THE OCCURENCE OF THE MONARCH BUTTERFLY, *Danaus plexippus* L. IN THE AZORES, WITH A BRIEF REVIEW OF ITS BIOLOGY

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The Monarch butterfly, *Danaus plexippus* L. (Lepidoptera, Nymphalidae), has been an occasional visitor to the Azores. However, during the last two decades it has become a resident species in these islands and has adapted its behaviour to the geographic conditions of this new habitat, feeding on *Gomphocarpus fruticosus* (L.) Aiton fil. (Asclepiadaceae). The first confirmed breeding of this butterfly in the Azores (Faial island) is reported here and dates from the summer of 1994. However, previous sightings of only a very few adult individuals indicate that there was already a small resident population before 1994. Breeding was confirmed in three additional sites: on 3 June 1999, three adults of Monarch butterfly were observed laying eggs on *G. fruticosus* bushes near Ribeirinha and on 28 June 1999, several caterpillars were found in the same place. Larvae were also found at S. Roque (Pico island) and larvae and pupae at S. Carlos (Terceira island) in the summer of 1999. Monarch butterflies have been observed, occasionally, in Faial, Pico, Terceira, São Miguel, Santa Maria and Corvo during winter and spring, indicating the existence of a resident population all year round, but the vegetation used for wintering shelters has not yet been confirmed.

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INTRODUCTION

General background

The Monarch butterfly, *Danaus plexippus* L., is a large danaid butterfly native to North and Central America, but today it has a nearly cosmopolitan distribution (HIGGINS & RILEY 1970; LEESTMANS 1975; BROWER & BOYCE 1991; BROWER 1996). The species is potentially long-lived; individuals reared in the laboratory have survived up to 40 days, and tagged individuals survived 2-4 months in the wild (URQUHART 1960). Their wings are orange with black stripes and margins. The margins and their black bodies bear several white dots. They can be sexed by the presence of a dark sex spot located on both wing surfaces of the males. Both sexes mate repeatedly and lifetime female fecundity averages 400 to 500 eggs. They have a flight pattern composed of flapping wings followed by gliding moments and can achieve a powered flight velocity of 40 km/h (URQUHART 1960).

The Monarch butterflies and their unique strategy of overwintering in a few isolated Mexican and Californian forests, returning northwards the following spring, are quite well-known, thanks to the efforts of lepidopterist Orley Taylor (WALDBAUER 2000). Moreover, *D. plexippus* is perhaps the most well known of the insect migrants, whose movements and ecology have been studied for several years by various authors (e.g. BROWER 1985, 1996; URQUHART 1987; WALTON & BROWER 1996, and literature cited). Monarch butterflies arrive at the overwintering areas in Mexico and California between November and early December, and by January consolidate in up to a dozen densely packed colonies. By late February the colonies begin to break up and by mid-March the butterflies start their migration northward, all departing by early April (BROWER 1985). There are apparently two different populations separated by the Rocky Mountains ridge, and these show different migration movements. Monarch butterflies belonging to the population east of the Rocky Mountains migrate between Canada and USA northern states to their overwintering grounds in central Mexican fir tree forests (BROWER 1985, 1996; URQUHART 1987; WALTON & BROWER 1996). Monarch butterflies are capable of displacements of thousands of kilometres over several weeks (BROWER 1985), and the monarch's annual fall migration along the Atlantic Coast of North America is considered a normal phenomenon (WALTON & BROWER 1996). Monarch Butterflies in North America use a Sun compass during their southward autumn migration, orienting their bodies using the time of day and the position of the Sun. In the absence of celestial cues on overcast days, however, Monarch butterflies still manage to orient towards the south-southwest, suggesting that they also have a non-celestial backup mechanism of orientation, such as a geomagnetic compass (PEREZ et al. 1997).

The species is, however, very variable in its migratory behaviour (BROWER 1985, 1996; WALTON & BROWER 1996), with populations in tropical Central and South America, the West Indies, and Hawaii being sedentary, and populations in western North America and Australia moving considerably shorter distances (MALCOLM & ZALUCKI 1993). There are also continuously breeding non-migratory monarch populations occurring in parts of Australia, in Mexico east and south of the overwintering sites, and throughout the lowlands of the neotropics, and on the Caribbean, Pacific Islands and in South Florida in the USA (BROWER 1985; BROWER & BOYCE 1991) and literature cited. The selective advantage of seasonal range expansion to utilise large populations of temperate milkweeds is regarded as the primary force for this life history strategy (BROWER & BOYCE 1991; WALTON & BROWER 1996).

