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Determination of Some Biological Characteristics of *Calosoma sycophanta* L. (Coleoptera: Carabidae)

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Abstract: This study was conducted to determine some biological characteristics of *Calosoma sycophanta* L. under laboratory conditions between 2001 and 2003 in Kahramanmaraş. The adult emergence period of *C. sycophanta* started at the end of February and extended until the first week of March (from soil). When they emerged, they fed on caterpillars of the pine processionary moth. After 1-1.5 weeks of feeding, adult beetles copulated and deposited their eggs into humid soil. The oviposition period continued for 20-25 days. The first instars hatched from eggs within 6-13 days.

The first instars were 7-8 mm in length and dirty whitish–yellow, but turned black within 1-1.5 h. Three larval instars were observed. The beetle became a pupa in June and this stage continued for 9 to 16 days. The biology of the predator was well synchronized with the that of pine processionary moths in the region.

Key Words: *Calosoma sycophanta*, predator, biological characteristics, Kahramanmaraş, the pine processionary moth

Calosoma sycophanta L.'nın Bazı Biyolojik Özelliklerinin Belirlenmesi

Özet: Bu çalışma *Calosoma sycophanta* L.'nın bazı biyolojik özelliklerini belirlemek amacıyla laboratuar koşullarında 2001-2003 yılları arasında Kahramanmaraş bölgesinde yürütülmüştür. *C. sycophanta* erginlerinin topraktan çıkış periyodu şubat sonunda başlamakta ve mart ayının ilk haftasına kadar sürmektedir. Erginler topraktan çıktıklarında çam keseböceği larvaları ile beslenmektedirler. Çam keseböceği larvaları ile 1-1,5 haftalık beslenmeden sonra çiftleşmekte ve nemli toprağa yumurta bırakmaktadırlar. Yumurta bırakma periyodu 20-25 gün sürmektedir. Larvalar yumurtadan 6-13 gün içerisinde çıkmaktadırlar.

İlk dönem larvalar 7-8 mm boy ve kirli sarı renkte olup, 1-1,5 saat içerisinde siyah renge dönüşmektedirler. Üç larva dönemi geçirmekte olan larvalar haziran ayında pupa olmakta ve pupa dönemi 9-16 gün sürmektedir. *C. sycophanta*'nın biyolojisi çam keseböceğinin biyolojisi ile uyum içerisindedir.

Anahtar Sözcükler: *Calosoma sycophanta*, predator, biyolojik özellikler, Kahramanmaraş, çam keseböceği

Introduction

The ground beetle, *Calosoma sycophanta* L. (Coleoptera: Carabidae), is considered an important predator of some pest species in different parts of the world. This beetle was exported from Europe to North America to use as a natural enemy against the gypsy moth, *Lymantria dispar* L. (Lepidoptera: Lymantriidae) (Weseloh et al., 1995; Schafer et al., 1999). The beetle has been well established in the United States to control the gypsy moth. There are several studies showing that the beetle may be a useful natural enemy against gypsy moth outbreaks (Bess, 1961; Campbell, 1967; Weseloh, 1985; Weseloh et al., 1995). The beetle can also feed on different species of Lepidoptera, particularly the pine processionary moth (PPM), *Thaumetopoea pityocampa* (Schiff.).

The ground beetle has been observed during feeding on the PPM, which is a very important pest of pine trees in Turkey. The PPM feeds on the needles of pine trees, causing annual growth loss, and even the death of trees in some cases. Extensive damage by this pest occurs generally on Calabrian pine trees in different parts of Turkey every year.

The host range of the PPM includes several pine species (i.e. *Pinus brutia*, *P. nigra*, *P. sylvestris*, *P. pinea*, and *P. halepensis*) and one species of Cedrus, *Cedrus libani*, growing in Turkey. The PPM occurs from 100 m to 1 800 m (Avtzis, 1998; Çanakçıoglu and Mol, 1998) altitude ranges with different levels of intensity. In Turkey, forest area for possible distribution of the PPM is close to 1,500,000 h (Anonymous, 1995).

It is well known that defoliation leads to increases in tree stress and their susceptibility to secondary pests such as bark beetles and pine weevils, particularly in young trees (Cadehia and Insuan, 1970; Kanat et al., 2002). Outbreaks of PPM are quite periodic, occurring almost every 5-7 years. It was reported that the loss of total shoots of *P. pinaster* was 41-50% in moderately defoliated trees and 54-64% in completely defoliated trees (Markalas, 1998). Due to PPM attacks on *P. brutia* (1-4 m in height) in Turkey, a great loss of shoots (68%) was determined (Babur, 2002).

