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Fecundity and Clutch Size of Green Shield Bug [*Palomena prasina* L. (Hemiptera: Pentatomidae)]

Fındık Yeşil Kokarcası [*Palomena prasina* L. (Hemiptera: Pentatomidae)]'nın Yumurta Paket Sayısı ve Üreme Kabiliyeti

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Abstract: This study was conducted to determine the fecundity, oviposition rhythm and clutch number variations of overwintering adult green shield bug (GSB) *Palomena prasina* (Hemiptera: Pentatomidae) in cages in hazelnut. The adults of GSB collected from hazelnut orchards were taken into cages on selected branches, one pair of overwintering adults were placed in each cage and the study was carried out with 20 repetitions. Daily observations were made during April-June (April 18-June 22) and it was found that the pest laid 94.88 eggs per female as a result of feeding on hazelnut fruits under field conditions. Oviposition period of females was found as 32 days on average. The average number of egg clutches laid per female is 4.38 and it was found that GSB laid eggs from the last week of April until the third week of June. The time required for each oviposition was varied and the average time was found as minimum 5 days and maximum 11.47 days. While postoviposition period was found as 12.25 days on average, death was found to occur on day 54.3 on average in overwintering females. It was found that most of the 79 clutches laid by the pest under cage conditions were included 28 and 14 eggs and there were an average of 21.62 eggs in the clutches laid by the bug. As a result, the determination of reproductive behaviours of the pest will also contribute to biological researches aiming to develop life tables, population models and biological control measures.

Keywords: *Palomena prasina*, Fecundity, Clutch size, Oviposition period

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Öz: Bu çalışma, fındık yeşil kokarcası (FYK) *Palomena prasina* L. (Hemiptera: Pentatomidae)'nın kışlamış erginlerinin fındıkta kafeslere alınarak üreme kabiliyetini, yumurta bırakma ritmini ve yumurta paket sayısındaki değişimlerini belirlemek amacıyla yapılmıştır. FYK'nın kışlayan erginleri bahçe içerisinde seçilmiş dallarda kafeslere alınmış olup, her kafese birer çift kışlamış ergin yerleştirilerek çalışma 20 tekerrürlü olarak yürütülmüştür. Nisan-Haziran (18 Nisan-22 Haziran) aylarında günlük gözlemler yapılmış ve zararlının arazi koşullarında fındık meyveleri ile beslenmesi sonucunda dişi başına 94.88 yumurta bıraktığı tespit edilmiştir. Dişilerde yumurta bırakma süresi ortalama 32 gün olarak bulunmuştur. Dişi başına düşen ortalama yumurtlama sayısı 4.38 olup, FYK'nın Nisan ayının son haftasından Haziran ayının üçüncü haftasına kadar yumurta bıraktığı tespit edilmiştir. Her yumurtlama için gereken süre değişkenlik göstermekte olup, ortalama süre minimum 5 gün, maksimum 11.47 gün olarak bulunmuştur. Son yumurta bırakma ve ölüm arasında geçen süre ortalama 12.25 gün olarak bulunurken, kışlayan dişilerde ölümlerin ortalama 54.3 günde gerçekleştiği tespit edilmiştir. Zararlının kafes koşullarında bıraktığı 79 adet yumurta paketinin çoğunun 28'li ve 14'lü paketler olduğu ve böceğin bıraktığı yumurta paketlerinde ortalama 21.62 adet yumurta olduğu tespit edilmiştir. Sonuç olarak, zararlının üreme davranışlarının belirlenmesi, yaşam tablolarının, popülasyon modellerinin ve biyolojik mücadele önlemlerinin geliştirilmesi gibi biyolojik araştırmalara katkı sağlayacaktır.

Anahtar Kelimeler: *Palomena prasina*, Üreme kabiliyeti, Yumurta paket sayısı, Yumurtlama periyodu

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INTRODUCTION

Pentatomidae is one of the families which include the highest number of species in the order of Hemiptera. This family include important pests in terms of agricultural production (Kaur and Singh, 2020; Panizzi et al., 2000). Green shield bug (GSB) *Palomena prasina* L. (Heteroptera: Pentatomidae) is differentiated from other bug species (Pentatomidae, Coreidae, and Acanthosomatidae) due to its density (~85%) and occurrence above the economic threshold level in Turkish hazelnut orchards. GSB causes decrease in yield and kernel quality of hazelnut during the all season by piercing in and sucking the fruits in many types (Tuncer et al., 2005; 2014). These included, aborting during early season, empty and grey-black nuts during nut development stage, shriveled kernels during kernel development and necrotic kernels during kernel filling/development (Tuncer et al,. 2014). Moreover, in addition to Turkey, this bug causes yield and quality losses in hazelnuts in Italy and Georgia (Moraglio et al., 2018; Arzone et al., 2000).

