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Presence of black rat *Rattus rattus* (Linnaeus, 1758) (Mammalia Rodentia) and possible extinction risk for micro insular populations of *Podarcis sicula* (Rafinesque, 1810) (Reptilia Lacertidae): the example of Lachea islet (Sicily, Italy)

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ABSTRACT

The black rat *Rattus rattus* (Linnaeus, 1758) in insular environments represents a threat for many species of vertebrates, invertebrates and plants, especially in equatorial islands. In the Mediterranean Basin as regards the herpetofauna, and lizards of the genus *Podarcis* in particular, the information available are still few. Since 2006, a study was initiated to verify the possible impact of the black rat on the micro-insular population of *Podarcis sicula* (Rafinesque, 1810) living in Lachea island, a natural reserve. During 2011 were collected and analyzed 2873 excrements of rats and in no case were found remains attributable to *Podarcis sicula*. The density of lizards, observed with the technique of the transept, was 0.3 ind./10 m^2. During the period 2006-2011 were analyzed (also by molecular type investigation) a total of 4696 excrements of rat, with no confirmation of predation against *Podarcis sicula*. However the rat predation on insects may cause an indirect effect like competition and have negative effects on populations of invertebrates and therefore also on *Podarcis sicula*. Moreover the Lachea island is affected by a moderate tourism. The lizards, in those very frequented areas, show lower values of the body condition index and a decrease of cells responsible for immune response. Although is not documented any form of predation by the black rat, that species is a potential source of threat and a combined action of the factors mentioned with accidental events, makes this small micro-insular population of *Podarcis sicula* as vulnerable to sudden decreases in numbers.

KEY WORDS *Rattus rattus*; *Podarcis sicula*; Lachea island; predation; competition.

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INTRODUCTION

The black rat *Rattus rattus* (Linnaeus, 1758) (Mammalia, Rodentia), a native of the East Asian region, is now cosmopolitan, widespread both in continental and insular areas. The first remains attributed to this species in the western Mediterranean date back about 2400 years ago (Amori et al., 2008; Masseti, 2008). Currently it is very common in the Mediterranean islands, and is present in all the medium and large ones and in many of the smaller ones (Perfetti et al., 2001; Angelici et al., 2009). In most cases the colonization has anthropochore origin, although in the islands situated at short distance from the mainland or other islands, can instead occur spontaneously (Palmer & Pons, 2001).

The black rat has directly caused or contributed to the extinction of numerous species of birds, small mammals, reptiles, invertebrates and plants, especially in equatorial islands (Palmer & Pons, 2001; Nogales et al., 2006; St Clair, 2011). It is, among allochthonous species, the most destructive for Mediterranean seabirds, being considered responsible for the disappearance of colonies of *Hydrobates pelagicus* (Linnaeus, 1758) and for number decreasing of *Calonectris diomedea* (Scopoli, 1769) (Igual et al., 2006). It can also cause a reduction in reproductive success of other species of seabirds such as *Puffinus yelkouan* (Acerbi, 1827), *Puffinus mauretanicus* P. R. Lowe, 1921, or rupicolous birds as Eleonora's Falcon *Falco eleonorae* Gené, 1839 and Pallid swift *Apus pallidus* (Shelley, 1870).

Information are scarce regarding reptiles in general and lizards of the genus *Podarcis* in particular. In the Balearic Islands are present 43 different insular populations of *Podarcis lilfordi* (Günther, 1874): in the islands without the presence of black rats this species has statistically significant higher density (Pérez-Mellado et al., 2008). Predation by black rat also appears to be the cause of the decline of *Podarcis filfolensis kieselbachi* (Fejervary, 1924), endemic subspecies of Selmunett island, off the northeast coast of Malta (Sciberras & Schembri, 2008). *Podarcis sicula* (Rafinesque, 1810) is present in Italy in numerous small islands, with populations showing eco-ethological peculiarities and having a high degree of vulnerability because of their isolation (Sindaco et al., 2006). On the Lachea island there is a population described as *Podarcis sicula ciclopica* (Taddei, 1949): it presents distinctive genetic features but not sufficient to justify the subspecies rank, although further studies are desirable to clarify the taxonomic status (G. Rappazzo, in verbis).

