

The land snails (Mollusca, Gastropoda) of Kea island (Aegean, Greece)

Leonidas Maroulis^{‡,§}, Katerina Vardinoyannis^{‡,§}, Danae Karakasi[§], Konstantinos Proios^l, Moïssis Mylonas[‡], Kostas A Triantis^l

[‡] University of Crete, Heraklion, Greece

[§] Natural History Museum of Crete, Heraklion, Greece

^l Faculty of Biology, Department of Ecology and Systematics, National and Kapodistrian University of Athens, Athens, Greece

Corresponding author: Leonidas Maroulis (leomaroulis@gmail.com)

Academic editor: Zoltán Fehér

Abstract

Background

Kea is the westernmost island of the Cyclades and is located between Syros and Attica, in central Greece. In this work, we have resampled the island after 43 years – i.e. when the island was first fully sampled – and we present its complete land snail fauna.

New information

We report 42 land snail species with 10 species being new records for the island. Based on our results we draw attention to the fact that sampling for land snails should be done during the wet period in order to survey the complete malacofauna in an island or a region. For such a complete survey, collection and inspection of soil and litter are also necessary. Finally, increased sampling effort through regular resurveys is a necessary prerequisite in order to effectively assess the temporal dynamics of biodiversity patterns.

Keywords

Aegean archipelago, biodiversity, land molluscs, taxonomy

Introduction

Land molluscs and slugs (henceforth land snails) comprise an important component of global biodiversity, representing one of the most species-rich groups of terrestrial animals with approximately 28,000 recognised species (MolluscaBase 2022). Although poor

dispersers (Cameron 2013, Cameron 2016), land snails are found almost everywhere on Earth (Cameron 2016) and occupy a wide range of habitat types such as deserts, forests, shrublands and alpine meadows.

For their area, islands host a disproportionate high number of species of many taxa (Fernández-Palacios et al. 2021, including land snails (Cowie 2004, Cameron et al. 2013). Global estimates of insular land snail richness, based on faunas of 727 islands, exceed 11,000 species – that is approximately 48% of all known land snail species – on less than 3% of the globe’s land mass, with 75% of them being single island endemics (Proios et al. 2021). Similarly, the Aegean Sea islands hold a unique malacofauna of 419 species, with 51% being regional endemics (Vardinoyannis and Mylonas 2019). Consequently, the Aegean Islands have long attracted scientific attention, having served as a model system for understanding the biogeography of the taxon (Fuchs and Käufel 1936, Heller 1976, Mylonas 1982, Vardinoyannis 1994, Botsaris 1996, Welter-Schultes and Williams 1999, Hausdorf and Hennig 2005, Triantis et al. 2005, Triantis et al. 2008, Goudeli et al. 2021). The systematic and intense study of land snails of the Greek islands, especially during the last four decades, has resulted in more than 150 islands being considered as well-sampled.

However, most of the island faunas have been studied through one or a limited number of field trips and thus our knowledge about their temporal dynamics is limited. In this framework, we studied and herein present the terrestrial malacofauna of Kea (Cyclades, Aegean Sea, Greece), an island that had been previously fully sampled in 1979.

Materials and methods

Study Area

Kea belongs to the Cyclades island group and is located 19.5 km off the mainland of Attica (Map 1). It is 19 km long (from north to south) and 9 km wide (from west to east), overall possessing an area of 131.7 km², with its highest elevation being 560 m. Kea is, geologically, part of the Attic-Cycladic Unit (Papanikolaou 2021) and consists almost exclusively of metamorphic rocks, mainly schist and marble remains (Yoxas et al. 2011). The island’s morphology is characterised by its intense topographic relief and the main (snail) habitat types are phrygana, maquis and *Quercus ithaburensis* forests.

