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Development of green shield bug (*Palomena prasina* L., Heteroptera: Pentatomidae) in different temperatures

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Abstract

Green shield bug (*Palomena prasina* L., Heteroptera: Pentatomidae) is a very common pest species in Turkish hazelnut orchards. This pest feeds on hazelnut fruits and causes premature nut dropping in early season and causes kernel damage toward post season. In this study, development periods and thermal thresholds of eggs and nymph stages were investigated in laboratory conditions at 16, 20, 24 and 28°C. The nymphs were fed on common bean seeds (*Phaseolus vulgaris* L.). The seeds were replaced every two days. The egg hatching periods were 12.38 ± 0.18, 8.23 ± 0.14, 6.82 ± 0.06 and 5.47 ± 0.07 days and hatching ratios of eggs were 82.9 ± 10.27% (46–100), 97.8 ± 1.43% (93–100), 96.4 ± 2.71% (86–100) and 90.7 ± 4.61% (75–100) respectively, depending on temperatures. At 16, 20, 24 and 28°C, egg hatching lasted 2–4, 1–3, 1 and 1 days respectively. The nymphal periods were 83.80, 66.73, 48.40 and 33.87 days, and development ratios of nymphs were 20, 44, 40 and 24% respectively depending on temperatures. Thermal thresholds were 14.06ºC and 8.67ºC for egg and nymphal stages respectively, and 9.54ºC for all development period. Thermal constants were 69.93 day-degree for egg stage, 666.66 day-degree for nymphal stage and 769.23 day-degree for the total development period including egg and nymphal stages.

Key words: *Palomena prasina*, development time, thermal threshold, thermal constant.

Introduction

About 4 million people are interested in hazelnut production directly and indirectly, and hazelnut area covers almost 550–600 thousand hectares in Turkey, therefore about 4 million people are interested someway or other in hazelnut production. Turkey produces 75% of the total worldwide hazelnut production and exports 70–75% of hazelnut (Anonymous, 2009). Most of the hazelnut is produced in the Black Sea Region of the country.

Among the *Pentatomidae* species found in hazelnut growing areas of the Black Sea Region, green shield bug (*P. prasina* L.) is the most important species. This pest is polyphagous and widespread, especially in fruit orchards of Turkey, although it causes economic damage only in hazelnut orchards (Lodos, 1986). Its population level is usually above economic damage threshold in overall hazelnut orchards. *P. prasina* feeds on hazelnut fruits, causes premature nut dropping and kernel damage. Numerous studies were done on this pest in the past. Kernel damage caused by *P. prasina* is one of the most important problems in export (Işık et al., 1987; Tuncer et al., 2005; Saruhan, Tuncer, 2009). Mean hazelnut kernel damage ranged from 1.92% to 5.02% and reached nearly 22% in some Turkish hazelnut orchards during the 1996–2000 period (Tuncer et al., 2005). *P. prasina* was very widespread in hazelnut orchards of Italy and 75% of surveyed hazelnut orchards were found to be infested (Tavella et al., 1997). The frequency of injured hazelnut kernels by *P. prasina* varied from 1.3% to 4.0% in Italy (Tavella et al., 2001).

Most of the research on *P. prasina* was focused on its biology, abundance, damage and population fluctuations in field conditions (Kiper, Yücetin, 1971; Kurt, 1982; Viggiani, 1984; Tavella et al.,

1997; 2001; Tuncer et al., 2005; Saruhan, Tuncer, 2009; Tuncer et al., 2009). There is very limited research on the temperature-development relations in *P. prasina*. Kurt (1975) studied nymphal development of *P. prasina* at one range of fluctuating temperatures in field and laboratory conditions. In this study, development rates and periods of egg and nymphal stages of *P. prasina* were investigated at four constant temperatures. In addition, thermal thresholds and thermal constants were calculated for each biological stage and total development period.

Materials and methods

This study was conducted in the laboratory of the Plant Protection Department of Ondokuz Mayıs University, Faculty of Agriculture in 2004. Experiments were carried out in climate chambers at four constant temperatures (16, 20, 24 and 28 ± 1°C), 55–65% relative humidity, and 16:8 hours light:dark periods.

Overwintered *P. prasina* adults were collected by beating sheet method from different hazelnut orchards in Samsun province. They were brought into laboratory and reared on fresh seeds of common bean (*Phaseolus vulgaris* L.) to produce eggs. These egg batches and nymphs hatched from egg clusters were used in experiments.

Petri dishes, 9 cm in diameter, were used in the experiments. Distilled water-saturated filter paper was put in the bottom of Petri dishes to regulate the humidity. Fresh bean fruits opened longitudinally and seeds were provided for insects to meet nutrition needs of nymphs in Petri dishes (Kurt, 1975; Çetin, Karsavuran, 2000). Seeds of common bean in Petri dishes were changed once every two days.

