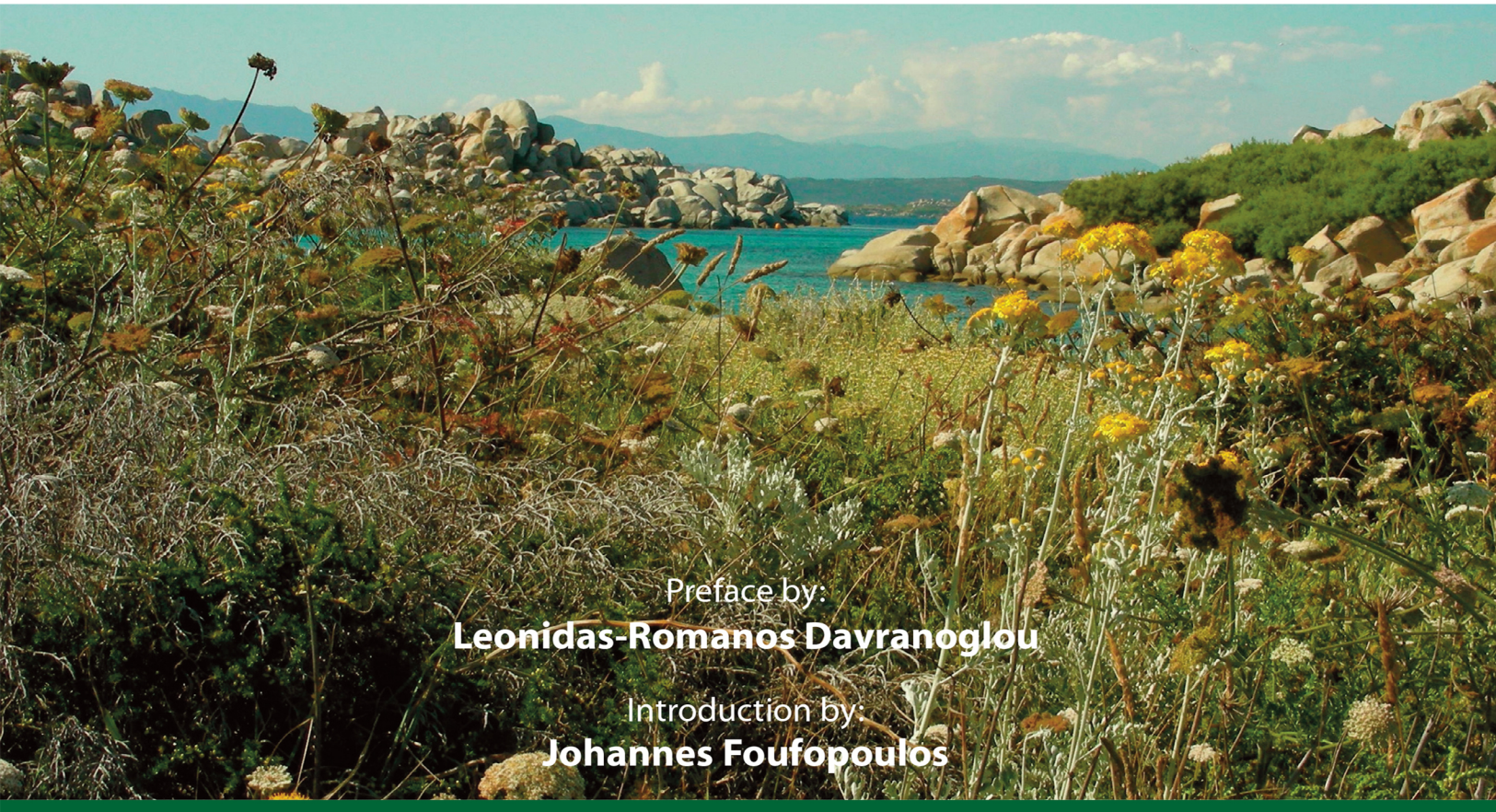
Conservatoire du littoral

PIM INITIATIVE — INTERNATIONAL NGO FOR MEDITERRANEAN SMALL ISLANDS

CLAUDIA CORTI - ROBERTO SINDACO
PIETRO LO CASCIO - ALAN LEVITON (eds.)