Since 2006 an investigation was initiated aimed at studying the possible impact of the black rat on this micro-insular population of *Podarcis sicula*, with the aim of collecting useful information for its preservation.

MATERIALS AND METHODS

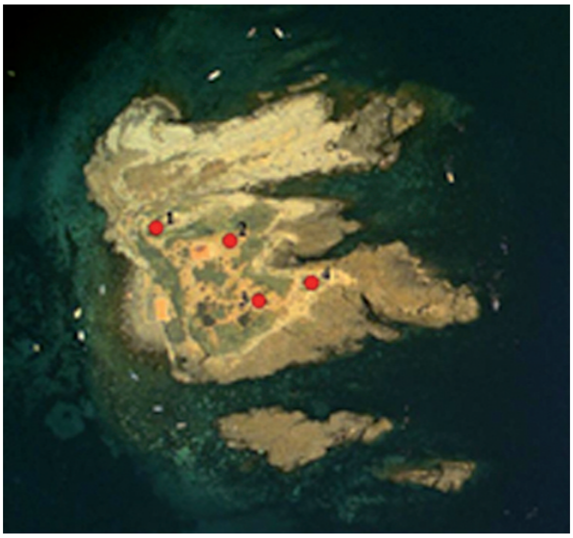
The Lachea island belongs to a small archipelago called "Islands of the Cyclops" at about 200 m from the coast of Acitrezza (Aci Castello, Catania, Sicily), and it has an area of 1.3 ha. The origin dates back to the Middle Pleistocene (500,000 to 700,000 years ago) where there was the ancient "pre-Etna gulf". The climate is mediterranean type and the vegetation has a thermo-xerophilous character; with around 180 plant species its flora is impoverished due to the insertion of alien species (*Ailanthus altissima* L., *Thuja orientalis* L.) and the agricultural activities practiced until a few decades ago. Since 1998 the island is an Integral Natural Reserve, whose management is assigned to C.U.T.G.A.N.A. of Catania University.

From January to December 2011 was carried out a monitoring of the population of black rat and *Podarcis sicula* with the main purpose of verifying any interference of this Rodent against this species of lizard. We proceeded to monthly collection of black rat excrements in four different stations (Fig. 1): station n. 1 (540 m^2), situated in the west of the island is characterized by a predominantly herbaceous cover; station n. 2 (555 m^2), dominated by herbaceous and shrub vegetation; station n. 3 (123 m^2), concerns a paved area surrounded by a predominantly arboreal vegetation; station n. 4 (75 m^2), consisting predominantly in rocky ground with sparse and exposed vegetation. This last is frequented by the *Larus michahellis* Naumann, 1840, which nests here. Excrements collected were analyzed in the laboratory, separating vegetal components and animal components (e.g. remains of insects and birds), giving particular attention to the possible presence of remains (scales, bone and egg fragments, skin) of *Podarcis sicula*. Data were then reported as percent frequency (F%), equal to the number of times that a single food category is found, divided by the total number of excrements and multiplied by 100 (n/N x 100).

Regarding *Podarcis sicula*, the survey was covered monthly by a fixed transect (Fig. 2), previously standardized, at three different time slots (8:00-9:00, 11:00-12:00 and 15:00-16:00). Counts were also made by direct sightings, during a period of 10 min., in 3 different stations, always in the same time slots (Fig. 3). The first station (42 m^2) is situated in the west side of the island; it is an elevated area surrounded by small walls built in lava stone and marly rocks; it presents herbaceous vegetation, especially during autumn and winter. The second station (70 m^2) is located in the upper part of the island (25.35 m a.s.l.); it appears flat with trees that do not exceed 1.5 meters in height, and annual plants. The third station (120 m^2) is located on the east side of the island, in the area known as Punta Monaco; this is the zone of maximum solar exposure, and is almost entirely made up of marly rocks; the vegetation is predominantly herbaceous (*Oryzopsis miliacea* (L.) Asch. et Schweinf., *Crithmum maritimum* L., *Carlina hispanica globosa* Meusel & Kästner), while at the edge of the station there are shrubs such as *Rubus fruticosus* L. and *Opuntia ficus-barbarica* A. Berger.

