

Germination capacity and temperature dependence in Mediterranean species of the Balearic Islands

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Abstract

To test the germination capacity and its temperature dependence in Mediterranean plants, sixteen species representative of a diversity of habitats of the Balearic Islands were selected. The percentage of germination, the half-response time and the dormancy period of these species were studied at three alternating temperatures: 5-15°C, 10-20°C and 15-25°C. Large differences were found among species in all three parameters studied. The influences of the temperature incubation in germination behaviour depended strongly on species, although the optimum temperature range to reach maximum germination was found to be 10-20°C for most species. Although part of the endemic flora of the Balearic Islands currently has a limited and regressive distribution, no clear pattern was observed when comparing endemic and non-endemic species. In fact, some of the endemics presented unfavourable characters, particularly a relatively high temperature independence of their germination pattern.

Key words: Balearic Islands, endemism, germination, Mediterranean, temperature.

Resumen

Capacidad de germinación e influencia de la temperatura en la germinación de especies mediterráneas de las Illes Balears

Con el objeto de determinar la capacidad germinativa y su dependencia de la temperatura en especies mediterráneas, se seleccionaron 16 especies representativas de la diversidad de hábitats de las Illes Balears. En ellas se estudió el porcentaje de germinación, el tiempo de respuesta medio y el período de dormancia bajo tres rangos de temperatura: 5-15°C, 10-20°C y 15-25°C. En dichos parámetros se encontraron importantes diferencias entre especies bajo cualquiera de los tres rangos de temperatura de incubación. La influencia de la temperatura de incubación sobre el comportamiento germinativo mostró una fuerte dependencia del factor especie, si bien el rango de incubación óptimo resultó 10-20°C para la mayoría de las especies. Aunque se ha descrito que parte de la flora endémica de las Illes Balears presenta una distribución reducida y en clara regresión, no parece ser que dicho fenómeno sea debido a diferencias en la capacidad de germinación entre estas especies y sus correlativas de amplia distribución.

Palabras clave: Illes Balears, endemism, germinación, mediterráneo, temperatura.

Introduction

The significance of seed stage capacity has long been recognized as one of the critical steps in the species spatial and temporal establishment success (Harper, 1977; Silvertown and Lovett-Doust, 1993; Hilhorst and Toorop, 1997). The response pattern of seed germination

is also regarded as a key characteristic in plant life history strategy (Angevine and Chabot, 1979; Mayer and Poljakoff-Mayber, 1989). Seed germination can be regulated not only through genotypic characteristics (Gutterman, 1993), but also by environmental conditions, being soil temperature the most important environmental factor controlling seed germination (Beardsell and Richards, 1987). Temperature can affect the germination capacity through its effects on seed deterioration, loss of dormancy and the germination process itself (Roberts, 1988).

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The Mediterranean climate is characterised by its seasonality in temperature and precipitation, which leads to a hot drought period in summer and a cool wet period in winter (Joffre *et al.*, 1999). This peculiarity of the Mediterranean climate has important implications on plant germination physiology, since dry summer conditions limit water availability and thus germination and growth, while cool winter temperatures also limit germination during the season with high water availability (Rundel, 1996). Spatial and temporal distribution of precipitation in these ecosystems is considered to be highly episodic and unpredictable (Terradas, 1991). The germination season, and for extension the temperature requirements for germination, might be crucial for plant survival. For instance, it is obvious that a species with high, massive germination process relatively independent of temperature may not be favoured, because any short precipitation in late spring would cause its seeds to germinate, but seedlings will not be capable to overcome the following summer stresses (Lloret *et al.*, 1999). Moreover, the presence of dormancy that delays germination is often advantageous in a competitive or seasonal environment (Harper, 1977; Vleeshouwers *et al.*, 1995).

