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# The Effect of *Calosoma sycophanta* L. (Coleoptera: Carabidae) Feeding on the Pine Processionary Moth, *Thaumetopoea pityocampa* (Denis & Schiffermüller) (Lepidoptera: Thaumetopoeidae), in the Laboratory

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**Abstract:** We determined the feeding capacity of *Calosoma sycophanta* L. (Coleoptera: Carabidae) by feeding them the pine processionary moth (PPM), *Thaumetopoea pityocampa* (Denis & Schiffermüller) (Lepidoptera: Thaumetopoeidae), under laboratory conditions. *C. sycophanta* is one of the most important predators of PPM larvae and pupae. Adult *C. sycophanta* can consume as much as 7-8 times their weight in food per day. On average, each *C. sycophanta* adult injured 10 PPM larvae while consuming 7 of these prey per day. The adults lived for 3-4 years. When young *C. sycophanta* larvae feed on 1 PPM larva, they can reach 1.4-1.6 cm in length and 0.11-0.16 g in weight. One adult beetle eats 210-280 PPM larvae per year and 840-1120 PPM larvae during its lifetime.

**Key Words:** *Calosoma sycophanta*, feeding effect, *Thaumetopoea pityocampa*

## *Calosoma sycophanta* L. (Coleoptera: Carabidae)' nin Çam Keseböceği, *Thaumetopoea pityocampa* (Denis & Schiffermüller) (Lepidoptera: Thaumetopoeidae) Üzerinde Beslenme Etkinliğinin Araştırılması

**Özet:** Bu çalışma da, *Calosoma sycophanta* L. (Coleoptera: Carabidae)'nin çam keseböceği, *Thaumetopoea pityocampa* (Denis & Schiffermüller) (Lepidoptera: Thaumetopoeidae) üzerinde beslenme etkinliği belirlenmiştir. *C. sycophanta*'nın hem erginleri hem de larvaları *T. pityocampa*'nın hem larvaları hem de pupaları ile beslenmektedirler. *C. sycophanta* erginleri günlük ortalama ağırlıklarının 7-8 katı besin tüketebilmektedirler. Bir *Calosoma* ergini günlük 10 adet çam keseböceği larvasını yaralamakta, bunlardan 7 adedini yiyebilmektedir. *C. sycophanta* erginleri, 3-4 yıl yaşayabilmektedirler. Yumurtadan yeni çıkmış *Calosoma* larvası bir adet *T. pityocampa* larvası yediğinde ağırlığı 0,11-0,16 g'a boyu ise 1,4-1,6 cm'e ulaşabilmektedir. Bir adet *C. sycophanta* ergini yılda 210-280, ömrü boyunca ise 840-1120 adet *T. pityocampa* larvası yemektir.

**Anahtar Sözcükler:** *Calosoma sycophanta*, Beslenme etkinliği, *Thaumetopoea pityocampa*

### Introduction

The pine processionary moth (PPM), *Thaumetopoea pityocampa* (Denis & Schiffermüller) (Lepidoptera: Thaumetopoeidae), is one of the most harmful insects that defoliate pines and cedars, causing serious economic damage in Mediterranean countries (Rive, 1966; Lightle and Weiss, 1974; Buxton, 1983; Markalas, 1985, 1986;

1989; Austra et al., 1987; Lyytikäinen-saarenmaa, 1999; Tiberi et al., 1999; Avtziş, 2001; Babur, 2002; Kanat et al., 2002). PPMs feed on the needles, which are the photosynthetic organs of the plant; therefore, the loss of needles reduces annual incremental diameter growth considerably and increases susceptibility to secondary pests (Cadehia and Insuan, 1970; Kanat, 1998; Kanat et

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al., 2002, 2005). PPMs prefer *Pinus brutia* Ten., *P. nigra* Arn., *P. sylvestris* L., *P. pinea* L., *P. halepensis* Mill., and *Cedrus libani* Loud. as hosts in Turkey. PPMs feed on the needles of pine trees, which causes annual growth reduction, even death in some cases. Extensive damage by this pest generally occurs to Calabrian pine trees (*P. brutia*) at various locations in Turkey every year (Çanakçıoğlu and Mol, 1998).

