

Habitat selection and dispersal power of the spider *Eresus cinnaberinus* (Olivier, 1789) in the porphyry landscape near Halle (Saale)

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ABSTRACT

In the porphyry landscape near Halle, habitat selection and dispersal power of *Eresus cinnaberinus* were studied. In this area, the species was found to inhabit only large patches with warm microclimate. Isolated patches had a very low degree of occupancy by colonies of this species. A logistic regression analysis revealed that the most important factor affecting the distribution pattern of *E. cinnaberinus* near Halle is the size of the habitat patch. As the number of offspring per female was low, and no ballooning behaviour could be observed, it is concluded that isolation effects may play an important role in habitat selection of *E. cinnaberinus*.

INTRODUCTION

An important aim of conservation biology is to conserve species within their natural habitats. However, conserving just single habitats cannot be the final practice. Habitat patches should be within the normal range of distribution of protected species. Otherwise populations may become isolated and decline, because of environmental stochasticity and genetic inbreeding (Shaffer 1981). If, based on this idea, conservation of populations should be effective, we have to think about their size, connectivity between them and their distribution powers, which means the ability to found new populations.

Eresus cinnaberinus [= *E. niger* (Pet.), Platnick 1993] belongs to the cribellate spider family Eresidae. Spiders of this species spend almost all of their lifetimes underground in their well camouflaged but unmistakable tube-webs. Each individual lives alone in its silk-lined burrow, but the majority of the webs are found in colonies (Wiehle 1953; Bellmann 1992). Individuals live for several years (females about four, males about two), but mate only once. Females feed their offspring, but after a few weeks they die and are themselves consumed by their offspring (Bellmann 1992). In Germany, this

species is reported to be rare and endangered (e.g. Harms 1984). A literature survey on the distribution and preferred habitats of this species in Germany and adjacent countries, however, reveals evidence that it does not inhabit a specific type of dry grassland habitat, but can cope with a wide variety of dry grassland localities and comparable biotopes with a warm microclimate. For instance, it is recorded from Corynepforeta (Martin & Uhlig 1986), stony steppe vegetation (Miller & Valešová 1964), various types of dry grassland (Heimer *et al.* 1986), heathland (Bellmann 1992) or gaps within *Quercus pubescens*-forests (Buchar 1975). This wide range of habitats is in contrast to the species' rarity.

In the following text we refer to a study of *Eresus cinnaberinus* with a conservation biological background in a fragmented landscape with patches of dry grassland. We want to present habitat preferences and some results that may explain low distribution power of this species.

MATERIAL AND METHODS

The study area is located near Halle (Saale) in Sachsen-Anhalt (Germany). Annual precipitation is not more than about 480 mm. Summers are dry and the climate can be considered as continental. Differences in altitude are small (some 30 m). The study area consists of patches of dry grassland surrounded by large areas of agricultural land and fallow land. Patches can be assigned to two different size-classes: large areas consisting of several hundred hectares of dry grassland and small hilltops of porphyric rocks surrounded by fields and fallow land.

Sixty-three sites of different size, vegetation type, and degree of connectivity throughout the whole porphyry area were examined for presence or absence of *Eresus cinnaberinus* webs. At 45 sites, relative population sizes were gained by searching an area of approximately 200 m² for two hours and counting all webs found during this time. For each site, vegetation structure and abiotic parameters were considered. Vegetation cover of various layers, dry weight of vegetation per 0.157 m, and the thickness of the litter layer were measured. Additionally, soil depth, slope and exposure were measured. Soon it became evident that habitat size had to be included in the analysis. For the purpose of statistical calculations, exposure was coded according to the deviation from southerly directions (S = 0, SE, SW = 1, E, W = 2, etc.). As *Eresus cinnaberinus* populations were found to inhabit different vegetation types, the borders of habitat patches could not be delimited by measuring the size of single plant associations in the field. Therefore, an indirect measurement was made. We followed the hypothesis that in a larger area a colony of a population should have more neighbouring patches inhabited by another colony of this species. Therefore, a circle with a radius of 100 m was drawn round each site and at each site the number of

intersecting circles was recorded. This value of 100 m was chosen as it is the same order of magnitude as the maximum distance that was observed to be covered by a wandering male (see below). Habitat parameters were analysed using logistic regression (Trexler & Travis 1993).