The Balearic Islands, located within the Mediterranean Basin, are characterised by the richness of its endemic flora (Cardona and Contandriopoulos, 1979). Nevertheless, a substantial number of them have been described to have a limited and regressive distribution (Alomar *et al.*, 1997). There are different lines of evidence showing that endemic species with a narrow distribution are less competitive than widespread species (Carlquist, 1970; Ehrendorfer, 1979; Givnish, 1998; Pattison *et al.*, 1998; Walck *et al.*, 1999; Durand and Goldstein, 2001; Gulías *et al.*, 2002; Gulías *et al.*, 2003). However, a comparative study of the germination capacity of endemic and non-endemic species is lacking in the literature, despite the fact that a reduced germination capacity and viability is a candidate to explain the declining distribution of some of endemic species. Furthermore, a good understanding of the germination capacity and requirements of endemic species is essential for an optimal biodiversity conservation and future management.

The main objective of this work was to compare the germination capacity and the ability to germinate under different temperature ranges, those typically occurring in the different seasons, of Mediterranean species of the

Balearic Islands, belonging to different taxonomic, evolutionary and life habit groups.

Materials and Methods

Plant species, seed collection and storage

Sixteen Mediterranean species inhabiting in the Balearic Islands were selected according to their distribution (endemic and non-endemic species of the Balearic Islands) and life habit. Species were classified in couples of one endemic and one non-endemic species having similar life habit and naturally occurring in similar niches, although not necessary belonging to the same family (Table 1).

Seeds from at least 10 plants per species were collected in the field. Depending on the distribution of each species, one to three different populations were sampled for seed collection. From these seeds, 10 to 20 plants per species were obtained and grown at optimum conditions outdoors at the University of the Balearic Islands (Mallorca, Spain). Completely developed seeds from these plants were collected in 2002 and 2003 to perform the experiment. Seasonal seed collection depended of the phenology of each species (Table 1). When needed, seeds were manually separated from their capsules, except for the two *Beta* species, with seeds located in a hard capsule with 2-3 embryos per capsule. Healthy seeds were selected, placed in paper envelopes, and dry-stored in a refrigerator at 4°C until their use.

Seeds from *Cistus albidus* and *Pistacia lentiscus* required pre-germination treatments. *Cistus albidus* presents dormancy due to the hardness and impermeability of its coat, which were broken with dry-heat pre-treatment placing seeds, spread on glass dishes, in an oven already at 90°C for 5 minutes (Thanos and Georghiou, 1988; Hanley and Fenner, 1998). In the case of *P. lentiscus*, fruit pulp was removed (García-Fayos and Verdú, 1998).

Germination tests

Seeds were placed in 9 cm diameter Petri-dishes on two layers of filter paper (Whatman no. 1) moistened to saturation with distilled water, so that germination was not limited by water. Additional water was added when

Table 1. List of the species selected for study, with their family, evolutionary history, life habit, habitat characteristics and seed collection season. Species are listed in couples of one endemic and one non-endemic competitors

