



Distribution of Tettigoniinae (Orthoptera, Tettigoniidae) bush-crickets in Turkey: the importance of the Anatolian Taurus Mountains in biodiversity and implications for conservation

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Abstract. The distribution of Tettigoniinae (Orthoptera, Tettigoniidae) species within four phytogeographical provinces in Turkey is reviewed and presented on the basis of field and collection studies during 1987–2001 and miscellaneous data from previous literature. One hundred and sixty species belonging to 28 genera have been recorded. The Anatolian species constitute approximately 30% of the world-wide species of the subfamily, with a very high proportion ($\geq 83\%$) being endemic or semi-endemic, nearly all of which are brachypterous. Regarding the numbers of total and endemic species, the provinces can be ordered as follows: Mediterranean > Irano-Anatolian > Euxin > Mesopotamia. Also, Anatolian Tettigoniinae have a very high rate of endemism in each province; 84.1% in the Mediterranean, 78.1% in Irano-Anatolia, 56.3% in Mesopotamia and 42.4% in Euxin. The two provinces in Anatolia having the greatest species diversity are also the two most mountainous provinces, so it is suggested that a primary factor in Tettigoniinae diversity is the Anatolian Taurus mountains. Finally, some conclusions are drawn on biodiversity and conservation of Tettigoniinae species in Anatolia and I have suggested 23 species to be included in the 'IUCN Red List' under VU B2+ac.

Introduction

Anatolia (Asian Turkey, also known as Asia Minor) is a biologically diverse region mainly due to (i) the variable topography and climate which provide many different macro- or micro-habitats, (ii) being a bridge between Asia and Europe in the south and also linking to the Ethiopian region via the Arabian peninsula, thus providing a natural pathway for the spread of species both north–south and east–west (Tchernov 1992; Çıplak et al. 2002), (iii) its tectonic evolution which has continuously changed through Tertiary and Quaternary periods and (iv) being an important refugium during the Quaternary ice ages, receiving populations via the Balkans and/or the Caucasus. Anatolia, or its mother continent the Aegeid plate, provided connections with the European, Arabian, Iranian and Caucasian plates many times throughout the Tertiary (especially during the Miocene) and provided many opportunities for faunal exchange. At other times the Aegeid plate was isolated within the Tethys or the Mediterranean Sea (Steininger and Rögl 1985; Rögl 1999), leading to much speciation. Also, the ice ages of the last 2.4 ky have had a large impact on

Table 1. Tettigoniinae of Turkey and their distribution according to phytogeographical provinces.

	MD	EU	MP	IA	DTT
<i>Tettigonia</i> Linnaeus, 1758					
<i>T. caudata</i> (Charpentier, 1845)		*	*	*	W
<i>T. viridissima</i> Linnaeus, 1758	*	*		*	W
[?] <i>T. turcicus</i> Ramme, 1951	ω			ω	E
[?] <i>T. acutipennis</i> Ebner, 1946	§				E
<i>Drymadusa</i> Stein, 1860					
<i>Dr. dorsalis</i> (Brulle, 1832)	Ω				SE
[?] <i>Dr. limbata limbata</i> Brunner von Wattenwyl, 1882	§				E
<i>Dr. limbata grandis</i> Karabağ, 1961	Ω				SE
<i>Anadrymadusa</i> Karabağ, 1961					
<i>An. adzharica</i> (Uvarov, 1934)		§			E
[?] <i>An. albomaculata</i> (Karabağ, 1956)	§				E
<i>An. brevipennis</i> (Brunner von Wattenwyl, 1882)	Ω				SE
<i>An. kosswigi</i> Karabağ, 1975			§		E
[?] <i>An. ornatipennis</i> (Ramme, 1926)	Ω				SE
<i>An. recticauda</i> (Werner, 1903)	§				E
<i>An. spinicercis</i> (Karabağ, 1956)	Ω				SE
<i>Pezodrymadusa</i> Karabağ, 1961					
<i>Pe. affinis</i> (Bolivar, 1899)				§	E
<i>Pe. angorensis</i> (Uvarov, 1930)				§	E
<i>Pe. diffusa</i> (Ramme, 1951)				§	E
<i>Pe. indivisa</i> Karabağ, 1961				§	E
<i>Pe. konowi</i> (Bolivar, 1899)				§	E
<i>Pe. kurmana</i> (Ramme, 1939)				§	E
<i>Pe. lata</i> Karabağ, 1961				§	E
[?] <i>Pe. magnifica</i> (Werner, 1901)				§	E
<i>Pe. sinuata</i> (Ramme, 1951)				§	E
<i>Pe. striolata</i> (Ramme, 1951)				§	E
<i>Pe. subinermis</i> Karabağ, 1961				§	E
<i>Pe. uvarovi</i> Karabağ, 1961				§	E
<i>Pezodrymadusa</i> sp.				§	E
<i>Gampsocleis</i> Fieber, 1852					
<i>G. acutipennis</i> Karabağ, 1956				§	E
<i>G. reticauda</i> Werner, 1901	§				E
<i>G. schelkovnikovae</i> Adelung, 1916				*	W
<i>Paradrymadusa</i> Herman, 1874					
<i>P. aksirayi</i> Karabağ, 1952				§	E
<i>P. brevicerca</i> Karabağ, 1956				§	E
<i>P. sordida</i> (Herman, 1874)				Ω	SE
<i>Anadolia</i> Ramme, 1939					
[?] <i>Ad. burri</i> Karabağ, 1952	§				E
<i>Ad. davisii</i> Karabağ, 1952	§				E
[?] <i>Ad. rammei</i> Karabağ, 1952	§				E
[?] <i>Ad. schwarzi</i> Ramme, 1939	§				E
<i>Phytodrymadusa</i> Ramme, 1939					
<i>Phy. armeniaca</i> Ramme, 1939				Ω	SE
[?] <i>Phy. hakkarica</i> Karabağ, 1956				§	E
[?] <i>Phy. miramae</i> (Uvarov, 1929)				Ω	SE

Table 1. (continued)

