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Floral biology of the Canarian *Echium wildpretii*: bird–flower or a water resource to desert bees?

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SUMMARY

The red corolla colour, the relatively large volume of nectar and the low concentration of sucrose in the nectar of *Echium wildpretii* are traits related to bird pollination, while its ultraviolet colour and floral morphology may attract bees. It is suggested that the species may serve as a water resource to solitary desert bees in nature.

Key-words: Canary Isles, *Echium wildpretii*, nectar secretion, pollination.

INTRODUCTION

Echium wildpretii Pearson ex Hook. fil. (Boraginaceae) is found on Tenerife and La Palma in the mountain zone above 1900–2000 m. While it may be locally frequent on Tenerife, e.g. Circo de las Cañadas, it is extremely rare on La Palma. Its inflorescence is up to 4 m high, columnar and consists of thousands of red flowers arranged spirally (Burchard 1929; Ceballos & Ortuño 1951; Bramwell & Bramwell 1974). This paper puts forward a hypothesis on the relationships between the pollination of this species by desert bees and birds, and the water demands of these animals.

MATERIALS AND METHODS

Two plants collected in Las Cañadas, Tenerife, in January 1982, were grown in a greenhouse at the University of Aarhus, Denmark. They flowered in the last half of May, 1983, and their anthesis was studied. Ultraviolet reflectance patterns from the corolla were detected with a Kodak Wratten 18A filter (Kevan *et al.* 1973). Nectar volume was measured as standing crop per flower in flowers of different age (insects excluded; greenhouse, 70% r.h., 15–22°C) using 10-µl micropipettes. Each flower was only sampled once. Concentrations of sucrose equivalents were measured with a Bellingham & Stanley pocket refractometer modified for small volumes of nectar (>0.5 µl; pct. was corrected to 20°C) (Corbet 1978). Each flower was sampled between 1 and 3 times. It has to be stressed that it is difficult to know how far one can use studies on greenhouse plants to investigate aspects of nectar secretion in the wild. The real situation on Tenerife and La Palma is unknown.

RESULTS AND DISCUSSION

Floral biology

The red flower of *E. wildpretii* is zygomorphic and creates a landing platform to insects. The depth of its corolla is 9–10 mm, and the diameter of the fully opened flower is approx.

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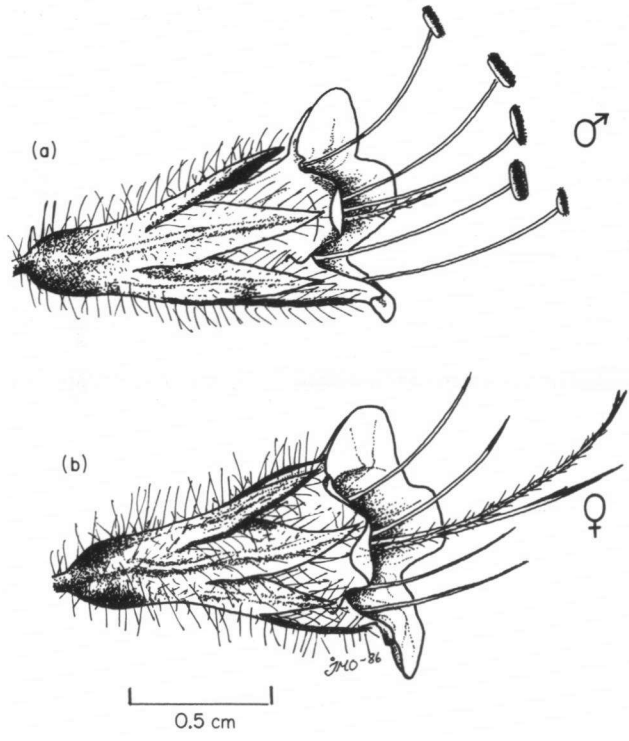

Fig. 1. (a) Flower of *E. wildpretii* in male phase. (b) Flower in female phase.

10 mm (Fig. 1). When withering, its colour sometimes turns blue. The same colour change is known from *Pulmonaria obscura* Dumort. (Olesen 1979); and the blue-flowered *Echium vulgare* L. has red buds. The flower reflects ultraviolet light from the distal parts of its corolla (Fig. 2, light areas). Ultraviolet is visible to insects (e.g. Kevan 1972), but probably not to most birds, which are very sensitive to red (e.g. Stiles 1976). The flower does not produce any scent detectable to humans.

