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POPULATION FLUCTUATIONS OF THE SCHAUS SWALLOWTAIL (LEPIDOPTERA: PAPILIONIDAE) ON THE ISLANDS OF BISCAYNE BAY, FLORIDA, WITH COMMENTS ON THE BAHAMAN SWALLOWTAIL

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ABSTRACT

Censuses of the Schaus swallowtail butterfly (*Heraclides* (= *Papilio*) *aristodemus ponceanus* (Schaus)), a federally listed threatened species, were conducted from 1979 to 1982 on islands in Biscayne Bay, southern Florida. The population size was small during 1979 and 1980, but adults were widely distributed in suitable habitat. Emergence season was similar in both years, from late April to late June. Numbers of the Schaus swallowtail were lower in 1981, and the emergence period seemed to be retarded, probably due to the very dry winter and spring. Following the wet winter of 1981-1982, the largest numbers of adult Schaus swallowtails since 1972 were recorded. It appears that the severity of the winter dry season may determine the population size of this species in southern Florida.

In combination with results of previous censuses, these data provide a continuous eleven-year record of Schaus swallowtail population fluctuations on the Biscayne Bay islands. Human disturbances, especially habitat destruction, have reduced the numbers and range of the Schaus swallowtail, so the butterflies on these islands presently form the nucleus of its population

in the United States. The Bahaman swallowtail (*Heraclides* (= *Papilio*) *andraemon bonhotei* (Sharpe)) was not observed during the censuses, and we conclude that it is not presently established on the islands we studied.

RESUMEN

Desde 1979 al 1982, en las islas de Biscayne Bay en el sur de la Florida se hizo un censo de la mariposa, *Heraclides* (=*Papilio*) *aristodemus ponceanus*, la cual el gobierno federal la ha declarado como una especie amenazada de extinción. El número de la población durante 1979 y 1980 fué mínimo, pero los adultos estaban bien distribuidos en habitación adecuada. La estación de emersión fué muy similar durante los dos años, desde finales de Abril al final de Junio. Los números de la mariposa Schaus fueron más bajos en 1981 y el período de emersión parece haber sido atrasado, posiblemente debido al invierno y la primavera seca. Luego del invierno húmedo de 1981-1982, se registró el mayor número de la mariposa Schaus desde el 1972. Así que parece que la severidad de la estación seca del invierno puede determinar el tamaño de la población de esta especie en nuestra área de estudio.

Junto a otros censos estos datos proveen un récord contínuo de once años de las fluctuaciónes en la población de la mariposa Schaus en los cayos de la Bahía de Biscayne. Los disturbios humanos, especialmente la destrucción del ambiente han reducido los números y el área geográfica de la mariposa Schaus y por lo tanto las mariposas en estas islas forman el núcleo de la población de este especie en los Estado Unidos. La mariposa *Heraclides* (=*Papilio*) *andraemon bonhotei* no se observó durante los censos, y dudamos que esté establecida allí.

The Schaus swallowtail (*Heraclides* (= *Papilio*) *aristodemus ponceanus* (Schaus)) was first described at the turn of this century from the Miami area of Dade County in southern Florida (Schaus 1911). It was eliminated from that site as the city developed but was rediscovered further south on the Florida Keys, Monroe County. The species received much attention following the 1935 hurricane because of a report of its extirpation on the keys by the storm (Grimshawe 1940). Henderson (1945a, b) later documented the continued existence of the Schaus swallowtail in the Florida Keys. By this time, the butterfly had become a glamour species in great demand by collectors, and, during the next two decades, both Klots (1951) and Kimball (1965) noted that over-collection of this rare species was possible. In 1972, Covell and Rawson (1973) and Brown (1973a, b) independently surveyed the upper Florida Keys, including the Elliott Key group in Biscayne Bay, Dade County, to the north of the main-line Florida Keys. They found that the Schaus swallowtail was well-established on these northern islands where Brown (1973a) reported seeing 100 adults in a day. From 1973 to 1976, Covell (1977) continued to observe this species on the islands of Biscayne Bay but found that it had decreased in numbers from the levels of 1972. He speculated that the decrease may have been the result of winter drought conditions that inhibited new growth of the larval food plants during those years. Limited surveys were also conducted during 1977 and 1978, with few adults being observed on the keys (J. Tilmant, pers. comm.).