Like many danaid butterflies, the monarch feeds almost exclusively on Asclepiadaceae, especially in the genus *Asclepias* L. (HIGGINS & RILEY 1970; LEESTMANS 1975; SOUSA 1984-85, 1991); the closely allied African genus *Gomphocarpus* R. Br. (=*Asclepias* L., PALHINHA 1966) (Asclepiadaceae) and *Gossypium arboreum* L. (Malvaceae) are also larval hostplants (BAEZ 1998). Asclepiadaceae provide Monarch butterflies with an abundant and predictable larval food supply as well as a source of defensive chemicals, which elicit emesis and have other noxious effects in vertebrates (BROWER 1985). In the Canary Islands and Madeira, monarch caterpillars of late larval stages were also found feeding on *Gossypium arboreum* L. and on a few species of the genus *Euphorbia* (HIGGINS & RILEY 1970; observed by HS).

There is little doubt that migrating Monarch butterflies (especially during the fall southward migration) are affected by dynamic weather systems with their attendant winds. They are, at times, blown out of their typical course. These weather systems force some Monarch butterflies to fly over the Pacific or Atlantic Ocean, and then colonise the new habitats encountered, for instance in the Atlantic islands.

Given the great numbers of Monarch butterflies (well over 100 million) that gather to migrate each fall, it is hard to imagine them facing any threat of extinction. In reality, however, Monarch butterflies and their amazing annual migration are seriously threatened by human activities, in both their summer and overwintering sites (WALDBAUER 2000). The Monarch Project in the United States supports efforts to preserve sites and has worked to include

information about monarch sites in zoning laws and land-use plans, especially in areas such as Pacific Grove and Santa Cruz where large aggregations gather each year.

The Monarch butterfly in the Macaronesian region

The Monarch butterfly is sometimes listed as a migratory species in Madeira, Porto Santo, Canary Islands (OWEN & SMITH 1993), and Azores archipelago (e.g. GODMAN 1870; CRUZ & GONÇALVES 1973; SOUSA 1984-85, 1991; VIEIRA 1997; 1998, 1999). However, in the Canary Islands, a local monarch population has been listed at least since 1880 (HIGGINS & RILEY 1970) or 1887 (LEESTMANS 1975; BÁEZ 1998). It inhabits the entire archipelago except for Lanzarote Island, and adults are observed flying throughout the year (BÁEZ 1998). The larvae feed on *Asclepias curassavica* L. (LEESTMANS 1975; BÁEZ 1998), *G. fruticosus* (Asclepiadaceae) and *G. arboreum* (Malvaceae) (BÁEZ 1998).

In Madeira island, it was first observed in 1860 (LEESTMANS 1975), and after this date several observations were published (see MEYER 1993 for review). It has recently become resident (SOUSA 1984-85, 1991), and larvae are observed through the entire year (Tatjana Anselm, Caniço, Madeira, pers. comm.). The species occurs in some numbers on Porto Santo Island (GARDNER & CLASSEY 1960; VIEIRA 1999).

Host plants

We have observed Monarch butterflies laying eggs on *G. fruticosus* L. R. Br. on Faial island (Fig. 1). In Portugal, this South African plant is called *Sunaúma-bastarda*, *Sedas* or *Pepino-da-seda,* and is planted for ornamental reasons (SCHÄFER 2000). The other Asclepiadaceae in the islands is *Araujia sericifera* Brot., but Monarch caterpillars have never been observed feeding on this species. They feed exclusively on *G. fruticosus*, which forms bushes ornamenting some of the private gardens on Faial. *G. fruticosus* is probably a rather old ornamental plant in the Azores. It is mentioned as growing subspontaneously on damp ground and riverbanks in some of the oldest plant lists of Faial island of the 19th century (SEUBERT 1844; WATSON 1844, 1870). At São Jorge, *G. fruticosus* occurs outside private gardens at least since 1903, when a specimen was collected for the herbarium of Coimbra by Bruno Carreiro (PALHINHA 1960). BROWER (1985) indicates the phenology, distribution and abundance of Asclepiadaceae as a major determinant of the monarch's life history strategy. As *Gomphocarpus sp.* is never found in large numbers, the availability of the food plant might be a limiting factor for the increasing population of monarch in these islands.

