Census method
for estimating the population size
of the endemic and threatened land snail
Iberus gualtieranus gualtieranus

G. Moreno–Rueda & M. Pizarro

Abstract

Census method for estimating the population size of the endemic and threatened land snail Iberus gualtieranus gualtieranus.— *Iberus gualtieranus gualtieranus* is an endemic and threatened land snail inhabiting south–eastern Spain. Because it seeks shelter in karstic fissures when inactive, detection is difficult, and censuses may be biased. In this study, a methodology is developed to take an adequate census of this subspecies. The census was performed in the population of Sierra Elvira when the probability of detection was the highest, minimizing the bias. The results show that this population is patchy and has about 500,000 specimens. However, this subspecies is probably vulnerable to extinction as only three isolated populations are known and it is threatened by several factors. The census method in this study may be useful to conserve this endemic species.

Key words: *Iberus g. gualtieranus*, Census technique, Population size, Distribution.

Resumen

Método de censado para estimar el tamaño poblacional del caracol Iberus gualtieranus gualtieranus, *especie endémica y amenazada.*— *Iberus gualtieranus gualtieranus* es un caracol endémico y amenazado que habita en el sudeste de España. Este caracol se refugia en las grietas kársticas cuando está inactivo, lo que dificulta su detección, sesgando las estimas sobre su tamaño poblacional. En este estudio se desarrolla una metodología para censar esta subespecie. El censo fue realizado en la población de Sierra Elvira cuando la probabilidad de detección de los ejemplares fue máxima, minimizando el sesgo de la estima. Los resultados muestran que esta población está parcheada y tiene unos 500.000 ejemplares. Sin embargo, esta subespecie probablemente sea vulnerable a la extinción, ya que su población mundial se reduce a tres poblaciones aisladas y algunos factores ponen en riesgo su supervivencia. El método de censado presentado en este estudio puede ser útil para el manejo y conservación de esta especie endémica.

Palabras clave: *Iberus g. gualtieranus*, Técnica de censado, Tamaño poblacional, Distribución.

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Introduction

Most animal conservation efforts are directed to vertebrates even though these animals represent only about 1% of the extant biodiversity (Ponder & Lunney, 1999). This contrasts with the current extinction risk among invertebrates, less than 0.3% of which have been evaluated for cataloguing in the IUCN lists (Baillie et al., 2004). Molluscs represent the group with the highest number of recorded extinctions, and terrestrial molluscs are especially prone to disappearance as they include many endemisms with restrained distributions and limited dispersion capacity; restoration of locally extinct populations is therefore difficult (Lydeard et al., 2004).

The land snail *Iberus gualtieranus* is an endemic species in Spain, with the subspecies *I. g. gualtieranus* being endemic to south–east Spain (Elejalde et al., 2005). This species is presently catalogued as "almost threatened" (LR/nt) by the IUCN (www.redlist.org), but the subspecies *I. g. gualtieranus* has been proposed as "endangered" (Arrébola, 2002) as only three isolated populations have been sighted: in Sierra de Gádor, Sierra de Jaén and Sierra Elvira (Alonso et al., 1985; fig. 1). Because these populations are some distance from each other, a local extinction would be irreversible (Hanski, 1998). Major threats to this subspecies are habitat destruction (Moreno–Rueda & Ruiz–Avilés, 2005), a primary causes of extinction in land snails (Backeljau et al., 2001), and collection by humans for food and ornamental purposes (Arrébola, 2002).

Conservation of this subspecies is important not only because it is endemic, but also because of its peculiar evolution (Backeljau et al., 2001; see Elejalde et al., 2005). Its morphology is flattened, presumably, in order to use karstic fissures as refuge against desiccation (López–Alcántara et al., 1983, 1985; Moreno–Rueda, 2002). This adaptation allows it to dwell in semiarid environments with karstic erosion (Alonso et al., 1985). Moreover, this snail plays a significant role in the semi–arid ecosystems in which it dwells. *Iberus g. gualtieranus* eats a variety of plants (Moreno–Rueda & Díaz–Fernández, 2003) and is consumed by a variety of organisms, such as birds, rodents and insects (Yanes et al., 1991; pers. obs.), making it an important link in trophic chains. As in other arid environments (Shachak et al., 1987), it probably affects soil fertilization and nutrient recycling.

This is the first study performed to determine the distribution and population of this endemic species in the mountains it inhabits. Detection is difficult because it frequently shelters inside crevices (Moreno–Rueda, 2007), making censuses unreliable. In this work, we developed a simple census method to gather reliable information on the population size of this subspecies.

Material and methods

First, we estimated the distribution of *Iberus g. gualtieranus* in Sierra Elvira based on records of presence–absence during numerous trips throughout the complete study area from 1998–2005. These data were marked on 1:25,000 maps, delimiting its distribution in polygons and including minimal distribution of the records. This map was transferred to a Geographic Information System (SAGA; Conrad, 2005) to estimate the surface occupied by *Iberus g. gualtieranus*.

