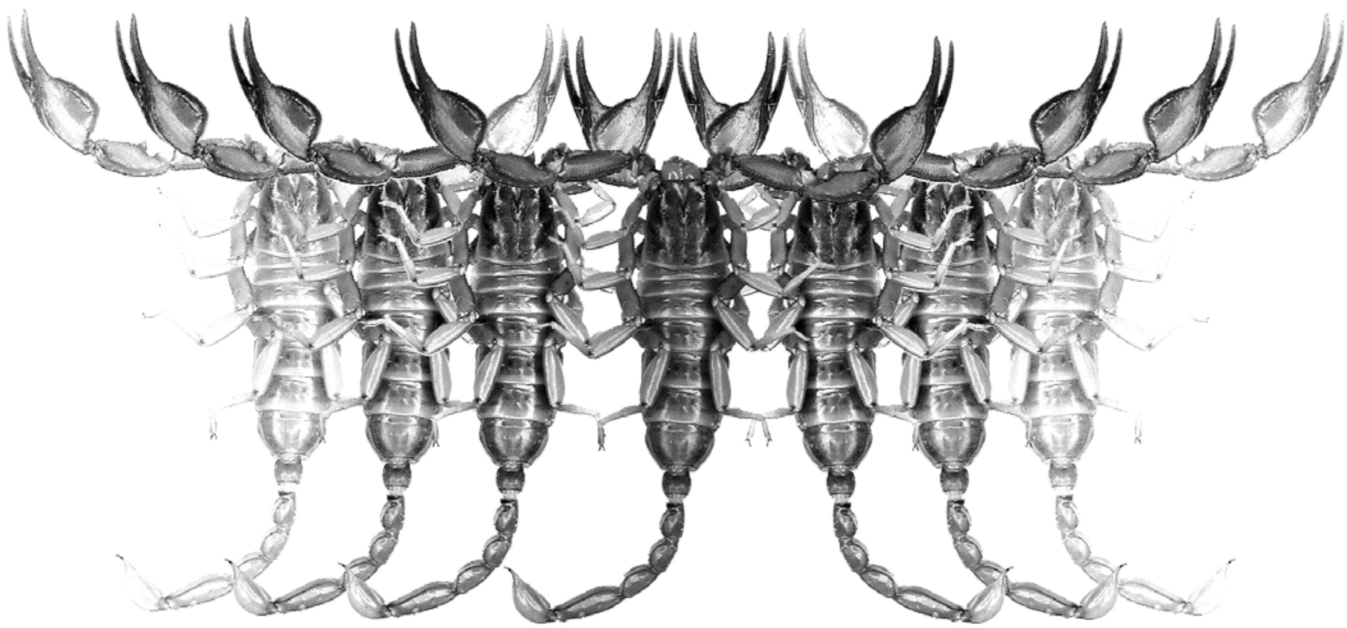
Euscorpius

Occasional Publications in Scorpiology



The Population Structure of *Mesobuthus gibbosus* (Scorpiones: Buthidae) on Koufonisi Island (Central Aegean Archipelago, Greece)

Dimitris Kaltsas and Moysis Mylonas

April 2007 – No. 55

Euscorpius

Occasional Publications in Scorpiology

EDITOR: **Victor Fet**, Marshall University, **'fet@marshall.edu'**

ASSOCIATE EDITOR: **Michael E. Soleglad, 'soleglad@la.znet.com'**

Euscorpius is the first research publication completely devoted to scorpions (Arachnida: Scorpiones). *Euscorpius* takes advantage of the rapidly evolving medium of quick online publication, at the same time maintaining high research standards for the burgeoning field of scorpion science (scorpiology). *Euscorpius* is an expedient and viable medium for the publication of serious papers in scorpiology, including (but not limited to): systematics, evolution, ecology, biogeography, and general biology of scorpions. Review papers, descriptions of new taxa, faunistic surveys, lists of museum collections, and book reviews are welcome.

Derivatio Nominis

The name *Euscorpius* Thorell, 1876 refers to the most common genus of scorpions in the Mediterranean region and southern Europe (family Euscorpiidae).

Euscorpius is located on Website **'http://www.science.marshall.edu/fet/euscorpius/'** at Marshall University, Huntington, WV 25755-2510, USA.

The International Code of Zoological Nomenclature (ICZN, 4th Edition, 1999) does not accept online texts as published work (Article 9.8); however, it accepts CD-ROM publications (Article 8). *Euscorpius* is produced in two *identical* versions: online (ISSN 1536-9307) and CD-ROM (ISSN 1536-9293). Only copies distributed on a CD-ROM from *Euscorpius* are considered published work in compliance with the ICZN, i.e. for the purposes of new names and new nomenclatural acts. All *Euscorpius* publications are distributed on a CD-ROM medium to the following museums/libraries:

- **ZR**, Zoological Record, York, UK
- **LC,** Library of Congress, Washington, DC, USA
- **USNM**, United States National Museum of Natural History (Smithsonian Institution), Washington, DC, USA
- **AMNH**, American Museum of Natural History, New York, USA
- **CAS**, California Academy of Sciences, San Francisco, USA
- **FMNH**, Field Museum of Natural History, Chicago, USA
- **MCZ**, Museum of Comparative Zoology, Cambridge, Massachusetts, USA
- **MNHN**, Museum National d'Histoire Naturelle, Paris, France
- **NMW**, Naturhistorisches Museum Wien, Vienna, Austria
- **BMNH**, British Museum of Natural History, London, England, UK
- **MZUC**, Museo Zoologico "La Specola" dell'Universita de Firenze, Florence, Italy
- **ZISP**, Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia
- **WAM**, Western Australian Museum, Perth, Australia
- **NTNU**, Norwegian University of Science and Technology, Trondheim, Norway

---

Publication date: 16 April 2007

Euscorpius — Occasional Publications in Scorpiology. 2007, No. 55

The population structure of *Mesobuthus gibbosus* (Scorpiones: Buthidae) on Koufonisi Island (central Aegean Archipelago, Greece)

Dimitris Kaltsas [1,2] and Moysis Mylonas [1,2]

[1] Department of Biology, University of Crete, Vassilika Vouton (P.O. Box 2208)
714 09 Irakleio, Crete, Greece
[2] Natural History Museum of Crete, University of Crete, Knossos Av. (P.O. Box 2208)
714 09 Irakleio, Crete, Greece

Summary

The population structure of *Mesobuthus gibbosus* was studied over 261 night-hours of sampling during 29 consecutive nights on Koufonisi Island (central Aegean Archipelago, Greece) using the capture-recapture method. The studied population proved to be the densest of all studied scorpion populations in chaparral or intertidal habitats of Mediterranean type ecosystems and even comparable to some populations of desert scorpion species. The negative influence of moon phase on the general activity of the species and synchronization in parturition were the main factors that caused the fluctuations in population density and therefore in the percentage of active scorpions.

Introduction

Scorpion research has advanced our general understanding of ecology (Polis, 2001) and has proved that scorpions represent a near-ideal organism for all types of ecological investigations (Polis, 1990), though ecology is the least-known aspect of scorpion biology (Polis, 1990) and especially the population structure is known only for few species (Polis, 1990; Kaltsas et al., 2006).

Mesobuthus gibbosus (Brullé, 1832) is the only species of Buthidae on the Balkan Peninsula. It is distributed throughout the southern part of the Balkan Peninsula (Albania, Bulgaria, FYROM, Greece, Montenegro), as well as in Turkey (Fet & Lowe, 2000). It is brownish-yellow with slim pedipalps. Adults may reach 8.5 cm in total length (Kinzelbach, 1975). It is nocturnal (Kinzelbach, 1975), aggressive and probably the most venomous of European scorpions (LD_{50}: 0.4 mg/ for mice and 2.4 mg for rats) (Lebez et al., 1980).

The aim of our study was to study the patterns and fluctuations of the population structure of *M. gibbosus* during the period of its maximal activity in a small island of the Aegean Archipelago.

Methods & Materials

The study was conducted in a coastal ecosystem on Koufonisi, the smallest inhabited island of Greece (5.7 km^2), southeast of Naxos (Fig. 1), at Pori bay (25^o 37' N, 36^{o}56' E) (Fig. 2). The area of study was 3900 m^2, at an elevation of 2–5 m. The substrate is limestone and the dominant plant species are *Thymus capitatus* (0.491 plants/m^2) and *Helichrysum barrelieri* (0.464 plants/m^2). Pilot samplings showed that *Mesobuthus gibbosus* is the only scorpion species in the area and probably on the whole island.

The samplings were conducted during the nights from 22 July to 19 August 2003, nine hours per night, from 21:00 to 05:00, using ultraviolet light, in order to observe active scorpions anywhere within the study site. The capture-recapture method was used. Mature individuals were marked with enamel paint on a specific segment of the mesosoma or/and the metasoma. Juveniles were not marked because of their small size and their high molting rate. After applying Equal Catchability Test (Leslie et al., 1953), we used the Jolly-Seber (Jolly, 1965) method to estimate population parameters using Ecological Methodology (Version 6.1). We chose the Jolly-Seber method because the population was open and thus constantly changing because of births, deaths, immigration and emigration (Krebs, 1989).

Results

During the whole study 442 scorpions were observed, 111 juveniles and 331 mature individuals (Table 1), 141 of which were marked. We considered two consecutive nights as one sampling, so as to