HERPETOFAUNA

OF THE ISLANDS OF THE MEDITERRANEAN BASIN



Preface by:
Leonidas-Romanos Davranoglou

Introduction by:
Johannes Foufopoulos

Texts by: **Francesco Allegrino, Hugues-Alexandre Blain, Wolfgang Böhme, Apostolos Christopoulos, Claudia Corti, Michel-Jean Delaugerre, Massimo Delfino, Charalampos G. Fassoulas, Francesco Gallozzi, Irena Grbac, Klaus Henle, Anthony Herrel, Pietro Lo Cascio, Enrico Lunghi, Petros Lymberakis, Brigitte Marin, Marco Masseti, Frédéric Médail, Panayiotis Pafilis, Maria Panitsa, Salvatore Pasta, Ana Pérez-Cembranos, Valentin Pérez-Mellado, Martina Podnar, Nikolaos Psonis, Roberto Sindaco, Savvas Zotos.**

edizioni danaus

Dedication

I have always felt a strong connection to the sea, and the islands scattered across its waters have always held a great fascination for me. Captivated since childhood by Robert Louis Stevenson's tales, I was convinced that islands harbored hidden treasures; that is why I have always longed to explore them.

I harbor a deep respect and love for these places – sometimes so small, delicate, and vulnerable – but above all, each one so unique. Whenever the boats that brought me there set sail to return to the mainland, I am filled with a profound sense of peace and freedom.

I have been fortunate enough to visit them often, returning to the same islands time and again for my studies, delving into their "simple" complexity, and discovering new facets on each visit – it has always been a deeply enriching experience! The islands taught me to observe them carefully, without prejudice, to humbly focus not on what most attracted me, but on the whole.

I have always been good at not simplifying my life, but this time I took a risk by involving my esteemed colleagues, young and "old", who agreed to share this project.

I am particularly grateful to Alan Leviton, formerly a senior curator at the California Academy of Sciences in San Francisco, with whom I outlined the structure of this volume several years ago; I also thank the CAS and its Department of Herpetology – and in particular my colleagues at the time – Bob (Robert) Drewes, Jens Vindum, and my friend Carol Prince – for always making me feel at home.

My thoughts turn to my mentor, Benedetto Lanza, who in 1989 sent me to Canterbury to attend the First World Congress of Herpetology; while staffing the *Societas Europaea Herpetologica* (SEH) stand alongside Wolfgang Böhme, Valentin Pérez Mellado, and Efstratios Valakos, we laid the groundwork for a conference dedicated entirely to Mediterranean lacertids – with a particular focus on island populations – an event that continues to this day and paved the way for close, intensive collaborations.

I would like to thank all the colleagues who contributed to this project, my dear friends Michel and Pietro—excellent naturalists with whom I shared years of fieldwork, as well as long, damp, yet unforgettable nights spent on small islands studying tiny geckos. Heartfelt thanks go to Ana, Anthony, Brigitte, Charalampos, Frédéric, Hugues-Alexandre, Irena, Johannes, Klaus, Marco, Maria, Martina, Massimo, Nikolaos, Petros, Panayiotis, Salvatore, Savvas and Valentin, who, over the years and with great expertise, have demonstrated that studying islands is a rewarding activity.

I wish a prosperous future to Apostolos, Enrico, Francesco, and Leonidas, the young and promising Mediterranean zoologists who contributed to this volume. Finally, I wish to express my deep friendship for Roberto, with whom I shared fruitful expeditions in the Caucasus and important publications.

Special thanks to the "*PIM Initiative*" and its entire staff; notably Eva Tankovic; very special thanks go to Fabrice Bernard and Céline Damery of the *Conservatoire du Littoral* (France) for believing in and supporting this project.

I would also like to express my gratitude to the Natural History Museum of the University of Florence, where I studied, trained, and worked for many years, and to the Museum Koenig in Bonn, which gave me the opportunity to count hundreds of scales.

On this occasion, I wish to pay tribute to esteemed herpetologists who are no longer with us – scientists with whom I had the honor of collaborating and the privilege of connecting. I remember with affection Bettino (Benedetto) Lanza, whose passion for natural history – and specifically for amphibians and reptiles – inspired me to dedicate myself to herpetology steering me away from marine biology; as well as Nick (Edwin Nicholas) Arnold and José Miguel Alfredo María Cei, from whom I learned a great deal; and also Felix D. Danielyan (Armenia), Martin Eisentraut (Germany), Werner Mayer (Austria), Hans Schneider (Germany), Joe (Joseph B.) Slowinski, and David B. Wake (USA), with whom I had the opportunity to interact. A special thought goes to my husband, Riccardo Saccardi, an excellent medical researcher, who has always supported me in my work.

To all those who read this book – which I hope you will enjoy – I would like to point out that studying island communities, especially those on smaller islands, requires particular attention, respect, expertise, great patience, a strong sense of responsibility, and, not least, humility. Communities defined by delicate balances must be treated with the utmost care; these places must be explored and experienced with extreme caution – almost on tiptoe.

