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MAN AND LACERTIDS ON THE MEDITERRANEAN ISLANDS: CONSERVATION PERSPECTIVES

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The aim of the present study is to synthesise the available data on the occurrence of lacertid lizards on Mediterranean islands better to understand how far human influence is involved in the present distributional patterns of insular lacertid lizard fauna. At present, the Mediterranean islands are inhabited by several lacertid genera, including endemic species of the genera *Algyroides* (viz. *fitzingeri*), »*Lacerta*« *Archaeolacerta* (viz. *bedriagae*) and *Podarcis* (*atratus, filfolensis, gaigae, lilfordi, milensis, pityusensis, raffonei, tiliguerta, waglerianus*). Recently reported data shed new light on the relationships between these endemics and some continental species that have recently colonised the islands. The arrival of the latter might be directly related to the progressive human colonisation of these islands. The arising conservation problems are also considered.

Key words: Lacertidae, Mediterranean islands, distribution, conservation

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Cilj ovog rada bio je sakupiti sve dostupne podatke o pojavljivanju lacertidnih guštera na otocima Sredozemlja da bi se bolje razumjelo koliko je čovjek utjecao na sadašnje uzorke rasprostranje-

nosti otočne faune lacertidnih guštera. Danas sredozemne otoke naseljuje nekoliko rodova lacertida, uključujući endemične vrste rodova *Algyroides* (viz. *fitzingeri*), »*Lacerta*« *Archaeolacerta* (viz. *bedriagae*) i *Podarcis* (*atratus, filfolensis, gaigae, lilfordi, milensis, pityusensis, raffonei, tiliguerta, wagleria-nus*). Nedavno objavljeni podaci bacili su novo svjetlo na odnose tih endemičnih i nekih kontinentalnih vrsta koje su nedavno naselile otoke. Dolazak potonjih mogao bi biti u direktnoj vezi s uznapredovalim naseljavanjem čovjeka na te otoke. Razmatraju se nastali problemi zaštite.

Ključne riječi: Lacertidae, sredozemni otoci, rasprostranjenost, zaštita

INTRODUCTION

Human activity must be considered one of the main factors explaining the present-day composition of vertebrate communities, as well as being the key factor in most recent island extinctions (WILLIAMSON, 1989). On Mediterranean islands, the turnover from the former to the present-day faunas took place during the Holocene, and it is generally held to be an effect of the human occupation which began in the early Neolithic or, even pre-Neolithic times. However, late Quaternary amphibians and reptiles on Mediterranean islands appear to have successfully resisted both climatic changes and the influence of man (VIGNE *et al.*, 1997; CORTI *et al.*, in press). In fact, if compared with mammals, which are considered among the main indicators of island faunistic population dynamics and of the relations with the continental faunas (cf. MAC ARTHUR & WILSON, 1967; SARÀ, 1996), the herpetofauna displays a surprising stability (HOLMAN, 1995; 1998).

Among Mediterranean reptiles, the lizards of the family Lacertidae represent an interesting case-study.

THE LACERTIDS OF THE MEDITERRANEAN ISLANDS

On the Mediterranean islands 9 genera (10, if we consider *Archaeolacerta* as a genus) and 39 species of Lacertidae are represented. Eleven of them are endemic and exclusively present on islands, the remaining are continental species also present on islands. We refrain from dealing here also with the innumerable »subspecies« that have been named and morphologically described from many Mediterranean islands, islets and even single, isolated rocks, because:

– (1) there is no generally accepted concept of what a subspecies is, and

– (2) the evolutionary phenomena lumped under the term subspecies include units of very different hierachical levels ranging from diverging forms just below species level to local populations which may exhibit genetic drift in just one single phenetic character.

The two following examples may elucidate this:

– BÖHME (1978) discussed aspects of infraspecific divergent evolution and the responsible selective forces. He claimed that for detecting them, ecophysiological characters (»properties« of the organism) would be more informative than morphogenetic characters. His concept, however, proved to be applicable only to widely distributed mainland forms. A modern overview of the problem was recently provided by SMITH *et al.* (1997).