One-day old egg clusters (1–12 hour aged) obtained from overwintered adults were used in the experiments to determine egg hatching rates and periods. Egg batch consisting of 28 one-day old eggs was placed in each Petri dish and replicated 5 times for each temperature. The dishes were kept in climate chambers at four constant temperatures. Eggs were checked every day and the numbers of eggs hatched and hatching periods were recorded.

One-day old (1–12 hour aged) first instar nymphs were obtained from eggs in laboratory insect culture. Five nymphs were placed in each Petri dish and replicated 5 times for each temperature. These Petri dishes were put in climate chambers at four constant temperatures. Petri dishes were checked every day until the nymphs reached adult stage. Moulting periods and dead nymphs were recorded daily in order to determine the time spent in each nymphal stage and survival rates.

Development and survival rates of each biological stage were compared by Duncan Multiple Range test. Thermal threshold and thermal constant were estimated from the regression line of development rate versus temperature ($v = a + bt$; v is development rate and calculated as $v = 1/\text{development time}$, a = intercept, b = slope, t = temperature). Thermal threshold at which development rate reaches zero was estimated by the equation, $t_{min} = -a/b$ and thermal constant (degree-days) was calculated by the equation, $S = 1/b$ (Sharov, 1998).

Results and discussion

Development times of eggs and nymphal stages of Palomena prasina. Mean hatching times for one-day old eggs of *P. prasina* were 12.38, 8.23, 6.82 and 5.47 days at 16, 20, 24 and 28°C respectively. Differences between hatching times were significant ($P > 0.05$) (Table 1). Kurt (1975) has found that average incubation period of eggs was 6.1 days for *P. prasina* at 25–27°C. Tischler (1937) observed egg hatching time of *P. prasina* as 8–10 days in 18–23°C in laboratory.

Development times were found for each nymphal stage at 4 constant temperatures respectively as follows: first instar nymph 8.6, 6.0, 3.72 and 4.2 days; second instar nymph 20.15, 17.12, 9.08 and 7.55 days; third instar nymph 14.34, 10.19, 9.64 and 7.63 days; fourth instar nymph 17.80, 14.39, 10.47 and 6.48 days; and fifth instar nymph was 23.11, 19.03, 15.49 and 8.01 days. The differences between development periods of the same nymphal stages at all temperatures were significant ($P < 0.05$), except those for first nymphal periods at 24 and 28°C. Development periods of different nymph stages at the same temperature were significantly different ($P < 0.05$) except those for second and third instars at 24 and 28 °C. Total development periods including egg and nymphal periods were found as 97.18, 74.96, 55.22 and 39.34 days at the temperatures 16, 20, 24 and 28°C, respectively (Table 1).

Average development periods of nymphs on common bean seeds were found as 3.9, 7.0, 7.4, 11.8 and 21.6 days, in total 51.7 days, at 25–27°C for *P. prasina* (Kurt, 1975). Boselli (1932) estimated total nymph development as 50–55 days for *P. prasina*.

Table 1. Development times (days) of the immature stages of *P. prasina* at four temperature regimes (mean ± SE)

Stage	Development time (days)			
	16 ± 1°C	20 ± 1°C	24 ± 1°C	28 ± 1°C
Egg	12.38 ± 0.18 a	8.23 ± 0.14 b	6.82 ± 0.06 c	5.47 ± 0.07 d
First instar	8.60 ± 0.26 a *E	6.00 ± 0.21 b E	3.72 ± 0.18 c D	4.20 ± 0.13 c D
Second instar	20.15 ± 0.49 a B	17.12 ± 0.58 b B	9.08 ± 0.50 c C	7.55 ± 0.28 d B
Third instar	14.34 ± 0.54 a D	10.19 ± 0.30 b D	9.64 ± 0.49 c BC	7.63 ± 0.71 d B
Fourth instar	17.80 ± 0.82 a C	14.39 ± 0.59 b C	10.47 ± 0.87 c B	6.48 ± 0.86 d C
Fifth instar	23.11 ± 1.30 a A	19.03 ± 2.63 b A	15.49 ± 0.83 c A	8.01 ± 0.82 d A
Total nymph period	83.8	66.73	48.4	33.87
Total development	97.18	74.96	55.22	39.34

Notes. Means followed by different letters in the rows are statistically different by the Duncan test ($P < 0.05$).
* – means followed by different capital letters in the columns are statistically different by the Duncan test ($P < 0.05$).

Hatching rate and periods, and survival rate of nymphs. Egg hatching ratios were found as 82.9%, 97.8%, 96.4% and 90.7% at the temperatures 16, 20, 24 and 28°C, respectively. No difference was found between hatching ratios ($P > 0.05$). While all eggs hatched on the same day at 24 and 28°C, egg hatchings were completed in 2–4 days at 16°C and 1–3 days at 20°C (Table 2). Kurt (1975) found egg hatching rate 43.2% at 25–27°C and 50% in field conditions. In the same study, it was observed that eggs laid on the same day hatched in 0–3 days.