Several control methods (mechanical, chemical and biological) have been used against this pest in Turkey but the problem has not been solved completely. In addition, it was observed that the use of a single control method was insufficient to control the population outbreak of the PPM. However, biological control is probably the best solution among the different methods to control PPM population outbreaks. Numerous parasites and predators of the PPM have been reported. One of the predatory insects of this pest is *C. sycophanta*, which has been observed to feed on the PPM extensively in Calabrian pine forests (Tosun, 1977; Ogurlu, 2000; Kanat, 2002). This predator consumes both the larvae and pupae of the PPM. *C. sycophanta* as a predator may control the population growth and density of the PPM in outbreaks. No extensive biological control studies using *C. sycophanta* against the PPM have been performed yet in Turkey.

The objectives of this study were to investigate and understand some biological characteristics of *C. sycophanta* for future mass production in biological control efforts.

Materials and Methods

This study was conducted under laboratory conditions between 2001 and 2003 in Kahramanmaraş, located in the east Mediterranean region of Turkey. The PPM and the adults of *C. sycophanta* used in this study were collected from different patches of Calabrian pine forests distributed throughout the Kahramanmaraş region and brought into the laboratory.

During this study, all research materials were kept under constant conditions, namely 23 °C, 60-65 % RH and a photoperiod of 8:16 (L:D) h. Adults of *C. sycophanta* were collected in March every year. Twenty adults were placed in a plastic crisper (13.3 by 31.5 by 12 cm) with 1 PPM silky nest. Predatory beetle collection was performed particularly in Kapıçam, Pınarbaşı and Hartlap near Kahramanmaraş.

The beetles brought from the fields were placed in rectangular (13.3 by 21.3 by 8 cm) or round plastic boxes (16.6 by 14.5 cm and 19 by 12.5 cm) in the laboratory. Before placement of the beetles, partly sterilized soil (under 100 °C for 10 h an autoclave) was put into the boxes.

Deposited eggs of *C. sycophanta* were collected daily. The eggs and newly hatched larvae of *C. sycophanta* were placed in plastic cups (5 by 3 cm). Several holes (5-6) were made in the lid of each cup to provide air. To maintain the humidity of the eggs, they were covered with soil. To determine the egg size of *C. sycophanta*, 30 eggs from 50 adults were randomly selected and measured. To investigate the length of the hatching period, 200 eggs were observed. The larvae and pupae of the PPM were placed in rectangular boxes containing 77 compartments each 4 by 4 by 10 cm. To prevent the escape of the PPM larvae and *C. sycophanta* adults, wire screen covers were used.

Every day newly hatched *C. sycophanta* larvae were transferred into plastic boxes containing moist soil. One larva of *C. sycophanta* was placed in each plastic box to prevent cannibalism among the larvae. They were kept in these boxes until they reached a certain size, 1.2-2.0 cm body length. PPM larvae were provided for feeding every 2 days depending on the consumption capacities of the beetle larvae. After they reached a certain size, 1.2-2.0 cm, they were transferred into bigger boxes (4 by 4 by 10 cm). The tops of the boxes were covered with tulle fabric. The larvae were observed in these boxes until the adult stage. A total of 150 larvae were used to observe the life stages of *C. sycophanta*.

Results

The adult emergence of *C. sycophanta* from the soil started at the end of February and continued until the first days of March. The weight of adults ranged between 0.8 and 1.13 g. The sex ratio of *C. sycophanta* brought into the laboratory from the field was 0.5. Newly emerged adults from overwintering sites had to feed well with the fourth and fifth instars or pupae of the PPM before mating and oviposition for 1 to 1.5 weeks. This feeding activity is well synchronized with the life stages of the PPM. It occurs when the larvae and early pupae of the PPM are abundant. After this feeding, female adults laid their eggs into humid soil.

The egg laying period continued for 20-25 days until the middle of April, depending on the quality of feeding. To deposit eggs, the females first removed soil by using the front and back legs and then inserted their last abdominal segment into the soil. If they were not able to find humid soil then they left the eggs on the surface of dried soil. If the humidity was not optimum then the eggs were crystallized. For egg deposition, humid soil is necessary; otherwise eggs lose their viability in dry or wet soil conditions.

The largest *C. sycophanta* egg was 6 mm in length (Table 1). The mean weight of the eggs was 0.01 g. They were ellipsoidal and yellow to white or light yellow. Before emergence of the first larval instars, the eggs became bigger and several black lines appeared on one side of the eggs. This side of the egg and the lines showed the segments of the larva. The weight of the eggs increased slightly with a mean of 0.02 g and thickness of about 2.5-3 mm.