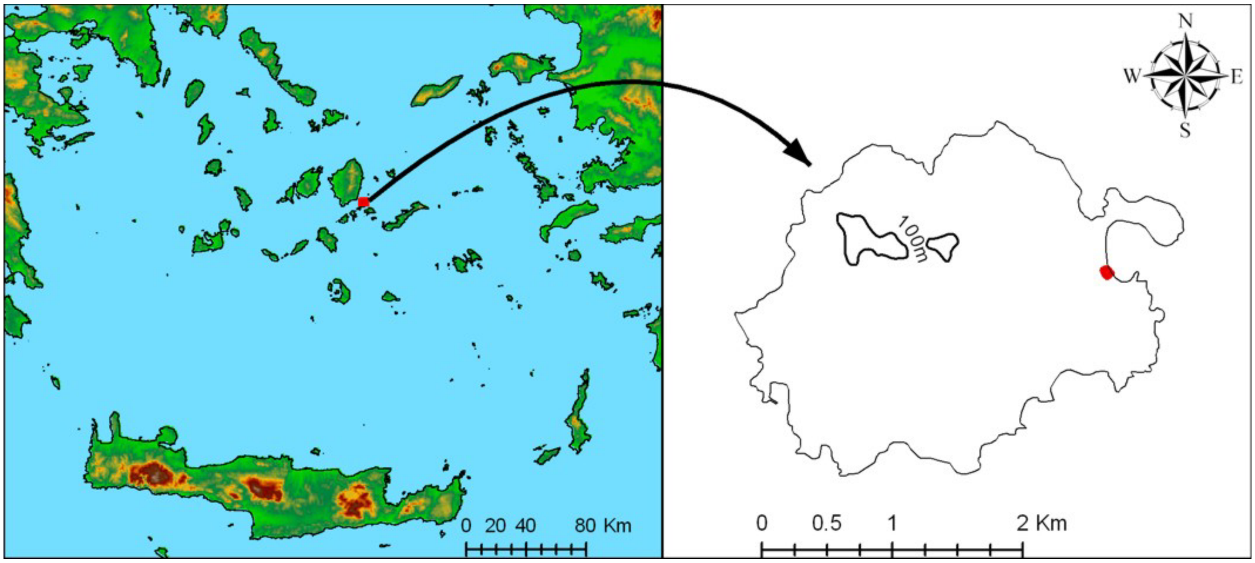


Figure 1: The geographic position of Koufonisi (red dot) in Greece and the location of the study site at Pori bay (in red).

maintain uniformity and extenuate fortuity as much as possible. Our study lasted for 29 nights, so for practical reasons we included the first three nights in the first of the 14 samplings.

Equal Catchability Test resulted in an overestimation of 0.89%, which showed that catchability was equal between samplings, so we applied the Jolly-Seber method in order to estimate population parameters (Figs 3, 4, 5). We also estimated the Relative Surface Density (R.S.D.) (Fig. 6), which is the percentage of the population appearing on the surface (Polis, 1980).

Discussion

The study was conducted during the reproductive period of the species. Thus, 76.74% of the observations of mature scorpions were males (Table 1), foraging or searching for females in order to mate. From the beginning of the study until August 9th, females were rarely seen and captures of females represented 13.52±9.99% of the total observations of mature scorpions. From then on until the end of the study (August 19th), females were much more active (38.35±10.3%).

There are three distinguishable levels in population density (Fig. 3): (a) intermediate, with average 0.051±0.009 scorpions/m^2; samplings 2 (25–26.07), 7–8 (4–7.08), and 13 (16–17.08); (b) low, with average 0.016±0.004 scorpions/m^2; samplings 9–12 (8–15.08); and c) high, with average 0.098±0.011 scorpions/m^2; samplings 3–6 (27.07–3.08). Such fluctuations in population density during only one month are astonishing and not at all coincidental. The moon phase influenced negatively the general activity of *M. gibbosus* on Koufonisi (Kaltsas et al., unpubl. data) and this had a great impact on population density. The visible part of the moon during nights with intermediate density was 50.5±27.51% in average, during nights with very high density, the moon was barely visible (8.88±10.27%) and during nights with low density the visible part of the moon was 93.63±6.16% and most scorpions were found hidden at the edges or inside bushes.

The estimated values of density of the studied population of *M. gibbosus* are much higher than those of all previously studied scorpion species in chaparral or intertidal habitats of Mediterranean type ecosystems, such as *Compsobuthus werneri* (Birula, 1908) in Israel (Zinner & Amitai, 1969), *Serradigitus gertschi* (Williams, 1968) in California (Toren, 1973) and five sympatric species in northern Israel (Warburg et al., 1980). Although the estimated population density included only the mature individuals, its high levels are comparable with, or even exceed, densities of some desert scorpion species such as *Urodacus yaschenkoi* (Birula, 1903) in Australia (Shorthouse, 1971), *Scorpio maurus palmatus* (Ehrenberg, 1828) in Israel (Shachak, 1980), and North American *Paruroctonus utahensis* (Williams, 1968) (Bradley, 1986), and *Vaejovis confusus* Stahnke, 1940 (Polis, unpubl. data). Based on 24 scorpion species belonging to four families, Polis (1990) stated that scorpion populations are remarkably dense in certain habitats, such as deserts and tropical forests. Nevertheless, there are many parameters, besides habitat, which affect population density, such as inter- and intraspecific competition, influence of abiotic factors, prey availability and the presence (or absence) of sympatric scorpion species. The general activity patterns of *M. gibbosus*, which was the only scorpion species in the area of study, showed that intraspecific competition was low, due to the fact that the species had

Figure 2: Northern (top) and western (bottom) view of the study site at Pori bay.