– The heterogeneity of phenomena lumped together under the term subspecies and the conceptual arbitrariness of the latter have been discussed by BÖHME (1983). They are illuminated by the situation of e.g. *Podarcis pityusensis*: SALVADOR (1986) distinguished 23 insular subspecies, CIRER (1997), however, only 7 (!); but both were relying on the same factual material. The example of *P. siculus* shows that most of the 91 nominal infraspecific names described are local microinsular forms, clearly hierachically subordinated to the neighbouring mainland (or main island) form (BÖHME l.c.; HENLE & KLAVER, 1986), but some of the formally equal-ranking names may even prove to be full species (e.g. *P. raffonei*: CAPULA, 1994).

Tab. 1. E = endemism.

Acanthodactylus schreiberi	
Algyroides fitzingeri	**E**
Algyroides moreoticus	
Algyroides nigropunctatus	
Lacerta anatolica	
Lacerta (Archaeolacerta) bedriagae	**E**
Lacerta bilineata	
Lacerta laevis	
Lacerta oertzeni	
Lacerta oxycephala	
Lacerta trilineata	
Lacerta viridis	
Ophisops elegans	
Podarcis atratus	**E**
Podarcis erhardii	
Podarcis filfolensis	**E**
Podarcis gaigae	**E**
Podarcis hispanicus	
Podarcis lilfordi	**E**
Podarcis melisellensis	
Podarcis milensis	**E**
Podarcis muralis	
Podarcis peloponnesiacus	
Podarcis pityusensis	**E**
Podarcis raffonei	**E**
Podarcis siculus	
Podarcis tauricus	
Podarcis tiliguerta	**E**
Podarcis waglerianus	**E**
Psammodromus algirus	
Teira perspicillata	
Timon lepidus	

Because of these ambiguities of Mediterranean insular lacertid subspecies, we prefer to discuss in this paper only those forms that have demonstrably proven to be species. We did not take into account the small lizard populations of some small islands of north Africa, eastern Spain and south-eastern Mediterranean offshore islands on which we find only small populations of colonisers from the nearby mainland. The considered Mediterranean lacertid species living on the islands are reported in Tab. 1.

DISTRIBUTION OF THE LACERTID FAMILY ON MEDITERRANEAN ISLANDS (• endemic species)

Acanthodactylus schreiberi, coastal areas of the Levant and the island of Cyprus: (BISCHOFF, 1990; BÖHME & CORTI, 1993).

• *Algyroides fitzingeri*: Corsica and Gargalu island; Sardinia and some of its satellite islands (ARNOLD & BURTON, 1978; DELAGUERRE, 1983; DELAUGERRE & CHEYLAN, 1992).

Algyroides moreoticus: Peloponnese, islands of Kefallonia, Ithaca and Zakynthos, Stamphani, Psili (CHONDROPOULOS, 1997a).

Algyroides nigropunctatus: Adriatic and Ionian coastal regions of the Balkan peninsula; islands of Krk, Cres, Rab, Lošinj (Croatia), Sazan (Albania), Kerkyra, Vido or Ptychia, Paxi, Lefkada, Kefallonia, Ithaca, and Zakynthos (Greece) BISCHOFF, 1990; CHONDROPOULOS, 1997b).

Lacerta anatolica: north-western Anatolia and the island of Samos (Greece): (BISCHOFF, 1991).

• *Lacerta* (*Archaeolacerta*) *bedriagae*: Corsica and Isolotto della Folaca; Sardinia and some of its satellite islands (LANZA & POGGESI, 1986; POGGESI *et al.*, 1995).

Lacerta bilineata: central-western and western Europe; islands of Porquerolles, Elba, Sicily (RYKENA, 1991; NETTMANN, 1995), Cres and Lošinj (NETTMANN, pers. comm.).