Sampling

Sampling of land snails was carried out between 4 and 8 November 2021 by five malacologists (LM, KV, KP, MM and KAT) at 22 localities (Fig. 1, Suppl. material 1). We collected samples from a great spectrum of ecosystems, including shrublands (phrygana, maquis or mixed), oak forests, riparian vegetation around streams, cultivations, urban and peri-urban areas. Moreover, we gathered soil and litter under various plants. The collected live specimens were drowned in water and then preserved in 75% ethanol. Some of the individuals were also preserved in 96% ethanol for future molecular analyses. In the

laboratory, the collected litter and soil were left to dry and then sieved. A 5-level test sieve was used (with mesh sizes of 5, 2.5, 1.7, 1 and 0.5 mm). Material passing through the 0.5 mm mesh was discarded, while the material obtained from each sieve was examined for small snails under a magnifying lens and good lighting. Shell morphology and reproductive systems were studied to perform identification at the species-level. The entire material collected is deposited in the malacological collection of the Natural History Museum of Crete (NHMC). Additionally, in order to supplement our recovered species list with species potentially not found, but reported in previous works, we re-examined material stored in the malacological collection of NHMC. Previous works reporting snails from the island (Fuchs and Käufel 1934, Fuchs and Käufel 1936, Mylonas 1982, Riedel 1992, Wiktor 2001) were also consulted for distributional data.

Data resources

Land snail species from Kea island

Albinaria discolor (Pfeiffer, 1846)

Material

- a. scientificName: *Albinaria discolor* (Pfeiffer, 1846); order: Stylommatophora; family: Clausiliidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 139D9795-F32F-5A05-8F0B-381A0EFF5E4F

Albinaria turrata (Pfeiffer, 1850)

Material

- a. scientificName: *Albinaria turrata* (Pfeiffer, 1850); order: Stylommatophora; family: Clausiliidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; year: 1979; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: D3DB0C32-BDC6-5A82-A62A-084473E18E98

Cantareus apertus (Born, 1778)

Material

- a. scientificName: *Cantareus apertus* (Born, 1778); order: Stylommatophora; family: Helicidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: L Maroulis; institutionCode: NHMC; occurrenceID: 8BD3B2CF-0510-533B-9249-D83D5EE4C5F5

***Caracollina lenticula* (Michaud, 1831)**

Material

- a. scientificName: *Caracollina lenticula* (Michaud, 1831); order: Stylommatophora; family: Trissexodontidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: D Karakasi; institutionCode: NHMC; occurrenceID: EB929BA7-14F4-5E38-A67A-3E58214C2FFD

***Candidula syrensis* (Pfeiffer, 1846)**

Material

- a. scientificName: *Candidula syrensis* (Pfeiffer, 1846); order: Stylommatophora; family: Geomitridae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 13FFB829-4469-5DFC-AEDE-53D6C6679760

***Cecilioides acicula* (Müller, 1774)**

Material

- a. scientificName: *Cecilioides acicula* (Müller, 1774); order: Stylommatophora; family: Ferussaciidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 0C3728FD-C8A8-52B1-9804-DB60F32BB1DF

***Cecilioides tumulorum* (Bourguignat, 1856)**

Material

- a. scientificName: *Cecilioides tumulorum* (Bourguignat, 1856); order: Stylommatophora; family: Ferussaciidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 6AAE62B8-BE6B-58BA-87AD-03AAA9B6F6C9

Notes: New record from Kea.

***Cernuella virgata* (Da Costa, 1778)**

Material

- a. scientificName: *Cernuella virgata* (Da Costa, 1778); order: Stylommatophora; family: Geomitridae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 3F567ACE-2F46-5E2F-A11A-4710B9A76864

Notes: *Xerocrassa cretica* reported by Martens 1889 and Fuchs and Käufel 1934 is a misidentification of *Cermea virgata*, which is very common on the island and some of its populations share shell characteristics with *Xerocrassa cretica*.