Species	Family	Evolutionary history	Life habit	Habitat	Seed collection season
<i>Diplotaxis ibicensis</i> Pau	<i>Brassicaceae</i>	Endemic	Herb annual	Coastal	May
<i>Lavatera maritima</i> Gouan	<i>Malvaceae</i>	Non-endemic	Woody hemi-deciduous	Coastal	June
<i>Limonium magallufianum</i> L. Llorens	<i>Plumbaginaceae</i>	Endemic	Woody evergreen	Coastal	September
<i>Limonium gibertii</i> (Sennen) Sennen	<i>Plumbaginaceae</i>	Non-endemic	Woody evergreen	Coastal	September
<i>Beta maritima</i> L. subsp. <i>marcosii</i> A. Juan & M. B. Crespo	<i>Chenopodiaceae</i>	Endemic	Herb evergreen	Coastal	July
<i>Beta maritima</i> L. subsp. <i>maritima</i>	<i>Chenopodiaceae</i>	Non-endemic	Herb evergreen	Coastal	July
<i>Hypericum balearicum</i> L.	<i>Guttiferae</i>	Endemic	Woody evergreen	Shrubland	August
<i>Pistacia lentiscus</i> L.	<i>Anacardiaceae</i>	Non-endemic	Woody evergreen	Shrubland	October
<i>Phlomis italica</i> L.	<i>Labiatae</i>	Endemic	Woody hemi-deciduous	Shrubland	August
<i>Cistus albidus</i> L.	<i>Cistaceae</i>	Non-endemic	Woody hemi-deciduous	Shrubland	July
<i>Urtica atrovirens</i> subsp. <i>bianorii</i> (Knoche) Paira	<i>Urticaceae</i>	Endemic	Herb annual	Ruderal	June
<i>Urtica membranacea</i> Poiret	<i>Urticaceae</i>	Non-endemic	Herb annual	Ruderal	May
<i>Lysimachia minoricensis</i> J. J. Rodr.	<i>Primulaceae</i>	Endemic	Herb evergreen	Water sources	August
<i>Mentha aquatica</i> L.	<i>Labiatae</i>	Non-endemic	Herb evergreen	Water sources	October
<i>Pimpinella bicknelli</i> Briq.	<i>Apiaceae</i>	Endemic	Herb annual	Ruderal	June
<i>Kundmannia sicula</i> (L.) D. C.	<i>Apiaceae</i>	Non-endemic	Herb annual	Ruderal	June

needed. Care was taken not to inundate the seeds. Petri-dishes were covered with parafilm to minimise water losses.

For all the species, 20 seeds were used per Petri-dish, with 6 replicates per species, excepting the two *Betas*, with 15 seeds per dish and 4 replicates. Germination tests were conducted in controlled environment chambers (Koxka, Spain). Petri-dishes were randomly distributed in germination chambers and their position was changed every 2-3 days. Seeds were incubated in continuous darkness at three alternating temperatures (12h-12h): 5-15, 10-20 and 15-25°C. These regimes were designed to simulate natural diurnal fluctuations of temperature in winter, spring/autumn and early summer, respectively. Germination was defined as the first emergence of the radicle. Newly germinated seeds were counted under green light every 2-3 days and subsequently removed from the Petri-dishes. Those seeds infected by fungi or bacteria were removed and

not considered for the calculations. The experiment lasted 91 days. Non-germinated seeds were dissected to determine if they had embryo (full seeds), with the aid of a magnifying glass when required.

The percentage of cumulative seed germination (G) for each replicate was calculated at the end of the experiment as:

$$\%G = 100 \times (SG/IS-ES)$$

were: SG = number of germinated seeds

ES = number of empty seeds

IS = number of seeds initiated in each replicate

The dormancy period (D) of a homogeneous group of seeds was determined as the number of days needed to observe the first seed germinated. Finally, the average time response (T_{50}) to germination conditions

was determined as the number of days elapsed from the initial until germination of 50% of total germinated seeds.

Statistical analysis

All percent G values were arcsine square root transformed before analysis to normalize the variance (Zar, 1999). T_{50} and D values were logarithm transformed for the same purpose. Statistical analysis of germination data was performed with the SPSS 11.5 software package (SPSS, Chicago, IL). A Tukey's multiple comparison test was then used to determine differences between species and temperatures for all the parameter means ($P < 0.05$).

Results

For a given temperature treatment, G largely diverged among species (Table 2). *D. ibicensis*, *L. magallufianum*, *L. gibertii*, *H. balearicum*, *U. membranacea* and *L. minoricensis* presented G values

higher than 80%, at least for one temperature regime. By contrast, *L. maritima*, *B. vulgaris* subsp. *marcosii*, *B. vulgaris* subsp. *maritima*, *P. italica* and *U. atrovirens* subsp. *bianorii*; did not reach 40% of G at any temperature. Despite the large differences observed between species, G did not differ significantly between endemic and non-endemic species at any of the three temperatures ($P > 0.05$), however, four of the five species with G higher than 90% were endemics, but also three of the five with G lower than 40%.