Lacerta laevis: Anatolia, the Levant, and the island of Cyprus (BISCHOFF, 1991).

Lacerta oertzeni: south-western coastal regions of Anatolia; island of Ikaria and Rhodes and its satellite islands (BISCHOFF, 1991).

Lacerta oxycephala: central-western Balkan peninsula; Dalmatian islands (CRNOBRNJA-ISAILOVICH & DZUKIC, 1997).

Lacerta trilineata: Balkan peninsula and western Anatolia; larger islands of the eastern Adriatic gulf, Ionian sea, and Aegean sea, such as Crete, Tinos, Milos Archipelago, Lesbos, Chios, Lemnos, Samos, Samothrace, Rhodes (KASAPIDIS *et al.*, 1996; SCHMIDTLER, 1997).

Lacerta viridis: eastern Europe and north-western Anatolia; Kerkyra, Euboia, Skyros, Skiathos, Thasos, Samothrace (ENGELMANN *et al.*, 1993), Tinos (NAULLEAU, 1997).

Ophisops elegans: southern Balkan peninsula and the Near East, western Middle East and Egypt; islands of Cyprus, Lesbos, Chios, Lemnos, Samos, Samothrace, Ag. Eftratios (KASAPIDIS *et al.*, 1996); Thasos and Karpathos (DAREWSKY, 1997).

• *Podarcis atratus*: Columbretes archipelago (Spain) (CASTILLA *et al.*, 1998)

Podarcis erhardii: south-eastern Europe; many of the Aegean islands (GRUBER, 1997).

• *Podarcis filfolensis*: Maltese and Pelagian archipelagos (BISCHOFF, 1997).

• *Podarcis gaigeae* Skyros archipelago and Piperi island (Northern Sporades, Greece) (HARRIS, 1998).

Podarcis hispanicus: Maghreb and Iberian peninsula; islands of »de Isabel«, »del Congreso«, »del Rey« (Chafarines islands), islets »de San Carlo«, and Peñon de Vélez in the Peñon de Alhuceima (off Morocco), and two of the Medas islands, Benidorm island and other small Spanish coastal islets (GUILLAUME, 1997a; PÉREZ-MELLADO, 1997c).

• *Podarcis lilfordi:* Gymnesic islands, today present only on several islets around the coast of Mallorca and Menorca, extinct on Menorca and Mallorca during the Holocene; on both islands there are recent records probably from imported individuals (PÉREZ-MELLADO, 1997a,b).

Podarcis melisellensis: east Adriatic coastal region; islands of the Croatian and Montenegrin coasts (TIEDEMANN, 1997a).

• *Podarcis milensis*: Milos archipelago: Milos, Polyaegos, Kimolos and surrounding islets, Antimilos, Phalkonera, Velopoula and Ananes (TIEDEMANN, 1997b).

Podarcis muralis: middle and south Europe and Anatolia; Mediterranean islands of France, excluding Corsica; Ligurian islands; Gorgona; Elba and some surrounding islets; La Scola islet; Pianosa, Palmaiola, Argentarola and Port'Ercole islands of the Tuscan archipelago; Cres, Samothrace and, perhaps, Thasos (CORTI *et al*., 1991; GUILLAUME, 1997b).

Podarcis peloponnesiacus: Peloponnese; Psili island (SOFIANIDOU, 1997).

• *Podarcis pityusensis*: Pityusic islands: Formentera, Ibiza and surrounding islets and rocks (CIRER, 1997; CIRER & MARTÍNEZ-RICA, 1997).

• *Podarcis raffonei*: Aeolian archipelago: Vulcano island, La Canna, Scoglio Faraglione and Strobolicchio rocks (CORTI *et al*., 1997).

Podarcis siculus: central-southern Europe and the facing Asiatic Turkey; on many of the islands and archipelagos facing the Italian coast, the islands of Corsica, Sardinia, Sicily, Elba, Krk, Cres and minor nearby islands, including some Marmara Sea islets, Menorca and introduced on Chateau d'If islet (CORTI *et al*., 1997).