	MD	EU	MP	IA	DTT
<i>Leptodusa</i> Stolyarov, 1994					
<i>L. expugnata</i> (Uvarov, 1916)	Ω			Ω	SE
<i>L. demirsoyi</i> (Karabağ, 1975)				§	E
³ <i>L. harzi</i> (Karabağ, 1975)	§				E
<i>Scotodrymadusa</i> Ramme, 1939					
² <i>S. amani</i> Ramme, 1951	§				E
² <i>S. anatolica</i> (Werner, 1901)	ω		ω	ω	E
² <i>S. kozana</i> Ramme, 1951	§				E
² <i>S. maculata</i> (Ebner, 1912)			§		E
² <i>S. rammei</i> (Uvarov, 1929)	ω		ω	ω	E
² <i>S. turcica</i> Ramme, 1939	§				E
² <i>S. ozkani</i> Erman-Salman, 1990				§	E
<i>Scotodrymadusa</i> sp.	§				E
<i>Festella</i> Giglio-Tos, 1894					
<i>F. rammei</i> Çıplak, 2000	§				E
<i>Bucephaloptera</i> Ebner, 1923					
<i>B. bucephala</i> (Brunner von Wattenwyl, 1882)	*	*			W
<i>B. bolivari</i> Karabağ, 1950	§				E
<i>B. konvergens</i> Karabağ, 1950	§				E
<i>B. robusta</i> Karabağ, 1956	§				E
<i>Decticus</i> Serville, 1831					
<i>D. verrucivorus</i> (Linnaeus, 1758)	*	*		*	W
<i>D. albifrons</i> (Fabricius, 1775)	*	*	*	*	W
<i>D. mīthati</i> Ramme, 1939	§				E
<i>Medecticus</i> Uvarov, 1912					
<i>Me. assimilis</i> (Fieber, 1853)			*	*	W
<i>Rhacocleis</i> Fiber, 1853					
² <i>R. acutangula</i> Karabağ, 1957	§				E
<i>R. anatolica</i> Werner, 1933	Ω			Ω	SE
<i>R. germanica</i> (Herrich-Schaeffer, 1840)	*	*			W
<i>R. tuberculata</i> Karabağ, 1978	§				E
<i>R. turcicus</i> (Uvarov, 1930)	ω			ω	E
<i>Sureyaella</i> Uvarov, 1934					
<i>Su. bella</i> Uvarov, 1934	ω			ω	E
<i>Anterastes</i> Brunner von Wattenwyl, 1882					
² <i>A. akdaghensis</i> Ramme, 1951	§				E
² <i>A. anaticus</i> Uvarov, 1934		§			E
<i>A. babadaghi</i> Uvarov, 1939	§				E
<i>A. burri</i> Karabağ, 1951	ω	ω		ω	E
<i>A. niger</i> Ünal, 2000		§			E
<i>A. serbicus</i> Brunner von Wattenwyl, 1882		*			W
<i>A. turcicus</i> Karabağ, 1951	§				E
<i>A. tolunayi</i> Karabağ, 1951	§				E
<i>A. uludaghensis</i> Karabağ, 1950		§			E
<i>Anterastes</i> sp. 1	§				E
<i>Anterastes</i> sp. 2	ω			ω	E
<i>Psorodonotus</i> Brunner von Wattenwyl, 1861					
<i>Ps. anaticus</i> Karabağ, 1952	§				E
<i>Ps. caucasicus</i> (Fischer de Waldheim, 1846)		Ω		Ω	SE
<i>Ps. davisi</i> Karabağ, 1956				§	E
<i>Ps. ebneri</i> Karabağ, 1952	§				E

Table 1. (continued)

	MD	EU	MP	IA	DTT
<i>Ps. rugulosus</i> Karabağ, 1952				§	E
<i>Ps. specularis specularis</i> (Fischer de Waldheim, 1846)				Ω	SE
<i>Ps. venosus</i> (Fischer de Waldheim 1839)				Ω	SE
<i>Psorodonotus</i> sp.	§				E
<i>Pholidoptera</i> Wesmael, 1838					
<i>Ph. aptera</i> (Fabricius, 1793)		*			W
<i>Ph. brevipes</i> Ramme, 1939		Ω			SE
<i>Ph. fallax</i> (Fischer, 1853)		*			W
<i>Ph. femorata</i> (Fieber, 1853)	*				W
<i>Ph. griseoptera</i> (De Geer, 1773)		*			W
<i>Ph. guichardi</i> Karabağ, 1961		§			E
<i>Exopholidoptera</i> Ünal, 1998					
³ <i>Ex. brevifemora</i> Ünal, 1998				§	E
<i>Apholidoptera</i> Mařan, 1953					
<i>Ap. kurda</i> (Uvarov, 1916)				Ω	SE
<i>Ap. pietschmani</i> (Ebner, 1912)			Ω	Ω	SE
<i>Uvarovistia</i> Mařan, 1953					
<i>Uv. satunini</i> (Uvarov, 1916)				Ω	SE
<i>Uv. zebra</i> (Uvarov, 1916)				Ω	SE
<i>Parapholidoptera</i> Mařan, 1953					
<i>Pa. antaliae</i> Nadig, 1991	§				E
<i>Pa. bolkarensis</i> Çıplak, 2000	§				E
<i>Pa. castaneoviridis</i> (Brunner von Wattenwyl, 1882)	Ω	Ω			SE
<i>Pa. distincta</i> (Uvarov, 1921)				*	W
<i>Pa. grandis</i> (Karabağ, 1950)	§				E
<i>Pa. flexuosa</i> Karabağ, 1961	§				E
<i>Pa. intermixa</i> Karabağ, 1961				§	E
<i>Pa. karabagi</i> Demirsoy, 1974				§	E
<i>Pa. kosswigi</i> Karabağ, 1950				§	E
<i>Pa. salmani</i> Çıplak, 2000		§			E
<i>Pa. signata</i> (Brunner von Wattenwyl, 1861)	Ω		Ω	Ω	SE
<i>Pa. spinulosa</i> Karabağ, 1956		ω		ω	E
<i>Pa. syriaca</i> (Ramme, 1930)	Ω				SE
<i>Pa. yoruka</i> Çıplak, 2000	§				E
<i>Pa. ziganensis</i> Karabağ, 1964		§			E
<i>Eupholidoptera</i> Mařan, 1953					
<i>E. anatolica</i> (Ramme, 1930)	§				E
<i>E. annulipes</i> (Brunner von Wattenwyl, 1882)	§				E
<i>E. cypria turciae</i> Salman, 1983	§				E
<i>E. excisa</i> (Karabağ, 1952)	§				E
³ <i>E. demirsoyi</i> Salman, 1983	§				E
<i>E. femorata</i> Çıplak, 1999	§				E
<i>E. karabagi</i> Salman, 1983	§				E
<i>E. kruperi</i> (Ramme, 1930)	ω	ω			E
<i>E. marashensis</i> Salman, 1983	§				E
<i>E. mersinensis</i> Salman, 1983	§				E
<i>E. prasina</i> (Brunner von Wattenwyl, 1882)	§				E
<i>E. raggei</i> Salman, 1983	§				E
<i>E. seveti</i> (Ramme, 1939)	§				E
<i>E. smymensis</i> (Brunner von Wattenwyl, 1882)	*	*			W

