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# ARTIFICIAL EGG-LAYING SITES FOR LIZARDS: A CONSERVATION STRATEGY

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**Abstract**

*This paper reports the development of a new technique that may help to increase the number of lizards in areas where scarcity of oviposition sites constitutes the major limiting factor. We have created artificial egg-laying sites for the endangered subspecies of lizard* Podarcis hispanica atrata *in the Columbretes archipelago. Our results demonstrate that such artificial sites were quickly accepted by the lizards as areas for basking and burrowing. Only one container was used for oviposition by one female, but the physical conditions in the artificial sites allowed successful development in 83% of the eggs which were experimentally placed in them. Additional studies will be required to improve this technique and to determine if it might be applicable to other lizard species.*

*Keywords:* Artificial nests, reproduction, Mediterranean islands, endangered species, habitat colonisation.

## INTRODUCTION

Species with restricted distributions or small population sizes are more vulnerable to extinction because they are particularly sensitive to stochastic changes, both demographic and genetic. Because of the uncertain fate of small populations and the increasing recognition of the inherent value of biodiversity, much attention has been given to the management of threatened species (see Council of Europe, 1993). When recovery plans for populations are considered, most attention is generally given to the adult stage. For many animal species, however, juvenile or egg stages may be of at least equal importance. For example, many studies of birds, sea turtles and alligators have attempted to enhance the number of hatchlings by protecting eggs in some way (Temple, 1978; Eckert, 1987; Hunt & Ogden, 1991).

Eggs in general have a limited ability to react to environmental changes, and in reptiles they may be the most vulnerable stage (Packard & Packard, 1988; Shine, 1988). In addition, temperatures of the substrate where egg incubation takes place can have long-term effects on the physiology, behaviour, and survival of hatchling reptiles (reviewed in Packard & Packard, 1988; Burger, 1989, 1990; Miller, 1993). The availability of appropriate areas in which to lay eggs is therefore fundamental for population survival, and scarcity of suitable egg-laying areas could constitute a limiting factor to the number of individuals in a population. Where the quality and/or quantity of such sites are limiting resources, the provision of artificial sites could increase the number of young and ultimately expand population size. This management strategy has been applied successfully in many bird and mammal conservation projects (Temple, 1978, 1983; Criel, 1988, Newton, 1994), but to our knowledge, this strategy has not been applied to lizard populations.

The present study was undertaken to gather preliminary data on the effectiveness and use of artificial oviposition sites by the lizard *Podarcis hispanica atrata*. This subspecies is endemic to the Columbretes islands, a small Mediterranean archipelago (Corbett, 1989). The entire world range is about 20 ha (see details in Castilla & Bauwens, 1991*a,b*). The lizard maintains a high population density only in some areas on the largest island of the archipelago, but is present in very low numbers on the three remaining islets (Castilla & Bauwens, 1991*b*). In view of the high degree of soil erosion and the rocky structure of the islets, scarcity of nesting sites appeared to be one possible reason for the low density of lizards. Our goal was, therefore, to test whether lizards accepted artificial sand boxes as laying sites, and to gain some experience with this new technique. The study was performed on the largest island, Columbrete Grande (13 ha), for possible future application on the remaining islets.

## STUDY AREA

The Columbretes islands (39° 54' N, 0° 41' E) constitute an archipelago of small uninhabited islets of volcanic origin situated in the Mediterranean *c.* 57 km off the coast of Castellón (province of Castellón, Spain). The climate of the archipelago is characterised by an average annual temperature of 17°C and low rainfall (265 mm/year). Vegetation consists mainly of perennial shrubs (*Suaeda vera, Lobularia maritima*), herbs (*Lavatera mauritanica*), and patches of grasses. The vegetative cover of herbs exhibits great seasonal fluctuations, and depends strongly on precipitation levels. Trees are absent, except for one introduced individual of *Ficus carica*. Large expanses of rock without any vegetative cover are also present.

## METHODS

### Creation and placement of artificial oviposition sites

This study was conducted between May and July 1993. Artificial egg-laying sites were constructed of commercially available opaque white plastic containers (20 × 15 × 7 cm) used extensively in laboratories. The containers were open above and totally filled with 5 kg of dry volcanic sand from the same island. The dimensions of the containers were considered appropriate because a communal nest site in the same study area containing up to 140 eggs was 40 × 30 × 15 cm, and eggs were found in soil between 5 and 15 cm deep (Castilla, 1992). We used three different types of surface, after noting where lizards laid their eggs under natural conditions (Castilla, 1992). In five of the containers we placed two flat rocks 10 cm in height covering *c.* 40% of the sand surface. In another five we placed a large stone shingle used for house construction which covered *c.* 80% of the sand surface. The last five cages had only sand (Fig. 1(a)). All 15 containers were covered with a stone slab allowing ventilation and shading (Fig. 1(b)). About 0·6 l of rain water, collected in cisterns, was added to each container initially, and thereafter 0·1–0·3 l of water was added to each nest every other day, after temporarily removing the rocks and shingle from the nest. The containers were placed in two different areas separated by a distance of about 300 m. Area I was rocky, had little soil and vegetation, and a very low density of lizards (<100 individuals/ha); this area appeared to have a scarcity of suitable natural nesting sites. Area II was near the warden's habitation, had high vegetation cover, abundant soil, a high density of lizards (*c.* 800/ha, Castilla & Bauwens, 1991*b*), and apparently a high availability of oviposition sites. All containers were placed on the ground surface in a horizontal position and near a *Suaeda vera* shrub of *c.* 50 cm height, from 19 May until 30 July 1993. They were separated from each other by a minimum distance of 5 m and a maximum of 15 m (mean *c.* 9 m). Small volcanic rocks were placed all around the containers to render them more accessible to lizards, and to hide their white colour.

