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## Frontiers of Biogeography

### Title

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### Permalink

<https://escholarship.org/uc/item/30z7q1q2>

### Journal

Frontiers of Biogeography, 11(2)

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### Publication Date

2019

### DOI

10.21425/F5FBG43921

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## A review of Aegean terrestrial biodiversity

Biogeography and biodiversity of the Aegean. In honour of Prof. Moysis Mylonas by Spyros Sfenthourakis, Panayotis Pafilis, Aristeidis Parmakelis, Nikos Poulakakis and Kostas A. Triantis (editors) 2018, Broken Hill Publishers Ltd, Nicosia, 300 pp., ISBN: 9789925563784. [www.brokenhill.com.cy/product/biogeography-and-biodiversity-of-the-aegean/](http://www.brokenhill.com.cy/product/biogeography-and-biodiversity-of-the-aegean/)

With about 8,000 islands and islets, the Aegean Islands are one of the largest archipelagos in the world, which, in itself, can already explain the interest of generations of biogeographers in these islands. But many other aspects make these islands so fascinating to biogeographers. First, the Aegean Islands are extremely variable in size. Beside a large number of islands of a few dozens square meters or hectares, they include about 400 islands that exceed one square kilometer and several large islands of hundreds of square kilometers (Crete, the largest one, is 8,261 km<sup>2</sup>) (Arnold 2008). Thus, their size spans over eight orders of magnitude, which makes them an ideal subject to investigate the multiple aspects of one of the most important biogeographical patterns, the species–area relationship (Fattorini 2002, 2006a, Fattorini et al. 2017). Second, these islands show a high degree of variation in their isolation from the mainland and each to other. Euboea is, in fact, more a sort of peninsula than an island, and many islands are just a few kilometers from the mainland; but others are more than 200 km far (Heller 1976). On the other hand, distance to the mainland does not always reflect island isolation because many islands are very close to each other. Actually, within the Aegean Islands, it is possible to recognize several island clusters that form small but well defined archipelagos in their own, such as the Cyclades or the Northern Sporades, characterized by different faunas and floras, and which can be recognized as phytogeographical or zoogeographical subregions (e.g., Strid 1996, Fattorini 2002, Panitsa et al. 2018). Moreover, many islands are surrounded by satellite islets, thus forming micro-archipelagos such as the case of Santorini, Astypalaia, Kalymons and Nisyros island groups. Crete is studded by islets, in respect of which it may be considered a sort of mainland. This high variability in inter-island isolation and distance to mainland also offers the opportunity to investigate colonization processes involving both long distance and stepping stone dispersal. Third, the islands vary greatly in their altitude (which in turn reflects their habitat diversity), with Crete reaching 2,456 m a.s.l., thus showing a great diversity in within-island heterogeneity and allowing the study of elevational gradients (Chatzaki et al. 2005).

If area, isolation and elevation are important to explain current island biodiversity patterns, the complex history of the Aegean makes these islands also a unique natural laboratory to explore the influence of historical factors on species assemblages. On the one hand, the Aegean Islands include both oceanic and land-bridge/continental islands; that is, islands that were never connected to the mainland vs. islands that were formerly part of, or were connected to, the mainland (Fattorini 2002, 2007). On the other hand, they are at the crossroads of three continents (Europe, Asia and Africa), thus receiving species from very different mainland floras and faunas (Strid 1996, Fattorini 2002, Fattorini and Fowles 2005). In fact, the whole Aegean area was formerly a continuous landmass, called “Aegaeis”, which underwent an extremely complex geological evolution (Fattorini 2007, Comes et al. 2008, Cellinese et al. 2009, Fassoulas 2018). Most areas corresponding to the current islands were subject to processes of disconnection and reconnection with the adjacent mainland and/or other islands (notably during the Pleistocene changes in sea level), but some emerged as oceanic islands and were subject to repeated volcanic eruptions. Thus, the current biota of many islands is a result of interchange and relaxation processes that spanned over millions of years, but some islands were colonized only recently (Dennis et al. 2000). If, on one hand, Crete is an ancient and isolated island which hosts relict species (with, for example, several phyletic lineages of the *Albinaria* molluscs whose origin and distribution reflect the geography of the island during its fragmentation in the mid-Miocene; Welter-Schultes 2001, Cellinese et al. 2009, Schilthuizen 2018), on the other hand most of the species currently present in the islands of the Santorini group are probably of recent immigration due to the continuous volcanic activity of this area (Dennis et al. 2000) (Nea Kameni, a small islet of only 3.4 km<sup>2</sup>, emerged less than 400 years ago; Bowman 1993). Thanks to this long and complex history, the Aegean Islands are characterized by high values of species richness and endemism, which make them a narrow hotspot of biodiversity within the broader Mediterranean hotspot (e.g., Fattorini 2006a,b).

