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The space utilization by the reptiles in Prespa National Park

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Abstract

In the first part of this paper data are presented on the habitat segregation of the reptile species of Lake Prespa National Park. Twenty species of reptiles are present in the study area. Most of them are of East-Mediterranean origin, some are Balkan endemics and a few are of northern origin. Systematic surveys and counts of reptiles were conducted in each of the following habitats: marshes and reedbeds, wet meadows, rocky coastal areas and sandy beaches, cultivated land, grazing lands, mixed deciduous, oak and beech forests, sub-alpine and alpine meadows. A list is provided of the typical reptile species occurring in each of these habitats, with notes on abundance and habits. The highest reptilian diversity was found in man-made/modified habitats, namely the farmland zone, which structurally is the more diversified. There was a dramatic fall of species richness with increasing altitude. The second part of the paper describes qualitative differences in habitat utilization among the members of the two major reptilian groups, lizards and snakes. The Sand Lizard *Lacerta agilis* is found exclusively in the alpine and subalpine grasslands above 1600 m. asl., the Common Wall Lizard *Podarcis muralis* is the more euryecous while all other Lacertids show a clear specialization in habitat use though retaining various degrees of overlap. Among snakes the Adder *Vipera berus* is restricted to high mountain grasslands, the two *Natrix* species are common and more or less confined to areas close to the lakes while the Nose-horned Viper *Vipera anmmodytes* the third commonest species of the area prefers rocky/stony slopes.The notes on habitat utilization by the remaining species of snakes are only of indicative value because of small number of observations.

Introduction

Although Prespa National Park is one of the best studied areas of wildlife interest in Greece, few publications refer to its herpetofauna. Scarce information on the reptiles of this area can be found in Karaman (1928), Kuhnelt (1981), Chondropoulos (1989) and Clark (1992). Catsadorakis (1986) presented an almost complete list of species with some notes on their habitat preferences. A checklist for all the mountainous area of Florina and Prespa has been prepared (Bousbouras & Ioannidis, 1994). A typical division of resources among species is along three main dimensions: Habitat, time and food type (Pianka, 1969). This study is mainly concentrated on habitat segregation, but we also give data on the abundances, distribution and activity patterns of the reptile species present in the area.

Methods

This study covers the area of the National Park and the surrounding mountains. The vegetation of the area is extensively described by Pavlides (1985).

Field work was carried out in April–May 1986 and 1987, July 1986 and August 1987. Additional data were collected from June to August 1988 and in June 1990.

During the summer months, we mainly conducted a general herpetological search and for each individual a number of variables were recorded: time of day, weather conditions, altitude, habitat type, microhabitat type and behavioural observations. Whenever possible, sex was also recorded and external body measurements were taken. Due to reasons of consistency the data, on which most of the analysis is based, was not combined

Table 1. List of species observed in the area and number of observations recorded.

Species	English name	n
Testudo hermanni boetgerii	Hermann's Tortoise	54
Emys orbicularis	European Pond Terrapin	33
Algyroides nigropunctatus	Dalmatian Algyroides	45
Lacerta viridis viridis	Green Lizard	192
Lacerta trilineata trilineata	Balkan Green lizard	2
Lacerta agilis bosnica	Sand Lizard	6
Podarcis erhardii liveti	Erhard's Wall Lizard	140
Podarcis muralis albanica	Common Wall Lizard	213
Podarcis taurica taurica	Balkan Wall Lizard	183
Ablepharus kitaibelii kitaibelii	Snake-eyed Skink	42
Anguis fragilis colchicus	Slow Worm	16
Malpolon monspessulanus insignitus	Montpellier Snake	3
Coluber caspius	Large Whip Snake	15
Elaphe quatuorlineata quatuorlineata	Four-lined Snake	5
Elaphe longissima longissima	Aesculapian Snake	7
Natrix natrix persa	Grass Snake	74
Natrix tessellata tessellata	Dice Snake	63
Coronella austriaca austriaca	Smooth Snake	7
Vipera ammodytes meridionalis	Nose-horned Viper	30
Vipera berus bosniensis	Adder	1

with the results of more specialized methods, such as density measurement or species-specific observations. Abundance was estimated from transects through a habitat, along predetermined paths of known distance, recording the numbers of individuals observed (Pianka, 1970). The results are expressed as numbers of individuals observed ha^{-1}.

