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Gnaphosidae of Crete: taxonomy and distribution

MARIA CHATZAKI[1,2], KONRAD THALER[3] & MOYSIS MYLONAS[1,2]
[1] *Dept of Biology, University of Crete, 71100, Irakleio, Crete, Greece*
[2] *Natural History Museum of the University of Crete, Knossou Av., PO Box 2208, 71409 Irakleio, Crete, Greece* (mchatzak@nhmc.uoc.gr)
[3] *Institut für Zoologie und Limnologie der Universität, Technikerstraße 25, A-6020 Innsbruck, Austria*

Abstract
Previous knowledge of the Gnaphosidae of Crete and Greece dates back to the work of Roewer (1928, 1959), Hadjissarantos (1940) and some earlier scientists. Until recently 35 species were recorded in the literature, among which several were described as new but were never again collected or revised. In course of the present study, ground spiders collected from 73 sites along Crete were studied. Since 1990, material was collected using pitfall traps. Among the c. 14,000 specimens examined so far, 53 Gnaphosidae species were identified. Eight of these species are new to science (genera *Cesonia*, *Cryptodrassus*, *Drassodes*, *Drassyllus*, *Leptodrassus* and *Zelotes*), eight are new records for Europe and another eight are new records for Greece. Most of the old records were verified, while a few are considered to be false. Most of the Cretan Gnaphosidae have a Mediterranean distribution (30%), while a considerable number of species have an eastern origin (19%). Endemism in the area is as high as 17% (9 species). On Crete species are more or less uniformly distributed; the most obvious ecological parameter that separates Gnaphosidae communities along Crete is altitude.

Key words: Mediterranean, Greece, spiders, Gnaphosidae, altitudinal gradient

INTRODUCTION

Owing to its position between the three continents Europe, Asia and Africa, Greece possesses a key role in the zoogeography of the Mediterranean. As has been observed by several researchers, Greece is a centre of speciation for many animal groups, confined mostly to its high mountains, caves (Deltshev 1999) and islands. Consequently endemism is another component which has greatly affected the Greek fauna.

Crete is an isolated island formation since Pliocene (5 m.y.a.) (Schule 1993; Meulenkamp et al. 1994). Since that time its connection with the mainland was indirect via the islands of the south Aegean island arc. The great heterogeneity of its landscape allows us to analyze the impact of a variety of ecological factors (such as altitude, temperature, aridity, human activities etc) on the composition and distribution of species within a relatively small geographical range.

Gnaphosidae is the most abundant and one of the most diverse of all spider families in the Mediterranean. Several contributions have dealt with Gnaphosidae in the adjacent areas, i.e. Italy (Di Franco 1993, 1996, 1997a,b and references therein, 1998; Di Franco & Pantini 2000), Israel (Levy 1995, 1998, 1999a,b), North Africa (Dalmas 1919; Denis 1952; Di Franco 1992a,b; Bosmans & Janssen 1999; Bosmans & Blick 2000). However, the present state of knowledge of the species distributions in the whole area of the East Mediterranean is far from thorough.

By comparison this family is not well represented in the spider literature of Crete, partly because of the nocturnal activity of many gnaphosid species, and also because earlier researchers focused on cave-dwelling rather than on epigeic spiders. Previous knowledge on the Gnaphosidae of the area stems from the work of Roewer (1928, 1959), Hadjissarantos (1940) and some other scientists, leading to a total number of 35 species recorded in the literature. Among them, several were described as new and were never again collected or revised.

The aim of the present study is to bring Gnaphosidae of Crete to a better state of knowledge, to clarify the taxonomical problems that are related to it and to try to interpret the distributions of the species recorded based on historical events and/or ecological factors that affect this area.

MATERIAL AND METHODS

In course of the present study, ground spiders collected from 59 sites along Crete were studied. Since 1990, material was collected using pitfall traps, in a series of projects organized by the Natural History Museum of Crete. In most cases material was collected at two-monthly intervals during the period of high activity of this family, i.e. from mid spring to mid autumn (Chatzaki et al. 1998). Identifications of the species were carried out at the Natural History Museum of Crete and at the Zoological Institute of Innsbruck, Austria.

RESULTS

Taxonomy

In total, 21 genera and 53 species were identified on Crete (Table 1). Among them, there are 8 new species, 8 new references for Greece and 8 new references for Europe (see Chatzaki et al. 2002a,b, 2003). From the 35 earlier records, 23 were verified and at least 5 are doubted. Furthermore, 8 new synonymies and 6 new combinations were proposed (Chatzaki et al. 2002a,b, 2003).

