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Original article (Orijinal araştırma)

A study of the Zygaenidae (Lepidoptera) fauna of Central Anatolia, Turkey[1]

Orta Anadolu Bölgesi (Türkiye) Zygaenidae (Lepidoptera) faunası üzerine bir araştırma

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Abstract

The Zygaenidae fauna in some provinces (Aksaray, Karaman, Kayseri, Konya, Nevşehir and Niğde) of Central Anatolia was studied using attractant traps as well as by netting specimens in biotopes in 2017. The sex attractants for the Procridinae had been produced in the Crimean Federal University and were esters of 2-dodecenoic acid and isomers of 2-butanol: EFETOV-2 [racemic mixture of *R*- and *S*-enantiomers], EFETOV-S-2 [R-enantiomer] and EFETOV-S-S-2 [*S*-enantiomer]. *Zygaena* attractants were made at Canterbury Christ Church University using a range of acetate compounds with known attraction to various genera as originally identified by Priesner et al. (1984). Fourteen Zygaenidae species from four genera belonging to Procridinae and Zygaeninae subfamilies were found: *Rhagades* Wallengren, 1863 (1 species), *Adscita* Retzius, 1783 (1 species), *Jordanita* Verity, 1946 (4 species), and *Zygaena* Fabricius, 1775 (8 species).

Keywords: Central Anatolia, Procridinae, sex attractants, Turkey, Zygaenidae, Zygaeninae

Öz

Orta Anadolu'nun bazı illerinde (Aksaray, Karaman, Kayseri, Konya, Nevşehir ve Niğde) Zygaenidae faunasını belirlemek için 2017 yılında, türlerin yaşam alanlarında, çekici tuzaklar ve atrap kullanılarak çalışılmıştır. Procridinae alt familyası için cinsel çekiciler 2-asit esterleri ve 2-butanol isomerleri: EFETOV-2 [*R*- ve *S*-enantiyomerlerinin rasemik karışımı], EFETOV-S-2 [*R*-enantiyomer] ve EFETOV-S-S-2 [*S*-enantiyomer] kullanılarak, Crimean Federal Üniversitesinde üretilmiştir. *Zygaena* türleri için çekiciler, Priesner et al. (1984) tarafından ilk defa tanımlanan ve birçok cins için çekici olduğu bilinen asetat bileşimlerinin farklı oranları kullanılarak Canterbury Christ Church Üniversitesinde hazırlanmıştır. Procridinae ve Zygaeninae alt familyalarına ait, 4 cinse giren, on dört Zygaenidae türü bulunmuştur: *Rhagades* Wallengren, 1863 (1 tür), *Adscita* Retzius, 1783 (1 tür), *Jordanita* Verity, 1946 (4 tür) ve *Zygaena* Fabricius, 1775 (8 tür).

Anahtar sözcükler: Orta Anadolu Bölgesi, Procridinae, cinsel çekiciler, Türkiye, Zygaenidae, Zygaeninae

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Introduction

Asian Turkey (Anatolia) is a biologically diverse region since the variable topography and climate provide many different macro or microhabitats; the region is a bridge between Asia and Europe and in the south to the Ethiopian region via the Arabian Peninsula. It thus provides a natural pathway for the spread of species both north-south and east-west. Its tectonic evolution has continuously changed through Tertiary and Quaternary periods, providing an important refuge during the Quaternary ice ages receiving populations via the Balkans and/or the Caucasus (Cıplak, 2003). Consequently, Anatolia has a distinctive zoogeography and biodiversity.

According to the contemporary classification the family Zygaenidae (Lepidoptera) is divided into five subfamilies: Inouelinae Efetov & Tarmann, 2017; Procridinae Boisduval, 1828; Chalcosiinae Walker, 1865; Callizygaeninae Alberti, 1954; and Zygaeninae Latreille, 1809 (Efetov et al., 2014a, b; Efetov & Tarmann, 2017). The family includes more than 1000 species (Efetov, 1996, 1997a, b, 1998, 1999, 2006, 2010; Efetov et al., 2004; Efetov & Hayashi, 2008; Efetov & Tarmann, 2013a, b, 2014a, b, 2016; Mutanen et al., 2016; Hofmann & Tremewan, 2017).

