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POLLINATION OF THE ENIGMATIC MAURITIAN ENDEMIC *ROUSSEA SIMPLEX* (ROUSSEACEAE): BIRDS OR GECKOS?

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INTRODUCTION

Roussea simplex (Rousseaceae) is an enigmatic Mauritian endemic plant whose biogeography and taxonomic position has puzzled botanists for many years. Recent molecular work has assigned it to a monotypic endemic genus in the family Rousseaceae, occupying a basal position within the Asterales (Lundberg 2001). It was once a common and widespread plant in wet high-altitude forests in Mauritius, but it is now critically endangered and confined to small, isolated patches (Friedmann 1988, Scott 1997, pers. obs.). Evidence of its former abundance is given by Vaughan and Wiehe (1937, p. 314), who remarked that, "In other places an extremely thick canopy of woody lianes (*Roussea simplex* Sm.) develops about 4–6 m. above ground level, causing such dense shade that both terrestrial and epiphytic plants are practically excluded". The plants have large, robust and slightly serrated leaves (7–12 × 3–5.5 cm), and the yellow flowers are also large and robust, measuring approximately 2.5 cm in both length and diameter (Scott 1997). The flowers are 4- or most commonly 5-meric, with a weak, sweet, almost yeasty smell. The 4–5 large anthers face outwards, away from the stigma, and pollen is secreted in a wet, very sticky, yellowish substance, which readily adheres to any surface (Fig. 1).

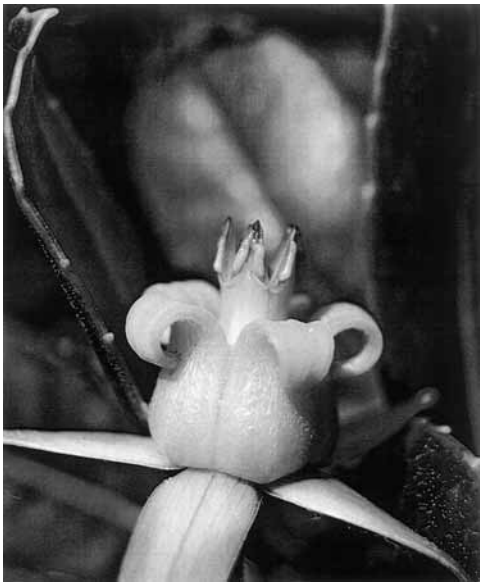

FIG. 1. *Roussea simplex* flower and leaves. Note the slimy and sticky pollen-substance on the anthers.

Despite the former widespread occurrence of *R. simplex* in Mauritius, very little is known about its ecology. Preliminary observations of a nectar-feeding bird, the Mascarene Grey White-eye *Zosterops borbonicus mauritianus*, at *R. simplex* suggested that it may be a pollinator. When nectar-feeding at *R. simplex*, all Grey White-eyes enter the flowers from the front, pressing their beak and lower forehead between anthers and corolla, Thus the birds certainly visit the flowers in a way that would suggest them to be poten-

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tial pollinators, and the sticky yellow pollen mass was often seen on the birds' foreheads upon withdrawing their heads from the flowers. The Grey White-eye is a generalist bird with very catholic feeding habits. It feeds on nectar from more than 30 plant species, and also eats many insects and some fruits (Gill 1971, Cheke 1987, Safford 1994, Hansen *et al*. 2002).

An identification of an efficient pollinator of *R. simplex* will be an important first step in understanding its ecology, and will potentially facilitate future conservation management. This study presents additional observations of flower visitors at *R. simplex* and seeks to assess their roles as potential pollinators, and to investigate the basic flowering phenology of the plant.

METHODS

To obtain baseline data on the flowers' value as a resource for potential pollinators, I recorded the phenology of several flowers, including data on anthesis, as well as nectar volume and concentration.