The Bahaman swallowtail (*Heraclides* (= *Papilio*) *andraemon bonhotei* (Sharpe)) has been recorded from southeastern Florida and the Florida

Keys on several occasions during this century. Only on a few occasions has the existence of a breeding population been suggested. The collection of a fresh adult on Long Key in Monroe County, Florida was used to support such a contention (Kimball 1965), as was a more recent report by Brown (1973a, b) of large numbers of adults, including ovipositing females, on the islands in Biscayne Bay.

The two swallowtail butterflies became the first invertebrates to be included on the U. S. List of Endangered and Threatened Species. The overlapping range of these species in the United States was thought to be limited to tropical hardwood hammocks of the upper Florida Keys, including those in southern Biscayne Bay, where environmental conditions are suitable for hammock growth. Such hammocks are normally found on the highest land in southern Florida and the Florida Keys, usually near the coast where rapid urban and commercial development has taken place. Habitat destruction has been devastating to the butterflies, especially considering that their population sizes and ranges in Florida appear to have been small under natural conditions.

Little biological data existed for these butterflies at the start of our study. Our purpose was to determine the status and distribution of these species on the relatively undisturbed islands in Biscayne Bay, to document the season and the duration of adult emergence, to confirm the larval food plants, and to define those factors that affect the population status of the butterflies. Preliminary results from 1979-1981 censuses and suggested management options for the Schaus swallowtail were presented by Loftus and Kushlan (1982). A companion study by Gerold Morrison (1981) examined food plants and larval ecology. Both species of butterflies, originally placed in the genus *Papilio*, have recently been reassigned to the genus *Heraclides* (Miller and Brown 1981).

Study Area

We studied two islands in Biscayne Bay, Elliott Key and Old Rhodes Key, because of their mature hardwood hammocks in which many swallowtails had been sighted in recent years.

On Elliott Key, we established an approximately 1-km transect south of Billy's Point, near Petrel Point (Fig. 1). This route crossed the island from the ocean to the bay through mature hammock, included a section of the cleared central portion of the island, and looped southward into a hammock on the bay side. The transect included large stands of the host plants for Schaus swallowtail larvae, torchwood (*Amyris elemifera*) and wild lime (*Zanthoxylum fagara*) (Rutkowski 1971), and an old grove of key limes (*Citrus aurantifolia*), the reported larval host plant of the Bahaman swallowtail (Klots 1951). A similar transect on Old Rhodes Key was an approximately 1-km loop through a mature hammock on the southern tip of the island (Fig. 1). This hammock had an unbroken canopy, except where trees had fallen and hosted large stands of torchwood and wild lime trees.

On the surveys in 1980, additional monthly visits were also made to an abandoned key lime grove at the northern tip of Totten Key (Fig. 1). The lime trees were mixed with encroaching hammock species, resulting in a more open canopy than in the mature hammock.