Chorological distribution

The chorological distribution of Cretan Gnaphosidae is presented in Fig. 1A. These results compared to data from neighbouring areas with fairly thorough knowledge of their arachnofauna, i.e. Bulgaria (Deltshev & Blagoev 2001), Israel (Levy 1995, 1998, 1999a,b) and Sicily (Di Franco 1993) (Fig. 1B-D) lead to the following conclusions:

1) Endemism is positively correlated with isolation, therefore the islands (Fig. 1A-B) present higher endemism than the continental areas (Fig. 1C-D). The high percentage of endemism in Israel (36%) may be partly attributed to the poor state of knowledge of Gnaphosidae in the surrounding areas of the East Mediterranean.

2) The Mediterranean element influences more the insular systems than the continental ones, which are affected more directly by their neighboring species sources, i.e. Central Europe for Bulgaria and Anatolia for Israel. However, there are not any East Mediterranean species on Sicily and West Mediterranean species on Crete.

3) Differences between the faunas of Sicily and Crete reveal the greater level of isolation of the latter (in both time and distance from the mainland), leading to a higher degree of endemism and its more complex association with different elements from both the Balkan and the Asia Minor peninsulas.

Distribution on Crete - Altitudinal gradient

Common Gnaphosidae species are distributed uniformly in the habitats of Crete. Distributions of the less common species along the horizontal axis of the island mainly reflect variations in their tolerance to aridity, since there is a remarkable gradient in precipitation, temperature and winds along the island, the south-east part of Crete being the most arid throughout Europe.

The most evident variation of gnaphosid communities is along the altitudinal gradient of the three main mountain massifs of Crete. This is supported by similarity and multivari-

Table 1. List of Gnaphosidae species on Crete and their chorological distribution. Ende: Cretan or south-Aegean endemic, East: East Mediterranean or Anatolian, Med: Mediterranean, Wide: widespread.

Species	Chorological distribution	ZER (0-500m)	LOW (500-999m)	MID (1000-1499m)	TOP (1500-1599m)	PEAK (2000-2400m)
Anagraphis pallens Simon, 1893	East	+	+	+	+	
Berinda amabilis Roewer, 1928	East	+	+			
Berinda ensigera (O. P.-Cambridge, 1874)	Ende	+				
Berlandina plumalis (O.P.-Cambridge, 1872)	Wide	+				
Callilepis cretica (Roewer, 1928)	East	+	+	+	+	
Camillina metellus (Roewer, 1928)	Ende	+	+	+		
Cesonia aspida Chatzaki, 2002	Ende	+	+	+		
Cryptodrassus creticus Chatzaki, 2002	Ende	+	+			
Drassodes lapidosus (Walckenaer, 1802)	Wide	+	+	+		
Drassodes lutescens (L. Koch, 1839)	Med	+	+	+	+	
Drassodes oreinos Chatzaki, 2002	Ende			+	+	+
Drassodes serratichelis (Roewer, 1928)	Ende	+		+	+	
Drassyllus praeficus (L. Koch, 1866)	Wide	+	+	+	+	
Drassyllus pumiloides Chatzaki, 2003	Ende	+	+	+	+	
Gnaphosa bithynica (Kulczyński, 1903)	East				+	+
Haplodrassus creticus (Roewer, 1928)	Ende	+	+	+	+	
Haplodrassus dalmatensis (L. Koch, 1866)	Wide	+	+	+	+	
Haplodrassus minor (O.P.-Cambridge, 1879)	Wide		+			
Haplodrassus signifer (C. L. Koch, 1839)	Wide			+		
Leptodrassus albidus Simon, 1914	Med	+	+			
Leptodrassus femineus Simon, 1873	Med	+	+			
Leptodrassus hadjissaranti Chatzaki, 2002	Ende	+				
Leptodrassus manolisi Chatzaki, 2002	Ende	+				
Leptodrassus pupa Dalmas, 1919	East	+	+			
Micaria albovittata (Lucas, 1846)	Wide	+	+	+		
Micaria coarctata (Lucas, 1846)	Wide	+	+	+	+	
Micaria dives (Lucas, 1846)	Wide		+	+		
Micaria pygmaea Kroneberg, 1875	Med	+				
Nomisia excerpta (O.P.-Cambridge, 1872)	Med	+	+	+	+	
Nomisia riparíensis (O.P.-Cambridge, 1872)	East	+	+			
Poecilochroa senilis (O.P.-Cambridge, 1872)	East	+	+			
Pterotricha lentiginosa (C. L. Koch, 1837)	Med	+	+	+	+	
Scotophaeus peninsularis Roewer, 1928	East	+				
Scotophaeus scutulatus (L. Koch, 1866)	Wide	+	+			
Setaphis carmeli (O.P.-Cambridge, 1872)	Med	+	+			
Synaphosus palearcticus Ovtsharenko, Levy & Platnick, 1994	East			+		
Synaphosus trichopus (Roewer, 1928)	Ende	+	+			
Trachyzelotes adriaticus (Caporiacco, 1953)	Med	+		+	+	
Trachyzelotes barbatus (L. Koch, 1866)	Med	+	+			
Trachyzelotes lyonneti (Audouin, 1826)	Med	+				
Trachyzelotes malkini Platnick, 1984	East	+	+	+		
Zelotes aerosus Charitonov, 1946	East	+				
Zelotes caucasius (L. Koch, 1866)	Wide	+	+	+	+	
Zelotes creticus (Kulczyński, 1903)	Ende	+	+	+	+	+
Zelotes daidalus Chatzaki, 2003	Ende	+	+			
Zelotes cf. *ilotarum* (Simon, 1884)	Ende	+	+	+		
Zelotes labilis Simon, 1914	Med	+	+	+	+	+
Zelotes minous Chatzaki, 2003	Ende	+	+			
Zelotes nilicola (O.P.-Cambridge, 1874)	Med	+				
Zelotes scrutatus (O. P.-Cambridge, 1872)	Med	+	+	+	+	
Zelotes solstitialis Levy, 1998	East	+	+			
Zelotes subterraneus (C. L. Koch, 1833)	Wide	+	+	+	+	+
Zelotes tenuis (L. Koch, 1866)	Med	+	+	+		

