

Competitive exclusion between *Podarcis* lizards from Tyrrhenian islands: Inference from comparative species distributions

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Podarcis sicula is an opportunistic and eurikous lacertid lizard occurring as autochthon species in peninsular Italy, Sicily and in a number of Tyrrhenian islands and islets (HENLE & KLAVER 1986). It inhabits also the Adriatic coast of Yugoslavia and several Adriatic islands (NEVO et al. 1972).

Distributional and genetic data indicate that in some Tyrrhenian islands, e.g. Sardinia, Corsica, Tuscan Archipelago, this lizard has been accidentally introduced by man in proto-historic or historic times, invading the range of other *Podarcis* species (e.g., *P. tiliguerta*, *P. muralis*) (LANZA 1983, 1988, CORTI et al. 1989). In these islands the allochthon *P. sicula* seems to have competed successfully with the native congeneric species, reducing their range (e.g., *P. tiliguerta* in Corsica and Sardinia) (LANZA 1983, 1988), or replacing them through competitive exclusion (e.g., *P. muralis* in the Tuscan Archipelago) (CORTI et al. 1989).

In the present paper preliminary data are given on the occurrence of exclusion of *P. wagleriana* by *P. sicula* in the Aeolian Islands (Sicily). *P. wagleriana* is endemic to Sicily, Aegadian, Stagnone (Isola Grande) and Aeolian Islands, and has been traditionally considered closely related to *P. sicula*.

Methods

Competitive exclusion is one of the most dramatic natural effects of interspecific competition. The competitive superiority of a species has proved to be exceedingly difficult to analyze in natural conditions. To overcome this difficulty, we inferred the occurrence of competitive exclusion from the comparative distributions and relative abundance of the two potentially competing species (GILLER 1984). An analysis of the habitat differences between *P. sicula* and *P. wagleriana* was also performed, so that the spatial niche could be investigated. Our observations were made during a three-year research period (1987-1989) at 20 sites in Sicily (see CAPULA 1990) and at 17 sites in the Aegadian (Marettimo, Favignana, Levanzo), Stagnone (S. Pantaleo), and Aeolian Islands (see Fig. 1). A set of 11 predefined qualitative microhabitat categories was designated following RAYNOR (1989). The categories were defined as follows: herbaceous vegetation (A), degraded scrub with maquis type vegetation (B), woody vegetation (C), intact walls (D), collapsed walls (E), exposed rock faces (F), open stony ground (karst type

terrain) (G), sandy banks (H), edge of cultivated land (I), edge of path or road (J), edge of vegetated banks (K). The niche breadth was measured using SHANNON-WEAVER (1949) information theoretic measure, standardized in such a way that the values obtained varied between 0 and 1 (the more specialized species having the lower values). The niche overlap was estimated using PIANKA's (1973) overlap parameter.

Results

Comparative species distributions

Podarcis sicula and *P. wagleriana* occur sympatrically in several localities of Sicily and in the Aegadian Islands (CAPULA 1990). Surprisingly, they are never sympatric in the Aeolian Islands, with the exception of Vulcano. *P. sicula* is widespread, inhabiting all the large Aeolian islands as well as most of the small ones (see Fig. 1). On the other hand, *P. wagleriana* is very localized, being confined to one island (Vulcano) and to three rock islets (Scoglio Faraglione, La Canna,

