both initial and final diapauses occur and the long life cycle is due to a prolonged initial diapause. (Ingrisch, 1986a). Low temperature before overwintering, high temperature in summer and maternal photoperiod factor with photoperiod determine initial diapause in many insects that diapause occurred during the egg stage, the regulation of offspring diapause is maternal and affected by photoperiod and temperature, (Ingrisch, 1986b; Mousseau and Dingle, 1991; Ando, 1993). Maternal photoperiod or photoperiod experienced by the parents are very imprtant kind and percentage diapause (Danks, 1987). Egg diapause in tettigonidae were studied before by (Hartley and Ando, 1988; Hartley, 1990; Ando, 1995; Higaki and Ando, 1999 and Ando ,2000). Bradyporus latipes, widely ditributed in North and Western of Iran, Turkey, Armenia and Azerbaijan. In The recent years had differential population level and in some years had sever damage on crops (Haghighian et al., 2007). By identification kind of insect diapause, we can predict population level of insect in next years (Corley et al., 2004; Fielding, 2006). In progressive model for integrated pest management a thorough understanding of the diapause process are very necessary (Mitchell and Onstad, 2005). For monitoring and predicting the population density of this insect we need basic information on insect biological information especially the type of diapause and longevity of one generation- time. The aim goal of this paper is to demonstrate the kinds of this insect diapause and show effects of temperature and photoperiod on egg diapause and emergence offspring in each year for designing integrated pest management program for this pest.

2 Material and Methods

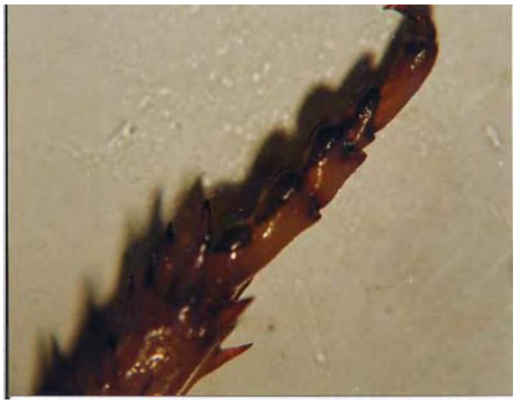
2.1 Insect collecting

The first instar nymphs of insect were collected from Doto-Shahrekord rangeland one of the most important center of pest infestation zone in east of the Chaharmahal and Bakhtiari province in the west of Iran. This area is covered with rangeland covering 8000 hectares, north of Shahrekord with 8 km distance from this city. The elevation of the study area is 2150 m.a.s.l. and annual precipitation is 330 mm. The average annual temperature is 11$^{℃}$ and the minimum and absolute maximum annual temperature were 37°C and 40°C respectively. The geographical features of the sampling area are 32° 21′ 35″ north latitudes and 50° 54′ 20″ east longitudes.

2.2 Insect rearing

The first instar nymphs of insect reared in two aluminum cages measuring 1 × 1 × 0.7 m were placed in a room measuring 5 × 4 m. temperature ranging from 15 to 30 ° C and relative humidity of 40 - 60%. The bottoms of cages were filled with soil and with a 100 wat- bulb day- length were controlled. (We have two photoperiods for adults, 16L:8D and 12L:12D). Insect feeding plants during the breeding period were *Phlomis olivierii,* *Convolvulus* sp, *and Bromus tomentellus.* When adults emerged and mated. The eggs were collected from soil weekly. The date of collected eggs wer recorded (Fig. 1).

1-eggs *of B. latipes*



2-Surface of *B. latipes* eggs

3-Tarsus of *B. latipes*

4-Spermatophyllax in *B. latipes*

5- Molting in *B. latipes*

6-Female and male of *B. latipes*

Fig. 1 Description of the *B. latipes*.

2.3 Methods

The study was conducted based on (Yamaguchi and Nakamura, 2015) methods. The eggs were collected from soil weekly. Eggs maintained on moist filtere paper in petrdish and filterpaper moisted every week. For study the egg duration and egg hatching numbers, the eggs that were laid by females, incubated at 15°C, 20°C, 25°C and 30°C in incubators in two photoperiod inlaboratory. The eggs maintained in this situations for 30 weeks and egg hatching number were calculated. 80 eggs at 25°C were transferred to 5 and 10°C for 30, 60 days in two maternal photoperiods to determine the effect of wintering on insect eggs diapuase and then return to primary situation. The experiments continued to next spring and 2nd next spring. Also 80 eggs from each maternal photoperiod were kept outdoor in field.

2.4 Data analysis

The obtained data were statistically analyzed using SAS statistical software (version 9.1) and the comparison of the mean data was performed using Duncan's Multiple Range Test at a 5% probability level.

3 Results

The results of effect of maternal photo period on egg hatching number and egg duration in laboratory condition are shown in Table 1.

The result showed that the maternal photoperiod or photoperiod that effect females are more important in egg hatching number and egg duration (Table 1). Statistical analysis indicated difference between egg hatching number and egg duration in two photoperiods were significant statistically and with increasing the long day, egg hatching number increased therefore, the periods spent in the egg stage were significantly dependent on the maternal photoperiod and egg periods were significantly longer if the maternal generation was kept under long day condition ($P \leq 0.05$) (Table 1).