Sampling	Total	Male	Female	Immature	Recaptures (2^{nd})	Deaths
1 (22–24.07)	46	27	1	18	0	0
2 (25–26.07)	31	21	1	9	7	0
3 (27–28.07)	42	24	3	15	4 (1)	0
4 (29–30.07)	31	22	4	5	6 (3)	0
5 (31.07–1.08)	29	22	2	5	9 (3)	0
6 (2–3.08)	38	22	3	13	7 (4)	1
7 (4–5.08)	41	21	8	12	11 (4)	1
8 (6–7.08)	30	17	8	5	11 (5)	0
9 (8–9.08)	19	13	1	5	6 (5)	0
10 (10–11.08)	13	8	3	2	5 (5)	0
11 (12–13.08)	18	11	5	2	8 (5)	0
12 (14–15.08)	30	15	8	7	10 (6)	0
13 (16–17.08)	34	15	13	6	12 (8)	1
14 (18–19.08)	40	16	17	7	16 (10)	1
Total	442	254	77	111	113 (59)	4

Table 1: The number of captures, recaptures and deaths per sampling during the study. Second recaptures (in a parenthesis) refer to individuals recaptured once or more.

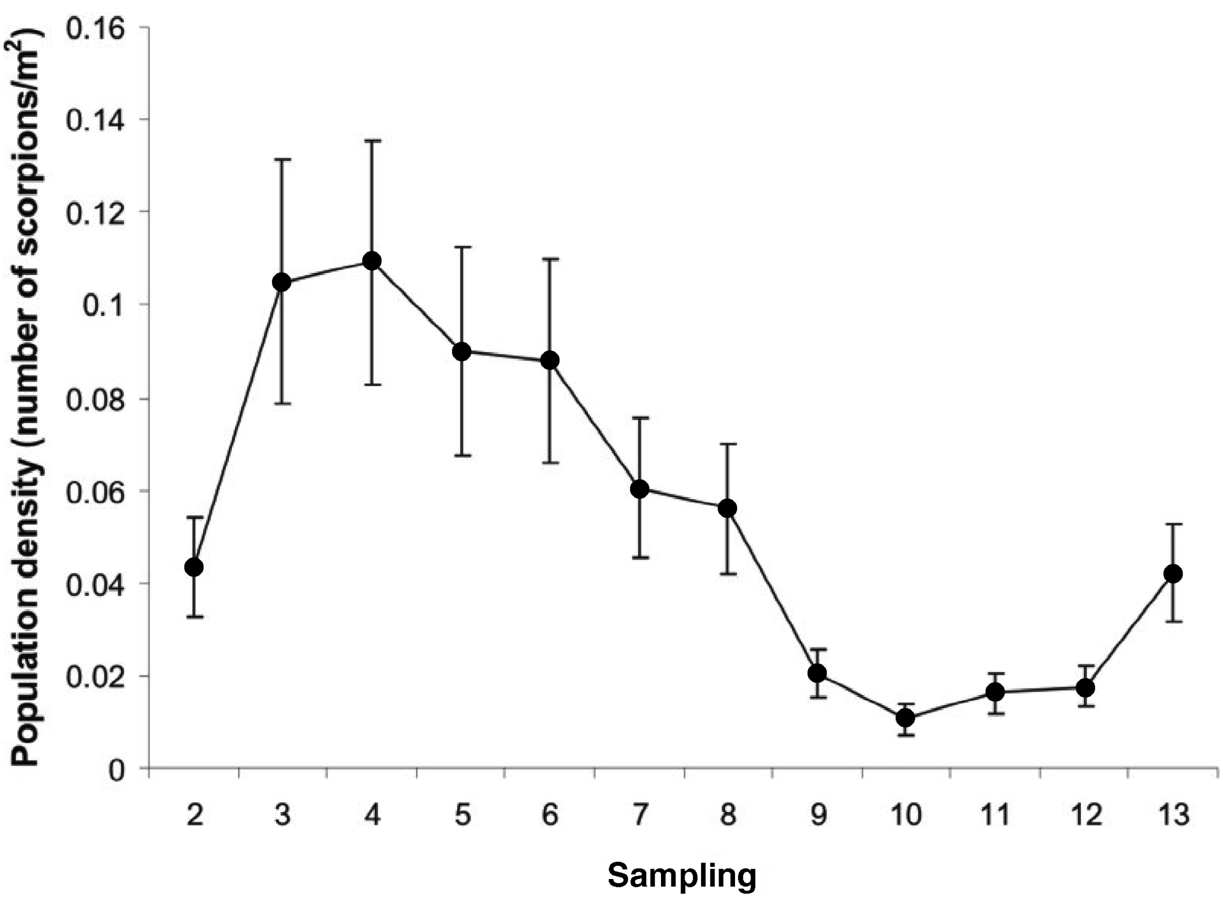


Figure 3: The population per sampling.