Fifty-four Zygaenidae species are known from Turkey (Mollet, 1995; Naumann et al., 1999; Efetov, 2001, 2005; Koçak & Kemal, 2007; Kemal & Koçak, 2010; Efetov & Tarmann, 2012). Recently, in the Thrace Region (the European part of Turkey) two Procridinae species new for Turkey were found, viz., *Rhagades* (*Rhagades*) *pruni* (Denis & Schiffermüller, 1775) and *Jordanita* (*Jordanita*) *globulariae* (Hübner, 1793), which were discovered with the help of sex attractants of the 'EFETOV-2' series (Can Cengiz et al., 2018). Now, the Zygaenidae fauna of Turkey includes 23 Procridinae species and 31 Zygaeninae species. Five of them are endemics of Turkey: *Jordanita* (*Jordanita*) *chloronota* (Staudinger, 1871), *Zygaena* (*Mesembrynus*) *lydia* Staudinger, 1887, *Zygaena* (*Agrumenia*) *formosa* (Herrich-Schäffer, 1852), *Zygaena* (*Agrumenia*) *peschmerga* Eckweiler & Görgner, 1981, and *Zygaena* (*Zygaena*) *problematica* Naumann, 1966. Identification of endemic and other zygaenid species, determination of their biological characteristics and definition of their distribution sites are crucial for the understanding, protection and control of the Turkish fauna. The family Zygaenidae also comprises many pest species (Tarmann, 2003). In addition, zygaenid moths colonize a great diversity of natural and occasionally secondary habitats, from coastal dunes and cliffs and dry Mediterranean landscapes to various arboreal habitats and even high alpine and extreme boreal regions.

Zygaenidae from Anatolia have been studied for many years (Staudinger, 1887; Alberti, 1954, 1958; Mollet, 1995; Efetov et al., 2010b). Sex pheromones and sex attractants are fast becoming key instruments in ecology-faunistic investigations to monitor distribution, seasonal flight and population density of Lepidoptera species as well as in agriculture and horticulture for pest control (Can et al., 2010; Efetov et al., 2010a, 2011, 2014a, 2015; Subchev et al., 2010, 2012, 2013, 2016; Witzgall et al., 2010; Oleander et al., 2015; Thackery & Burman, 2016; Razov et al., 2017). The aim of this research was to study the occurrence and distribution of Zygaenidae in Central Anatolia because the fauna of this family has not been sufficiently studied in this region of Turkey.

Material and Methods

The Zygaenidae fauna of Central Anatolia was studied using attractant traps and by netting specimens in different biotopes in 2017. The Procridinae sex attractants were synthesized from chiral alcohol *sec*-butanol and lauric acid in Simferopol (Crimea) as described in Efetov et al. (2014c). Three different attractants were used and are designated as EFETOV-2 [a racemic mixture of the two esters (2*R*)-butyl 2-dodecenoate and (2*S*)-butyl 2-dodecenoate], EFETOV-S-2 [*R*-enantiomer] and EFETOV-S-S-2 [*S*-enantiomer]. Previously, the biological activity of these attractants for some species of Procridinae had been confirmed in field tests conducted in the Crimea and Japan (Efetov et al., 2016a, 2018).

Zygaeninae attractants were made at Canterbury Christ Church University using a range of acetate compounds with known attraction to various genera as originally identified by Priesner et al. (1984), as well as modified combinations of (*Z*)-9-tetradecenyl acetate, (*Z*)-11-hexadecenyl acetate and (*Z*)-11-tetradecenyl acetate designated ZtA, ZtB and ZtC (Table 1).