**Fig. 1.** Different types of artificial nests designed for *P. h. atrata* (a), and their location on the island of Columbrete Grande (area I) (b).

**Occupation of artificial sites**

A necessary condition for the use of the containers as oviposition sites is that they should not be avoided by the lizards during their normal activities. To quantify the presence of active lizards in each nest, we made 5-min observations on 19 days between 25 May and 8 July 1993 and within the periods 0700–0900 h and 1800–1900 h (mean European time: MET). Observations took place at a distance of 2 m from the nests and without disturbing the lizards. During each 5-min observation period, we recorded the number of male, female and juvenile lizards seen. As lizards were not individually recognisable, the total number of sightings is likely to include resightings. During 40 observations over 20 days, we recorded the presence of burrows in the sand and collected all faecal pellets from each of the 15 containers (as only one lizard species occurs in the study area, identification was certain).

**Eggs as a biological assay for site suitability**

To test the adequacy of physical conditions in the artificial oviposition sites, we initially placed three recently laid eggs in each container, and scored their survival every week. The eggs were obtained from 26 females with a mean body size of 65·5 mm which had oviductal eggs. Each female was kept in a separate terrarium, placed under natural conditions and provided with food, water, and partial shade for 1–20 days before laying their eggs. The presence and condition of the eggs were monitored weekly. Eggs were removed from the terraria 15 min–4 h after they were laid, marked and placed in an artificial site the same day. To avoid confounding site and maternal effects, three eggs from three different females were placed in each container. The presence and condition of the eggs were monitored weekly. Eggs that disappeared, broke or proved to be infertile were replaced by a new egg as soon as one was obtained. Therefore, in some containers more than three eggs were placed over the entire experimental period.

**Recording natural clutches in the artificial sites**

All 15 containers were fully inspected once during the reproductive season, and again at the end of the season, after we were unable to find any more gravid females. On both occasions, we first removed the eggs we had placed there, and then carefully searched the sand in the containers for naturally laid eggs.

## RESULTS

All artificial sites were regularly visited by adult males and females as basking sites soon after their placement in the field (Table 1, Fig. 2). The presence of lizards, faecal pellets, and burrows was higher in the nests placed in area II than in area I. Nevertheless only one container in area II was used as an oviposition site. One clutch of two eggs was found buried 4 cm deep. These hatched a week after.

**Table 1. Total number of active lizards and burrows in the artificial sites (1–8), and number of faecal pellets collected during 40 days in May and June 1993 in areas I and II**

| | *Lizards* | | *Pellets* | | *Burrows* | |
|---|---|---|---|---|---|---|
| | I | II | I | II | I | II |
| 1 | 6 | 10 | 12 | 18 | 1 | 2 |
| 2 | 7 | 13 | 2 | 20 | 0 | 1 |
| 3 | 11 | 35 | 12 | 43 | 1 | 3 |
| 4 | 17 | 33 | 5 | 66 | 0 | 2 |
| 5 | 3 | 17 | 3 | 42 | 1 | 1 |
| 6 | 9 | 29 | 13 | 32 | 3 | 4 |
| 7 | 7 | 7 | 3 | 34 | 2 | 1 |
| 8 | — | 93 | — | 136 | — | 9 |

