Assessing the conservation status of the strict endemic Desertas wolf spider, *Hogna ingens* (Araneae, Lycosidae)

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**A B S T R A C T**

The Desertas Islands (Madeira, Portugal) are the sole home of one of the largest and rarest wolf spider species, *Hogna ingens* (Blackwall 1857) (Araneae, Lycosidae). Despite its size, it inhabits a single valley in the North of the Deserta Grande Island, Vale da Castanheira, currently invaded by the herb *Phalaris aquatica*. This invasive species competes with the native flora and was subject to several eradication experiments, namely through fire and chemicals. The objectives of this work were to: (1) estimate the current distribution and abundance of *H. ingens* and respective trends; (2) evaluate the impact of the invasive plant and eradication methods on the spider population; (3) suggest future measures for the recovery of the species; and (4) evaluate its conservation status according to the IUCN criteria.

The current distribution of *H. ingens* covers 23 ha, a recent reduction from its original 83 ha, corresponding to the entire Vale da Castanheira. A total of 4447 and 4086 adults and 71,832 and 24,635 juveniles were estimated to live in the valley during 2011 and 2012, respectively. We found a significant negative impact of *P. aquatica* cover on the presence and abundance of *H. ingens* and that chemical treatment specifically directed towards the invasive plant species may be the only way to effectively recover the spider’s habitat. We suggest (1) regular monitoring; (2) extend chemical treatments; (3) ex-situ conservation with future reintroduction of adults. Based on the current area of occupancy (AOO) of *H. ingens* and its recent decline in both AOO and number of individuals, it was recently classified as Critically Endangered by IUCN and we suggest its urgent inclusion in the Habitats Directive species lists.

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**Introduction**

Often islands, especially oceanic “darwinian” islands (sensu Gillespie & Roderick 2002), have large proportions of endemics, and of them being keystone species, an ecological role exacerbated by the relative low species richness of the most isolated and small islands. The isolated and specific biota found in islands provides researchers with an opportunity to analyze interactions between species and several types of disturbance, human based disturbance being one of the major causes of extinctions (Channell & Lomolino 2000; Gaston 2008; Cardoso, Arnedo, Triantis, & Borges 2010).

Spiders are often regarded as top predators in terrestrial ecosystems, being usually abundant and ubiquitous in most biomes (Wise 1993). Although almost all are predators (nectar and blood feeding in spiders has been recently described as complementary to regular prey: Jackson, Pollard, Nelson, Edwards & Barrion 2001; Jackson, Nelson, & Sune 2005; Taylor & Pfannenstiel 2008), they occupy a large array of ecological niches, ranging from aerial weavers, ground weavers or active hunters, among others (Cardoso, Pekár, Jocqué, & Coddington 2011a). The number of species currently known approaches 45,000 (Platnick 2014) and the description of new species is not reaching an asymptote (Platnick & Raven 2013), as in many other invertebrate taxa, since most species should still

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remain undescribed (Scheffers, Joppa, Pimm, & Laurance 2012). Only 157 out of 44,906 described species are currently classified by IUCN.

The Macaronesian archipelagos house a great richness of endemic species. Updated faunistic checklists are currently available for all territories (Arechavaleta, Zurita, Marrero, & Martín 2005; Arechavaleta, Rodríguez, Zurita, & García 2010; Borges et al. 2008, 2010), although knowledge of each of these regions is biased. Extensive standardized sampling and publishing was conducted in the Azores (revised in Borges et al. 2011), but the same cannot be said about the other archipelagoes, where the Linnean and Wallacean shortfalls (Cardoso, Erwin, Borges, & New 2011b) are still considerable (see also Lobo & Borges 2010).

There are several cases of spider genera experiencing adaptive radiation in the Macaronesian archipelagos, most notably Dysdera, Pholcus and Spermophorides (Wunderlich 1987, 1992, 1995; Arnedo & Ribera 1997; Arnedo and Ribera 1999; Arnedo, Oromi, & Ribera 2000). In a smaller scale, and mainly in Madeira archipelago, the large wolf spiders belonging to the genus Hogna, is represented by seven species. Of these, five are single-island endemics. One of these species, the one with the most restricted distribution (hence the one for which populational data can be most easily assessed) is Hogna ingens (Blackwall 1857) (Fig. 1), an impressive 40 mm body size spider, known only from a valley at the northern end of Deserta Grande Island, Vale da Castanheira (Fig. 2).

