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Investigation of the toxicity of ethanol extracts obtained from six different *Satureja* L. species on Colorado Potato Beetle, *Leptinotarsa decemlineata* (Say, 1824), (*Coleoptera: Chrysomelidae*)

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Altı farklı *Satureja* L. türünden elde edilen etanol ekstraktının Patates Böceği, *Leptinotarsa decemlineata* (Say, 1824), (*Coleoptera: Chrysomelidae*) üzerindeki toksisitelerinin araştırılması

Abstract: In the present study, ethanol extracts obtained from *Satureja cilicica* P. H. Davis, *Satureja cuneifolia* Ten, *Satureja hortensis* L., *Satureja spicigera* (C. Koch) Boiss., *Satureja thymbra* L. and *Satureja montana* L. were tested against on the adults and larvae of Colorado potato beetle (*Leptinotarsa decemlineata* (Say, 1824)). The experiments were conducted in glass Petri dishes and vacuum desiccators including 15 individual for each period with three replicates under laboratory conditions. 10, 15 and 20 mg/mL doses of ethanol extracts conducted in the Petri dishes and the desiccators showed that depending on concentration increase and duration of exposure time resulted between 2.22-100% toxic effects on the potato beetle larvae and adults. In Petri trials, the highest mortality rate was recorded as 100% for the second larval stage at the 20 mg/mL dose of *S. spicigera* ethanol extract after 96 hours the treatment. In desiccator experiments, the highest toxicity rate was determined as 100% for first larval stage at the 20 mg/mL dose of *S. thymbra* ethanol extract after 96 hours of the application. In addition to, when LD values of the ethanol extracts were taken into account the highest toxicity of adult period was determined for *S. thymbra* extract (LD_{25}: 0.000, LD_{50}: 0.010 µL/insect), the lowest toxicity was determined for *S. cilicica* extract (LD_{90}: 436.020 µL/insect). The results obtained from this study suggested that the ethanol extracts of tested *Satureja* L. species could be used for *L. decemlineata* larvae and adults as bio-larvicides and insecticides.

Key words: Ethanol extracts, *Leptinotarsa decemlineata*, *Satureja* species, toxic effect

Özet: Bu çalışmada, *Satureja cilicica* P. H. Davis, *Satureja cuneifolia* Ten, *Satureja hortensis* L., *Satureja spicigera* (C. Koch) Boiss., *Satureja thymbra* L. ve *Satureja montana* L. bitkilerinden elde edilen ethanol ekstraktları patates böceğinin ergin ve larvaları üzerinde test edilmiştir. Testler laboratuvar koşulları altında cam Petri ve vakumlu desikatörlere yerleştirilmiş her bir döneme ait 15 bireyde 3 tekerrürlü olarak yapılmıştır. Petri ve desikatör denemelerinde ethanol ekstraklarının 10, 15 ve 20 mg/mL'lik dozları konsantrasyon artışına ve maruz kalma süresine bağlı olarak patates böceği larva dönemleri ve erginleri üzerinde 2.22-100% oranında toksik etki göstermiştir. Petri denemelerinde, en yüksek ölüm oranı uygulanmadan 96 saat sonra *S. spicigera* ethanol ekstraktının 20 mg/mL'lik dozunda ikinci larva döneminde %100 olarak kaydedilmiştir. Desikatör denemelerinde ise, en yüksek toksisite oranı uygulamadan 96 saat sonra *S. thymbra* etanol ekstraktının 20 mg/mL'lik dozunda birinci larva dönemi için % 100 olarak belirlenmiştir. Ek olarak, etanol ekstraktlarının LD değerleri dikkate alındığında, en yüksek toksitite ergin dönemde *S. thymbra* ekstraktında (LD_{25}: 0.000, LD_{50}: 0.010 µL/böcek), en düşük toksitite ise *S. cilicica* ekstraktında (LD_{90}: 436.020 µL/böcek) olarak belirlenmiştir. Bu çalışmadan elde edilen sonuçlar, test edilen *Satureja* L. türleri etanol ekstraklarının *L. decemlineata* larvaları ve yetişkinleri için biyo-larvisit ve insektisit olarak kullanılabileceğini göstermiştir.

Anahtar Kelimeler: Etanol ekstraktı, *Leptinotarsa decemlineata*, *Satureja* türleri, toksik etki

1. Introduction

The Colorado potato beetle, *Leptinotarsa decemlineata* (Say, 1824), (*Coleoptera: Chrysomelide*) is the most destructive pest in the potato cultivations and damages on many plants (such as eggplants, some tomato species) of the *Solanaceae* family (Popova, 2014; Alkan et al., 2015). Both adults and larvae feed on the greens of the host plants. However, larval stages are the most damaging life process that causes economic harm (Ferro et al., 1983). In studies conducted, it was determined that the pest resulted in loss of 70% - 80% of potatoes (Oerke et al., 1994). Many synthetic chemicals are broadly used to control this pest. However, these synthetic pesticides can cause environmental, soil and water pollutions in the environment (Barnard et al., 1997; Gelman et al., 2001). But, due to the threat posed to the natural environment and the fact of pest vaccination to the active substances contained in these compounds (Szendrei et al., 2012) it is important to try to find non-chemical methods of controlling the pest. So, there is an increasing interest in new alternative biopesticides, insect growth regulators, natural products such as plant essential oil and extracts and secondary metabolites for pest control in agricultural production by many researchers (Hoffmann and Frodsham 1993; Gonzalez-Coloma et al., 1995, 1998, 2002, 2004; Hu et al., 1999; Isman 2000; Chiasson et al., 2001; Zolotar et al., 2002; Scott et al., 2003, 2004). These metabolite products have been tested against many insect pest species and hopeful results for control of *L. decemlineata* have been reported (Hough-Goldstein, 1990; Scott et al., 2003, 2004; Gokce et al., 2006; Alkan et al., 2015; Tampe et al., 2015). Therefore, the number of studies on plant extracts and oils has been increasing rapidly in recent years in the world (Gokturk et al., 2017; Duru et al., 2003; Kordali et al., 2007a, 2007b; 2008; 2009).

The genus *Satureja* L. (savory), which is one of the most important genera belonging to *Lamiacaeae* family in Turkey and throughout the world. These families are reported nearly 7.000 species belonging to more than 230 genera (Zarshenas and Krenn, 2015). Among those genera, *Satureja* (savory) includes over 200 different herbs and shrubs, often aromatic, widely distributed in the Mediterranean area, Asia (Cronquist, 1988). In Turkey, there are 40 *Satureja* species (42 taxa) and 18 of them are endemic (Öztekin, 2012). *Satureja* species are known as "kekik", "sivri kekik", "kılıç kekik", "keklik otu", "catlı" or "firubi" by their names among local people in Anatolia (Başer et al., 2001). The leaves, flowers and stems of *Satureja* species are used as herbal tea, and also to treat infectious diseases in traditional medicine (Güllüce et al., 2003). *Satureja* species is high rated essential oil containing and the yield of essential oil often changes to 5% in different species of this genus (Momtaz et al., 2010). *Satureja* essential oils contain main monoterpenes such as "carvacrol" and "thymol". (Hadian et al., 2010). Essential oils and extracts of this genus have shown antibacterial, fungicidal, antiviral and insecticidal activities. So, they can be used as natural pesticides (Michaelakis et al., 2007). Insecticidal impact experiments of different essential oils, extracts and some monoterpen components have been broadly studied against various insects by many researchers (Lee et al., 2003; Kordali et al., 2007a; Bashır et al., 2013).