We use the following indices:

Margalef's species richness index: $D_{\mathrm{m}} = S - 1/\log N$ (Margalef, 1951)

Shannon-Wiener's diversity index (Pielou, 1966)

$$D_{\mathrm{s}} = -\sum_{i=1}^{S} \mathrm{pi}\ (\log_e \mathrm{pi}),$$

where pi = proportional abundance of the ith species, S = number of species, N = total number of individuals.

Niche Breadth was calculated using the reciprocal of Simpson's (1949) measure (Pianka, 1986):

$$B = 1/\sum_{i=1}^{S} \mathrm{pi}^2,$$

where pi = the proportion of the ith category, S = total number of categories.

The reptile community

A total of 20 species of reptiles was found to occur in our study area (Table 1), including 2 Chelonia, 9 Sauria and 9 Ophidia. The absence of the thermophilous members of the Gekkonidae family and the presence of two species with a far more northerly distribution centre *(Lacerta agilis, Vipera berus)*, clearly separates this area from the mediterranean lowlands.

The majority of the species present in the area are of East Mediterranean origin. There are also some Balkan endemics (*Algyroides nigropunctatus, Podarcis erhardii*). A few species have reached this area from the north. Such species with a Pontic origin are *Lacerta agilis* and *Coronella austriaca*. It is also worth mentioning the presence in the area of intergrades between *Emys orbicularis hellenica* and *E. o. orbicularis*, the Greek and the Pontic subspecies of the European Pond Terrapin (Fritz, 1992). No endemic forms are present in the area, which was to be expected as no real geographical barriers for reptiles are present and the majority of the species have a continuous distribution encompassing the National Park area.

We have not included *Elaphe situla* in this list of species, although a road casualty specimen (from Prespa) was given to us. As no other animal has been

Table 2. Distribution of the species in the four major habitat groups.

	Testudo hermanni	*Emys orbicularis*	*Algyroides nigropunctatus*	*Lacerta viridis*	*Lacerta trilineata*	*Lacerta agilis*	*Podarcis erhardii*	*Podarcis muralis*	*Podarcis taurica*	*Ablepharus kitaibelii*	*Anguis fragilis*	*Malpolon monspessulanus*	*Coluber caspius*	*Elaphe quatuorlineata*	*Elaphe longissima*	*Natrix natrix*	*Natrix tessellata*	*Coronella austriaca*	*Vipera ammodytes*	*Vipera berus*	Margalef's species richness index	Shannon-Wiener's diversity index
Lake zone	+	+					+	+	+						+	+	+	+	+		4.3	1.6
Man-influenced zone	+	+		+	+		+	+	+	+	+	+	+	+	+	+	+	+	+		5.5	2.0
Forest	+		+	+			+	+		+	+	+		+	+			+	+		4.1	1.8
Subalpine meadows						+		+												+	2.1	0.8

observed by us, we decided to exclude it as not fully documented. The presence of *Coluber najadum* is also possible, as we have observed this species less than 30 km. E.SE. from the lakes, in an area with similar climatic conditions. Finally G. Catsadorakis has informed us that he has repeatedly found road-killed individuals of *Coluber gemonensis* from the National Park area.

Habitats and species composition

The lake area

The two *Natrix* spp. and *E. orbicularis* are quite common in the lakes. Apart from these three, a few other species were observed on the coastal area. The coastal area is not homogeneous and can, in general terms, be divided as follows:

– marshes and reed beds, where only the three above mentioned species are present;

– wet-meadows. *Podarcis muralis, Vipera ammodytes* and *Elaphe longissima* were observed in these areas, whenever the water had withdrawn. Despite this it seems that no reptiles, except the three closely associated with water, permanently use these areas;

– rocky coastal areas. These areas are largely used by the two *Natrix* species as basking places, in contrast to *Emys orbicularis* which usually prefers less exposed and safer locations. *Podarcis muralis* and especially *P. erhardii* are also often encountered in these places. Occasionally we have recorded the temporary presence of a few other snakes (*V. ammodytes, C. austriaca)* near the water;

– Coastal areas with low gradients, usually with sandy soil. The main difference of this area is the presence of *Podarcis taurica.*

The zone influenced by humans

Apart from the human settlements this area can be divided into two categories:

– the cultivated zone, with irrigation canals, drainage ditches and hedges. *Lacerta viridis* and *Testudo hermanni* are common along the hedges and canal borders as long as there are adequate hiding places. *Podarcis muralis* and *P. taurica* are also encountered in this area. The cultivated zone is also used as feeding grounds for a number of snake species such as *Malpolon monspessulanus, Elaphe quatuorlineata, Coluber caspius* and *Vipera ammodytes.* The drainage ditches are used by *N. natrix* and *E. orbicularis* which are found in high densities but only if the edges are well vegetated and can provide a good refuge;

– grazing pastures, these are situated either in the lowlands or in the mountains, sometimes up to the alpine meadows. There is a variety of pasture types and many species are present here. In the low altitude vegetation areas, on flat ground *P. taurica* and *A. kitaibelli* are very common as are *L. viridis* and *T. hermanni* if shrubs are present. *P. erhardii, P. muralis,*

V. ammodytes and *C. austriaca* are often present on the rocky overgrazed slopes. *N. natrix* is sometimes found in the rivers that run throught this area. Some other species are found mainly on the borders of this zone.

The forests

These can be separated into three main categories:

– mixed forests, often situated on rocky ground. *P. muralis, P. erhardii* and *L. viridis* are very common in the open parts of these forests but also of great importance is the presence of *A. nigropunctatus,* which is almost exclusively found in these areas. A number of snake species is also present, with *V. ammodytes* being the most commonly encountered, at some distance from the lakes;

– oak forests. The main differences from the previous category in the lizard fauna is the absence of *A. nigropunctatus* and the frequent presence of *A. fragilis* and *A. kitaibelii. P. muralis* is more common along the roads. *T. hermanni* is locally abundant here as well as in the mixed forests. Among the snakes, *C. austriaca* and mainly *E. longissima* are present;

– beech forests. These are situated at higher altitudes. Few species are present generally at low densities. *P. muralis, A. fragilis, A. kitaibelii* and occasionally *L. viridis* are the main reptile species of this area.

Subalpine-alpine meadows

This area is used for livestock grazing during summer and it is characterized by *L. agilis. V. berus* has also been found in the vicinity of surface water (Ioannidis & Bousbouras, 1989). *P. muralis* is also encountered in a few localities.

In Table 2, two species diversity indices for the four main 'groups' of habitat are given. Margalef's index is used as a simple expression of species richness but it does not take into account the relative abundance of each species and is affected by the sample size. Shannon-Wiener's index is used to show the diversity of species within a habitat-group. The effects of sample size are low and apart from the number of species, it is also influenced by the evenness with which individuals are distributed among the species (Spellerberg, 1991). Both indices have lowest values for the alpine meadows. This habitat type is the least diverse of all four and as it is situated at high altitudes, unfavourable for the reptiles, the low values are expected. These values can therefore be used as a comparative measure showing a habitat type to be more or less unsuitable for reptiles. For the other three habitat type groups, the results can be misleading. The highest values are for the man-influenced zone. Although this may seem strange, it is quite expected, as this is the most diverse habitat group. A clearer picture can be given if we calculate the two indices for each habitat-type within each group (Table 3), as these have been presented earlier.

Table 3. Marlagef's and Shannon-Wiener's indices for the more important habitats.

	Marlgalef's richness index	Shannon-Wiener's diversity index
Marshes	1.2	1.1
Beaches	3.6	1.5
Wet meadows	3.8	1.3
Grazing pastures	5.1	1.9
Cultivation	5.3	2.0
Mixed Forest	4.1	1.7
Oak Forest	4.0	1.5
Beech Forest	2.3	1.3
Subalpine meadows	2.1	0.8

Some explanations in Table 3 are necessary. Margalef's index for marshes is lower than for the alpine meadows, although the number of species is the same. This is due to the smaller sample size from the latter habitat. At the same time Shannon-Wiener's index is higher for the former habitat showing a higher evenness. Both indices still attain their highest values in the two man influenced habitat types. Apart from conditions being suitable for the reptiles in these areas, we can still attribute this to the variability of microhabitats present in these two habitat types. So, if we exclude the individuals present in or at the vicinity of drainage ditches, the values for cultivated areas ($D_m = 3.4$, $D_s = 1.4$) are lower than those from the various forest types. Similarly the values we get for the overgrazed rocky slopes ($D_m = 2.5$, $D_s = 1.0$) are much closer to the 'unsuitable' alpine meadows.

The general conclusion is that the variability of habitats is a major reason for the diverse herpetofauna being present in this mountainous region.