Last but not least, the Aegean Islands had a history of human influence that dates from the pre-Neolithic period, with important impacts on species distributions

(Dennis et al. 2000, Masseti 2018). The landscape of most of the major islands has been more or less profoundly altered by a millenarian human exploitation, and many islands are now important tourist destinations, which poses serious threats to biodiversity conservation (Arnold 2008, Fattorini 2008; Fattorini et al. 2016)

It is therefore not surprising that the Aegean Islands have attracted the attention of many naturalists and have become one of the most investigated archipelagos from a biogeographical point of view (see reviews in Hausdorf and Hennig 2005, Fattorini 2006c). However, due to historical and socio-economic reasons, the biological exploration of this area has been mostly made by non-Greek people until very recent times. The situation changed in the 1980s mainly thanks to the activity of the Greek malacologist Moysis Mylonas, to whom this book is dedicated. Professor Moysis Mylonas can be considered the founder of the Greek biogeographical school, and all the editors of this book were (directly or indirectly) Mylonas' students. This can be appreciated by the list of Mylonas' publications and PhD theses by Mylonas' students that is also provided at the end of the book. Indeed, the Preface is dedicated to illustrate the merits of Professor Mylonas in promoting the study of the Aegean biogeography (Sfenthourakis et al. 2018), whereas the first chapter (Cameron 2018) is dedicated to Mylonas' contribution to Greek malacology. The complex evolution of the Aegean area is reviewed by Fassoulas (2018), whose detailed synthesis is illustrated by paleogeographical maps that represent the state of the art and, I think, will be useful to any biogeographer interested in these islands.

A large part of the book is devoted to describing the diversity of several terrestrial groups in the Aegean in particular, often with references to the whole of Greece. Not surprisingly, given the dedication of Prof. Mylonas to malacology, three chapters are dedicated to molluscs. Vardinoyannis et al. (2018) present an overview of the land mollusc diversity in Greece (695 species, 59% of which endemic), whereas Schilthuizen (2018) discusses the causes (possibly including local selection by predators and harsh abiotic conditions) of the impressive radiation in *Albinaria*, a genus endemic to the Aegean and which includes about 140 species. Radea (2018) examines the freshwater valvatiform hydrobiid molluscs of Greece: the Balkan peninsula appears as an important evolutionary center for the western Palaearctic fauna, hosting about 63% of the genera (82% of which are endemic), with many species under threat.

Sfenthourakis and Schmalzfuss (2018) review the biogeography of Greek terrestrial isopods, presenting a brief illustration of the spatial variation in species richness and endemism among the biogeographical regions of Greece, along with some observations about elevational gradients, the possible factors (including competitive exclusion) for allopatric distributions, the shape of the species–area relationship in the Aegean Islands, the role of paleogeographical and ecological factors in determining current distributional patterns, the possibility of recognizing functional groups, and the conservation status of these crustaceans. Chatzaki and Kaltsas (2018) present an overview of the progresses

in the taxonomy, ecology, and biogeography of Greek spiders over the past twenty years. It is apparent from their review that, in spite of the great diversity (1,121 known species), distributional data are still scattered (with many islands without records) and ecological and biogeographical research is very limited. This is even more extreme in the case of scorpions, whose diversity has been mainly uncovered in the last decade through the use of molecular markers, raising from the eight species that were recognized less than a decade ago to 32 confirmed species, most of which cryptic, plus a number of unassigned taxa, making Greek fauna the most diverse in Europe (Fet et al. 2018). The picture emerging from the recent discovery of this impressive cladogenesis has changed considerably previous conclusions about the scorpion biogeography of the Aegean Islands, showing a much more complex evolutionary history than previously thought, in which recent colonization processes overlapped with relict faunas (as indicated by the presence of many island endemics). The geophilid centipede fauna (ten species) of the Aegean Islands is reviewed by Kardaki et al. (2018), who report locality records for 1,083 specimens from 85 islands and islets.

