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A NON-MIGRATORY, NON-DIAPAUSING POPULATION OF THE MONARCH BUTTERFLY, *DANAS PLEXIPPUS* (LEPIDOPTERA: DANAIDAE), IN BERMUDA

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ABSTRACT

A non-migratory, non-diapausing population of the monarch butterfly, *Danadus plexippus* L. (Lepidoptera: Danaidae), became established on Bermuda after the precolonial cedar/palmetto forest was opened up by settlers. As part of the Bermuda Department of Agriculture and Fisheries Monarch Conservation Project, 703 monarchs were tagged to gather information on their distribution and movements. One hundred sixty-nine recoveries were made, 96% at the same site at which the butterfly was first captured. Twenty-three individuals were recaptured two or more times. Adult resident monarchs in Bermuda live about 3 to 4 weeks in summer, but up to 13 weeks in winter. They tend to remain near or return continually to a few large milkweed patches. Males spend more time at these sites than females.

RESUMEN

Una población no-migratoria y no en diapausa de la mariposa monarca, *Danaus plexippus* L. (Lepidoptera: Danaidae), se estableció en las Bermudas después que un bosque precolonial de cedros y palmetos fue abierto por colonizadores. Como parte del Proyecto de Conservació de la Mariposa Monarca del Departamento de Agricultura y de Pesca de las Bermudas, 703 monarcas se marcaron para obtener información sobre su distribución y movimientos. Se recobraron 109, 96% en el mismo lugar donde se capturaron por primera vez. Se recapturaron 23 individuos dos o más veces. Monarcas adultos residentes de las Bermudas viven de 3 a 4 semanas en el verano, pero hasta 13 semanas en el invierno. Ellas tienden a mantenerse cerca o retornan continuamente a varias áreas grandes con plantas de 'milkweed'. Los machos pasan más tiempo en estos lugares que las hembras.

Bermuda is a small cluster of islands 1040 km east-southeast of Cape Hatteras, North Carolina, USA. Seven main islands, now connected by bridges, form a fishhook-shaped cluster 35 km long and 1.5 km or less in width. Total land area is only 54 km^2 with a maximum elevation of 74 m. The Gulf Stream passes near Bermuda and moderates the climate; temperatures rarely exceed 33° C or fall below 5° C. Rainfall averages 1420 mm annually and is distributed fairly evely throughout the year.

Before the first colonists arrived in 1609, Bermuda was covered by a cedar/palmetto forest (*Juniperus bermudiana* L and *Sabal bermudana* Bailey). Migratory monarch butterflies, *Danaus plexippus* L., must have visited Bermuda occasionally as they do today, but there were no native *Asclepias* spp. on which they could become established. After the forest was opened up by settlers, two species of milkweed became naturalized: *Asclepias curassavica* L., a native of tropical America and *A. (=Gomphocarpus) physocarpa* (Meyer), a native of South Africa (Britton 1918).

The first mention of monarchs in Bermuda is in Jones (1859) who report they were found wherever a patch of *A. curassavica* was in bloom. Sometime previous to this, probably in the eighteenth century, this milkweed and monarchs had become established on the islands. By the late nineteenth century monarchs were so common that residents referred to them as the "Bermuda butterfly" (Jones 1876) and Hurdis (1897) reported they were abundant throughout the year.

Monarchs are much less common now. Pastures and open areas where milkweed used to grow have been replaced by houses and lawns. One thousand four hundred hectares of agricultural land at the turn of the century have dwindled to just a few hundred today (Hayward & Rowlinson 1981). Sixty thousand people now live in Bermuda; houses and artificial landscapes blanket virtually the entire land surface except for a few small parks and nature reserves.

In 1988 the Department of Agriculture and Fisheries initiated a two part Monarch Conservation Project. An educational effort promotes growing of *A. curassavica* and *A. physocarpa* as ornamental plants. Along with this a tagging program was implemented to gather information on monarch distribution and movements in Bermuda.

Methods

Adhesive wing tags, supplied by Mr. Chris Nagano at the Natural History Museum of Los Angeles County, California, were attached to the right forewing of monarchs captured in the field with standard butterfly nets. Tags were consecutively numbered and carried instructions on where they should be mailed if found. The sex and age (condition) of each individual was recorded before release. Butterflies with intact wings and bright coloration indicating little loss of scales were considered young. Those with any sign of tattering along the wing margin or with faded colors were recorded as old.

