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F E *Entomologie Faunistique – Faunistic Entomology* 2014 **67,** 27-36

Overview of the Distribution and Biogeography of Sphecidae in Turkey (Hymenoptera: Aculeata)

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Reçu le 23 avril 2012, accepté le 14 août 2013

Les études faunistiques sur les Sphecidae de Turquie ont été passées en revue. La distribution et la biogéographie de la faune sphécidée turque a été analysée. Un total de 61 espèces et 5 sous-espèces appartenant à 12 genres de la sous-familles Sceliphrinae, Sphecinae et Ammophilinae ont été enregistrés en provenance de Turquie. La composition des espèces, la diversité et la proportion d'endémisme varient considérablement entre les sous-régions biogéographiques du pays.
Mots clés: Hymenoptera, Sphecidae, distribution, biogéographie, Turquie.

Faunistic studies on Sphecidae from Turkey are reviewed and the distribution and biogeography of the Turkish sphecid fauna is analyzed. A total of 61 species and 5 subspecies belonging to 12 genera of the subfamilies Sceliphrinae, Sphecinae, and Ammophilinae have been recorded from Turkey. Species composition, diversity and proportion of endemism varies considerably between the biogeographic subregions of the country.
Keywords: Hymenoptera, Sphecidae, distribution, biogeography, Turkey.

1. INTRODUCTION

Biogeography is the branch of biology that studies the geographical distribution of animals and plants. Biogeographic regions are usually defined separately for floral and faunal communities and are largely restricted to the terrestrial areas of the Earth. Turkey is generally divided into seven geographical regions. These geographical regions were separated according to their climate, location, flora and fauna, human habitat, agricultural diversities, transportation, topography and so on. Four regions were named after the seas bordering them; the Aegean Region, the Black Sea Region, the Marmara Region and the Mediterranean Region. The other three regions were named in accordance with their location in the whole of Anatolia; Central, Eastern and Southeastern Anatolia Regions (**Figure 1**). Turkey is a mountainous mass averaging about 1.000 meters in height. The topographic and climatic structure give to the country the opportunity to hosts a rich and diverse fauna. Turkey is one of the most interesting countries from the point of view of Hymenoptera taxonomy and biogeography. The Hymenoptera is one of the four great orders of insects, with over 100.000 described species around the world (Goulet & Huber, 1993).

Turkey occupies Asia Minor between the Mediterranean Sea and the Black Sea and stretches into continental Europe. Turkey has long been known to possess a potentially rich Sphecidae fauna (Ljubomirov & Yildirim, 2008). Sphecidae fauna in Turkey is very rich also in comparison to others countries of the Mediterranean region. Turkey is one of the most interesting countries located in West Palaearctic region, where most of the insect families including Sphecidae are known to survive . Thus, many faunistic and systematic studies about the family Sphecidae have been conducted by some foreign and native researchers in Turkey (Yildirim, 2011). However, there is no attempt to prepare the distribution and biogeography of Sphecidae in Turkey. It is essential to have such a study of Sphecidae from Turkey for the researchers who are interested in working with Sphecidae in West Palaearctic region including Turkey.

In this study, the studies on the Sphecidae in Turkey were reviewed (André, 1886; Berland, 1926, 1928; Coulon, 1925; de Beaumont, 1960, 1967, 1969; de Beaumont *et al*., 1956; Fahringer,

1922; Fahringer & Friese, 1921; Gayubo *et al*., 1992; Gayubo & Özbek, 2005; Gülmez & Tüzün, 2005; Hensen, 1987, 1988; Kohl, 1884, 1885, 1888, 1890, 1905, 1906, 1918; Kohl & Handlirsch, 1889; Leclercq, 1973; Lepeletier de Saint-Fargeau, 1845; Ljubomirov & Yildirim, 2008; Menke & Pulawski, 2000; Mocsáry, 1883; Roth, 1963, 1967; Schmid-Egger, 2005; Smith, 1856; Tezcan *et al*., 2006; Tüzün *et al*., 1999; Tüzün & Yüksel, 2010; Yildirim & Ljubomirov, 2005, 2007, Yildirim, 2011) and the distribution and biogeography of the Turkish fauna of Sphecidae is analyzed.