The main aim of this study was to determine the toxic effects of ethanol extracts obtained from six *Satureja* species against the 1st, 2nd, 3rd and 4th instars larvae and adults of *L. decemlineata* Petri dishes and desiccator in laboratory conditions.

2. Materials and Method

2.1. Plant materials and extraction

The plants used in this study, *Satureja cilicica* P. H. Davis and *S. cuneifolia* Ten (from Konya, Selçuklu), *S. hortensis* L. (from Erzurum, Şenkaya), *Satureja spicigera* (C. Koch) Boiss. (from Trabzon, Maçka), *Satureja thymbra* L. (from Antalya, Demre) and *Satureja montana* L. (from İzmir, Ödemiş), were collected during flowering time between June and September in the years 2011 and 2012. The identification of collected plants was done by Prof. Dr. Yusuf Kaya, Ataturk University, Faculty of Science, Department of Biology, Erzurum (Turkey). The herbariums of these plant specimens, *S. cilicica* (ATA. HERB 9845), *S. cuneifolia* (ATA. HERB 9843), *S. hortensis* (ATA. HERB 9842), *S. spicigera* (ATA. HERB 9847), *S. thymbra* (ATA. HERB 9846), and *S. montana* (ATA. HERB 9844), have been deposited in the herbarium laboratory of Ataturk University Department of Biology, Faculty of Science, Erzurum. Collected plant materials were dried in a shady room and powdered by grinding in the grinder (about 0.100–0.400 mm particle). Then, 100 g of each sample was individually extracted with ethanol (400 mL×6) at room temperature. The extracts were filtered using Whatman filter paper (No. 1) and then concentrated under reduced pressure at 40ºC using a rotary evaporator (RV 05 Basic 1B IKA Group, Wilmington, NC, U.S.A.). Residues of each plant species were diluted with sufficient HPLC grade ethanol (Sigma-Aldrich, Milwaukee, WI, U.S.A.) and sterile water to give 100% (w/w) stock solutions. The extracts (yields 11, 7.6, 8.8, 16.2, 8.06 and 17% respectively) were stored in a freezer at 4ºC until further tests.

2.2. Bioassays using ethanol extracts

Glass Petri dishes (9 cm wide×1.5 cm deep, corresponding to 120 ml volume) were used as exposure chambers to test the toxicity of ethanol extracts of six plants against adults and larvae of *Leptinotarsa decemlineata* (Say, 1824). The ethanol extracts were dissolved in Ethanol–water solution (10%, v/v) to determine their contact toxicity effects. The final concentrations of the treatments were 10, 15 and 20 mg/mL.

A filter paper was placed in bottom of each of the Petri dishes (9 cm×1.5 cm deep). Then, 15 adults and larvae of *L. decemlineata* were placed on this filter paper, containing the appropriate amounts of potato leaves. Thus, there was direct contact between the extracts and the adults and larvae. The emulsions were sprayed to Petri dishes (9 cm diameter) and two layers of filter paper were placed in the bottom (1 ml/Petri dish). 10, 15 and 20 mg/mL doses of the ethanol extracts were sprayed to adults insects by using spray equipment. The Petri dishes were covered with a lid and transferred into incubator, and then kept under standard conditions of 25 ± 1°C, 64 ± 5 relative humidity and 16:8 (light: dark) photoperiod for 4 days. The toxic effects against adults and larvae were tested using 20 mg/mL dose of ethanol extracts in the desiccator test. In this method, 5 liters of vacuum desiccators 250 mm in diameter disinfected with 1 % sodium hypochlorite were placed in 15 larvae and adult individuals of each potato beetle period. Inside the desiccator, 10 mL of standard glass tubing was added to 1/3 of pure water, and potato plant branches were placed in the tubes. Doses of 20 mg/mL of ethanol extracts diluted in the solvent-water solution were sprayed at a rate of 2 ml per desiccator and to thoroughly soak the potato leaves.

The treatments were arranged in a completely randomized design with three replications including controls. Izoldesis 2.5 EC (Deltametrin) (10, 15 and 20 mg/mL) was used as positive control in the same above mentioned conditions. After exposure, the mortality of the adults was counted at 24, 48, 72 and 96 h. Sterile water and Ethanol were used as control in the same way. Each experiment was replicated three times at each dose.

2.3. Biological material

The adults and larvae of *Leptinotarsa decemlineata* were collected from potato fields (Tepe and Söğütlü villages) at Eastern Anatolia (Erzurum) in Turkey and were reared in laboratory at 25±1°C, 64±5 relative humidity in the Department of Plant Protection at Atatürk University. First, second, third and fourth instar larvae (determined according to their head length and width of the body) and 3-5 day-old adults were used as test insects and larvae. The cultivation of potato plants was grown in 25 square meter area belonging to Department of Plant Protection, in Agriculture Faculty, at Atatürk University and the tested insects and larvae feed on fresh leaves provided from this field. All tests were carried out under the same laboratory conditions.

2.4. Data Analysis

The results of mean mortality were subjected to one-way variance analyses (ANOVA), using SPSS 17.0 software package. Differences between means were tested through Duncan's test was used for comparison between means. Significance of differences between means was determined at $p < 0.05$. LD_{25}, LD_{50} and LD_{90} values were calculated according to the method of Finney (1971). Probit analysis of concentration-mortality data was conducted to estimate the $LD_{25,50,90}$ values and associated 95 % confidence limits for each treatment (EPA Probit Analysis).

3. Results and Discussion

3.1. Insecticidal activity extracts

The insecticidal and larvicidal effects of ethanol extracts of *Satureja cilicia*, *S. cuneifolia*, *S. hortensis*, *S. spicigera*, *S. thymbra* and *S. montana* were studied on the 1st, 2nd, 3rd and 4th instars larvae and adults of the *L. decemlineata.* Petri dish and desiccator in laboratory conditions at different concentrations and exposure times were investigated. Maximum mortalities were recorded after 96 h of exposure at all concentrations (Table 1, 2, 3, 4, 5, 6 and 7). The results showed that ethanol extracts of *S. cilicia*, *S. cuneifolia*, *S. hortensis*, *S. spicigera*, *S. thymbra* and *S. montana* had significant toxic effects on both the larvae and adults of *L. decemlineata* comparison with the negative control and positive control (Izoldesis). In the larvae and adults the mortality increased with increasing doses of the ethanol extracts and exposure time. Varience analysis showed that the effects of ethanol extracts extracted from six different *Satureja* species on the mortality rates among 1st, 2nd, 3rd and 4th instars larvae and adults of *L. decemlineata* were highly significant on the foundation of concentration and exposure time tested (Table 1, 2, 3, 4, 5, 6 and 7). The lowest mortality rates were recorded at the different exposure time (12, 24, 48 and 72 hrs) and in the same dose (10 mg/mL) of *S. cuneifolia* ethanol extract (8.88, 22.2, 42.2 and 60.0%) on the 1st instar larvae of *L. decemlineata* (Table 1).