Iberus g. gualtieranus inhabits crevices when inactive, especially during aestivation (Moreno–Rueda, 2007). Its population size would be underestimated if it were censured when inactive and sheltered. To avoid this bias, we performed a study of snail detection during sampling, considering different times throughout the year and the day (day–night). We delimited an area of about 500 m^2, where we sampled in 55 plots of 9 m^2. During sampling, we recorded the density of adult and immature individuals detected. We used both adult and immature individuals because the immature:adult ratio is relatively constant throughout the year (personal observations). Exhaustive samples were taken from October 2000 to September 2001, covering the 24 h. To determine the appropriate time to sample the snail, we tested whether density varied between two annual periods: spring–summer ($n = 109$; when the snail was inactive) and autumn–winter ($n = 41$; when it was active). Within autumn–winter (the activity period), we tested whether the snail density varied between day ($n = 63$; the snail was inactive) and night ($n = 46$; it was active). Activity periods were known from previous unpublished studies. Sampling was performed on randomly selected days.

With this methodology, we determined that the appropriate sampling time was in autumn–winter (day or night; see Results). For sampling, we randomly assigned 33 points within the distribution area of *Iberus g. gualtieranus* (fig. 1). During 2002–2004, we reached these points using maps and a GPS, and we delineated a 9 m^2 (3 x 3 m) plot at each point. Therefore, a surface area of 297 m^2 was sampled. Live specimens (adult or immature) were exhaustively searched for inside the plots, placing special attention to positions inside fissures, under stones, and in vegetation. With these data, we estimated the average density ± standard error of the mean. Assuming that snail density is homogeneous within its distribution area, we estimated the population size (with an associated error according to the standard error of the mean) in Sierra Elvira with a simple multiplication: density × distribution area.

Results

Iberus g. gualtieranus was distributed primarily on the eastern slope of Sierra Elvira. Its population was divided into sub–populations (fig. 1), but one of them (polygon 1) included 95% of the surface occupied by this land snail. Therefore, in Sierra Elvira, the population of *Iberus g. gualtieranus* was concentrated in a large sub–population with minor sub–populations to the north and south. In total, it occupied 323.5 hec-
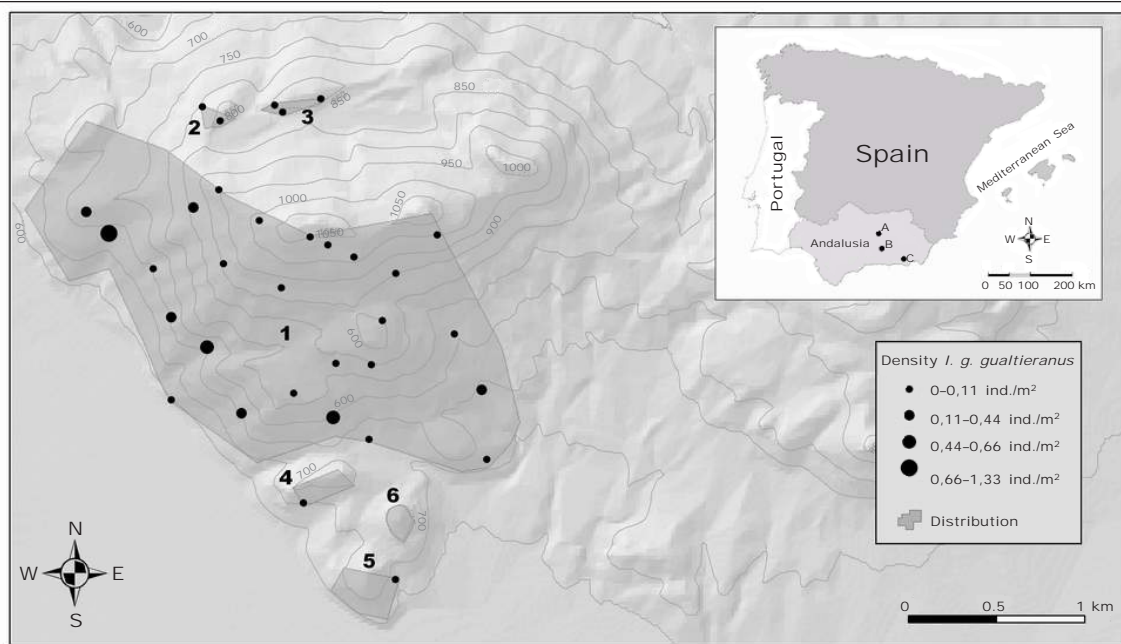
Fig. 1. Location of the three populations of *Iberus g. gualtieranus* in Spain (A. Sierra de Jaén; B. Sierra Elvira; C. Sierra de Gádor), and distribution of this subspecies in Sierra Elvira. Sampling points and density of individuals are showed. Each subpopulation is designated with a number.