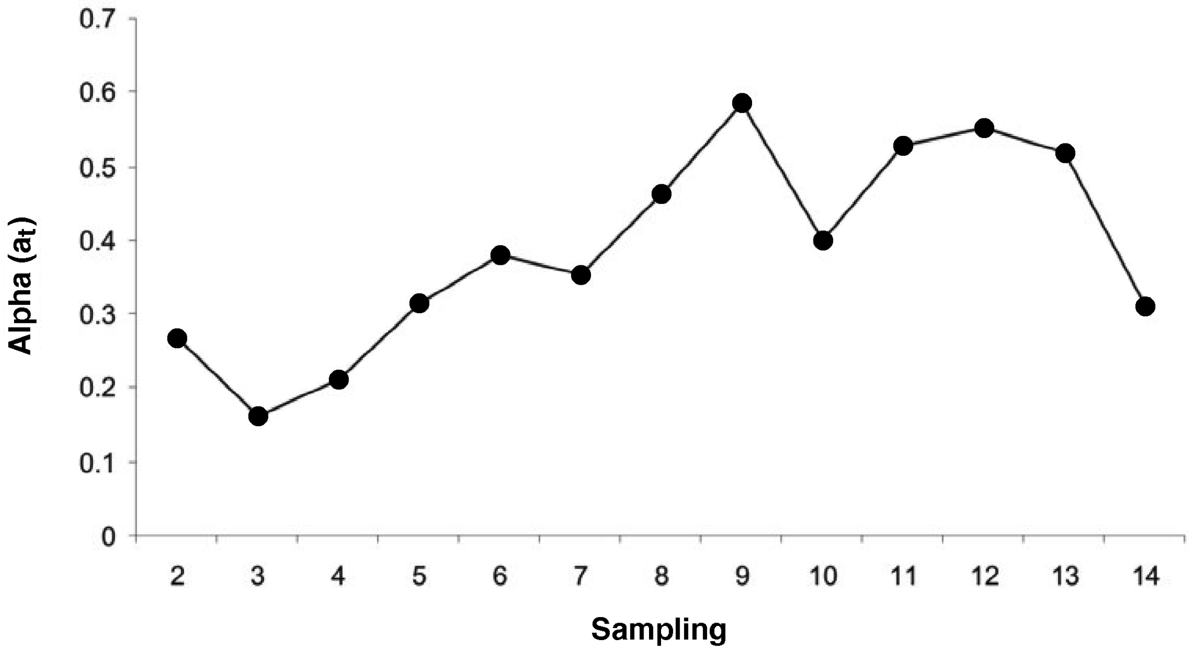


Figure 4: The proportion of marked scorpions per sampling.