Table 1. Blends of acetate attractants formulated as lures for the attraction of various *Zygaena* spp. numbers in table show the quantity of each component added to a single rubber lure

Attractant*	Attractant dose (µg/lure)						
	Z7-12:Ac	Z9-14:Ac	Z5-12:Ac	Z7-14:Ac	Z11-16:Ac	Z11-14:Ac	Z9-12:Ac
Za						100	
Zc	100	30			3		
Zf	100	10	3	3			
Zl	3		100				
Zp	100	100		10			
ZtA		100			10	10	
ZtB		10			100	10	
ZtC		10			10	100	
Zv	100	10	10		5		1

* For taxa: *Zygaena* (*Zygaena*) *angelicae* Ochsenheimer, 1808, *Zygaena* (*Agrumenia*) *carniolica* (Scopoli, 1763), *Zygaena* (*Zygaena*) *filipendulae* (Linnaeus, 1758), *Zygaena* (*Zygaena*) *lonicerae* (Scheven, 1777), *Zygaena* (*Mesembrynus*) *purpuralis* (Brünnich, 1763), *Zygaena* (*Mesembrynus*) *tamara* Christoph, 1889, and *Zygaena* (*Agrumenia*) *viciae* (Denis & Schiffermuller, 1775).

Rubber caps with different attractants were fixed in cardboard rectangles with corresponding labels. Prepared lures were placed in transparent Delta traps with removable sticky sheets. The traps were attached to branches of bushes or trees at a height of 1.0-1.5 m above the ground. Control traps without attractant baits were also present in all studied localities. The distance between the traps was more than 10 m.

Traps with attractants EFETOV-2, EFETOV-S-2, EFETOV-S-S-2 and the nine acetate blends as detailed in Table 1, and controls with no attractant were set up in six localities (detailed below). The baits were deployed from 13-18 May 2017 and inspected from 29 May-4 June 2017, 17-23 June 2017 and 3-9 July 2017.

Fieldwork was undertaken in 42 localities in six provinces of Central Anatolia: Aksaray, Karaman, Kayseri, Konya, Nevşehir and Niğde (Table 2). Specimens were dissected in the laboratory, with the genitalia embedded on slides in either in Entellan or in Euparal following standard procedures. The material collected was deposited in the collection of Hatay Mustafa Kemal University (Hatay, Turkey).

Localities of traps

The location of the traps were: Aksaray-Saratlı, Bilişim Valley, 38º28’04” N, 34º13’10” E, 1184 m; Karaman-Seyithasan, 37º03’37” N, 33º13’08” E, 1202 m; Kayseri-Yeşilhisar, 38º17’00” N, 35º06’19” E, 1128 m; Konya-Selçuk University Campus, 38º01’55” N, 32º30’25” E, 1166 m; Nevşehir-Hacıbektaş, Kızılağıl, 39º01’05” N, 34º47’12” E, 1203 m; and Niğde-Çamardı, Çukurbağ, 37º49’55” N, 35º02’06” E, 1460 m.