The transept and the stations have been identified taking into account the ecological diversity, in order to have an overview on the distribution and abundance of lizard population of the island. The transept involves observation and counting of all individuals contacted along the predetermined path (at a perpendicular distance of 1 m from it, both right and left) of length equal to 500 m. The reliability of the method is linked to the proper functioning of certain procedures (equiprobability of detection of all the subjects, certain identification of the animals counted, independence of each observation and precision in measuring the perpendicular distance).

The subsequent density estimates were calculated using the following equation: $D = n/2Lw$, where "n" is the number of individuals observed, "L" is the length of the transept and "w" is the mean of the perpendicular distance to the line of progression (Burnham et al., 1980). Throughout the year of sampling were collected meteorological and climatic parameters, in particular: monthly mean temperature, monthly minimum and maximum temperature, and monthly total precipitation, using data from the weather station of Aci Trezza (7 m a.s.l.) (www.meteosicilia.it). To assess possible differences in the number abundance of black rat excrements, found in the stations, the t-test has been applied. For the correlation between climate variables and number of individuals of lizards observed the nonparametric test of Spearman rank coefficient (rs) was applied. For comparisons with results from previous studies were used just monthly samples similar to this research. Data processing was carried ut by the statistical package Statistics 5.0.



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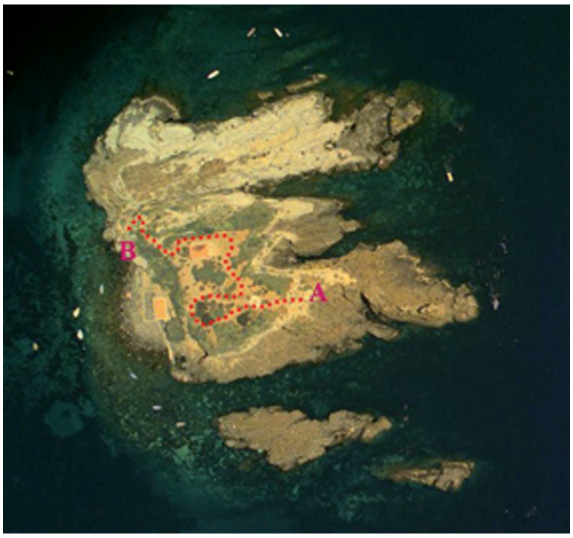

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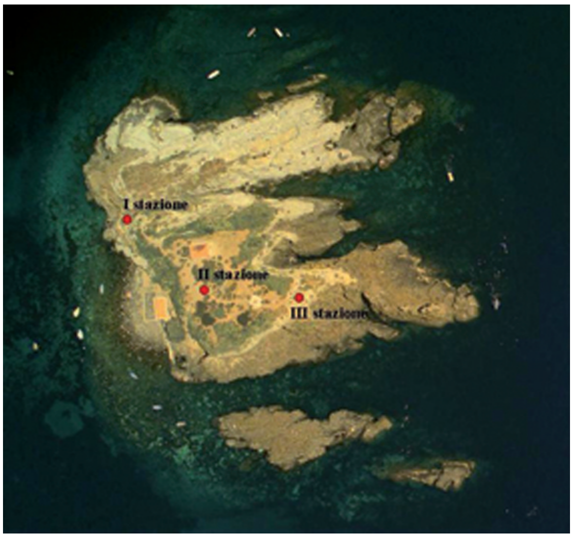

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Figure 1. Location of the 4 sampling stations for the black rat excrements. Figure 2. Transept standard used for the counting of *Podarcis sicula* individuals. Figure 3. Location of the 3 stations used for the sampling of *Podarcis sicula*.