Table 1. (continued)

	MD	EU	MP	IA	DTT
<i>E. tahtalica</i> (Uvarov, 1949)	§				E
³ <i>E. tauricola</i> (Ramme, 1939)	§				E
<i>E. tasheliensis</i> Çıplak, 1999	§				E
<i>E. tucherti</i> Harz, 1988	§				E
<i>E. unimacula</i> Karabağ, 1956	§				E
³ <i>E. wernerii</i> Ramme, 1951	Ω				SE
<i>Eupholidoptera</i> sp.	§				E
<i>Rammeola</i> Uvarov, 1934					
<i>Ra. anatolica</i> Uvarov, 1934	§				E
<i>Metriopectera</i> Wesmäl, 1838					
<i>M. (Bicolorana) burri</i> Uvarov, 1921				*	W
<i>M. (Roseliana) bispina</i> (Bolivar, 1899)				*	W
<i>M. (R.) fedtschenkoi</i> (Saussure, 1874)		*		*	W
<i>Platycleis</i> Fieber, 1853					
<i>P. (Platycleis) affinis</i> Fieber, 1853	*	*	*	*	W
<i>P. (P.) albopunctata</i> (Goeze, 1778)	*	*		*	W
<i>P. (P.) escaleraii</i> Bolivar, 1899	*	*	*	*	W
<i>P. (P.) intermedia intermedia</i> (Serville, 1839)	*	*	*	*	W
<i>P. (Incertaina) incerta</i> Brunner von Wattenwyl, 1882	*	*			W
<i>P. (L.) persica</i> Uvarov, 1917			*	*	W
<i>P. (Montana) ankarensis</i> (Karabağ, 1950)				§	E
<i>P. (M.) armeniaca</i> Ramme, 1930				Ω	SE
<i>P. (M.) elegans</i> (Uvarov, 1934)				§	E
<i>P. (M.) schereri</i> Werner, 1901	§				E
<i>P. (M.) taurica</i> Bolivar, 1899				§	E
<i>P. (M.) uvarovi</i> (Karabağ, 1950)				§	E
<i>P. (Sepiana) sepium</i> (Yersin, 1854)	*	*			W
<i>P. (Sporadiana) sporadarum</i> Werner, 1933	Ω				SE
<i>P. (Squamiana) kurmana</i> (Ramme, 1951)			ω	ω	E
<i>P. (S.) melendisensis</i> Çıplak, 2002				§	E
<i>P. (S.) salmani</i> Çıplak, 2002				§	E
<i>P. (S.) sinuata</i> Ramme, 1951			ω	ω	E
³ <i>P. (S.) weidneri</i> (Demirsoy, 1974)				§	E
<i>P. (Tessellana) nigrosignata</i> (Costa, 1863)	*	*			W
<i>P. (T.) tessellata holoptera</i> Ramme, 1951			§		E
<i>P. (T.) veyseli</i> Koçak, 1984				*	W
<i>Platycleis (Yalvaciana) yalvacii</i> (Demirsoy, 1974)				§	E
<i>Bolua</i> Ünal, 1999					
<i>B. turkiyae</i> Ünal, 1999		§			E

MD: Mediterranean; EU: Euxin; MP: Mesopotamia; IA: Irano-Anatolia; DTT: distribution type for Anatolia (E: endemic to Turkey; SE: semi-endemic species whose range extends beyond the borders of Turkey to the adjoining countries; W: widespread). ³Species not evaluated according to 'IUCN Red List' criteria because of insufficient data on their distribution and/or taxonomical status. §: endemic species that are only found in the respective provinces; ω: Anatolian endemic (recorded from more than one province) in the province; Ω: semi-endemic species in the province; *: widespread species in the province.

Anatolian faunal composition. Later, climatic change during the ice ages pushed many northern populations, especially those found in the Balkans, the Caucasus and/or in northern Anatolia, to the south and led to their isolation and speciation at higher altitudes in southern regions (De Lattin 1967; Hewitt 1996, 2000; Çıplak, unpublished data). For all of these reasons, there have been many speciation events in Anatolia and therefore a rich biodiversity.

Defining species distribution in accordance with the variable topography and climate of Anatolia has special importance for understanding contemporary biodiversity and developing conservation strategies. Anatolia has many mountain ranges such as the southern Taurus, eastern Taurus, southeastern Taurus and Pontic Taurus. Thus, Anatolia is fragmented into many small parts which may have their own faunal identity. This study evaluates the distribution of Tettigoniinae with reference to this fragmentation and identifies 'hotspots' in Anatolia, especially those of the Mediterranean and Eastern Taurus ranges.

Orthoptera is a relatively well studied insect order for Turkey and has been used as a marker group for biogeographical evaluation of the region (Uvarov 1921; Demirsoy 1977; Çıplak et al. 1993). Similarly, the eastern Mediterranean was suggested to be the radiation centre for Decticinae, a subfamily included in Tettigoniinae (Tettigoniidae, Orthoptera) (Kaltenbach 1971). Additionally, it was reported that more than 50% of the species of Tettigoniidae present in Anatolia are endemic (Çıplak and Demirsoy 1995). Thus, this group is a useful tool for evaluating biodiversity and defining 'hotspots' in Anatolia.