This small valley is currently mostly covered by Phalaris aquatica L. The settlement of this herb in the Vale da Castanheira was hidden for some years, due to the presence of rabbits (Oryctolagus cuniculus L.), who grazed and stalled the proliferation of this species. Given that rabbits were eradicated from the Vale da Castanheira in 1996, P. aquatica lost its main predator and now proliferates. This herb appears to not only displace the native herbs but also many of the native animals, as one of the most common arthropods is now the invader diploped Ommatoiulus moreleti (Lucas, 1860). Also, P. aquatica covers the surface of the soil and rocks, making the micro-habitats below the rocks harder to access for the spiders, which take shelter there during daytime. This is especially critical given the many species that only subsist in the valley or for which it is an important part of their global distribution, such as land snails (e.g. Boettgeria jensi Neubert & Groh, 1998; Discula lyelliana Lowe, 1852). The rangers and technicians of the Natural Park of Madeira tried to eradicate the invasive plant in delimited areas using different methods, namely fire and chemicals.

Spiders have been found to be particularly sensitive to habitat destruction and disturbance. Cardoso et al. (2010) suggested that spider extinctions may provide indication of trends of future extinctions of other taxa, when the study of other insular faunas is not sufficient to make these predictions using quantitative data. This way, studying the fate of endemic spiders, such as H. ingens, may provide clues to what happens to other endemic taxa, many of them restricted to Vale da Castanheira or other small enclaves in Desertas.

The objectives of this work were to: (1) estimate the current distribution and abundance of H. ingens and respective trends; (2) evaluate the impact of the invasive plant and eradication methods on the spider population; (3) suggest future measures for the recovery of the species; and (4) evaluate its conservation status according to the IUCN criteria.

Material and methods

Study site

The Madeira archipelago is situated in the Atlantic Ocean, at roughly 1000 km from the Iberian Peninsula and 600 km from Africa. Together with the archipelagoes of Azores, Selvagens, Canary Islands and Cape Verde, they constitute the Macaronesia, a region where native ecosystems pre-date the last ice age, mostly due to the buffering capacity of the oceanic climate. The Madeira archipelago is formed by Madeira Island (742.0 km², 4.6 M.y.), Porto Santo Island (43.0 km², 14.0 M.y.) and the Desertas Islands (13.5 km², 5.0 M.y.) (Fig. 3).

The Desertas sub-archipelago, 20 km Southeast of Madeira, is composed of three islands, the Deserta Grande (10.0 km²), Ilhéu Chão (0.5 km²) and Bugio (3.0 km²). Due to the harsh environment and lack of water sources, the Desertas remained uninhabited,
despite historical attempts to colonize the island of Deserta Grande. The geomorphology is very rugged, with very steep slopes, rising from sea level to about 400 m, being the dominant landscape.

These islands are now protected under the Natural Reserve of the Desertas, created due to the urge to protect a sustainable use of the abundant marine resources, as well as to protect the Mediterranean monk-seal (Monachus monachus Hermann, 1779). The management of human activities and of most of the projects that concern the conservation of native species and ecosystems in the Desertas belongs to the Service of the Natural Park of Madeira.

The Vale da Castanheira is approximately 2.8 km long and its width varies between 180 m and 400 m. The estimated area is 83 ha. The geomorphology separates the valley in two distinct areas: for most of its length, two opposing slopes are divided by a small riverbed, which is dry most of the year; in the north end of the valley, near the site where the riverbed meets the ocean, rises a small plateau, which extends to the end of the island.

The Desertas wolf spider and current threats

Hogna ingens was described in 1857 by Blackwall (1857). Despite several redescriptions from pioneer arachnologists (Blackwall 1867; Kulczynski 1899; Roever 1960; Denis 1962 and later Wunderlich 1992), every other aspect of this remarkable species remained unknown. In the absence of native terrestrial mammals, this spider with a 40 mm body length is a top predator in this small habitat, and although its major prey consists of other invertebrates, such as the staphylid beetle Ocyopus olens (Müller, 1764) or the invasive millipede O. moreleti, adults have even been seen predating on juveniles of Lacerta dugesii mauli Mertens, 1938. The latter, along with birds and mice, should nevertheless be the major predators of H. ingens, mostly during its juvenile stage. It is in this stage that the spider is most vulnerable to predators, because adding to its smaller size, it tends to disperse in order to find new shelters, thus maximizing the likelihood of encounters with potential predators (including conspecific adults). As spiders grow and find proper shelters (mostly below rocks but also in soil crevices), their dispersal propensity gradually decreases, and it should take about two years for an adult to mature.