PPM occurs almost everywhere in Turkey, at varying degrees of intensity, from sea level to the altitude of 1800 m (Ogurlu, 2000). The peak of PPM flight was observed during August-September in Turkey and Greece (Mol et al., 2001; Athanassiou et al., 2007). Several control methods (mechanical, chemical, and biological) have been used against this pest in Turkey. Biological control is the best solution for controlling PPM outbreaks. Numerous parasites and predators of the PPM have been reported. Predators of the PPM include *Calosoma sycophanta* L. (Coleoptera, Carabidae), *Formica rufa* L. (Hymenoptera, Formicidae), and *Cuculus canorus* L. (Aves, Cuculidae) (Ogurlu, 2000).

*C. sycophanta* feeds on *Dasychira pudibunda* (L.) (Lep., Lymantriidae), *Euproctis chrysorrhoea* (L.) (Lep., Lymantriidae), *Hyphantria cunea* (Drury) (Lep., Arctiidae), *Lymantria dispar* (L.) (Lep., Lymantriidae), *Lymantria monacha* (L.) (Lep., Lymantriidae), *T. pityocampa* (Lep., Thaumetopoeidae), *T. solitaria* (Frey.) (Lep., Thaumetopoeidae), and *Tortrix viridana* (L.) (Lep., Tortricidae) (Çanakçıoğlu, 1993; Ogurlu, 2000).

*C. sycophanta* feeding on PPMs is very important for Turkey and it feeds on them extensively in Calabrian pine forests (Tosun, 1977; Ogurlu, 2000; Kanat, 2002). This predator consumes both PPM larvae and pupae, and, therefore, *C. sycophanta* may control the population level and density of PPMs in an outbreak situation.

Adult *C. sycophanta* live 3-4 years. Because of their high reproduction capacity this beetle is considered an important predator of some pest species in different parts of the world (Weseloh, 1996). *C. sycophanta* was imported from Europe to North America to use as a natural control agent against the gypsy moth, *Lymantria dispar* L. (Lepidoptera: Lymantriidae) (Weseloh et al., 1995; Schaefer et al., 1999). In the United States *C.*

*sycophanta* has been shown to effectively control gypsy moth outbreaks (Weseloh et al., 1995). This beetle is also an important predator of the PPM in Turkey. Extensive biological control studies using *C. sycophanta* against the PPM have not been conducted in Turkey. The aim of the present study was to investigate the effect of feeding PPMs to *C. sycophanta*.

## Materials and Methods

Late PPM larvae were collected in the spring from different stands of *P. brutia* forest throughout the Kahramanmaraş region of Turkey and brought to the laboratory. Predatory beetles were collected from Kapıcım, Pınarbası, and Hartlap, which are also in Kahramanmaraş. *C. sycophanta* adults and PPM larvae were collected in March and April of 2001-2004. In the laboratory, late PPM larvae (4<sup>th</sup> or 5<sup>th</sup> instars) were kept alive in a cooler maintained at 4-6 °C.

The beetles brought from the field were placed in plastic boxes (12 × 23 × 8 cm) in the laboratory. Twenty adults were placed in individual plastic boxes containing sterilized soil (at 100 °C for 10 h in autoclave) with 1 PPM silky nest. Conditions of the rearing room were kept constant (23 °C, 60%-65% RH, and a photoperiod of 8:16 h (L:D)).

Every day newly hatched *C. sycophanta* larvae were transferred into plastic boxes containing moist soil. One *C. sycophanta* larva was placed in each plastic box to prevent cannibalism among the larvae. PPM larvae were provided for feeding every day, and the quantity fed depended on the consumption capacity of each *C. sycophanta* larva. We used a random parcel experimental design.