Claudia Corti

Index

- **DEDICATION** [*Claudia Corti*] pag. 5
- **PREFACE** [*Leonidas-Romanos Davranoglou*] » 9
- **INTRODUCTION** [*Johannes Foufopoulos*] » 11
- **GENERAL SECTION** » 15

Geological history of the Mediterranean Region
[*Charalampos G. Fassoulas*] » 17

The vascular flora and the plant communities of the Mediterranean islands: a biogeographical and historical sketch
[*Salvatore Pasta, Frédéric Médail, Maria Panitsa*] » 25

The fossil herpetofaunas of the Mediterranean islands: the past distribution of the Extant Taxa
[*Massimo Delfino, Hugues-Alexandre Blain*] » 87

Endemic and anthropochorous herpetofauna of the Mediterranean islands
[*Marco Masseti*] » 113

Molecular phylogenetics insights into the historical biogeography of Mediterranean islands' Amphibians and Reptiles
[*Petros Lymberakis and Nikolaos Psonis*] » 157

A historical overview of Mediterranean insular herpetological research
[*Wolfgang Böhme*] » 175

When conservation underestimates populations' value: from target definition to strategies
[*Francesco Gallozzi, Anthony Herrel, Valentín Pérez-Mellado, Ana Pérez-Cembranos, Klaus Henle, Claudia Corti*] » 195

Afterword - Islands in history
[*Brigitte Marin*] » 201

- **CASE STUDIES** » 207

The lizards of the Balearic Islands. A case study of the insular Mediterranean fauna
[*Valentín Pérez-Mellado and Ana Pérez-Cembranos*] » 209

Islands within islands: the case of European plethodontids
[*Enrico Lunghi*] » 225

Lizards and Eleonora's falcon interactions
[*Michel Delaugerre and Pietro Lo Cascio*] » 229

- **SPECIAL SECTION** » 231

The Mediterranean islands and their herpetofauna
[*Claudia Corti, Pietro Lo Cascio and Roberto Sindaco*] » 233

Checklist of the amphibians and reptiles of the Mediterranean islands
[*Claudia Corti and Roberto Sindaco*] » 237

Mediterranean islands hosting herpetofauna
[*Claudia Corti, Roberto Sindaco, Pietro Lo Cascio, Francesco Allegrino, Apostolos Christopoulos, Michel-Jean Delaugerre, Irena Grbac, Petros Lymberakis, Panayiotis Pafilis, Ana Pérez-Cembranos, Valentin Pérez-Mellado, Martina Podnar, Savvas Zotos*] » 245

Distribution maps
[*Roberto Sindaco and Claudia Corti*] » 351

Photographs of endemic and "island specialist" species » 383

Affiliations of Authors and Editors » 393

Preface

Mediterranean islands have occupied a special place in the natural sciences since the time of Aristotle, more than 2,300 years ago. This should come as no surprise, given that insular ecosystems serve as natural laboratories where evolution, colonisation, extinction, and adaptation unfold on a scale that can be observed even in our short human lifespans, in manners endlessly fascinating.

Yet islands should not be perceived as merely isolated fragments of land scattered across the sea. As the present oeuvre demonstrates, each island is its own universe that is characterised by a unique combination of geological and climatic history, species interactions, and human influence. Some islands emerged from ancient tectonic events, while others were repeatedly connected to and separated from continental landmasses by changing sea levels. Some harbour lineages that have persisted for millions of years, while others are home to species that arrived in more recent times, whether by natural dispersal or through human agency.

The Mediterranean Basin comprises thousands of islands and islets, which are characterised by a complex herpetofauna that has arisen through complex layers of geological upheavals, climatic oscillations, ecological interactions, and, increasingly, the actions of our own species. Humans have been shaping Mediterranean islands for millennia, by transforming landscapes, altering habitats, transporting species across seas, and inadvertently creating novel ecological communities; even in the smallest uninhabited islets, the histories of their herpetofauna cannot be understood without acknowledging this deep and enduring human presence.

At the same time, we find ourselves living during a period of unprecedented environmental change, where even our own traditional way of life, our own ecosystem, moulded by millennia of cultural adaptation to the Mediterranean realm, has also been forever disrupted. Biological invasions, habitat degradation, altered fire regimes, climate change, and sea level changes are reshaping island ecosystems at a pace never witnessed in the historical record. These challenges are particularly acute on islands, where ecological balances are often delicate and where the loss of a single population may represent the disappearance of an irreplaceable and globally unique evolutionary lineage.

It is therefore difficult to imagine a more timely moment for a synthesis such as the current volume. This work represents the most comprehensive account of Mediterranean insular herpetofaunas assembled to date, bringing together centuries of observations by naturalists and decades of state-of-the-art, multinational research. The chapters contained herein are the product of the collective efforts of leading specialists in the field, some with a lifetime of experience studying Mediterranean biodiversity, and others at earlier stages of their careers, who are already leaving a substantial mark in the field of island biodiversity.