Prior to the invasion of the Vale da Castanheira by P. aquatica, and according to the field observations of the second author, who worked regularly in Deserta Grande until 1996, H. ingens inhabited the entire valley. Since this invasion, first noted in 2005, its range has declined abruptly, as did the range for a number of other endemic taxa, such as land snails. The Madeira Natural Park services tried to halt and revert this invasive process using different methods (Fig. 4). Most of the valley was subject to human–made fire on September 2010. The attempt to eradicate P. aquatica by fire was unsuccessful. In fact, the species spread throughout most of Vale da Castanheira, with exception of its northern end, an extremely small secluded plateau. Later, in January 2011, a small area was treated with an herbicide specific for Poaceae herbs.

Experimental design

We setup two parallel transects comprising 100 points in total, separated by approximately 50 m, longitudinal to Vale da Castanheira (Fig. 5). Each sampling point was separated from the next by 50 m, except for the 88th to 99th points, which were spaced by roughly 20 m, forming a square covering the small area used to test the chemical treatment. Transects were designed to cover the entire valley, in both slopes. Besides the aforementioned 12 sampling points in the chemically treated area, the only area which was not subject to the 2010 fire, the northern end plateau, included the 35th to the 55th points. The remainder points (68) were in areas subject to fire. Sampling was conducted by counting all H. ingens specimens in a radius of about 2 m around each point. The sex, maturity or presence of egg sacs was registered.

At each point, four photos of the soil surface were taken, roughly orthogonally, to quantify the soil cover. A 2 × 2 grid was superimposed onto each photo and the cover at each of the four grid intersections was recorded (Fig. 6). This way, each sampling point corresponded to 16 soil cover samples. Each of these could be classified as “rock”, “dirt”, “native vegetation”, “Phalaris” and “dead Phalaris”. This last variable was applied only in the site subject to chemicals where the dead rhizomes of Phalaris were still visible. As geomorphology variables, at each point we recorded the slope (using a clinometer) and orientation (using a compass) of the terrain. The “orientation” was transformed in “Eastness” and “Northness”, to avoid the analysis of a circular variable. These were respectively, the trigonometric functions of sin(orientation) and cos(orientation). Sampling was done in April of two consecutive years, 2011 and 2012. Unfortunately, in 2012 the island of Deserta
Table 1
Abundance data for *Hogna ingens*. The full extent of Vale da Castanheira was divided into three sections (North plateau, Chemically treated area, and Valley remainder), for spatial information see Fig. 4. Values refer to number of individuals found in the sum of the sampling points inside each section. These sections are not equal in area, hence the use of an average abundance value, for a better empirical comparison between the different sections.

<table>
<thead>
<tr>
<th>Adults sampled in 2011</th>
<th>Individuals sampled in 2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>North plateau</td>
</tr>
<tr>
<td>Adult ♀ sampled</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Juveniles sampled</td>
<td>85</td>
</tr>
<tr>
<td>Total number of specimens sampled</td>
<td>92</td>
</tr>
<tr>
<td>Average total abundance per sampling site</td>
<td>4.38</td>
</tr>
</tbody>
</table>

Fig. 7. Schematic detail of Vale da Castanheira with the polygons used for abundance estimation. The number of specimens present in each polygon is extrapolated from each corresponding sampling point.

Grande suffered a considerable drought. This led to very different soil cover variables in both years.

Data analysis

To estimate the population size and the Area of Occupancy (AOO) of *H. ingens* we assumed each sampling point to be representative of a rectangle 50 m wide and with length determined by the outer edge of the Vale da Castanheira and the inner riverbed (Fig. 7). After the determination of the area of each of these rectangles, a simple extrapolation was made based on the number of specimens observed in the effectively sampled area (about 13 m² per point). The points in the chemically treated area were averaged as they were clumped in a small area. GIS analyses, including estimation of the Extent of Occurrence (EOO) were performed with OziExplorer trial version, available at http://www.ozixplorer.com.