Besides, the lowest mortality rates (77.7%) was found at the 96 hrs of treatment with the 10 mg/mL dose for *S. cilicica* and *S. hortensis* ethanol extracts on the 1st instar larvae of *L. decemlineata.* But, the highest mortality rates (31.1% after 12 h of ethanol extracts of *S. thymbra* and *S. montana*); (48.8% after 24 hrs of ethanol extracts of *S. cuneifolia* and *S. spicigera*); (66.6% after 48 hrs of ethanol extract of *S. spicigera*); (80.0% after 72 h and 95.5% after 96 hrs of ethanol extracts of *S. spicigera* and S. *thymbr*a) of treatment in the 20 mg/mL dose of ethanol extracts on the 1st instar larvae of *L. decemlineata*. After 96 h of the treatment, the lowest mortality rate (88.8%) was recorded in the 10 mg/mL dose of *S. cilicia* ethanol extract, while, the highest mortality rate (100%) was in the 10 and 20 mg/mL doses of *S. thymbra* ethanol extract and in the 20 mg/mL dose ethanol extracts of *S. spicigera* and *S. montana* on the 1st instar larvae of *L. decemlineata.* However, the mortality rates of izoldesis using as positive control were established as 95.5, 97.7 and 100% after 12 h in the 10, 15 and 20 mg/mL doses for 1st instar larvae of *L. decemlineata*, respectively. Additionally, the mortality rates after 24, 48, 72 and 96 hrs of treatment with all doses (10, 15 and mg/mL) of izoldesis were found as 100% for 1st instar larvae of *L. decemlineata*. No mortality for 1st instar larvae of *L. decemlineata* (except 0.0% 12h; 2.22% 24 h; 4.44% 48 h;6.66% 72 h and 96 h) in the negative control. The lowest mortality rate was recorded at the different exposure time (12, 24, 48,72 and 96 hrs) and in the dose (10 mg/mL) of *S. cilicica* ethanol extract (4.44, 17.7, 28.8, 46.6 and 66.6%) but, after 96 h of the treatment, the highest mortality rate (100%) was found of in the 20 mg/mL dose of ethanol extract of *S. spicigera* on the 2nd instar larvae of *L. decemlineata.* Additionally, the mortality rates after both at all times and at all doses of izoldesis were found as 80.0-100% for 2nd instar larvae of *L. decemlineata*. No mortality for larvae (except 0.0% 12h; 2.22% 24 h; 4.44% 48 h;6.66% 72 h and 96 h) in the negative control (Table 2). In comparison with the mortalities of six *Satureja* species ethanol extracts, the lowest mortality rates were recorded between 6.66% and 73.3 % in all doses and all times on the 3rd instar larvae of *L. decemlineata*. Likewise, the highest mortality rates were found between 24.4 and 91.1% 3rd larvae and the mortality rates after 12, 24, 48, 72 and 96 h of treatment with all doses of izoldesis were found from 91.1 to 100% for 3rd instar larvae of *L. decemlineata*. No mortality was for larvae (except for 0.0% 12 h; 2.22% 24 h; 4.44% 48 h and 72; 6.66% 96 h) in the negative control (Table 3). Similarly, the lowest mortality rates were recorded at the different exposure time and in the same dose (10 mg/mL) test of ethanol extracts between 2.22% and 66.6% on the 4th instar larvae of *L. decemlineata*. However, after 96 h of treatment, the highest mortality rates were determined in the 20 mg/mL concentration of *S. montana* ethanol extract as 93.3% for 4th larvae. Besides, the mortality rates both at all times and at all doses of izoldesis were found between 95.5 and 100% for 4th larvae and no mortality for 4th instar larvae of *L. decemlineata* (except 0.0% 12h; 2.22% 24 h, 48 h, 72 h and 96 h) in the negative control (Table 4). When looking at adults, the lowest mortality rates were showed as 2.22% at 12 h, 13.3% at 24 h, 31.1% at 48 h, 51.1% at 72 h and 71.1% at 96 h in the 10 mg/mL for *S. thymbra* ethanol extract. However, the highest toxicity rates after 96 h treatment final concentration 20 mg/mL of *S. spicigera* and *S. montana* ethanol extracts were calculated as 86.6% on adults (Table 5). In addition, the mortality rates after both at all times and at all doses of Izoldesis were estimated between 93.3 and 100% against the adults of *L. decemlineata*. But, there was no mortality adults in the negative control groups during the test period. (Table 5).

The LD_{25}, LD_{50} and LD_{90} values after 96 h were estimated for 1st, 2nd, 3rd and 4th instars larvae and adults of the *L. decemlineata.* According to LD values, although the lowest toxic effects (LD_{90}) were found 436.020 mg/mL for *S. cilicica* ethanol extract, again the most toxicity effects were determined as 0.000 and 0.010 mg/Petri (LD_{25} and LD_{50}) for *S. thymbra* ethanol extracts on the adults of *L. decemlineata,* respectively (Table 6).

In the desiccator experiments, the maximum toxicity rates were found in higher concentration and longer exposure times on 1st, 2nd, 3rd and 4th instar larvae and adults of the *L. decemlineata* when compared with controls. The analysis results showed that the lowest mortality rates were observed as 11.1% after 12 h, 28.8% 24 h, 44.4% 48 h, 62.2% 72 h and 80.0% 96 h in the 20 mg/mL dose of *S. cilicica* ethanol extract on the 1st instar larvae of *L.*

Table 1. Insecticide effects against the 1st instar larvae period of *L. decemlineata* in-vivo conditions of ethanol extracts obtained from *Satureja* species

