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THE UNEXPECTED “PERSISTENCE” OF THE ENDEMIC
ARCHAEOLACERTA BEDRIAGAE ON THREE CORSICAN ISLETS

SUMMARY

Archaeolacerta bedriagae is a Corso-Sardinian endemism, known only from the Corsican Islet La Folaca, but recently discovered on two other islets (Lavezzi satellite islands). All three populations genetically belong to the sub-Corsican clade. The micro-insular distribution of this lizard is limited to the islands and islets of the Strait of Bonifacio. The absence of the Bedriaga's rock lizard in the Corsican main islands of Lavezzi and Cavallo still remains unexplained; however, for the latter, habitat alterations and the introduction of alien species could be the cause. The absence of the Bedriaga's rock lizard from the other Lavezzi islets may have been influenced by the morphology and vegetation cover of these islets.

Key words: Lacertidae, Mediterranean, Corsica, islands.

RIASSUNTO

L'inaspettata persistenza di Archeolacerta bedriagae su tre isolotti della Corsica. La Lucertola di Bedriaga, endemita sardo-corsa nota per essere presente su un solo isolotto costiero della Corsica meridionale, è stata di recente scoperta anche su due isolotti satelliti dell'Isola di Lavezzi. Tutte e tre le popolazioni appartengono geneticamente a un sub-clade corso. L'assenza della specie sulle isole maggiori di Lavezzi e Cavallo non è facilmente interpretabile, tuttavia, in particolar modo relativamente a quest'ultima, le alterazioni dell'habitat nonché l'introduzione di specie aliene da parte dell'uomo potrebbero esserne stata la causa. La sua assenza sugli altri isolotti dell'arcipelago di Lavezzi potrebbe dipendere dalla morfologia e relativa copertura vegetale degli isolotti.

Parole chiave: Lacertidae, Mediterraneo, Corsica, isole.

INTRODUCTION

Lizards are widespread on many islets in the Mediterranean. Since the Last Glacial Maximum most of these small lands remained isolated from the mainland as happened for the satellite islets of Corsica and Sardinia (LANZA & POGGESI, 1986; SENCZUK *et al.*, 2019). In most cases the presence of a species on an islet, when not introduced by humans, derives from its presence on the nearby mainland before the separation took place, as well as from its ability to persist in impoverished ecosystems characterized by scarce availability of food and space and from the aptitude to cope with drastic environmental changes (DELAUGERRE & CORTI, 2020). An interesting question that follows might be: How can a Lacertid lizard successfully persist in such extreme habitats?

On many satellite islands of Corsica and Sardinia there are species commonly present on islets, such as the European leaf toed gecko (*Euleptes europaea*) and the Tyrrhenian wall lizard (*Podarcis tiliguerta*) (LANZA & POGGESI, 1986; DELAUGERRE & CHEYLAN, 1992; POGGESI *et al.*, 1996; CORTI *et al.*, 2006, 2014; DELAUGERRE & CORTI, 2020), while others, although similar in size and life history traits, are quite rare on islets but relatively widely distributed on the two main islands. One of these is the paleoendemic Bedriaga's rock lizard (*Archaeolacerta bedriagae*). In the present work we try to define why this species is found only on some islets and it is absent on others, focusing on the islands of the Strait of Bonifacio.

MATERIALS AND METHODS

Study species

Archaeolacerta bedriagae (Camerano, 1885) is a medium-sized rupicolous lizard found exclusively in rocky habitats. Head and body are depressed (Fig. 1). The dorsal pattern is mostly reticulated, and the colouration varies from greenish to brown-black. The species is endemic to Corsica and Sardinia and can be found from sea level up to a maximum altitude of 2,500 m (in Corsica, SINDACO *et al.*, 2010). In Sardinia its insular range includes several islands of the La Maddalena Archipelago (CORTI *et al.*, 2006, 2014) whereas the species has been reported, before the present study, only for La Folaca Islet among the numerous satellite islands of Corsica (LANZA & POGGESI, 1986; DELAUGERRE & CHEYLAN, 1992).

Study area

Our study focuses on the islands of the Strait of Bonifacio, which separates Corsica (France) from Sardinia (Italy). From 2010 to 2021, the herpeto-



Fig. 1 — *Archaeolacerta bedriagae*, Île A Magrunaghja (Photo M. Biaggini).

fauna of the Cerbicale and Lavezzi islands, as well as that of other islands of southern Corsica and northern Sardinia, was carefully studied (CORTI *et al.*, 2014, Biaggini & Corti, 2021). The coastal island Isola Rossa di Trinità d’Agultu, located along the north-western coast of Sardinia, was also visited twice in search of *A. bedriagae* previously reported by POGGESI *et al.* (1995).