Table 2. Localities studied in Central Anatolia, Turkey

Location no.	Province and town	Latitude, longitude and elevation
1	Niğde-Çamardı, Yelatantown	37º40’31” N, 35º00’27” E, 1250 m
2	Niğde-University Campus	37º56’36” N, 34º37’43” E, 1206 m
3	Kayseri-Yeşilhisar	38º28’28” N, 35º09’26” E, 1088 m
4	Nevşehir-Ürgüp, Başderetown	38º34’30” N, 35º03’52” E, 1372 m
5	Nevşehir-Ürgüp, Akköy1	38º34’54” N, 35º03’06” E, 1323 m
6	Nevşehir-Ürgüp, Akköy 2	38º35’31” N, 35º01’47” E, 1240 m
7	Nevşehir-Ürgüp, Boyalıköy	38º35’35” N, 35º00’09” E, 1213 m
8	Nevşehir-Göreme	38º39’43” N, 34º49’55” E, 1060 m
9	Nevşehir-Göreme, Çavuşin Köyü	38º43’54” N, 34º52’47” E, 944 m
10	Nevşehir-Gülşehir	38º43’46” N, 34º40’43” E, 972 m
11	Aksaray	38º24’23” N, 34º02’16” E, 1113 m
12	Karaman-Seyithasan 1	37º04’18” N, 33º13’26” E, 1158 m
13	Karaman-Seyithasan 2	37º05’20” N, 33º14’20” E, 1218 m
14	Karaman-Organize Sanayi	37º13’09” N, 33º18’00” E, 1027 m
15	Niğde-Darboğaz I	37º29’17” N, 34º33’57” E, 1364 m
16	Niğde-Alpu	37º28’06” N, 34º52’14” E, 859 m
17	Niğde-Emli	37º47’02” N, 35º03’55” E, 1631 m
18	Kayseri-Niğde border	38º12’36” N, 35º13’54” E, 1356 m
19	Kayseri-Develi	38º26’31” N, 35º13’40” E, 1077 m
20	Kayseri-Develi, Hüseyin Şahin Vocational School	38º22’48” N, 35º27’13” E, 1201 m
21	Kayseri-Soysallı	38º23’31” N, 35º21’44” E, 1080 m
22	Nevşehir	38º30’18” N, 35º07’49” E, 1269 m
23	Nevşehir-Karacaören	38º37’00” N, 34º58’16” E, 1168 m
24	Nevşehir-Ürgüp	38º39’34” N, 34º53’59” E, 1066 m
25	Nevşehir-Avanos	38º40’58” N, 34º34’03” E, 1030 m
26	Nevşehir-Acıgöl	38º33’09” N, 35º34’03” E, 1327 m
27	Aksaray-Alayhan	38º31’15” N, 34º21’55” E, 1293 m
28	Konya-Karatay, Yenice	38º10’36” N, 33º17’47” E, 990 m
29	Konya-Karatay	38º03’22” N, 32º59’24” E, 1120 m
30	Konya-Karatay, Ortakonak	37º59’16” N, 32º44’10” E, 1022 m
31	Konya-Selçuklu, Silile	37º55’07” N, 32º26’27” E, 1112 m
32	Konya-Selçuklu, Tatköy	37º56’33” N, 32º22’39” E, 1353 m
33	Karaman-Kazımkarabekir, Kızılkuyu	37º19’55” N, 32º49’50” E, 1056 m
34	Konya-Adabağ, Ereğli	37º27’46” N, 33º54’24” E, 1018 m
35	Niğde-Darboğaz II	37º30’16” N, 34º34’14” E, 1270 m

Table 2. (Continued)

36	Kayseri-Sarız, Yeşilkent	38º16’25” N, 36º26’15” E, 1545 m
37	Kayseri-Sarız, İncemağara	38º22’47” N, 36º26’37” E, 1498 m
38	Kayseri-Pınarbaşı	38º47’15” N, 36º27’01” E, 1538 m
39	Kayseri-Büyüktuzhisar	38º57’06” N, 35º52’26” E, 1217 m
40	Kayseri-Sarımsaklı	38º53’23” N, 35º42’45” E, 1169 m
41	Kayseri-Melikgazi, Hisarcık	38º37’22” N, 35º30’56” E, 1600 m
42	Niğde-Çamardı, Bademdere	37º56’07” N, 35º04’52” E, 1609 m

Results and Discussion

The attractants used attracted males of four Procridinae species: *Rhagades* (*Wiegelia*) *amasina* (Herrich-Schäffer, 1851), *Adscita* (*Adscita*) *obscura* (Zeller, 1847), *Jordanita* (*Praviela*) *anatolica* (Naufock, 1929) and *Jordanita* (*Solaniterna*) *subsolana* (Staudinger, 1862) (Figure 1, Table 3).

Figure 1. Sticky trap baited with EFETOV-2 with 49 males of *Jordanita* (*Praviela*) *anatolica*, Karaman-Seyithasan, 17-23 June 2017.

Jordanita (*P.*) *anatolica* was mainly found on sticky traps baited with EFETOV-2, whereas, *Rh.* (*W.*) *amasina* was attracted to EFETOV-S-S-2. *Adscita* (*A.*) *obscura* was mainly attracted to EFETOV-2 and EFETOV-S-2. *Jordanita* (*S.*) *subsolana* was attracted to EFETOV-S-2. This was as expected and confirmed data obtained in the Crimea, Austria, Italy, and Greece (Efetov et al., 2016b, 2017). No specimens were found in the control traps during the study.