Materials and methods

This study is based on field studies by the author between 1987–2001 in different parts of Turkey, supplemented using specimens from The Natural History Museum, London; The Museum für Naturkunde, Berlin; Hacettepe University, Department of Biology, Ankara and Akdeniz University, Department of Biology, Zoological Museum, Antalya, Turkey. The taxonomy and distribution of Tettigoniinae in Turkey is documented based on new data in addition to the literature, as follows. Data on Orthoptera of Turkey (including Tettigoniinae) was first catalogued by Karabağ (1958), and Ramme (1951) published an important work on bush-crickets. After Karabağ (1958) many studies were published, mainly faunistic lists (Karabağ et al. 1971, 1981; Demirsoy 1975; Salman 1978; Çıplak and Demirsoy 1995; Naskrecki and Ünal 1995; Çıplak et al. 1996; Satar 1997; Ünal 1999; Sevgili and Çıplak 2000), descriptions of new genera or species (Karabağ 1961a, 1964, 1975, 1978; Demirsoy 1974; Stolyarov 1983; Harz 1988; Nadig 1991; Ünal 1998, 2000; Çıplak 1999b) and/or reviews of some genera (Mañan 1953; Karabağ 1961b; Salman 1983; Ragge 1990; Çıplak 1999a, 2000; Çıplak et al. 2002). A full list of the taxa, including author and date of the publication, is given in Table 1.

The distribution of Anatolian Tettigoniinae species is classified according to the phytogeographical provinces of Turkey (Table 1) following the terminology developed by Zohary (Davis 1965; Zohary 1973). This terminology was also used by

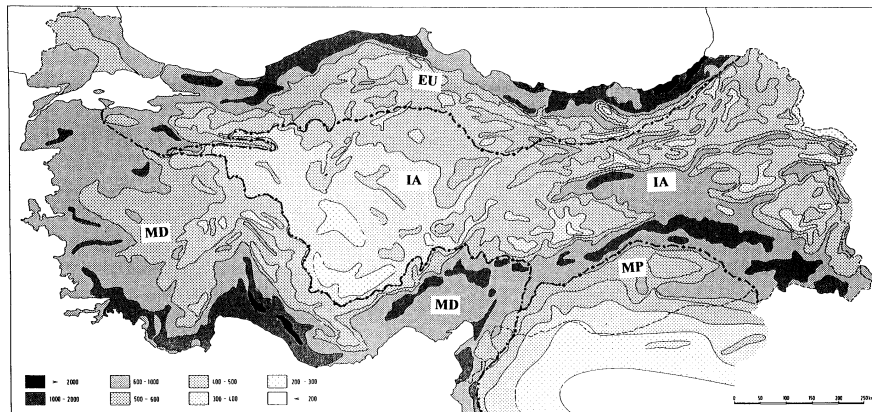


Figure 1. The principal isohyets and phytogeographical provinces in Turkey. MD: Mediterranean, EU: Euxinic, MP: Mesopotamia, IA: Irano-Anatolia [modified from Hesselbarth et al. 1995].

Hesselbarth et al. (1995) for Turkish butterflies and by Ayal et al. (1999) for Israeli Tettigoniidae. Recognised provinces and their borders within Anatolia (and European Turkey) are also briefly described (Figure 1).

The East Mediterranean province belongs to the Mediterranean and includes the Mediterranean Taurus, Antitaurus and Aegean Anatolia up to the Bursa province in the north, and roughly to 31° latitude in the east.

The Euxinic province belongs to the Euro-Siberian and in Turkey this territory extends along north Anatolia and European Turkey. This region was named tragacant by Ayal et al. (1999), and boreal by Uvarov (1921).

The Mesopotamian province belongs to the Irano-Turanian region and covers the Mesopotamia below southeastern Taurus. It is limited by the Amanus mountain range in the west. It is equivalent to the Eremial elements by Uvarov (1921) and Demirsoy (1999). Although it was considered to be within the Irano-Turanian, the distributions of many Irano-Anatolian species and genera do not extend to Mesopotamia and they are treated separately here.

The Irano-Anatolian province belongs to the Irano-Turanian and covers central and eastern Anatolia, between the southeastern Taurus line and the Pontic Taurus. This territory is divided into two parts by the Anatolian Diagonal [see Çıplak et al. (1993) and Hesselbarth et al. (1995) for detailed conclusions], which consist mainly of the eastern Taurus, and there are distinct differences in the faunal composition between the eastern and western sides of the Diagonal. Demirsoy (1999) and Uvarov (1921) refer to Eastern Anatolia, including the Diagonal, as the territory of the Siberian elements.

The following definitions were used to describe types of distribution. Endemic species have a restricted distribution and are only recorded from Asian parts of Turkey (Anatolia). Some of these species are present in only one phytogeographical province (provincial endemics), while others are present in more than one province. Like the endemic species, semi-endemics have a restricted distribution; however,

Table 2. Species number and frequency of endemic (E), semi-endemic (SE) and widespread (W) species recorded from Turkey.

	E	SE	W	T
Species number	109	24	27	160
Proportion	0.681	0.150	0.169	1.0

their range is not limited by the political border of Turkey and more or less extends to adjoining countries. Widespread species have a wide range in Anatolia and other parts of the Palearctic.

Finally, Anatolian tettigoniinae were classified according to criteria of the International Union for Conservation of Nature and Natural Resources (IUCN), excluding some insufficiently known species (labelled with '?' in Table 1).

