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A review on the presence of the Genus *Rattus* (Mammalia, Rodentia) in the Northern Sporades Islands (Greece), with some new records

ABSTRACT

A review on the presence of the brown rat *Rattus norvegicus* Berkenhout, 1769 and the black rat *Rattus rattus* Linnaeus, 1758 in the Northern Sporades islands is provided in this article. Furthermore, the presence of *R. rattus* on the islet of Aspronissos and *R. norvegicus* on the islet of Tsougrias is reported for the first time.

Keywords: Aegean Sea, conservation, eradication, mammals, rodents.

INTRODUCTION

Human activities have resulted in the intentional or unintentional introduction of numerous species outside of their natural ranges. In situations where these species become established in new habitats, they have the potential to alter ecosystems through increased competition with and predation on native taxa. Such invasive species are considered by the International Union for the Conservation of Nature (IUCN) a threat to multiple taxa around the world (Hilton-Taylor, 2009; Weber, 2014). Rats (*Rattus* spp.) are believed to be one of the most widespread exotic mammals.

The spread of rats across new habitats, especially isolated islands, dates back at least 3,000 years and has often been the outcome of shipping activities (Atkinson, 1985). Today, rats are found on over 80% of the world's major islands and island groups (Atkinson, 1985). Furthermore, rats in Greece are dangerous carriers of diseases such as *Leishmania* infection (Schnur *et al.*, 1989; Tsakmadikis *et al.*, 2017), *Bartonella* (Papadogiannakis *et al.*, 2017), *Lectospiro* (Burriel *et al.*, 2008), *Rickettsia* (Tselentis *et al.*, 1996), and *Salmonella* (Badi *et al.*, 1992 a; Badi *et al.*, 1992 b). Both *R. rattus* and *R. norvegicus* transmit the plague bacterium *Yersinia pestis* through fleas in some areas of the world.

Despite these serious problems, rodents on islands are usually regarded by conservationists mainly as invasive pest species, which have caused considerable ecological

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damage to islands around the world. However, almost one in five of the world's nearly 2300 rodent species is an island endemic, and insular rodents suffer from high rates of extinction and endangerment (Amori *et al.*, 2008).

MATERIALS AND METHODS

Study area

The Northern Sporades Archipelago lies along the east coast of Greece, northeast of the island of Euboea. It consists of four islands permanently inhabited such as Alonissos, Skopelos, Skiathos, Skyros and of many small uninhabited islets: Adelfi, Adelfopoulo, Agios Ermolaos, Agios Fokas, Agios Georgios, Arkos, Aspronissos (Aspronisi), Astakida, Dio Adelfia, Erinia (Eirneia), Exo Diavatis, Exo Podia (Exo Podies), Gaidaros, Gramiza (Grammeza, Grammiza), Gioura (Youra, Yiura), Kasidis (Kassidis), Kastronissia (Kastronisia), Kyra (Ormos), Kyra Panaghia, Koulouri, Korakas, Lakkonisi, Lachanou (Lahanou), Lechoussa, Melissa, Mesa Diavatis, Pappous, Pelagonisi, Pelerissa (Fagrou), Peristera (Aspro), Piperi, Platia, Polemika, Pontikonissi, Prasso (Paraos, Parausa, Praso), Psathoura (Psathura), Psathonisi, Sarakino, Skantili, Skantzoura (Scandira, Skandeira, Scandila), Skyropoula, Sika, Thalia, Tsougrias (Tsougria, Tsoungria, Tsoungria), Valaxa (Fig. 1). The isolation of the Aegean landmass occurred 4.5 million years ago, but the formation of this archipelago, by further fragmentation, is supposed to have occurred by early Holocene (Van Andel and Shackleton, 1982; Perissoratis and Conispoliatis, 2003). The largest island of the study area is Skyros and the smallest one is Melissa.