The reproductive performance of Hemipterans varies greatly depending on the plant they feed on, including egg hatchability, fecundity, number of copulations, daily mating rhythms, and preoviposition duration. (McLain et al., 1990; Panizzi, 1997; Schotzko and O'Keeffe, 1990a; Wang and Millar, 1997). *Palomena prasina* of sexual index was 1:2 in favor of females. Overwintered adults survived until end of June, thus overall adult longevity longed almost 10 months (Saruhan and Tuncer, 2006).

Ovipositional rhythm of stink bugs have two main components as total egg laying rhythm and 24-hour egg laying circle (Schotzko and O'Keeffe, 1986). Whole oviposition rhythm of a bug which lays clutches in every few days consists of two components as the number of days between clutches laid and the number of eggs in each clutch. This oviposition time preference is unique for bugs that lay their eggs in clutches because their short egg laying periods are differentiated from longer periods in which no eggs are laid (Schotzko and O'keeffe, 1990b).
This study, which was carried out under field conditions inside cages in hazelnut production areas, was conducted to find out the variations in the fecundity, ovipositional rhythm and clutch size of overwintering adults of GSB.

MATERIAL AND METHOD

Bug Collection

Overwintering adults of GSB used in the study were collected from the hazelnut production areas in Çarşamba and Atakum districts of Samsun province where hazelnut production is intense by using beat and bedsheet method, taking into consideration their time of emerging winter quarters.

Cage Trials

The collected overwintering adults were taken in cages of 50 x 70 cm made from plastic sieves by selecting branches of appropriate size and fruit in hazelnut orchards, one pair of overwintering adults were placed in each cage and the study was carried out in 20 repetitions. Each repetition was checked daily and the study was continued until the females died. In case of death of males, substitute males were placed for the continuity of parameters obtained.

Daily observations were made during April-June (April 21-June 22) and oviposition times and the number of eggs in clutches was recorded. The study was continued until the last day overwintering adults died and the number and days of clutches laid for 68 days were recorded. Thus, the data regarding the oviposition period and the intervals between first - second, second - third, third - fourth, fourth - fifth, fifth - sixth, sixth - seventh, seventh – eighth, eighth - ninth, ninth - tenth and first - tenth ovipositions were calculated (Panizzi and Mourao, 1999).

RESULTS AND DISCUSSION

As a result of feeding on hazelnut under field conditions, overwintering GSB females laid at least 28 and at most 198 eggs per female and they produced an average of 94.88 eggs on the lower surface of hazelnut leaves and rarely on the upper surface of leaves and leaf stalk and after laying the egg, they brought it closer to other eggs with their hind legs and form a regular clutch (Table 1).

Table 1. Reproductive performance of *P. prasina* in field cages [Mean±SE (min.-max. value)] [n=number of female oviposition].
Tablo 1. Kafeslerdeki P. prasina'nın üreme performansı [Ortalama±SH (min.-mak. değer)] [n=yumurtlayan dişilerin sayısı].

% females ovipositing	Number/Female		
	Egg masses	Total laid egg	Total eggs/masses
90 [18]	4.38±0.72 (1-10)	94.88±15.53 (28-198)	21.62±3.21

Oviposition period of females was found as minimum 15 days, maximum 50 days and an average of 32 days. The number of average clutches per female was 4.38 and maximum and minimum number of clutches was found as between 1 and 10, respectively (Table 1, 2).