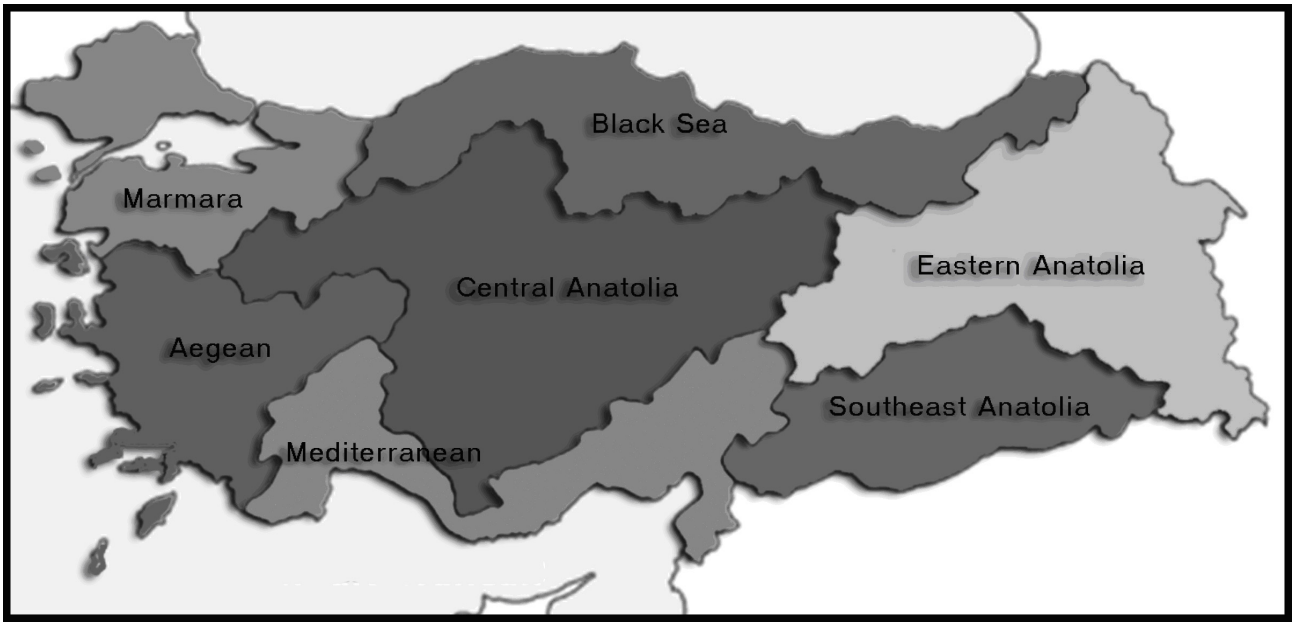

Figure 1. Biogeographical map of Turkey (1/3.200.000).

2. MATERIAL AND METHODS

In this study, the previous studies on the Sphecidae of Turkey are reviewed and the distribution and biogeography of the Turkish fauna of Sphecidae is analyzed. The genera, species and subspecies whose type localities are in Turkey are marked with an asterisk.

Faunal similarities between biogeographical regions of Turkey were evaluated, without regard to differences in region area by using Sorensen's coefficient of similarity (Legendre & Legendre, 1998). The similarity matrix resulting from pair-wise calculations was then subjected to unweighted arithmetic average clustering (UPGMA; PAST program, version 1.57, Hammer *et al.,* 2006).

3. RESULT AND DISCUSSION

As a result, a total of 61 species and 5 subspecies from 12 genera belonging to three subfamilies Sceliphrinae, Sphecinae, and Ammophilinae from Sphecidae were recorded from Turkey. Among them, the type localities of four species and one subspecies in Sphecidae are situated in Turkey (**Tables 1-3**).

Table 1. The current knowledge of Sphecidae (Hymenoptera) in Turkey.