1st INSTAR LARVAE						
Extracts	**Dose**	**Mortality% (Mean) ± SE**				
		Exposure time (h)				
		12	**24**	**48**	**72**	**96**
S. cilicica	**10**	13.3±3.84 bc	28.8±2.22 bc	46.6±3.84 bc	68.8±2.22 cde	77.7±5.87 b
	15	20.0± 3.84 cdef	33.3±3.84 cd	55.5±2.22 def	71.1±2.22 def	84.4±2.22 bc
	20	26.6±3.84 fgh	40.0±3.84 de	57.7±5.87 efg	73.3±6.66 def	93.3±3.84 def
S. cuneifolia	**10**	8.88±2.22 b	22.2±2.22 b	42.2±2.22 b	60.0±3.84 b	82.2±2.22 bc
	15	17.7±2.22 cde	33.3±3.84 cd	53.3±3.84 cde	71.1±2.22 def	82.2±4.44 bc
	20	28.8±2.22 gh	48.8±2.22 f	64.4±2.22 gh	77.7±2.22 ef	93.3±3.84 def
S. hortensis	**10**	13.3±3.84 bc	22.2±2.22 b	44.4±2.22 b	62.2±2.22 bc	77.7±4.44 b
	15	17.7±2.22 cde	31.1±2.22 c	55.5±2.22 def	73.3±3.84 def	84.4±2.22 bc
	20	22.2±2.22 defg	42.2±2.22 ef	62.2±2.22 fgh	77.7±4.44 ef	93.3±3.84 def
S. spicigera	**10**	17.7±2.22 cde	28.8±4.44 bc	48.8±4.44 bcd	68.8±5.87 cde	82.2±5.87 bc
	15	26.6±0.0 fgh	40.0±3.84 de	53.3±3.84 cde	71.1±2.22 def	86.6±3.84 cd
	20	28.8±2.22 gh	48.8± 2.22 f	66.6±3.84 h	80.0±3.84 f	95.5±2.22 ef
S. thymbra	**10**	22.2±2.22 defg	33.3±3.84 cd	53.3±3.84 cde	71.1±2.22 def	88.8±2.22 cde
	15	24.4±2.22 efgh	44.4±2.22 ef	60.0±0.0 efgh	75.5±2.22 def	95.5±2.22 ef
	20	31.1±2.22 h	46.6±3.84 ef	64.4±2.22 gh	80.0±3.84 f	95.5±3.84 ef
S. montana	**10**	15.5±2.22 cd	28.8±2.22 bc	48.8±2.22 bcd	66.6±3.84 bcd	84.4±2.22 bc
	15	26.6±3.84 fgh	40.0±3.84 de	55.5±2.22 def	66.6±3.84 bcd	86.6±0.0 cd
	20	31.1±3.84 h	42.2±2.22 ef	62.2±2.22 fgh	77.7±2.22 ef	93.3±0.0 def
P. Control (İzoldesis)	**10**	95.5±2.22 ı	100±0.0 g	100±0.0 ı	100±0.0 g	100±0.0 f
	15	97.7±2.22 ı	100±0.0 g	100±0.0 ı	100±0.0 g	100±0.0 f
	20	100±0.0 ı	100±0.0 g	100±0.0 ı	100±0.0 g	100±0.0 f
N. Control (Ethanol+S. water)	**20**	0.0±0.0	2.22±1.85 a	4.44±1.85 a	6.66±0.0 a	6.66±0.0 a

* Values followed by different letters in the same column differ significantly at P ≤ 0. 05 according to Duncan Multiple test. Mean±SE of three replicates. Each set up with 15 larvae.

Table 2. Insecticide effects against the 2nd instar larvae period of *L. decemlineata* in-vivo conditions of ethanol extracts obtained from *Satureja* species

2nd INSTAR LARVAE						
Extracts	**Dose**	**Mortality% (Mean) ± SE**				
		Exposure time (h)				
		12	**24**	**48**	**72**	**96**
S. cilicica	**10**	8.88±2.22 bc	22.2±5.87 bc	42.2±5.87 cde	64.4±2.22 de	75.5±2.22 c
	15	17.7±2.22 def	31.1±2.22 def	46.6±3.84 def	66.6±3.84 def	86.6±3.84 de
	20	24.4±2.22 fgh	44.4±2.22 hı	60.0 ± 3.84 hı	75.5±2.22 fgh	93.3±3.84 efg
S. cuneifolia	**10**	4.44±2.22 ab	17.7±2.22 b	28.8 ± 2.22 b	46.6±3.84 b	66.6±3.84 b
	15	17.7±2.22 def	28.8±2.22 cde	35.5±4.44 bc	55.5±4.44 c	80.0±3.84 cd
	20	22.2±2.22 efg	46.6±3.84 ı	57.7±4.44 ghı	73.3±3.84 efg	88.8±4.44 def
S. hortensis	**10**	11.1±5.87 bcd	22.2±4.44 bc	37.7±3.84 bcd	60.0±3.84 cd	75.5±5.87 c
	15	20.0±0.0 efg	31.1±2.22 def	48.8±3.84 efg	68.8±4.44 efg	82.2±4.44 cd
	20	22.2±4.44 efg	35.5±2.22 efg	51.1±2.22 efg	73.3±3.84 efg	88.8±2.22 def
S. spicigera	**10**	4.44±2.22 ab	24.4±2.22 bcd	51.1±2.22 efg	68.8±2.22 efg	84.4±2.22 de
	15	6.66±0.0 ab	24.4±4.44 bcd	57.7±5.87 ghı	80.0±3.84 h	95.5±2.22 fg
	20	8.88±2.22 bc	31.1±2.22 def	62.2±4.44 ı	88.8±2.22 ı	100±0.0 g
S. thymbra	**10**	20.0±3.84 efg	35.5±2.22 efg	60.0±3.84 hı	71.1±4.44 efg	88.8±2.22 def
	15	24.4±2.22 fgh	44.4±2.22 hı	57.7±2.22 ghı	73.3±3.84 efg	80.0±3.84 cd
	20	31.1±2.22 h	46.6±3.84 ı	57.7±2.22 ghı	77.7±2.22 gh	93.3±3.84 efg
S. montana	**10**	15.5±2.22 cde	28.8±2.22 cde	55.5±2.22 fghı	66.6±3.84 def	84.4±2.22 de
	15	26.6±3.84 gh	37.7±4.44 fgh	57.7±2.22 ghı	73.3±3.84 efg	84.4±5.87 de
	20	26.6±0.0 gh	42.2±2.22 ghı	62.2±2.22 ı	75.5±4.44 fgh	91.1±2.22 ef
P. Control (İzoldesis)	**10**	80.0±6.66 ı	93.3±0.0 j	97.7±2.22 j	100±0.0 j	100±0.0 g
	15	88.8±2.22 j	95.5±2.22 j	100±0.0 j	100±0.0 j	100±0.0 g
	20	93.3±0.0 j	100±0.0 j	100±0.0 j	100±0.0 j	100±0.0 g
N. Control (Ethanol+S. water)	**20**	0.0±0.0 a	2.22±1.85 a	4.44±1.85 a	6.66±0.0 a	6.66±0.0 a

* Values followed by different letters in the same column differ significantly at P ≤ 0. 05 according to Duncan Multiple test. Mean±SE of three replicates. Each set up with 15 larvae.