Most of the species presented significantly different G values depending on the temperature treatment ($P < 0.05$) and different optimum temperature (i.e. the temperature regime at which G was maximal) (Table 2). Only *H. balearicum*, *P. italica*, *L. minoricensis* and *M. aquatica* showed no effect of temperature on G. In general, most of the species presented the lowest G at 15-25°C and only *D. ibicensis* showed significant higher G values at 5-15°C than at any other temperature regime ($P < 0.05$).

T_{50} ranged from 3.0 for *L. magallufianum* at 15-25°C to 70.2 for *M. aquatica* at 5-15°C (Table 2). In general, T_{50} was lower at 10-20°C. For *L. maritima*, *L. magallufianum*, *L. gibertii*, *H. balearicum* and *U.*

Table 2. Means of percentage of cumulative seed germination (G), , average time response (T_{50}) and dormancy period (D) at the three alternating temperature treatments for each species. Different letters denote statistically significant differences by a Tukey's multiple comparison test ($P < 0.05$) within each parameter and species (small letters) or within each parameter and temperature range (capital letters)

Species	G (%)			T_{50} (days)			D (days)		
	5-15°C	10-20°C	15-25°C	5-15°C	10-20°C	15-25°C	5-15°C	10-20°C	15-25°C
<i>Diploaxis ibicensis</i>	97.9 ^{c,G}	84.4 ^{b,FG}	52.7 ^{a,DE}	5.0 ^{a,A}	5.0 ^{a,A}	8.0 ^{b,AB}	5.0 ^{b,A}	5.0 ^{b,A}	3.0 ^{a,A}
<i>Lavatera maritima</i>	1.3 ^{a,A}	20.0 ^{b,AB}	2.0 ^{a,AB}	24.5 ^{a,EF}	10.0 ^{a,B}	21.0 ^{a,BCDEFG}	24.5 ^{ab,BCD}	6.3 ^{a,AB}	21.0 ^{b,FG}
<i>Limonium magallufianum</i>	98.4 ^{b,G}	93.6 ^{ab,HI}	92.7 ^{a,F}	5.0 ^{a,A}	5.0 ^{a,A}	3.0 ^{a,A}	5.0 ^{b,A}	5.0 ^{b,A}	3.0 ^{a,A}
<i>Limonium gibertii</i>	91.2 ^{ab,G}	91.2 ^{b,HI}	73.6 ^{a,E}	9.0 ^{a,B}	8.3 ^{a,B}	9.0 ^{a,ABCD}	7.0 ^{b,A}	5.0 ^{a,A}	4.0 ^{a,AB}