Egg hatching number and egg duration were different in level of temperature ($P \leq 0.05$). The egg hatching number increased with incressing the temperature but egg duration decreased with increasing the temperature ($P \leq 0.05$) (Table 2).

Table 1 The effect of maternal photoperiod on egg hatching number and egg duration in laboratory condition.

Maternal photoperiod	Egg number	Egg hatching (Number)	Egg duration (Day)
12L : 12D	40	20.93±.35 [a]	119.9± .25 [a]
16L : 12D	40	17.06±.16 [b]	99.46± .43 [b]

Table 2 The effect temperature on egg hatching number and egg duration in laboratory condition.

Temperature	Egg number	Egg hatching (Number)	Egg duration (Day)
15°C	40	21.12±.1 [a]	132.5±1.2 [a]
20°C	40	20.06±.2 [bc]	107.875±3 [b]
25°C	40	16.87±.4 [ab]	102.25±.4 [b]
30°C	40	16.25±.25 [b]	96.165±.8 [c]

The levels of egg photoperiod weren't different in egg hatching number and egg duration, therefore, embryonic photoperiod hadn't effect in our study. The results showed that between intractions effect of temperature, maternal photoperiod and embryonic period only interaction between temperature and materrnal photoperiod were statistically significant (P≤0.05) (Table 3).

Table 3 The effect of embryonical photoperiod on egg hatching number and egg duration in laboratory condition.

Embryonical photoperiod	Egg hatching (Number)	Egg duration (Day)
12L : 12D	19.34±.5 [a]	112.03±.8 [a]
16L : 12D	17.81±.2 [a]	107.34±1.2 [a]

Table 4 Statistical analysis of the effect of maternal photoperiod, temperature and embryonical photoperiod and interaction between them on egg hatching number and egg duration of *B. latipes* in laboratory condition

Sources	df	Egg hatching number (Mean square)	Egg duration (Mean square)
Maternal photoperiod	1	147***	6683.1***
Temperature	3	90.7***	4069.8***
Embryonical photoperiod	1	37.5[ns*]	351.5 [ns]
Maternal photo period and temperature	3	19.01 [ns]	295.3 [ns]
Maternal photo period and embryonical photoperiod	1	9.7 [ns]	20.25 [ns]
Temperature and embryonical photoperiod	3	61.6**	34.06** [ns]
Maternal photo period (temperature and embryonical photoperiod)	3	1.7 [ns]	121.4

*ns= No statistically significant difference between cardinal directions.
- *= Significant in 5% and 1% probablity level and none significant respectively.

The result of this experiment indicated that interaction between this three factors, only interaction between temperature and embryonical photoperiod were statistically significant and the others werent statistically significant (P≤0.05).

Table 5 Effect of low temterature on number of egg hatching in two maternal photoperid on *B. latipes* in laboratory condition.

Low temperature	Period (Days)	Egg hatching number in 12L:12D (Next spring)	Egg hatching number 16L:12D maternal photo period (2nd Next spring	Egg hatching number 16L:12D maternal photo period (2nd Next spring)
10	30	29 [a]	-	28 [a]
10	60	23 [a]	-	22 [a]
5	30	27 [a]	-	24 [a]
5	60	19 [a]	-	22 [a]

The results indicated that eggs hatched next spring only in 12L:12D maternal photoperid and when eggs affected by low temperature, hatched next 2nd spring (Table 4). The egg hatching number in two maternal photoperid between two low temperatures, was not significant statistically (Table 5). The results in laboratory and field indicated that this species had initial diapause when, eggs laid in 12L: 12D maternal photoperiod, if the eggs affected by low temperature, eggs had initial diapause and hatched in 2nd spring but if the eggs were not affected by low temperature, eggs hatched next spring therefore Short day maternal photoperiod and low temperature determined initial diapause in eggs of *B. latipes* (Table 6).

Table 6 Effect of maternal photoperid on outdoor number of egg hatching number in *B. latipes*.

Maternal photoperiod	Egg number	Egg hatching number (Next spring)	Egg hatching number (2nd Next spring)
16L:12D	40	23	-
12L:12D	40	-	19

4 Discussions

The results approved that in some insect photoperiod is the most factors that determined diapause in laboratory condition and photoperid induce diapuase (Mousseau and Dingle, 1991) that declared that short days in photoperiods induced diapause and long days in diapause break egg stage or other insect diapause stages (Vinogradova, 1974). In this insect short day photoperiod induced diapause and diapause disrupted emberyogenesis but not sufficient and when low temperature occurred this disruption completed and initial diapause formed although in other research low temperatures often play a role in the termination of winter diapause (Tauber et al., 1976; Danks, 1987; Kostal, 2006). The results approved (Hartly, 1990) and this insect diapause are placed in life cycle type 2 annual and biennial life cycle that eggs may enter initial diapause faculta- tively induced by low temperature and parental short photoperiod (Ingrisch, 1986a). In this research the effect of temperature and photoperiod were determined although other researcher state that moisture food and intensity has interaction wih photoperiod. This research should be continuing to distinguish other factors such as moisture and food on *B. latipes* egg diapause.

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