Podarcis tauricus: south-eastern Europe; island of Kerkyra, Paxi, Ithaki, Lefkada, Kefalonia, Zakynthos, Arpya, Thasopoulos (CHONDROPOULOS, 1997c).

• *Podarcis tiliguerta*: Corsica and Sardinia, and their satellite islands (LANZA & POGGESI, 1986; POGGESI *et al*., 1996).

• *Podarcis waglerianus*: Sicily, Egadian islands (Favignana, Levanzo and Marettimo), and Isola Grande dello Stagnone (LANZA & CORTI, 1997; CORTI *et al*., 1997), Maraone island (LO VALVO, 1998).

Psammodromus algirus: western North Africa, and Iberian peninsula; some small islands facing the Spanish Mediterranean coast such as Meda Gran, Grossa; Galitone, Aguglia, Zembra and Zembretta (Tunisia) and Isola dei Conigli (Italy) (GUILLAUME, 1997c).

Teira perspicillata: North-western Africa; introduced onto Menorca island shortly before 1928 (MERTENS, 1929; MAYOL, 1997).

Timon lepidus: south-western Europe; Porquerolles and Ratonneau islands (France); Palomas (Murcia), Olla de Altea (Alicante) and Mitjana (Spain) (BISCHOFF *et al.*, 1984; MATEO, 1997; MATEO & CHEYLAN, 1997).

ENDEMIC LACERTIDAE OF THE MEDITERRANEAN ISLANDS

On the Mediterranean islands we can record only 15 endemic species of reptiles, 4 of which are snakes (*Coluber cypriensis*, *Coluber gyarosensis*, *Natrix (natrix) cetti*, *Macrovipera schweitzeri*), the remaining 11 belonging to the lacertid lizards. This means that representatives of the Lacertidae family account for 73%.

The endemic Lacertidae of the Mediterranean islands are represented by the following genera: *Algyroides*, *Lacerta Archaeolacerta* and *Podarcis*.

Eleven lacertid species are endemic to the Mediterranean islands (Tab. 1), 9 of them belong to the genus *Podarcis*, thus 82% of the endemics are *Podarcis* versus *Lacerta (Archaeolacerta) bedriagae* and *Algyroides fitzingeri*, who together represent 18% of the remaining endemics. *Podarcis* is the genus mainly characterized by endemic *taxa*. In fact, of the 16 species of *Podarcis* recorded on Mediterranean islands, 9 are endemic. Within the latter it is also remarkable that seven species belong to the western part of the Mediterranean basin and only two (*P. milensis* and *P. gaigae*) belong to the eastern part of the basin.

MEDITERRANEAN LACERTIDAE AND MAN

To identify the faunal changes occurring in historical times it would be fruitful to compare the present distribution with the palaeontological data, but unfortunately the fossil record is particularly poor and anyway of little help. This is for at least the following reasons:

– the taxonomy of the living members of this family is complex and still under debate;

– there are few works dealing with the comparative osteology of this group and its osteologically homogenous species (exceptions are for example: ARNOLD, 1973, 1983, 1989; BARBADILLO & SANZ, 1983; BARBADILLO, 1989);

– an approach based only on the size of the remains, although attempted by some researchers in the past, is generally unsatisfactory and unsuitable for specific allocation even in areas with limited taxonomic diversification;

– the taxonomic allocations of lacertid remains have been almost essentially based on teeth and teeth bearing bones but a proper allocation needs to take into account a group of characters perceivable on several other skeletal elements (e.g. parietal, frontal, jugal, postfrontal, postorbital, anterior autotomic caudal vertebrae, etc.; see ARNOLD, 1989);

– owing to the taphonomic history of the remains, only very rarely does an adequate number of these disarticulated skeletal elements occur in one single site.