Family	Subfamily	Genus	Species	Sub species	Number of species and subspecies type localities
Sphecidae	Sceliphrinae	*Chalybion*	5	-	-
		Sceliphron	5	-	-
	Sphecinae	*Isodontia*	2	-	-
		Sphex	8		
		Chilosphex	2	-	-
		Palmodes	5	2	1
		Prionyx	10	2	1
	Ammophilinae	*Ammophila*	11	1	1
		Eremochares	1	-	-
		Hoplammophila	2	-	1
		Parapsammophila	1	-	-
		Podalonia	9	-	1
	Total	**12**	**61**	**5**	**5**

Table 2. Distribution of Sphecidae (Hymenoptera) to Biogeography Regions in Turkey.

Names of taxa	EA	SA	BS	CA	MD	A	M
Sceliphrinae Ashmead 1899							
Sceliphrini Ashmead 1899							
Chalybion Dahlbom 1843							
Chalybion (*Chalybion*) *flebile* (Lepeletier de Saint-Fargeau 1845)	+	+	-	+	+	+	+
Chalybion (*Chalybion*) *minos* (de Beaumont 1965)	-	-	-	-	+	-	+
Chalybion (*Chalybion*) *omissum* (Kohl 1889)	-	-	-	+	+	+	-
Chalybion (*Chalybion*) *walteri* (Kohl 1889)	+	+	+	+	+	+	-
Chalybion (*Hemichalybion*) *femoratum* (Fabricius 1781)	+	-	-	+	-	+	+
Sceliphron Klug 1801							
Sceliphron (*Henesia*) *funestum* Kohl 1918	-	-	+	-	+	+	-
Sceliphron (*Sceliphron*) *arabs* (Lepeletier de Saint-Fargeau 1845)	+	-	-	-	+	-	-
Sceliphron (*Sceliphron*) *destillatorium* (Illiger 1807)	+	+	+	+	+	+	+
Sceliphron (*Sceliphron*) *madraspatanum tubifex* (Latreille 1809)	-	-	+	+	+	+	+
Sceliphron (*Sceliphron*) *spirifex* (Linnaeus 1758)	-	-	+	+	-	+	+
Sphecinae Latreille 1802							
Sphecini Latreille 1802							
Isodontia Patton 1880							
Isodontia paludosa (Rossi 1790)	+	-	+	+	-	-	+
Isodontia splendidula (Costa 1858)	-	-	-	+	+	-	-
Sphex Linnaeus 1758							
Sphex (*Fernaldina*) *melanocnemis* Kohl 1885	-	-	+	+	+	+	+
Sphex (*Sphex*) *atropilosus* Kohl 1885	+	-	-	-	-	-	-
Sphex (*Sphex*) *flavipennis* Fabricius 1793	+	-	+	+	+	+	+
Sphex (*Sphex*) *fumicatus fumicatus* Christ 1791	+	-	-	-	+	-	-
Sphex (*Sphex*) *funerarius* Gussakovskij 1934	+	-	+	+	+	+	+
Sphex (*Sphex*) *leuconotus* Bullé 1833	+	-	+	+	+	-	-
Sphex (*Sphex*) *oxianus* Gussakovsky 1928	-	+	+	+	-	-	-
Sphex (*Sphex*) *pruinosus* Germar 1817	+	-	+	+	+	-	+
Prionychini Bohart & Menke 1963							
Chilosphex Menke 1976							
Chilosphex argyrius (Brullé 1833)	+	-	-	-	-	+	+
Chilosphex pseudargyrius (Roth 1967)	-	-	-	-	+	-	-
Palmodes Kohl 1890							
Palmodes melanarius (Mocsáry 1883)	-	-	-	+	-	+	-