The study area is characterized by a Mediterranean-type climate with humid winters and dry summers, belonging to the sub-humid bioclimatic zone characterized by mild winters (Gouvas and Sakellarios, 2011). The xerothermic index (Bagnouls & Gaussen, 1953) suggests that the study area belongs to the Meso-Mediterranean zone. Northern Sporades were declared as Greece's first national marine park "National Marine Park of Alonissos and Northern Sporades" in 1992 (Presidential Decree 519/28-5-92). Also, it is part of four overlapping NATURA 2000 sites, two Special Areas of Conservation (GR1430004 & GR1430003) and two Special Protection Areas (GR1430005 & GR1430009) (Mihalatou *et al.*, 2002; Iliadou *et al.*, 2020). Meteorological data in Tan. I are obtained from EMY (Hellenic National Meteorological Service).

Data analysis

To drawing up of this work specific bibliography has been consulted and the curators of the Greek and European museum collections have been contacted. In addition, the author's private osteological collection was used. The acronyms of the museum and private collections are: BHNH (Natural History Museum, London); COMGR (Collezione Osteologica Mauro Grano Roma); SMF (Senckenberg Research Institute and Natural History Museum, Frankfurt am Main); ZMUA (Zoological Museum University of Athens).

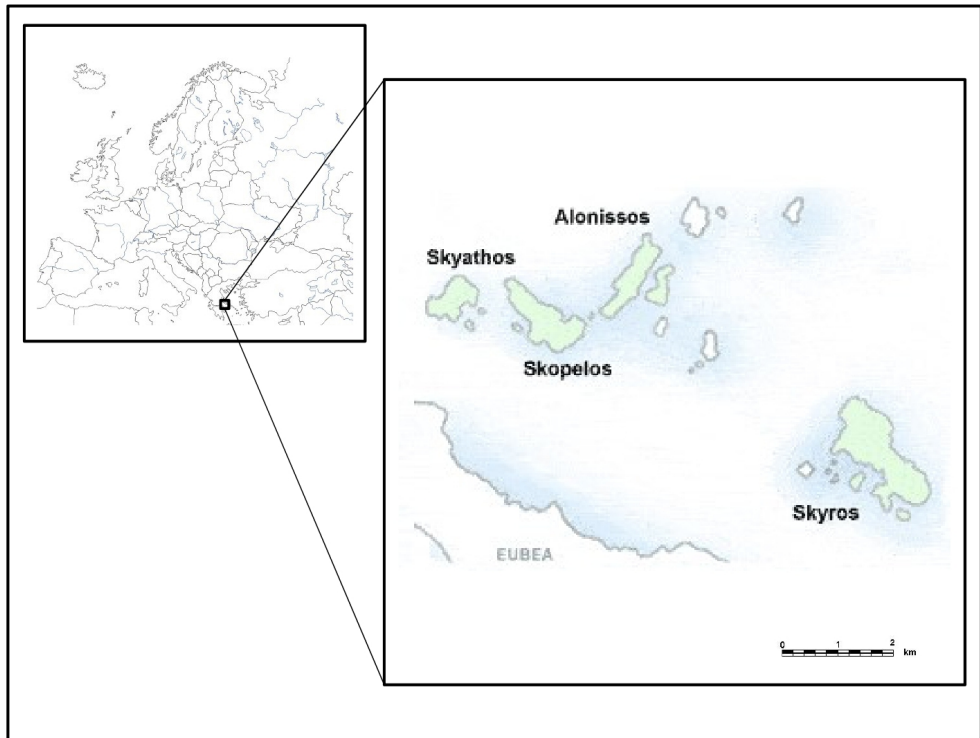


Fig. 1. Localisation of Sporades Islands.

Month	Max Temperature (°C)	Min Temperature (°C)	Precipitation (mm)	Relative Humidity (%)	Wind direction	Wind speed (Kt)
January	12.3	7.4	70.6	76.2	NE	12.7
February	12.7	7.4	55.3	74.2	NE	12.9
March	14.1	8.7	49.9	73.7	NE	11.4
April	17.7	11.4	24.3	71.5	N	9.0
May	22.0	15.0	15.4	70.0	N	7.3
June	26.3	19.3	6.5	66.0	N	7.6
July	27.9	21.7	5.9	66.2	N	8.9
August	27.6	21.7	8.4	68.0	N	9.4
September	24.7	18.8	19.4	70.8	N	9.5
October	20.8	15.5	36.7	74.5	N	10.9
November	17.2	12.0	54.6	76.6	NE	10.3
December	13.9	9.1	81.1	77.0	NE	12.1

Tab. I. Climate data of the Northern Sporades obtained from EMY.