Altitudinal influences

The altitudinal range of each species in the Prespa area is presented in Figure 1. Eight species are restricted

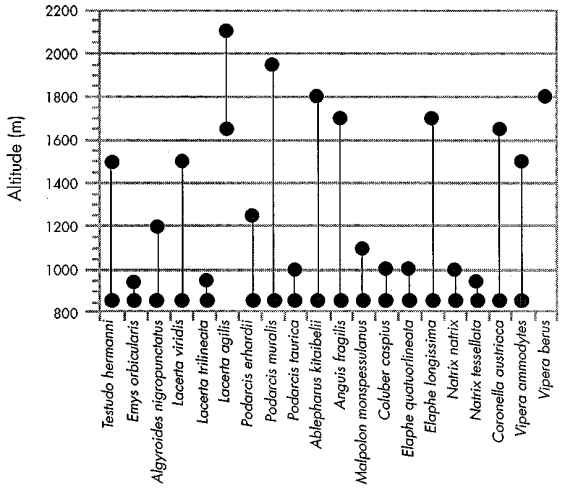

Figure 1. Altitudinal distribution of the reptile species in the study area.

to the lower parts of the area, that is around the lakes, while two others are restricted to the higher mountains. There is a significant decrease in the number of species with increasing altitude (Bousbouras & Ioannidis, 1994). This can be attributed to the decrease of spatial heterogeneity (fewer habitats at higher altitudes) and to the limitations imposed by climatic factors. The active period at higher altitudes is generally retarded because of the snow cover and the lower temperatures. Strijbosch et al. (1989) have demonstrated this for *A. kitaibelli* from the Evros province. In our area the peak activity for this species, at an altitude of around 900 m, was between mid April to mid May and some individuals where active even in summer, mainly in early morning or late evening. This is in agreement with the data from the higher mountains (>500 m) of Evros province (north-eastern Greece).

Habitat utilization

A major ecological differentiation between the lizard and the snake community is their food preferences (invertebrates vs vertebrates). In addition, the amount of data is much less for snakes than for lizards, we will therefore discuss the two communities separately.

Lizard community

One way of examining spatial partitioning among species is to look at the habitats and their relative use by the various species. We can even try to calculate the niche breadth of each species, but as the amount of field effort was not equal for all habitats this can only be used as an indication. There are some limits in using of spatial niche breadth from general data like ours, because of the difficulties of setting exact limits on the various habitats and also because of the difficulty in differentiating between the extent of the habitat and of the microhabitat components which may be present in various habitats, and have the same value for the occurrence of a species. For this more precise data are necessary.

For two members of the Lacertidae in our area the niche breadth is very small (close to 1), which means that mainly only one habitat type was used. *Lacerta agilis*, by using the subalpine and alpine meadows, has avoided interspecific competition, at least from other lizards. *Algyroides nigropunctatus* on the other hand shares the mixed forests with two other small lacertids, *P. muralis* and *P. erhardii*. *A. nigropunctatus* seems to be restricted to the shaded, rocky parts of the wood (73% of the observations) while the two other species are more abundant in the open parts (67%). If we try to correlate the species with the various components within each habitat (microhabitat preferences) we can have a much clearer picture of niche separation.

Podarcis taurica is restricted to sunny areas with low vegetation (90% of the observations), away from trees and shrubs (79% over 2 m away), seeking cover in the herb layer (Chondropoulos & Lykakis, 1983). It is more abundant in sandy areas (with a herb layer) in the northern part of the small lake, reaching densities of 80 ind. ha^{-1}. *Lacerta viridis*, the young of which are almost equal in size to *P. taurica*, also favours areas with low vegetation but this species is strongly connected to areas with trees and shrubs (84% less than 2 m away).

In contrast with the previous species *Podarcis erhardii* shows a strong preference to sunny rocky areas with 88% of the observations near, on, or under rocks or stones. The greatest density measured for this species was 57 ind. ha^{-1}, i.e. far lower in relation to the densities that it can reach in the Aegean islands (Catsadorakis, 1984; Valakos, 1990) or in some mainland lowlands (Ioannidis & Bousbouras, unpubl. data).

Podarcis muralis has the widest niche breadth of the four small Lacertids (3.68 in an analysis based on Table 3). It can be found almost anywhere (Clark, 1992) but in the strongholds of the other three species it has a rather marginal distribution and relatively low densities.