Palmodes minor (Morawitz 1890)	-	-	+	+	-	-	-
Palmodes occitanicus occitanicus (Le Peletier de Saint-Fargeau & Audinet-Serville 1828)	+	-	-	-	-	-	+
Palmodes occitanicus puncticollis (Kohl 1888)	+	-	-	+	+	-	-
Palmodes occitanicus syriacus (Mocsáry 1881)	+	+	+	+	+	+	-
**Palmodes parvulus* (Roth 1967)	-	-	-	+	-	-	-
Palmodes strigulosus (Costa 1861)	+	+	+	+	-	-	+
Prionyx Vander Linden 1827							
Prionyx crudelis (Smith 1856)	-	-	-	-	+	+	-
**Prionyx guichardi* (de Beaumont 1967)	-	-	-	+	-	-	-
Prionyx kirbii kirbii (Vander Linden 1829)	+	-	+	+	+	+	+
Prionyx lividocinctus lividocinctus (Costa 1861)	-	+	-	+	+	+	+
Prionyx niveatus niveatus (Dufour 1854)	+	-	-	+	-	-	-
Prionyx nudatus (Kohl 1885)	+	-	+	+	+	+	+
Prionyx songaricus (Eversmann 1849)	-	+	-	+	+	-	-
Prionyx subfuscatus subfuscatus (Dahlbom 1845)	+	-	-	+	+	-	+
Prionyx viduatus argentatus (Mocsáry 1883)	+	-	-	-	+	-	-
Prionyx viduatus pollens (Kohl 1885)	-	-	-	+	-	-	-
Prionyx viduatus viduatus (Christ 1791)	+	-	+	+	+	+	-
Prionyx vittatus (Kohl 1884)	-	-	+	-	-	-	-
Ammophilinae André 1886							
Ammophila Kirby 1798							
Ammophila assimilis Kohl 1901	-	-	-	-	+	-	-
Ammophila barbara judaeorum Kohl 1901	-	-	-	+	-	-	-
**Ammophila barbara semota* de Beaumont 1967	-	-	-	+	-	-	-
Ammophila campestris Latreille 1809	+	-	+	+	+	-	+
Ammophila heydeni heydeni Dahlbom 1845	+	+	+	+	+	+	+
Ammophila hungarica Mocsáry 1883	+	-	+	+	+	+	+
Ammophila pubescens Curtis 1836	+	-	-	+	-	-	-
Ammophila sabulosa sabulosa (Linnaeus 1758)	+	-	+	+	+	+	+
Ammophila sareptana Kohl 1884	+	-	+	+	+	-	+
Ammophila sinensis Sickmann 1894	+	-	-	-	-	-	-
Ammophila striata striata Mocsáry 1878	+	-	-	+	+	+	-
Ammophila terminata mocsaryi Frivaldsky 1877	+	-	+	+	+	-	+
Eremochares Gribodo 1883							
Eremochares dives (Brullé 1833)	-	-	-	+	+	+	-
Hoplammophila de Beaumont 1960							
**Hoplammophila anatolica* de Beaumont 1960	-	-	-	-	+	-	-
Hoplammophila armata (Illiger 1807)	-	-	+	+	-	-	-
Hoplammophila clypeata (Mocsáry 1883)	-	-	-	-	+	-	+
Parapsammophila Taschenberg 1869							
Parapsammophila caspica (Gussakovskij 1930)	-	-	-	-	+	-	-
Podalonia Fernald 1927							
Podalonia affinis affinis (Kirby 1798)	+	-	+	+	+	-	+
Podalonia alpina (Kohl 1888)	+	-	+	+	+	-	-
Podalonia ebenina (Spinola 1839)	+	-	+	+	-	-	-
**Podalonia fera* (Lepeletier de Saint-Fargeau 1845)	+	-	+	+	+	+	+
Podalonia harveyi (de Beaumont 1967)	-	-	-	+	+	-	-
Podalonia hirsuta hirsuta (Scopoli 1763)	+	+	+	+	+	+	+
Podalonia luffii (Saunders 1903)	+	-	-	-	-	-	-
Podalonia rothi (de Beaumont 1951)	-	-	-	+	-	+	-
Podalonia tydei tydei (Le Guillou 1841)	+	-	+	+	+	+	+
Total species and subspecies	**39**	**10**	**32**	**50**	**44**	**28**	**29**

Remarks: EA – Eastern Anatolia, SA – Southeastern Anatolia, BS – Black Sea, CA – Central Anatolia, MD – Mediterranean, A – Aegean, M – Marmara, + presence, - absence

* The type locality is Turkey.