Table 2. Egg hatch and nymph survival of *P. prasina* at four different temperatures

Temparature °C	n	No. of hatched eggs (n)	Egg hatch % mean ± SE min-max	Hatching period (days)
16	140	116	82.9 ± 10.27 (46–100) a	2–4
20	140	137	97.8 ± 1.43 (93–100) a	1–3
24	140	135	96.4 ± 2.71 (86–100) a	1
28	140	127	90.7 ± 4.61 (75–100) a	1

Note. Means followed by different letters in the columns are statistically different by the Duncan test ($P < 0.05$).

Percentages of nymphal survival were relatively low. They were found as 20, 44, 40 and 24% at the temperatures 16, 20, 24 and 28°C, respectively. No nymph mortality was observed in first instar and mortality increased after third nymphal stage. The highest nymphal mortality occurred in fifth stage (Table 3). First nymph deaths started in 25, 15, 5 and 5 days at the temperatures 16, 20, 24 and 28°C, respectively (Figure 1). Kurt (1975) has determined survival rate for *P. prasina* as 34.7% on common bean at 25–27°C in the laboratory, 40.1% on common bean and 57.4% on hazelnut in field conditions.

Table 3. Mortality of *P. prasina* nymphs at different development stages

Nymphal stages	Mortality of nymphs % (n = 25/temperature)			
	16°C	20°C	24°C	28°C
First	0.0	0.0	0.0	0.0
Second	8	4	8	4
Third	16	12	16	16
Fourth	24	12	12	20
Fifth	32	28	24	36
Survival %	20 ± 6.32 c	44 ± 7.48 a	40 ± 6.32 ab	24 ± 4.0 bc

Note. Means followed by different letters in the rows are statistically different by the Duncan test ($P < 0.05$).

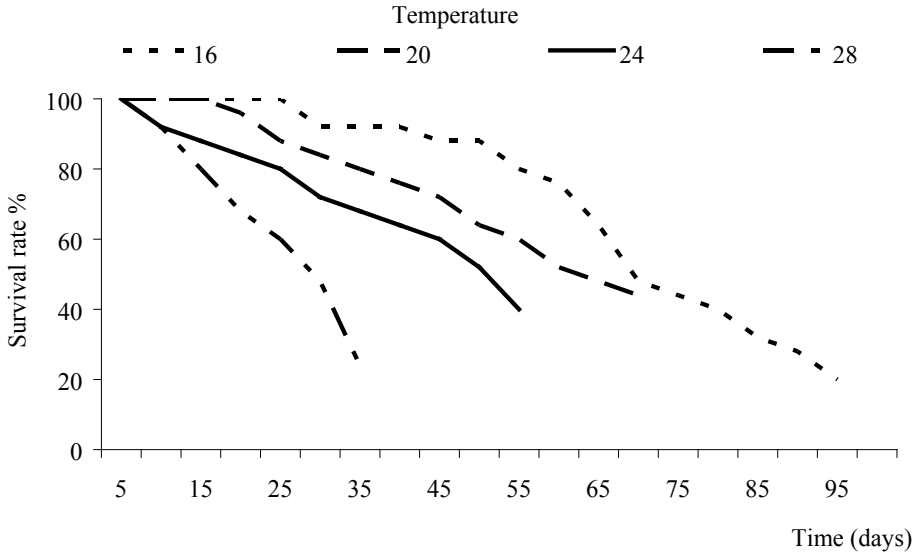
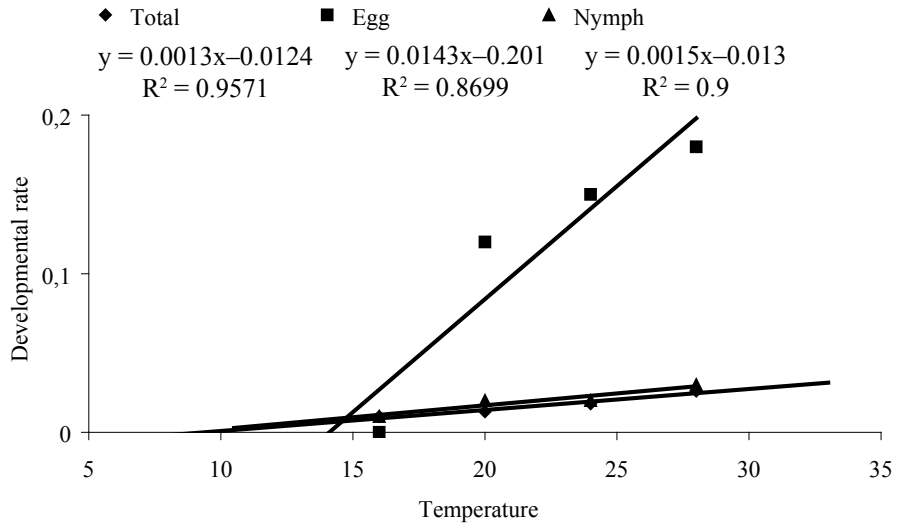


Figure 1. Survival rates of *P. prasina* nymphs (n = 25)



Note. The line represents the linear regression of the data between 16 and 28°C.