Ablepharus kitaibelii is usually found among leaf litter (55% of the observations) but also in the herba-

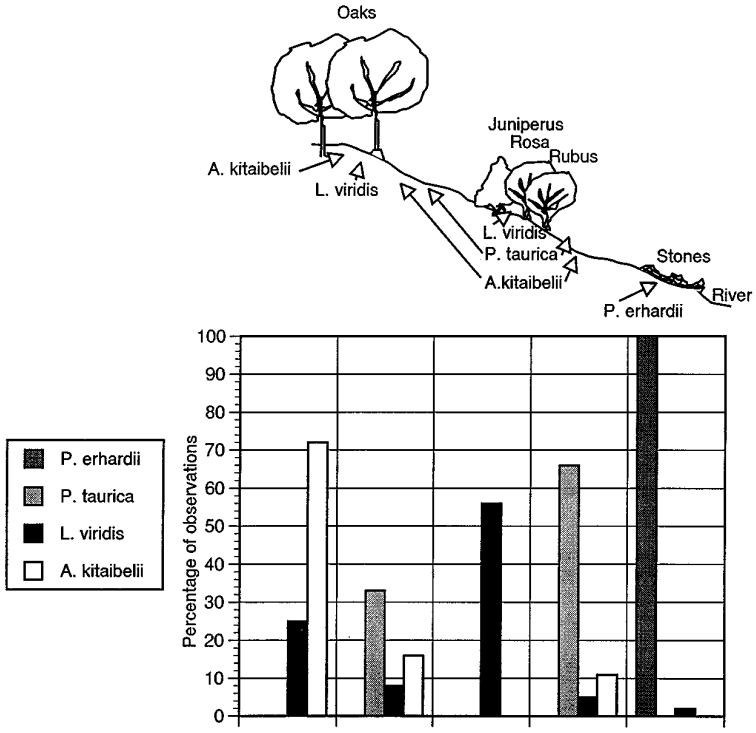

Figure 2. Percentages of captures of four lizard species in an 1.4 ha study area.

ceous cover of grazing pastures (45%). *A. kitaibelii* differs from *P. taurica*, which also favours this area, as it is much smaller and has a different temporal pattern of activity.

The spatial separation among the species found in a 1.4 ha area is shown schematically in Figure 2. Most reptiles were removed from this site over a two day period and released the day after (Bury, 1977). The positions of the animals recorded are the positions where the captured animals were first sighted.

Anguis fragilis shows a preference for humid areas near or in the forests. Most animals were found under stones at sunset but the amount of data for this species is insufficient.

With *L. trilineata* we faced a particular problem. We didn't find any adults that could be cleary identified as belonging to this species and the only specimens we definitely identified were two characteristic juveniles.

Snake community

For most of the species the results can only be considered as an indication of their habitat preferences in the area because of the low number of observations considered here.

Vipera berus is clearly separated from the rest of the species being restricted to the high mountain areas where no other snake has been observed.

Natrix natrix and *N. tessellata* are connected with water although they sometimes wander fairly large distances from it. That is especially the case with *N. natrix*. Of the two species, *N. tessellata* is by far more common in or near the lakes, while *N. natrix* is more often found away from the lakes, in drainage ditches or streams (Bousbouras & Ioannidis, 1994).

Of the other six species, three are present only in lower altitude areas and most of the observations come from cultivated areas or open grassy fields. *Coluber caspius* is the commonnest of the three. It has the widest habitat range and it is also present in wet areas. It is more often active in the high summer temperatures (Figure 3).

Malpolon monspessulanus and *Elaphe quatuorlineata* both prefer the open woods and fields but *E. quatuorlineata* is more common in cultivated zone while *M. monspessulanus* in stony places with shrubs.