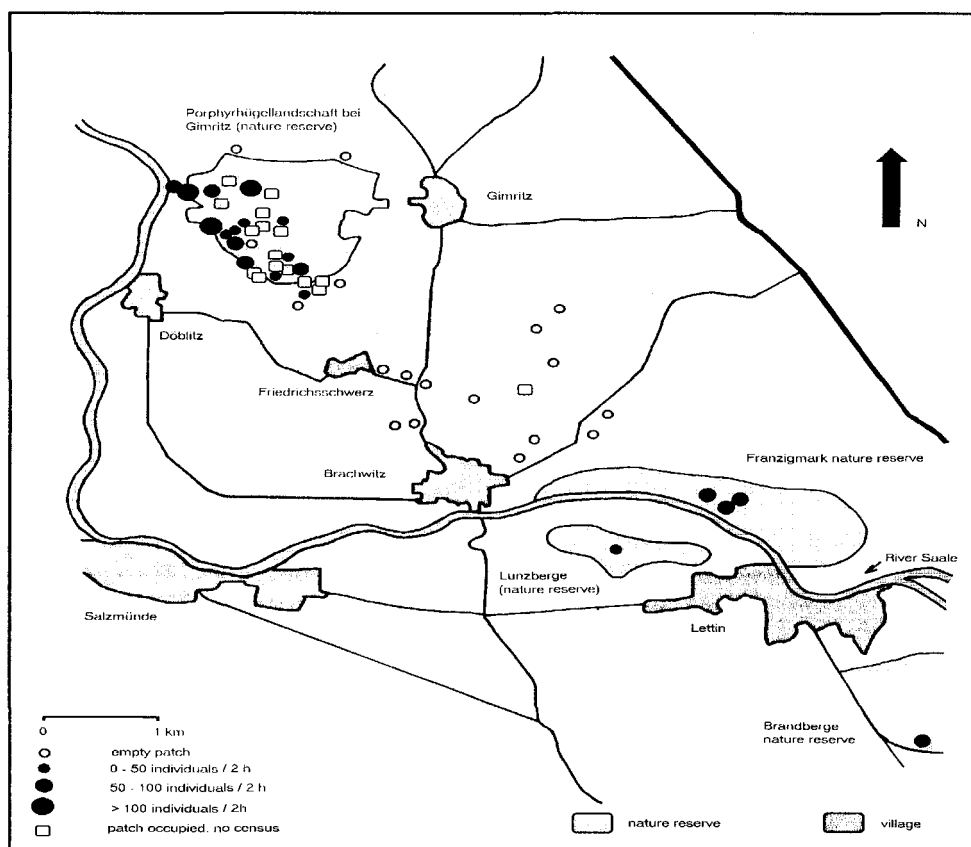


Fig. 1. Distribution of *Eresus cinnaberinus* in the porphyry area north of Halle/Saale, Germany. Relative population sizes were achieved by counting webs per site found within two hours. Open circles: Sites without *Eresus*; black circles in various sizes give relative population sizes; open squares: only the presence of *Eresus* was noted.

In May 1994, 60 pitfall traps were exposed on 5 locations and were controlled daily. Also in May, the vegetation of each location was controlled for ballooning *Eresus* juveniles with a sweep net on various occasions under warm weather conditions. As both approaches gave little results, the number of pitfall traps was increased in 1994 and 1995 (191 and 206 respectively) and the search for juveniles already started in the middle of April.

The mobility of adult males was studied with grids of pitfall traps. In 1994 at three sites, 191 live pitfall traps were exposed from the end of August to the middle of October (plastic cups with a diameter of 7 cm). The distance between single traps was 3 m. Traps were controlled daily. Each male was marked individually with a paint marker (edding 780, extra fine) with coloured spots on femora and opisthosoma (Mühlenberg 1993) in the field and released immediately after marking. Below, only the results from the largest site (89 traps) are referred to.

RESULTS

In 1994 a large number of colonies and 1380 *Eresus cinnaberinus* webs were found (Fig. 1). Most colonies were found in or close to (less than 400 m) large patches of dry grassland in or very near to nature reserves, and the degree of patch occupancy depends on the distance from those reserves (Fig. 2). In larger nature reserves, 28 of 30 sites were occupied. Also, 9 of 12 locations in the close vicinity of larger reserves were occupied. In contrast, only 1 of 15 more remote hillocks was found to be occupied, whereas in the remaining 14 no *Eresus* was recorded. No *Eresus* populations were found in patches of fallow land, even if those patches were close to occupied sites.

