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Recovery plan for the giant lizard of El Hierro (Canary Islands), *Gallotia simonyi*: project outline and preliminary results

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Introduction

The Giant Lizard of El Hierro, *Gallotia simonyi* is one of the most endangered reptile species of the world (CORBETT 1989, 1993, MACHADO et al. 1985). The first scientific news about a living population of *G. simonyi* dates back to 1975 (BÖHME & BINGS 1975, 1977; see also BISCHOFF et al. 1979). The giant lizard, widely distributed in El Hierro in the past (BÖHME et al. 1981) is presently restricted to a small area of the Fuga de Gorreta (fig. 1). The Canarian Government prohibited the access to this area which now is declared "Paraje Natural de Interés Nacional" including the Roques of Salmor islets (DOMÍNGUEZ-CASANOVA 1994). During the following nine years, some limited studies on the situation of this population were sponsored by the ICONA (Spanish National Institute of Conservation of Nature) as well as the Viceconsejería de Medio Ambiente (Environmental Agency) of the Autonomous Government of Canary Islands (DOMÍNGUEZ-CASANOVA 1994). Finally, starting on 1984, a recovery plan for *G. simonyi* was devised (MACHADO 1985a) and the first breeding programme was started by the biologist CARLOS NAESLUND.

Some information concerning the natural history of the giant lizard of El Hierro Island can be extracted from this first recovery plan, as the identification of several threats for the natural population and its very small size, that puts this species in the list of the most endangered reptiles of the world.

In 1986 a captive breeding program began, with four individuals (two males and two females) captured at the Fuga de Gorreta. After a year of maintenance in a shed in Frontera (El Hierro Island), three clutches (13,13 and 8 eggs each) were obtained. A total of 21 lizards hatched. The lack of technical assistance stopped this initial recovery plan since 1988 (DOMÍNGUEZ-CASANOVA 1994).

From 1988 to 1994, the only actions undertaken by the Viceconsejería de Medio Ambiente de Canarias in relation to *G. simonyi* were the maintenance of individuals obtained during the captive breeding program, the construction of a new "Lizard farm" (the "Centro de Recuperación del Lagarto de El Hierro") at the base of Fuga de Gorreta, where the actual recovery plan was launched and two scientific studies sponsored by the Canarian Government and made by Prof. LUIS FELIPE LÓPEZ-JURADO: "A cartographic and descriptive study of the habitats for the reintroduction of the giant lizard of El Hierro" and "The different ecological parameters of future reintroduction areas of the giant lizard of El Hierro".