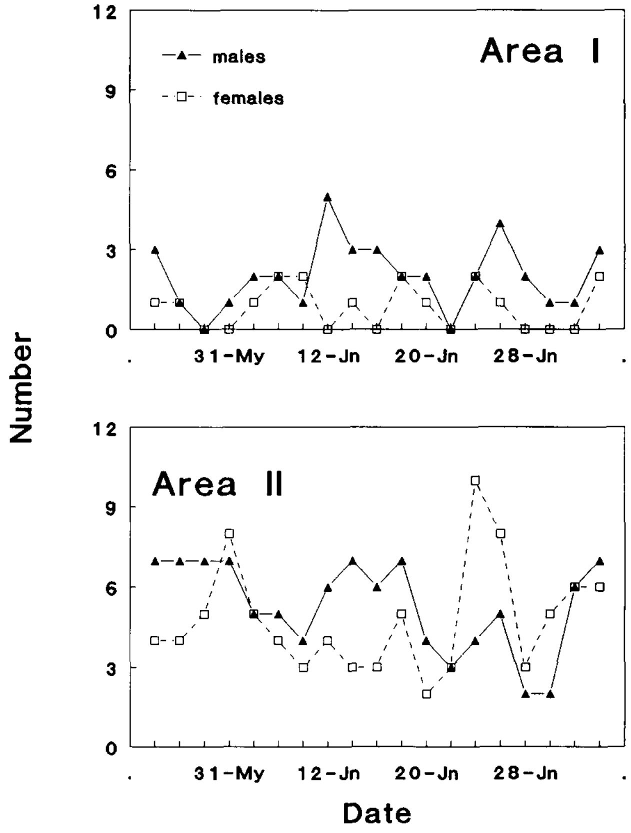


**Fig. 2.** Maximum number of lizards (males and females) present on the 15 artificial sites in areas I and II during 19 different days from 25 May to 8 July.

A total of 60 introduced eggs developed in the containers. One egg was infertile, two were broken when handled, and 10 were predated. Of the 47 remaining eggs, eight (17%) died inside the containers during the first month of incubation and 39 (83%) developed successfully (Table 2). All eggs in area I in all types of containers developed successfully whereas only 70% were successful in area II. The proportion of predated eggs was higher in area II (21%, where the density of lizards was higher) than in area I (13%), but this difference was not significant ($\chi^2$ = 0·51, 1 d.f., $p$ > 0·50).

**Table 2. Successful introduced eggs in the different types of cages in areas I and II (predated, infertile and broken eggs have not been included)**

| | | Surface cover | | |
|---|---|---|---|---|
| | | Shingle | Rock | Sand |
| I | Total | 6 | 6 | 8 |
| | Successful | 6 | 6 | 8 |
| | (%) | (100) | (100) | (100) |
| II | Total | 12 | 5 | 10 |
| | Successful | 8 | 4 | 7 |
| | (%) | (67) | (80) | (60) |

## DISCUSSION

*Podarcis hispanica atrata* was considered an ideal species for testing the efficacy of artificial laying sites for several reasons. First, we had the necessary information on natural sites that allowed us to proceed with the experiment (Castilla, 1992). To our knowledge, such information is available for only two other European species of lizards (*Lacerta agilis* and *Podarcis bocagei*: Strijbosch, 1988; Galán, 1992). Secondly, previous observations on Columbrete Grande indicated temporary concentrations of up to 100–150 gravid females in certain restricted areas and the existence of communal egg-laying sites (Castilla, 1992). These observations suggested possible heterogeneity in the availability of suitable sites, as well as their apparent scarcity. Thirdly, this species has an extended period of laying of about 3–4 months within a single year. Finally, *P. h. atrata* is a very 'curious' species that typically explores and uses any new object placed within its natural habitat (Castilla, unpublished data). We presumed that some of these factors would increase the likelihood of the sand boxes being used by lizards.

The containers were placed on the surface of the ground because soil erosion is a major conservation problem in the islands and digging holes in rocky areas is difficult. The fact that the majority of the eggs could finish their development in most of the artificial sites shows that the performance of all types of containers, and the conditions maintained in them, was adequate. The eight eggs that died during the first month of development were placed in different containers where other eggs developed successfully, so mortality cannot be attributed to special characteristics of those sites. In view of the infanticidal behaviour shown by *P. h. atrata* on Columbrete Grande (Castilla, unpublished data) and the absence of other predators of lizard eggs on the island, we have assumed that adult lizards were responsible for egg predation.

### The use of artificial sites as laying areas

Several reasons may have accounted for the infrequent use of the containers as actual oviposition sites in the lizard *P. h. atrata*, including the overall time of availability, disturbance by researcher, microclimatic conditions and female behavioural preferences. However, with modifications to the current nest box, we would be able to eliminate some problems associated with the present design. For example, building more climatically self-maintained boxes would reduce watering intensity and reduce disturbance for the lizards. By using biophysical measurements, those boxes that maintain the proper conditions of soil moisture and temperature could be used to provide oviposition sites (W. P. Porter, pers. comm.). Relatively moist sand substrate and mean temperatures between 25° and 28°C are appropriate for the success of hatchlings in some lizards species (Van Damme *et al.*, 1992; D. Bauwens & R. Van Damme, pers. comm.).

For other species, and perhaps even for *P. h. atrata*, it may not be necessary to build special boxes if one can construct sufficiently deep holes with moist sand well-protected from heat, cold and flooding. Although limiting conditions for incubation may not differ greatly between related lizard species, physical conditions in natural oviposition sites may vary between species and seasons. To facilitate the replication of artificial sites for specific cases more effort should therefore be put into the location and study of nests in nature.

In summary, although the artificial egg-laying sites were not highly utilised by *P. h. atrata*, we nevertheless believe that this technique, with improvements, could under some circumstances potentially be an important conservation tool for lizards in general. It would also be of interest to see whether unsuccessful programmes for repatriation, relocation and translocation of lizards might benefit from the provision of artificial sites (see also Dodd & Seigel, 1991).

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