Monarchs were tagged at the following sites listed in descending order of importance (Figure 1): Jubilee Road (JR), Devonshire Parish, a 2 ha pasture on the north side of Jubilee Rd. that supports a large population of *A. curassavica* in a diffuse stand throughout the pasture; Spittal Pond (SP), Smith's P., a 1 ha pasture just north of the pond which contains a 9 m^2 stand of *A. c.* in the southeast corner and scattered plants throughout; Botanical Gardens (BG), Paget P., a butterfly garden established in March 1988 containing approximately 200 *A. c.* and 20 *A. physocarpa* plants; Somers Garden (SG), St. George's P., where two dozen *A. c.* plants form the nucleus of a small butterfly garden; Warwick Secondary School (WS), Warwick P., a 1 ha marshy area west of the school playing field supporting a diffuse stand of *A. c.* along its eastern edge; Berry Hill Rd. (BH), Paget P., where three dozen *A. c.* plants were planted in March and April 1988 at the residence of the author; Otterleigh (OL), Smith's P., a 2 ha cow pasture supporting a small patch of *A. c.* along its western edge; and Elm Lodge (EL), Warwick P., a private home with approximately two dozen *A. c.* and four *A. p.* in a formal garden.

Tagging was carried out throughout the year, but not on a regular schedule. More tags were applied in the summer and fall when monarchs were most abundant and student help was available.

Results

A total of 703 butterflies were tagged, and 169 recoveries were made. Four recoveries were made by members of the public not connected with the tagging program,