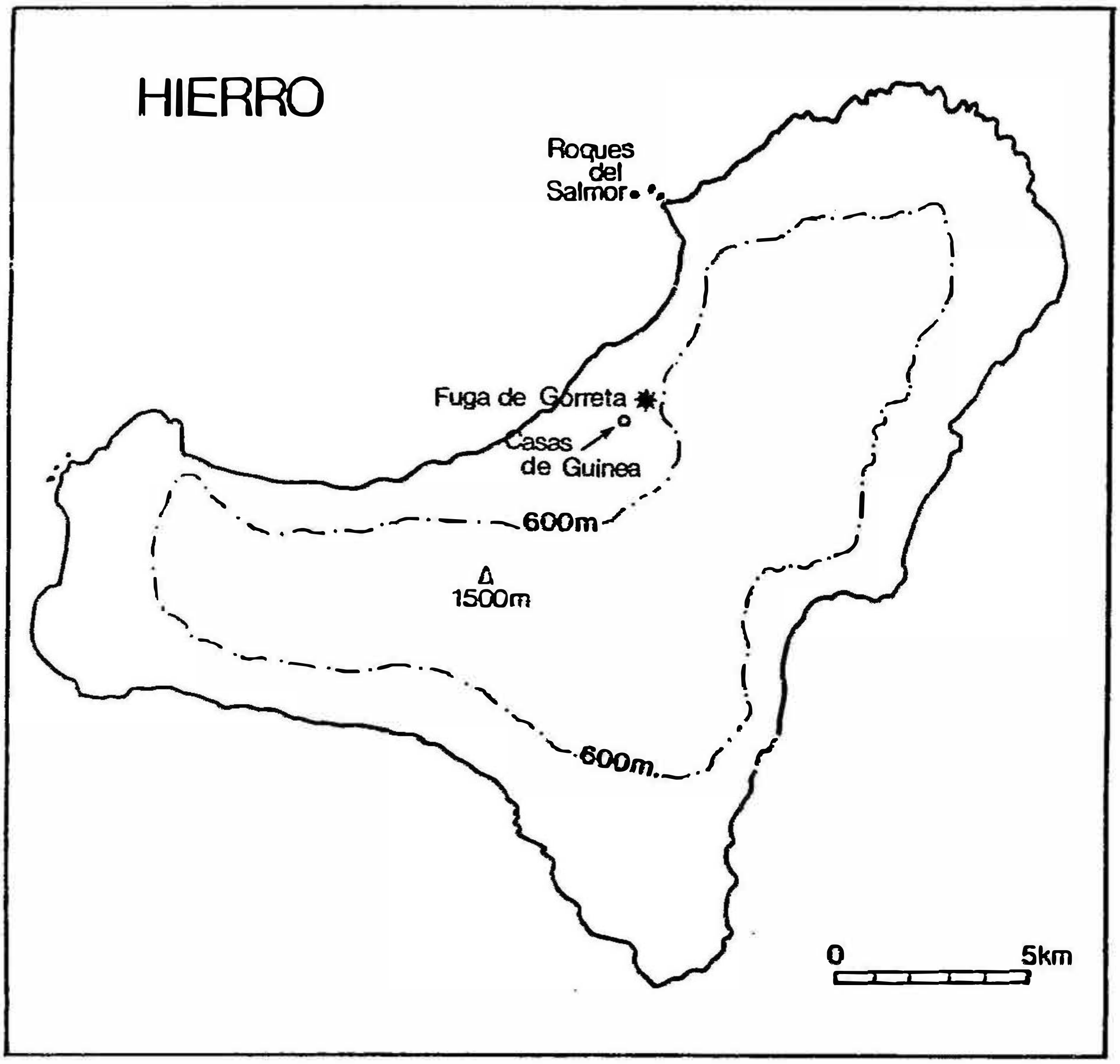

Fig. 1. Location of the last relict population of *Gallotia simonyi* on Hierro Island.

In the application of EEC Directive 79/409/EEC of 2nd April 1979, the recovery plan of the giant lizard of El Hierro Island is considered a 1994 priority action as it is a program to recover a priority species (code A.2.1.2, see LIFE, Information Document, 1994). The giant lizard of El Hierro is considered a priority species for the European Union due to its extremely endangered situation (ICONA 1986, BLANCO & GONZÁLEZ 1992, CORBETT 1989, 1993).

In this paper we present the recovery plan for the giant lizard of El Hierro Island sponsored by the LIFE Program of the European Union. We show the main lines of actions and research as well as the very first results obtained during the first five months of work.

The recovery plan is a two years project co-ordinated by LUIS FELIPE LÓPEZ-JURADO. The recovery plan includes several objectives with direct responsables for each of them: captive breeding (Canarian Government), genetic characteristics of *G. simonyi* (BEGOÑA ARANO and GERMÁN ASTUDILLO), natural history of free-living population (VALENTÍN PÉREZ-MELLADO and MARISA ROMERO-BEVIÁ), behaviour and thermal requirements (RAFAEL MÁRQUEZ and DANIEL CEJUDO), food adaptation, competitive interactions and reintroduction plan at the area of "La Dehesa" in the southwestern part of El Hierro island (GUSTAVO LLORENTE, JOSÉ A. MATEO, MARCOS GARCÍA-MÁRQUEZ and NURIA ORRIT).

Results and Discussion

Genetic characteristics of *Gallotia simonyi*: The success of captive breeding, as well as the future reintroduction of *Gallotia simonyi* outside its restricted actual distribution, depends primarily on the maintenance of the genetic variability of the population (BALLOU 1984, CHESSER et al. 1980, GILPIN & SOULÉ 1987, HAIG et al. 1990). Unfortunately, the founders of the captive population were only a few individuals. Hence, it can be expected that the present captive breeding population would not be fully suitable from a genetic point of view. However, we cannot reach the same expectation for the natural population, because it is well known that several island lizard populations, originated from a very small stock of founders, were nonetheless viable for millenia. Additionally, we do not know the genetic variability of the wild population which has also a reduced size.