Results

One hundred and sixty species of Tettigoniinae, representing 28 genera, are recorded from Turkey (Table 1) and all are present in Anatolia except *Ph. aptera*, which is only known from European Turkey. Endemic+semi-endemic species constitute more than 83% of the Anatolian Tettigoniinae. One hundred and thirty-

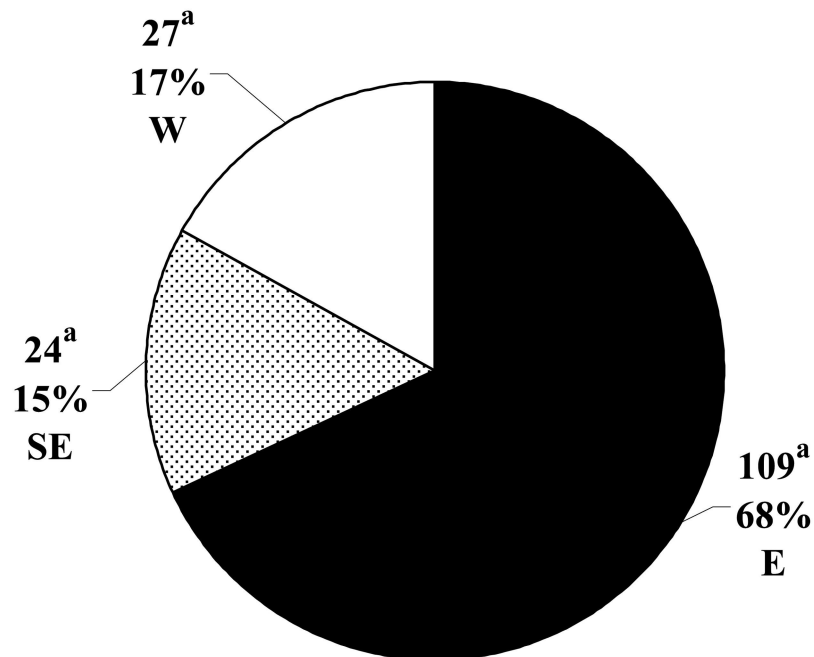


Figure 2. Species number (^a) and percentage of endemic (E), semi-endemic (SE) and widespread (W) species recorded from Turkey.

Table 3. Species number and frequency of the provincial endemic (§), Anatolian endemic (ω), semi-endemic (Ω), and widespread (*) species respective to the phytogeographical provinces of Turkey.

	MD		EU		MP		IA	
	Number	%	Number	%	Number	%	Number	%
§	54	0.614 ^a	8	0.242 ^a	3	0.186 ^a	33	0.452 ^a
ω	8	0.091 ^a	3	0.091 ^a	4	0.25 ^a	10	0.137 ^a
Ω	12	0.136 ^a	3	0.091 ^a	2	0.125 ^a	14	0.192 ^a
§ + ω + Ω	74	0.841 ^a	14	0.424 ^a	9	0.563 ^a	57	0.781 ^a
*	14	0.159 ^a	19	0.576 ^a	7	0.438 ^a	16	0.219 ^a
§ + ω + Ω + *	88	0.550 ^b	33	0.206 ^b	16	0.100 ^b	73	0.456 ^b

^aProportion of the species number out of the total number in the respective province. ^bProportion of the respective total out of the 160 species recorded from Turkey.

three of the total 160 species are endemic or semi-endemic; 109 (68.1%) are known only from Anatolia, and 24 (15%) are semi-endemic and their range extends only slightly beyond the borders into adjoining countries (Table 2, Figure 2). The monotypic genera *Exopholidoptera*, *Sureyaella*, *Rammeola* and *Bolua* and a polytypic genus *Anadolua* are endemic to Anatolia. In addition, there are many genera that are dominantly Anatolian in distribution, such as *Drymadusa*, *Anadrymadusa*, *Pezodrymadusa*, *Leptodusa*, *Bucephaloptera*, *Anterastes*, *Psorodonotus*, *Apholidoptera* and *Paraholidoptera*, which can be regarded as Anatolian semi-endemic genera.

Twenty-seven species recorded from Turkey have a relatively wide distribution when compared to the endemic/semi-endemic species. Of these, *T. caudata*, *T. viridissima*, *G. schelkownikovae*, *D. verrucivorus*, *D. albifrons*, *Me. assimilis*, *R. germanica*, *M. burri*, *M. bispina*, *M. fedtschenkoi*, *P. affinis*, *P. intermedia*, *P. escaleraei*, *P. albopunctata*, *P. incerta* and *P. veyseli* are known from relatively large parts of the Palearctic (especially in the north of Anatolia), outside Turkey. The other species, which are considered to be widespread (W), do not have as wide a range outside Turkey; *A. serbicus*, *B. bucephala* and *Ph. brevipes* are distributed in the Balkans, *Pa. distincta* in the Caucasus, *P. sepium*, *Ph. aptera*, *Ph. femorata* and *Ph. grasioaptera* on the Black Sea coast or in parts of Europe and *P. persica* in Iran. Thus, these species can also be considered as semi-endemic.

Each of the four provinces have a different Tettigoniinae faunal composition (Tables 1 and 3, Figure 3). The most diverse province is the Mediterranean, with 88 species (55% out of the 160 species recorded from Turkey) and 74 of them (84.1% out of the respective total of the province) are endemic/semi-endemic; 54 species (60.7%) are only known from the Anatolian part of the province, 12 (13.5%) are semi-endemic and eight (9.1%) are Anatolian endemics that are also recorded from the other provinces. The second most diverse province is Irano-Anatolia, which has 73 species (45.6% of the total). Like the Mediterranean, this province also has a high degree of endemism with 78.1% of the species recorded from the area. Of the total 57 endemic/semi-endemic species, 33 (45.2%) are endemic to the Turkish part of the province, 14 (19.2%) are semi-endemic and 10