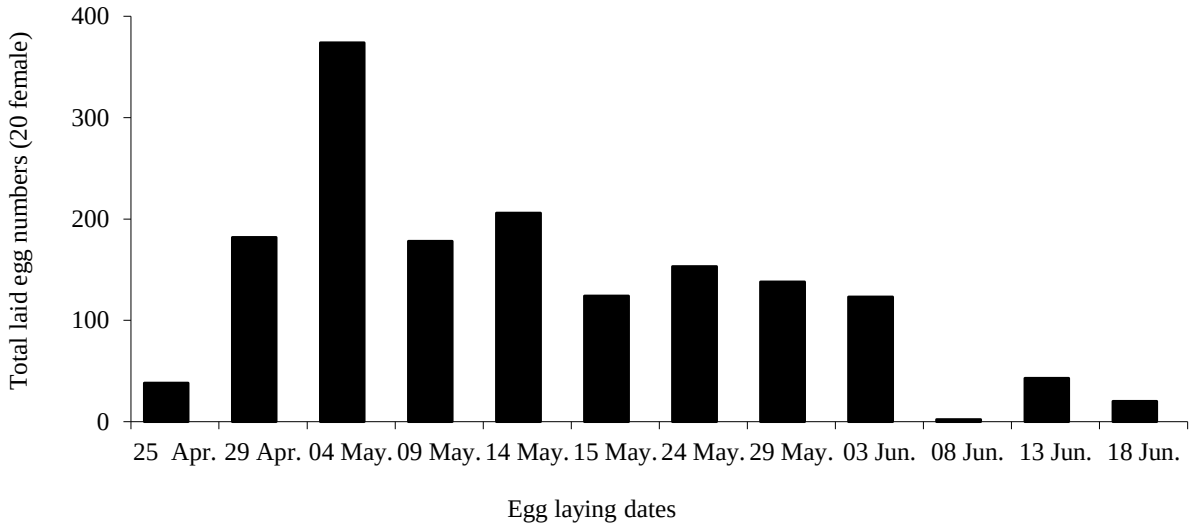

Figure 1. Total egg numbers laid on different days by *P. prasina* in field cages.
Şekil 1. Kafeslerde bulunan P. prasina tarafından farklı günlerde bırakılan toplam yumurta sayısı.

The first clutches laid in cages were found on April 25, while the last clutch was found on June, 18. As of April 25, the number of eggs laid increased gradually and reached the maximum number of 374 eggs as of May 4 (Figure 1). With this study carried out in different cages with 20 pairs of individuals, GSB was found to lay eggs starting from the last week of April until the third week of June.

Since overwintering adults were used in the study, preoviposition period was not determined. The time required for each oviposition was differed and the average oviposition intervals were detected as minimum 5 and maximum 11.47 days. In addition, average oviposition period was found as 32 days (min. 15 – max. 50). While postoviposition period was determined as 12.55 (min. 4 – max. 25) days on average, the death of females was found to occur in 54.3 (min. 13 – max. 62) days on average (Table 2).

Table 2. Mean time±Sh (min.-max. days) of oviposition intervals, oviposition and postoviposition period and death of female of *P. prasina* in field cages [n].
Tablo 2. Kafeslerdeki P. prasina'nın dişilerinin ovipozisyon aralığının, yumurtlamasının, postovipozisyon periyodunun ve ölümlerin ortalama zamanı±Sh (min.-mak. günler).

1. - 2. ovp.	2. - 3. ovp.	3. - 4. ovp.	4. - 5. ovp.	5. - 6. ovp.	6. - 7. 7. - 8. 8. - 9. 9. - 10. oviposition	Oviposition period	Postoviposition period	Death of female
8.17±2.07 (5-15) [17]	11.47±2.64 (5-35) [16]	9.16±2.35 (5-20) [12]	6.87±2.29 (5-10) [8]	7.5±2.35 (5-15) [4]	5±0.00 [1]	32±4.60 (15-50)	12.55±1.87 (4-25)	54.3±3.39 (13-62)

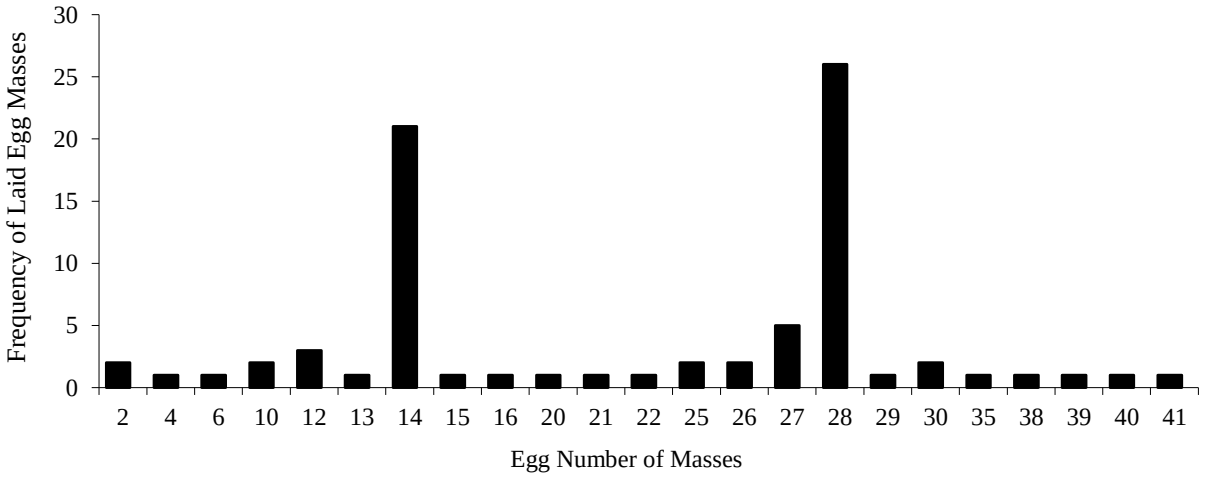

Figure 2. Frequency of masses size of *P. prasina* in field cages.
Şekil 2. Kafeslerde bulunan P. prasina'nın yumurta paket sayısının frekansı.