<i>Beta maritima</i> L. subsp. <i>marcosii</i>	31.5 ^{b,CDE}	31.4 ^{b,ABC}	3.7 ^{a,A}	27.0 ^{g,G}	15.0 ^{a,CD}	12.6 ^{a,BCDEF}	19.3 ^{c,BCD}	9.5 ^{a,CDE}	13.7 ^{b,EF}
<i>Beta maritima</i> L. subsp. <i>maritima</i>	31.1 ^{b,CDE}	28.3 ^{b,ABC}	7.2 ^{a,AB}	26.7 ^{b,FG}	14.7 ^{a,CD}	14.8 ^{a,BCDEF}	21.0 ^{c,CDE}	10.3 ^{a,DE}	14.0 ^{b,EF}
<i>Hypericum balearicum</i>	97.7 ^{a,G}	97.8 ^{a,I}	98.6 ^{a,F}	12.3 ^{a,BCD}	12.7 ^{a,C}	11.8 ^{a,ABCDE}	12.0 ^{b,B}	12.0 ^{b,E}	6.5 ^{a,BCD}
<i>Pistacia lentiscus</i>	47.3 ^{b,EF}	39.3 ^{b,BCD}	4.7 ^{a,AB}	42.2 ^{b,H}	34.0 ^{b,F}	16.5 ^{a,BCDEFG}	32.7 ^{b,EF}	23.7 ^{a,F}	21.0 ^{a,FG}
<i>Phlomis italica</i>	15.8 ^{a,ABC}	17.4 ^{a,A}	8.7 ^{a,AB}	16.5 ^{ab,CDE}	13.0 ^{a,C}	18.8 ^{b,DEFG}	13.3 ^{a,BC}	12.0 ^{a,E}	13.0 ^{a,DEF}
<i>Cistus albidus</i>	41.3 ^{a,DE}	70.7 ^{b,EF}	37.0 ^{a,CD}	57.5 ^{b,HI}	23.7 ^{a,E}	35.0 ^{a,EF}	25.3 ^{b,DEF}	10.8 ^{a,DE}	22.0 ^{b,FG}
<i>Urtica atrovirens</i> subsp. <i>bianorii</i>	8.1 ^{a,AB}	36.1 ^{b,ABC}	20.4 ^{a,BC}	18.2 ^{b,DEF}	9.0 ^{a,B}	26.3 ^{b,DEFG}	16.4 ^{b,BCD}	7.7 ^{a,BC}	17.7 ^{b,EF}
<i>Urtica membranacea</i>	34.7 ^{a,DE}	80.2 ^{b,FG}	20.9 ^{a,BC}	12.0 ^{a,BC}	9.0 ^{a,B}	26.0 ^{a,BCDEFG}	7.0 ^{a,A}	5.0 ^{a,A}	13.2 ^{b,DEF}
<i>Lysimachia minoricensis</i>	98.7 ^{a,G}	98.0 ^{a,I}	96.7 ^{a,F}	19.0 ^{b,EF}	9.0 ^{a,B}	6.0 ^{a,ABC}	19.0 ^{c,BCD}	9.0 ^{b,CD}	6.0 ^{a,BC}
<i>Mentha aquatica</i>	67.3 ^{a,F}	70.9 ^{a,EF}	68.7 ^{a,E}	70.2 ^{b,I}	17.3 ^{a,D}	13.0 ^{a,CDEFG}	36.8 ^{b,FG}	9.5 ^{a,CDE}	9.7 ^{a,CDE}
<i>Pimpinella bicknelli</i>	25.1 ^{b,BCD}	47.6 ^{c,CD}	14.4 ^{a,AB}	66.5 ^{c,I}	54.2 ^{b,G}	48.0 ^{a,G}	55.3 ^{b,G}	44.8 ^{a,G}	42.8 ^{a,H}
<i>Kundmannia sicula</i>	30.0 ^{a,CDE}	58.7 ^{b,DE}	20.7 ^{a,BC}	43.5 ^{b,H}	34.3 ^{a,F}	34.2 ^{a,FG}	33.5 ^{a,EF}	29.7 ^{a,F}	30.3 ^{a,GH}