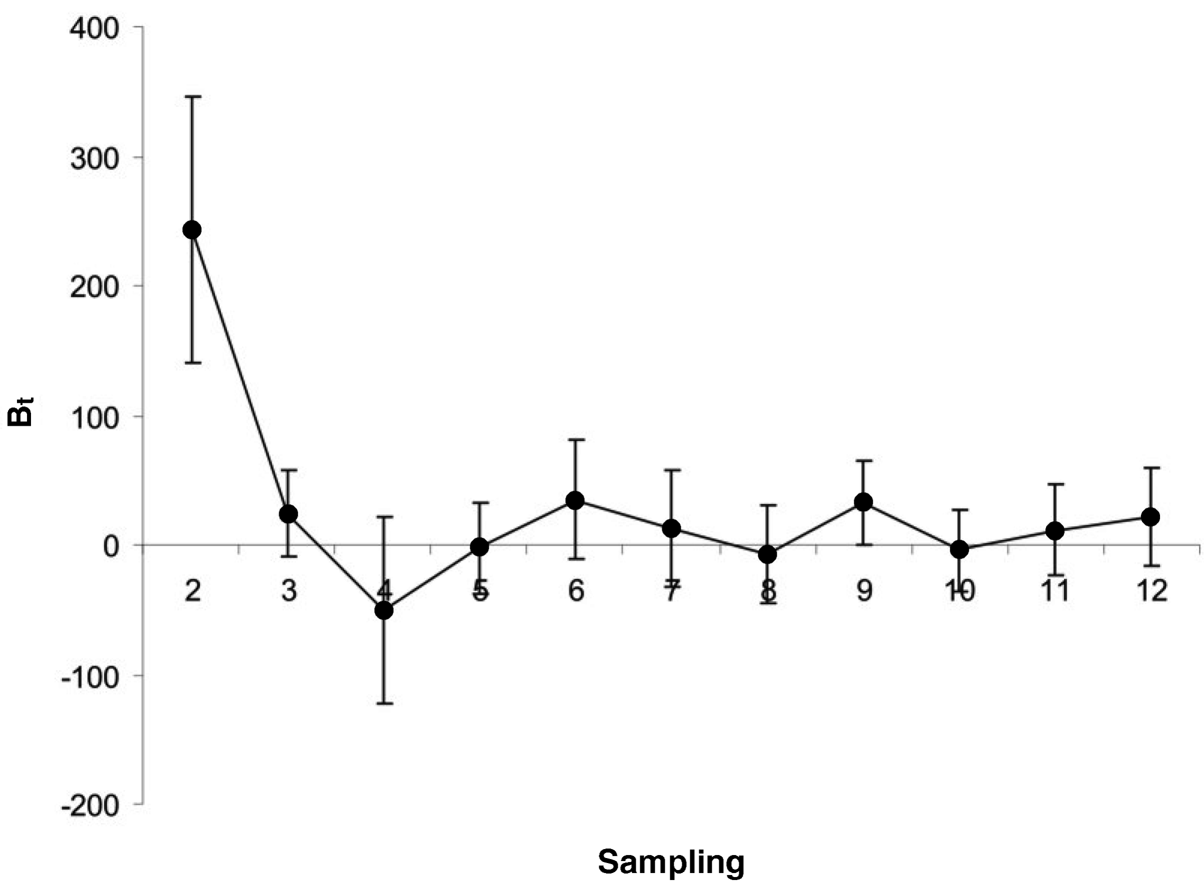


Figure 5: The number of animals joining/leaving the population from one sampling to the next.

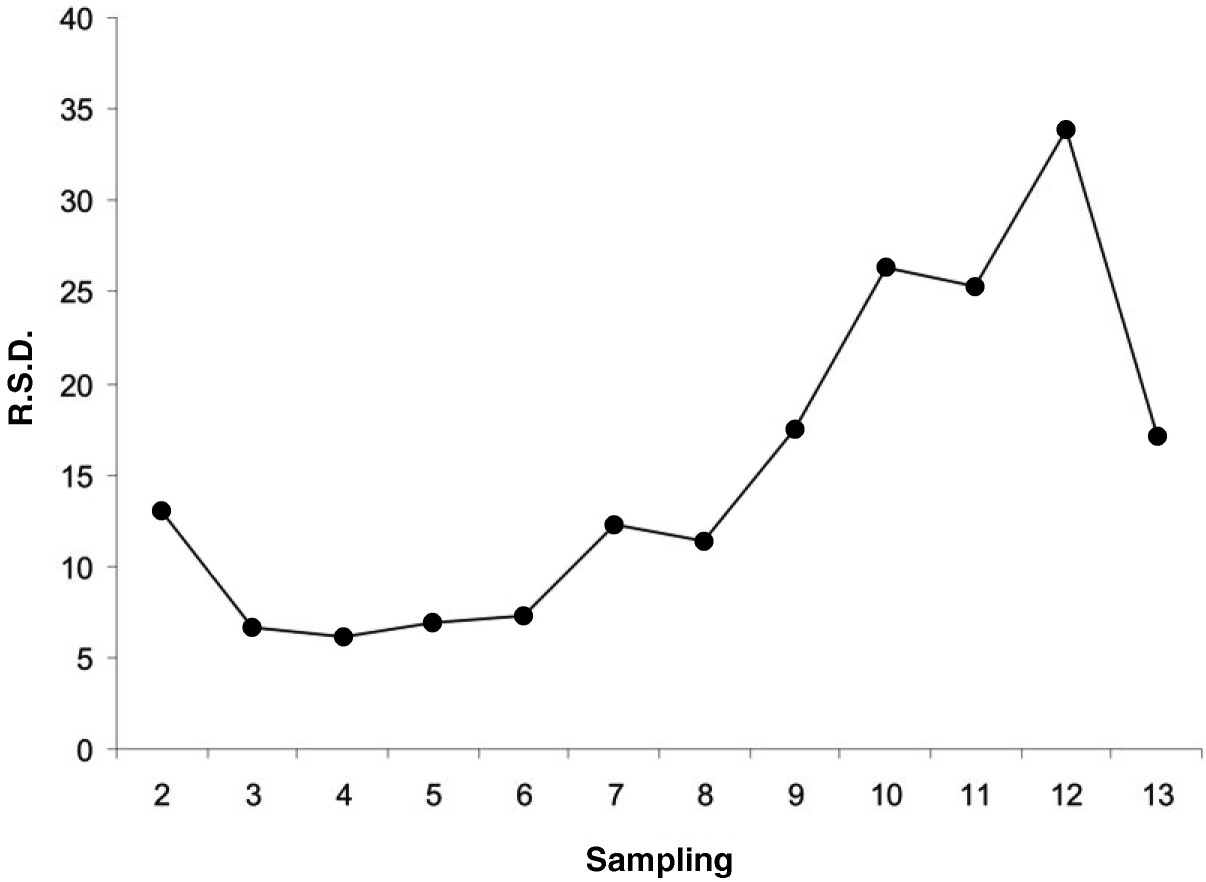


Figure 6: The Relative Surface Density per sampling.

prevailed among the animals which comprised the terrestrial invertebrate nocturnal macrofauna in the area. The diet of the species during the one month of study included species belonging to eight arthropod orders, which showed that prey availability was high.