Figure 2. The relationship between temperature and development rates for egg and nymph of *P. prasina* at the temperatures 16, 20, 24 and 28°C

Development thresholds. Development threshold of egg, nymph and total immature stages (egg + nymph) of *P. prasina* were evaluated separately and estimated as 14.06, 8.67 and 9.54°C, respectively (Figure 2). This was the first attempt to estimate development thresholds for *P. prasina*. Some species from the same family exhibited similar results. Development threshold was estimated as 14.2°C by Karsavuran (2001) for *A. leucogrammes.* Development thresholds of egg period and total development stages were found 10.48°C and 12.25°C, respectively in another study carried out on *Picromerus bidens* (L.) (Mahdian et al., 2008).

Thermal constants. Thermal constants of egg, nymph and total immature phases (egg + nymph) were estimated as 69.93, 666.66 and 769.23 degree-days respectively. Similarly, this was the first estimation for *P. prasina*. Thermal constant was found 404.2 degree-days for *Ancyrosoma leucogrammes* (Karsavuran, 2001) and 500 degree-days for *P. bidens* (Mahdian et al., 2008).

Conclusion

In this study, hatching rate, survival rate and development periods of each nymphal instars of *P. prasina* were determined at the temperatures 16, 20, 24 and 28°C. Total development time for immature stages ranged from 97.18 days to 39.34 days at 16 and 28°C, respectively. Hatching rate of eggs ranged between 82.9–97.8% at the temperatures 16, 20, 24 and 28°C in the laboratory. Nymph survival was comparatively very low and varied between 20–44%. Egg hatching and nymph survival at 20 and 24°C were better than those in the other temperatures. The thermal thresholds for egg and nymphal periods were 14.06°C and 8.67°C, respectively. When egg and nymph stages were evaluated together, thermal threshold was 9.54°C and thermal constant was 769.23 degree-day.

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Medinės blakės (*Palomena prasina* L., Heteroptera: Pentatomidae) vystymasis esant skirtingoms temperatūroms

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Santrauka

Medinė blakė (*Palomena prasina* L., Heteroptera: Pentatomidae) yra Turkijoje labai paplitęs riešutmedžių sodų kenkėjas. Šis kenkėjas maitinasi riešutų vaisiais ir sukelia riešutų priešlaikinį kritimą sezono metu bei pažeidžia jų branduolius po derliaus nuėmimo. Tyrimo metu laboratorijoje palaikant skirtingą temperatūrą – 16, 20, 24 ir 28 °C, buvo tirta kenkėjo kiaušinėlių bei nimfų vystymosi trukmė ir šilumos riba. Nimfos maitintos dažinės pupelės (*Phaseolus vulgaris* L.) sėklomis, kurios keistos kas dvi dienas. Kiaušinėlių ritimosi trukmė buvo 12,38 ± 0,18, 8,23 ± 0,14, 6,82 ± 0,06 ir 5,47 ± 0,07 dienos, o ritimosi koeficientas buvo atitinkamai 82,9 ± 10,27 % (46–100), 97,8 ± 1,43 % (93–100), 96,4 ± 2,71 % (86–100) ir 90,7 ± 4,61 % (75–100), priklausomai nuo temperatūros. Temperatūrai esant 16, 20, 24 ir 28 °C, kiaušinėlių ritimasis truko atitinkamai 2–4, 1–3, 1 ir 1 dieną. Nimfų tarpsnis truko 83,80, 66,73, 48,40 ir 33,87 dienos, o jų vystymosi koeficientas buvo atitinkamai 20, 44, 40 ir 24 %, priklausomai nuo temperatūros. Šilumos ribos buvo 14,06 ºC bei 8,67 ºC kiaušinėlių bei nimfų tarpsniais, ir 9,54 ºC per visą vystymosi laikotarpį. Šilumos konstantos buvo 69,93 dienos laipsniai kiaušinėlių tarpsniu, 666,66 dienos laipsniai nimfų tarpsniu ir 769,23 dienos laipsniai per visą vystymosi laikotarpį, įskaitant kiaušinėlių bei nimfų tarpsnius.

Reikšminiai žodžiai: *Palomena prasina*, vystymosi laikas, šilumos riba, šilumos konstanta.