Anastasiou et al. (2018) provide an account of the faunistic and taxonomic research conducted on the tenebrionid beetles of the Aegean Islands from the nineteenth century to the present. They further present a critical evaluation of species richness data and a brief review of the known biogeographical patterns of this group, including the species–area relationship, the influence of current and historical process in determining species richness, levels of endemism, and inter-island relationships, with some considerations about taxonomic problems. This review is enriched with the contribution of recent phylogeographic studies to understand the role of ecological and historical processes in the diversification of tenebrionid lineages across the Aegean. Recently, Sfenthourakis and Triantis (2017) expressed the idea that the main conclusions about tenebrionid distribution on the Aegean islands presented by Fattorini (2002) were “largely incongruent” and “were probably the result of using an incomplete data set”. They also affirmed that this problem undermines results reported in Fattorini (2006a,b,c, 2007). The questioned conclusions are: (1) that there is clear faunal discontinuity between western plus central Aegean and eastern islands, as a result of Pleistocene island configurations; (2) that the Aegean tenebrionids are relictual; and (3) that most tenebrionid species colonized the Aegean islands by means of land-bridges during Pleistocene falls of sea level. Actually, these conclusions are perfectly congruent because it is the Pleistocene island configuration that determined the observed discontinuity, and this is an indication that the fauna is relictual, not equilibrial. Interestingly, the same authors presented a study in this book (Triantis et al. 2018) in which tenebrionids are used, which seems in contrast with their assumption they are poorly known. Unfortunately, Triantis et al. (2018) do not report which data they used, which makes it impossible to see how these are different from those used in the questioned analyses.

Lymberakis et al. (2018) follow a similar approach, describing the role of molecular tools in disclosing the hidden diversity and complicated phylogenies of amphibians (26 species, with three endemics) and reptiles (69 species, with 12 endemics). They further discuss in detail the ecophysiological adaptations of insular populations to survive under the demanding conditions of Aegean islands and the conservation status of their herptile fauna.

The last part of the book focuses more explicitly on Aegean biogeography patterns and processes. This block starts with a chapter on fossil vertebrates, which opens a window on the influence of human colonization on the original fauna of the East Mediterranean islands through species introductions and extinctions. The emerging picture is that of an insular world populated by endemic dwarf elephants and hippopotamuses, endemic cervids, peculiar reptiles, and even giant birds of prey (Masseti 2018). The historical perspective on the build-up of Aegean fauna is further enlarged by Panitsa et al. (2018), who delve on the phytogeographical subdivisions of the Aegean and their levels of endemism, the possible factors responsible for plant diversification (mainly as a result of genetic drift due to geographical isolation), the role of climate, area, elevation, habitat diversity, substrate and isolation in determining patterns of species richness and distribution, the peculiarities of small island floras, and the incidence of alien species. The recent diversification of Aegean flora is exemplified by the detailed description of the recent and rapid radiation in the genus *Nigella* (Ranunculaceae) through genetic drift presented by Comes and Jaros (2018). The evolution of biogeographical research on the Aegean Islands from studies based on distributional data to phylogeographic analyses using mitochondrial or chloroplast loci and next-generation sequencing is illustrated by Poulakakis and Parmakelis (2018). Finally, a zoogeographical regionalization for the Aegean Islands is proposed by Triantis et al. (2018). The book ends with a list of Mylonas' papers and PhD theses by Mylonas' students.

Due to the variety of issues involved, this book is a key reference for anyone who is interested in the biodiversity of the East Mediterranean. Indeed, it is a stimulating reading for island biogeographers in general. Despite its low price, the book is beautifully illustrated and finely printed. All these reasons make it a must in the reading chairs and shelves of the biogeographers and biodiversity researchers that may be tempted to travel through the white islands surrounded by the deep blue and warm waters of the Aegean Sea.

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- Submitted: 28 December 2018  
Accepted: 5 June 2019  
Edited by Joaquín Hortal