Fieldwork

We performed visual encounter surveys (VES) both on linear transects and during free search depending on the features of the habitats. All records were georeferenced and tail tips of *A. bedriagae* (N = 8) were collected and preserved in 95% alcohol for genetic analysis.

Lab work

Total genomic DNA was extracted from alcohol-preserved tail tip muscle collected from live individuals following standard high-salt protocols (SAMBROOK *et al.*, 1989). According to SALVI *et al.* (2010), a fragment of 848 base pairs (bp) of mitochondrial DNA, including ND4 gene, tRNAs for Serine (tRNASer), Histidine (tRNAHis) and Leucine (tRNALeu), was amplified by polymerase chain reaction (PCR) using ND4 and Leu primers published

by ARÉVALO *et al.* (1994). Amplifications were conducted following SALVI *et al.* (2010) and PCR products were sequenced on an ABI310 Genetic Analyser (Applied Biosystems), with the same primers used for amplification.

To determine the haplotypes of the eight individuals analysed, the sequences obtained were aligned with homologous sequences retrieved from Gen-Bank and representing Corsican and Sardinian haplotypes of *A. bedriagae* previously identified by SALVI *et al.* (2010). Sequences from four Lacertid species (namely, *Podarcis siculus*, *P. muralis*, *P. hispanica*, and *Lacerta viridis*) were selected as outgroups in the phylogenetic analyses. Sequence alignment was carried out in ClustalW (LARKIN *et al.*, 2007) using default parameters. The relationships between *A. bedriagae* haplotypes were determined using the Neighbor-Joining (NJ) method as implemented in MEGA version 5 (TAMURA *et al.*, 2011). NJ analysis was based on Kimura 2-parameters distances (K2P) and the confidence at nodes assessed by 1000 bootstrap replicates.

RESULTS

The presence of *A. bedriagae* on La Folaca (BODINIER, 1981; LANZA & POGGESI, 1986; DELAUGERRE & BRUNSTEIN, 1987), a rocky islet characterized by scarce vegetation cover, has been confirmed together with *Euleptes europaea*.

Lavezzi, the main island of the Lavezzi archipelago, is surrounded by numerous islets and rocks (LANZA & POGGESI, 1986). For two of these islets, Île des Fiori and A Magrunaghja islets, *A. bedriagae* is reported here for the first time. For these islets LANZA & POGGESI (1986) and THIBAUT *et al.* (1987) report only *E. europaea*, *Podarcis tiliguerta* and *Hierophis viridiflavus*. Both islets are characterized by large bare granite outcrops. Plant communities are composed of few halophiles (MÉDAIL *et al.*, 2019) and vegetation covers 7% and 25% of their surface respectively. It is hard to believe that a stable population of the Green whip snakes lives on these islets, indeed it is to be assumed that snakes swim from one island to the another as already hypothesized for some neighbouring islands of the La Maddalena Archipelago (north Sardinia) (CORTI *et al.*, 2014) and observed for the satellite islands of Ibiza by MONTES *et al.* (2021). The population of *A. bedriagae* appears to be relatively small on Île des Fiori, where only few individuals have been sighted. The opposite has been observed on A Magrunaghja Islet, where the populations of *A. bedriagae* and *Podarcis tiliguerta* can be considered relatively dense.

As regards the Archipelago of La Maddalena and neighbouring islands, *A. bedriagae* has been confirmed only for the islands of Caprera, La Mad-

dalena and Spargi: in all these sites a relatively small number of lizards have been observed. For the other islands reported by LANZA *et al.* (1984) the species has not been confirmed, as also noted by BOMBI & VIGNOLI (2004) for those islands of the Archipelago they visited. Further investigations will be needed to confirm the presence of the Bedriaga’s rock lizard on these islands (Table 1).

Table 1

Geographical data of the Corsican (C) and Sardinian (S) islands where *Archaeolacerta bedriagae* is found (LANZA & POGGESI, 1986; POGGESI *et al.* 1995; MÉDAIL *et al.*, 2019; present work). Categories *sensu* POGGESI *et al.*, 1995 refer to island area: (A) up to 10.000 m²; (B) from 10.001 to 100.000 m²; (C) from 100.001 to 1.000.000 m²; (D) from 1.000.001 to 10.000.000 m²; (E) from 10.000.001 to 100.000.000 m²).