RESULTS

Brown rat, *Rattus norvegicus* Berkenhout, 1769

Analysed museum and private collections specimens - Skiathos: COMGR 0206; Tsougrias: COMGR 0209. Two specimens, whose origin is generically referred from Sporades (Masseti, 2012), are also present in the collections of the Zoological Museum University of Athens (ZMUA 291 and 308, collected by Krüper).

The brown rat *Rattus norvegicus* is one of the most common and widely distributed mammals around the world, since it is found in almost all areas inhabited by humans and on all continents except for Antarctica. Native in northern China and Mongolia, this rat did not appear in Europe until the 1500 s. (Puckett *et al.*, 2016). Originally when the brown rat lived only in Asia, used to occupy forests and bushy areas. Nowadays, it is able to live in a wide variety of environments such as open fields, woodlands, basements, garbage dumps and sewers. In the Mediterranean islands, *Rattus norvegicus* is not as widespread as its relative *Rattus rattus*, since it is presumably unable to successfully colonize the dry environments, due to its dependence on water (Masseti, 2012; Castiglia *et al.*, 2019). In the Ionian and Aegean islands, as far as is currently known, brown rat has been found on Corfu, Cephalonia, Zakynthos, Kythera, Euboea, Atalandi (north Euboean Gulf), Crete, Karpathos, Rhodes, Kos, Ikaria, Chios, Skiathos, Lemnos (Masseti, 2012) and Symi (Castiglia *et al.*, 2019). The occurrence of the brown rat even for Alonissos, Skopelos and Skyros is reported from Masseti (2012), but without references.

Black rat, *Rattus rattus* Linnaeus, 1758

Analysed museum and private collections specimens - Aspronissos: COMGR 0210; Peristera: SMF 55646-55649, 55843-55845; Piperi: SMF 55840-55841, 55854; Psathoura: SMF 55819-55821; Skantzoura: SMF 55842; Skiathos: BHNH 66,1468-1471; COMGR 0212; SMF 45204-45211. Skyros: COMGR 0214; SMF 49541-49548.

The black rat, belonging to the *Rattus rattus* species complex, is recognized as one of the world's most invasive vertebrate species (Aplin *et al.*, 2011; Lowe *et al.*, 2000). The origin centre and dispersion of the *R. rattus* complex corresponds to the eastern part of Asia where it originated between 0.64 and 1.42 million years ago (Aplin *et al.*, 2011; Colangelo *et al.*, 2015). The black rat is largely confined to warmer areas, having been replaced by the brown rat (*Rattus norvegicus*) in cooler regions and urban areas. Besides the fact that the brown rat being larger and more aggressive, the transfer from wooden structures and thatched roofs to bricked and tiled buildings favoured the burrowing brown rats over the arboreal black rats.

Moreover, brown rats eat a wider variety of foods, and are more resistant to extremes environmental conditions. Black rats fit in a wide range of habitats. In urban areas, they are found around warehouses, residential buildings, and other human settlements. They also inhabit agricultural areas, such as barns and crop fields. In urban areas, they live in dry upper levels of buildings, so they are commonly found in wall cavities and false ceilings. In nature, black rats occupy cliffs, rocks, ground, trees, and since they are excellent climbers, prefer to live in palms and trees, such as pine trees. The

exact period in which the species arrived in the Mediterranean basin is unclear due to the few and fragmentary zoo-archaeological remains (Ruffino and Vidal, 2010; Colangelo *et al.*, 2015).