Fig. 1. Distribution of *Gomphocarpus fruticosus* (L.) Aiton fil. outside private gardens in Faial (SCHÄFER 2000).

RESULTS

The sightings of monarch butterfly in the Azores archipelago

The earliest two records of *Danaus plexippus* in the Azores archipelago date from 1864 (GODMAN 1870): one adult taken in Flores, the other given to him by J. Dabney from Faial, where it had been caught during the previous summer (1864). This author met with no one who knew the insect or had ever seen it before (GODMAN 1870). In 1893, the naturalist J.C. Abranches illustrated his manuscript "Album Illustrado de Zoologia Michaelense" (present in Carlos Machado Museum, Ponta Delgada, S. Miguel) with a specimen caught in S. Miguel. On Terceira, SAMPAIO (1904) observed some individuals. Some adults, captured in 1929, are deposited in the Carlos Machado Museum collection, according to CRUZ & GONÇALVES (1973). FREY (1938, cited by REBEL 1940) listed *D. plexippus*

adults from Pico island (at Silveira and Madalena). SOUSA (1991) lists the Monarch butterfly on Santa Maria and S. Miguel. Generally, some adults are observed flying every year in the Azores islands (SOUSA 1991), particularly close to the villages.

A group of about 30 Monarch butterflies was observed early in October 1973 at Praia de Porto Pim, Faial Island. In spite of their worn wings, they were observed soaring in the thermal updrafts originated by sunshine heating the black lava of the western slopes of Monte Queimado (JC Fraga, pers. observation). It is known that Monarch butterflies have been occasional visitors to these islands (CRUZ & GONÇALVES 1973) and according to Mrs. Maria Silvina from the parish of Salão, Faial island, who is now in her late sixties, Monarch butterflies have occurred here before. They were rare and promptly noticed, due to previous contacts with them by Azorean immigrants to Canada and U.S. of America. Monarch butterflies were known as "Americanas" and were very prized for insect collections by the elementary school pupils. Monarch butterflies are also known in the Azores as "Feiticeiras" (=Little witches).

In recent years observations of Monarch butterflies have been made on Faial, Pico, Terceira, Graciosa, Santa Maria, S. Miguel and Corvo (Table 1). Due to the large amount of observations, we only included the ones made between September and April, the period when Monarch butterflies normally overwinter.

Settlement and breeding in Faial, Pico and Terceira islands

Observations of breeding in the Central Group are shown in Table 2. The first confirmed breeding on Faial dates from the summer of 1994 (M. Castro, pers. comm.). Although the species is very prolific, it is generally believed that this was not the first year of local breeding and that the previous sightings of a few adult individuals during different months of the year indicated that there was already a small resident population.

DISCUSSION

CRUZ & GONÇALVES (1973) refer to the presence of the Monarch butterfly in all the islands of the Archipelago and consider them to be established in the Azores though rare in some of the islands. But "established" for CRUZ & GONÇALVES (1973) certainly does not mean breeding since they have few observations and are restricted to a few months of the year. Considering the number of eggs usually deposited by each female, if they had been breeding successfully in the early 70's, one would expect a larger current population. The date of these early 70's sightings (September and October) possibly indicates vagrancy. The passive transport by boat is of course possible, and some examples are given by LEESTMANS (1975). Also, we cannot exclude the introduction of *D. plexippus* by man. However, it is reasonable to accept that Monarch butterflies are being blown by westerly winds during their southward migration. The group seen at Porto Pim in October 1973 indicated by their worn condition, that they were probably transatlantic vagrants. Monarch butterflies must have been blown offshore during their southbound migrations, when their life span is longer and the prevailing winds between the east American shores and the archipelago of the Azores are westerly.

Table 1
Records of *Danaus plexippus* sightings in some islands of the Azores archipelago.