***Chondrula bergeri* (Roth, 1839)**

Material

- a. scientificName: *Chondrula bergeri* (Roth, 1839); order: Stylommatophora; family: Enidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: D Karakasi; institutionCode: NHMC; occurrenceID: 3B524F39-1DA3-5A9A-9582-929E6F9A6CEA

***Chondrus zebrulus* (Férussac, 1821)**

Material

- a. scientificName: *Chondrus zebrulus* (Férussac, 1821); order: Stylommatophora; family: Enidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: C3E7B5F7-8B00-5E3D-9047-EEE40CF17318

***Cochlicella acuta* (Müller, 1774)**

Material

- a. scientificName: *Cochlicella acuta* (Müller, 1774); order: Stylommatophora; family: Geomitridae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: L Maroulis; institutionCode: NHMC; occurrenceID: 32171D18-5BD5-5509-B55A-D89F72733414

***Cornu aspersum* (Müller, 1774)**

Material

- a. scientificName: *Cornu aspersum* (Müller, 1774); order: Stylommatophora; family: Helicidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: L Maroulis; institutionCode: NHMC; occurrenceID: DE1B067D-F697-51CC-A4FE-8EF965DACE6C

***Deroceras keanense* van Regteren Altena, 1973**

Material

- a. scientificName: *Deroceras keanense* van Regteren Altena, 1973; order: Stylommatophora; family: Agriolimacidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: K Vardinoyannis; institutionCode: NHMC; occurrenceID: CD25A3B2-8E59-5DAA-BC77-F61F78191604

Notes: *Derocheras berythense* is not distributed in Greece according to Wiktor (2001) and all the records of *D. berythense* from Kea should be regarded as belonging to *D. keanense*.

***Derocheras laeve* (Müller, 1774)**

Material

- a. scientificName: *Derocheras laeve* (Müller, 1774); order: Stylommatophora; family: Agriolimacidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; year: 1979; identifiedBy: A Wiktor; occurrenceID: 500ACE39-D4F9-5761-9684-8E494823AF86

***Derocheras pseudopanormitanum* Wiktor, 1984**

Material

- a. scientificName: *Derocheras pseudopanormitanum* (Wiktor, 1984); order: Stylommatophora; family: Agriolimacidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/202; identifiedBy: K Vardinoyannis; institutionCode: NHMC; occurrenceID: 79BB4A37-DD23-59CE-80E7-25DED15C671E

Notes: New record from Kea and the Aegean Islands.

***Derocheras seriphium* Wiktor & Mylonas, 1981**

Material

- a. scientificName: *Derocheras seriphium* Wiktor & Mylonas, 1981; order: Stylommatophora; family: Agriolimacidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: K Vardinoyannis; institutionCode: NHMC; occurrenceID: D5698666-D128-5378-8D2F-B2905D4ADD6E

***Eobania vermiculata* (Müller, 1774)**

Material

- a. scientificName: *Eobania vermiculata* (Müller, 1774); order: Stylommatophora; family: Helicidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: L Maroulis; institutionCode: NHMC; occurrenceID: 4D0DB245-4B56-55BA-AAEA-450C57B02BE9

***Granopupa granum* (Draparnaud, 1801)**

Material

- a. scientificName: *Granopupa granum* (Draparnaud, 1801); order: Stylommatophora; family: Chondrinidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece;

countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: D Karakasi; institutionCode: NHMC; occurrenceID: DBE2091E-76AF-5369-A379-2C859575C482

***Helix figulina* Rossmässler, 1839**

Material

- a. scientificName: *Helix figulina* Rossmässler, 1839; order: Stylommatophora; family: Helicidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: L Maroulis; institutionCode: NHMC; occurrenceID: D8471784-2BBF-5461-A77F-E7784EEAE183

***Idyla bicristata* (Rossmässler, 1839)**

Material

- a. scientificName: *Idyla bicristata* (Rossmässler, 1839); order: Stylommatophora; family: Clausiliidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: D Karakasi; institutionCode: NHMC; occurrenceID: 7C113F4E-C211-5F4F-94D4-013662E761A0

***Lauria cylindracea* (Da Costa, 1778)**

Material

- a. scientificName: *Lauria cylindracea* (Da Costa, 1778); order: Stylommatophora; family: Lauriidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: D Karakasi; institutionCode: NHMC; occurrenceID: 67547A2F-F5B8-5551-A663-1D061A20F136

Notes: New record from Kea.