RESULTS

The results of the excrements (n = 2873) analysis are reported in Table 1. The high number of excrements found in the month of January was attributed to the non elimination of the previous ones before the start of sampling.

Excrements contain predominantly plant remains, always present and showing the maximum frequency; only in a small percentage have been found birds and insects remains. In no case were identified remains attributable to *Podarcis sicula*.

Using collected data was also calculated the density of the number of excrements found in each station (Table 2). The average values found in each station are reported in Table 3.

There were no statistically significant differences between the abundance of excrement in stations 1 and 4 and stations 2 and 3 (Table 4). The individuals density of *Podarcis sicula* observed along the transect is shown in Table 5 and Tables 6-8 show the values observed in each station.

Along the transect the highest number of individuals observed occurs in the month of May. In winter there is a drastic decrease of individuals recorded. The maximum number of individuals observed per month is also significantly positively correlated with the mean temperature ($r_s = 0.756$, $t(6) = 2.832$, $P = 0.03$) and the maximum temperature ($r_s = 0.756$, $t(6) = 2.832$, $P = 0.03$), while instead it is statistically significantly negatively correlated with the total precipitation ($r_s = -0.903$, $t(6) = 5.139$, $P = 0.00$).

The number of individuals observed is also significantly positively correlated with the average of the individuals sum observed at stations ($r_s = 0.957$, $t(6) = 8.103$, $P = 0.00$).

The maximum density observed at the stations is recorded for the month of May with the first station showing 3.6 ind./10 m^2 and station 3 showing

Month	n°. excr.	Vegetals	Birds	Insects	*Podarcis sicula*
January	*1604*	*100.00*	*2.49*	*0.00*	*0.00*
February	266	100.00	0.00	0.00	0.00
March	181	100.00	0.00	4.42	0.00
April	107	100.00	0.00	0.00	0.00
May	66	100.00	0.00	1.51	0.00
June	81	100.00	0.00	0.00	0.00
July	71	100.00	0.00	2.82	0.00
August	nr	nr	nr	nr	nr
September	309	100.00	0.00	1.94	0.00
October	nr	nr	nr	nr	nr
November	188	/	/	/	/
December	nr	nr	nr	nr	nr
Nb. Total excrements	**2873**				

Table 1. Food categories and relative frequency percentage (F%) reported monthly in the black rat excrements (nr = no detection due to adverse weather conditions; / = not analyzed because excrements rotten). The values for January are shown in italics.

Month	Station 2	Station 3	Station 4	Station 4
January	*1.55*	*1.14*	*1.89*	*5.79*
February	0.43	0.20	0.33	0.43
March	0.22	0.14	0.16	0.59
April	0.14	0.12	0.10	ne
May	0.14	0.06	0.05	0.00
June	0.12	0.04	0.08	0.37
July	0.09	0.06	0.10	0.12
August	nr	nr	nr	nr
September	0.39	0.22	0.47	0.75
October	nr	nr	nr	nr
November	0.24	0.12	0.45	0.27
December	nr	nr	nr	nr

Table 2. Monthly density of black rat excrements found in each station (ne = no detection due to presence of nesting gulls; nr = no detection due to adverse weather conditions). The values for January are shown in italics.

	mean	sd
Station 1	10.23	0.13
Station 2	1.18	0.72
Station 3	2.42	1.77
Station 4	10.36	0.26

Table 3. Yearly mean values and standard deviation of the number of black rat excrements found at each station.

	t	d.f.	p
Stat. 1 - Stat. 2	32.726	12	0.000
Stat. 1 - Stat. 3	11.643	12	0.000
Stat. 1 - Stat. 4	1.183	12	0.260
Stat. 2 - Stat. 3	1.717	12	0.112
Stat. 2 - Stat. 4	31.728	12	0.000
Stat. 3 - Stat. 1	28.242	12	0.000
Stat. 3 - Stat. 4	11.743	12	0.000

Table 4. Statistical comparison (t-test) between the averages of black rat excrements found in each of 4 sampling stations.