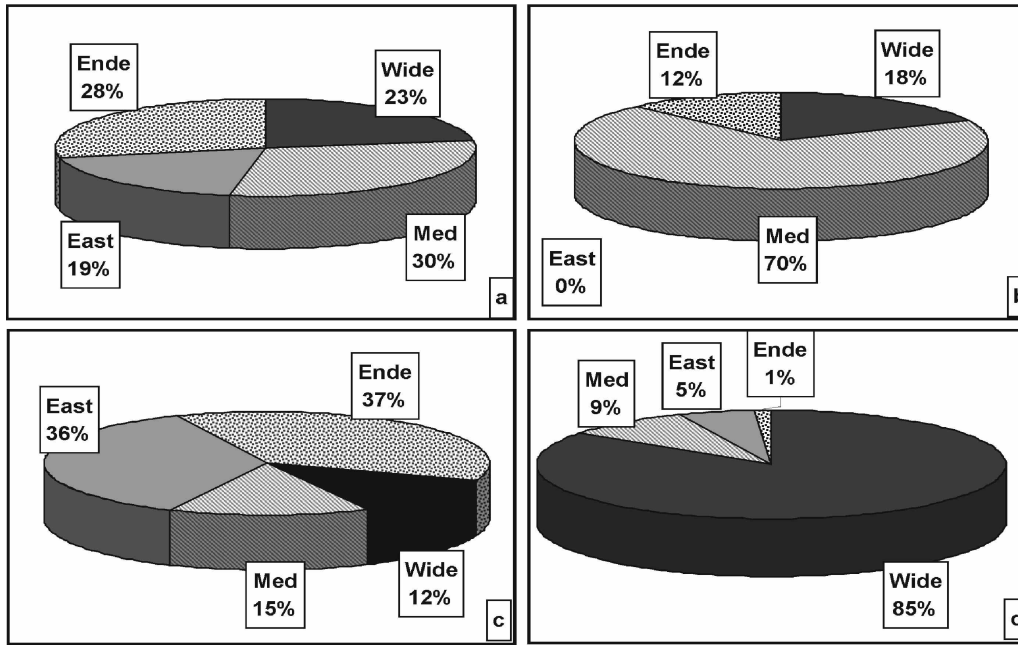

Fig. 1. Chorological distribution of species in four regions: (**A**) Crete, (**B**) Sicily, (**C**) Israel, (**D**) Bulgaria. Ende: endemic, East: East Mediterranean or Anatolian, Med: Mediterranean, Wide: widespread (Palearctic, Holarctic, Turano-European, Euro-Mediterranean species)

ate analyses that reveal a smooth species turnover from 0 to 1500 m, a rather abrupt change above 2000 m, and a transitional zone at 1500-2000 m. Table 2 shows the number of species and the mean abundance of Gnaphosidae per site along five altitudinal zones of 500 m each. In each of the first four zones there is a decrease of about 10 species and a statistically similar mean abundance (Fig. 2) (ANOVA: $F_{2,4}$=0.610). At the last zone there is a dramatic change in both number of species and abundance.