Perhaps the most important lesson conveyed throughout these pages is that islands resist simplification. Generalisations that may appear reasonable at one scale often fail when confronted with the unique realities of a particular island – theory and practice, after all, can represent entirely different realms. Effective conservation therefore requires humility; to understand an island, one must first understand its individuality. The chapters that follow offer precisely such an opportunity. They reveal the Mediterranean as an archipelago of worlds, each carrying its own evolutionary legacy. They remind us that biodiversity is not simply a catalogue of species, but the cumulative result of countless interactions that have been taking place across space and time.

In this tumultuous era, humanity remains uniquely equipped to address many of the challenges facing island ecosystems. Yet any solutions must begin with an appreciation of our place within nature. We are not external observers of these systems, but participants in them, one species among many, albeit one with an extraordinary capacity to alter the world around us. The responsibility that follows is clear: to understand before we act, to conserve before we lose, and, as has often been said of islands, to proceed with care, curiosity, and respect.

Most importantly, this monumental work clearly demonstrates that to achieve lasting conservation outcomes on the Mediterranean islands, and to properly unveil their carefully hidden mysteries, cooperation between people from different ethnicities, creeds and experiences is required. We are children of the Mediterranean, after all.

Leonidas-Romanos Davranoglou
Oxford University Museum of Natural History, University of Oxford;
The Steinhardt Museum of Natural History, Tel Aviv University

Introduction

It is with a sense of great professional satisfaction that I welcome the publication of *Herpetofauna of the Islands of the Mediterranean Basin*. This is a landmark volume that brings together an extraordinary breadth of scientific expertise, uniting the minds of the foremost authorities on Mediterranean geology, botany, paleontology, molecular genetics, and field herpetology under a single, cohesive framework. The academic quality demonstrated by the contributing authors elevates this work beyond a simple regional compilation; it is an important, comprehensive synthesis that is both timely and necessary. Timely because a decades-deep body of accrued knowledge requires integration, but also necessary as the ecosystems of the Mediterranean face unprecedented anthropogenic pressures requiring coherent background knowledge.

Historical and Scientific Importance of Mediterranean Islands

The Mediterranean Basin has long played a foundational role in the development of European science, serving as the geographic cradle where early natural philosophers first sought to categorize and understand the physical world. From the empirical biological observations of Aristotle and Theophrastus to the early modern geologists who elucidated the principles of stratigraphy along Italian shores, this region has consistently structured our understanding of the natural world. Within this vast basin, the diverse island archipelagos have emerged as further epicenters of scientific inquiry. Their complex geological histories, steep environmental gradients, and clear geographic boundaries create distinct, isolated systems that are tractable enough that complex patterns of continental biology can be distilled into readily understood processes. For over three centuries, these archipelagos have functioned as natural laboratories, offering modern researchers a setting to test foundational theories of diversification, community assembly, and population persistence.

Advancing Ecological and Evolutionary Science

The study of Mediterranean herpetofaunas has been instrumental in advancing the broader discipline of **ecology**, particularly regarding our understanding of how the spatial set-up and resource constraints shape species community structure and life-history strategies. Seminal research projects investigating the dietary shifts and population densities of insular lacertids—such as those exploring the dietary flexibility of the *Podarcis* lizards —have demonstrated how species adapt to the severe seasonal resource limitations characteristic of small islets. These studies have shown that in the absence of diverse communities of competitors, island reptiles frequently expand their ecological niches, transitioning toward omnivory and frugivory. This dynamic reveals the pliable nature of trophic interactions and highlights how food availability and intense intraspecific competition alter behavioral and functional ecology.

In **evolutionary biology**, the region's reptiles and amphibians have provided crucial empirical evidence for microevolutionary processes, morphological divergence, and physiological adaptation. Early landmark studies by M. Soulé on the genetic make-up and morphological shifts of insular lizard populations relative to their mainland counterparts set the stage for our understanding of evolution on islands. Investigations into the rapid evolution of specialized structures, such as the modification of digestive tracts and bite-force mechanics in response to shifting dietary pressures, underscore the capacity for rapid phenotypic adaptation within isolated environments. Furthermore, molecular phylogenetic analyses across the Aegean, Balearic, and Adriatic archipelagos have illuminated how vicariance, driven by geological events like the Messinian Salinity Crisis, interacts with long-distance dispersal to shape modern biodiversity patterns.

Within **conservation biology**, Mediterranean island herpetofaunas have served as critical models for studying the mechanics of population extinction and the compounding impacts of habitat fragmentation. Empirical research calculating historical extinction rates of reptile populations across land-bridge archipelagos since the Last Glacial Maximum has demonstrated how island area, duration of isolation, and topography interact with shifting climates to drive localized extirpations. These studies provide a predictive framework for modern conservation, revealing that specialized, cold-

adapted, or mesic-dependent species are disproportionately vulnerable to climate change and human-mediated habitat degradation. Furthermore, our understanding of small declining island reptile populations has been fundamentally advanced by the careful studies on the *Podarcis* wall lizards. As a result, the Mediterranean has become a key testing ground for designing conservation strategies that account for long-term climate dynamics and the genetic value of isolated, endemic lineages.