The preliminary observations were made from September 1999 to January 2000, when I was mist-netting and color-banding Grey White-eyes for another study (Hansen *et al*. 2002). The two mist-netting sites were located inside Le Pétrin, a 6.2-ha fenced Conservation Management Area (CMA) in the Black River Gorges National Park in Mauritius (20°24'S, 57°28'E). While following foraging Grey White-eyes around in the CMA for this study, I obtained 13 observations of the birds foraging for nectar in one large, bush-like plant of *Roussea simplex* that grew within 200 m of both mist-netting sites. Only one other *R. simplex* plant was found in the CMA and its vicinity, but it was not observed flowering. A total of 48 Grey White-eyes were caught and ringed in the CMA. Eight of these birds (16.7%) had a distinct zone of very fouled feathers, from the base of the bill extending 1.0–1.5 cm upwards onto the forehead. The feathers were soiled with a white-yellowish sticky substance. Another bird, caught at the beginning of November, had a distinct naked area just above the bill. Of my 13 preliminary observations of Grey White-eyes foraging at *R. simplex*, six observations were of two birds (four and two observations respectively), which had been previously color-banded. They were two of the eight birds mist-netted, which had fouled feathers. I thus suspected the wet, sticky pollen or the copious nectar of the *R. simplex* flowers as being the initial source of the sticky substance on the soiled feathers. To investigate this, and to judge the birds' effectiveness as pollinators, I sampled 2–3 whole feathers from the forehead of five of the eight mist-netted birds with fouled feathers (a total of 11 feathers). The sampled feathers were sputter-coated with gold and examined using scanning electron microscopy (SEM) at Aarhus University, Denmark.

Lastly, to identify any other flower visitors and potential pollinators of *R. simplex*, I spent a total of four hours in the morning and three hours around noon over three consecutive days in December 1999 observing the flowering plant, as well as occasional observations during another field-season in 2003.

RESULTS

The flowers are protandrous, with the large stamens being dropped after 3–4 days, revealing the large central style and stigma. Nectar is produced in very large amounts throughout a flower's life (5–8 days, n = 9 flowers). The nectar standing crop at noon is 25–320 µl (mean ± SD = 131.4 ± 90.8 µl, n = 11 flowers). Nectar sugar concentration is 9–15% sucrose (mean ± SD = 11.0 ± 1.4%, n = 11 flowers).

The SEM investigation revealed that all 11 feathers were fouled by thick layers of pollen and dirt (Fig. 2a). The amount of dirt precluded any quantitative analysis of the relative amounts of different pollen. Visible pollen grains were compared with a reference collection, and were found to be mainly from Myrtaceae species, probably both endemic (*Syzygium mauritianum* and *S. venosum*) and introduced (*Callistemon citrinus*), on which the Grey White-eyes foraged for nectar to a great extent (Hansen *et al*. 2002). On all feathers, however, I could also identify pollen grains of *R. simplex*, which are large and circular, 24.5–31.2 µm in diameter (mean ± SD = 28.1 ± 2.2 µm, n = 19). Myrtaceae pollen grains are smaller and triangular, typically 15–20 mm across. The *R. simplex* pollen grains were completely or half-embedded in the layers of dirt and pollen (Fig. 2b).

During the seven hours of observation of flower visitors in 1999 I observed a total of 11 Grey White-eyes probing the flowers. Furthermore, I observed the introduced ant *Technomyrmex albipes* at the flowers. Large numbers of this species were observed drinking nectar continuously at some of the flowers. They apparently lived on the flowers, developing fruits, branches and leaves of the plant, where numerous

small structures of dirt had been built. More intriguingly, on four occasions during August and September 2003 I observed the endemic, diurnal gecko *Phelsuma cepediana* feeding on nectar at *R. simplex* flowers.

DISCUSSION

The SEM examination of the *Z. borbonicus mauritianus* feathers suggests that the soiling is caused by the sticky pollen substance of *R. simplex*, probably combined with spilled nectar from the often semi-pendulous flowers. This stickiness could cause an initial clotting of the feathers and a subsequent soiling with dirt and pollen from other plant species. Craig and Hulley (1995) give an account of a similar phenomenon in the Cape White-eye *Zosterops pallidus*. They found that nectar- feeding at *Aloe* spp. would sometimes cause a clotting of the feathers with nectar and pollen on the forehead of this bird species. A subsequent partial molt in this area after termination of the annual complete molt was observed and interpreted as a consequence of the clotted feathers, in order to restore insulation. This phenomenon continues to be noted each year (A. Craig, pers. comm.). Furthermore, Oatley and Skead (1972) report observations of *Zosterops* spp. in South Africa with 'bedraggled or even missing' feathers on the forehead as a consequence of nectar feeding.