AUGÉ (1988) states that, only at genus level, it is difficult and perhaps impossible to refer the fossil material to the members of the group that was formerly called *Lacerta*. So, as it paradoxically happens with other groups of highly homogeneous skeletal morphology (e.g. snakes, SZYNDLAR, 1991), it is probably easier to study Tertiary lacertids and to refer them to fossil taxa, than to study Quaternary remains that need to be referred almost exclusively to the living species.

In the light of all this, it is quite difficult to make a comparison between the past and the present distribution of each single taxon and even to understand the exact role played by man in the redefinition of the Lacertid distribution.

It is noteworthy that Quaternary lacertids have been allocated to a specific level almost only on islands with one or few living species. Obviously, these data have to be used with caution by neoherpetologists and the original descriptions need to be evaluated case by case.

HOLMAN (1995, 1998) recently pointed out the importance of low metabolic rates, aestivation, hibernation, small size, food relationship with other vertebrates and reproductive potentials of reptiles and amphibians. Apart from some exceptions, such as *Alytes talayoticus* on Menorca, and *Podarcis lilfordi* on Menorca and Mallorca, probably these characteristics also played a key role in the high survival rates of the insular Mediterranean herpetofauna when man began to redefine the islands' ecosystems and introduced allochthonous faunistic elements (PÉREZ-MELLADO, 1997b; CORTI *et al*., in press). In this regard, the example of the lacertids of the Gymnesic and the Pityusic islands has been considered as particularly significant. Only *P. lilfordi* and *P. pityusensis* are considered as palaeoendemics of these islands, and, plausibly, they – or their predecessors – colonised the islands during the Messinian (KOTSAKIS, 1981; ALCOVER & MAYOL, 1988; CIRER A. M., 1997; PÉREZ-MELLADO, 1997b). Apart from the representatives of the genus *Alytes*, all the remaining present day herpetological species must have immigrated to the Gymnesic and the Pityiusic islands due to the intervention of man (ALCOVER & MAYOL, 1988).

In the light of this, the disappearance of *P. lilfordi* from Mallorca and Menorca is probably referable to the introduction, in relatively recent times, of allocthonous snakes, such as the false smooth snake (*Macroprotodon cucullatus*), carried out by man (KOTSAKIS, 1981; MAYOL, 1985; CHEYLAN & POITEVIN, 1994; PLEGUEZUELOS *et al.*, 1994; PÉREZ-MELLADO *et al*., 1997). We cannot also exclude that some other predators, such as martens, genets or domestic carnivores could have contributed to this extinction (cf. PÉREZ-MELLADO, 1995). *P. lilfordi* is present today only on several islets surrounding the Mallorcan and Menorcan coasts. Some individuals recently reported from the two main islands are reputed to have been imported (PÉREZ-MELLADO, 1997b). Neither can it be excluded that the present distribution of *P. raffonei*, today restricted to a part of the island of Vulcano and to some islets of the Aeolian archipelago, was more extensive in former times. Recent electrophoretical studies showed the sporadic occurrence in the genome of *P. siculus* from Lipari of some alleles diagnostic for *P. raffonei*, seemingly witnessing past introgressive phenomena (CAPULA, 1990). If we follow this hypothesis, *P. siculus* could be the cause of the decline of *P. raffonei* in this area (CORTI *et al*., 1997). Since the Island of Vulcano (Aeolian archipelago) seems to have been colonised by man not before the