The proportion of marked scorpions per sampling (Fig. 4) was lowest during the nights with the highest density (27–30.07), increased and reached a peak level (0.5–0.6) during the nights with low density (12–17.08). As the samplings proceeded, more scorpions were marked and towards the end of the study during nights with few captures, a_t was expected to be high. This explanation is enhanced by the fact that there was a balance of immigrations and emigrations of mature individuals after the second sampling (Fig. 5), which means that a_t was not influenced by new incomers. The comparatively high value of B_t during the second sampling was due to the abrupt increase of activity, the impact of which became obvious the surface density of the population in the samplings during 27.07–1.08.

The percentage of the population that appeared on the surface was generally low (never higher than 34%), and its highest values were estimated during the samplings under intense moonlight, when the population density was low (10–15.08) and thus most of the active scorpions were captured. All scorpion species that have been studied exhibited low levels of activity throughout the whole year (Bacon, 1972; Toren, 1973; Tourtlotte, 1974; Polis, 1980; Bradley, 1982, 1983; Kaltsas et al., 2006) as a result of low metabolic rate, efficient foraging and/or avoidance of predation and cannibalism (Warburg & Polis, 1990). In our case, the low relative surface density of *M. gibbosus*, which is generally a non-cannibalistic species (Kaltsas et al., unpubl. data), was probably due to efficient foraging and synchronization in parturition. The sex ratio during the first nine samplings was 6.1♂:1♀, whereas during the samplings 10–14 it was 1.41♂:1♀. During samplings 1–9, 48.38% of females beared a black dot at the edges of their genital operculum, which was part of a male's spermatophore (spermatocleutrum, or mating plug; Polis & Sissom, 1990) (only 8.7% during samplings 10–14), 22.58% were pregnant at the last stages (none during samplings 10–14), and three individuals were observed carrying their offspring on their backs (number of offspring: 25, 28, 35) (none during samplings 10–14). The results lead us to the assumption that the abrupt increase in the activity of females after August 10th was a sign that synchronized parturition and maternal protection had ended. Generally, female scorpions reduce their activity before and after giving birth (Williams, 1969; Fet, 1980; Polis, 1990; Polis & Sissom, 1990; Benton, 1991, 1992; Lourenço, 2000; Benton, 2001), due to instinctive maternal protection (Vannini et al., 1978; Ugolini et al., 1986; Mahsberg, 2001). Synchronization of births is common in many scorpion species, such as *Hadrurus arizonensis* Ewing, 1928, *Vaejovis vorhiesi* Stahnke, 1940 (Williams, 1969), *Euscorpius flavicaudis* (DeGeer, 1778) (Benton, 1992), *Smeringurus mesaensis* (Stahnke, 1957) (Polis & Farley, 1979) but not in tropical species (Polis & Sissom, 1990). Although it is still unclear, the phenomenon is probably a result of synchronized mating season (Francke, 1979) or a pulse in prey availability, which accelerates embryonic growth and thus synchronizes development (Polis & Farley, 1979).

The population density of *M. gibbosus* in Koufonisi is higher than what would be expected for a non-desert/tropical scorpion species. Thus, although the study on the population structure in Crete and continental Greece (Kaltsas et al., 2006) did not include the period of maximal activity of the species, our results confirm the expectations of Kaltsas et al. (2006) on the population structure of insular populations on small islands, where interspecific competition is lower than in larger islands or areas in the mainland.

Acknowledgments

We are grateful to Dr. Stelios Simaiakis, who did samplings for his PhD on Koufonisi and gave us the idea to go there and study *M. gibbosus*, and to Manolis Nikolakakis for map editing and artistic photography. We thank two anonymous reviewers for their comments on this manuscript.

References

BACON, A. D. 1972. *Ecological Studies on a Population of* Uroctonus mordax *Thorell*. Master's Thesis, California State University, San Francisco, CA. 54 pp.

BENTON, T. G. 1991. Reproduction and parental care in the scorpion *Euscorpius flavicaudis. Behaviour*, 117(1–2): 20–28.

BENTON, T. G. 1992. The ecology of the scorpion *Euscorpius flavicaudis* in England. *Journal of Zoology*, 226: 351–368.

BENTON, T. G. 2001. Reproductive ecology. Pp. 278–301 *in* Brownell, P.H. & G.A. Polis (eds.). *Scorpion Biology and Research.* Oxford University Press, Oxford, UK.

BRADLEY, R. A. 1982. Digestion time and re-emergence in the desert grassland scorpion *Paruroctonus utahensis* (Williams) (Scorpionida, Vaejovidae). *Oecologia*, 55: 316–318.

BRADLEY, R. A. 1983. *Activity and Population Dynamics of the Desert Grassland Scorpion (*Paruroctonus utahensis*): Does Adaptation Imply Optimization?* Ph.D. dissertation, University of New Mexico, Albuquerque, NM. 282 pp.

BRADLEY, R. A. 1986. The relationship between population density of *Paruroctonus utahensis* (Scorpionida: Vaejovidae) and characteristics of its habitat. *Journal of Arid Environments*, 11: 165–171.

FET, V. 1980. Ecology of the scorpions (Arachnida, Scorpiones) of the southeastern Kara-Kum. *Entomologicheskoe obozrenie*, 59(1): 223–228.