According to these needs, we devised a genetic study of *G. simonyi* with the following objectives:

– a) Estimates of the genetic variability in the natural population

The aim is to find genetic markers at the nuclear level, and for this purpose multilocus heterozygosity will be estimated from allozyme data. Toes clipped from wild lizards for individual marking and skeletochronology (see below) will also be used in allozyme studies. In the case of captive lizards, muscular tissue from tail tips will be used, since obtention of blood samples could be traumatic for the lizards and it would be extremely difficult to obtain enough blood volume to do this kind of analysis.

– b) The maintenance of genetic diversity in the captive population

The success of captive breeding does not depend exclusively on the number of reproductive individuals, successful clutches and hatchlings. It is also important to maintain an appropriate level of genetic variability. Hence, from 1996, according to individual genetic information, breeding individuals will be to preserve as much genetic variability as possible.

The use of genetic markers will allow the individual characterization of potential reproducers and the follow up of the progeny of released individuals after reintroduction.

The use of microsatellites and RAPD techniques is very suitable for this purpose (BRUFORD & WAYNE 1993, PAETKAU et al. 1995), as well as for estimates of effective population size, which is a very important parameter in the conservation of endangered populations (LANDE & BARROWCLOUGH 1987). DNA can easily be extracted from diverse tissues (Tail tips, toes, skin sheddings, etc.), or even from faeces found in the wild (KOHN et al. 1995).

The genetic research will be complemented by ecological studies (see below). Simultaneously, a survey of sperm viability to check potential problems of fertility in captive individuals and to aid the selection of reproductive individuals for the 1996 breeding program will be carried out.

– c) Survey of genetic variability in the reintroduced population

Our aim is to follow the genetic status of the free-living population at the reintroduction site to assure its future viability. This survey will be done by periodical genetic monitoring using tissues from tail tips or clipped toes as mentioned above.

As initial results from this part of the program, during the past four months, we chose a set of 28 different enzymatic systems experimentally checked on tissue samples of a related species, *Gallotia stehlini*. We found that muscular tail tissue yielded 25 of these systems, an acceptable result that permits the use of muscle in our analysis of living *G. simonyi*. Electrophoretical and DNA analyses are currently being carried out on the giant lizard and we expect conclusive results in the near future.

Natural history of free-living *Gallotia simonyi*: The main objective of this part of the program is to obtain a complete idea of the size and boundaries of the natural population of *G. simonyi* and to collect important information on the natural history of the species for use in management of captive individuals and the reintroduction plan.

– Description of the area and habitat selection: The area of Fuga de Gorreta was exhaustively analysed. Vegetation and rock cover, existence of refuges for lizards, degree of ground inclination, and other features of the habitat (see previous information in MARTÍNEZ-RICA 1982 and MACHADO 1985b). This work began in March 1995 and is still in progress.

In the zone situated between 450 and 500 m, we marked a plot of 600 m^2 in 10 x 10 m squares. This grid helps us to locate the position of each observed lizard during time budget samples (see below). The position data allow the estimation of home range size, degree of individual overlap of home ranges, territoriality, occupied substrate, and microhabitat selection.

– Population range: The distributional limits of *G. simonyi* were established by direct observation and the presence of faeces (see also MACHADO 1985b). The population of *G. simonyi* was regarded as restricted to a very narrow area of no more than 1500 – 2000 m^2 of the protruding rocky ridge of Tibataje cliff by MACHADO (1985b; see also BINGS 1985).

Our observations, made from March 1995, enlarged significantly this area. We found direct evidence of giant lizards from 550 m to the base of the cliff, and in a large area of the right side of the cliff. A third smaller zone with lizards is located on the northern side of the cliff, reaching its base. A complete connection between these three areas is possible. Thus, we can give a very preliminary estimation of no less than 30,000 to 50,000 m^2 for the present day range of the free-living population of *G. simonyi*.

Hence, the extension of distribution range of the giant lizard is significantly larger than previously thought. We do not know whether the present day situation was similar ten years ago (MACHADO 1985b), or whether it is the result of an expansion of the range, as a consequence of conservation measures taken by the Environmental Agency of the Canarian Government. In any case, it is extremely important to show that the population, even in its condition, extends over a larger range, though it nevertheless remains threatened.