Rainfall on the keys follows a pattern similar to that of the mainland,

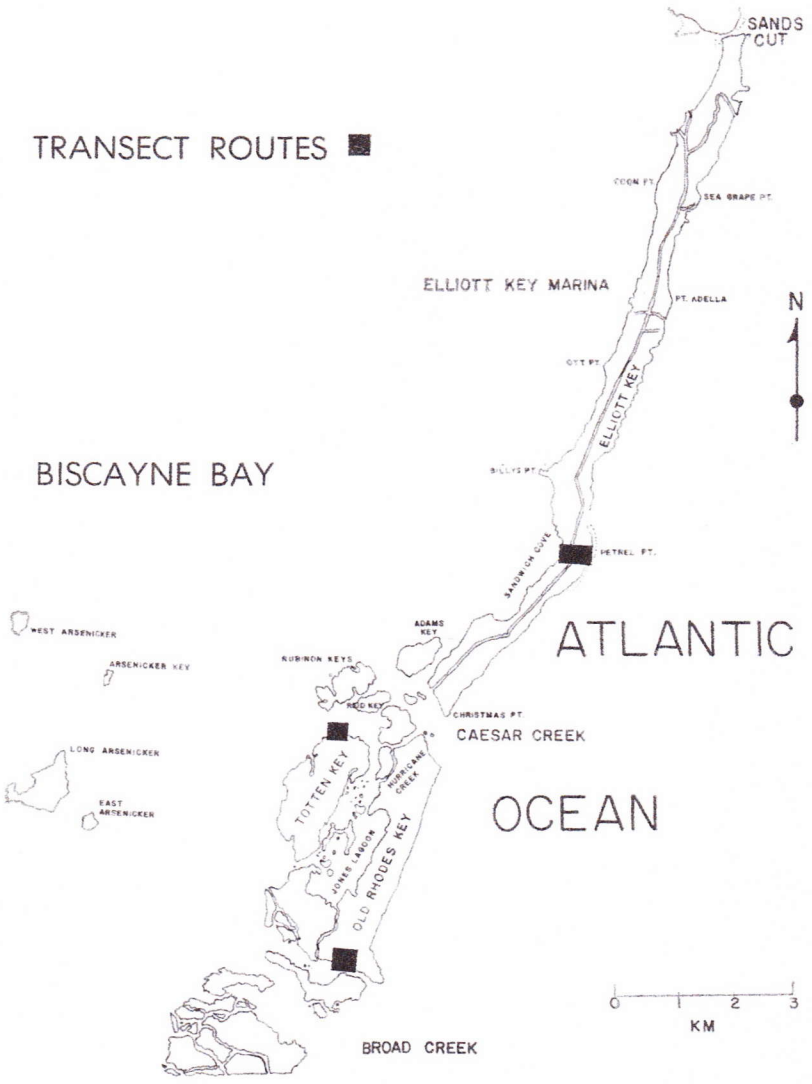

Fig. 1. Map of the major keys in Biscayne National Park showing the locations of the survey transects.

with most precipitation occurring during summer and fall (Fig. 2). Winter and spring are normally times of low rainfall, although this pattern can vary considerably from year to year.

Methods

Monthly censuses of the transects were conducted from late March to late September in 1979 and 1980, except for March 1979 when boat trouble

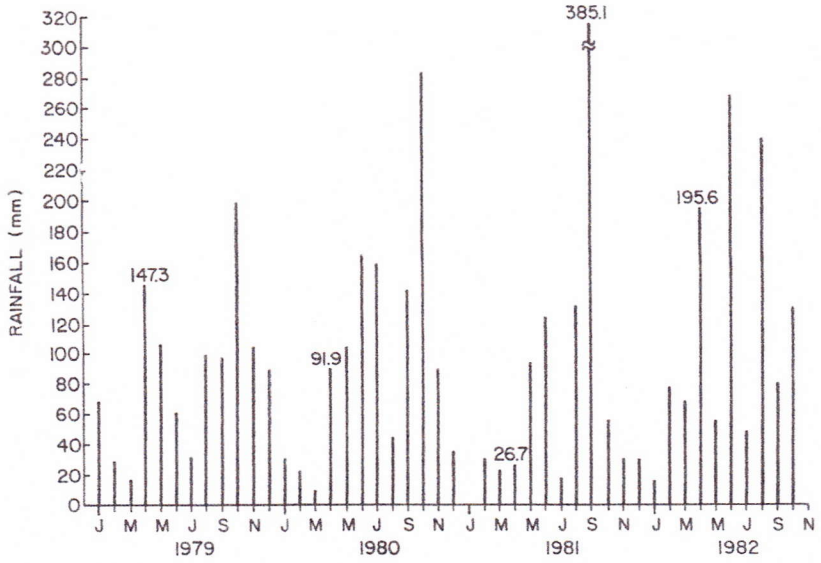

Fig. 2. Monthly rainfall (mm) at Adams Key, Biscayne National Park, based upon daily observations from 1979 to 1982.

precluded work on Elliott Key. All transects were monitored on the same day. In 1981 and 1982, Daniel Peters of Biscayne National Park continued monthly censuses from April to July along the same transects. Each transect required from two to three hours to complete. The censuses were taken only on sunny days when we expected butterflies to be active. During the emergence period, censuses were increased to twice per month so that we could determine the timing and duration of emergence.