***Lindholmiola lens* (Férussac, 1832)**

Material

- a. scientificName: *Lindholmiola lens* (Férussac, 1832); order: Stylommatophora; family: Helicodontidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: D Karakasi; institutionCode: NHMC; occurrenceID: 89C8B5F4-00DA-53CE-AE5B-8C0A41821284

***Mediterranea hydatina* (Rossmässler, 1838)**

Material

- a. scientificName: *Mediterranea hydatina* (Rossmässler, 1838); order: Stylommatophora; family: Oxychilidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 870017BD-E77A-59D8-9C91-A0A2AF7A8502

***Monacha parumcincta* (Menke, 1828)**

Material

- a. scientificName: *Monacha parumcincta* (Menke, 1828); order: Stylommatophora; family: Hygromiidae; continent: Europ; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: K Vardinoyannis; institutionCode: NHMC; occurrenceID: 355D0EEE-F92C-50CC-B010-65EA0383095F

***Orculella critica* (Pfeiffer, 1856)**

Material

- a. scientificName: *Orculella critica* (Pfeiffer, 1856); order: Stylommatophora; family: Orculidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: L Maroulis; institutionCode: NHMC; occurrenceID: 2EAEB8EC-B825-56FD-8D1A-C76821C5D4D4

***Oxychilus cyprius* (Pfeiffer, 1847)**

Material

- a. scientificName: *Oxychilus cyprius* (Pfeiffer, 1847); order: Stylommatophora; family: Oxychilidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: A1062069-A4DD-5C67-95CE-6856F18F9E5B

***Oxyloma elegans* (Risso, 1826)**

Material

- a. scientificName: *Oxyloma elegans* (Risso, 1826); order: Stylommatophora; family: Succineidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 28F391EC-C916-56D1-8F21-1A2E5D4CABD5

Notes: New record from Kea.

***Paralaoma servilis* (Shuttleworth, 1852)**

Material

- a. scientificName: *Paralaoma servilis* (Shuttleworth, 1852); order: Stylommatophora; family: Punctidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: D Karakasi; institutionCode: NHMC; occurrenceID: 8608E9BB-6447-58E0-B5FB-213DCB2E9174

Notes: New record from Kea.

***Pyramidula cephalonica* (Westerlund, 1898)**

Material

- a. scientificName: *Pyramidula cephalonica* (Westerlund, 1898); order: Stylommatophora; family: Pyramidulidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: E49EFBFC-ECE8-5086-8FC3-E7B6AB8AF7AE

Notes: New record from Kea.

***Pyramidula chorismenostoma* (Westerlund & Blanc, 1879)**

Material

- a. scientificName: *Pyramidula chorismenostoma* (Westerlund & Blanc, 1879); order: Stylommatophora; family: Pyramidulidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; year: 1979; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: FBD040ED-E4E9-589F-B1FD-860978406AD6

***Rumina saharica* Pallary, 1901**

Material

- a. scientificName: *Rumina saharica* Pallary, 1901; order: Stylommatophora; family: Achatinidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: L Maroulis; institutionCode: NHMC; occurrenceID: D0005616-E97B-56B5-ABA5-DF8DFAC8AF4D

***Rupestrella philippii* (Cantraine, 1841)**

Material

- a. scientificName: *Rupestrella philippii* (Cantraine, 1841); order: Stylommatophora; family: Chondrinidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: D Karakasi; institutionCode: NHMC; occurrenceID: C844705F-4911-5DF1-AB01-62A31A9B7F5C

***Tandonia sowerbyi* (Férussac, 1823)**

Material

- a. scientificName: *Tandonia sowerbyi* (Férussac, 1823); order: Stylommatophora; family: Milacidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: K Vardinoyannis; institutionCode: NHMC; occurrenceID: 340B9B5A-AE78-51A5-8B51-9FB1513D3B45

***Theba pisana* (Müller, 1774)**

Material

- a. scientificName: *Theba pisana* (Müller, 1774); order: Stylommatophora; family: Helicidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: L Maroulis; institutionCode: NHMC; occurrenceID: E6E3F70F-7A80-514F-A7B5-F788CF3EDC8B

Notes: New record from Kea.