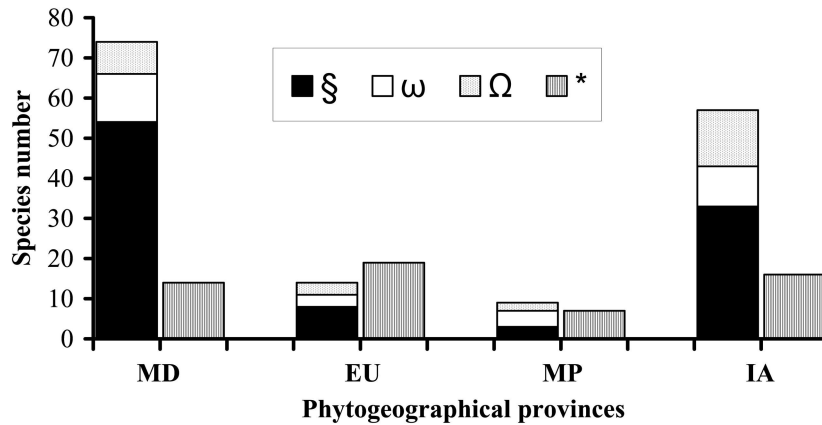


Figure 3. The number of the total endemic (left columns) and widespread (right columns) species in each of the four phytogeographical provinces. MD: Mediterranean, EU: Euxin, MP: Mesopotamia, IA: Irano-Anatolia, §: provincial endemic species in the respective province; ω: Anatolian endemic species (recorded from more than one province) in the province; Ω: semi-endemic species in the province; *: widespread species in the province.

Table 4. The number and proportion (out of the total species number) of the common species between provinces.

	MD-EU	MD-MP	MD-IA	EU-MP	EU-IA	MP-IA
Species number	16	7	17	5	11	13
Proportion	0.101	0.044	0.107	0.031	0.069	0.082

(13.7%) are Anatolian endemics shared with adjacent provinces. Euxin and Mesopotamia are poor compared to the other two provinces. The subfamily is represented by 33 species in Anatolian Euxin, 14 (42.4%) of which are endemic/semi-endemic to the province, and eight of the endemic species are known from the Anatolian part of the province. Sixteen species are recorded from Mesopotamian Turkey and nine of these are endemic/semi-endemic. Typical endemic species of the province are *An. kosswigi*, *S. maculata* (its taxonomic status is unclear) and a subspecies *P. (Tessellana) tessellata holoptera*.

There is a low degree of similarity between provinces, mostly less than 10% of the total number of species recorded in Turkey (Table 4). The species in common are mainly widespread species, especially those belonging to *Tettigoniia*, *Decticus* and *Platycleis* (s.str.). Also, of the endemic/semi-endemic species, *S. rammei*, *S. anatolica*, *A. burri* and *Pa. signata* have been recorded in three provinces (Tables 1 and 4). The highest similarity is firstly, 17 species in common between the Mediterranean and Irano-Anatolia, secondly, 16 species in common between the Mediterranean and Euxin, thirdly, 13 species in common between Irano-Anatolia and Mesopotamia, and finally 11 species between Euxin and Irano-Anatolia (Table 4).

Discussion and conclusions

Tettigoniinae is estimated to contain 500 species in 120 genera world-wide (Kaltenbach 1971; Rentz and Colless 1990; Naskrecki and Otte 1999) and approximately 30% were recorded in Anatolia. Moreover, of these 160 species 133 (83%) are endemic or semi-endemic to the area. The high ratio of endemism indicates that there has been high speciation activity within Anatolia and it supports Kaltenbach (1971) in suggesting the eastern Mediterranean as a radiation centre for 'Decticinae' (a subfamily now included in Tettigoniinae). Of all the endemic species, 109 are endemic and 24 are semi-endemic to Anatolia; however, the species belonging to the second group do not have a wide range outside Anatolia. The distribution of these semi-endemic species extends to the northern Levant (especially northwestern Syria), the Elburs-Zagros mountain ranges (in Armenia, Nahcevan, Iran and Iraq) and some of the Aegean islands. It is worth noting that a great majority of the endemic/semi-endemic species are brachypterous, while most of the widespread species are macropterous (Çıplak et al. 1992; Ayal et al. 1999).

Twenty-seven of the species have a wide range outside Turkey and all are Palearctic in distribution. They were considered to be widespread species, although most of them have a restricted range in the Caucasus and/or continental Europe in addition to Turkey [compare Table 1 with Harz (1969), Sergeev (1993) and Heller et al. (1998)], with a few exceptions such as those belonging to *Tettigonia*, *Decticus* and *Platycleis* (s.str.). However, there are no species of Tettigoniinae that can be considered common species of the Siberian and Anatolia, except *D. albifrons* (Sergeev 1993) and our data do not support Uvarov (1921) and Demirsoy (1999) in this respect. Those species that prefer colder climates (those recorded from high altitudes in eastern or southern Anatolia) are possibly derivatives of some lineages found in northern adjacent areas such as the Balkans, Caucasus or the Elburus and Zagros mountains. This suggestion is mainly supported by the distribution of semi-endemic Anatolian genera such as *Psorodonotus*, *Pezodrymadusa* and *Anterastes*, which are found at high altitudes and whose distribution does not extend to the north of Caucasia, Transcaucasia or the Balkans (Harz 1969; Sergeev 1993). In addition, there is no Ethiopian element (belonging to Tettigoniinae) in Anatolia.

Considering the total number of species, and the number of endemics/semi-endemics, the provinces can be ordered as east Mediterranean > Irano-Anatolian > Euxin > Mesopotamia (Table 3, Figure 3). However, each of these phytogeographical provinces has specific features that need to be considered separately.

East Mediterranean

The Tettigoniinae fauna of this province demonstrates the highest rate of endemism (Tables 1 and 3, Figure 3). There are two genera endemic to the Anatolian Mediterranean, *Anadolua* (which includes four species) and a monotypic genus *Rammeola* (see Çıplak 1999a). In addition, the genera *Drymadusa*,