To conduct a census, we walked slowly along the transect, frequently stopping to scan the surrounding hammock for butterflies. The weather conditions at the time of census were noted, and all butterflies were counted and recorded. We tried to avoid duplicate counts of individual butterflies. In addition, we checked torchwood leaves for eggs, larvae, and signs of feeding during the surveys. During the emergence period of *H. aristodemus ponceanus*, we observed the number, condition, and behavior of the adults. By noting the condition of the few specimens present (i.e., the number of tails missing, notches in the wings), it was possible to recognize individual Schaus swallowtails along the survey route, and to obtain an accurate count of individuals. Daily rainfall records from Adams Key were collected from 1979 to 1982 (Fig. 2).

Results

The peak of the flight season of the Schaus swallowtail was mid-to-late May (Table 1), although adults were observed from late April (G. Morrison, pers. comm.) to mid-July (D. Peters, pers, comm.). Adults emerged in early May; all individuals present on the transects at that time looked very fresh and untattered. By late May and June, nearly all adults were tattered

and dull. The exception to this pattern was the sighting of three freshly-emerged adults on 23 June, 1980 on Totten Key.

In 1979 and 1982, adults were found on the transects only during May (Table 1). Limited data from the 1983 season showed a similarily restricted emergence period, with 8 adults located on 8 May and 15 adults seen on 15 May (C. Hauke, pers, comm.). The flight seasons in 1980 and 1981 were more protracted, extending into June and July respectively (Table 1). The number of adults seen on the transects was lowest in 1981 and the emergence period appeared to be retarded. In 1982, the highest numbers of Schaus swallowtails during the four years of censusing were recorded (Table 1). The limited data from 1983 suggest that this was also a year of high population levels.

TABLE 1. DATES OF CENSUSES AND NUMBERS OF OBSERVATIONS OF INDIVIDUAL SCHAUS SWALLOWTAIL ADULTS ON TWO BISCAYNE BAY ISLAND TRANSECTS FROM 1979-1982.

	Elliott Key	Old Rhodes Key
1979		
19 March	—	0
12 April	0	0
24 May	5	7
19 June	0	0
25 July	0	0
30 August	0	0
27 September	0	0
1980		
31 March	0	0
22 April	0	0
5 May	2	2
20 May	2	4
23 June	2[a]	0
17 July	0	0
25 August	0	0
29 September	0	0
1981		
24 April	0	0
13 May	2	0
28 May	0	0
10 June	1	0
25 June	3	0
8 July	1	1
1982		
20 April	0	0
7 May	2	9
15 May	25[b]	—
10 June	0	0
7 July	0	0

[a]3 additional adults seen on Totten Key.
[b]11 additional adults seen elsewhere on Elliott Key.

Surveys of the keys in Biscayne National Park during peak emergence times revealed that the Schaus swallowtail is widespread. It appears to be limited to hammock and hammock edge habitats. We observed specimens on Elliott, Old Rhodes, Adams, and Totten Keys and assume that this species is present in suitable habitat throughout the Park.

We rarely observed mating or oviposition, although courtship activity was common. On 24 May 1979 we watched a Schaus swallowtail oviposit on wild lime (*Zanthoxylum*). Efforts to locate Schaus swallowtail larvae on new torchwood leaves were usually unsuccessful, although fresh feeding signs were often visible. We were able to find and photograph only a few larvae during this study. Fresh feeding sign was most apparent in May and early June, with a few weeks of adult emergence. The few larvae discovered along the transects were also located during May.

We never found the Bahaman swallowtail on the keys in Biscayne Bay, in spite of attempts to locate this species. We planned our census times to include the times of Brown's (1973a, b) sightings. The transects included old key lime plantings, and if this butterfly was present, we would have expected to find it there. Dennis Leston (pers. comm.) and Gerold Morrison (pers. comm.) were studying butterflies on the keys at the times of our censuses and did not find this species. Bahaman swallowtails were not observed in 1981 or 1982 surveys on these keys (D. Peters, pers. comm.; C. V. Covell, Jr., pers. comm.).

Discussion

Bahaman swallowtail

The specimen history of the Bahaman swallowtail in Florida has been sporadic. Some records appear dubious and few provide any evidence that the butterfly has been established (Klots 1951, Kimball 1965, Florida Game and Fresh Water Fish Commission 1982). Records of *H. andraemon* in Florida appear to be the result of sporadic colonizations during which short-term breeding colonies may form, only to eventually die out (Miller 1975, Morrison 1981). Morrison (1981) pointed out that current taxonomic interpretation of *H. andraemon* does not recognize a distinct Florida subspecies. This would indicate that if establishment had ever taken place, it has not been of sufficient duration for morphological differentiation to have developed.