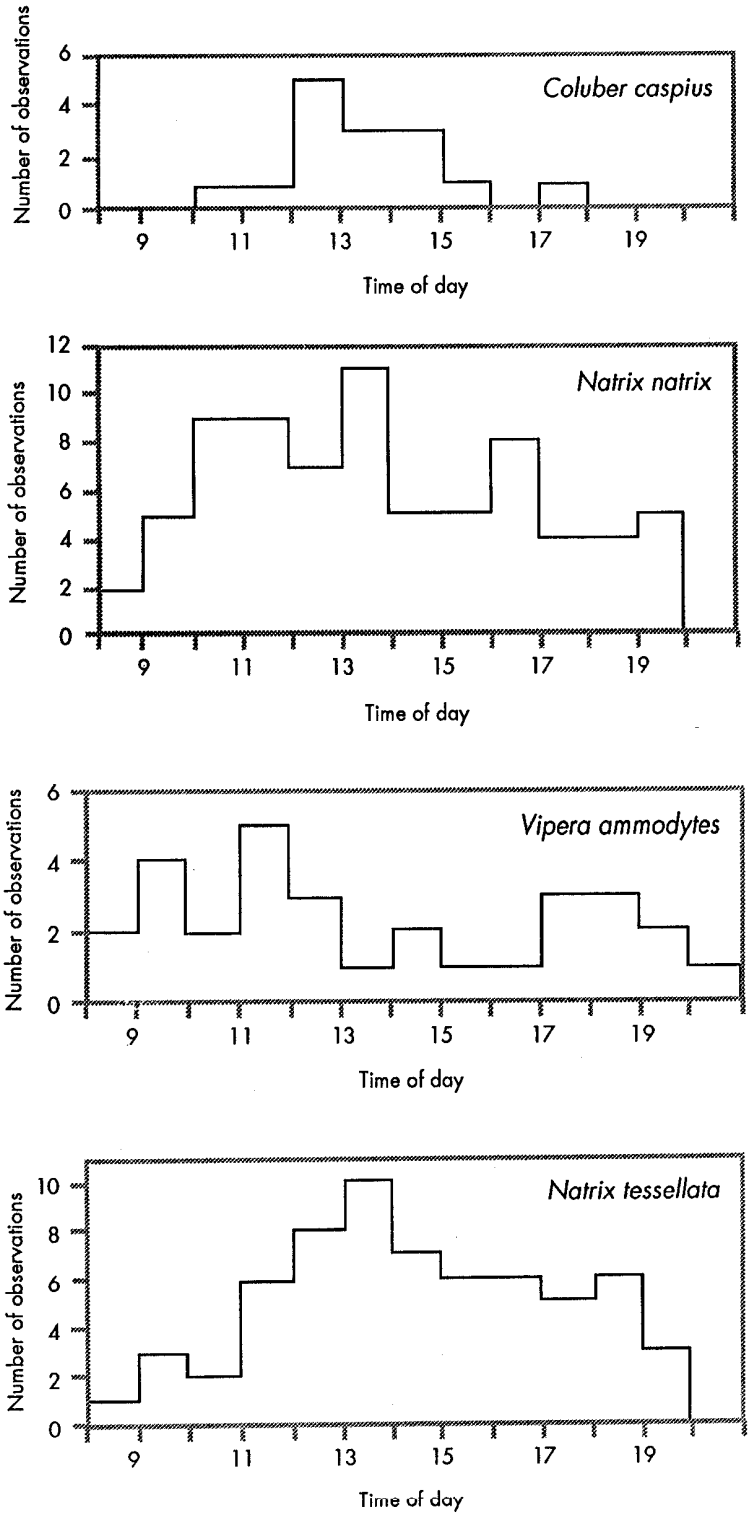

Figure 3. Activity periods for several snake species present in the area.

Of the three species that can also be found higher up on the mountains, *Vipera ammodytes* is the more common, in fact the most frequently met snake after the watersnakes. It has a wide habitat selection but seems more common in rocky or stony ground (63% of the observations). It is active in early morning or evening as well as at midday in spring (Figure 3).

Elaphe longissima is found in wooded areas and even in the open fields it is close to shrubs or trees. *Coronella austriaca* favours the same areas but it is also found in bare ground such as overgrazed slopes. While both species are active mainly in the morning or evening hours, both have also been observed at midday. While *E. longissima* has been observed basking, mainly on low temperature days, *C. austriaca* was never seen exposed under direct sunlight. It was only observed active at midday on cloudy days.

Conclusions

A very diverse herpetofaune occurs at the Prespa National Park mainly due to the variability of habitats present.

The reptile fauna of the area is composed of East Mediterranean and of Central European elements. The species of a clearly Mediterranean origin are present mainly around the lakes. Those of Central European origin are more evenly distributed occurring also among the mountains, while two are restricted to the mountains. The human influence in the area doesn't have any clear serious negative impact upon the reptiles, on the contrary some species may have benefited from the open (non-forested) areas. This is true as long as the land use is not yet highly intensive. The negative effects of intensive land use are shown on the overgrazed slopes.