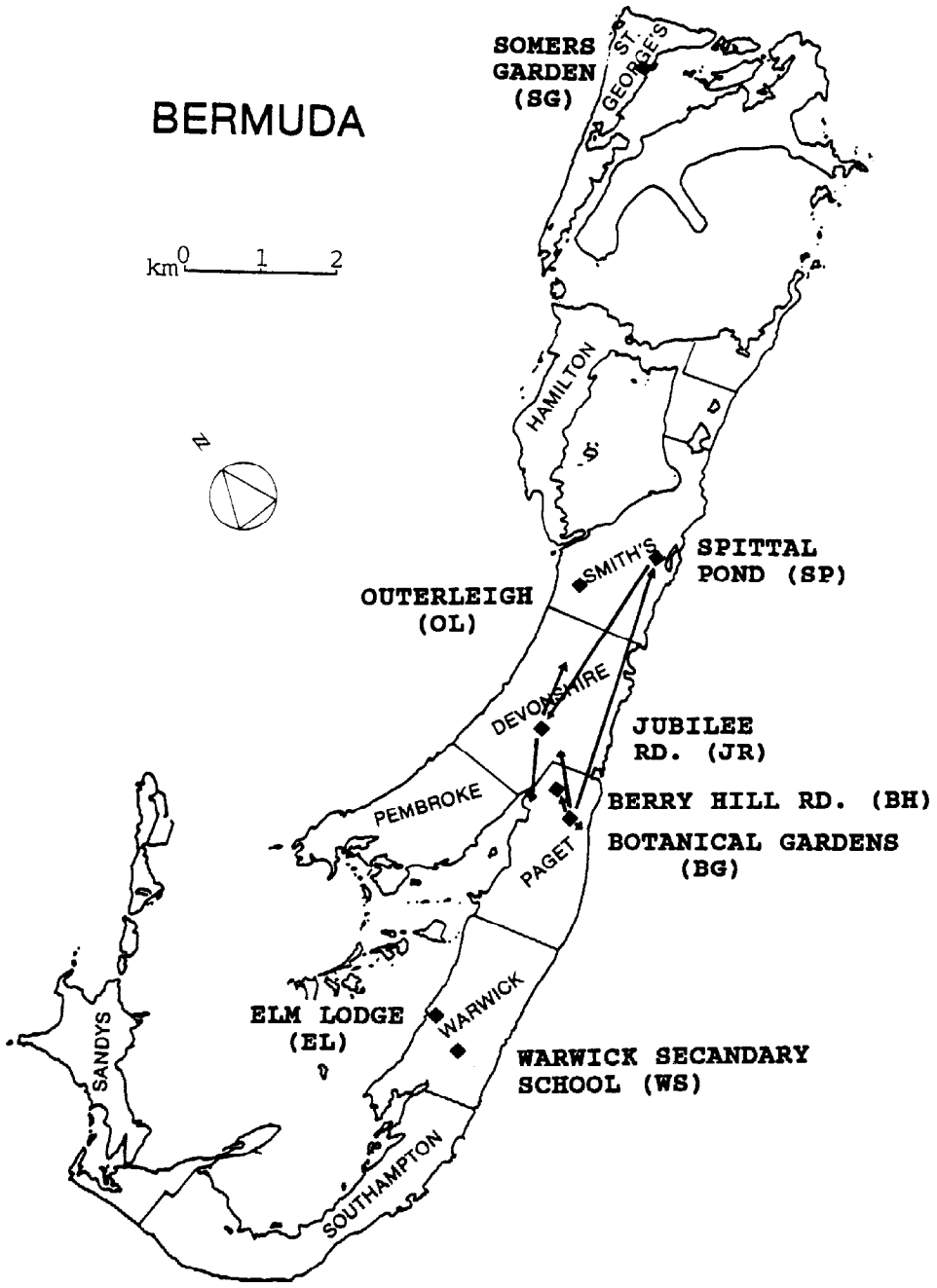

Fig. 1. Monarch tagging sites in Bermuda during 1988. Arrows indicate movement of individuals recovered at sites other than where they were tagged.

the rest were made by the author or other taggers. Nearly all the recoveries (96%) were made at the same site at which the butterfly was tagged and 93% were recaptured within 15 days after tagging (Table 1). During summer, the longest tagging to recovery intervals were 24 days for a butterfly recovered dead, and 23 days for two butterflies recovered alive. In the winter, one butterfly was found alive after 57 days; another was recovered alive but moribund after 87 days.

TABLE 1. MONARCH TAGGING/RECOVERY RECORDS IN BERMUDA DURING 1988.

Month	Sex	*No. Recovered* No. Tagged	same site	diff. site	Interval in days Tagging-Recovery 1-5	6-10	11-15	16-20	21+	57	87
Jan.-May	M	19	1		1						
	F	6	1				1				
June	M	44	21		10	4	7				
	F	44	21		10	5	6				
July-Sept.	M	310	85	3	34	39	12	1	2		
	F	105	5	2	2	4			1		
Oct.-Dec.	M	141	28	2	6	8	7	3	4	1	1
	F	34									
Sub	M	514	135	5	51	51	26	4	6	1	1
Total	F	189	27	2	12	9	7		1		
Total		703	162	7	63	60	33	4	7	1	1

Twenty-three individuals were recaptured more than once (Table 2). Only one, a young male tagged at SP, Aug. 24, was recovered twice at a site other than where it was tagged (JR, 3.0 km). Six other butterflies, each recaptured only once, were found at sites other than where they were tagged (Figure 1): a young male tagged Aug. 10

TABLE 2. TAGGING/RECOVERY RECORDS OF MONARCHS RECAPTURED MORE THAN ONCE DURING 1988 IN BERMUDA.

Date Tagged		Sex	Age	Site Tagged	Recovery Sites and Days after Tagging ()
June	8	M	Old	BG	BG(2), BG(5), BG(9)
	8	M	Yg.	BG	BG(2), BG(15)
	8	M	Yg.	BG	BG(11), BG(13), BG(14), BG(15)
	17	M	?	BG	BG(2), BG(4)
	17	F	Old	BG	BG(6), BG(11)
	17	F	?	BG	BG(6), BG(11)
	17	F	?	BG	BG(4), BG(5)
	22	M	Yg.	BG	BG(8), BG(11)
	22	F	?	BG	BG(1), BG(12)
	22	F	Yg.	BG	BG(12), BG(13)
	28	M	Yg.	BG	BG(2), BG(3)
July	1	M	Old	BG	BG(2), BGF(3), BG(4)
	1	M	Old	BG	BG(2), BG(4)
	1	M	Yg.	BG	BG(3), BG(10), BG(21)
	4	M	Old	SP	SP(1), SP(6), SP(7)
Aug.	8	M	Yg.	SG	SG(1), SG(2)
	10	M	Yg.	BG	BG(1), BG(5)
	11	M	Yg.	BG	BG(6), BG(8), BG(10)
	18	M	Old	BG	BG(8), BG(10)
	21	M	Yg.	BH	BH(6), BH(11), BH(14)
	24	M	Yg.	SP	JR(2), JR(8)
	24	M	Yg.	JR	JR(2), JR(8)
Dec.	8	M	Yg.	BG	BG(16), BG(21), BG(23), BG(57)

at BG was recovered 11 days later at BH (0.5 km); a young female first captured Aug. 10 at BG was found dead at "Toby Jug", South Shore Rd., Paget Parish, 24 days later (0.5 km); an old male tagged Aug. 18 was recaptured at SP six days later (4.0 km); an old male tagged Sept. 8 at JR was recovered deat at 1 Poinciana Rd., Devonshire P., 17 days after tagging (1 km); an old female tagged Sept. 20 at JR was found dead at Aberfeldy Nursery, Paget P. after 8 days (1.5 km); and a young male tagged Nov. 8 at BG was recovered alive but moribund at Garthowen Estate, Devonshire P., after 87 days (1 km). In addition, tagged butterflies were spotted but not captured on June 22 at Garthowen Estates, Devonshire P.; on Aug 19 at Ordinance Island, St. George's P.; and on Aug. 4 and Nov. 15 at the Arboretum, Devonshire P.

