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AN APPLICATION OF GEOGRAPHIC INFORMATION SYSTEMS USING THE ENDEMIC AND PROTECTED REPTILE SPECIES OF GREECE

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Abstract The geographic distribution and the distribution of richness of the Greek reptile species included in Annex II of the Directive 92/43/EEC and of the reptiles which are endemic to Greece are mapped to look into some of the possibilites of Geographic Information Systems. Richest areas for the species included in Annex II are the Aegean and Ionian islands, whereas the Peloponnese is the richest area for reptile species endemic to Greece. Major applications of GIS in biogeographic studies are found to be: a) the representation of species presence over an area, b) the determination of species richest areas of a region, c) the determination of the appropriate cell size in case it is necessary to use a grid, d) the check of questionable records, e) the indication of areas that are under-investigated in case of deficient sampling as well as the fill of some gaps.

Περίληψη Η γεωγραφική κατανομή και η κατανομή της αφθονίας των ειδών ερπετών της Ελλάδας που περιλαμβάνονται στο Παράρτημα II της Οδηγίας 92/43/ΕΚ και των ενδημικών ερπετών της Ελλάδας, χαρτογραφήθηκαν για να διερευνηθούν οι δυνατότητες των Γεωγραφικών Συστημάτων Πληροφόρησης (GIS). Οι περιοχές οι πιο άφθονες σε είδη που περιλαμβάνονται στο Παραρτ. II είναι τα νησιά του Αιγαίου και του Ιονίου, ενώ η Πελοπόννησος είναι η περιοχή η περισσότερο άφθονη σε ενδημικά είδη της Ελλάδας. Οι βασικές εφαρμογές των GIS βρέθηκαν ότι είναι α) η αναπαράσταση της παρουσίας των ειδών σε μια περιοχή, β) ο καθορισμός των περισσότερο πλούσιων σε είδη περιοχών, γ) ο καθορισμός του κατάλληλου μεγέθους του τετραγώνου στην περίπτωση που χρειάζεται κάνναβος, δ) ο έλεγχος των αβέβαιων δεδομένων, ε) ο εντοπισμός περιοχών που δεν έχουν εξερευνηθεί επαρκώς.

INTRODUCTION

It is well known that species present a wide dissimilarity in the size of their geographic distribution area. Their geographic range may extend from a global distribution (cosmopolitan species) to a very restricted one (endemics or rare) (BROWN & GIBSON 1983). Species of small geographic distribution are more vulnerable, and prone to extinction in case of a severe population decline under whatever reason (SOULÉ 1986). So one of the parameters that may indicate the degree of threat a species faces is the size of its distribution range; also it is one of the important criteria for the determination of species which are in need of protection. To this end, a preparatory work that should be done in Greece, is

a) the determination of the range of all species, especially of the endemics, and

b) the determination of the areas that are in need of protection for the conservation of the particular species.

Considering these distributions we can easily identify the species richest areas which should be taken into account when designing protected areas networks.

Geographic Information Systems provide a useful tool for this purpose. A GIS is a computer system for creating maps, at different scales, in different projections and with different colours. The main advantage of the GIS though, is that it is an analysis tool; it does not hold maps or pictures but databases. The maps, represent these data. As a consequence, data from two or more different maps can be combined to produce a new one which retains all the information of the original coverages.

In this work we investigate some of the possibilities of GIS, mapping the geographic distribution and the distribution of richness of the Greek reptile species included in Annex II of the Directive 92/43/EEC and of the reptiles which are endemic to Greece. It should be noted that the above Directive constitutes the basis for the creation of a European protected areas network, known as "Natura 2000". We use the reptiles as a case study because they constitute a very well studied group for which a lot of data is available. Furthermore, they are very appropriate as a biogeographic indicators (HUEY et *al.* 1983) because of their comparatively small dispersal ability as well as because many biogeographic studies have been carried out, a fact that allows us to make comparisons. Finally, reptiles together with freshwater fishes and the endemic mammal species *Acomys minous* (Mammalia, Rodentia) of Crete is a vertebrate group with species endemic to Greece (KARANDINOS 1992).

METHODS

We examine the geographic distribution of:

a) the endemic species of Greece (Table 1) and

b) the species that are included in Annex II of the Directive 92/43/EEC (Table 2).