None of the reptile species seems to be really threatened in the area. The only possible exceptions are *Lacerta agilis* and *Vipera berus* due to their limited range in the subalpine-alpine meadows. This area is used for grazing, in places intensively, during the spring and summer which is also the lizard's active period. Apart from this, only the human atittude, mainly towards snakes, and traffic have some negative effects but, at least until now, these are not severe enough to threaten any reptile species.

References

Bousbouras, D. & Y. Ioannidis, 1994. Amphibien und Reptilien des Prespa-Nationalparks und der Gebirgeregion um Florina (Mazedonien, Griechenland). Salamandra 30: 209–220.

Bury, R. B., 1977. Structure and composition of Mojave Desert reptile communities determined with a removal method. Symposium S.S.A.R. and Herp. League, Wildlife Res. Report 13: 135–142.

Catsadorakis, G., 1984. Aspects of Ecology and Behaviour in the lizard *Podarcis erhardii*. Biologia Gallo-Hellenica 11: 99–110.

Catsadorakis, G., 1986. Biotopes and vertebrates in Prespa National Park. Univ. of Athens, 161 pp. (in Greek).

Chondropoulos, B. P., 1989. A checklist of Greek reptiles. II. The snakes. Herpetozoa 2: 3–36.

Chondropoulos, B. P. & J. J. Lykakis, 1983. Ecology of the Balkan Wall Lizard, *Podarcis taurica ionica* (Sauria: Lacertidae) from Greece. Copeia: 991–1001.

Clark, R., 1992. An account of herpetological observations in Macedonia, The Pindos Mountains and Prespa Lake region, Greece. Herptile 17: 49–63.

Fritz, U., 1992. Zur innerartlichen Variabilitat von *Emys orbicularis* (Linnaeus, 1758). 2. Variabilitat in Osteuropa und Redefinition von *Emys orbicularis orbicularis* (Linnaeus, 1758) und *E. o. hellenica* (Valenciennes, 1832) Reptilia, Testudines: Emydidae). Zool. Abh. Mus. Tierkd. 47: 37–77.

Ioannidis, Y. & D. Bousbouras, 1989. Erster Bericht über die Balkan Kreuzotter *Vipera berus bosniensis* Boettger, 1889 aus Griechenland. Salamandra 25: 77–80.

Karaman, S., 1928. Prilog Herpetologiji Jugoslavije. Glasn. skopsk. nauc. dr., Skoplje 4: 129–143.

Kuhnelt, W., 1981. Vorlaufige Übersicht über die wechselwarme (Poikilotherma) Land und Ufertierwelt der Umgebung der Biologischen Station bei Mikrolimni am kleinen Prespasee. Physis, Athinai 26: 32–39.

Margalef, R., 1951. Diversidad de especies en las comunidades naturales. Publnes. inst. Biol. apl., Barcelona 6: 59–72.

Pavlides, G., 1985. Geobotanical Study of the Prespa Lakes National Park (NW. Greece). Part A: Ecology, Flora, Phytogeography, Vegetation. Aristotelian Univ., Thessaloniki, 308 pp. (in Greek).

Pianka, E. R., 1969. Sympatry of desert lizards (*Ctenotus*) in western Australia. Ecology 50: 1012–1030.

Pianka, E. R., 1970. Comparative autecology of the lizard *Cnemidophorus tigris* in different parts of its geografic range. Ecology 51: 703–720.

Pianka, E. R., 1986. Ecology and Natural History of Desert Lizards. Princeton Univ. Press, Princeton, New Jersey, 208 pp.

Pielou, E. C., 1966. The measurement of diversity in different types of biological collections. J. Theor. Ecol. 13: 131–144.

Simpson, E. H., 1949. Measurement of diversity. Nature 163: 688.

Spellerberg, I. F., 1991. Monitoring ecological change. Cambridge University Press, 334 pp.

Strijbosch, H., W. Helmer & P. T. Scholte, 1989. Distribution and ecology of lizards in the Greek province of Evros. Amphibia-Reptilia 10: 151–174.

Valakos, E. D., 1990. The ecology of the lizard *Podarcis erhardii* (Bedriaga, 1882) (Sauria: Lacertidae) in a typical insular ecosystem on Naxos Isl. Ph.D.Thesis, University of Athens, 213 pp. (in Greek with English summary).