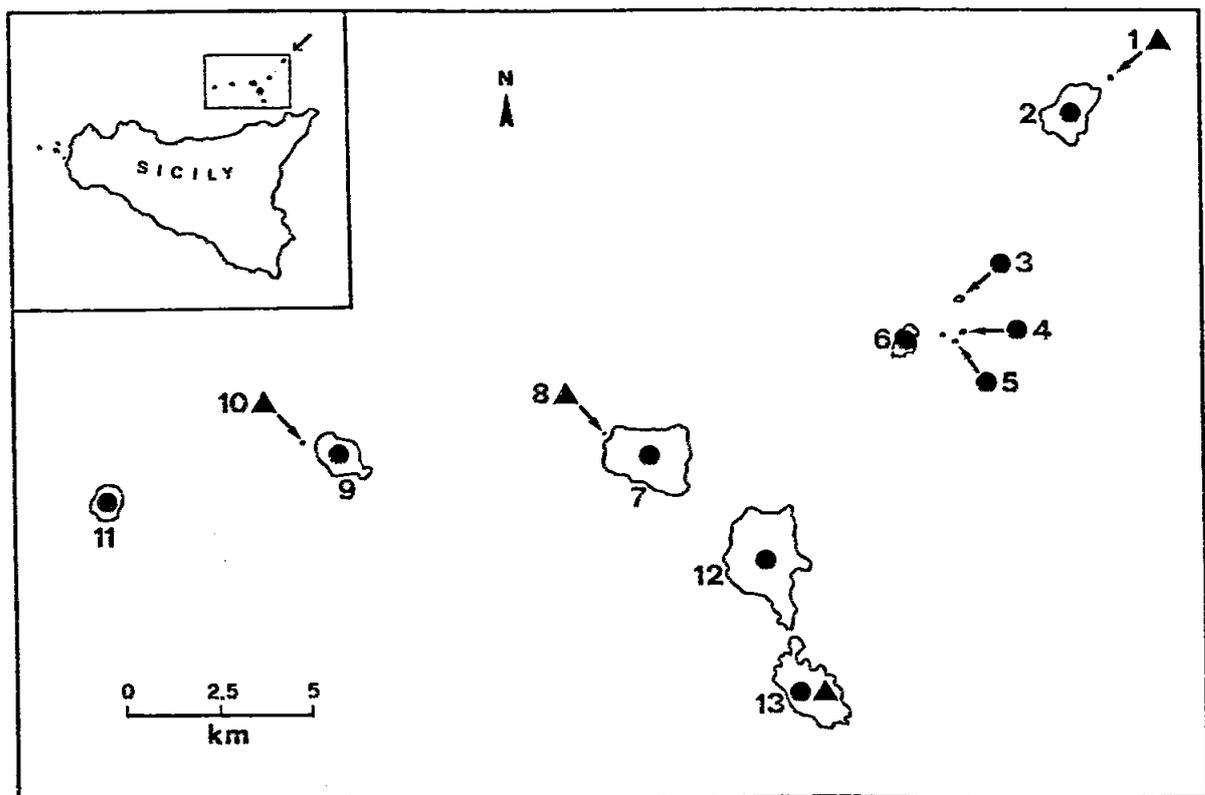


Fig. 1. Distribution of *P. sicula* (circles) and *P. wagleriana* (triangles) in the Aeolian Islands. 1= Strombolicchio, 2= Stromboli, 3= Basiluzzo, 4= Lisca Bianca, 5= Bottaro, 6= Panarea, 7= Salina, 8= Scoglio Faraglione, 9=Filicudi, 10= La Canna, 11= Alicudi, 12= Lipari, 13= Vulcano

Strombolicchio). Vulcano is the only Aeolian island inhabited by both species, but in fact *P. sicula* is very abundant and spread all over the island, while *P. wagleriana* is very rare, nearly reaching the extinction (CAPULA et al. 1987).

P. sicula can be considered a quite recent colonizer in the Aeolian Islands. It has been probably introduced by man in historic times, subsequently spreading all over the islands. This is confirmed by the low genetic divergence found comparing Aeolian and Sicilian samples of *P. sicula* (NEI's average $D=0.003$) (CAPULA et al. 1987). The colonization of the Aeolian Islands by *P. wagleriana* is considerably more ancient, as shown both by the higher values of genetic distance found comparing Aeolian and Sicilian samples of the species (NEI's average $D=0.142$) (CAPULA 1990), and by the distinctive colouration pattern of the Aeolian populations (BÖHME 1986, CAPULA 1990). It is therefore evident that *P. wagleriana* is the autochthon lacertid lizard in the Aeolian Archipelago, though at present confined to a few islands.