In the list of the endemic reptiles we included *Podarcis erhardii*, as this species is distributed only in the southern Balkan peninsula and is mainly differentiated in the Aegean islands.

Table 1 The endemic reptile species of Greece, including *Podarcis erhardii*.

Algyroides moreoticus	(Sauria-Lacertidae)
Lacerta graeca	(Sauria- Lacertidae)
Podarcis peloponnesiaca	(Sauria- Lacertidae)
Podarcis milensis	(Sauria- Lacertidae)
Podarcis erhardii	(Sauria- Lacertidae)
Podarcis gaigeae	(Sauria- Lacertidae)
Anguis cephallonicus	(Sauria - Anguidae)
Vipera schweizeri	(Serpentes-Viperidae)

Table 2 The reptile species in Annex II of the Directive 92/43/EEC.

Testudo hermanni	(Chelonia - Testudinidae)
Testudo graeca	(Chelonia - Testudinidae)
Testudo marginata	(Chelonia - Testudinidae)
Emys orbicularis	(Chelonia - Emydidae)
Mauremys caspica	(Chelonia - Emydidae)
Elaphe situla	(Serpentes - Colubridae)
Elaphe quatuorlineata	(Serpentes - Colubridae)
Vipera ursinii	(Serpentes - Viperidae)
Vipera schweizeri	(Serpentes - Viperidae)

Almost all the available bibliography, from the end of the previous century until nowadays (e.g., BEDRIAGA 1882, DOUGLASS 1892, WERNER 1938, WETTSTEIN 1953, CHONDROPOULOS 1986, CHONDROPOULOS 1989) was used to describe the distribution of each species. All localities where each species has been recorded were digitized as points on a map of Greece (scale 1: 1.000.000) using Arc/Info. This work constitutes the preliminary stage in the preparation of the "Atlas of the Reptiles of Greece".

For each point it was assumed that the species is present within a 10 km radius of the locality where it was found applying a buffer zone around each point. When a species has been recorded on an island, then the whole island is considered as the area in which this particular species exists (except for the largest Greek island, i.e. Crete).

All these coverages were overlaid to produce a final map showing the number and the list of the species present in different areas.

RESULTS AND CONCLUSIONS

The illustrations of the species distributions are presented in Figs 1,2. Most of the species included in Annex II (with the exception of *Vipera ursinii* and *Vipera schweizeri*), are widely distributed in the country. The richest areas for these species are the Aegean and Ionian islands (Fig.4). All Greek endemic species are of small to medium distribution and some of them are confined to only one or a few islands. The Peloponnese is the richest area for reptile species endemic to Greece (Fig.3). This is a particular feature of the Greek area, in contrast to other Mediterranean countries, such as Spain which is also rich in endemic reptile species that are widespread all over the country (MARTINEZ RICA 1989). Another interesting note is the absence of endemic reptiles from the islands of Crete, Kasos and Karpathos, which had been isolated since the upper Tortonian (8 million years ago) (DERMITZAKIS 1990), in contrast to other Mediterranean islands which are very rich in endemic reptiles (MYLONAS & VALAKOS 1990). The list of endemic reptile species of the Aegean archipelago consists of two lizards of the genus *Podarcis* (*P. milensis* and *P. gaigeae*), and is probably connected to the old isolation of the islands on which these species are distributed (DERMITZAKIS 1990).

Table 3 The combination of the various cases that can emerge in the study of the geographic distribution of species and species richness.

	SPECIES GEOGRAPHIC RANGE	SPECIES RICHNESS DISTRIBUTION
GOOD SAMPLING	A	B
DEFICIENT SAMPLING	C	D

The mapping of species and species richness distribution, provides information depending on the kind and on the quality of the available data. In biogeographic studies, quality of the data means, the intensity of sampling and the reliability of the records. On many occasions there may appear cases of questionable records for a species presence: records significantly outside the known geographic range of the particular species. Greece, unlike other countries of western Europe, is a region for which there are not yet complete sets of biogeographic information about species distribution. This is a fact that should be taken into account, and GIS provides a useful aid towards this direction.