***Thiessea sphaerostoma* (Bourguignat, 1857)**

Material

- a. scientificName: *Thiessea sphaerostoma* (Bourguignat, 1857); order: Stylommatophora; family: Helicidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 9E1EF6CE-8CC5-5614-96C9-DE8967BDAB15

Notes: *Thiessea cyclolabris* mentioned by Martens (1889) should be regarded as a synonym of *T. sphaerostoma*, after the revision of the genus by Subai (1996).

***Trochoidea pyramidata* (Draparnaud, 1805)**

Material

- a. scientificName: *Trochoidea pyramidata* (Draparnaud, 1805); order: Stylommatophora; family: Geomitridae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 210B4F2E-4DAF-52EE-8B3F-509E5AD084EB

***Truncatellina cylindrica* (Férussac, 1807)**

Material

- a. scientificName: *Truncatellina cylindrica* (Férussac, 1807); order: Stylommatophora; family: Truncatellinidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identificationID: D Karakasi; institutionCode: NHMC; occurrenceID: 56B10542-4454-5AFF-93C6-569064E46221

Notes: New record from Kea.

***Vitrea clessini* (Hesse, 1882)**

Material

- a. scientificName: *Vitrea clessini* (Hesse, 1882); order: Stylommatophora; family: Pristilomatidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece;

countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: FE97783A-E243-5026-B932-740E3E82C868

***Vitrea contracta* (Westerlund, 1871)**

Material

- a. scientificName: *Vitrea contracta* (Westerlund, 1871); order: Stylommatophora; family: Pristilomatidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 066E33B4-BB78-5CAE-BAB5-B7B9FE2B2565

Notes: New record from Kea.

***Vitrea keana* Riedel & Mylonas, 1981**

Materials

- a. scientificName: *Vitrea keana* Riedel & Mylonas, 1981; order: Stylommatophora; family: Pristilomatidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; decimalLatitude: 37.5597; decimalLongitude: 24.3296; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 1A35EFDf-A886-5476-8821-EB07FED998D0
- b. scientificName: *Vitrea keana* Riedel & Mylonas, 1981; order: Stylommatophora; family: Pristilomatidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; decimalLatitude: 37.5813; decimalLongitude: 24.3435; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: BA35B55B-F063-5253-8F77-BAFC6A5FB040

Notes: Fig. 2. The only endemic land snail of Kea.

***Vitrina pellucida* (Müller, 1774)**

Material

- a. scientificName: *Vitrina pellucida* (Müller, 1774); order: Stylommatophora; family: Vitrinidae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: 2BF1877E-1752-51AA-A0A3-47E624FD8785

Notes: New record from Kea and the Aegean Islands.

***Xerotracha conspurcata* (Draparnaud, 1801)**

Material

- a. scientificName: *Xerotracha conspurcata* (Draparnaud, 1801); order: Stylommatophora; family: Geomitridae; continent: Europe; islandGroup: Cyclades; island: Kea; country: Greece; countryCode: GR; eventDate: 4/11-8/11/2021; identifiedBy: M Mylonas; institutionCode: NHMC; occurrenceID: E9101925-9336-501D-B5C1-3A0D1739815D

Notes: New record from Kea.

Analysis

Faunistic results

Our study found 42 land snail species in Kea, belonging to 34 genera. The most species-rich genus is *Deroceras* with four species. The complete list of species is shown in the checklist section, with 11 species constituting new records for the island. Furthermore, *Deroceras pseudopanormitanum* and *Vitrina pellucida* are reported for the first time from an Aegean island.