The abundance classes for Fig. 5 were defined after selecting a threshold for the few sampling points with maximum abundances, and then splitting the values below for medium abundances and low abundances.

For statistics, a Kruskal–Wallis test was performed to compare abundance data from different areas in the valley, corresponding to different treatments. Next, Spearman correlations were made between each individual explanatory variable and spider abundance. Finally, multiple regression was performed with abundance of *H. ingens* (log(n + 1) transformed) as dependent variable and three sets of explanatory variables: (1) soil cover (percentages of “rock”, “dirt”, “native vegetation”, “Phalaris” and “dead Phalaris”); (2) geomorphology (slope, eastness and northness); and, (3) space (latitude and longitude). As soil cover variables were percentages, they were arcsine transformed. Because we knew beforehand that maximum abundance was in the extremes of the species distribution (maximum and minimum latitude and longitude, with concave relations with abundance) these were rescaled to average = 0 and SD = 1 and then multiplied, forming a single spatial variable with maximum values in both extremes of the valley. A forward–selection procedure was made for the soil and geomorphology variables, so that three minimum sets were retained. To understand how much of the variation could be explained by each set alone and the potential interactions, we analyzed all data under a variation partitioning framework (Borcard, Legendre, & Drapeau 1992). Partitioning was done through a series of partial regression analyses. The R² values were adjusted to account for the number of sampling sites and explanatory variables (Peres-Neto, Legendre, Dray, & Borcard 2006). Analyses were performed in the R statistical package (R Development Core Team 2011), using the package vegan (Oksanen, Kindt, Legendre, & O’Hara 2011) for variation partitioning.

Results

Distribution and abundance estimation

The estimated population size of *H. ingens* was 4447 adult specimens in 2011 and 4086 in 2012. The same estimate computed for both adults and juveniles points to 71,832 specimens for 2011 and 24,635 specimens for 2012. The contrast between the estimations of adults and juveniles can be explained by the life span and territoriality of adult females. Some of the adult females sampled in 2011
probably lived through to 2012, then appeared in a near sampling point, if not the same (Fig. 5). The adult females sampled on 2011 in the area treated with chemicals were not found again in 2012. No adult males were found, only a few subadults. This is consistent with the typical phenology of adult males of large lycosid species in the Mediterranean area (as well as with the field observations of the second author), which appear mainly in Summer instead of Spring.

The Area of Occupancy (AOO) was estimated to be 23 ha in 2011, and 15 ha in 2012. The Extent of Occurrence (EOO) can be considered to be the entire valley in both years (83 ha), similar to the original. Given that originally (pre-2005) the AOO corresponded to the EOO, we estimated a decrease in less than a decade of nearly 72% of AOO in 2011, reaching 81% in 2012.

However, caution is needed when we consider the temporal analysis: samples from different years are not directly comparable, because in 2012 the Deserta Grande experienced a severe dry period. This drought led to a different soil cover, much more arid and devoid of vegetation than that observed in 2011. This caused spiders to hide in soil crevices instead of under rocks, creating a detectability problem. Therefore, the most robust results are provided by the 2011 dataset and only these are shown in the analysis of the impact of *P. aquatica* (below).

In both years the spider was mainly found in the still natural northern plateau (Table 1, Fig. 5). This is particularly true for adults, as juveniles can be found while searching for unoccupied, but often unsuitable, territories.

**Evaluation of the impact of the invasive plant and eradication methods on the spider population**

The 2011 data set did not show differences between the chemically treated area and the North plateau (p = 1.0000) when total abundance is considered (too few data for adults only), but the remainder of the valley, occupied by *P. aquatica*, showed significant differences (p values: valley vs North plateau p < 0.0001; valley vs chemical treatment p < 0.0001). In 2012 the chemically treated area presented intermediate values between the other two, with insignificant differences (p values; chemical treatment vs North plateau p = 0.29; chemical treatment vs valley remainder p = 0.62)
while the North end did present significantly more specimens per site than the remainder of the valley \( (p = 0.0013) \).

For single variable correlations with spider abundance and the 2011 samples, only the variable “dead Phalaris” had statistical significance \( (r = 0.371; p < 0.001) \). For the 2012 samples, only “native vegetation” and “Phalaris” were statistically significant \( (r = 0.243; p = 0.014; r = -0.232; p = 0.02) \).