membranacea T₅₀ was independent of the temperature treatment (Table 2). By contrast, *D. ibicensis* and *P. italica* germinated more slowly at higher temperatures, and both *Beta* species, *P. lentiscus*, *C. albidus*, *L. minoricensis*, *M. aquatica*, *P. bicknelli* and *K. sicula* had higher T₅₀ at lower temperature regimes.

In respect to D, *D. ibicensis* and *L. magallufianum*, with 3 days at 15-25°C treatment, had the lowest values. By contrast, *P. bicknelli*, with 55.3 days at 5-15°C presented the highest D. Temperature did not have significantly effects ($P > 0.05$) on *P. italica* and *K. sicula* dormancy period (Table 2).

Discussion

As expected for Mediterranean ecosystems, where many species have been related to present different types and degrees of dormancy (Baskin and Baskin, 1998), large differences in G, D and T₅₀ were found between species (Table 2). This wide range of variation could be partly explained by intraspecific differences, between populations and years, as already observed in some species, due to both environmental and genetic causes (Melzack and Watts, 1982; Baskin and Baskin, 1998; Gasque and García-Fayos, 2003). The production of seeds with different viability is one of the most important survival strategies for species growing under unpredictable environmental conditions (Gutterman, 1994; Kigel, 1995).

It was noteworthy the low percentage of germination of some of the species, i.e. the percentage of non-germinated seeds at the end of the experiment (Table 2). Seven of the sixteen species did not reach 50% of germination at any of the temperature regimes analyzed. This is in agreement with other studies that have also reported low germination percentages in Mediterranean species, some of them included in this study, such as *P. italica* and *U. atrovirens* subsp. *bianorii* (Ayerbe and Ceresuela, 1982; Salvador and Lloret, 1995). This could be due to the presence of dormancy mechanisms in a large percentage of the seeds, as already described in *Cistus* species (Thanos and Georghiou, 1988; Delgado *et al.*, 2001). Seed dormancy has been argued as a mechanism by which plants have adapted to unpredictable or seasonal environments (Bender *et al.* 2003), as the Mediterranean climate.

In general, the optimum temperature range to reach maximum G values was found to be 10-20°C (Table 2).

Only *D. ibicensis* presented an optimum temperature other than 10-20°C. This optimum germination temperature range is similar to that reported for many other Mediterranean species (Ayerbe and Ceresuela, 1982; Lagarda *et al.*, 1983; Baskin and Baskin, 1998; Barragán *et al.*, 1999; Thanos, 2000). By contrast, Mitrakos (1981) showed that other Mediterranean species, such as *Nerium oleander*, *Ceratonia siliqua* and *Myrtus communis*, presented their optimum germination temperatures at 27.5°C, which might be disadvantageous under Mediterranean climate, where high temperatures coincide with the dry season. Mitrakos (1981) suggested that this trait was acquired by these species before Mediterranean climate was originated in the late tertiary, when Mediterranean Basin was characterized by a tropical climate. However, this disadvantageous trait in the germination pattern of these species has been compensated by other successful adaptive strategies to the Mediterranean stresses (Demmig *et al.*, 1988; Lo Gullo and Salleo, 1988; Rhizopoulou and Mitrakos, 1990).

Four species, *H. balearicum*, *P. italica*, *L. minoricensis* and *M. aquatica* (the former three, endemic species) presented a temperature-independent germination behavior, with G values higher than 70%, regardless of temperature incubation (Table 2). This ability to germinate over a wide range of temperatures has been described to be an important characteristic of disturbed ecosystems (Santon, 1984) and has been also associated with species in which water supply is the main determinant of the timing of germination in the field (Grime *et al.*, 1981). By contrast, in *L. maritima*, *B. maritima* subsp. *marcosii*, *B. maritima* subsp. *maritima*, *P. lentiscus*, *U. atrovirens* subsp. *bianorii*, *U. membranacea* and *K. sicula*, maximum G doubled minimum G, suggesting a strong temperature-dependence of G. The low germination percentages of these species under some temperature regimes could be due to significant degrees of secondary dormancy (Baskin and Baskin 1998).

The high G of the extinct in the wild *L. minoricensis*, regardless of the temperature treatment, was in accordance with previous results reported by Rosselló and Mayol (2002), suggesting that seed viability was not the major cause of extinction of this species. Ayerbe and Ceresuela (1982), working with constant temperatures, reported different G values for *H. balearicum*, *U. atrovirens* subsp. *bianorii*, *P. bicknelli* and *P. italica*. Many other studies have shown different

responses of G depending whether the incubation took place in constant or alternating temperatures (Beardsell and Richards, 1987; Del Monte and Tarquis, 1997).