Habitat differences

The abundance of *P. sicula* and *P. wagleriana* in each microhabitat is shown in Fig. 2. *P. wagleriana* was found mainly in grassy open ground and in degraded scrub areas ($p < 0.05$; χ^2 test), although in the Aeolian Islands it often occurred on exposed rock faces. The species was never observed either climbing on dry-stone walls or in cultivated land. *P. sicula* was much more diverse in its microhabitat

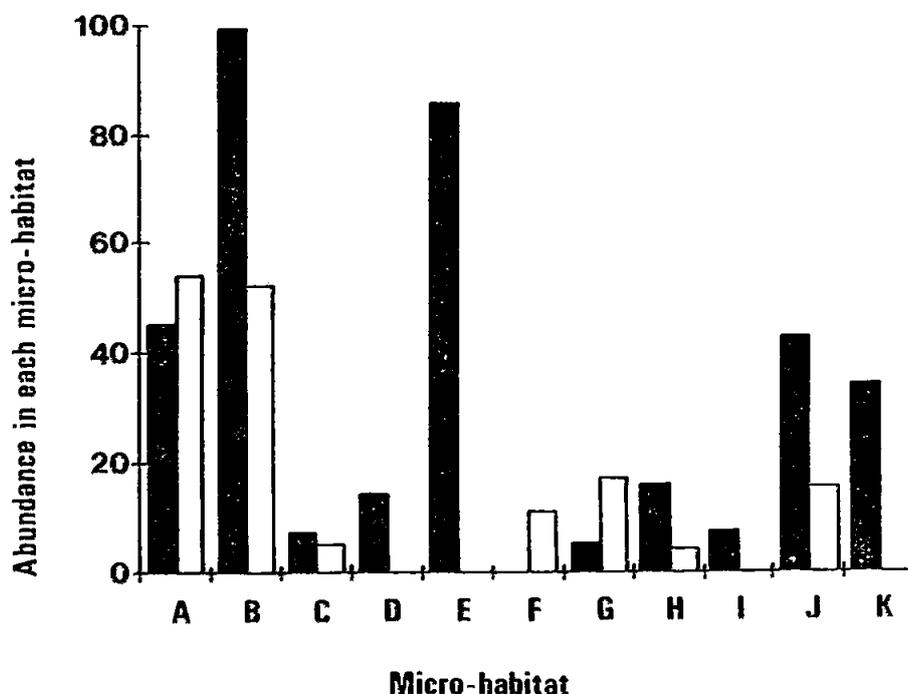


Fig. 2. The abundance of *P. sicula* (black histograms) and *P. wagleriana* (white histograms) in each microhabitat. For microhabitat codes (A-K) see Methods

choice, being present in all but one predefined microhabitat categories (Fig. 2). This lizard showed a marked preference for vegetated open ground and dry-stone walls, especially the collapsed ones ($p < 0.05$; χ^2 test), but was not observed on exposed rock faces.

At most sites both species were largely sympatric, frequently occupying the same microhabitat. *P. sicula* occurred alone in microhabitat D, E, I, K. It was numerically more abundant than *P. wagleriana* in the following microhabitats: B ($p < 0.01$; χ^2 test), H ($p < 0.05$; χ^2 test), J ($p < 0.05$; χ^2 test). *P. wagleriana* did not co-occur with *P. sicula* in microhabitat F, and was numerically more abundant than the latter species only in microhabitat G ($p < 0.05$; χ^2 test). From these data one can suppose an influence of *P. sicula* on *P. wagleriana* when they co-occur. Moreover, the niche breadth values calculated for both species (*P. sicula* = 0.828; *P. wagleriana* = 0.685) clearly indicate that the presence of *P. sicula* appears to reduce the niche breadth of *P. wagleriana*. This, coupled with the observation that the two species are frequently sympatric, often occupying the same microhabitat (PIANKA's overlap parameter = 0.705), suggests that *P. sicula* and *P. wagleriana* are likely to be competing for the same resource.

Discussion

The comparative species distributions in the Aeolian Islands clearly indicate that the recent invader *P. sicula* has competed successfully with *P. wagleriana*, highly reducing the range of the latter and causing the extinction of most of its populations. This seems to be a classic case of competitive exclusion of a native form by a species introduced by man.

The pattern inferred from the negative correlations between the spatial distributions of the two species in the Aeolian Islands is supported by the analysis of the habitat differences. This shows that in *P. sicula* and *P. wagleriana* there was niche overlap, involving negative effects due to competition. In Sicily and Aegadian Islands the competition superiority of *P. sicula* results in a much more diverse microhabitat choice, but competitive exclusion of *P. wagleriana* is avoided by the habitat richness characterizing these large islands. In the Aeolian Archipelago competitive exclusion of *P. wagleriana* did occur, probably due to the highly reduced habitat diversity. In this insular area *P. sicula* could have been favoured also by the drastic habitat alteration caused by man in the last century (e.g., deforestation, fire, agricultural activities).

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