Each day of the experiment 11 PPM larvae and 2 PPM pupae were provided to each *C. sycophanta* adult (Tables 1 and 2); however, 1 PPM larva was provided for each *C. sycophanta* larva. The experiments were replicated 6 times.

After they reached a certain size (i.e. 1.2-2.0 cm) they were transferred into bigger boxes (4 × 4 × 10 cm). The tops of the boxes were covered with tulle fabric. Weight and length of 50 *C. sycophanta* larvae were measured daily. The data were evaluated using SPSS.

Table 1. Number of PPM larvae injured or consumed by *C. sycophanta* (Coleoptera: Carabidae) adults in the laboratory.

Sex	Number of adult beetles	Number of PPM larvae	Number of PPM larvae (injured)	Number of PPM larvae (eaten)
Male	30	330	300	210
Female	30	330	270	212
Male + Female	30	330	270	183
Male + female	60	660	540	420
Total	150	1650	1 380	1025
	Mean per beetle		9.2	6.8

Table 2. Number of PPM pupae eaten by *C. sycophanta* (Coleoptera: Carabidae) adults in the laboratory.

Sex	Number of adult beetles	Number of PPM pupae	Age of pupae (days)	Not eaten	Eaten
Male	30	30	1	-	30
Female	30	30	2	-	30
Male	30	60	3	-	60
Female	30	60	3	-	60
Male	30	30	4	30	-
Female	30	30	5	30	-
Male	30	30	6	30	-

## Results

Emergence of adult *C. sycophanta* from soil started at the end of February and continued until the first days of April. Newly emerged adults from overwintering sites fed well on the late PPM larvae (4<sup>th</sup> or 5<sup>th</sup> instars). Both the *C. sycophanta* adults and larvae ate the PPM larvae and pupae.

The average weight of *C. sycophanta* adults was 0.8 g. *C. sycophanta* adults can consume more than their weight in food each day. On average, 9.2 PPM larvae were injured and 6.8 of them were eaten by each *C. sycophanta* adult per day. The number of PPM late larvae and pupae eaten by *C. sycophanta* adults in the laboratory are shown, respectively, in Tables 1 and 2.

Fifty *C. sycophanta* larvae (0.8 cm in length and 0.02 g in weight) were statistically tested to determine the

effects of feeding on PPM and development on weight and length. Half of them were fed with late PPM larvae and half were not fed PPM larvae. Larvae were measured the control and feeding groups after 3 days. The length and weight of *C. sycophanta* larvae fed PPM larvae increased (average 1.4 cm in length and average 0.13 g in weight), but the controls did not (Table 3 and 4).

Both adult beetles and larvae ate PPM pupae (body length 2.0-3.5 cm, weight 0.6-0.9 g) in the first 3 days. After 4 days, due to hardening of the exterior surface, pupae were not eaten by adult beetles or larvae (Table 2).

*C. sycophanta* larvae cannot completely consume PPM larvae during the first days. As *C. sycophanta* grow, their food intake regularly increases. Their length and weight are shown in Table 4. When *C. sycophanta* larvae did not feed on PPM larvae, their lengths and weights did not change.

Table 3. Analysis of variance (nourishment).

Larval	Nourishment	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Weight	Feeding	1.130	0.003	1.125	1.135
	Not Feeding	0.02	0.003	0.02	0.02
Length of Larvae	Feeding	1.130	0.003	1.125	1.135
	Not Feeding	0.02	0.003	0.02	0.02

Table 4. Weight and length of *C. sycophanta* (Coleoptera: Carabidae) larvae that were fed 1 PPM first instar larva.