The forward selection of soil cover variables selected both the percentage of dead Phalaris and native vegetation \( (R^2_{adj} = 0.228; p < 0.001; \text{Fig. 8}) \). Among the geomorphology variables only slope was selected, although with a marginally insignificant value \( (R^2_{adj} = 0.025; p = 0.062; \text{Fig. 8}) \). The single spatial variable (latitude \( \times \) longitude) was highly significant \( (R^2_{adj} = 0.362; p < 0.001; \text{Fig. 8}) \). Only 4.3\% of the total variation could be attributed to soil cover variables alone, with more than 20\% being spatially structured environmental variation \( (\text{Fig. 9}) \). Spatial factors alone, related with dispersal of the population, explained 15.4\%. Geomorphology, namely slope kept by forward-selection, explained only 0.4\% in isolation, a residual value.

**Evaluation of its conservation status according to IUCN criteria**

The five criteria used by IUCN assessments are: (a) reduction in population size; (b) small geographic range; (c) small population size and decline; (d) very small or restricted population; and, (e) quantitative analysis of extinction risk \( (\text{International Union for Conservation of Nature 2001}) \).

An overview of the IUCN criteria and its applicability to H. ingens can be seen in Table 2. Criteria (b), (c) and (d) are applicable while (a) and (e) are data deficient due to lack of additional observations. Both criteria (c) and (d) meet the category of Vulnerable, but criteria (b) is at the highest level of threat, thus receiving priority over the former.

**Discussion**

**Distribution and abundance estimation**

The methodology used for assessing the distribution and abundance of H. ingens has some limitations. The slopes of Vale da Castanheira were sampled only once for each 50 m, and extrapolating from an area of roughly 13 m\(^2\) to areas as large as 7,000 m\(^2\) can provide errors if the sampling point is not representative of the majority of the polygon area. Ideally, several additional rows of sampling points could be spread out along the length of the valley, but the authors suspect that while the logistic conditions for working at Vale da Castanheira are not improved, it will be impossible to do such an increasingly intensive sampling protocol. The protocol used was the most intensive option possible under the given conditions, and one that can be easily replicated by other researchers in future evaluations with a minimum cost and high efficiency.

**Evaluation of the impact of the invasive plant and eradication methods on the spider population**

Hogna ingens appears to prefer areas where P. aquatica does not occur, either in areas dominated by native vegetation or areas recovering due to the chemical treatments. However, this does not prove that the existence of P. aquatica by itself is the sole cause for the absence of H. ingens. The area burnt by fire, as a failed attempt to eradicate P. aquatica, was an area that showed lower abundance of H. ingens and greater concentrations of the plant. Human disturbance by means of fire, together with a lesser predisposition of the spider to colonize the areas populated with P. aquatica, may jointly account for the results. As most spiders, H. ingens is a generalist predator, able to use abundant resources such as the invasive millipede Ommatoïdus moreletii (Lucas, 1860) for prey, as we observed in the field. We can then assume that H. ingens is directly affected by the presence of the invasive plant, even if indirect effects on potential prey may add to the explanation. With its voluminous rhizomes and thick foliage, the plant covers possible shelters for the spider, and, in addition, might displace several endemic or native herbivore invertebrates, which themselves may constitute part of the original diet of the spiders.

Soil cover is allied with spatially-related phenomena, such as dispersion of juveniles to sub-optimal areas or aggregation of spiders in non-disturbed areas such as the North plateau of Vale da Castanheira. This may be reflected in a small-scale source-sink population dynamics with juvenile populations occupying suboptimal areas while adults are able to survive and reproduce only in less-disturbed patches, from where the population is able to spread.

In the experimental area where herbicide was used, we observed that it seemed to affect only herbs, while plants of other families were present and apparently proliferate, together with H. ingens. However, it should be noted we did not study other taxa, and it remains to be proven that these chemicals did not cause a significant impact on the native community of arthropods and other invertebrates, which might feed on native herbs also killed by the chemicals. Another limitation in the conclusions of this study is the fact that the chemically treated plot is rather small compared to the area where fire was used and sampling artifacts may influence the results, even when these seem robust. Still, areas where P. aquatica now thrives appear to be unfavourable to H. ingens, and the disappearance of the herb from the chemically treated plot appears to have facilitated recolonization by the spiders.
Table 2
Overview of the IUCN Red List criteria, and its applicability in the present study. (AOO—Area of Occupancy; EOO—Extent of Occurrence; n—mature individuals) (based on Cardoso et al., 2011b).

