

BULLETIN OF THE ALLYN MUSEUM

3621 Bayshore Rd.
Sarasota, Florida 34234

Published By
The Florida State Museum
University of Florida
Gainesville, Florida 32611

Number 121

15 September 1988

ISSN-0097-3211

BIOGEOGRAPHICAL AFFINITIES OF THE BUTTERFLIES OF A 'FORGOTTEN' ISLAND: MONA (PUERTO RICO)

David Spencer Smith

Hope Entomological Collections and Department of Zoology, Oxford University, England

Stuart J. Ramos

Department of Biology, Mayaguez Campus, University of Puerto Rico, Mayaguez

Faustino McKenzie

Institute of Neurobiology, University of Puerto Rico, San Juan

Eugene Munroe

Granite Hill Farm, RR 2, Dunrobin, Ontario, Canada

Lee D. Miller

Allyn Museum of Entomology of the Florida State Museum, 3621 Bay Shore Road, Sarasota, Florida 34234

Introduction

The existence of an island, about 23 square miles (62 km²) in area and situated approximately midway between the populous Greater Antillean islands of Puerto Rico and Hispaniola, but with no substantial or continuous human population since the mid-16th century, seems improbable. Yet this is true of Mona Island, lying in the Mona Passage, between the Atlantic Ocean and the Caribbean Sea, at 18° 3-8'N and 67° 51-57'W

This island has been referred to as Amoná, reportedly the Taino Indian name recorded when visited by Columbus in 1494 (Wadsworth, 1973) but the form 'Mona' is now generally used¹. Wadsworth has admirably outlined the recorded history of the island, and a brief summary is given below.

Following Columbus' initial visit, Juan Ponce de Leon made landfall there in 1508 and is recorded as being supplied with cotton cloth and cassava by the Tainos. In 1513, direct charge of the island was assumed by Francisco de Barrionuevo (recorded now in the name of the NW cape; see Fig. 1) who succeeded for a number of years to maintain Mona as an effective source of crop food and other supplies for the new Spanish colony of San Juan Bautista (Puerto Rico), supporting their contribution by providing the Tainos with a variety of goods. The Taino population numbered 152 in 1517, and thereafter dwindled. Wadsworth documents the unfortunate last years of Taino presence on Mona: that their success as suppliers of food and cotton, and lack of fortification of the island laid Mona and its Indian population open to attack by pirates, notably the French, until, in 1578, "some 10 to 30 Tainos, all those remaining were transported to Puerto Rico to save them from the French raiders". Thus, only 85 years after their 'discovery' by Europeans, the Taino period of Mona ended.

¹. Kaye (1959) suggests that "There seems no reason to speculate, as did Fra Bartolome de las Casas in the 16th century, that the Admiral was influenced by the ancient Celtic name for Anglesey, Mona off the north coast of Wales in naming this obscure island."

One Taino village was situated at Sardinera (Fig. 1) and crops were presumably produced on the adjacent coastal plain but nothing remains (other than to the archaeologist) of their presence there, while on the central plateau, traces of two ball courts have been found amidst the dense xeric forest suggesting that unrecognised village sites lie nearby.

Following the departure of the Taino, Wadsworth describes an extraordinary period of three centuries during which the island was abandoned by the colonial government in San Juan. Before the end of the 16th century, Sir Walter Raleigh visited Mona and Sir Francis Drake was active near the island; thereafter, documentation (primarily from English sources) suggests that Mona was visited sporadically by a succession of pirates and privateers.

The island appears to have supported a minimal post-Taino population, at least sporadically, attracting marauding pirates and occasional fishermen in search of food and water, though of these, few records remain. Even after extensive piracy in the area waned in the 1830's, Mona still remained forgotten, or at least neglected by Puerto Rico, and interest in the island was rekindled only by the realisation that extensive deposits of bat guano were present in many of the caves that perforate the island's cliffs and central plateau. Officially sanctioned mining started in 1878, and continued intermittently until 1920. Today, industrial archaeological remains survive in a small area at Playa de Pajeros (Fig. 1) and in several caves, but extraction and processing of the guano did not substantially damage the island.

The small satellite island of Monito lies 3.1 miles N 21° W of Cabo Barrionuevo (Woodbury et al., 1977). It occupies about 40 acres, and is structurally similar to Mona. Its largely treeless but relatively extensive flora has been described by Woodbury et al. (1977). Monito is difficult of access, and it does not seem to have been visited by entomologists: certainly, we have no butterfly records at present.

Mona has changed, over the years, but it has changed remarkably little, for its geographical situation. No discernible damage dating from the early period is present, but Wadsworth mentions that the clearing of 200 acres of the coastal plain took place during the 'guano period' to provide cultivated land contributing to the miners' food. Between 1937 and 1942, the 'Civilian Conservation Corps' established forestry plantations covering 415 acres of the plain near Sardinera, with fortunately small mahogany plantations on the NW plateau (Fig. 1).

Mona and Monito survived a hazardous few years from 1954 when, following their lease to the U.S. Government, aerial bombardment exercises were reportedly conducted on Monito, and some 'straight tracks' were bulldozed on the plateau of Mona, which are now faintly visible only from the air, as obscure lines near the eastern cliffs. In 1962, Mona and Monito were returned to the jurisdiction of the Government of Puerto Rico. When Wadsworth wrote in 1973, the future of these islands was quite uncertain: proposals for the 'use' of Mona ranging from development as a Club, a prison, a target for naval military manoeuvres and a 'Superport' petroleum storage and industrial area.