ISLAND	Type <i>sensu</i> POGGESI <i>et al.</i> , 1995	Confirmed Yes/No/Nr (new record)	Main island	Area (ha)	Elevation	Herp- species
SARDEGNA						
Isola Rossa di Trinità d’Agulto	B	No	S	6.2	15	2
Razzoli	D	No	S	167	65	7
Budelli	D	No	S	172	88	9
Santa Maria	D	No	S	190	49	12
Spargi	D	Yes	S	420	153	10
La Maddalena	E	Yes	S	5201	156	17
Santo Stefano	D	No	S	305	100	10
Giardinelli	C	No	S	44,25	16	8
Caprera	E	Yes	S	1570	212	15
CORSICA						
Île des Fiori (named by Lanza & Poggesi, 1986 “Luigi Giafferri”)	B	Nr	C	1.94	18	3
Île A Magrunaghja (named by LANZA & POGGESI, 1986 “Giacinto Paoli”)	B	Nr	C	1.68	29	4
La Folaca	A	Yes	C	0.208	15	2

On Isola Rossa di Trinità d'Agultu, a small coastal island in the Asinara Gulf (northern Sardinia) several miles (~ 20) away from the Bonifacio Strait, POGGESI *et al.* (1995) report, after an “*in litteris*” communication dated 1990, the sighting of many Bedriaga's rock lizards. This island is made up of leucogranites dating back to the late Hercynian phase and is geologically referable to the “Granitoid complex of Gallura” while the flora is typically Mediterranean (BOCCHIERI & IIRITI, 2002). *Malva arborea* (L.) Webb & Berthel dominates the island as already reported by BOCCHIERI & IIRITI (2002). In a first exhaustive work by DESOLE (1954), the presence of this plant and many others found by BOCCHIERI & IIRITI (2002) is not mentioned, indicating that in the last half-century there has been a significant change in the floristic composition of the island. After careful and repeated searches on the island, no individuals of *A. bedriagae* have been sighted, while numerous Tyrrhenian wall lizards, *Podarcis tiliguerta*, have been observed. POGGESI *et al.* (1995) considering the presence of *Euleptes europaea* doubtful for this island did not use this record in their analyses. We can confirm that *E. europaea* is not present on Isola Rossa di Trinità d'Agultu but we report instead, for the first time, the presence of a large population of *Tarentola mauritanica*.

The genetic analysis, focusing on the populations of the southern Corsican islets (La Folaca, Île des Fiori and A Magrunaghja islets) revealed that they nested, as expected, in the widespread lineage B within the clades previously described by SALVI *et al.* (2010) (Fig. 2). Indeed, the only specimen from La Maddalena Island fell into the sub-clade IV harbouring individuals from North Sardinia; Corsican samples from Mont de La Trinité on Corsica main island, La Folaca Islet and the five specimens from the two small islands, Île des Fiori and A Magrunaghja islets, not included in SALVI *et al.* (2010), located within the Southern Corsican sub-clade (sub-clade III, according to SALVI *et al.*, 2010).

DISCUSSION

On the satellite islands of Sardinia, the Bedriaga's rock lizard is recorded exclusively on relatively large islands (area 44-5201 ha, type C, D, E *sensu* POGGESI *et al.*, 1996) of the La Maddalena Archipelago, while in Corsica, on the contrary, the species is found only on islets with a surface of 0.2-1.9 ha (type A and B *sensu* POGGESI *et al.*, 1996). Two out of three of these islets are characterized by poor vegetation cover. Only one islet, A Magrunaghja, offers a more complex habitat and is home to a relatively dense population of the Bedriaga's rock lizard. On Île des Fiori and La Folaca islets the population is represented by few individuals as already observed, about 40 years ago, by Benedetto Lanza on La Folaca (LANZA *et al.*, 1984), indicating that this population is still viable despite the small number of individuals.