Discussion

Our sampling on Kea, an arguably well-surveyed island, yielded an impressive number of 11 additional land snail species, thus increasing its species richness by ~ 30% compared to that previously reported (i.e. 31 land snail species, Mylonas 1982). The recovery of 11 new species records could be mainly attributed to two different factors. First, some species known to be anthropophilous (e.g. *Xerotracha conspurcata*, *Theba pisana*, *Oxyloma elegans*) were not previously present on the island and have probably colonised it in the period between the two samplings, potentially through human direct or indirect assistance. Second, some small-sized species – readily missed unless deliberately looked for (e.g. *Vitrea contracta*, *Paralaoma servillis*, *Truncatellina cylindrica*, *Cecilioides tumulorum*, *Lauria cylindracea*) – have been discovered thanks to the inspection of litter and soil, a practice not systematically adopted in previous sampling attempts, but necessary in order to recover the entire malacofauna of a region (Cameron and Pokryszko 2005).

Our results call attention to potential inaccurate estimations of island-level species richness due to undocumented species presences. In general, the main causes for incomplete data are sampling during unfavourable periods and inadequate sampling effort (Triantis et al. 2008). The most favourable sampling period for land gastropods in the Aegean area is from October to April, when snails are active (Mylonas 1982). Two major problems arise from sampling during unfavourable periods: first, a number of species will not be collected, since they probably aestivate hidden, either deep in the ground or in rock crevices and second, the limited number of live specimens in the samples. These shortcomings are strongly correlated to underestimation of species richness and misidentification of species, respectively (Triantis et al. 2008). Furthermore, as snails on islands can usually be located in very limited areas or habitats, recovery of full island-level species lists requires thorough examination of a complete array of available ecological space.

Our findings are also relevant with regards to accurately assessing global island diversity patterns. Recently, the first ever global inventory of island land snails (Proios et al. 2021) was based on a compilation of complete species lists from 727 islands, including 11,139 species, approximately 48% of all known land snail species. In this context, our work

serves as a reminder that such attempts – as much as being essential to address the implications of large scale macroecological patterns – have their basis on rigorous local-scale faunistic studies that set the solid foundations required for large databases to be based on robust data.

Acknowledgements

This study was funded by the General Secretariat for Research and Technology (GSRT) and the Hellenic Foundation for Research and Innovation (HFRI), under the HFRI Support of Faculty Members (DEP) and Researchers (GA. number HFRI-FM17-488).

We would like to thank Zoltán Fehér, Ivailo Dedov and an anonymous reviewer for useful comments that improved the manuscript, and Apostolos Trichas for the photograph.

References

- Botsaris I (1996) The biogeography of terrestrial molluscs on the islands and islets of Saronikos Gulf. Phd Thesis. University of Athens, Athens, 322 pp. [In Greek].
- Cameron RA, Pokryszko B (2005) Estimating the species richness and composition of land mollusc communities: Problems, consequences and practical advice. *Journal of Conchology* 38 (5): 529-548.
- Cameron RA (2013) The diversity of land molluscs-questions unanswered and questions unasked. *American Malacological Bulletin* 31 (1): 169-180. <https://doi.org/10.4003/006.031.0108>
- Cameron RA, Triantis KA, Parent CE, Guilhaumon F, Alonso MR, Ibanez M, Frias Martins AM, Ladle RJ, Whittaker RJ (2013) Snails on oceanic islands: testing the general dynamic model of oceanic island biogeography using linear mixed effect models. *Journal of Biogeography* 40 (1): 117-130. <https://doi.org/10.1111/j.1365-2699.2012.02781.x>
- Cameron RA (2016) *Slugs and snails*. HarperCollins Publishers, London, 508 pp. [ISBN 9780007113002]
- Cowie RH (2004) Disappearing snails and alien invasions: The biodiversity/conservation interface in the Pacific. *Journal of Conchology Special Publication* 3: 23-37.
- Fernández-Palacios JM, Kreft H, Irl SD, Norder S, Ah-Peng C, Borges PA, Burns C, de Nascimento L, Meyer J, Montes E, Drake D (2021) Scientists' warning - The outstanding biodiversity of islands is in peril. *Global Ecology and Conservation* 31: e01847. <https://doi.org/10.1016/j.gecco.2021.e01847>
- Fuchs A, Käufel F (1934) Land- und Süßwassermollusken aus Griechenland und von den Inseln des Ägäischen Meeres . In: Werner F (Ed.) *Ergebnisse einer zoologischen Studien- und Sammelreise nach Griechenland, namentlich nach den Inseln des Ägäischen Meeres*. 143 (1/2). *Sitzungsberichte, Akademie der Wissenschaften in Wien*, 71-90 pp.