FET V. & G. LOWE. 2000. Family Buthidae. Pp. 54–286 *in* Fet V., W.D. Sissom, G. Lowe & M.E. Braunwalder. *Catalog of the Scorpions of the World* (1758–1998). New York Entomological Society, New York, NY. 690 pp.

FRANCKE, O. F. 1979. Observations on the reproductive biology and life history of *Megacormus gertschi* Diaz (Scorpiones: Chactidae: Megacorminae). *Journal of Arachnology*, 7: 223–230.

JOLLY, G. M. 1965. Explicit estimates from capture-recapture data with both death and immigration-stochastic model. *Biometrika*, 52(1/2): 225–247.

KALTSAS, D., I. STATHI & M. MYLONAS. 2006. The effect of insularity on the seasonal population structure of *Mesobuthus gibbosus* (Scorpiones: Buthidae). *Euscorpius*, 44: 1–8.

KINZELBACH, R. 1975. Die Skorpione der Ägäis. Beiträge zur Systematik, Phylogenie und Biogeographie. *Zoologische Jahrbücher Abteilung für Systematik*, 102:12–50.

KREBS, C. J. 1989. *Ecological Methodology*. Harper & Row Publishers, New York, NY.

LEBEZ, D., Z. MARETIC, J. LADAVAC & M. MEDEN. 1980. *Mesobuthus gibbosus*–A potentially dangerous European scorpion. *8 Internationaler Arachnologen Kongress, Wien*: 187–190.

LESLIE, P. H., D. CHITTY & H. CHITTY. 1953. The estimation of population parameters from data obtained by means of the capture-recapture method:

III. An example of the practical applications of the method. *Biometrika*, 40(1/2): 137–169.

LOURENÇO, W. R. 2000. Aspects of the ecology of some savannicolous Brazilian scorpions. *Biogeographica*, 76(4): 185–192.

MAHSBERG, D. 2001. Brood care and social behaviour. Pp. 257–277 *in* Brownell, P.H. & G.A. Polis (eds). *Scorpion Biology and Research.* Oxford University Press, Oxford, UK.

POLIS, G. A. 1980a. Seasonal patterns and age-specific variation in the surface activity of a population of desert scorpions in relation to environmental factors. *Journal of Animal Ecology*, 49: 1–18.

POLIS, G. A. 1990. Ecology. Pp. 247–293 *in* Polis, G.A. (ed.). *The Biology of Scorpions.* Stanford University Press, Stanford, CA.

POLIS, G. A. & R. D. FARLEY. 1979. Characteristics and environmental determinants of natality, growth and maturity in a natural population of the desert scorpion, *Paruroctonus mesaensis* (Scorpionida: Vaejovidae). *Journal of Zoology*, 187: 517–542.

POLIS, G. A. & W. D. SISSOM. 1990. Life history. Pp. 161–223 *in* Polis, G. A. (ed.). *The Biology of Scorpions.* Stanford University Press, Stanford, CA.

SHACHAK, M. 1980. Energy allocation and life history strategy of the desert isopod *H. reaumuri*. *Oecologia*, 45: 404–413.

SHORTHOUSE, D. J. 1971. *Studies on the Biology and Energetics of the Scorpion,* Urodacus yaschenkoi *(Birula, 1904).* Ph.D. dissertation, Australian National University, Canberra, Australia. 163 pp.

TOREN, T. J. 1973. *Biology of the California Coast Range Scorpion* Vaejovis gertschi striatus *Hjelle*. Master's thesis, California State University, San Francisco. 74 pp.

TOURTLOTTE, G. I. 1974. Studies on the biology and ecology of the Northern scorpion, *Paruroctonus boreus* (Girard). *The Great Basin Naturalist*, 34(3): 167–179.

UGOLINI, A., I. CARMIGNANI & M. VANNINI. 1986. Mother-young relationship in *Euscorpius*: adaptive value of the larval permanence on the mother's back (Scorpiones, Chactidae). *Journal of Arachnology*, 14: 43–46.

VANNINI, M., A. UGOLINI & C. MARUCELLI. 1978. Notes on the mother-young relationship in some *Euscorpius* (Scorpiones: Chactidae). *Monitore Zoologico Italiano (N.S.)*, 12: 143–154.

WARBURG, M. R., S. GOLDENBERG, & A. BEN-HORIN. 1980. Scorpion species diversity and distribution within the Mediterranean and arid regions of northern Israel. *Journal of Arid Environments*, 3: 205–213.

WARBURG, M. R. & G. A. POLIS. 1990. Behavioral responses, rhythms, and activity patterns. Pp. 224–226 *in* Polis, G.A. (ed.). *The Biology of Scorpions.* Stanford: Stanford University Press.

WILLIAMS, S. C. 1969. Birth activities of some North American scorpions. *Proceedings of the California Academy of Sciences*, 37(1): 1–24.

ZINNER, H. & P. AMITAI. 1969. Observations on hibernation of *Compsobuthus acutecarninatus* E. Sim. and *C. schmiedeknichti* Vachon (Scorpionidea, Arachnida) in Israel. *Israel Journal of Zoology*, 18: 41–47.