end of the 19th century (LO CASCIO & NAVARRA, 1997), the decrease of the population of *P. raffonei* due to competition with *P. siculus* seems to be evident (CAPULA, 1993). The same seems to be happenning on other islands, like Sardinia and Corsica and the Tuscan archipelago, in which the autochthonous lizards *P. tiliguerta* and *P. muralis* compete with *P. siculus* that was accidentally introduced on these islands in protohistorical or historical times (LANZA, 1983, 1988; CORTI *et al.*, 1989). Due to the recent increase of its geographical diffusion beyond its natural distribution, could *P. siculus* be possibly regarded as a commensal species with man? As it is well known, commensalism is regarded as a symbiotic relationship between two species in which the one derives benefit from a common food supply, whilst the other is neither adversely affected nor harmed. Species commensal with man are usually euryoecious and euryophagous (cf. TCHERNOV, 1984). These species may be in direct association with man, but they also colonise dumps and even prosper within them (BON & MASSETI, 1995). Since *P. siculus* is mostly insectivorous**,** it cannot be considered as a fully established member of the family of the commensals with man. Thus in some respects it may be appropriate to regard *P. siculus* as a weed species. For weed species, human beings are in fact part competitor, part predator and part host (cf. RICHARD *et al.*, 1989). There are also many examples on western Mediterranean islands on which human activities changed a forested landscape to an open cultivated one, consequently favouring species better adapted to open environments, such as *P. siculus*, and banishing the indigenous species to what remained of the native habitat. On the other hand we could also stress that some native populations inhabiting, for instance, islets showing extreme environmental poverty, could be naturally preserved from immigration of particular adaptable immigrants, such as *P. siculus*, just because of their extreme degree of adaptation. Could be this be the case of *P. raffonei* on Strombolicchio Islet in front of Stromboli Island in the Aeolian archipelago?

Regarding some examples of introduction we could mention the north-west-African species, *Teira perspicillata*, that was introduced to Menorca at an unknown, but probably recent date. This introduction was likely to be a consequence of trade between Menorca and North Africa during the 19th century (MAYOL, 1997). There is also the case of endemic insular lizards that have been imported involuntarily to the mainland, as in the case of *P. pityusensis* in the area of Barcelona (CIRER & MARTINEZ RICA, 1997).

For the eastern Mediterranean island of Cyprus, it has been hypothesized that the populations of *Lacerta laevis* occurring there may have originated from multiple introductions of different mainland populations of the *L. laevis* group (including *L. kulzeri*?) and that isolating mechanisms that had since long been established on the mainland between these forms, may have secondarily broken down in a newly colonised environment (BÖHME, 1996).

In the light of the above mentioned examples, there are several effects produced by man that have acted on the present distribution of the lizard fauna on Mediterranean islands and many different measures must be taken to preserve the extant populations' biodiversity. Human effects could be summarized as follows:

– colonisation and exploitation of habitats due to activities like agriculture, shipping (effects that in some cases do not lead to a decrease in overall species richness

but select the species better adapted to open habitats**)** (PÉREZ-MELLADO, 1995); and in more recent times the building of restoration plants that cause great changes in the environment;

– direct and indirect effects of habitat pollution, including the diffusion of diseases;

– the introduction of predators and allochthonous competitors (see above and CORTI *et al.*, 1997), including domestic animals such as feral cats, mainly carried out in recent historical times, a problem that for instance affects the reintroduction of the Hierro Giant Lizard *Gallotia simonyi* in some sites of Hierro island;

– in the case of small populations, trade and collecting by amateurs could be particularly injurious.

The Mediterranean region is an important biogeographical »crossroads« CHEYLAN & POITEVIN (1994) and the islands represent very important biodiversity reserves that are particularly rich in number of endemic species. Even though in the present work we have mentioned the most important lacertid lizard species present on the Mediterranean islands without getting deeply inside their taxonomical subspecific status (see above), we would like to point out the importance of the eco-ethological features developed over thousands of years on several small islands and islets (e.g. *P. lilfordi*) (PÉREZ-MELLADO & CORTI, 1993; CORTI *et al.*, 1997). These features are so notable and different within those populations that their taxonomical status could be based on infraspecific evolutionary divergences (BÖHME, 1978). Focusing our attention on the eco-ethological features of single island populations is the only way to recognise the real conservation strategies that must be employed, taking into account also for instance the interactions between lizard populations and other vertebrate species under protection (PÉREZ-MELLADO & CORTI, 1995). The survival of all of them must be the ultimate goal of any future conservation strategy (PÉREZ-MELLADO, 1995).

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