Bucephaloptera and *Anadrymadusa* are predominantly Mediterranean in distribution, with few species outside Anatolia. Interestingly, *Eupholidoptera* is represented by 21 species in Anatolia, mostly as local endemics. Thus, the range of *Eupholidoptera* accurately defines the borders of the Mediterranean in Anatolia. This province has close affinities with areas outside of Turkey, such as the Aegean islands, Peloponnese and central Greece in the west (Willemse and Kruseman 1976; Willemse 1980, 1984, 1985) and the Levant in the east (Kaltenbach 1974; Ayal et al. 1999). In general the genera/species recorded from the Anatolian Mediterranean are mostly restricted to Anatolia plus other parts of the eastern Mediterranean (Levant, Greece and parts of the Balkans). Thus, it may be concluded that this distribution may also be an indication for the origin of these genera. Within Anatolia, its highest similarity is with the Irano-Anatolian and then with the Euxin province. The similarity between the Mediterranean and Irano-Anatolian provinces is mainly due to widespread species and also because of the distribution of some species belonging to *Rhacocleis*, *Anterastes*, *Sureyaella*, *Paraholidoptera*, *Scotodrymadusa* and *Leptodusa*. The distribution of the last three genera especially illustrates the role of the Mediterranean Taurus and Anatolian Diagonal (see Çıplak et al. 1993) in the distribution and speciation of Tettigoniinae. The main infiltration between the Mediterranean and Irano-Anatolian provinces for this subfamily occurs around the Binboğa mountains, which are located at the connection of the eastern and Cilician Taurus (in the Niğde and Kahramanmaraş political provinces).

Irano-Anatolian province

The second highest rate of endemism and species number is recorded in this territory (Tables 1 and 3, Figure 3). The distribution of semi-endemic species of this province extends to northern Iraq, western Iran and/or Armenia, i.e. the Elbursian and Zagrosian mountains. More importantly, there are many genera such as *Pezodrymadusa*, *Phytodrymadusa*, *Leptodusa*, *Apholidoptera*, *Uvarovistia* and *Platycleis* (*Squamianana*) that are restricted to the Irano-Anatolian province and are represented by only a few different species outside Anatolia (Sergeev 1993; Stolyarov 1996). These findings support Zohary (1973) in suggesting this province as an important radiation centre of endemism. For these reasons it seems more likely that the endemic/semi-endemic genera/species originated in this area and should be considered as typical elements of the province.

Central Anatolia was suggested to be a part of the Irano-Anatolian province by Zohary (1973) because of its floral composition. However, the distribution of Tettigoniinae species does not strongly support this suggestion. Excluding the Diagonal-side inner Anatolian species (especially those recorded in the political provinces of Sivas, Kayseri and Niğde, in Turkey), there are few affinities between the two sides of the Diagonal, and the western side of the Diagonal is quite poor in Tettigoniinae faunal composition when compared with the eastern side. I propose that species in the Anatolian Diagonal should be regarded as Elbursian-Zagrosian-Diagonal elements because of the eastward distribution of genera (e.g.

Pezodrymadusa) which includes those species. Of the endemic species present in the province, eight, *Pe. angorensis*, *R. anatolica*, *R. turcicus*, *Su. bella*, *A. burri*, *Anterastes* sp. 2, *P. ankarensis* and *Platycleis* sp. 1, are only present in central Anatolia but not in the Diagonal or eastern Anatolia. It is important to note that those species belonging to *Rhacocleis* and *Anterastes* are recorded from the western and/or southern peripheral of central Anatolia and have relatives in the Mediterranean or Euxinic provinces.

This province was suggested to be the territory of the Siberian elements (Uvarov 1921; Demirsoy 1999). Importantly, there are no common species in the Turkish part of Irano-Anatolia and Siberia (Angara) except a common Palearctic species, *D. verrucivorus* (Sergeev 1993). This is also true for the Anatolian Euxin. Thus, at least on the basis of Tettigoniinae, our data do not support this suggestion.

Euxinic province

There are 33 Tettigoniinae species recorded from the Turkish side of this province and 14 of them are endemic/semi-endemic (Tables 1 and 3, Figure 3). Most of the endemics are concentrated in Uludağ (in Bursa) or in Zigana Dağ (in Trabzon). The genus *Bolua* is endemic to the Anatolian part of this province (Çıplak and Heller 2001). The primary affinities of this region are firstly with the Mediterranean and secondly with Irano-Anatolia, mainly because of the species that have wide distributions (Tables 1 and 3). *Psorodonotus* spp. represents the infiltration between the Euxin province and Irano-Anatolia through the Pontic Taurus and the Erzurum-Kars plateau. In addition, this region has affinities with areas outside of Turkey, namely the circum-Black Sea and central Europe.

The Mesopotamian province

This region is the smallest and the poorest in faunal composition of Tettigoniinae. Sixteen species belonging to the subfamily were recorded from the area (Sevgili and Çıplak 2000) and half of them are widespread (Tables 1 and 3, Figure 3). Omitting two endemic species (*An. kosswigi* and *S. maculata*) and one subspecies (*P. (Tesselana) tessellata holoptera*), there are no distinctive elements that define this area. Furthermore, the distribution of Irano-Anatolian species rarely reaches Mesopotamia and the species common to both provinces are recorded around the southeastern Taurus. From these data it can be concluded that the southeastern Taurus mountain range is one of the main barriers limiting the distribution of Irano-Anatolian elements in the south and that of the Mesopotamian elements (or Syrio-eremian, *sensu* Uvarov 1921) in the north.

The role of the Anatolian Taurus in biodiversity

Anatolian Tettigoniinae demonstrate a very high degree of endemism. The endemic species show restricted local distributions and are present especially at high altitudes or in mountain ranges. This kind of distribution indicates the

Table 5. Species proposed to be included in the ‘vulnerable’ (VU B2+ac) category of the IUCN Red List (the uppercase words indicate the political provinces of Turkey).