Island	Location	Date	Number of adult flying	Personal observation
Faial	Horta	13/10/98	1	VV
	Feteira	13/10/98	1	VV
	Ribeira do Cabo	13/10/98	1	VV
	Varadouro	25/1/99	1	ACP
	Ribeira dos Flamengos	19/9/99	1	VN
	Capelo	2/10/99	1	HS
	Horta	1/00*	1	MB
Pico	Piedade (Porto Manhenha)	31/11/98	1	ACP
	Madalena (Quinta das Rosas)	1/12/98	1	ACP
	Cachorro (Aeroporto)	2/12/98	1	ACP
	Santa Luzia	3/2/99	1	ACP
	Madalena	3/2/99	1	ACP
	Lajes (Almagreira)	9/2/99	1	ACP
	São Roque	16/2/99	2	JCF
	Madalena	8/4/99	1	ACP
	Piedade	11/4/99	1	ACP
	Lajes (Terras)	20/1/00	1	ACP
	São João	21/11/00	2	VN
Terceira	São Carlos	3/10/99	2	JCF
	Porto da Praia da Vitória	12/10/99	2	HS
Santa Maria	Santo Antão	26/4/00	1	VN
São Miguel	Relva	11/98	1	VV
	Ponta Delgada	5/10/98	1	VV
	Praia Pequena Pópulo	30/4/00 10/11/00	1	VN
	Praia Grande do Pópulo	2/9/00	1	VN
	Jardim António Borges**	13/11/00	8	VN
Corvo	Vila Nova do Corvo	18/10/00	1	PDM

* various dates; ** some of the individuals observed seemed to be hibernating (they were static and with the wings closed) in a *Araucaria* sp.; ACP=Ana Cecília Pereira, HS=Hanno Schäfer, JCF=João Carlos Fraga, MB=Mark Bolton, PDM =Pedro Mendonça Domingues, VN=Verónica Neves, VV=Virgílio Vieira.

Table 2
Records of *Danaus plexippus* breeding in the Azores

Island	Location	Date	Notes	Personal observation
Faial	Horta	Summer/94	Larvae and pupae	MC
	Ribeirinha	3/6/99	Adults laying eggs	HS
	Ribeirinha	28/6/99	Larvae	HS
	Horta	November / 2000 *	Larvae and pupae	MC
Pico	S. Roque	25-29/8/99	Larvae and pupae	ABS
Terceira	S. Carlos and Terra-Chã	12/9/99 and 16/9/00	Adults copulating, larvae and pupae	PB

ABS=António Bivar de Sousa; HS= Hanno Schäfer; MC=Marília Castro; PB=Paulo Borges.
* Extraordinary temperature conditions in November, higher than usual, may have induced egglaying. The eggs reached pupae but not butterflies, probably due to sudden temperature decrease.

Fig. 2. Monarch butterfly breeding in Faial island. (a & b larvae; c pupae and d adult).

Though not very frequently, Monarch butterflies have been observed, at least, in Faial, Pico and São Miguel during winter and spring, indicating the existence of a resident population, but the vegetation used by them as wintering shelters, is not yet been found in all the islands. It is interesting to note that the simultaneous sighting of 2 adults in Pico in February 1999 occurred in an area where pine trees *Pinus pinaster* Aiton are very common forming dense woods with other tree species, among them *Pittosporum undulatum* Vent. On Pico island, the individuals observed at Manhenha were near a patch of *Myrica faya –Erica azorica – Juniperus brevifolia*, which indicates some adaptation to non-managed areas. The only problem for their development is due to garden owners killing the caterpillars in order to protect their plants and to some occasional collectors. Birds avoid the poisonous butterfly and its caterpillars, and no other enemies that could have some influence on population growth have been observed in the Azores up to now.

In 1999, probably all the bushes of *Gomphocarpus* outside private gardens at Faial supported at least some caterpillars (observed by HS). The fertility of these grazed plants is often reduced and there might be a degree of overexploitation of this resource by the insect. The bushes of *G. fruticosus* are normally not very dense and are usually almost destroyed by the voracity of the caterpillars, by the time they reach maturity and pupate. Caterpillar movements to other plants and other areas of the gardens have been recorded in the later instars. Interiors of porches, edges of roofs and even the surfaces of a

garden chair have been used for pupation. When exposed directly to the sun, or during hot days, pupae have been observed secreting liquid to keep their skin flexible.

The number of *Gomphocarpus* plants is probably too small for the growing population of Monarch butterflies in the Azores. Consequently there might be a future switch to other host species, e.g. of the genus *Euphorbia* as has occurred in the Canaries and in Madeira.

The geographic location of the Azores, as well as its weather conditions, must account for the Monarch butterflies overwintering here, as the above-mentioned sightings suggest. The degree, to which genetic differentiation may have accumulated between these populations is important to assess, as this information would be particularly relevant to understanding the evolution of the migratory phenomenon, and the monarch's current distribution in Macaronesia.

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