In accordance with the literature, colonies of *Eresus* were found in different vegetation types belonging to different plant associations (Schubert *et al.* 1995) (e.g. rock communities, dry grassland with *Festuca valesiaca*, dry grassland with *Galium verum* and *Agrostis*). No significant correlations were found between the numbers of *Eresus cinnaberinus* per site and any vegetation structure parameters (rank correlation coefficients after Spearman). Thus, the distribution of single plant associations or single vegetation structure parameters will not explain the pattern of distribution of *Eresus cinnaberinus*. However, we found a good correlation between incline and the number of *Eresus*-webs per site found within two hours time ($p = 0.55$ ***; rank correlation coefficient; two-sided test; $n = 41$) and the number of neighbouring colonies per site ($p = 0.59$ ***; rank correlation coefficient; two-sided test; $n = 41$). The differences were analysed using logistic regression. The presence of *Eresus* in the porphyry area can be explained by a combination of the factors: occupied sites within 100 m distance, cover of the lowest vegetation layer, vegetation cover (negative effect), deviation from south (negative effect), and slope (Tab. 1). With this model a perfect fit of the data was achieved and 100 % of the sites were grouped correctly. Besides the effects of neighbourhood, the remaining factors may be interpreted as a preference of dry grassland on slopes with southerly exposure. The most important factor, the presence of occupied sites in close vicinity, requires a comparatively larger area for the survival of *Eresus* populations.

Tab. 1. Result of a stepwise forward logistic regression analysis. Parameters are ordered according to their importance in the analysis.

Parameter	Effect
number of neighbouring colonies	+
vegetation cover of vascular plants	-
vegetation cover of the layer 0-2 cm	+
deviation from southerly aspect	-
incline	+

With 89 pitfall traps 540 *Eresus* males were caught and marked. The number of recaptures was 134 (24.8 %), 103 of them being recaptured once, 27 twice, and 4 three times.

In this mark-recapture study, distances covered by marked males were small (Fig. 3). The median of all observations was not more than 13 m. The maximum single distance observed was 59.43 m and the maximum value of the sum of all distances per male (cumulative distance) was 76.25 m. As not many individuals were recaptured more than one time, the lines for cumulative and single distances in figure 3 do not differ much.

A minimum days alive analysis revealed an average value of about 9 days (8.6 +/- 6.6; n = 134) for an active *Eresus* male. With a time span of 30 days the maximum value is much higher. This maximum is the same order of magnitude as was observed in males kept in captivity, where, a value of about 6 weeks was observed.

As this species is protected in Germany, we did not want to disturb its populations too much. Therefore, only some cocoons were collected, and their eggs were counted. Before counting, diameter and height of those cocoons were measured, and the cocoons were weighed. In 1994, a mean number of 43 (+/- 11.4; n = 3) and in 1995 a mean number of 55 (+/-15.5; n = 13) eggs per cocoon was found. The means for 1994 and 1995 are not significantly different (t-test; p = 0.179).

Altogether, 45 additional cocoons were only measured and weighed in the field, without counting their eggs. No significant difference between the values cocoon diameter, cocoon height and cocoon weight was found for cocoons, where eggs had been counted and for cocoons which had only been measured and weighed (ANOVA, p = 0.84). Even though the egg number of only 16 cocoons had been counted, it can be assumed that there was a mean number of 52 (+/- 15; n = 16) eggs for an average *Eresus*-cocoon in 1994 and 1995.

Before its death in summer, each female closes the web entrance. When tube webs where there had been a cocoon in summer were controlled in autumn their entrances were still closed. At this time, a mean number of 15 juveniles per web

was found in 1994 (n = 8). In 1995 the number was 14 (+/-9.4; n = 12). In summer, often groups of webs of juvenile spiderlings not older than about one year were found in colonies that were already occupied.

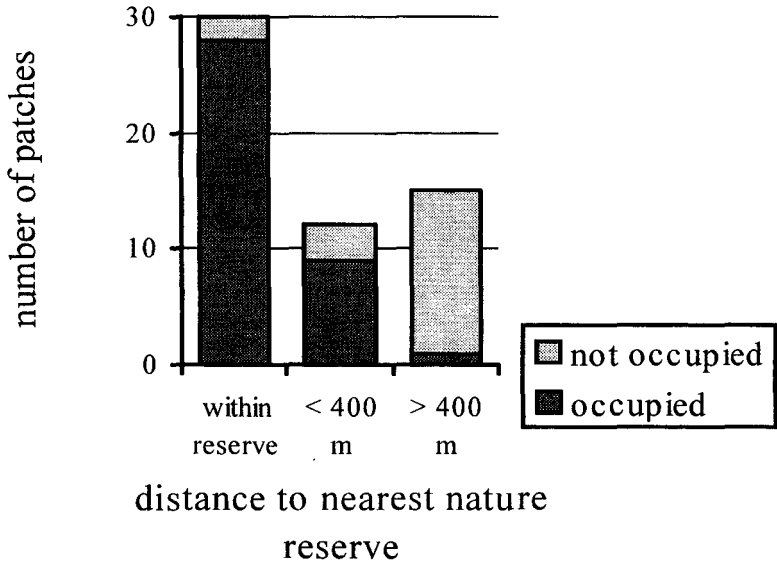


Fig. 2. Degree of occupancy of dry grassland patches in the porphyry area near Halle (Saale) at increasing distances from large nature reserves in the spider *Eresus cinnaberinus*.