Seventy-three percent of these butterflies tagged ware males, as were 83% of the individuals recaptured. Seventy-two percent of the recoveries of females were in June.

Discussion

The resident monarch population in Bermuda is non-diapausing: all life stages are present throughout the year. Populations are highest from June through October when milkweed plants are growing vigorously. Both *A. curassavica* and *A. physocarpa* are perennial in Bermuda, but they grow slowly if at all during the cooler months of winter. These plants have very restricted distributions. Except where purposely planted *A. c.* is found only in a few of Bermuda's remaining pastures. *A. p.* is found rarely in open waste areas.

Results from the tagging/recapture study indicate adult resident monarchs live about 3 to 4 weeks in summer, but up to 13 weeks in winter. They tend to remain near or continually return to a few large milkweed patches. The evidence indicates that the local population does not migrate. Males may remain near a single milkweed patch for most or all of their adult life. Only 3% of tagged males were recaptured at places other than where they were first caught and many were captured repeatedly at the same site over a period of several weeks.

Females were caught less frequently overall (even though rearing indicated a sex ratio near 1:1, n=45, M=19, F=26) and only in June were relatively large numbers recaptured. Tagging was done almost exclusively at sites with large stands of milkweed. Males may remain near these areas to increase their chances of finding a mate. Females spend less time at these sites, perhaps avoiding the attention of males after they are mated. Much of their time is apparently spent searching for small milkweed patches and isolated plants on which to lay their eggs. They are exceptionally good at finding small stands of milkweed even when separated by many kilometers from the nearest large milkweed patch. Predation by the giant toad, *Bufo marinus* (L.), the only known natural enemy of monarchs in Bermuda, could skew the sex ratio toward males. Ovipositing females may be more easily caught, although this is not supported by preliminary results from four dissected toads from BG whose stomachs contained a total of 98 monarch caterpillars and 5 adults of which two were females.

The recapture of a relatively large number of females in June may be due to the restricted amount of milkweed available at the end of the cool season. The data are insufficient to determine if this trend applies during the entire period when milkweed growth is minimal.

In September 1970, Dr. I. W. Hughes photographed monarchs flying in over the water from the north and landing by the dozen on casuarina trees near the shore at Ferry Reach, St. George's P. Reports of monarchs arriving over the water on the north and west sides of the island are not uncommon in September and October. The sightings are thought to be associated with the passage of swiftly moving cold fronts. Mr. Eric Amos, a respected amateur bird-watcher, also reports seeing monarchs leave Bermuda in September and October heading south at wave top level from Great Head Park, St.

George's P., and from the dunes and beaches along the south shore in Warwick P. and Southampton P. (personal communication).

The number of arriving migratory monarchs is small in most years. Those that attempt to continue their journey to the overwintering sites in Mexico (Urquhart & Urquhart 1978) probably perish. The closest land to the southwest (Bahamas) is over 1200 km away and prevailing winds would not be favorable. Some migrants may stay in Bermuda, as the original colonizers must have done. Monarchs are established in the West Indies, Galapagos, Maderia, and Canary islands, as well as many Pacific islands from Hawaii to New Zealand and Norfolk Island (Ackery & Van-Wright 1984), indicating that non-migratory populations have been founded by stray migrants on many occasions. A moderate, frost-free climate, as found on many oceanic islands, allows *Asclepias* spp. to grow year-round and eliminates the necessity for monarchs to migrate.

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EFFECTS OF PARENTAL PHOTOPERIOD ON METABOLIC RATE IN *DROSOPHILA MELANOGASTER*

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ABSTRACT

The metabolic rates of adult female *Drosophila melanogaster* Meigen were measured on single individuals in "closed system" metabolic chambers. Adults whose parents were reared under short-day conditions (8 h light:16 h dark) had significantly higher metabolic rates than did adults whose parents were reared under long-day conditions