In the Ionian and Aegean islands, as far as is currently known, black rat has been found on Corfu, Paxos and Antipaxos (south of Corfu), Lefkada, Cephalonia, Zakynthos, Antikythera (Alivizatos *et al.*, 2005), Kythera, Antimilos, Milos, Skiathos, Alonissos, Kassidis, Lachanou, Polemika and Kasidis (east of Alonissos), Kyra Panaghia, Gramiza (Grammeza), Gioura (Youra), Psathoura, Pappous, Piperi, Skantzoura, Peristera, Skyros, Euobeia, Andros, Tinos, Mykonos, Delos, Paros, Naxos, Folegandros, Sikinos, Thera, Theodorou, Dhia, Crete, Paximada, Ghianissada, Dragonada, Gavdhos, Koufonisi, Astypalea, Armathia, Kasos, Karpathos, Rhodes, Tilos, Gyali, Nisiros, Kos, Patmos, Arkios, Kavalos, Psathonissi, several satellite islets of Lipsoi, Agathonissi, Ikaria, Kiseria (Fourni), Chios, Lesbos, Samothrace, Tasos, Stamphani (Strophades), Sapientza, Astakida, Salamis, Aegina, Hydra, Siphnos, Kymolos, Polyaiagos, Syros, Kea, Amorgos, Levitha, Gavdhopoula and Aghii Pantas (off Crete), Chamilonisia, Zafora, Chalki, Symi, Macronisi, Frangos, Petrocarbo, Anidros, Leros, Agrelousa, Farmakonissi, Lipsoi, Arki, Anthropofas, Lemnos (Masseti, 2012), Leros and Patmos (Cattaneo, 2008), Ithaca (Colangelo *et al.*, 2015).

Black rat constitutes a human-introduced predator in Mediterranean islands and islets, responsible for severe decreases on population size of several birds (Croxall *et al.*, 2012; Jones *et al.*, 2008; Ruffino *et al.*, 2009; Petrella *et al.*, 2012) for this reason eradication campaigns have been carried out in some Aegean islands. In spring 2005 started a project for the eradication of rats from three small islets, Kasidis, Lachanou and Polemika, located near Skantzoura in the National Marine Park of Northern Sporades. This was the first project of its kind in Greece. It was part of the conservation measures taken in order to protect Eleonora's falcon *Falco eleonora*. The eradication took place on the aforementioned islets, one of which, Lachanou, is known for hosting a breeding colony of Eleonora's falcon. The other two nearby islets, Kasidis and Polemika, had to be cleared of rats in order to prevent their reinvasion of Lachanou. Early spring was the time chosen for eradication, when there is less density of bird species in the area, to avoid their disturbance. The baiting was performed in late March 2005, followed by intense monitoring for the following three months.

The preliminary results show that rats have been eradicated from all three islets, without creating any negative impact on the ecosystem whatsoever. However, its long-term benefits may only be evident in the future in greater abundance and diversity of avian, as well as other animal and plant species (Fric *et al.*, 2006). In all rat eradication programs, rats were completely removed from the target islets. One of the previously rat-free islets was invaded by black rat, which was subsequently removed. On another islet, where black rat was eradicated, the same species attempted a reinvasion. Lastly, an attempted brown rat (*Rattus norvegicus*) invasion was recorded in a different islet, which however was unsuccessful due a network of permanent bait stations (Fric and Evangelidis, 2017).

DISCUSSION

Relying on the available literature data and the valuable private and public naturalistic collections, it is possible to outline a detailed situation on the presence of the black rat and the brown rat in the many islands that constitute the Northern Sporades Archipelago. Information on the presence of these two species closely related to human activities and so important in the delicate ecosystem of small islands is always of great importance. The presence of the black rat *R. rattus* in Aspronissos Islet and of the brown rat *R. norvegicus* in Tsougrias Islet are here recorded for the first time. Tab. II reports the presence of *R. rattus* and *R. norvegicus* in the islands and islets of the Northern Sporades archipelago.

The black rat seems to be present in many islands where the presence of man is steady or occasional. Even activities such as agriculture and sheep farming in small islands where the human presence is not stable, leads to the black rat settlement. Historical records and genetic evidence suggest that *R. rattus* was transported via shipping activities; however, the warm Mediterranean climate may have also facilitated additional rat dispersal without human assistance (McCormick, 2003). The occurrence of brown rat in some little islets, characterized by a dry and barren environment, apparently quite unsuited to the species, demonstrates the great adaptive capacities of this species that normally depends on water to settle stable populations (Castiglia *et al.*, 2019). Also in many areas, the replacement of *R. rattus* by the brown rat could be due to the greater ability of brown rat to survive in adverse conditions (Twigg *et al.*, 2008). The presence of this rat in the small and uninhabited Tsougrias Islet confirms these theses. In the Northern Sporades, the occurrence of *Rattus* sp. is proved for 27 islands and islets. *R. norvegicus* occurs on five islands, while *R. rattus* on 24 islands, and only in three islands both species coexist (Alonissos, Skiathos, and Skyros). This is because these three islands, which are the largest within the archipelago, offer a wide variety of environments allowing optimal exploitation of the ecological niches and the different needs of the two species.