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Critically endangered</th>
<th>Endangered</th>
<th>Vulnerable</th>
<th>Applicability</th>
<th>Justification/decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Population reduction (over 10 years or three generations)</td>
<td>($\geq$90% AND causes are reversible, understood and ceased OR $&gt;80%$ OR AOO &lt;100 km$^2$ OR AOO &lt;10 km$^2$) AND two of: (a) fragmentation and/or a single location; (b) continuing decline; (c) extreme fluctuations)</td>
<td>($\geq$70% AND causes are reversible, understood and ceased) OR ($\geq$50% OR EOO &lt;5000 km$^2$ OR AOO &lt;500 km$^2$) AND two of: (a) fragmentation and/or locations ≤5; (b) continuing decline; (c) extreme fluctuations)</td>
<td>($\geq$50% AND causes are reversible, understood and ceased) OR ≥30% OR (EOO &lt;100 km$^2$ OR AOO &lt;10 km$^2$) AND two of: (a) fragmentation and/or locations ≤10; (b) continuing decline; (c) extreme fluctuations)</td>
<td>No</td>
<td>Insufficient data</td>
</tr>
<tr>
<td>B. Geographic range</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Small population size and decline</td>
<td>$n &lt; 250$ AND (reduction ≥25% over 3 years OR one generation OR (reduction AND [larger subpopulation ≤50 OR ≥90% individuals in a single subpopulation OR extreme fluctuations)))</td>
<td>$n &lt; 2500$ AND (reduction ≥20% over 5 years OR two generations OR (reduction AND [larger subpopulation ≥250 OR ≥95% individuals in a single subpopulation OR extreme fluctuations)))</td>
<td>$n &lt; 10,000$ AND (reduction ≥10% over 10 years OR three generations OR (reduction AND [larger subpopulation ≤1000 OR 100% individuals in a single subpopulation OR extreme fluctuations)))</td>
<td>Yes</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>D. Very small or restricted population</td>
<td>$n &lt; 50$</td>
<td>$n &lt; 250$</td>
<td>$n &lt; 1000$ OR AOO &lt;20 km$^2$ OR locations ≤5</td>
<td>Yes</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>E. Quantitative analysis of extinction risk</td>
<td>≥50% over 10 years or three generations</td>
<td>≥20% over 20 years or five generations</td>
<td>≥10% over 100 years</td>
<td>No</td>
<td>Insufficient data</td>
</tr>
</tbody>
</table>

Future measures for the recovery of the species
Given the results discussed above, the authors suggest three measures directed towards a recovery of H. ingens:

- regular monitoring to understand the evolution of the population status and its distribution, thus providing more robust data for ecological and conservation studies and allowing to overcome the detectability problem observed in 2012;
- extend the chemical treatments in the areas affected by the presence of P. aquatica; this could prove to be essential to remove the invasive herb from Vale da Castanheira, and beneficial also to other endemic invertebrates. On the other hand, as it could have been readily observed even without the use of any statistical method, the use of fire is strongly discouraged;
- ex-situ conservation with future reintroduction of adults in the Vale da Castanheira; this could be done by the service of the Madeira Natural Park, in the Deserta Grande facility at Doca, by a team led by the second author; wolf spiders are typically generalist predators and this process should be easy to accomplish. This would not only assure that several juvenile specimens would certainly reach maturity to be left to colonize previously unoccupied areas, but it would also be a means of showing a remarkable endemic species to those who visit the Deserta Grande, thus connecting the public with a nearly unknown value of the Madeira natural patrimony.

