



Hawkmoth Pollination in Arizona's Sonoran Desert: Behavioral Responses to Floral Traits

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Adult butterflies forage for a broad spectrum of resources, including floral nectar, pollen, fruit, sap, fungal fluids, mineral salts, and animal tissues, secretions and waste products (Owen 1971; Gilbert and Singer 1975; Ray and Andrews 1980; Boggs 1987b; DeVries 1988a; Boppré 1990). Flower-visiting butterflies have long been recognized as important pollinators (Delpino 1874; Knuth 1898; van der Pijl 1961), as their patterns of movement affect plant outcrossing distances and population structure (Levin 1978; Murawski and Gilbert 1986; Johnson and Bond 1994). Recent studies have explored the role of butterflies as pollen vectors (Cruden and Hermann-Parker 1979; Wiklund et al. 1979; Murphy 1984; Venables and Barrows 1985; Stanton et al. 1986), their effectiveness as pollinators of specific plants (Levin and Berube 1972; Opler et al. 1975; Spears 1983; Jennersten 1984; Schemske and Horvitz 1984; Erhardt 1990), their learning abilities in the context of floral feeding (Lewis 1986; Goulson and Cory 1993; Weiss 1995, 1997), and their allocation of nectar resources to flight energetics and reproductive output (Watt et al. 1974; Boggs 1981a; Murphy et al. 1983; May 1992).

In parallel with butterflies, adult nectar feeding has evolved in a number of moth families and is especially prominent among hawkmoths (Sphingidae: Rothschild and Jordan 1903; Newman 1965; Hodges 1971; Schreiber 1978; Miller 1997). Nectar-feeding hawkmoths constitute an important class of pollinators in warm temperate and tropical habitats worldwide (Baker 1961; Gregory 1964; Silberbauer-Gottsberger and Gottsberger 1975; Grant 1983; Bawa et al. 1985; Nilsson et al. 1985; Haber and Frankie 1989; Singer and Cocucci 1997; Johnson et al. 1998). By virtue of their hovering flight, large body size, and high vagility, hawkmoths visit more flowers per foraging bout (Cruden et al. 1976; Heinrich 1983; Herrera 1989), carry