Month	n° ind./10 m^2
January	0.0 ind./10 m^2
February	0.0 ind./10 m^2
March	0.1 ind./10 m^2
April	nr
May	0.3 ind./10 m^2
June	0.2 ind./10 m^2
July	0.2 ind./10 m^2
August	nr
September	0.2 ind./10 m^2
October	nr
November	0.0 ind./10 m^2
December	nr

Table 5. Density values of *Podarcis sicul*a observed in each month along the transept (nr = no detection due to adverse weather conditions)

1.0 ind./10 m^2. At station 2 the maximum density is 2.1 m^2 ind./10 m^2 registered in June and July. The mean value for the three stations together was equal to 2.2±1.30 ind./10 m^2 (n = 3).

DISCUSSION

Based on the results obtained have not been documented any cases of predation by black rat versus *Podarcis sicula*. During the whole period of investigation (2006 - 2011) were analyzed 4696 excrements of rats but never obtaining any evidence that would confirm the lizard as a trophic source of this Rodent in the island (Siracusa et al., 2010; pres. stud.; unpublished data). Even molecular analysis were negative (Siracusa et al., 2010).

Rats direct the predation especially versus young lizards; in studies carried out in recent years have been observed only sporadically attempts by rats to catch lizards. Moreover, the average density of black rats observed was equal to 39.1 ind./ha, not particularly great compared to other similar-size Mediterranean islands; all individuals captured also showed very high values of body condition index (Petralia et al., 2010).

These considerations and the fact that there seems to be no correlation between the frequency of *Podarcis sicula* (number of individuals counted with transect method) and black rat (Table 9), would indicate that predation is insignificant. Should nevertheless be taken into account indirect effects that may be particularly important in a longer time. Predation of the rat versus insects and its consumption of plants can determine an indirect effect of competitive type against *Podarcis sicula* especially with regard to invertebrates (Pérez-Mellado et al., 2008).

Month	n° ind./10 m^2
January	0.0 ind./10 m^2
February	0.2 ind./10 m^2
March	0.2 ind./10 m^2
April	nr
May	3.6 ind./10 m^2
June	2.4 ind./10 m^2
July	2.6 ind./10 m^2
August	nr
September	2.1 ind./10 m^2
October	nr
November	nr
December	nr

Table 6. Number of individuals /10 m^2 of *Podarcis sicula* observed at station 1 (nr = no detection due to adverse weather conditions).

Month	n° ind./10 m^2
January	0.0 ind./10 m^2
February	0.0 ind./10 m^2
March	0.1 ind./10 m^2
April	nr
May	2.0 ind./10 m^2
June	2.1 ind./10 m^2
July	2.1 ind./10 m^2
August	nr
September	1.9 ind./10 m^2
October	nr
November	nr
December	nr

Table 7. Number of individuals /10 m^2 of *Podarcis sicula* observed at station 2 (nr = no detection due to adverse weather conditions).

Month	n° ind./10 m^2
January	0.0 ind./10 m^2
February	0.5 ind./10 m^2
March	0.7 ind./10 m^2
April	nr
May	1.0 ind./10 m^2
June	0.9 ind./10 m^2
July	0.8 ind./10 m^2
August	nr
September	0.8 ind./10 m^2
October	nr
November	0.2 ind./10 m^2
December	nr

Table 8. Number of individuals /10 m^2 of *Podarcis sicula* observed at station 3 (nr = no detection due to adverse weather conditions).

	2006-2007[1]	2007-2008[2]	2008-2009[3]	2011[4]
Rattus rattus **(excr./10 m^2)**	nr	4.30	8.70	11.40
Podarcis sicula **(trans.) (ind./10 m^2)**	0.2	nr	nr	0.3
Podarcis sicula **(stat.) (ind./10 m^2)**	7.3	nr	nr	2.2

Table 9. Abundance values of *Podarcis sicula* and *Rattus rattus* registered between 2006 and 2011 (nr = no detection) (1 = Fiorini, 2006; 2 = Siracusa et al., 2010; 3 = Zappalà, 2010; 4 = pres. stud.).