Historical Trajectories of Mediterranean Herpetology

To fully appreciate the contribution of this volume, it must be situated within the rich historical context of past herpetological work across the Mediterranean. Early systematic foundations were laid by pioneering European naturalists who mapped the distinct compositions of various island subgroups. For example, for the Aegean Sea, the most diverse Mediterranean archipelago, Franz Werner's seminal monograph *Die Amphibien und Reptilien Griechenlands* (1938), as well as Wettstein's *Herpetologia Aegea* (1953) established the first comprehensive regional baseline. Similarly, the unique, relic-rich herpetofauna of the Balearic Islands received definitive attention in the foundational works of Valentín Pérez-Mellado, whose decades of systematic and ecological publications, redefined our understanding of Western Mediterranean insular ecosystems. These historical works set the stage for modern synthesis by detailing the basic distributions that modern researchers now analyze through advanced ecological and molecular lenses.

Global Archipelagos and the Evolution of Island Theories

On a global scale, islands have consistently driven the conceptual advancement of ecology, population biology, and evolutionary theory. The foundation of evolutionary biology itself was forged in archipelagos, where Charles Darwin's observations on the Galápagos and Alfred Russel Wallace's field studies across the Indo-Australian Archipelago (the 'Malay Archipelago') revealed the geographic mechanisms of species diversification and natural selection. A century later, the field of ecology was mathematically transformed by Robert H. MacArthur and Edward O. Wilson's *The Theory of Island Biogeography* (1967), which used island systems to formalize the relationship between immigration, extinction, area, and isolation. This equilibrium model was subsequently refined and expanded into real-world terrestrial landscapes by researchers like Jared Diamond, whose studies on the birds of the Southwest Pacific islands linked biogeographical theory to community assembly rules and conservation design.

In parallel, islands proved indispensable for developing modern population biology paradigms. Ilkka Hanski's research on the Åland islands, led to the formulation of metapopulation dynamics was deeply rooted in the patchy, island-like distribution of habitats, utilizing discrete spatial networks to model how localized extinctions are balanced by recolonization events. Furthermore, Gary Polis's pioneering work on the islands of the Sea of Cortez (Gulf of California) revolutionized ecosystem ecology through the theory of ecological subsidies. By studying insular food webs, Polis demonstrated how marine inputs—such as shore drift, marine carrion, and seabird guano—substantially subsidize terrestrial consumers, fundamentally reshaping our understanding of nutrient transport and consumer-resource dynamics across ecosystem boundaries.

Despite the foundational role of islands globally, contemporary herpetological literature has been characterized by a distinct geographic imbalance. For the past several decades, empirical synthesis and theoretical modeling within island herpetology have been disproportionately dominated by research out of other major archipelagos. The West Indies (Caribbean), driven by Jonathan Losos's extensive work on *Anolis* adaptive radiations, has long served as the textbook standard for ecological niche conservatism and replicated evolution. Similarly, the species-rich systems of the Philippines, the South Pacific archipelagos, and the desert islands of the Sea of Cortez have generated massive, integrated volumes detailing their herpetofaunal ecology and biogeography.

In comparison, the accumulated knowledge of the Mediterranean Basin has lagged, remaining scattered across fragmented, country-specific journals, localized checklists. This fragmentation has obscured the global significance of Mediterranean systems from the broader scientific consciousness. *Herpetofauna of the Islands of the Mediterranean Basin* decisively closes this critical gap. By presenting an integrative, synthetic, and cross-boundary volume, this book breaks entirely new ground, elevating Mediterranean insular herpetology to its rightful place alongside the most thoroughly studied archipelagos of the planet.

Structural Preview of the Volume

The architecture of this volume is deliberately designed to guide the reader from macro-environmental baselines to fine-scale biological realities, culminating in actionable conservation strategies. The **General Section** establishes the foundational physical and historical parameters of the basin. It opens with an examination of the region's complex geological history by Dr. Fassoulas, providing the essential paleogeographic timeline required to understand modern isolation. This is complemented by Salvatore Pasta, Frédéric Médail, and Maria Panitsa's

biogeographical sketch of vascular flora, which maps the structural and botanical communities that dictate terrestrial energy budgets.