I observed a total of three species of flower-visiting animals at the flowers of *R. simplex*. The Grey White-eyes visited the flowers in a way as to suggest potential pollen transport, but the tangled mass of pollen, nectar and dirt on the soiled feathers was solid and very sticky, and the embedded *R. simplex* pollen are unlikely to be effectively transferred onto a stigma. The introduced, nectar-feeding *T. albipes* ants are also unlikely pollinators of *R. simplex*, as they were very seldomly observed on the anthers or stigma, and were never observed with any of the large, yellow pollen on their bodies. Hence, the most likely candidates for providing an efficient pollination service seem to be the endemic diurnal *P. cepediana* geckos. Lizard pollination has only recently started to receive serious scientific attention, and it is worth noting that it has been reported to be almost exclusively an island phenomenon (Olesen & Valido 2003). The lowland Mauritian gecko *P. ornata* has been observed nectar-feeding on several species (Vinson & Vinson 1969, Staub 1988), and recent work showed that they visit flowers regularly, and can carry pollen over relatively large distances within 24 h (Nyhagen *et al.* 2001).

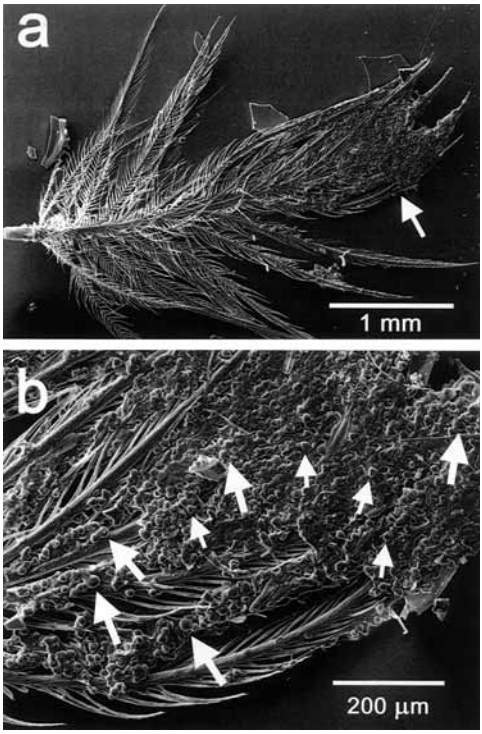

FIG. 2. a) SEM image of a soiled Grey White-eye forehead feather. The arrow indicates the enlarged area shown below. b) Enlarged area of soiled feather. Large arrows indicate large, circular *Roussea simplex* pollen, small arrows indicate smaller, triangular Myrtaceae spp. pollen.

The characteristics of *R. simplex* certainly support the idea of gecko pollination: large, robust leaves and sturdy, brightly colored flowers with copious amounts of nectar and a sweet, yeasty, albeit weak smell. These floral traits are similar to traits associated with lizard-dispersed fruits (van der Pijl 1982). Furthermore, the scales of a lizard could be much better suited than bird feathers to transport the wet and sticky pollen of *R. simplex*, and – most importantly – subsequently release it onto a stigma. In the Balearic Islands, Traveset and Sáez (1997) found that more pollen grains of *Euphorbia dendroides* (Euphorbiaceae) adhered to the skin of the lacertid lizard *Podarcis lilfordi* if it had come into contact with the sticky nectar prior to touching

stamens. The wet and sticky *R. simplex* pollen grains together with the nectar may function in a similar way.

Roussea simplex is now a critically endangered forest plant, but as a wide-spread, proliferous nectar producer, it must have been of great ecological importance for nectar-feeding animals in pristine Mauritius. The basal taxonomic position of *R. simplex* in the Asterales, combined with its narrow distribution, makes its reproductive ecology interesting from an evolutionary and biogeographical perspective (Lundberg 2001). Clearly, further field studies of this unique plant are needed in order to understand its reproductive system and its interactions with *Phelsuma* geckos, and to facilitate its conservation.

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