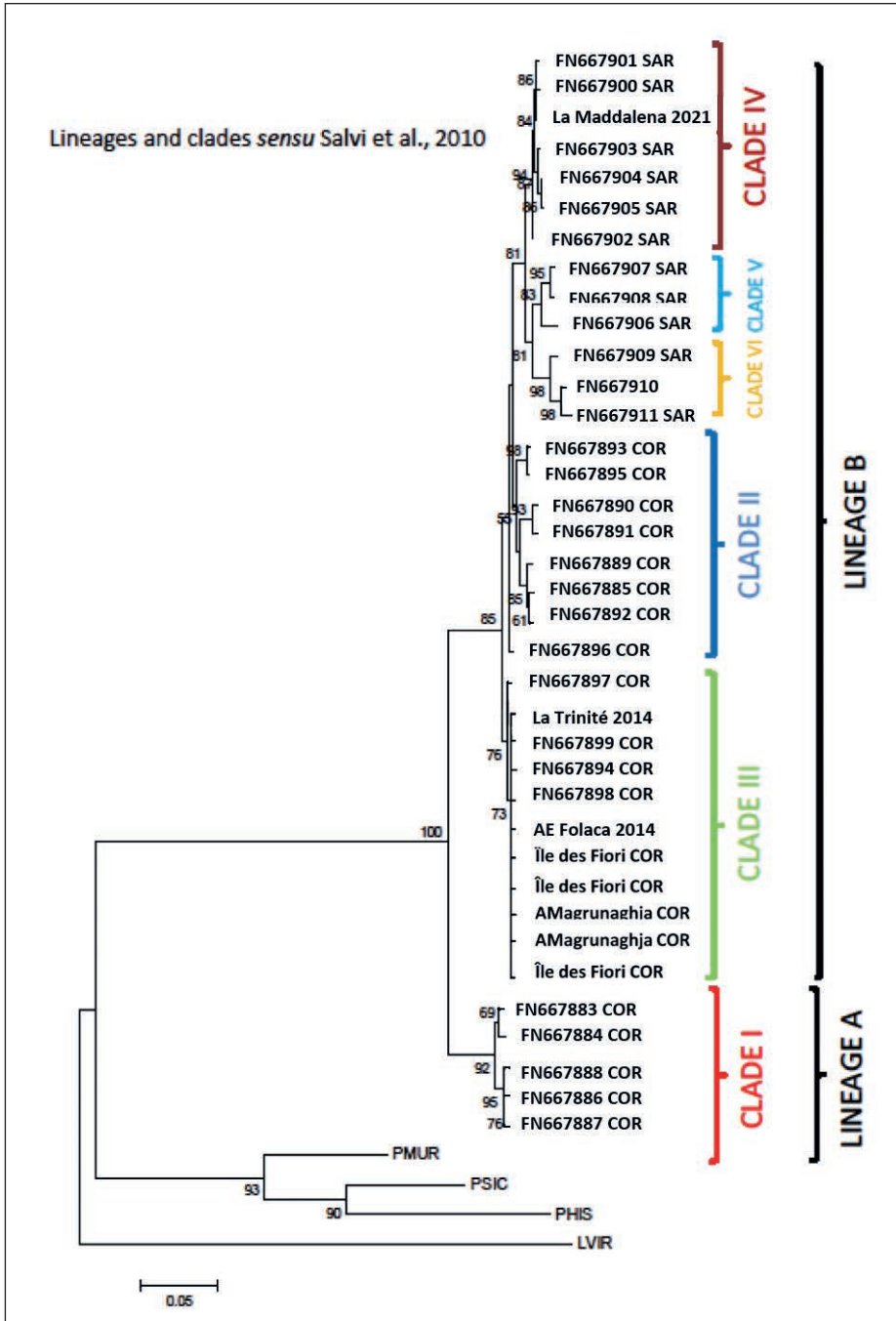


Fig. 2 — *Archaeolacerta bedriagae* tree.

According to SILLERO *et al.* (2018), habitat diversity and topographical complexity (i.e., elevation and ruggedness) are factors that provide more information than simply area, in characterizing environmental heterogeneity and thus influencing the number of species and/or population density. As observed for the islet A Magrunaghja, the structural complexity in terms of substrate (alternation of closely spaced bare rock outcrops, i.e., high “ruggedness”) allows the presence of safe basking sites, thus reducing exposure to potential predators, and offering greater trophic availability thanks to a richer plant community that settles in this environment because better protected from atmospheric and marine agents. The topographic complexity of La Folaca and Île des Fiori is considerably lower, as is the vegetation cover is, characteristics that certainly do not play in favour of high density of lizards.

The narrow and shallow channels that separate the Lavezzi islands, as well as those that separate the latter from the main island, suggest that in the past *A. bedriagae* was present both on the major islands of the Lavezzi archipelago and along the coast of Corsica (LANZA & POGGESI, 1986; VACCHI *et al.*, 2016). Despite extensive but fruitless searches for *A. bedriagae* in the main islands of Lavezzi and Cavallo, where natural habitats appear to be preserved and the alien Black Rat (*Rattus rattus*) has been eradicated, the lack of the species remains unexplained. However, a possible explanation could be related to the habitat alterations caused by humans upon their early arrival on the islands, including the introduction of predators. The absence of *A. bedriagae* from the other Lavezzi islets is probably due to the lack of the species’ minimum environmental requirements, represented by a given arrangement of the large bare granitic outcrops and vegetation cover.

As regards the presence of *A. bedriagae* on the island Isola Rossa di Trinità d’Agulto, it cannot be excluded that the changes in the floristic composition reported by BOCCHIERI & IIRITI (2002) have somehow negatively influenced the presence of the Bedriaga’s rock lizard, although misidentification of the species appears to be more likely.

Islands are often used as a model of simplified ecosystems, but life on small islands is often determined by a set of variables that are not always immediately definable but decisive in determining the composition and structure of both plant and animal communities.

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