Evaluation of the conservation status of H. ingens according to IUCN criteria and its inclusion in habitats directive

Even though invertebrates in general and spiders in particular are under- and misrepresented (Cardoso et al. 2011b), the IUCN criteria and respective Red List (International Union for Conservation of Nature 2001) are one of the most commonly used and useful tools for evaluation of extinction risk (Mace et al. 2008; Cardoso, Borges, Triantis, Ferrández, & Martín 2011c). They provide a framework useful for lobbying for conservation, even if the active conservation measures are the responsibility of the local authorities to whom the conservation of the taxon is assigned to. The criteria and their applicability to H. ingens can be overviewed in Table 2. Some comments on each one of them are as follows:

a) To use criterion (a) a good estimate of the relative temporal change in species abundance is needed. As pointed out by Cardoso et al. (2011c), it is usually difficult to determine the total abundance of a particular species of invertebrate. The same authors suggest that the Area of Occupancy (AOO) should be used instead. However, the case of a large species in an extremely small area, as is the case of H. ingens in Vale da Castanheira, is an exception to this quasi-impossibility. In the present study, population size was inferred using a methodology that involved high sampling effort over the entire area. However, as no similar sampling of the species was made before this study, comparable data is not available and this criterion should not be applicable to the risk assessment of H. ingens. Comparing the estimates of 2011 and 2012 might provide doubtful data, due to the detectability problem mentioned earlier (see Results on abundance and distribution estimation);

b) Criterion (b) can be analyzed in terms of the Extent of Occurrence (EOO), which is the convex polygon encompassing all presences of the target species. The estimated EOO fits the category for Critically Endangered (EOO <100 km$^2$) but EOO is thought to be very similar throughout the years, not meeting the requirements to classify the target species as Critically Endangered (a continuing decline or extreme fluctuations in EOO). The estimated Area of Occupancy (AOO) is likewise below the threshold required for classification as Critically Endangered. Furthermore, our data records a reduction of 72% of the original AOO in 2011, reaching 81% in 2012. The only available information concerning the AOO of H. ingens prior to this work were unrecorded observations by the second author, who has worked in the area for the past two decades, indicating that H. ingens was present in the entire valley at least until 1996, with the invading Phalaris being detected only in 2005, due to the absence of field surveys in the years between. Adding to the fact that the Vale da Castanheira is the only location for the species and that the invasion of the valley by P. aquatica diminishes the quality of this habitat (requirement
B2(b)(iii), the category of Critically Endangered is the one best suited for criterion (b);

(c) Criterion (c) fits the category of Vulnerable due to the abundance estimation of 4447 adults for 2011, and the fact that 100% of the individuals exist in one subpopulation;

(d) The abundance estimation mentioned for criterion (c) is above the threshold value for the category of Vulnerable in criterion (d), but this criterion also points, alternatively, to the AOO and the number of locations where the species can be found, and in both cases the requirements for the classification as Vulnerable are met. As criterion (a), these two last criteria require new abundance thresholds as pointed out by Cardoso et al. (2011c);

(e) Criterion (e) demands a large amount of data, which are not available so far.

From the applicable criteria, (b) takes priority over (c) and (d) since it is the one with the highest extinction threat level (the former fitting the category for Vulnerable), the authors have classified *H. ingens* as Critically Endangered. Based on the present data, this classification was recently integrated in the IUCN database (Cardoso 2014).

Cardoso (2012) recently suggested an urgent revision of the Habitats Directive species lists (Council of the European Communities 1992). The inclusion of species in these lists was entirely subjective, and lacks the use of proper objective data for risk assessment of particular taxa. Indeed, such lists seem to mainly use characters such as aesthetic value and large body size, neglecting taxa thought as repulsive or plainly unknown by the general public. Adopting a different perspective, the authors believe that the inclusion of *H. ingens* in the Habitats Directive would be a worthy opportunity to begin this needed revision.

Conclusion

This species is a strict endemic, being present in a single valley of an oceanic island, and faces a continuing degradation of its habitat due to biological invasions. We emphasize the need to future monitor the population of the species, replicating the sampling protocol used, to provide more robust population and distribution data; we recommend the use of the herbicide against *P. aquatica* in another sections of the valley, to increase desirable sites for *H. ingens*; we suggest the practice of ex-situ conservation, collecting live juveniles and rearing them in captivity, reintroducing adults in Vale da Castanheira; the recent inclusion of *H. ingens* in the Red List of IUCN with the status of Critically Endangered should be followed by a parallel inclusion in the Habitats Directive, as these two instruments could support lobbying of stakeholders interested in granting effective conservation measures for the species protection.

Lastly, we stress that protecting the emblematic spider *H. ingens* would favour the protection of the entire Vale da Castanheira, an area harbouring several other strictly endemic species of invertibrates.

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