Each sidebranch of the inflorescence is a cyme presenting a new flower every second day. The flowers are protandrous (Fig. 1). Most of them open in the morning (Fig. 3). Flower-opening is spread throughout the day in *E. vulgare* and *E. plantagineum* L. (Corbet 1978; Corbet & Delfosse 1984).

The stamens elongate and the blue anthers present their blue pollen (Fig. 1a). The male phase ends during the following morning (Fig. 3).

The hairy style begins to elongate during the afternoon of day 1. At the end of this day the style may extend 4·0–13·5 mm out of the opening of the corolla tube. The flower enters its female phase during Day 2, and when mature the style extends 7·0–15·0 mm out of the opening of the corolla tube (Fig. 1b). Autogamy is possible during Day 2. Most flowers live for 2·5–3 days ($n=30$; range 2–4). The flowers often look withered on Day 3, and the style is probably unreceptive (Fig. 2). Flowers excluded from insect visitors do set seeds ($n=50$; $2{\cdot}1 \pm 0{\cdot}7$ nutlets per flower; four is the theoretical maximum. Thus, self-pollination happens during Day 2.

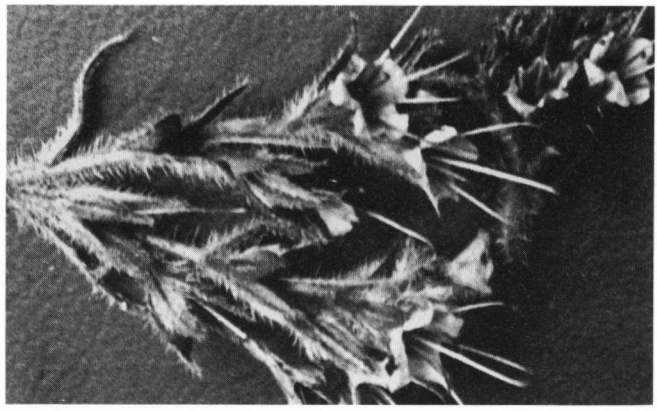

Fig. 2. Ultraviolet reflectance pattern from flowers of *E. wildpretii*. White areas show ultraviolet reflectance areas, while dark areas may show ultraviolet absorbing areas.

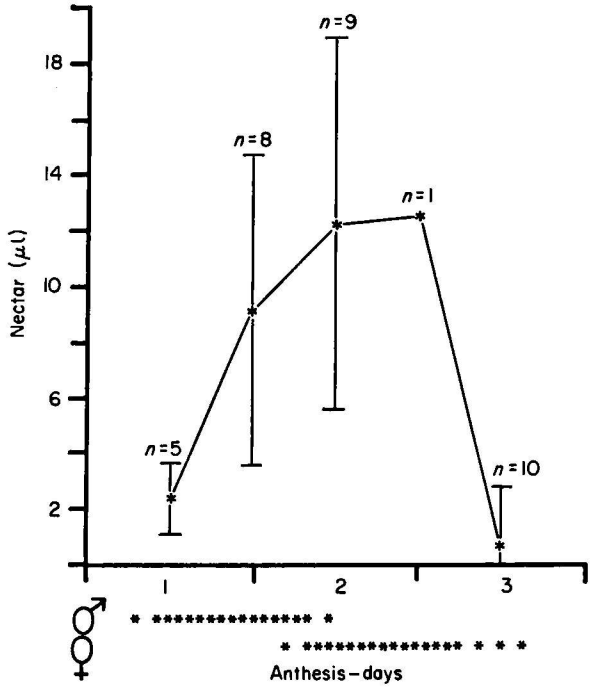

Fig. 3. Anthesis and change in volume of nectar per flower of *E. wildpretii*.