Most of the species included in the present survey present their seed maturation and dispersal in late-spring or summer. Only *L. magallufianum*, *L. gibertii*, *P. lentiscus* and *M. aquatica* differ, with mature seeds occurring in autumn. This fact has ecological implications on seed germination, since under Mediterranean climate favourable conditions for germination will start in early autumn, when precipitation usually initiates. Consequently, the presence of mechanisms that allow seeds to avoid germination under high temperatures would be positive in these environments. By contrast, high germination percentages and low dormancy period at 15-25°C, together with mature seed cycle completed in late spring-summer might be disadvantageous in the Mediterranean climate, since any summer precipitation could lead to a massive germination, and seedlings will not be able to withstand summer constraints. However, most of the species analyzed are likely to avoid this situation, since, at high temperatures (15-25°C regime), although most of them decreased D and T_{50} , also decreased G to 20% or less (Table 2). *L. magallufianum*, *L. gibertii* and *M. aquatica* presented high G values at the high temperature regime, but, their seed maturation is not reached until autumn. *C. albidus* also maintained a relative high G at high temperatures, but a primary dormancy and capacity to establish a large seed soil bank is well-known in *Cistus* species (Thanos and Georghiou, 1988; Delgado *et al.* 2001).

Hence, only *D. ibicensis*, *H. balearicum* and *L. minoricensis* are likely to present a non-suitable germination behavior under the Mediterranean climate, with water limitation as the only environmental factor controlling germination. Nevertheless, in the present work the highest temperature range analyzed was 15-25°C, and it is obvious that higher temperatures are commonly reached in summer and might inhibit germination in these species. Furthermore, field emergence is affected by a number of other biological, physical and chemical factors (Hegarty, 1973; Egli and TeKrony, 1996; Weaich *et al.*, 1996).

On the other hand, since the Mediterranean climate is characterized by highly episodic and unpredictable rainy events (Terradas, 1991), and therefore water availability in soil, it could be argued that a rapid and massive germination would constitute a positive

adaptation to such environment. *D. ibicensis*, *L. magallufianum*, *L. gibertii*, *H. balearicum* and *L. minoricensis* may have reached this strategy, although assuming the intrinsic potential risks drawn from the rapid changes of both temperature and humidity conditions under Mediterranean climate, or the regularly presence of disturbances in this area (Noble and Slayer, 1978; Noble and Gitay, 1996).

Because of wide range found on germination parameters among the species analyzed, none of the statistical analyses made after grouping species according to their evolutionary history resulted in significant differences. However, there are some qualitative aspects to be mentioned. For instance, endemic species generally present a higher germination capacity under any of the three alternate temperature incubations. Hence, at the 5-15°C treatment, four of the five species that overcome 90% of G were endemics (Table 2). A similar pattern was found in the other two temperature treatments analyzed, being endemics three of the four species with G higher than 90% at 10-20°C, and only three endemic species were able to reach G of 90% at the 15-25°C regime. Although a higher plasticity to temperature response is expected to be found in the more widespread and cosmopolitan species (Bouwmeester and Karssen, 1993), rather than among endemic species, the only three species that overcome 90% of G despite of the temperature incubation were all them endemics. By contrast, in some widespread species, such as *P. lentiscus* and *U. membranacea*, G, T_{50} and D highly depended on temperature. Indeed, endemic species tend to reduce their dormancy period as the temperature increases to a larger extent than do non-endemic species. Hence, five endemic and two non-endemic species presented their lowest D at the 15-25°C treatment, while three endemic and six non-endemic species after 10-20°C incubation. Therefore, it can be argued that the reduced and declining distribution of some endemic species of the Balearic Islands are not due to a general deficient germination of endemic species. Moreover, the global change effects on the Mediterranean climate likely provide more frequent and longer drought periods, together with an increase of the temperature (Osborne *et al.* 2000). Consequently, germination capacity of some endemic species, such as *Limonium*, *H. balearicum* and *L. minoricensis*, will result less affected because of their high capacity to germinate under moderate and high incubation temperatures.

In conclusion, this study shows a wide range of diversity in the temperature influences on the germination capacity of Mediterranean species, which might be related to different strategies adopted by these species as a consequence of the heterogeneity of habitats and climatic seasonality intrinsic to the Mediterranean ecosystems. The endemic species of the Balearic Islands are likely to present a similar or even a higher germination capacity and ability to germinate over a wide range of temperature than their relative widespread species. Therefore, at least for the species analyzed, other physiological characters than germination may be responsible for the limited and declining distribution of some of these endemic species.

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