The sightings by Brown (1973a) and his students provided the impetus to list the Bahaman swallowtail as a threatened species. They reported the presence of numerous adults on Elliott Key in 1972, including females that were ovipositing on citrus trees. Covell (1976) was collecting on Elliott Key in 1972, and, although he collected Schaus swallowtails, he did not observe the Bahaman swallowtails. Covell (1977) continued to collect in the park area from 1973-1976 but never observed *H. andraemon bonhotei*. This species was not observed during surveys of Elliott Key in 1977-1978 (J. Tilmant, pers. comm.) or during our censuses. We also examined a number of key lime trees for larvae during each month of the 1979-1980 censuses, but we never found *H. andraemon* larvae. We believe that the specimens reported by Brown (1973a, b) failed to establish a breeding colony in Florida.

There appears to be an inconsistency in identification in Brown's papers

(Brown 1973a: 139, and Brown 1974: 11). Recounting what seems to be the same experience, Brown (1973a) stated "on one occasion a *P. aristodemus ponceanus* eluded our pursuit and flew safely from the south end of one key and entered the jungle on the northeast side of an adjacent key in a route that covered over one-half mile," while in Brown (1974), he stated in identical wording that *H. andraemon bonhotei* eluded capture. Both Brown (1973a, 1974) and Covell (1977) use this incident to show that *H. aristodemus ponceanus* can fly between islands; however, it would seem that the identity of the species is unclear.

Based upon the results of our work and of others, we do not believe that sufficient evidence exists to establish the permanent residency of the Bahaman swallowtail in the United States. The Bahaman swallowtail does not appear to be in danger of extirpation in its native Bahaman Islands, and it has become numerous in Jamaica where it was recently introduced (Tyler 1975). Under the 1978 amendments to the Endangered Species Act regarding invertebrates, this subspecies should not be listed unless it can be shown to be in danger throughout a significant portion of its range. Until the existence of established breeding populations in this country can be verified, it must be assumed that the occurrence of this butterfly in the United States is sporadic.

Schaus swallowtail

The Schaus swallowtail is adapted to life within the shady tropical hammocks of the Biscayne Bay keys and upper Florida Keys. Its normal population size appears to be low in all life stages, although the numbers of adults may follow a cyclical pattern of unknown periodicity. Large numbers of adults were present throughout its known range on the Biscayne Bay keys from 1969-1972 (Brown 1973, Covell and Rawson 1973). The population levels were low during the next nine years but rebounded in 1982 and 1983.

In both 1979 and 1980, adults occurred in small numbers along the transects. The slightly lower numbers observed in 1980 do not necessarily represent a decline but may be an artifact of the census method. The emergence season in both years extended from late April to June and corresponded well with the times of emergence reported by Covell and Rawson (1973) and Brown (1973).

In 1981, the number of Schaus swallowtails recorded along the transects was lower than in 1979 and 1980 (Table 1). This decrease may have been the result of high larval mortality in 1980 (Morrison 1981) or could have been related to the severe spring dry season of 1981. The 1981 data indicate that spring droughts may affect the butterfly and its larval food plant by delaying emergence and new leaf production, respectively. On 13 May 1981, torchwood trees were just beginning to produce new leaves and many trees showed no new leaves at all, while in previous years, most torchwood trees were fully flushed with new growth by late April. A coincident delay in the emergence of Schaus swallowtail adults occurred in 1981. The first adults were recorded on 13 May 1981 and not on earlier censuses in late April and early May. The last sighting of adults occurred in mid-July 1981. The emergence period of the Schaus swallowtail appears to have been delayed by several weeks in 1981, coinciding with the delayed flush of new leaves by

torchwood. Sightings in July 1981, several weeks later than the final sightings in 1979 and 1980, suggest that the entire emergence season was retarded in 1981. Other lepidopteran species along the transects showed similar delays in emergence in 1981 when compared with the previous two years (D. Peters, pers. comm.). It appears that the severe spring dry season may have been responsible for the retardance of emergence in 1981, but this relationship requires much more study.