Despite the rat eradication campaigns from some Mediterranean islands and islets, the presence of this rodent in Northern Sporades is remarkable. Only a careful monitoring of these rats with a great invasive potential can serve to safeguard the delicate balance in small islands.

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Island	<i>Rattus norvegicus</i>	<i>Rattus rattus</i>	Notes and references
Alonissos	+	+	<i>R. norvegicus</i> : (Masetti, 2012). <i>R. rattus</i> : (Masetti, 2012).
Skopelos	+		<i>R. norvegicus</i> : (Masetti, 2012).
Skiathos	+	+	<i>R. norvegicus</i> : COMGR 0206; (Cattaneo, 1997); (Masetti, 2012); (Castiglia <i>et al.</i> , 2019). <i>R. rattus</i> : BHNH 66, 1468-1471; COMGR 0212; SMF 45204-45211; (Masetti, 2012).
Skyros	+	+	<i>R. norvegicus</i> : (Masetti, 2012). <i>R. rattus</i> : COMGR 0214; SMF 49541-49548; (Masetti, 2012).
Agios Ermolaos	-	+	Eradication 2010 (Weber, 2014).
Aspronissos	-	+	COMGR 0210 - New record!
Astakida	-	+	(Masetti, 2012).
Dio Adelfia	-	?	(J. Fric, pers. comm. 2020).
Exo Podia	-	+	Eradication 2009 (Weber, 2014).
Gaidaros	-	+	(Masetti, 2012).
Gioura	-	+	(Masetti, 2012).
Gramiza	-	+	(Masetti, 2012).
Kasidis	-	+	Eradication 2005 (Fric <i>et al.</i> , 2006); (Masetti, 2012).
Kastronissia	-	+	(Masetti, 2012).
Kyra Panaghia	-	+	(Masetti, 2012).
Korakas	-	+	(Masetti, 2012); (J.Fric, pers. comm. 2020).
Lachanou	-	+	Eradication 2005 (Fric <i>et al.</i> 2006); (Masetti, 2012).
Pappous	-	+	(Masetti, 2012).
Peristera	-	+	SMF 55646-55649, 55843-55845; (Masetti 2012).
Piperi	-	+	SMF 55840-55841, 55854; (Masetti, 2012); (J. Fric, pers. comm. 2020).
Polemika	-	+	Eradication 2005 (Fric <i>et al.</i> , 2006); (Masetti, 2012).
Pontikonissi	-	+	(Masetti, 2012).
Prasso	-	+	(J. Fric, pers. comm. 2020).
Psathoura	-	+	SMF 55819-55821; (Masetti, 2012).
Skantili	-	+	(Masetti, 2012); (J. Fric, pers. comm. 2020).
Skantzoura		+	SMF 55842; (Masetti, 2012); (J. Fric, pers. comm. 2020).
Tsougrias	+		COMGR 0209 - New record!

Tab. II. Presence of *R. norvegicus* and *R. rattus* in the Northern Sporades.

RIASSUNTO

Review della presenza del genere Rattus (Mammalia, Rodentia) nelle Isole Sporadi Settentrionali (Grecia), con alcuni nuovi record

In questo articolo viene fornita una rassegna sulla presenza del ratto bruno *Rattus norvegicus* Berkenhout, 1769 e del ratto nero *Rattus rattus* Linnaeus, 1758 nelle Isole Sporadi Settentrionali. Viene inoltre segnalata per la prima volta la presenza di *R. rattus* sull'isolotto di Aspronissos e di *R. norvegicus* sull'isolotto di Tsougrias.

Parole chiave: conservazione, Mar Egeo, mammiferi, roditori, eradicazione.

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