decemlineata. But, the highest mortality rates were estimated as 100% after 96 h of treatment same concentration of *S. thymbra* ethanol extract on the larvae. In addition, the mortality rates after different times and 20 mg/mL of concentration of Izoldesis were recorded between 97.7 and 100% on the larvae (Table 7). Similarly, the lowest mortality rates were showed between 11.1 and 80.0%, while the highest mortality rates after 12 h 22.2%, 24 h 46.6%, 48 h 66%, 72 h 88.8% and 96 h %93.3 in the 20 mg/Petri for *S. thymbra* ethanol extract on the 2nd instar larvae of *L. decemlineata*. The mortality rates after different times and 20 mg/mL of concentration of Izoldesis were determined 100% on the larvae (Table 7). In the 3rd instar larvae of *L. decemlineata,* the lowest mortality rate in the 20 mg/mL dose after 96 h of treatment was reckoned as 75.5% for *S. cilicica* ethanol extract. However, the highest mortality rate at the same exposure time and in the same dose was 95.5% for *S. hortensis* ethanol extract. The mortality rates at all times of Izoldesis used as positive control were determined as 97.7-100% for the 3rd instar larvae (Table 7). Similarly, the lowest mortality rates were between 11.1% and 80.0%, while the highest mortality rates after 72 h 82.2% and 96 h %91.1 in the 20 mg/mL were found for *S. spicigera* ethanol extract on the 4th instar larvae of *L. decemlineata* (Table 7). The mortality rates at different times and in the 20 mg/mL concentration of Izoldesis were found between 97,7% and 100% larvae (Table 7). Additionally, the lowest mortality rates were recorded between 11.1% and 77.7%, while the highest mortality rates were determined after 96 h %95.5 in the 20 mg/mL for *S. thymbra* ethanol extract on the adults of *L. decemlineata*. The mortality rates at different times and in the 20 mg/Petri concentration of Izoldesis were found between 93.3% and 100% for *L. decemlineata* adults. But, there was no mortality in the 1st, 2nd, 3rd and 4th instar larvae and *L. decemlineata* adults in the negative control groups during the test period (Table 7).

Toxic effects of plant extracts, essential oils and various secondary metabolite products have been reported in different researches (Kesdek et al., 2015; Usanmaz et al., 2016; Kısa et al., 2018). The present study showed that under in vivo (between 2.22 and 100%) and in vitro (between 8.88 and 100%) conditions, the ethanol extracts of six *Satureja* plant species had the strong insecticidal activity based on the mortality of all the tested (1st, 2nd, 3rd and 4th) instars larvae and adults of *L. decemlineata*. (Table 1, 2, 3, 4, 5, 6 and 7). The results are in agreement with the previous literature reports on plant extracts (Kesdek et al., 2014; Güzel et al., 2017). The successful result was obtained from the ethanol extracts. It was demonstrated that the wild thyme (*Thymus serpyllum* L.) water extracts had toxic effects at different concentrations on 4th instars larvae and adults of *L. decemlineata* (Rusin et al., 2016). In this study, we have found that six *Satureja* species ethanol extracts have a toxic effect (between 2.22 and 93.3%) in the 10, 15 and 20 mg/Petri concentrations on adults and 4th instar larvae of *L. decemlineata* (Table 5). In a previous study, it was found that the ethanol extracts of *M. chamomilla* had toxic effects on the L_3 and L_4 larvae (44.83% and 42.87%) of *L. decemlineata* (Biniaś et al., 2017). Besides, it was reported that ethanol extracts of five *Vincetoxicum* species had toxicity in the different doses and at exposure times on 3rd instar larvae of *L. decemlineata* (Güzel et al., 2017).

In the current study, we have found that the ethanol extracts of *Satureja* species have larvicidal effects in all the exposure times (12, 24, 48, 72 and 96 hrs) and treatment doses (10, 15 and 20 mg/mL) with mortality rates (between 2.22% and 100%) on the 1st, 2nd,3rd and 4th instar larvae of *L. decemlineata* (Table 1, 2, 3 and 4). Previous studies showed that the extracts obtained from *S. officinalis* and *R. officinalis* plant species had insecticidal effects between 85.9 and 97.5% mortality rates under field and laboratory conditions on adults of *L. decemlineata* (Kara et al., 2014). In our desiccator work, it was determined that the ethanol extracts obtained from six *Satureja* species had important insecticidal effects (with between 2.22% and 93.3% the mortality rates) in all exposure times and treatment dose (20 mg/mL) on *L. decemlineata* adults (Table 7).

Many studies conducted with desiccator trials; Topuz et al. (2018) presented *M. pulegium* essential oil to be the most toxic oil against *Tetranychus urticae* in all the biological stages tested (LC_{50}= 0.60 µL/L air for eggs, 0.60 µL/L air for larvae and 0.49 µL/L air for adult females), followed by *F. vulgare* essential oil (LC_{50}= 2.67 µL/L air for eggs and adult females, and 2.56 µL/L air for larvae). In the same way, it was stated that the essential oils of three different plant species had a strong insecticidal activity under desiccator conditions on *Tribolium confusum* and *Sitophilus granarius* adults (Yıldırım et al., 2005). In another study, it was determined that the extracts obtained from three different plant species were effective against *L. decemlineata* larvae (Pavela, 2010). In our study, we found that the ethanol extracts obtained from six *Satureja* species have larvicidal effects all the exposure times and treatment (20 mg/mL) between 8.88% and 100% with the mortality rates on the 1st, 2nd, 3rd and 4th instars larvae and adults of the *L. decemlineata* (Table 7).

Emsen et al., (2012) reported that two lichen extracts had an important insecticidal effect on 4th instar larvae and adults of *L. decemlineata.* The same researchers stated that the most efficient crude extracts on the 4th instar larvae and adults of *L. decemlineata* was diffractaic acid (LC_{50} = 1.509 and 1.783 ppm, respectively). In the present study, we have determined that the most effective ethanol extract on the 4th instar larvae and adults of *L. decemlineata* was for *S. thymbra* plant (LD_{50}=2.127 and 0.010 ppm, respectively) (Table 7).

On the other hand, in our study, we recorded that the most toxicity effects of *S. spicigera* (in the LD_{50} value) and *S. thymbra* ethanol extracts (in the LD_{90} value) were 0.873 and 10.350 on the 1st instar larvae *L. decemlineata*, respectively. At the same time, it was determined that the ethanol extracts of *S. montana* were 0.205 in the LD_{50} and 1.016 in the LD_{90} values on the 2nd instar larvae of *L. decemlineata*. In addition, it was stated that the highest toxicity effects of *S. cuneifolia* ethanol extracts were found as 0.312 in the LD_{50} and 19.241 in the LD_{90} values on the 3rd instar larvae of *L. decemlineata* (Table 7).

Table 3. Insecticide effects against the 3rd instar larvae period of *L. decemlineata* in-vivo conditions of ethanol extracts obtained from *Satureja* species