There are great differences in species composition and richness between the biogeographic regions of Turkey (**Table 2**, **Figure 2**). 50 species and subspecies of the Sphecidae have been recorded from Central Anatolia (76% of the recorded species and subspecies), 44 from Mediterranean (67% of the recorded species and subspecies), 39 from Eastern Anatolia (59% of the recorded species and subspecies), 32 from Black Sea (48% of the recorded species and subspecies), 29 from Marmara region (44% of the recorded species and subspecies), 28 from the Aegean (42 of the recorded species and subspecies), and 10 from Southeastern Anatolia (15 of the recorded species and subspecies). Apparently, species diversity is higher in the Central Anatolia region than in other regions. A cluster analysis of faunal similarities among the regions for Sphecidae demonstrates the existence of four major clusters. The first cluster is formed by the Central Anatolia region, the second cluster by the Mediterranean and Eastern Anatolian regions, the third cluster by the Black Sea, Marmara and Aegean regions and the fourth cluster by the Southeastern Anatolia region.

The sphecid fauna of Turkey is known rather well and currently includes 66 species and subspecies from 12 genera. Among them, the type localities of four species and one subspecies in Sphecidae are located in Turkey. These species: *Palmodes parvulus*, *Prionyx guichardi* and *Ammophila barbara semota* from Central Anatolia region; *Hoplammophila anatolica* from Mediterranean region; *Podalonia fera* from Aegean, Black Sea, Marmara, Mediterranean, Central Anatolia and Eastern Anatolia regions. Central Anatolia region has the richest fauna (**Table 2**, **Figure 2**).

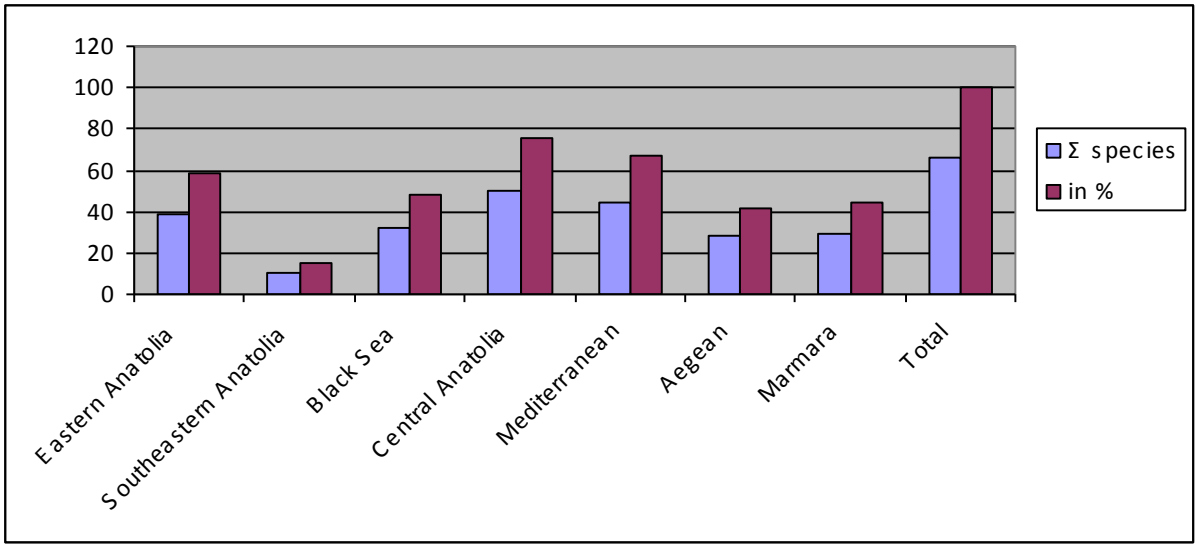

Figure 2. Number of species and subspecies of Sphecidae in the biogeographical regions of Turkey

Cluster analysis of faunal similarities among seven biogeographical regions of Turkey (Figure 3 and 4) produce one large combined cluster (similarity 0.68, bootstrap probability 45 %) with five biogeographical regions (Black Sea, Central Anatolia, Eastern Anatolia, Marmara, Mediterranean) which united with Aegean region (similarity 0.65, bootstrap probability 99 %). These six regions belong to East Mediterranean province of Palaearctic (the division of Palaearctic follows Semenov-Tian-Shanskij, 1935). Southeast Anatolia demonstrates minimal similarity (0.35) with other Turkish fauna and belongs to Sumerian province of Palaearctic.