The egg stage continued for a maximum of 13 days (Table 2). Before hatching, some eggs became completely black; these did not produce any larvae. Larvae continued to hatch from the eggs until the last week of April. The hatching took almost 10 min. After the first instars hatched, the remaining egg parts melted and disappeared. The larvae were dirty white or yellow when they emerged. The dorsal side of the larvae became black in 1-1.5 h after hatching. The abdominal side of the larvae was light gray.

The larvae were very active in the boxes. When the humidity rate increased, the head of the larvae was directed to the top of the boxes. The mean body length of the first instars was 11.5 mm (Table 1). The weight and width of the first larval instars were 0.02 g and 2 mm, respectively. During this study, 3 larval stages were observed. When the first instars were passing through the next larval stage, they were yellowish white; they

Table 1. Minimum, maximum and mean body length values (mm) for egg, larvae (first, second and third instars), pupa and adult of *C. sycophanta* in Kahramanmaraş.

Biological Stage	N	Mean	Min	Max	SD
Egg	30	4.96	4	6	0.83
Larva-1 (L_1)	30	11.5	7	16	2.92
Larva-2 (L_2)	30	18.1	12	25	4.2
Larva-3 (L_3)	30	31.1	25	38	4.2
Pupa	30	21.5	19	24	1.73
Adult	30	22.1	15	31	4.6

Table 2. Minimum, maximum and mean duration time (days) for eggs, larvae (first, second and third instars), pupal stages of *C. sycophanta* in Kahramanmaraş.

Biological Stage	N	Mean	Min	Max	SD
Egg	30	9.3	6	13	2.26
Larva-1(L_1)	30	9	7	11	1.43
Larva-2 (L_2)	30	10	8	12	1.43
Larva-3 (L_3)	30	16.4	15	18	1.13
Pupa	30	21.5	19	24	1.73

turned brown after 20-25 min and then black over the following 25-30 min.

When the instars reached an average of 20-25 mm in length, they shed their second larval skin. Third larval instars were larger than previous instars (Table 1). At the end of the last larval stage, the larvae did not feed very much and became almost inactive. This inactive period continued for 1 week; then they shed their third larval skin and pupated. The longest larval stage was the third, with a maximum of 18 days duration (Table 2).

After 3 larval stages, *C. sycophanta* became a pupa in the soil in the middle of May. This life stage continued until the first week of June. The body length of pupae ranged between 19 and 24 mm (Table 1). The shortest pupal stage was 19 days (Table 2).

Adult emergence started at the end of May and continued until the middle of June. Callow adults opened the pupal skin from the dorsal side. The length of newly emerged adults was about 2 cm. The antenna, eyes and legs were black. The other parts of the body were yellowish brown.

Discussion

The biology of *C. sycophanta* is well adapted to the biology of the PPM in the region, which may the increase efficiency of *C. sycophanta* in the event of outbreaks. Similar synchrony has been reported between gypsy moths and the beetles (Weseloh et al., 1995). The beetles are capable of living for 3 or more years and they emerge from the soil when gypsy moth larvae are present in the environment. In the current study, beetles emerged from the soil when PPM larvae were fourth instars. Weseloh (1993) reported that if female beetles did not feed extensively on caterpillars of the gypsy moth within 1 week of emergence, they entered a reproductive diapause even if they obtained prey later. According to the results of this study, females have to feed on caterpillars of the PPM for 1-1.5 weeks before egg deposition. Otherwise, they enter a diapause without laying eggs. Therefore, an abundance of PPM larvae was crucial when *C. sycophanta* emerged from the soil. When the PPM enter the soil for pupation beetles also re-enter the soil. Similar results were reported by Weseloh (1993) for gypsy moths.

Weseloh et al. (1995) suggested that physiology, behavior and phenology make *C. sycophanta* a specific predator and so they can affect lepidopteran species that have life history traits similar to those of the gypsy moth. It was observed that the beetles and the PPM have similar life history traits, presenting a very important opportunity to use this beetle against the PPM. Therefore, we think that this carabid is one of the most important mortality agents of the larvae and early pupae of the PPM. Thus, it should be used intensively in the biological control of the PPM.

In the next stage, the population densities of *C. sycophanta* should be determined and conserved in the natural environment. Studies should be conducted to establish the colony of the beetles and augmented through laboratory rearing techniques for field releases to control PPM epidemics in the region. The effectiveness of the beetles should be evaluated in outbreak populations of the PPM under field conditions.

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