3rd INSTAR LARVAE						
Extracts	**Dose**	**Mortality% (Mean) ± SE**				
		Exposure time (h)				
		12	**24**	**48**	**72**	**96**
S. cilicica	**10**	6.66±3.84 ab	15.5±2.22 b	40.0±3.84 bc	64.4±2.22 bcde	77.7±2.22 bcd
	15	6.66±0.0 ab	20.0±3.84 bcd	35.5±2.22 b	66.6±3.84 bcdef	77.7±5.75 bcd
	20	11.1±2.22 bcd	31.1±2.22 efg	51.1±2.22 def	71.1±4.44 def	88.8±4.44 e
S. cuneifolia	**10**	8.88±2.22 bc	22.2±2.22 bcde	48.8±2.22 cde	68.8±2.22 cdef	82.2±2.22 bcde
	15	15.5±2.22 cde	33.3±3.84 fgh	60.0±3.84 fg	73.3±3.84 ef	84.4±5.87 cde
	20	24.4±2.22 f	44.4±2.22 ı	62.2±3.84 g	77.7±2.22 f	86.6±3.84 de
S. hortensis	**10**	6.66±3.84 ab	17.7±4.44 bc	35.5±2.22 b	57.7±2.22 bc	73.3±3.84 b
	15	15.5±2.22 cde	26.6±3.84 cdef	42.2±2.22 bcd	55.5±5.87 b	73.3±3.84 b
	20	22.2±2.22 ef	33.3±3.84 fgh	48.8±2.22 cde	66.6±3.84 bcdef	84.4±2.22 cde
S. spicigera	**10**	8.88±2.22 bc	20.0± 3.84 bcd	35.5±5.87 b	55.5±5.87 b	75.5±5.75 bc
	15	15.5±2.22 cde	28.8 ± 5.87 def	46.6 ± 6.66 cde	71.1 ±5.87 def	88.8±4.44 e
	20	17.7 ± 2.22 def	40.0 ± 3.84 ghı	62.2 ± 2.22 g	77.7 ± 2.22 f	88.8±5.87 e
S. thymbra	**10**	11.1±4.44 bcd	22.2±5.87 bcde	42.2 ± 5.87 bcd	60.0 ± 3.84 bcd	75.5±2.22 bc
	15	15.5±5.87 cde	31.1±4.44 efg	51.1±2.22 def	68.8±9.68 cdef	84.4±8.01 cde
	20	24.4±2.22 f	42.2±4.44 hı	55.5±8.01 efg	71.1±2.2 def	86.6±3.84 de
S. montana	**10**	6.66±3.84 ab	15.5±4.44 b	35.5±4.44 b	60.0±3.84 bcd	75.5±2.22 bc
	15	15.5±2.22 cde	26.6±3.84 cdef	46.6±3.84 cde	66.6±3.84 bcdef	84.4±2.22 cde
	20	22.2±2.22 ef	40.0±3.84 ghı	60.0±3.84 fg	75.5±2.22 ef	91.1±2.22 ef
P. Control (İzoldesis)	**10**	91.1±2.22 g	97.7±2.22 j	100±0.0 h	100±0.0 g	100±0.0 f
	15	91.1±2.22 g	97.7±2.22 j	100±0.0 h	100±0.0 g	100±0.0 f
	20	93.3±0.0 g	100±0.0 j	100±0.0 h	100±0.0 g	100±0.0 f
N. Control (Ethanol+S. water)	**20**	0.0±0.0 a	2.22±1.85 a	4.44±1.85 a	4.44±1.85 a	6.66±0.0 a

* Values followed by different letters in the same column differ significantly at P ≤ 0. 05 according to Duncan Multiple test. Mean±SE of three replicates. Each set up with 15 larvae.

Table 4. Insecticide effects against the 4th instar larvae period of *L. decemlineata* in-vivo conditions of ethanol extracts obtained from *Satureja* species

4th INSTAR LARVAE						
Extracts	**Dose**	**Mortality% (Mean) ± SE**				
		Exposure time (h)				
		12	**24**	**48**	**72**	**96**
S. cilicica	**10**	8.88±2.22 abcd	17.7±2.22 bc	35.5±5.87 b	48.8±2.22 b	66.6±3.84 b
	15	6.66±3.84 abc	20.0±3.84 bcd	37.7±2.22 bc	62.2±2.22 cde	68.8±2.22 bc
	20	11.1±2.22 bcd	24.4±2.22bcde	42.2±2.22 bcde	62.2±5.87 cde	77.7±5.87 bcde
S. cuneifolia	**10**	6.66±3.84 abc	22.2±4.44 bcd	37.7±5.87 bc	57.7±5.87 bc	73.3±3.84 bcd
	15	13.3±3.84 cde	26.6±3.84 cdef	44.4±5.87 bcdef	60.0±7.69 bcd	75.5±4.44 bcde
	20	22.2±2.22 e	33.3±0.0 efg	51.1 ± 2.22 def	75.5 ± 4.44 f	86.6±3.84 ef
S. hortensis	**10**	2.22±2.22 ab	15.5±2.22 b	35.5 ± 2.22 b	60.0±3.84 bcd	77.7±4.44 bcde
	15	13.3 ± 3.84 cde	28.8±2.22 defg	51.1±2.22 def	64.4±2.22 cdef	86.6 ± 3.84 ef
	20	17.7 ± 4.44 de	35.5 ± 5.87 fg	53.3 ± 3.84 ef	73.3 ± 3.84 ef	86.6 ± 6.66 ef
S. spicigera	**10**	8.88±2.22 abcd	20.0± 3.84 bcd	40.0±3.84 bcd	60.0±3.84 bcd	75.5±2.22 bcde
	15	11.1±5.87 bcd	24.4±5.87 bcde	37.7±5.87 bc	57.7± 5.87 bc	80.0± 6.66 cde
	20	13.3±3.84 cde	26.6±3.84 cdef	48.8±4.44 cdef	71.1 ± 2.22 def	86.6 ± 3.84 ef
S. thymbra	**10**	13.3±3.84 cde	28.8±2.22 defg	46.6±3.84 bcdef	64.4±2.22 cdef	77.7±2.22 bcde
	15	17.7±2.22 de	33.3±3.84 efg	55.5±2.22 f	71.1±5.87 def	82.2±4.44 def
	20	17.7±5.87 de	37.7±2.22 g	55.5±5.87 f	75.5±2.22 f	86.6±3.84 ef
S. montana	**10**	2.22±2.22 ab	22.2±2.22 bcd	40.0±3.84 bcd	57.7±5.87 bc	75.5±4.44 bcde
	15	4.44±2.22 abc	26.6±3.84 cdef	44.4±5.87 bcdef	62.2±5.87 cde	75.5±5.87 bcde
	20	13.3±2.22 cde	33.3±3.84 efg	51.1±5.87 def	75.5±5.87 f	93.3±3.84 fg
P. Control (İzoldesis)	**10**	95.5±2.22 f	97.7±2.22 h	100±0.0 g	100±0.0 g	100±0.0 g
	15	95.5±2.22 f	100±0.0 h	100±0.0 g	100±0.0 g	100±0.0 g
	20	95.5±2.22 f	100±0.0 h	100±0.0 g	100±0.0 g	100±0.0 g
N. Control (Ethanol+S. water)	**20**	0.0 ± 0.0 a	2.22 ± 1.85 a	2.22 ± 1.85 a	4.44 ± 1.85 a	4.44 ± 1.85 a

* Values followed by different letters in the same column differ significantly at P ≤ 0. 05 according to Duncan Multiple test. Mean±SE of three replicates. each set up with 15 larvae.