The number of adult swallowtails increased greatly in 1982 (Table 1). Rainfall during the winter and spring of 1982 was relatively high (Fig. 2) which may have contributed to the greater survival of individuals. Adult emergence began in early May, but did not extend into June, resulting in a very short flight season. Numbers of other butterfly species on the islands was also high during 1982 (D. Peters, pers. comm.).

The factors leading to changes in abundance are not well understood, but Covell (1976) suggested that severe droughts may have deleterious effects on the timing of emergence and numbers of adult Schaus swallowtails. There is evidence that the pupae can overwinter for two years during a severe drought (Covell 1976), a capability which may have been an important evolutionary factor for this species (Morrison 1981). Droughts occur naturally in southern Florida and, even during relatively wet years, there is a period in winter and early spring when rainfall is low (Fig. 1). It appears that *H. aristodemus ponceanus* emergence coincides with the beginning of leaf flush in the larval host plant, torchwood. Our census results indicate that rainfall during the months immediately preceding the usual emergence time may affect both the timing and duration of emergence and the number of adults that will emerge. This relationship had been previously suggested by Covell (1976), Miller (1975), and was discussed by Morrison (1981). In 1981, total rainfall during the period of February through April (80.7 mm) was the lowest recorded for the four survey years (Fig. 2), and the number of Schaus swallowtail adults was correspondingly low on the transects. In addition, the timing of emergence was delayed and the entire flight season was retarded. Rainfall from February through April of 1982 (337.6 mm) exceeded that of any similar period during the four survey years (Fig. 2), and butterfly numbers were also the highest recorded. Similarly, in February through April in 1983, when rainfall totaled 396.5 mm, limited censusing data showed high numbers of adults present in May.

We usually observed fresh herbivory on torchwood leaves within one or two weeks after the emergence of adult Schaus swallowtails. The adults presumably mate and lay eggs soon after emerging. From our lack of results in locating larvae, it appears that few larvae are either produced or survive, and those that do survive through several instars often disappear before pupating (Morrison 1981). Much of the life cycle of the Schaus swallowtail is spent in the pupal stage, in which it can remain in diapause for up to two years (Grimshawe 1940).

Covell (1977) discussed the possibility of a second emergence of Schaus swallowtail adults in late summer. The latest sighting of adults during four years of censusing occurred in mid-July 1981, even though censuses were continued into August or September. Food for early instar larvae produced by a second emergence would probably be scarce because they feed on new

leaves which are primarily produced in spring (Morrison 1981). This source would be less available later in the year. It seems more likely that the late season records of adults represent sporadic emergences, possibly resulting from asynchronous termination of diapause.

Several natural and human factors, such as freezes, insecticides, and collecting, may affect Schaus swallowtail populations (Covell 1976). Such factors are more serious on the upper Florida Keys than on the islands we studied. Collecting, destruction of habitat, and insecticide spraying are minimal on the islands in Biscayne National Park; however, good habitat outside the park, especially on Key Largo, is constantly being degraded by aerial mosquito spraying or lost through destruction of hammock for development. The amount of collecting outside of the park is unknown, but poaching inside the park is discouraged by the isolation of the keys and the patrolling by park rangers during the emergence period.

Freezes do not seem to be as damaging on the islands as they are on the mainland. During the hard freeze of 1977, no adverse effects on vegetation or wildlife occurred on the islands in Biscayne Bay because of the moderating effect of the surrounding waters (J. Tilmant, pers. comm.). Hurricanes can severely affect vegetation and insect populations in south Florida (Grimshawe 1940; Craighead 1971). A direct pass of a hurricane over the Biscayne Bay keys could devastate the remaining population of the Schaus swallowtail through wind damage, flooding, and reduced availability of the food plant for several seasons. Such an event could extirpate the Florida subspecies because its geographical range is now limited, and because populations on the upper Florida Keys from which recolonization might occur have been severely reduced.

The butterflies on the islands of Biscayne Bay, located in Biscayne National Park, appear to form the nucleus of the Schaus swallowtail population in Florida at this time. Little evidence of breeding on the major Florida Keys outside the park was found in 1980 (Morrison 1981), and recent development pressures on northern Key Largo will result in the further diminution of suitable habitat. The islands in the park therefore represent the last undisturbed and unthreatened Florida habitat for this insect.

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