The historical timeline is further deepened by Massimo Delfino and Hugues-Alexandre Blain's synthesis of fossil herpetofaunas, tracking the past distributions of extant taxa and establishing baseline natural ranges before human intervention. Marco Masseti then sheds light on the complicated layers of human influence by distinguishing between endemic lineages versus anthropochorous introductions. This historical-biogeographical baseline is brought into the modern molecular era by Petros Lymberakis and Nikolaos Psonis, who utilize molecular phylogenetics to reveal cryptic diversifications and vicariant splits. The section appropriately concludes with an elegant historical overview of Mediterranean insular herpetological research by Wolfgang Böhme, anchoring modern inquiries within the efforts of past generations.

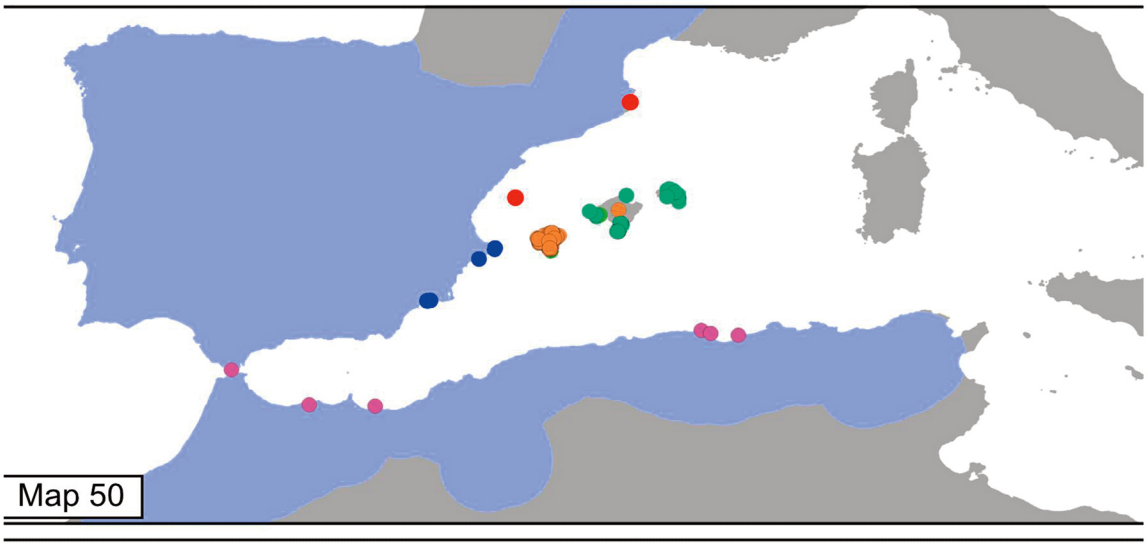
Building directly upon these regional baselines, the **Case Studies** section shifts focus to highly specific, empirical ecological interactions that illustrate broader evolutionary themes. Valentín Pérez-Mellado and Ana Pérez-Cembranos present a comprehensive assessment of Balearic lizards, offering a definitive model for insular behavioral adaptation and plant-animal mutualisms. Enrico Lunghi explores micro-spatial isolation through the lens of European plethodontid salamanders, demonstrating how subterranean micro-refugia create "islands within islands." Shifting to interspecific interactions, Michel Delaugerre and Pietro Lo Cascio document the fascinating, specialized trophic interactions between insular lizards and Eleonora's falcon (*Falco eleonorae*), showcasing how avian predators introduce massive seasonal marine subsidies into terrestrial reptile food webs.

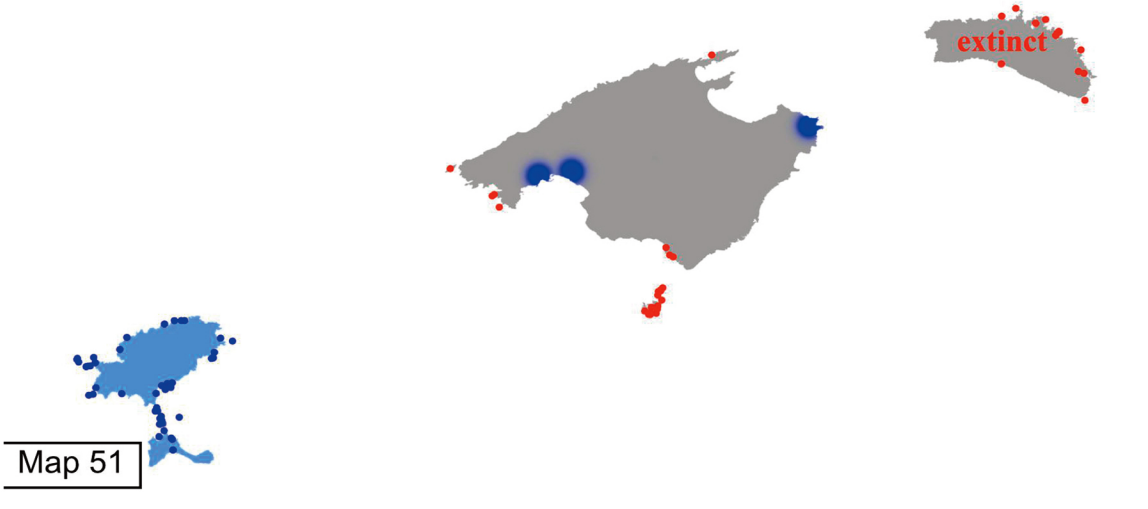
These ecological insights feed directly into the **Conservation** section, where Francesco Gallozzi, Anthony Herrel, and colleagues confront the systemic mismatches between political conservation boundaries and biological realities. This section highlights how traditional conservation strategies frequently underestimate the evolutionary value of distinct insular populations, providing a vital framework for transforming localized data into regional preservation initiatives. Finally, the book moves toward its conclusion with an **Afterword** by Brigitte Marin, who contextualizes these ecological networks within the broader human history of Mediterranean island societies. The volume concludes with an invaluable **Special Section**, including definitive checklists, island indices, and precise distribution maps prepared by Claudia Corti, Roberto Sindaco, and an extensive network of regional collaborators. This ensures that the book remains an irreplaceable reference work for decades to come.