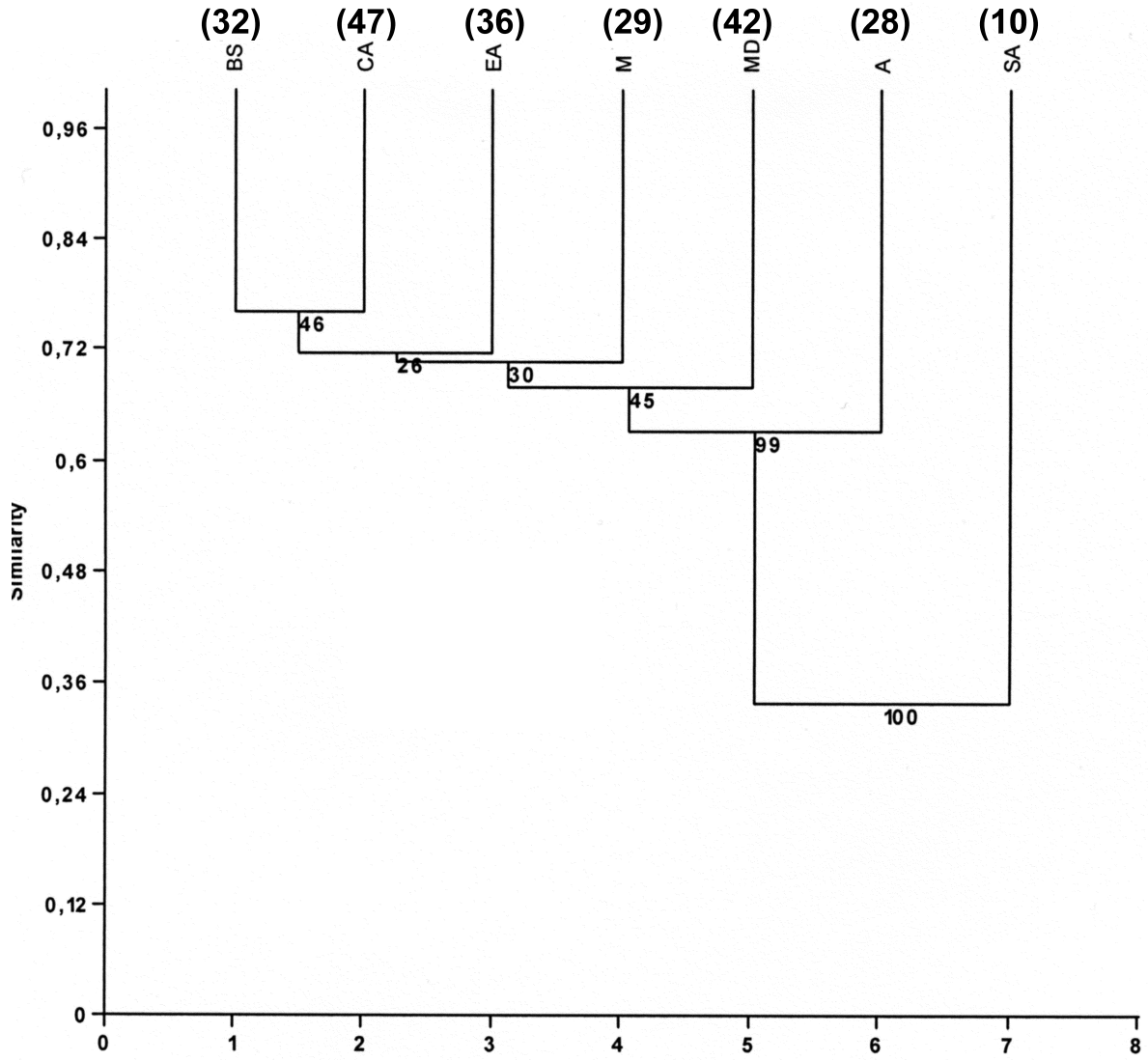

Figure 3. Similarity of 62 species of Sphecidae from seven biogeographical regions of Turkey. (Dice, r = 0.98). Bootstrap probabilities (expressed in percentages) are indicated at node of each cluster. The number of species is given above the region name. Names of regions: A – Aegean, BS – Black Sea, CA – Central