Zygaena (*A.*) *carniolica*, *Zygaena* (*Zygaena*) *ephialtes* (Linnaeus, 1767) and *Z.* (*Z.*) *filipendulae* were attracted to the acetates used. *Zygaena filipendulae* was attracted to lures containing (*Z*)-7-dodecenyl acetate, (*Z*)-9-tetradecenyl acetate and (*Z*)-5-dodecenyl acetate, and this blend also attracted some *Z. carniolica*, possibly because both blends contained a similar ratio of (*Z*)-7-dodecenyl acetate to (*Z*)-9-tetradecenyl acetate. *Zygaena ephialtes* was also attracted to a lure containing (*Z*)-11-tetradecenyl acetate as its primary component (Table 4).

Table 3. Number of males of Procridinae species attracted the three attractants during three trapping periods

Species trapped	29 May-4 June 2017			17-23 June 2017			3-9 July 2017		
	EFETOV -2	EFETOV -S-2	EFETOV -S-S-2	EFETOV -2	EFETOV -S-2	EFETOV -S-S-2	EFETOV -2	EFETOV -S-2	EFETOV -S-S-2
Adscita obscura	1♂ Aksaray	-	-	3♂♂ Aksaray	3♂♂ Nevşehir 1♂ Karaman	1♂ Karaman	-	-	-
Jordanita anatolica	-	-	-	49♂♂ Karaman	14♂♂ Karaman	-	2♂♂ Konya 11♂♂ Karaman	1♂ Konya 5♂♂ Karaman	-
Jordanita subsolana	-	-	-	-	-	-	-	5♂♂ Niğde	-
Rhagades amasina	-	-	-	-	-	-	1♂ Konya	-	11♂♂ Konya 20♂♂ Karaman

Table 4. Number of males of three *Zygaena* spp. attracted to nine attractants in two tapping periods

Attractant	17-23 June 2017			3-9 July 2017		
	Z. carniolica	*Z. ephialtes*	*Z. filipendulae*	*Z. carniolica*	*Z. ephialtes*	*Z. filipendulae*
Za	-	-	-	-	-	-
Zc	-	-	-	3♂♂ Karaman 1♂ Konya	-	-
Zf	-	-	2♂♂ Karaman 1♂ Nevşehir	7♂♂ Karaman 1♂ Konya	-	1♂ Karaman
Zl	-	-	-	-	-	-
Zp	-	-	-	5♂♂ Karaman	-	-
ZtA	-	-	-	-	-	-
ZtB	-	-	-	-	-	-
ZtC	-	-	-	-	1♂ Karaman	-
Zv	-	-	-	2♂♂ Karaman	-	1♂ Niğde

Also, nine Zygaenidae species were collected by netting, viz., *Adscita* (*Adscita*) *obscura* (Zeller, 1847), *Jordanita* (*Jordanita*) *graeca* (Jordan, 1907), *Jordanita* (*Jordanita*) *chloros* (Hübner, 1813), *Jordanita* (*Praviela*) *anatolica* (Naufock, 1929) (Procridinae), *Zygaena* (*Mesembrynus*) *brizae* (Esper, 1800) (Figure 2), *Zygaena* (*Mesembrynus*) *diaphana* Staudinger, 1887, *Zygaena* (*Mesembrynus*) *purpuralis* (Brünnich, 1763), *Zygaena* (*Mesembrynus*) *laeta* (Hübner, 1790) and *Zygaena* (*Agrumenia*) *loti* (Denis & Schiffermüller, 1775) (Zygaeninae) (Table 5).

Table 5. Zygaenidae species caught by netting in Central Anatolia in 2017

Species netted	Localities										
	2	4	5	11	17	25	26	29	31	38	41
Adscita obscura	-	-	1♂	-	-	-	-	-	-	-	-
Jordanita anatolica	1♀	-	-	-	-	1♂	-	-	-	-	-
Jordanita chloros	-	-	-	2♂♂ 1♀	-	-	-	-	1♂	-	-
Jordanita graeca	-	-	-	-	-	2♂♂	1♂	-	-	5♂♂	-
Zygaena brizae	-	-	-	-	2♂♂	-	-	2♂♂	-	-	-
Zygaena diaphana	-	4♂♂ 3♀♀	1♂ 1♀	-	-	-	-	-	-	-	-
Zygaena laeta	-	-	-	-	-	-	-	-	-	-	1♂ 1♀
Zygaena loti	-	5♂♂ 2♀♀	1♂	-	-	-	-	-	-	-	-
Zygaena purpuralis	-	1♂	-	-	-	-	-	-	-	-	-

Zygaenidae of Central Anatolia, Turkey

Rhagades (*Wiegelia*) *amasina* (Herrich-Schäffer, 1851): 1♂ to EFETOV-2 (Konya); 31♂♂ to EFETOV-S-S-2 (Konya and Karaman).