Rats also can have negative impacts on populations of invertebrates and thus indirectly on lizards (Pyke et al., 1977). Densities of this rodent vary according to availability of food of vegetal origin and size of islands colonized (VV. AA. in Martin et al., 2000; Guyot, 1989 in Martin et al., 2000). The flora diversity and productivity are also responsible for both the incoming and the numerical variations of the species, even in small islands (Palmer & Pons, 2001).

Moreover the population of nesting *Larus michahellis* (present with a small colony on the island), favoring nitrophilous plant species and making available additional food sources (carcasses, remains of eggs, food remains), allows the number increase of rats. Over the past 30 years, the *Larus michahellis* population has exploded in the Mediterranean and serious effects on ecosystems, especially in relation to rare plant and animal species have already been documented (Vidal et al., 1998).

CONCLUSIONS

The Lachea island is affected by the tourism, even if controlled. Tourism is considered a potential source of threat to different populations of lizards (Amo et al., 2006), especially in small islands. In areas frequented by human lizards show lower values of the body condition index and unfavourable effects in the host-parasite interaction, due to a decrease of cells responsible for immune response (Amo et al., 2006).

Antipredator strategies are expensive in terms of fitness (Martin & Lopez, 1999) and because of that lizards may suffer an increase in the risk of predation (López et al., 2005). Moreover in order to protect the reserve from fire risk, trimming is also executed during the spring.

These interventions eliminate or modify microhabitats colonized by different species of arthropods, potential prey of *Podarcis sicula*. For the conservation of the herpetofauna, especially in regard to small and isolated populations, is then recommended a control of the black rat (Salvador & Veiga, 2005; 2008): after eradication or control of this species in 10 Tyrrhenian islands was observed in some cases a sudden increase in the density of lizards (Capizzi et al., 2006). Combined actions of the factors listed before, together with possible stochastic events, make this small population of *Podarcis sicula* vulnerable to sudden decreases in numbers.

Rattus rattus because of its ethological and ecological features is a potential source of threat (predatory activity on invertebrates, potentiality to expand the population, indirect competition) even though has not been documented any form of predation on that *Podarcis* species.

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REFERENCES

Angelici F.M., Laurenti A. & Nappi A., 2009. A Checklist of the mammals of small italian islands. Hystrix Italian Journal of Mammalogy, 20: 3-27.

Amo L., López P. & Martin J., 2006. Nature-based tourism as a form of predation risk affects body condition and health state of *Podarcis muralis* lizards. Biological Conservation, 131: 402-409.

Amori G., Contoli L. & Nappi A., 2008. Fauna d'Italia - Mammalia II (Erinaceomorpha, Soricomorpha, Lagomorpha, Rodentia). Calderini ed., Bologna, 736 pp.

Burnham K.P., Anderson D. R. & Laake J.L., 1980. Estimation of density from line transect sampling of biological population. Wildlife Monographie, 72: 1-102.

Capizzi D., Baccetti N., Corbi F., Giannini F., Giunti M., Perfetti A., Sposimo P. & Zerunian S., 2006. Eradication versus local control *Rattus rattus* on Tyrrhenian island: ecological aspects, field techniques and economics. Hystrix, Italian Journal of Mammalogy, Supp.: 33.

Fiorini C., 2006. Indagini ecologiche su *Podarcis sicula ciclopica* e su *Rattus rattus* nell'isola Lachea (Acitrezza, Catania). Università di Catania. Anno Accademico 2005-2006.

Igual J.M., Forero M.G., Gomez T., Orueta J.F. & Oro D., 2006. Rat control and breeding performance in Cory's shearwater (*Calonectris diomedea*): effect of poisoning effort and habitat features. Animal Conservation 9: 59-65.