In case of adequate sampling, the simplest application of GIS in a biogeographic study, is the representation of species presence over an area (case A, Table 3) which can provide a picture of any barriers in their distribution. The representation of the species

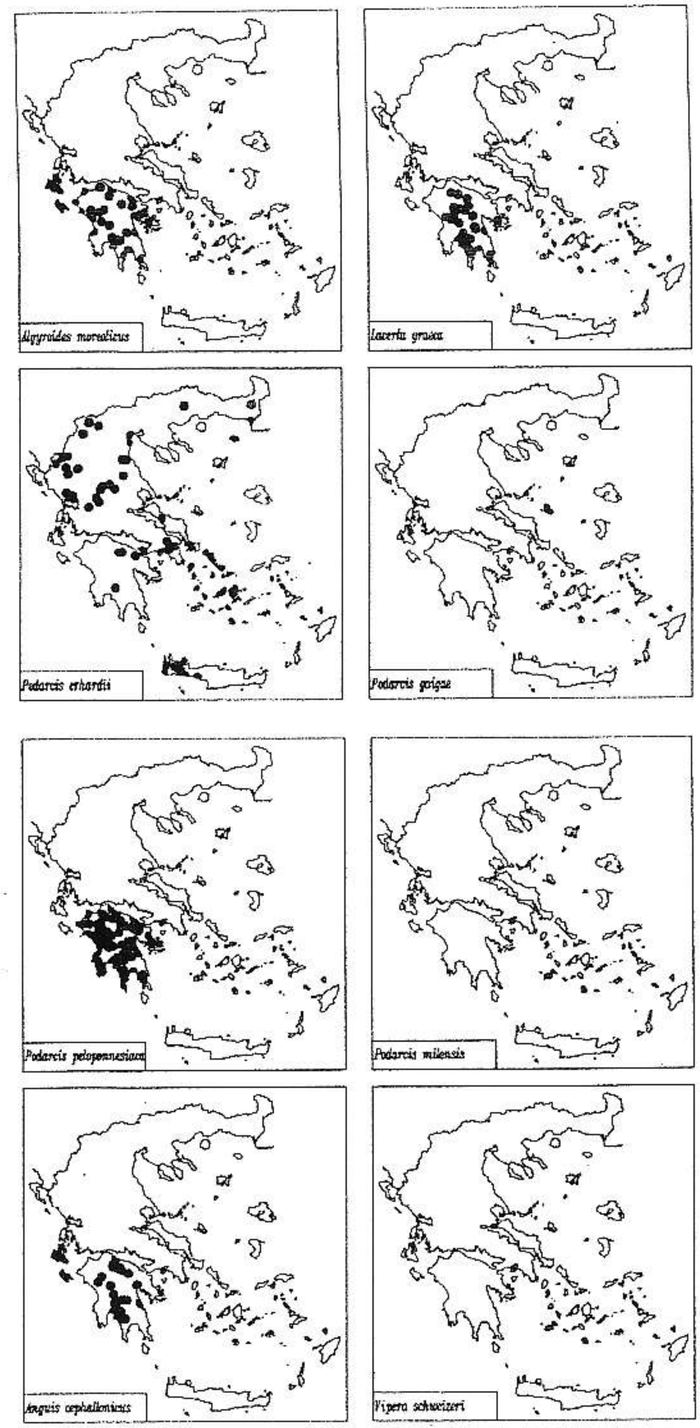

Fig. 1 Distribution maps of the reptile species endemic to Greece

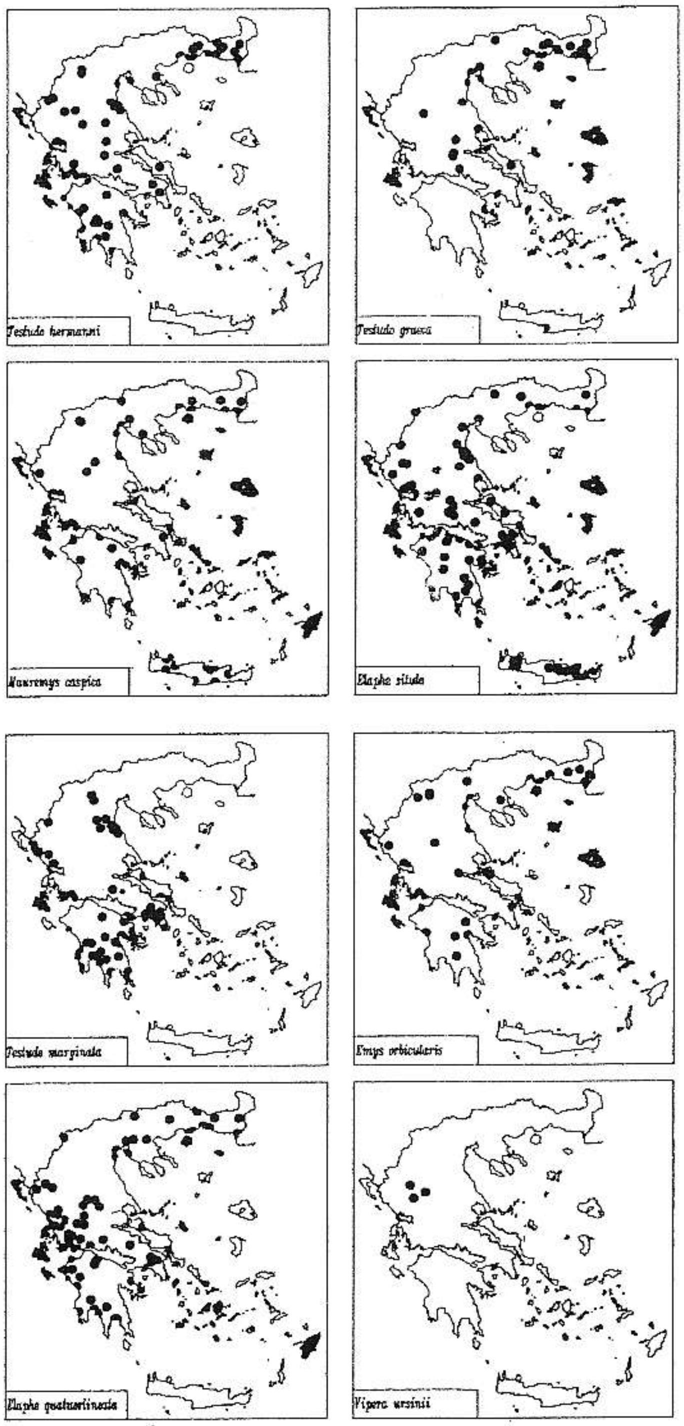

Fig. 2 Distribution maps of reptile species in Annex II of the Directive 92/43/EEC