Table 5. Insecticide effects against adults of the period *L. decemlineata* in-vivo conditions of ethanol extracts obtained from *Satureja* species

ADULT PERIOD						
Extracts	**Dose**	**Mortality% (Mean) ± SE**				
		Exposure time (h)				
		12	**24**	**48**	**72**	**96**
S. cilicica	**10**	8.88±2.22 bcd	20.0±3.84 bcd	37.7±4.44 bcde	55.5 ± 2.22 bcd	71.1±2.22 b
	15	6.66±0.0 abc	26.6±0.0 def	44.4±2.22 defg	62.2±2.22 bcdef	73.3±3.84 bc
	20	11.1±2.22 cd	26.6±3.84 def	46.6±3.84 efgh	57.7±5.87 bcde	75.5± 5.87 bcd
S. cuneifolia	**10**	8.88±2.22 bcd	24.4±4.44 cde	40.0±3.84 bcde	53.3 ± 3.84 bc	71.1±2.22 b
	15	8.88±2.22 bcd	20.0±3.84 bcd	40.0±7.69 bcde	60.0±3.84 bcde	75.5± 2.22 bcd
	20	15.5±2.22 d	28.8±5.87 def	48.8±5.87 fgh	64.4±5.87 cdefg	80.0±3.84 bcde
S. hortensis	**10**	6.66±0.0 abc	15.5±2.22 bc	37.7±2.22 bcde	64.4±2.22 cdefg	75.5±2.22 bcd
	15	11.1±4.44 cd	28.8±5.87 def	48.8±5.87 fgh	66.6±3.84 defg	80.0±3.84 bcde
	20	13.3±3.84 cd	33.3±3.84 ef	55.5±5.87 h	75.5±5.87 g	84.4±4.44 de
S. spicigera	**10**	2.22±2.22 ab	15.5±2.22 bc	35.5±2.22 bcd	57.7±2.22 bcde	73.3±3.84 bc
	15	6.66±0.0 abc	22.2±2.22 bcd	42.2± 2.22 cdefg	60.0±3.84 bcde	80.0±3.84 bcde
	20	11.1±2.22 cd	35.5±2.22 f	51.1±2.22 gh	73.3±3.84 fg	86.6±3.84 e
S. thymbra	**10**	8.88±2.22 bcd	22.2±2.22 bcd	42.2±2.22 cdefg	66.6±3.84 defg	82.2±2.22 cde
	15	8.88±5.87 bcd	22.2±5.87 bcd	42.2±5.87 cdefg	66.6±3.84 defg	84.4±5.87 de
	20	11.1±2.22 cd	22.2±2.22 bcd	46.6±3.84 efgh	68.8±2.22 efg	84.4±4.44 de
S. montana	**10**	2.22±2.22 ab	13.3±0.0 b	31.1±2.22 b	51.1±5.87 b	71.1±5.87 b
	15	6.66±3.84 abc	15.5±4.44 bc	33.3±3.84 bc	53.3±3.84 bc	77.7±2.22 bcde
	20	8.88±2.22 bcd	26.6±3.87 def	46.6±3.84 efgh	66.6±3.84 defg	86.6±3.84 e
P. Control (İzoldesis)	**10**	93.3±0.0 e	97.7±2.22 g	100±0.0 ı	100±0.0 h	100±0.0 f
	15	93.3±0.0 e	97.7±2.22 g	100±0.0 ı	100±0.0 h	100±0.0 f
	20	95.5±2.22 e	100±0.0 g	100±0.0 ı	100±0.0 h	100±0.0 f
N. Control (Ethanol+S. water)	**20**	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a

* Values followed by different letters in the same column differ significantly at $P \leq 0.05$ according to Duncan Multiple test. Mean±SE of three replicates. Each set up with 15 adults.

Table 6. Petri conditions of ethanol extracts obtained from *Satureja* species LD_{25}, LD_{50} and LD_{90} values against adult and four larval stages of *L. decemlineata*

1st INSTAR LARVAE					
Extracts	**LD_{25}**	**LD_{50}**	**LD_{90}**	**λ^2**	**Slope (±SE)**
S. cilicica	0.961	2.697	19.158	8.627	1.505 ± 0.649
S. cuneifolia	1.097	2.923	18.839	4.816	1.584 ± 0.738
S. hortensis	2.380	4.748	17.640	3.582	2.248 ± 1.521
S. spicigera	0.170	0.873	19.675	7.515	0.947 ± 0.056
S. thymbra	0.818	1.963	10.350	6.555	1.775 ± 0.520
S. montana	0.217	0.989	17.641	1.674	1.024 ± 0.005
2nd INSTAR LARVAE					
Extracts	**LD_{25}**	**LD_{50}**	**LD_{90}**	**λ^2**	**Slope (±SE)**
S. cilicica	3.046	5.501	16.918	3.516	2.627 ± 1.945
S. cuneifolia	3.762	6.872	21.594	3.230	2.577 ± 2.158
S. hortensis	1.600	3.999	22.809	3.454	1.695 ± 1.020
S. spicigera	4.659	6.353	11.456	2.387	5.006 ± 4.020
S. thymbra	426.818	122.773	11.506	5.004	1.246 ± 2.604
S. montana	0.205	1.016	21.214	4.045	0.971 ± 0.007
3rd INSTAR LARVAE					
Extracts	**LD_{25}**	**LD_{50}**	**LD_{90}**	**λ^2**	**Slope (±SE)**
S. cilicica	0.897	2.930	27.806	4.900	1.311 ± 0.612
S. cuneifolia	0.024	0.312	39.321	3.857	0.610 ± 0.309
S. hortensis	0.834	3.224	42.046	2.541	1.149 ± 0.584
S. spicigera	1.842	4.136	19.243	7.386	1.919 ± 1.184
S. thymbra	0.652	2.389	28.172	6.807	1.196 ± 0.452
S. montana	2.299	4.783	19.241	1.164	2.120 ± 1.441
4th INSTAR LARVAE					
Extracts	**LD_{25}**	**LD_{50}**	**LD_{90}**	**λ^2**	**Slope (±SE)**
S. cilicica	0.395	2.822	118.546	3.353	0.789 ± 0.356
S. cuneifolia	1.410	4.077	30.635	3.464	1.463 ± 0.893
S. hortensis	0.648	2.271	24.634	6.087	1.238 ± 0.441
S. spicigera	0.969	3.127	28.967	4.125	1.326 ± 0.656
S. thymbra	0.533	2.127	29.506	2.661	1.122 ± 0.368
S. montana	2.590	5.335	21.067	7.498	2.129 ± 1.562
ADULT PERIOD					
Extracts	**LD_{25}**	**LD_{50}**	**LD_{90}**	**λ^2**	**Slope (±SE)**
S. cilicica	0.017	0.568	436.020	2.582	0.444 ± 0.109
S. cuneifolia	0.005	0.243	433.691	4.952	0.391 ± 0.240
S. hortensis	0.500	2.216	37.506	2.442	1.043 ± 0.360
S. spicigera	1.531	4.110	26.833	2.717	1.573 ± 0.965
S. thymbra	0.000	0.010	130.578	4.050	0.312 ± 0.622
S. montana	2.057	4.988	26.848	3.034	1.753 ± 1.224

λ^2: Chi-square value **LD:** µl/insect

According to this information, it can be suggested that these tested plant extracts contain the high content of these compounds and can be used as new insecticidal test subjects against *L. decemlineata.*