López P., Hawlena D., Polo V., Amo L. & Martín J., 2005. Sources of individual shy-bold variations in antipredator behaviour of male Iberian rock lizards. Animal Behaviour: 69: 1-9.

Martin J. & López P., 1999. An experimental test of the costs of antipredatory refuge use in the wall lizard, *Podarcis muralis*. Oikos, 84: 499-505.

Martin J.L., Thibaut J. C. & Betragnolle V., 2000. Black rats, island characteristics, and colonial nesting birds in the Mediterranean: consequences of an ancient introduction. Conservation Biology, 14: 1452-1466.

Masseti M., 2008. Uomini e (non solo) topi. Gli animali domestici e la fauna antropocora. Firenze University Press, Firenze, 337 pp.

Nogales M., Rodríguez-Luengo J.L. & Marrero P., 2006. Ecological effects and distribution of invasive non-native mammals on the Canary Islands. Mammal Review, 36: 49-65.

Palmer M. & Pons G., 2001. Predicting rat presence on small islands. Ecography, 24: 121–126.

Pérez-Mellado V., Hernández- Estévez J.Á., García-Díez T., Terrassa B., Ramón M.M., Castro J., Picornell A., Martín-Vallejo J. & Brown R., 2008. Population density in *Podarcis lilfordi* (Squamata, Lacertidae), a lizard species endemic to small islets in the Balearic Islands (Spain). Amphibia-Reptilia, 29: 49-60.

Perfetti A., Sposimo P. & Baccetti N., 2001. Il controllo dei ratti per la conservazione degli uccelli marini nidificanti nelle isole italiane e mediterranee. Avocetta, 25: 126.

Petralia E., Messina A., Petralia A., & Siracusa A.M., 2010. Stato della popolazione di *Rattus rattus* (Linnaeus, 1758) (Rodentia, Muridae) nella Riserva Naturale Integrale "Isola Lachea e Faraglioni dei Ciclopi" di Acicastello (Catania). Bollettino dell'Accademia Gioenia, 43: 12-22.

Pyke G.H., Pulliam H.R. & Charnov E.L., 1977. Optimal foraging - a selective review of theory and tests. Quarterly Review of Biology, 52: 137-154.

Salvador A. & Veiga J.P., 2005. Activity, tail loss, growth and survivorship of male *Psammodromus algirus*. Amphibia-Reptilia, 26: 583-585.

Salvador A. & Veiga J.P., 2008. A permanent signal related to male pairing success and survival in the lizard *Psammodromus algirus*. Amphibia-Reptilia, 29: 117-120.

Sciberras A. & Schembri P.J., 2008. Conservation status of the St Paul's Island wall lizard (*Podarcis filfolensis kieselbachi*). Herpetological Bulletin, 105: 28-34.

Sindaco R., Doria G., Razzetti E. & Bernini F. (eds)., 2006. Atlante degli Anfibi e dei Rettili d'Italia / Atlas of Italian Amphibians and Reptiles. Societas Herpetologica Italica, Edizione Polistampa, Firenze, 792 pp.

Siracusa A.M., Messina A., Monaco I., Petralia A., Petralia E. & Rappazzo G., 2010. Abitudini alimentari di *Rattus rattus* (Linnaeus, 1758) (Rodentia, Muridae) della Riserva Naturale Integrale "Isola Lachea e Faraglioni dei Ciclopi" di Acicastello (Catania, Italia). Bollettino Accademia Gioenia Scienze Naturali, 42: 1-12.

St Clair J.J.H., 2011. The impacts of invasive rodents on island invertebrates. Biological Conservation 144: 68-81.

Vidal E., Medail F. & Tatoni T., 1998. Is the yellow-legged gull a superabudant bird species in the Mediterranean? Impact on fauna and flora, conservation measures and research priorities. Biodiversity and Conservation, 7: 1013-1026.

Zappalà M., 2010. Dieta di *Rattus rattus* (Linnaeus, 1758) nell'Isola Lachea (Acicastello, Catania). Università degli Studi di Catania. Anno Accademico 2009-2010.