Adscita (*Adscita*) *obscura* (Zeller, 1847): 4♂♂ to EFETOV-2 (Aksaray); 1♂ to EFETOV-S-S-2 (Karaman); 4♂♂ to EFETOV-S-2 (Nevşehir and Karaman); 1♂ by net (Nevşehir).

Jordanita (*Jordanita*) *graeca* (Jordan, 1907): 10♂♂ and 1♀ by net (Aksaray, Kayseri and Nevşehir).

Jordanita (*Jordanita*) *chloros* (Hübner, 1813): 1♂ by net (Konya).

Jordanita (*Praviela*) *anatolica* (Naufock, 1929): 62♂♂ to EFETOV-2 (Karaman and Konya); 20♂♂ to EFETOV-S-2 (Konya and Karaman); 1♂ and 1♀ by net (Niğde and Nevşehir).

Jordanita (*Solaniterna*) *subsolana* (Staudinger, 1862): 5♂♂ to EFETOV-S-2 (Niğde).

Zygaena (*Mesembrynus*) *brizae* (Esper, 1800): 4♂♂ by net (Konya and Niğde).

Zygaena (*Mesembrynus*) *diaphana* Staudinger, 1887: 6♂♂ and 3♀♀ by net (Nevşehir).

Zygaena (*Mesembrynus*) *purpuralis* (Brünnich, 1763): 1♂ by net (Nevşehir).

Zygaena (*Mesembrynus*) *laeta* (Hübner, 1790): 1♂ and 1♀ by net (Kayseri).

Zygaena (*Agrumenia*) *carniolica* (Scopoli, 1763): 4♂♂ to Zc trap (Konya and Karaman); 8♂♂ to Zf trap (Konya and Karaman); 2♂♂ to Zv trap (Karaman); 5♂♂ to Zp trap (Karaman).

Zygaena (*Agrumenia*) *loti* ([Denis & Schiffermüller], 1775): 6♂♂ and 2♀♀ by net (Nevşehir).

Zygaena (*Zygaena*) *ephialtes* (Linnaeus, 1767): 1♂ to ZtC trap (Karaman).

Zygaena (*Zygaena*) *filipendulae* (Linnaeus, 1758): 4♂♂ to Zf trap (Karaman and Nevşehir); 1♂ to Zv trap (Niğde).

Figure 2. *Zygaena* (*Mesembrynus*) *brizae,* Niğde-Emli, 21 June 2017.

Conclusions

It was found that EFETOV-2, EFETOV-S-2 and EFETOV-S-S-2 attracted males of four Procridinae species, *Rh.* (*W.*) *amasina*, *A.* (*A.*) *obscura*, *J.* (*P.*) *anatolica*, and *J.* (*S.*) *subsolana*. Four species of Procridinae were also collected by netting, *A.* (*A.*) *obscura*, *J.* (*J.*) *graeca*, *J.* (*J.*) *chloros*, and *J.* (*P.*) *anatolica*.

The lures containing the *Zygaena* acetates were attractive for three Zygaeninae species, viz., *Z.* (*A.*) *carniolica*, *Z.* (*Z.*) *ephialtes*, and *Z.* (*Z.*) *filipendulae*. Five Zygaeninae spp. were collected also by netting, viz*., Z.* (*M.*) *brizae*, *Z.* (*M.*) *diaphana*, *Z.* (*M.*) *purpuralis*, *Z.* (*M.*) *laeta*, and *Z.* (*A.*) *loti*.

Jordanita (*P.*) *anatolica* was the most numerous species caught in this study. The attractants applied in this work helped to discover the biotopes with *Rh.* (*W.*) *amasina*, a potential pest species for apple, pear, plum and cherry orchards in Central Anatolia.

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