Fig. 1. Localización de las tres poblaciones de Iberus g. gualtieranus *en España (A. Sierra de Jaén; B. Sierra Elvira; C. Sierra de Gádor), y distribución de la subespecie en Sierra Elvira. Se muestran los puntos de muestreo y la densidad de individuos. Cada subpoblación se designa con un número.*

tares (3,235,449 m^2) in Sierra Elvira. These results are similar to those previously found by G. González and J. M. Gil–Sánchez (unpublished), suggesting that they are reliable.

Density of individuals detected during sampling in autumn–winter (0.22 ± 0.23 individuals/m^2, n = 109 samples) was significantly higher than in spring–summer (0.06 ± 0.12 ind./m^2, n = 41) (Mann–Whitney U–test, z = 4.49, p < 0.001), suggesting that the census should be performed during the autumn–winter period. This period showed no significant differences in density during the day (0.19 ± 0.18 ind./m^2, n = 63) and the night (0.25 ± 0.28 ind./m^2, n = 46) (U–test, z = 0.50, p = 0.62), justifying the census being performed during the day for logistical reasons. These results are due to the different use of refuges between the two periods of activity, with individuals deeply sheltered in crevices during aestivation (Moreno–Rueda, 2007).

In the census performed during autumn–winter in the years 2002–2004, we detected 46 specimens. The mean density was 0.155 ± 0.049 individuals per m^2. With these data, we estimated a population size in Sierra Elvira of 501,495 ± 158,537 individuals of *Iberus g. gualtieranus*. With the standard error, this population size may oscillate between 342,958 and 660,032 individuals.

Discussion

In this study, we developed a census method for estimating abundance of *Iberus g. gualtieranus*, an endemic and threatened land snail that is difficult to detect. This is the first census for this subspecies. It is improbable that the results were affected by population dynamics, as density of individuals (both adult and immature) is almost constant throughout the year, especially in autumn–winter (unpublished data). The seasonal use of refuges also could affect the results (Moreno–Rueda, 2007); for this reason, censuses should be performed in autumn–winter. In these seasons, the activity period of this snail (active primarily during the night) did not have significant effects on the density estimated, as they seemed easy to detect during the day. As this methodology appears to be effective it could be used for the other two known populations of this snail, and for other species presenting a similar problem. Information gathered may also be useful to determine the conservation status of this endemic subspecies in Sierra Elvira.

Iberus g. gualtieranus showed a patchy distribution in Sierra Elvira (fig. 1). Patchy populations bear a higher risk of extinction, so that re–colonization of locally extinct sub–populations is lower (Schwartz,

1997; Hanski, 1998). This effect is probably higher for snails, because their dispersal capacity is very restricted (Denny, 1980). Some 95% of the population was concentrated in polygon 1, thus this sub–population is probably at lower risk of extinction than the other sub–populations. The small size of the other sub–populations (polygons 2–6) may make them very vulnerable to extinction (Hanski, 1998). Habitat destruction by mining (Moreno–Rueda & Ruiz–Avilés, 2005), excessive collection (Arrébola, 2002), or fire (C. M. A., 2003) could easily drive these sub–populations to extinction. These patches should be protected, for example, by the creation of micro–reserves.

The total population size of *Iberus g. gualtieranus* in Sierra Elvira was about 500,000 individuals. This result is similar to that found in a preliminary study, performed in 1998 in 148 m^2 and using the same methodology, in which the population was estimated at about 575,000 individuals (Moreno–Rueda & Cabrera Coronas, 2000). That both studies give very similar results in different years strongly suggests that the methodology gives repeatable findings. This not only supports the method's reliability, but also suggests that sampling an area of 297 m^2 is sufficient for an appropriate estimate. The relatively large number of specimens found may suggest that the population of Sierra Elvira is not endangered. Nevertheless, this population is completely isolated from populations in Jaén and Almería, and this situation of biogeographic isolation implies that it would be irrecoverable if it went extinct. On the other hand, the number of individuals does not define population viability, which is determined by the relationship between the number of extant individuals and those necessary for a viable population. The latter depends on the characteristics of the species. Studies of population dynamics are needed to conclude whether this population is stable or in decline.

In conclusion, the low density, geographic isolation and a patchy distribution are risk factors that should be considered in order to conserve this endemic subspecies. Because the worldwide population of this snail is severely patchy, with only three, completely isolated, populations (fig. 1), it can be considered endangered. For these reasons, we suggest that protection measures should be taken in order to avoid excessive exploitation and habitat destruction. We also recommend that the methodology employed in the present study be used in future censuses in the three populations in order to update information on the status of this endemic subspecies. Any population decline could thus be detected and appropriate measures could be taken.

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