– Population size and structure: The lack of agreement regarding the estimated size of the population of this lizard is not surprising. Given the extremely difficult habitat, as well as the use of questionable techniques.

MARTÍNEZ-RICA (1982) estimated a population size of 100 to 200 lizards using a strip census, similar to the line transect method (HAYNE 1949). This method requires several assumptions to allow robust estimations (see BURNHAM et al. 1980) that cannot be matched at the Fuga de Gorreta. MARTÍNEZ-RICA (1982) calculated a density of 1400 individuals/ha putting together both species, *G. simonyi* and *G. galloti*. Obviously, this density cannot be directly compared with our own estimate. In a total population of 200 lizards, MARTÍNEZ-RICA (1982) estimated that half of them were juveniles.

According to the recovery plan of MACHADO (1985a; see also DOMÍNGUEZ-CASANOVA 1994), the population of the Fuga de Gorreta was believed to be around 100 specimens. On the other hand, NAESLUND (in: DOMÍNGUEZ-CASANOVA 1994) estimated a total population of 900 lizard in a bigger area than previously described.

During June and July 1995, we made a first estimation of population density using a capture, mark, and recapture technique with baited traps (KREBS 1989). This preliminary work was done at the basal area (see above), where we observed a "medium" density of lizards. Probably, the area of Paso del Pino, higher on the cliff, has also a higher density but on very reduced surfaces.

We used a capture-recapture program of four consecutive days with 13 pitfall traps. We estimated a covered area of 5000 m^2. According to our results, the density in this surface was of 19.48 individuals, with 95 % of confidence limits between 17.93 and 21.31 (Schumacher method, KREBS 1989) or 19.36 ind., limits between 11.18 and 40.02 (Schnabel method, KREBS 1989). Hence, an average density of 40 ind./ha could be expected in this area of the Fuga de Gorreta. This value is much lower than the supposed density given by MARTÍNEZ-RICA (1982). It is also a lower density that recorded for other Canarian lizards as *Gallotia atlantica* (3620 to 4130 ind./ha) or *G. galloti* (4660 to 6400 ind./ha, CASTANET pers. comm.).

If we accept a range of 3 ha for the species, the total population of adult and subadult animals can be around 120 to 150 individuals, a smaller population than previously estimated by MARTÍNEZ-RICA (1982), but extended over a larger area. We have to stress that this is a very preliminary estimation, that will be surely modified with a more precise calculation of the surface occupied by the population and the differences in density between altitudinal zones. In any case, these data, together with those yielded by use of microsatellites, will give a more exact estimate of the effective population size.

MACHADO (1985b) gave a sex-ratio of 1 : 1, but, our captures were fully biased towards females (sex ratio of 0 : 1, n = 5) in "Paso del Pino" area and with an almost equilibrated sex-ratio in the area of "El Gaterón" (1 : 1.25, n = 22), not significantly different from a 1 : 1 sex-ratio ($\chi^2 = 0.1818$, $p > 0.05$).

– Food requirements: This is an important topic of the recovery plan. Previous data can be found in MACHADO (1985b) and MARTÍNEZ-RICA (1982). Because obvious reasons in a highly endangered species, we discarded the use of stomach flushing or any other traumatic technique and we obtain our data from faeces. This method precludes the study of smaller faeces from juvenile individuals, because they cannot be distinguished from faeces of adult *G. galloti*. Thus, our study is (at least in this first step) focused on adult individuals. We collected more than 350 excrements of *G. simonyi* from three different areas, at the cliff (the ridge between 450 and 550 m, see above) and two basal areas where the presence of lizard was recently discovered (see above). The exhaustive sampling of three smaller plots at the above mentioned areas will allow us to assess the age of faeces. Hence, we are able to study food requirements of *G. simonyi* at different altitudinal levels and throughout the year. *G. simonyi* consumes a high proportion of plant matter (MARTÍNEZ-RICA 1982, MACHADO 1985b), so we started a comparative collection of vegetal epidermis from plant species present at Fuga de Gorreta. This information is complemented by food choice experiments made with captive individuals (see below).