Nectar

The volume of nectar reaches a maximum of approx. 12·5 μl on Day 2 ($n = 33$). During this day production of nectar stops (Fig. 3). On Day 3 nearly all the flowers are empty. The nectar may have been reabsorbed. This is also known for other *Echium* spp. (Corbet & Delfosse 1984). The concentration of nectar in sucrose equivalents is 11% ($n = 22$; range

6·5–17·5). S. Vogel (personal communication) measured a concentration of 12% ($n = 10$) from greenhouse individuals in Tübingen. Male and female phases display no differences. In other *Echium* spp. the concentration depends heavily on ambient relative humidity and the rate of photosynthesis (Corbet & Delfosse 1984). Thus, in the desert-like Cañadas the concentration of nectar solutes may be considerably higher. Honeybees prefer a solution that contains above 20% sucrose (Frisch 1950). The threshold of acceptance increases if there are other flowers in bloom (Frisch 1950; Lindauer 1961). Cherry attracts honeybees though its concentration of sucrose is only 12% (Percival 1969). *E. vulgare* and *E. plantagineum* have a solute concentration between 20–60% and 20–50%, respectively (Corbet 1978; Corbet & Delfosse 1984). In the Macaronesian bird–flower species relatively low solute concentrations are found compared to European relatives (Olesen 1985).

The effect of the very thin nectar on bee behaviour was investigated briefly. An *E. wildpretii* individual was placed 3 m from a honeybee hive. Between one and three workers at a time were observed to make short visits to the inflorescence with more than 1000 flowers during a 2-day period. The tap to provide the hive with water was turned off. A few hours later and during the following 10 days, 30–50 workers were observed to pay at least a total of 100 visits per minute to the flowers of *E. wildpretii*. The weather conditions were fairly constant during the days of the experiment. Thus, the *E. wildpretii* flowers may act as a water resource to bees. Honeybees do not store water in the hive, but it is collected as needed, either to dilute honey stores, or to evaporate inside the hive to lower the temperature when it becomes too high. Thinner solutions were preferred during overheating experiments (Lindauer 1961).

The relationships between the pollination of E. wildpretii *and the food demands of its potential flower visitors*

The flower morphology and the ultraviolet colour of the corolla of *E. wildpretii* may attract bees. M. Báez (personal communication) observed a large number of bees on *E. wildpretii* in Las Cañadas. The low sucrose concentration, the relatively large amount of nectar, the extended sexual organs out of the corolla, and the red corolla colour, however, are bird–flower characteristics (e.g. Olesen 1985). If both bees and birds are potential visitors, and pollinators of *E. wildpretii*, they may have a very different impact upon the pollen flow pattern. *E. wildpretii* is found in small patches separated by very long distances throughout the *Pinus canariensis* forests and Las Cañadas. Birds may be important interpatch pollen agents, while bees may largely mediate pollen inside patches and between neighbouring patches.

Most Canarian *Echium* spp. have blue or white corollas (Bramwell & Bramwell 1974). Many of these are visited by solitary bee species (S. Vogel, personal communication). *E. wildpretii*, the white-flowered *E. simplex* DC., and the blue-flowered *E. pininana* Webb & Berth. constitute the section *Simplicia*. The evolutionary relationships inside *Simplicia* and between this section and other Canarian *Echium* spp. are virtually unknown. Has *E. wildpretii* evolved from truly bee-pollinated Canarian congeners? Or is it, indeed, a member of the old Macaronesian bird–flower element (Vogel 1954; Vogel *et al.* 1984; Olesen 1985)? Only extensive field studies may answer these questions.

The bee fauna of the habitats of *E. wildpretii* is not well known. Wolf (1979) found 27 species of bees on Tenerife: 11 of these in *Pinus canariensis* forest, and only one *Anthophora* sp. and one *Andrena* sp. in Las Cañadas. *E. wildpretii* flowers mainly in May–June,

two almost completely dry months in Las Cañadas (Burchard 1929). Dessication is the major problem encountered by animals active in the dry season. According to Janzen (1975) this can be partly overcome by harvesting nectar in flowers; thus gathering moisture becomes a major reason for animals to visit flowers. Flowers of *E. wildpretii* may thus both be an important water source to desert bees and a sugar and water source to birds in these arid vegetation zones. Only scarce general information is available about the water economy of solitary bee species (Wesenberg-Lund 1899; Nielsen 1902; Willmer 1986).

The mutual relationships between endemic Canarian flowers and their pollinators need further study in nature.

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