4. Conclusion

As a result, the development of biological insecticides will help to reduce the adverse effects on environmental of synthetic chemicals. In the present study, ethanol extracts obtained from *Satureja cilicia*, *S. cuneifolia*, *S. hortensis*, *S. spicigera*, *S. thymbra* and *S. montana* plant species had the toxic effects on the 1st, 2nd, 3rd and 4th instar larvae and adults of *L. decemlineata.* In this respect, it can be suggested that the ethanol extracts obtained from these *Satureja* species can be noted as potential bio-insecticides alternatives to control against the all the instar larvae and adults of *L. decemlineata* in agricultural pruducts. But, further studies are necessary to determine whether it could have value in the struggle of *L.decemlineata.*

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Table 7. Insecticide effects of *L. decemlineata* against adult and four larval stages with desiccator tests of ethanol extracts obtained from *Satureja* species

1st INSTAR LARVAE					
Extracts	**Mortality% (Mean) ± SE**				
	Exposure Time (h)				
	12	**24**	**48**	**72**	**96**
S. cilicica	11.1±2.22 b	28.8±4.44 b	44.4±2.22 b	62.2±4.44 b	80.0±3.84 b
S. cuneifolia	20.0±0.0 cd	37.7±2.22 bc	57.7±4.44 c	77.7±2.22 cd	82.2±2.22 b
S.hortensis	13.3±3.84 bc	33.3±6.66 b	64.4±8.01 cd	84.4±5.87 de	93.3±3.84 cd
S. spicigera	24.4±2.22 d	55.5±4.44 d	75.5±4.44 d	93.3±3.84 ef	97.7±2.22 cd
S. thymbra	22.2±4.44 d	48.8±4.44 cd	73.3±3.84 d	95.5±2.22 f	100±0.0 d
S. montana	13.3±0.0 bc	40.0±3.84 bc	53.3±3.84 bc	71.1±2.22 bc	91.1±2.22 c
P.C.(İzoldesis)	97.7±2.22 e	97.7±2.22 e	97.7±2.22 e	100±0.0 f	100±0.0 d
N. Control	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a
2nd INSTAR LARVAE					
Extracts	**Mortality% (Mean) ± SE**				
	Exposure Time (h)				
	12	**24**	**48**	**72**	**96**
S. cilicica	8.88±2.22 b	28.8±2.22 b	51.1±5.87 b	71.1±5.87 b	80.0±3.84 b
S. cuneifolia	15.5±2.22 cd	31.1±2.22 b	55.5±5.87 bc	73.3±3.84 b	88.8±2.22 bc
S.hortensis	11.1±2.22 bc	28.8±2.22 b	51.1±2.22 b	80.0±3.84 bc	91.1±4.44 cd
S. spicigera	17.7±2.22 de	31.1±4.44 b	53.3±3.84 b	75.5±5.87 b	91.1±4.44 cd
S. thymbra	22.2±2.22 e	46.6±6.66 c	66.6±3.84 c	88.8±5.87 cd	93.3±3.84 cd
S. montana	11.1±2.22 bc	26.6±3.84 b	51.1±5.87 b	84.4±2.22 bc	93.3±3.84 cd
P.C.(İzoldesis)	100±0.0 f	100±0.0 d	100±0.0 d	100±0.0 f	100±0.0 d
N. Control	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a
3rd INSTAR LARVAE					
Extracts	**Mortality% (Mean) ± SE**				
	Exposure Time (h)				
	12	**24**	**48**	**72**	**96**
S. cilicica	8.88±2.22 b	17.7±2.22 b	37.7±2.22 b	60.0±3.84 b	75.5±5.87 b
S. cuneifolia	17.7±2.22 c	35.5±2.22 d	55.5±5.87 c	75.5±5.87 c	93.3±3.84cde
S.hortensis	11.1±2.22 b	28.8±2.22 cd	42.2±2.22 b	82.2±2.22 c	95.5±2.22 de
S. spicigera	13.3±0.0 bc	33.3±3.84 d	53.3±3.84 c	77.7±2.22 c	88.8±2.22 cd
S. thymbra	17.7±2.22 c	35.5±2.22 d	55.5±2.22 c	71.1±4.44 c	88.8±2.22 cd
S. montana	8.88±2.22 b	24.4±2.22 bc	42.2±2.22 b	73.3±3.84 c	84.4±4.44 bc
P.C.(İzoldesis)	97.7±2.22 d	97.7±2.22 e	100±0.0 d	100±0.0 d	100±0.0 e
N. Control	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a
4th INSTAR LARVAE					
Extracts	**Mortality% (Mean) ± SE**				
	Exposure Time (h)				
	12	**24**	**48**	**72**	**96**
S. cilicica	15.5±2.22 bc	28.8±2.22 bcd	42.2±2.22 b	71.1±2.22 bc	80.0±3.84 b
S. cuneifolia	15.5±2.22 bc	26.6±3.84 bc	44.4±4.44 b	66.6±3.84 b	82.2±2.22 b
S.hortensis	13.3±0.0 bc	31.1±2.22 cd	44.4±2.22 b	73.3±3.84 bcd	86.6±3.84 b
S. spicigera	15.5±2.22 bc	35.5±2.22 d	48.8±2.22bc	82.2±2.22 d	91.1±4.44bc
S. thymbra	17.7±2.22 c	31.1±2.22 cd	53.3±3.84 c	75.5±2.22 bcd	88.8±2.22bc
S. montana	11.1±2.22 b	22.2±2.22 b	44.4±2.22 b	77.7±4.44 cd	86.6±6.66 b
P.C.(İzoldesis)	97.7±2.22 d	97.7±2.22 e	97.7±2.22 d	100±0.0 e	100±0.0 c
N. Control	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a

* Values followed by different letters in the same column differ significantly at $P \leq 0.05$ according to Duncan Multiple test. Mean±SE of three replicates. Each set up with 15 adults.

Table 7. (Cont.)

Extracts	ADULT PERIOD				
	Mortality% (Mean) ± SE				
	Exposure Time (h)				
	12	24	48	72	96
S. cilicica	11.1±2.22 b	24.4±2.22 b	44.4±2.22 b	64.4±2.22 bc	77.7±2.22 b
S. cuneifolia	13.3±0.0 b	31.1±8.01 b	44.4±11.1 b	68.8±5.87 bc	82.2±4.44 b
S.hortensis	11.1±2.22 b	24.4±2.22 b	42.2±4.44 b	66.6±3.84 bc	86.6±3.84 bc
S. spicigera	17.7±2.22 b	31.1±2.22 b	51.1±2.22 b	73.3±3.84 c	86.6±3.84 bc
S. thymbra	13.3±3.84 b	26.6±3.84 b	48.8±2.22 b	68.8±2.22 bc	95.5±2.22 cd
S. montana	13.3±0.0 b	24.4±2.22 b	40.0±3.84 b	60.0±3.84 b	86.6±3.84 bc
P.C.(İzoldesis)	93.3±3.84 c	95.5±2.22 c	97.7±2.22 c	100±0.0 d	100±0.0 d
N. Control	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a	0.0±0.0 a

* Values followed by different letters in the same column differ significantly at $P \leq 0.05$ according to Duncan Multiple test. Mean±SE of three replicates. Each set up with 15 adults.

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