– Activity and time budget: The amount of time dedicated to different daily activities depends, at least partially, on the availability of resources. Several constraints for the time budgets are expected because of low food availability and as only few hours of direct insolation are available for heliothermic thermoregulation on the cliffs. We studied time budgets making focal samples of behaviour (see MARTIN & BATESON 1991) of five to ten minutes of duration, from several individuals. So far, we have collected more than 12 hours of behavioural observations on free-living animals (around 144 focal samples). A similar amount of samples will be taken during the next seasons, to obtain a full picture of activity and time budgets of *G. simonyi*. A comparative set of focal samples of *G. galloti caesaris* was taken at the same time at the Dehesa area (proposed reintroduction site, see below). Hence, we will be able to compare both species also from this point of view.

– Thermal biology: Almost all biological features of lizards are temperature-related (see, for example, HUEY 1982 and references therein). For this reason, we measure preferred body temperatures (PBT) of lizards in a thermal gradient. As the thermal biology of all *Gallotia* species is scarcely known (BÁEZ 1985), we will estimate this parameter also for the syntopic *Gallotia galloti*, as well as for the similarly sized *Gallotia stehlini*.

So far, we measured preferred body temperatures of captive individuals of *G. simonyi* and of a sample of free-living *G. galloti caesaris* inhabiting the area of Fuga de Gorreta. Our previous results indicate similar preferred body temperatures for *G. galloti caesaris* and *G. simonyi* (MÁRQUEZ et al. in press).

In the future we will obtain data on the body temperatures of free-living *G. simonyi*, as well as an estimation of operative temperatures available for both species at the Fuga de Gorreta and one of the future release sites. For this purpose we made several copper models that will be connected to a data logger to record temperatures of the models exposed to different microhabitat conditions during activity period.

These data of thermal biology will be of key importance for the evaluation of the thermal suitability of natural locations of lizards and of the best thermal conditions for captive breeding.

C a p t i v e p o p u l a t i o n – Marking lizards: The captive population of *G. simonyi* was only partially marked with toe-clipping. We began marking these individuals with transponders. During March 1995 we marked for an evaluation of the technique four *G. g. caesaris* and two *G. simonyi.* No undesirable effect occured within four months. In the course of this year we will complete the marking of all captive individuals with transponders. We continue toe-clipping newborn lizards obtained from captive breeding.

The first *G. simonyi* released will be equipped with a radiotransmitter collar to follow their movements. Previously, we followed in captivity six individuals with radio collars during a week with good results regarding tolerance.

– Captive breeding: At present, the Recovery Centre of El Hierro has 58 captive individuals of *Gallotia simonyi* (31 adult ♂♂, 25 ♀♀ and 2 juveniles). This captive population stems from six founders (3 ♂♂, 2 ♀♀, and 1 juvenile) captured at Fuga de Gorreta (four in 1985, one in 1988, and one in 1994). Unfortunately, the schedule of breeding from 1986 to present was not designed in the way to optimize the genetic variability of the captive population. For example, in 1988, breeding pairs were chosen among individuals that shared their father. Hence, captive breeding was carried out lacking scientific criteria. The aim is to improve this situation by planning captive breeding, such that individually identified specimens will be selected to avoid, as much as possible, the undesirable effects of inbreeding.

– Food adaptation: One of the problems of captive individuals is their rearing and maintenance on an artificial diet. For this reason, we devised a protocol to readapt future reintroduced lizards to plant and arthropod species available in the wild. Our first results indicate a good acceptance of captive *G. simonyi* for these natural foods. These data, in addition with the information on feeding habits of free-living individuals (see above), will be extremely useful to assess the suitability of the reintroduction sites.

T h e r e i n t r o d u c t i o n p l a n : To plan a sound reintroduction, we started a complete description of selected reintroduction areas and evaluated their suitability. Also, we focused our attention on different factors that can affect the success of the reintroduced population, especially competition and predation.

– The reintroduction area: During March and April 1995, an experimental plot for a first reintroduction of lizards was chosen in the area of "La Dehesa", at El Hierro Island. The experimental plot is 4000 m^2 (a rectangle of 50 x 80 m) marked in squares of 5 x 5 m. This plot is covered by a dense autochthonous scrubland with some isolated trees. This particular area was chosen because of several reasons:

– The established presence of subfossil remains of *Gallotia simonyi* and *Gallotia* aff. *goliath.*

– The isolated situation of the area, far from villages and undisturbed by visitors.