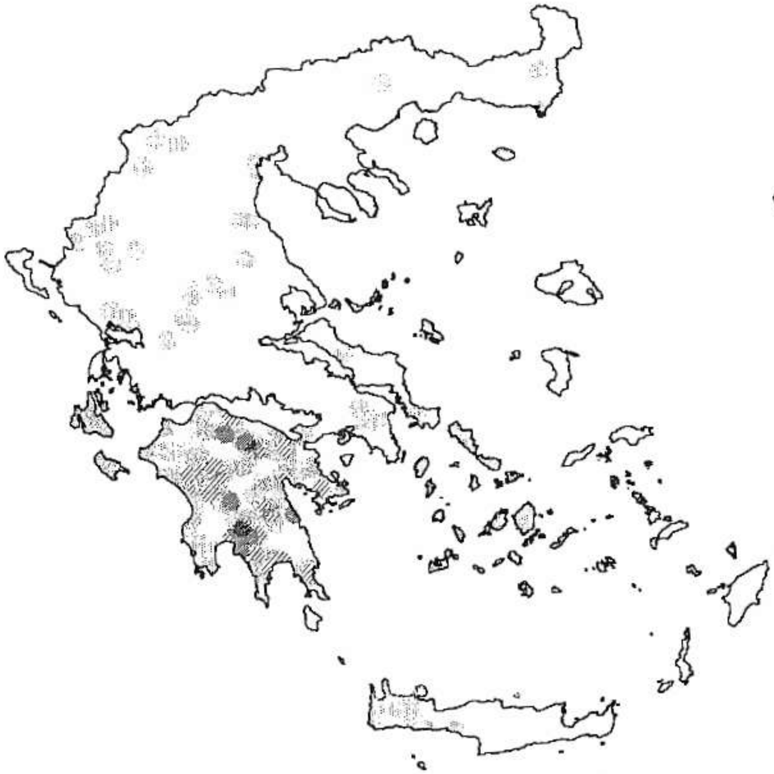

Fig. 3 Species richness distribution of the reptile species endemic to Greece

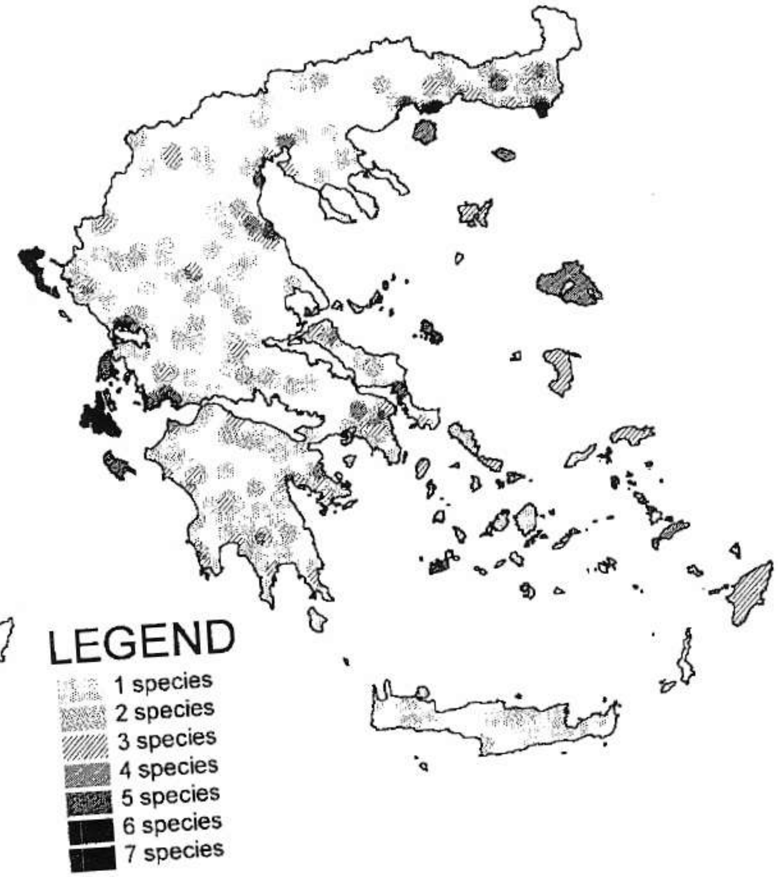

Fig.4 Species richness distribution of reptile species in Annex II of the Directive 92/43/EEC

richness for a particular taxon (case B, Table 3) helps in the determination of the species richest areas or hot-spots, of a region (MYERS 1988, 1990). On a large scale the method of overlapping the geographic distribution ranges of the species is much more accurate than the grid cell method. In the latter method, we have one single number for the species present in the whole area of the cell, which might be misleading since we do not take into account the environmental heterogeneity of the cell area (especially for regions as heterogeneous as Greece); on the contrary in the former method the number of species present in every point of the area under investigation is the result of the overlapping of the geographic distribution of every and each individual species. In the process of the study, if it is necessary to use a grid (for example if we want to correlate the distributions of one species or of species richness with various biotic or abiotic factors), this method is a powerful tool for determining the appropriate cell size.

If sampling effort is not equally distributed over an area, the representation of species presence over this area (case C, Table 3), contributes to the checking of questionable records. Moreover, by using more sophisticated modules of GIS, for example by applying a grid of appropriate size and considering autocorrelation as well as various biotic and abiotic factors, it is possible to fill some gaps (with a certain degree of probability) in the geographic distribution of a species.

The representation of species richness geographic distribution in cases of deficient sampling (case D), can offer an indication of the areas that are under-investigated. In Fig.3 for example, white coloured areas in Peloponnese can not be considered as empty of species but rather as under-investigated areas. In this case, the application of GIS helps in the planning of the appropriate sampling effort for a complete inventory of the fauna.

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