- Fuchs A, Käufel F (1936) Anatomische und systematische Untersuchungen an Land- und Süßwasser- schnecken aus Griechenland und von den Inseln des Ägäischen Meeres. *Archiv für Naturgeschichte, Zeitschrift für Systematische Zoologie* 5: 541-662.
- Goudeli G, Parmakelis A, Proios K, Anastasiou I, Radea C, Pafilis P, Triantis KA (2021) The land snails of Lichadonisia islets (Greece). *Ecologica Montenegrina* 39: 59-68. <https://doi.org/10.37828/em.2021.39.6>
- Hausdorf B, Hennig C (2005) The influence of recent geography, palaeogeography and climate on the composition of the fauna of the central Aegean Islands. *Biological Journal of the Linnean Society* 84: 785-795. <https://doi.org/10.1111/j.1095-8312.2005.00467.x>
- Heller J (1976) The biogeography of Enid land snails on the Aegean Islands. *Journal of Biogeography* 3: 281-292. <https://doi.org/10.2307/3038018>
- Martens Ev (1889) Griechische Mollusken. Gesammelt von Eberh. von Örtzen. *Archiv für Naturgeschichte* 1 (2): 169-240. [In German].
- MolluscaBase (Ed.) (2022) MolluscaBase. <http://www.molluscabase.org>. Accessed on: 2022-3-20.
- Mylonas M (1982) The zoogeography and ecology of the terrestrial molluscs of Cyclades. Phd Thesis. University of Athens, Athens, 236 pp. [In Greek].
- Papanikolaou DI (2021) The geology of Greece. Springer Cham <https://doi.org/10.1007/978-3-030-60731-9>
- Proios K, Cameron RA, Triantis KA (2021) Land snails on islands: building a global inventory. *Frontiers of Biogeography* 13 (2): 51126. <https://doi.org/10.21425/F5FBG51126>
- Riedel A (1992) The Zonitidae (sensu lato) (Gastropoda, Pulmonata) of Greece. *Fauna Graeciae V. Hellenic Zoological Society, Athens*, 194 pp. [ISBN 9608529816]
- Subai P (1996) Revision der Ariantinae. 1. Die Helicigona-Untergattung Thiessea (Gastropoda: Pulmonata: Helicidae). *Archiv für Molluskenkunde* 126 (1/2): 1-49. <https://doi.org/10.1127/arch.moll/126/1996/1>
- Triantis KA, Mylonas M, Weiser MD, Lika K, Vardinoyannis K (2005) Species richness, environmental heterogeneity and area: a case study based on land snails in Skyros archipelago (Aegean Sea, Greece). *Journal of Biogeography* 32: 1727-1735. <https://doi.org/10.1111/j.1365-2699.2005.01322.x>
- Triantis KA, Vardinoyannis K, Mylonas M (2008) Biogeography, land snails and incomplete data sets: the case of three island groups in the Aegean Sea. *Journal of Natural History* 42 (5-8): 467-490. <https://doi.org/10.1080/00222930701835431>
- Vardinoyannis K (1994) Biogeography of land snails in the south Aegean island arc. Phd Thesis. University of Athens, Athens, 330 pp. [In Greek].
- Vardinoyannis K, Mylonas M (2019) Land gastropods' view of the Aegean. Key islands and key species. In: Tsikliras A, Dimarchopoulou D, Youlatos D (Eds) *Proceedings of the International Congress on the Zoogeography and Ecology of Greece and Adjacent Regions*. 14th ICZEGAR, Thessaloniki, 27-30/6/2019.
- Welter-Schultes FW, Williams MR (1999) History, island area and habitat availability determine land snail species richness of Aegean islands. *Journal of Biogeography* 26: 239-249. <https://doi.org/10.1046/j.1365-2699.1999.00276.x>
- Wiktor A (2001) The slugs of Greece (Arionidae, Milacidae, Limacidae, Agriolimacidae-Gastropoda, Stylommatophora) *Fauna Graeciae VIII. Natural History Museum of Crete; Hellenic Zoological Society, Irakleio*, 240 pp. [ISBN 9603670057]