Anatolia, EA – Eastern Anatolia, M – Marmara, MD – Mediterranean, SA – Southeastern Anatolia.

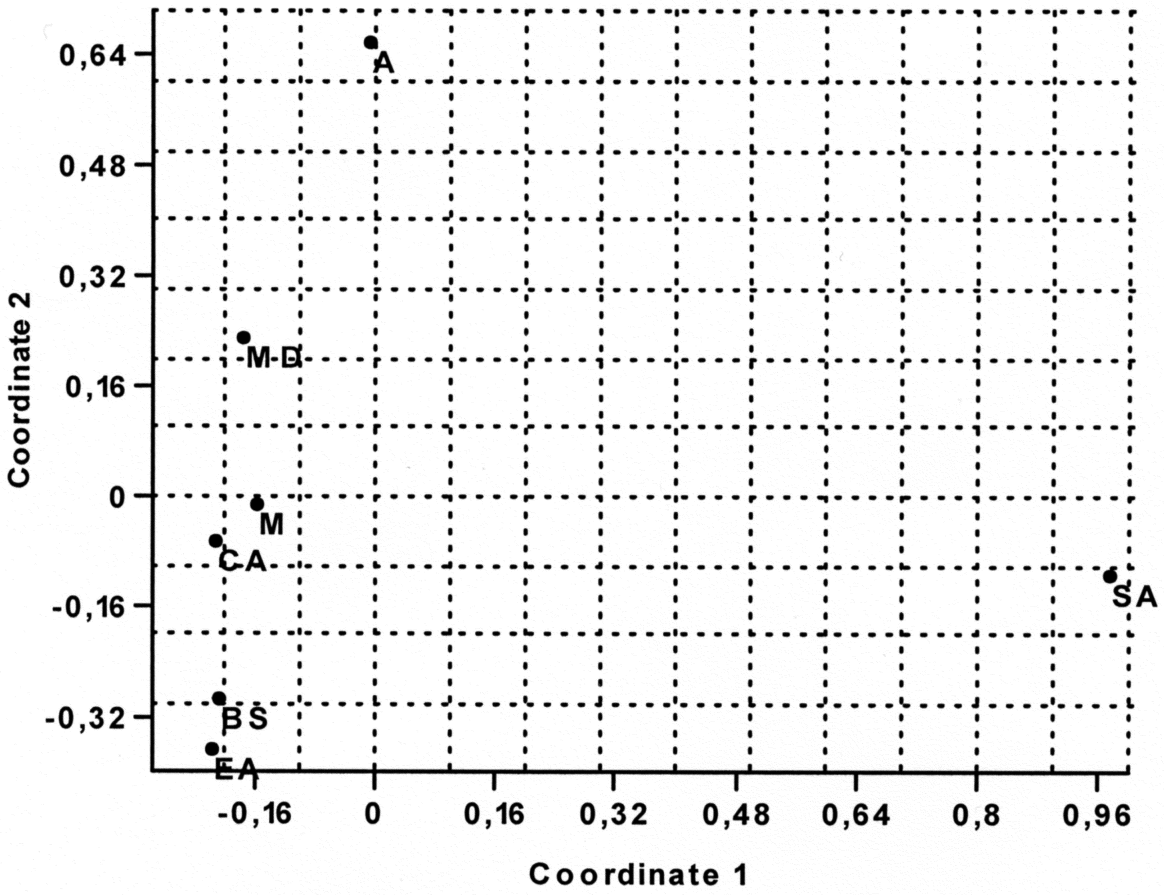

Figure 4. Ordination of the seven biogeographical regions of Turkey in the reduced space of the first two principal coordinates for 62 species of Sphecidae. (Dice, r = 0.98). The names of regions see **Figure 3**.