The dominant species at the zone 1500-2000 m is *Pterotricha lentiginosa* (C.L. Koch, 1837) which is the most abundant species all over Crete. At 2000m mainly Mediterranean and endemic species occur. For some of them (see Table 1) this is the highest limit of their distribution (*Anagraphis pallens* Simon, 1893, *Drassodes lutescens* (L. Koch, 1839), *Haplodrassus dalmatensis* (L. Koch, 1866), *Zelotes scrutatus* (O. P.-Cambridge, 1872), etc.), while for others this is the zone of maximum abundance (*Callilepis cretica* (Roewer, 1928), *Drassyllus praeficus* (L. Koch, 1866), *Haplodrassus creticus* (Roewer, 1928), *Zelotes creticus* (Kulczyński, 1903)). At the summits Gnaphosidae become very limited: *Drassodes oreinos* Chatzaki, 2002, a Cretan endemic (?) occurring above 1200 m; *Gnaphosa bithynica* (Kulczyński, 1903), a high altitude species, occurring above 1600 m on Crete and on neighboring mountain peaks (see Chatzaki et al. 2002a); *Z. creticus*, a Cretan endemic occurring at humid places in the lowlands and at high altitudes of the western parts of the island; *Z. subterraneus* (C.L. Koch, 1833), a palearctic species, common all along Crete; *Z. labilis* Simon, 1914, a south European species with unclear taxonomical status and morphological variations on the Cretan mountains (see Chatzaki et al. 2003).

Table 2. Number of species and abundance of Gnaphosidae along five altitudinal zones of Crete

Altitudinal zone	Number of species	Sum of the mean number of indvs / 100 trap-days / site
0 – 499 m	49	10.06
500 – 999 m	39	9.01
1000 – 1499 m	28	11.99
1500 – 1999 m	19	13.34
2000 - 2400 m	5	5.91

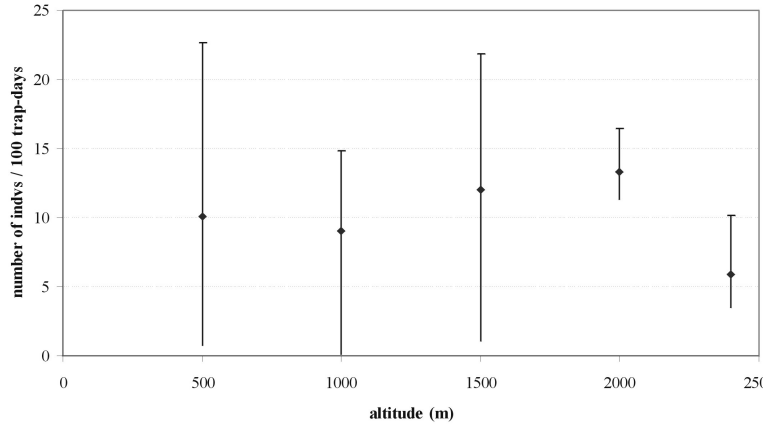

Fig. 2. Mean abundance of Gnaphosidae at the sites of study area devided into five altitudinal zones (500 m). Deviation reflects the variation of the mean abundance at the sites of the corresponding zones.

DISCUSSION

Gnaphosidae are represented on Crete with at least 53 species and show great diversity in all habitats of the island. The chorological distribution of these species reflects the geographical position of Crete between three continents and its insular character, resulting in high endemism rates. The strong influence of Eastern and Circum-Mediterranean elements probably reflects the xerophilic character of this family.

Species numbers decrease almost linearly with altitude, while numbers of individuals persist. This can be explained by ecological reasons (relaxation of interspecific competition, higher activity within a shorter period of time) and by the presence of newly appearing taxa that are able to survive the harsh conditions of high mountain habitats. A few species tolerating extremes of temperature and aridity reach the summit zones and overexploit this poor environment.

Also in other groups of invertebrates, i.e. in land snails (Vardinoyannis 1994) and Coleoptera (Trichas 1996) the high mountain fauna of Crete derives from tolerant species of the lowlands. The origin of this fauna is related to the course of paleo-events that gave rise to the mountains of Crete. During the early Pliocene period (5 m.y.a.) Crete did not exceed the altitude of 500 m (Meulenkamp et al. 1988). After this period, continuous vertical movements led to an uplift of more than 600-700 m in some regions (Papapetrou-Zamani 1973). Lowland species were the most proximate and probable source of organisms to invade these new territories. The zone above 1500 m was formed on Crete after the Pleistocene (1.5 m.y.a.) (Meulenkamp et al. 1994). This period may account for endemic forms of lowland species (i.e. *Z. labilis* variations), but is too short for speciation of true high altitude species (Vardinoyannis 1994) reported en-

demic species of landsnails on the high mountains of Crete. However the high endemism of this taxon on Crete (50%) implies a much higher rate of speciation, non comparable to that of any other invertebrate group). Some spiders (i.e. *D. oreinos*) apparently are not closely related to any lowland taxon. This is in favor of our opinion that both gnaphosid species confined to the summits (*D. oreinos*, *G. bithynica*) might belong to a high mountain eastern fauna that passed from Asia Minor to Crete via the East Aegean islands.

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