- Yoxas G, Samara T, Sargologou L, Stournaras G (2011) Multiple criteria analysis for selecting suitable sites for construction of sanitary landfill based on hydrogeological data; Case study of Kea Island (Aegean Sea, Hellas). Environmental Earth Sciences, Advances in the Research of Aquatic Environment 2: 97-104. https://doi.org/10.1007/978-3-642-24076-8_12

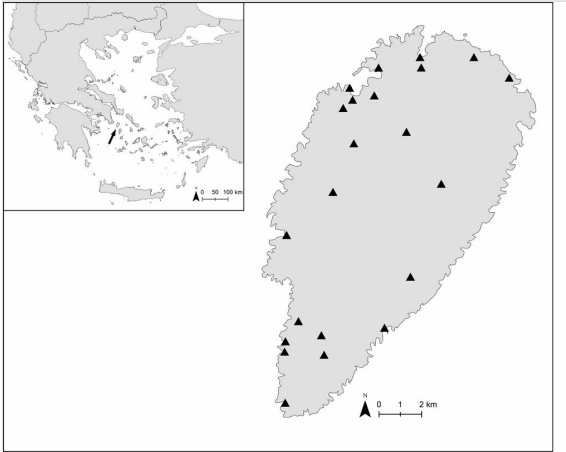


Figure 1.

Map of Kea, the island's location in the Aegean archipelago (Greece) and the 22 localities sampled for land snails shown with a triangle.

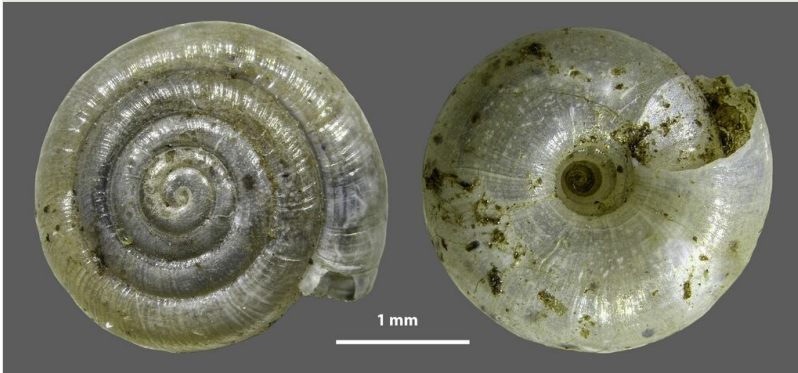


Figure 2.

Digital microscopic images of *Vitrea keaana* Riedel & Mylonas, 1981.

Specimen from Poles (37.5597, 24.3296).

Supplementary material

Suppl. material 1: Suppl. Table 1. Collection sites

Authors: Maroulis, Vardinoyannis, Karakasi, Proios, Mylonas, Triantis

Data type: Sampling

[Download file](#) (19.37 kb)