Turkish sphecid fauna can be considered as very rich. The fauna of the Sphecidae of Turkey contains a large number of species in comparison to others countries of the Mediterranean region, which are well known for their high biodiversity. The faunal riches analyzed between Turkey and Europe and examined the composition of the sphecid fauna of Turkey (**Table 3**, **Figure 5**). The sphecid fauna of Turkey is known rather well and currently includes 67 species and subspecies in 12 genera. Separately, 72 species and subspecies in 12 genera from Europe (Barbier, 2004). The highest number of species is known from the biogeographical province of Turkey. Turkish sphecid fauna is very rich. The great richness and diversity of the Turkish sphecid fauna is the result of the various topographic and climatic structure of the country. In other hand Turkey is a boundary of East Mediterranean, Sumerian and Irano-Turanian provinces of Palaearctic region that caused the richness of the fauna.

Table 3. The current knowledge of Sphecidae in Turkey and Europe

Subfamily	Present in Turkey		Number with type localities situated in Turkey		Present in Europe	
	Genus	Species and subspecies	Species	Subspecies	Genus	Species and subspecies
Sceliphrinae	2	10	-	-	2	10
Sphecinae	5	31	4	-	5	25
Ammophilinae	5	25	-	1	5	37
Total	**12**	**66**	**4**	**1**	**12**	**72**

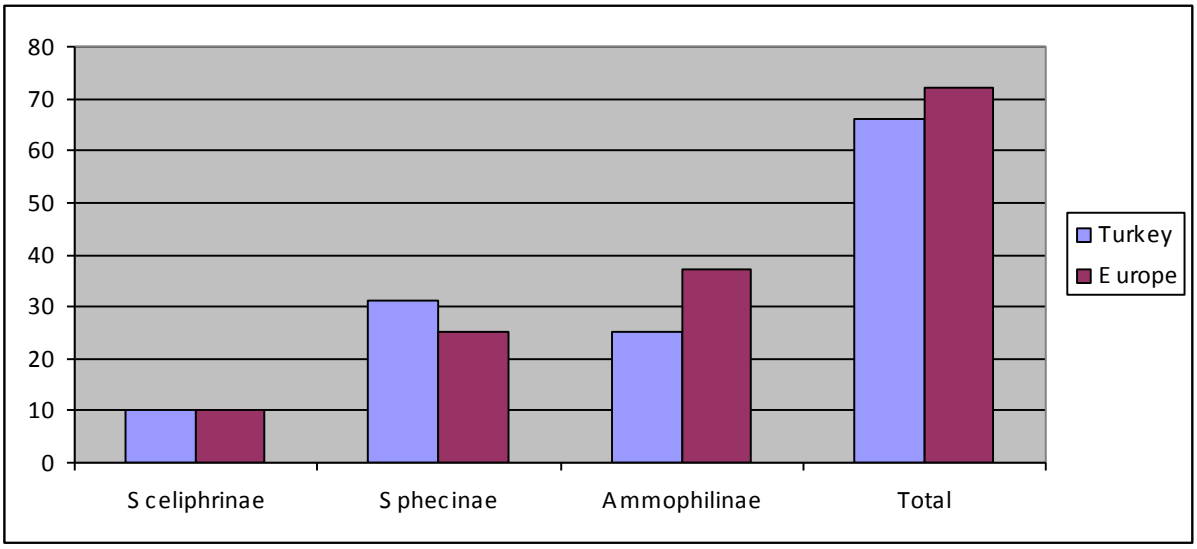

Figure 5. Number of species and subspecies of Sphecidae in Turkey and Europe by subfamilies

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