N	Days	Mean length (cm)	Min.-Max. length (cm)	Mean weight (g)	Min.-Max. weight (g)
30	1	0.8	0.7-0.9	0.02	0.01-0.03
30	2-3	1.4	1.3-1.6	0.12	0.10-0.14
30	4-10	1.8	1.6-2.0	0.32	0.16-0.42
30	11-19	2.4	2.1-3.0	0.62	0.56-0.71
30	20 -	3.2	3.0-3.5	0.8	0.73-0.92

Some data on the feeding of *C. sycophanta* larvae are shown in Table 5 (Kanat et al., 2005). Completely grown *C. sycophanta* larvae eat the entire body of PPM late larvae, except their integument. *C. sycophanta* larvae consume about 14-16 PPM late larvae as 1<sup>st</sup> and 2<sup>nd</sup> instars. While *C. sycophanta* larvae mature, the number of PPM larvae eaten increased. Both adult beetles and larvae ate only living PPM larvae.

*C. sycophanta* larvae generally started to eat PPM larvae from the abdomen. Some of *C. sycophanta* larvae ate the integument of PPM larvae, too. When *C. sycophanta* larvae fed on PPM larvae, they matured in a short time. On the other hand, injured PPM larvae eventually died. *C. sycophanta* larvae in the last instars (2.5-3 cm in length and 0.8-1 cm in width) could not eat PPM larvae.

Table 5. Mean body length (mm) and duration of (days) 1st, 2nd, 3rd instars of *C. sycophanta* (Coleoptera: Carabidae) (Kanat et al., 2005).

Larva stage	n	Body length	Duration (days)
Larva-1 (L <sub>1</sub> )	30	11.5	9
Larva-2 (L <sub>2</sub> )	30	18.1	10
Larva-3 (L <sub>3</sub> )	30	31.1	16.4

(Kanat et al., 2005)

## Discussion

The PPM has 5 instars between September and April, while *C. sycophanta* can feed between February and April on the late larvae (4<sup>th</sup> or 5<sup>th</sup> instars) in the Kahramanmaraş region. At other times, *C. sycophanta* adults were in the soil.

Overwintering adult beetles (n = 30) weighed about 0.8 g (0.62-1.27 g) and feeding adult beetles weighed approximately 1.13 g (0.65-1.6 g).

As shown in Table 1, adult beetles injured about 10 PPM late larvae (4<sup>th</sup> or 5<sup>th</sup> instars), 7 of which were completely eaten, per day.

*C. sycophanta* larvae also consumed 1 or 2 PPM larvae per day and injured some others. Injuring activity was frequently observed in third instars of *C. sycophanta*. Adult beetles and larvae fed on PPM pupae, except for their hard membranes.

It was reported that the damage that results from PPM larvae eating the needles of *P. brutia* and *P. nigra* continues for about 7 or 8 months throughout much of Turkey. In particular, 4<sup>th</sup> and 5<sup>th</sup> instar larvae consume all the leaves of Calabrian pine trees, and the damaged trees look like as they are burned by fire (Kanat and Alma, 2004).

Adult beetles hibernate in the soil during the winter. The emergence period of adult beetles in the Kahramanmaraş region was well synchronized with 4<sup>th</sup> or 5<sup>th</sup> instar PPM larvae, which were eaten for 30-40 days per year. Each adult beetle eats 210-280 PPM larvae per year and 840-1120 PPM larvae during its lifetime.

Because of the high reproductive potential of *C. sycophanta*, it appears that about 400 adult beetles per hectare are enough to decrease pest populations (*L. dispar*) to innocuous levels (Weseloh, 1985a, 1985b). The number of pupae (*C. sycophanta*) released per hectare in damaged regions was between 200 and 250. Pupae were released into a ditch (25-30 cm depth) one by one (Kanat and Alma, 2004) in May and June. The best suitable *C. sycophanta* release stage is pupa.

Weseloh et al. (1995) suggested that physiology, behavior, and phenology make *C. sycophanta* a specific predator; therefore, they can affect lepidopteran species with similar life history traits as those of the gypsy moth. In the present study it was observed that the beetles and the PPM had similar life history traits, suggesting a very important opportunity to use this beetle against PPM. *C. sycophanta* is one of the most important predators of PPM larvae and early pupae.

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