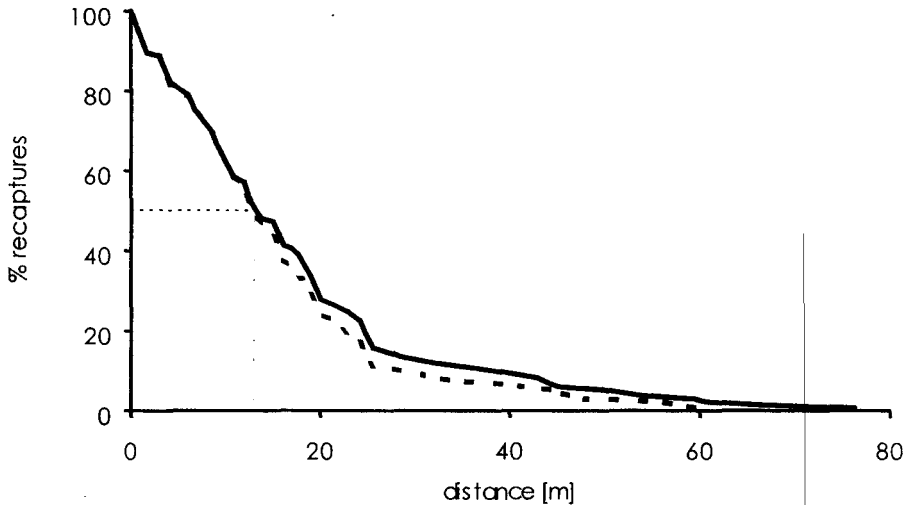


Fig. 3. Distances covered by marked *Eresus cinnaberinus*-males in a grid of 89 life-pitfall traps. Dashed line: maximum single distances; solid line: cumulative distances. The thin dashed lines refers to the median.

In May 1994 only four juvenile *Eresus* were caught in pitfall traps. A comparable result could not be achieved in the following years; neither in April and May 1995 nor in April and May 1996 any juvenile *Eresus* was caught in pitfall traps. In addition, no young *Eresus* could be caught with a sweep net in all three years.

DISCUSSION

The gap in the distribution pattern of *Eresus cinnaberinus* in the porphyry landscape near Halle was probably not a result of a gap in the distribution of suitable habitat patches, as no vegetation structure parameter that is restricted to large sites could be found. According to our habitat model, large numbers of remote but unoccupied patches should have suitable habitat quality. However, they are comparably small in contrast to the patches in the large nature reserves. The patch size proved to be very important in our study. It was found to be most important in a logistic regression analysis. But what is the reason for this? Why do these spiders not inhabit small patches?

One possible explanation may be that in larger patches a higher number of *Eresus cinnaberinus*-individuals are able to live, and therefore the risk of extinction is smaller. In small habitat patches, extinction events may occur more often. This does not matter if a species is a good disperser as it is observed, for instance, in the case of *Argiope bruennichi* (Scopoli) (e.g. Gauckler 1967; Guttmann 1979). However, if a species' dispersal power is weak, then a situation like the one near Halle may be observed.

When we want to find out reasons for a potential lack of dispersal power, we have to look at the possible colonisers, the juveniles, that, as in many spider species, are able to reach new habitats. In our study, ballooning behaviour was neither observed in the field nor in the case of juvenile spiders that were kept in captivity, and no juveniles were caught in the vegetation with a sweep net, which would have been a good hint for ballooning in an epigaeic species. Only very few juveniles were caught in live pitfall-traps. Thus, general dispersal activity of juveniles seems to have been low during the study period. Ratschker (1995) also found no ballooning behaviour. In his study as well as in the previous one, hatched juveniles were often found together in groups. According to Ratschker (1995) young *Eresus* often settle directly near the place, where their mothers lived. This group formation in *Eresus cinnaberinus*-spiderlings is probably caused by a lot of social interactions between group members (Holl & Reinbach 1991). Thus, it can be assumed that only little ballooning will occur in the field and that most juveniles do not migrate much, but settle near their mothers web sites. Long-distance colonisation seems to be very rare.

From the previous study, some arguments for nature conservation are obvious. If we want to protect *Eresus* near Halle, it is useless to protect

patches of dry grassland or similar vegetation even at moderately large distances from occupied patches and to hope that they will be colonized within a reasonable time-frame of several years. A comparatively large area of suitable habitat is needed in the very close vicinity of occupied patches. This means that a comparatively large area is needed to protect the situation as it exists today. A scenario like this, where a lot of area is required for the conservation of an invertebrate species, is probably not only true for *Eresus* in the porphyry area near Halle. We have to think about similar effects in a lot of European invertebrate species (e.g. Webb & Thomas 1993).

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