Ultimately, *Herpetofauna of the Islands of the Mediterranean Basin* succeeds because it treats the region not as a collection of isolated political territories, but as a unified, historically complex, and dynamically connected biological system. It takes an interdisciplinary approach by weaving together geology, paleontology, molecular approaches, and modern community ecology into a single, compelling *corpus* of knowledge. This book stands as a definitive monument to Mediterranean natural history, offering an enduring framework that will inspire, inform, and guide herpetologists, ecologists, and conservation biologists for generations to come.

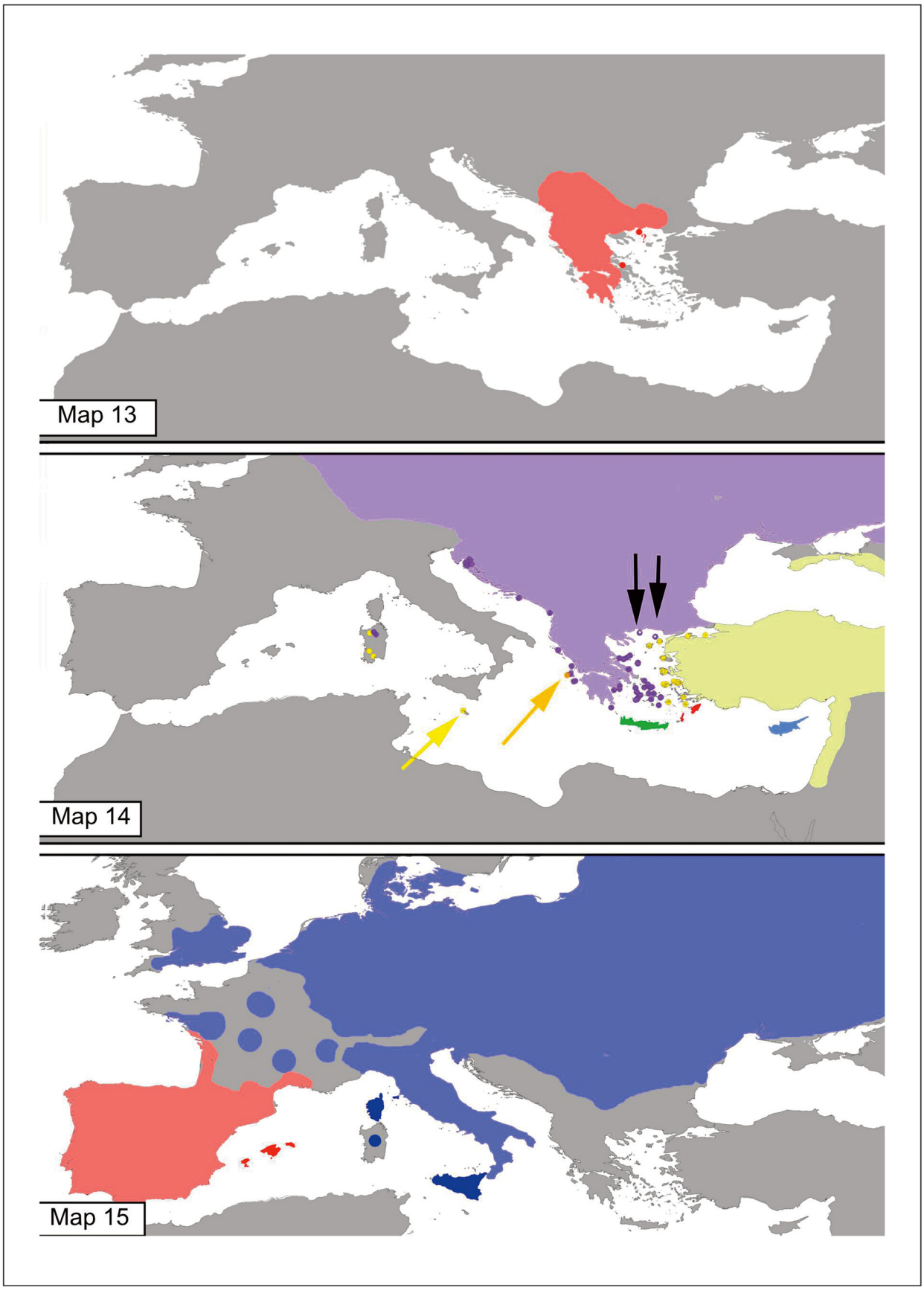
Johannes Foufopoulos
Ann Arbor, Michigan, USA