Species	Locality
<i>An. kosswigi</i>	Mardin: Mazıdağı
<i>Pe. kurmana</i>	Malatya: Beydağları
<i>Pe. subinermis</i>	Elazığ: Sivrice
<i>G. accutipennis</i>	Elazığ: Palu, Dabanlı
<i>A. niger</i>	Tokat: Çamlıbel pass
<i>A. turcicus</i>	Antalya: Tahtalıdağ mt.
<i>A. uludaghensis</i>	Bursa: Uludağ mt.
<i>Anterastes</i> sp. 1	Antalya: Elmalı, Kızlarsivrisi mt.
<i>Ps. anatolicus</i>	Manisa: Gördes
<i>Ps. ebneri</i>	Antalya: Tahtalıdağ mt.
<i>Ph. guichardi</i>	Trabzon: Zigana dağı mt.
<i>Pa. bolkarensis</i>	Niğde: Bolkardağı mts
<i>Pa. grandis</i>	Antalya: Akseki, Ibradı
<i>Pa. intermixa</i>	Kahramanmaraş: Göksun, Binboğa mts.
<i>Pa. salmani</i>	Tokat: Çamlıbel mt.
<i>Pa. yoruka</i>	Mersin: Sertavul mt.
<i>Pa. ziganensis</i>	Trabzon: Zigana mt.
<i>E. femorata</i>	Mersin: Sertavul mt.
<i>E. karabagi</i>	Antalya: Beydağları mts
<i>E. tahtalica</i>	Antalya: Beydağları range mts
<i>E. tasheliensis</i>	Antalya: Taşeli plateau (Maha yaylası)
<i>E. unimacula</i>	Mersin: Nazimiye and Fındıkpınarı
<i>P. ankarensis</i>	Ankara: Aydos mt.

importance of topography in the evolution and distribution of Tettigoniinae. The mountains/ranges in Anatolia, mainly the Taurus that are divided by many valleys, especially in the south, have a special role in speciation and they also define biogeographical subregions and provinces. The East Mediterranean province can mainly be defined by the Cilician and western Taurus. The southeastern Taurus is the border of the Irano-Anatolian and Mesopotamian provinces. Likewise, the penetration of Irano-Anatolian elements to Euxin or vice versa occurs via the Pontic Taurus, whereas the eastern Taurus causes distinct differences between central and eastern Anatolia. Although these ranges are barriers for some species and groups, they are also natural pathways for some other species. For example, there are many Irano-Anatolian species which penetrate to Levant via the eastern Taurus and Amanus. Notably, the Tettigoniinae faunal diversity of Anatolia, excluding high altitudes such as Mesopotamia and central Anatolia, is quite poor, while that of Mediterranean and eastern Anatolia, the two most mountainous parts, is higher. All of these findings suggest that the Anatolian mountains, especially those in Mediterranean and eastern Anatolia, are ‘hotspots’ of biodiversity for Tettigoniinae. This has also been suggested for plants (Zohary 1973) and butterflies (Hesselbarth et al. 1995). Thus, a special conservation perspective needs to be developed for these (mountainous) habitats, which might have been refugia for species that demand cold climates and extended their range from northern territories (possibly from the Caucasus and Transcaucasus below the Siberian

subregion and from the Balkans or northern Anatolia) towards the south during ice ages. Also, it is highly likely that these kinds of populations have undergone genomic subdivision in southern altitudes (Cooper et al. 1995; Hewitt 1996; Çıplak, unpublished data) and in addition to the species diversity there is also an important genetic diversity. Consequently, each mountain or range (especially in southern Anatolia) has its own endemic species and therefore requires conservation initiatives.

Implications for conservation

So far, none of the species in the Tettigoniinae have been included in the IUCN Red List or suggested for inclusion. This is mainly because (i) there are no ecological studies on Anatolian tettigoniinae that include data on population densities, geographical ranges, habitat preference, etc.; (ii) Anatolia occupies a large land area, so faunistic and taxonomical studies are limited; (iii) tettigoniinae bush-crickets are hidden within bush plants, therefore it is difficult to observe them in the field; and (iv) conservation activities in Turkey have generally been carried out on vertebrates, such as mammals, birds and reptiles.

The present inadequate state of our knowledge precludes us from making definite IUCN Red List categorisations for Anatolian tettigoniinae, especially for those species belonging to *Scotodrymadusa*, *Paradrymadusa*, *Anadolua* and some in other genera. These species are labelled with ‘?’ in Table 1. On the other hand, both from the literature and from our recent studies, it seems that many species are restricted to areas of less than 20,000 km². Even though the occupancy areas of these species are unknown, the occurrence area can be estimated from some characteristics of their distribution. First, each species is mostly associated with a typical altitude, or typical habitat that is related to a certain altitude, and so each is restricted to some particular topography, especially mountains. Second, the species in a particular genus are generally allopatric in distribution and are present in related but separate topographies, such as mountains in a range. For example, 21 species belonging to the genus *Eupholidoptera* are mostly allopatric (the distribution of only three species overlaps). Third, all of the species proposed for inclusion in the ‘Red List’ are bracypterous and flightless (excluding *An. kosswigi*), and are mostly Anatolian endemics. Besides, there is no other obvious factor to cause their passive dispersal. Thus, all bracypterous species have a limited dispersal ability. From these assessments, I propose that 23 Anatolian tettigoniinae be included in the ‘Red List’ in the ‘vulnerable’ (VU B2+ac) category (Table 5) on the basis of extent of occurrence and quality of habitat. Of these species, three occur in conservation areas: *A. uludaghensis* in Uludağ mt. National Park (Bursa province), *E. karabagi* and *E. tahtalica* in Termessos and Beydağları National Parks (Antalya province). In contrast, *Ps. anaticus*, *Ps. ebneri*, *P. ankarensis* and *A. uludaghensis* need to be studied extensively to raise their category to ‘endangered’ or ‘critically endangered’ status; the first three species have not been observed during recent field studies.

Excluding the species suggested for the IUCN Red List and the species without

adequate data for categorisation, others (semi-endemic and widespread species) were recorded/observed over a relatively wide range. Unfortunately, present data are extremely limited with respect to threat factors. There are no pest species among Anatolian tettigoniine and none have economic importance. Thus, the main type of threat comes from habitat destruction by human activities. In general, endemic and semi-endemic species occur on highlands. Because human activity is mostly concentrated at low altitudes, these species are relatively safe. Additionally, there are numerous 'national and nature parks' and 'nature conservation areas', established by the General Directorate of National Parks and Wildlife in Turkey (Ceylan 1993). These are based mainly on floral and/or archaeological features. Of the 23 national parks, 12 are in the Mediterranean, six are in the Euxinic and five are in the Irano-Anatolian province. Among the species suggested for the 'vulnerable' category, three are present in these national parks. However, there is still little information about faunal and floral structure of these national parks and it is difficult to estimate their role in conservation.

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