– The degree of conservation of natural vegetation cover and, consequently, its potential food availability for lizards.

– It lacks any kind of agriculture or livestock use.

– It is a public land in the hands of local Administration. Hence, an effective control of its use is possible.

Plant cover and microhabitat features (rock cover, isolated trees, potential refuges for lizards, ground inclination, and open areas for basking) of this plot was carefully described. The vegetation of the experimental plot is formed principally by *Artemisia canariensis*, *Asphodelus microcarpus*, *Cistus monspeliensis*, *Echium hierrense*, *Euphorbia obtusifolia*, *Juniperus canariensis*, *Micromelia hyssopifolia*, *Opuntia ficus-indica*, *Reichardia* sp., *Rubia fruticosa*, *Rumex lunaria*, *Schizogyne sericea*, *Senecio kleinia*, *Sonchus* sp., *Argyranthemum* sp., some lichen species, and some Graminaceae still undetermined.

Also, we began to study vegetal biomass production, employing a monthly line transect and counting number of leaves, flowers, and fruits per plant specimen, as well as the collection of a sample of the same plant species for an estimation of dry weight. We estimate arthropod availability by the use of a cubic (1 x 1 x 1 m) biocenometer (see, for example, SOUTHWOOD 1978). Our first results indicate a very low arthropod availability.

At the reintroduction plot, a demographic survey of *Gallotia galloti caesaris* is in progress. We marked more than 300 individuals, studying their body size distribution, reproductive condition, space use (home range size and degree of territoriality) and time use. Our final aim is to have a full picture of the demography and natural history of *G. galloti* as the most important potential competitor of *G. simonyi* during its juvenile stage (see, for example, MACHADO 1985b). Additionally, a full study of feeding habits of *G. galloti caesaris*, with a monthly sample of stomach contents and faeces was in progress at a location close to the reintroduction area.

– Predation pressure: This is perhaps one of the most important factor in the decline of *G. simonyi* population (MACHADO 1985c). To estimate the potential effect of predators on lizards, we began a survey on feral cats in March 1995, mapping their presence on the island and collecting a monthly sample of faeces for analysis of food habits (see previous results in NOGALES et al. 1988).

The other main predator of lizards could be the kestrel (*Falco tinnunculus*), extremely common on the island of Hierro (BANNERMAN 1963; see also BÖHME & BINGS 1975 for other potential predators). In March 1995 we began mapping its distribution in the island as well as collecting monthly pellets in the area of Fuga de Gorreta and La Dehesa.

Additionally, the potential effects of predators on *G. simonyi* will be evaluated using two experimental procedures. The first experiment concerns the ability of this lizard species to detect the presence of terrestrial predators, especially feral cats. During the first third of 1996 we will perform an experimental analysis of this capacity, using a protocol of one experimental stimulus and two controls for olfactive and visual cues. Individuals obtained from captive breeding will be used for experiments. The second experiment addresses flying predators (mainly kestrels in our case). It is performed with plasticine models of lizards, located in open areas which are checked for predators´attacks after several hours of exposure (see a similar procedure in PÉREZ-MELLADO & CORTI 1995).

– Competitive relations: This is an important aspect of the recovery plan due to the potential competition between adult individuals of *G. galloti* and juveniles of *G. simonyi*. The density of the former species is very high on El Hierro Island. Therefore, we expect competition between individuals of similar body size (see MARTÍNEZ-RICA 1982 and MACHADO 1985b).

A way to measure the potential competition between two different species is to devise an experiment of spatial interaction. Following BOWKER & JOHNSON (1980), we designed a circular thermal gradient, with heat lamp at the centre, where a pair of individuals are tested during a fixed time. Thus, their respective location at the arena, behaviour and interactions are recorded with a video camera and analyzed with a computer program. With this experimental procedure, it is also possible to measure sprint speed of lizards, as well as their activity rhythms in controlled conditions. This experiment was done, in collaboration with Prof. RICHARD G. BOWKER, with specimens of *G. simonyi* and *G. galloti* and three different treatments: pairs of conspecific individuals (similar body size), pairs of ♂♂ from both species, and pairs of ♀♀ from both species. These data are now under analysis.

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