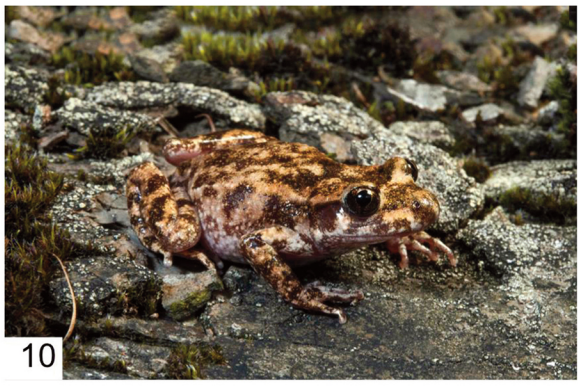


Map 49 – *Podarcis muralis.*
Map 50 – *Podarcis hispanicus* complex (blue range). *P. liolepis* (red dots), *P. hispanicus* (dark blue dots), *P. vaucheri* (purple dots). *P. lilfordi* (green), *P. pityusensis* (orange).
Map 51 – *Podarcis lilfordi* (red), *P. pityusensis* (blue). *P. lilfordi* is extinct on the main island of Menorca. On Mallorca, *P. pityusensis* is an introduced species. The red dots indicate the area where *P. lilfordi* is still present.



Map 13 – *Rana graeca*.
Map 14 – *Pelophylax ridibundus* (incl. *P. kurtmuelleri*) (purple), *P. bedriagae* (yellow), *P. cerigensis* (red), *P. cretensis* (green), *P. cypriensis* (blue), *P. epeiroticus* (orange).
Map 15 – *Pelophylax lessonae* (incl. *P. esculentus* and *P. hispanicus*) (blue) and *P. perezi* (red).


9


10


11


12


13


14


15


16

Fig. 9 - *Salamandra corsica*. Corsica (photo R. Sindaco).
Fig. 10 - *Alytes muletensis*. Mallorca (photo B. Trapp).
Fig. 11 - *Discoglossus montalentii*. Corsica (photo R. Sindaco).
Fig. 12 - *Discoglossus sardus*. Corsica (photo R. Sindaco).
Fig. 13 - *Bufotes cypriensis*. Cyprus (photo E. Razzetti).
Fig. 14 - *Bufotes viridis*. Krk (photo R. Sindaco).
Fig. 15 - *Hyla sarda*. Sardinia (photo C. Corti).
Fig. 16 - *Pelophylax cerigensis*. Karpathos (photo A. Christopoulos).


41


42


43


44


45


46


47


48

Fig. 41 - *Podarcis levendis*. Pori (photo A. Christopoulos).
Fig. 42 - *Podarcis lilfordi*. Sen Trosqueta near Minorca (photo A, Pérez Cembranos).
Fig. 43 - *Podarcis melisellensis*. Cres (photo R. Sindaco).
Fig. 44 - *Podarcis milensis*. Megali Akradia (photo A. Christopoulos).
Fig. 45 - *Podarcis muralis*. Port Cros (photo C. Corti).
Fig. 46 - *Podarcis pityusensis*. Escull de s'Espartar near Ibiza (photo A, Pérez Cembranos).
Fig. 47 - *Podarcis raffonei*. Strombolicchio (photo P. Lo Cascio).
Fig. 48 - *Podarcis siculus*. Lisca Bianca near Panarea, Sicily (photo P. Lo Cascio).

This volume documents the Mediterranean islands where the presence of at least one species of herpetofauna has been recorded to date. The work is essentially divided into two parts: the first is a general section covering geological, botanical, paleontological, and archaeozoological aspects, as well as biogeography, Mediterranean islands' history, the history of herpetology on the Mediterranean islands, and conservation. This is followed by a section dedicated to the individual islands where herpetofauna has been detected; it presents species lists for the various islands, images of endemic species and those considered "island specialists," and distribution maps for all species found on the islands.









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