In hazelnut orchard cage trials, when the frequency distribution of egg numbers in clutches of GSB was examined, it was found that a great majority of number of eggs in clutches were in groups of 28 and 14. An average of 21.62 (min. 2 – max. 41) eggs were found in clutches laid by the pest (Table 1). It was found that 26 of the 79 clutches had a group of 28 eggs, 21 clutches had a group of 14 eggs, 5 clutches had a group of 27 eggs, 3 clutches had a group of 12 eggs, 2 clutches had groups of 30, 26, 25, 10 and 2 eggs and 1 clutch had groups of 41, 40, 39, 38, 35, 29, 22, 21, 20, 16, 15, 13, 6 and 4 eggs. While the number of eggs in the first clutches laid by GSB was 28, there were generally 14 eggs in clutches green shield bug laid towards the end of its life (Figure 2).

Although the GSB is one of the most important pests in Turkey hazelnut orchards (Tuncer et al., 2005; 2014) and its presence has also been reported in some hazelnut producing countries such as Italy and Georgia (Bosco et al., 2018; Tavella et al., 2018), there is no up-to-date and sufficient information about the bug's fecundity.

Kurt (1975) reported about 20 (1-56) eggs on average in clutches of GSB. Similarly, the bug laid its eggs in clutches in the present study and there were 21.62 (2-41) eggs in an average clutch. GSB lays an average of 94.88 (28-198) eggs during oviposition period. It has been reported that in stink bugs, average number of clutches, total number of eggs laid and average number of eggs per clutch differed according to the type of the bug and the host plant (Panizzi and Mourao, 1999; Silva et al., 2011).

It was found that adult females of *Halyomorpha mista* (Hemiptera: Pentatomidae) laid egg clutches with intervals of 4-5 days on average under laboratory conditions. In addition, it was observed that females in the field laid eggs starting from June until the end of August (Kawada and Kitamura, 1983). Similarly, egg laying interval of GSB was found to occur in intervals of 5 days or in multiples of 5 days. In addition, it was found that the adults that left winter quarters laid eggs starting from the last week of April to the third week of June in hazelnut orchards.

While the first two clutches laid by overwintering GSB were predominantly in groups of 28 or more, the clutches laid after the second oviposition were generally clutches of 14 eggs. In addition, the highest number of clutches (41) was found to occur as a result of the first oviposition. In a study by Kurt (1975) with the same pest, it was found that a great majority of clutches were laid in groups of 28 and 14. Similarly, as a result of a study conducted by McMlain et al. (1990) on *Nezara viridula* (Hemiptera: Pentatomidae), it was reported that the number of eggs laid in a row tended to decrease gradually, the clutches laid first were two times larger than the ones laid later and the pest laid the highest number of clutch in the second or third oviposition. In parallel with the results of our study, the number of eggs in clutches laid by adult females of *H. mista*, which has a pair of ovaries consisting of 7 ovarioles, was commonly determined to be 28 (Kawada and Kitamura, 1983). Mating and adequate nutrition are prerequisites for full spawning in *Perillus bioculatus* (Hemiptera: Pentatomidae). The virgins laid an average of 22 eggs compared to 138 eggs in multiple matched controls and 84 eggs alone. It is 42 in mated females and 42 in multiple mated females given an artificial diet. The clutch count was not significantly affected by the accumulative process, but the number of eggs per clutch was significantly lower in virgins and those given an artificial diet compared to controls or one-time mating females. The number of eggs per clutch did not change significantly as the female aged. Ovulation rates were calculated for each female over 5-day periods and presented as daily eggs. As females age, a decrease in the daily number of eggs they lay is associated with an increase in time (Adams, 2000).

The number of ovarioles in insects can vary significantly from one (Coleoptera) to thousand (termites) (Chapman et al., 2013; Nijhout, 1998). The number of ovaries observed in *N. Viridula* is the same as described with other Hemipteran species (ovaries between 8 and 14) (Büning, 1994). It has been stated that the variation in the number of ovarioles is not only common within species, but it may also be seasonal or it may be affected by the reproduction strategy of the insect. It has been reported that in addition to the production of different sizes of eggs, the variation in the number of ovarioles may also affect the development of offspring or female reproduction capacity (Stewart et al., 1991; Tschinkel, 1987; Wellings et al., 1980). Single *N. viridula* isolated in mating chambers with six females differed in the number of matings obtained. Females mating with relatively successful males were more fertile than females mating with less successful males (McLain and Marsh, 1989).

CONCLUSION

In the present study, the fecundity, number of clutches and the length of oviposition period of GSB have been determined. In addition, the determination of reproductive behaviors of its will also contribute to biological research aiming to develop life tables, population models and biological control measures.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

DECLARATION OF AUTHOR CONTRIBUTION

IS, IOO and CT designed the study, participated in experiment, and drafted the manuscript.

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