Mona and Monito survived these potentially destructive threats and are now under the control and close scrutiny of the Department of Natural Resources of the Government of Puerto Rico, and biological and other research is welcomed by permit from the Under Secretary for Scientific Research of the Department. Continuation of this policy will ensure the preservation of these unique islands.

In addition to direct land disturbance on the coastal plain, human interference on Mona includes the introduction of a variety of mammals, including pigs, rats and goats. The first present in immediate threat to turtles through egg predation. These, and goats, which undoubtedly to some extent damage Mona's vegetation, are regularly hunted, and any

efforts designed to reduce their numbers would be of obvious benefit.

The topography and vegetation of Mona

The above introductory outline is designed to place in context the physical and vegetational features of Mona, which in turn provide the ecological setting for discussion of the butterflies of the island.

Approached by air (Fig. 2) or sea, Mona appears as a flat island, ringed by near-vertical cliffs: of its ca. 14,000 acres (23 mi²) over 90% is occupied by a plateau ranging in elevation from ca. 100 ft near Playa de Pajoros (to the South) to 270 ft at Cabo Noreste (Fig. 1). The island is composed almost entirely of limestone and dolomite, extant formations dating from the Lower/Middle Eocene to the Holocene (Aaron, 1973) and appears never to have had a land link with its neighbours, from which it is separated by depths of the Mona Channel reaching to 500 fathoms.

Woodbury, Martorrel and Garcia-Tuduri (1977) have provided a detailed account of the remarkably rich and varied flora of Mona and Monito, in which they record 417 species of vascular plants and define the principal vegetational zones. The plateau is accessible from the coastal plain at three points: from Sardinera beach to the NW trail towards Cabo Barrionuevo, *via* the continuation of the road bordering the airstrip which ascends the escarpment near Uvero and, further east, *via* the link between the road to El Faro and the narrow coastal plain at Playa de Pajoros, which houses a disused jetty and ruins of the guano processing plant. Woodbury *et al.* (1977) state that "the dominant vegetation type of the Mona plateau (Figs. 4, 5) is a semi-open xerophytic or dry forest characterised by few trees that reach 7 m or more, the rest being usually shrubby". Numerous sink holes are present on the plateau, the largest of which (*bajuras*) possess a deeper accumulation of soil and a higher moisture retention capacity: here, Woodbury and colleagues recorded a wider flora or more mesic trees and associated plants (Figs. 3, 6).

Much of the plateau area fringing the northern and eastern cliffs is conspicuously dwarfed (Fig. 2) resulting, as Woodbury *et al.* (1977) point out, from exposure to prevailing strong easterly winds and salt spray. They designate 940 acres (ca. 7.5% of the total plateau area), as 'Dwarf coastal scrub' ranging from a zone of succulent or semi-succulent species less than 1 ft tall with a scattering of low shrubs merging westwards and along the north coast with a zone, up to 2 m tall, 'dwarf woody to semi-succulent' (Fig. 7) that, in turn, merges irregularly with the main plateau xeric forest². Around the lighthouse (El Faro) and to the SW (Punta Este), they described an area of 300 acres, dominated by large cacti, up to 5 m in height (Fig. 2).

The NW plateau forest (towards Cabo Barrionuevo) is not demarcated from that of the general plateau from the air, but it appeared to us a taller, more varied and less obviously xeric extension of the principal plateau forest, and with more plentiful nectar sources, in accord with its relative protection from prevailing winds. As will be detailed later, during three of our four visits, this area sustained a much richer butterfly fauna than any other plateau zones sampled.

The remaining ca. 1300 acres of Mona account for under 10% of the total area, and are largely distributed along the coastal plain and littoral zone (Fig. 10) from the westward-facing Playa Sardinera SW to beyond Uvero (Fig. 1). Wadsworth (1973) and Woodbury *et al.* (1977) note that this area has been extensively disturbed between Pre-Columbian and recent times, primarily for cultivation but also by *Casuarina* and mahogany

². (1) In their vegetational map, Woodbury *et al.* (1977) label the eastern plateau zone 'scrubby vegetation' in common with the NW edge of the plateau. We have retained their more descriptive term in Fig. 1. (2) In an earlier account, Wadsworth (1954) considered the '*matorral de cacto*' to be considerably more extensive, accounting for almost 2900 acres, or over 20% of the total plateau area.

plantations. A cleared area adjoining Sardinera beach is grassed, with coconut palms and the DRN buildings, and a grassed airstrip area is situated between Sardinera and Uvero.

The limit of the coastal plain is defined by the cliff rising to the plateau edge, thickly clad by forest (Fig. 8) that extends as a narrow strip along the escarpment base flanking the airstrip and eastwards towards Uvero. Woodbury *et al.* (1977) estimated this forest (Fig. 9) as only ca. 50 acres in extent, but noted it as "...the best natural forest in the island with trees attaining heights of 25 m or more and trunk diameters of about 1 m." This very limited (and only partly accessible) region resembles a well developed 'hammock' hardwood forest of South Florida or the Cambalache Forest of Puerto Rico, a similarity impressively reflected in its butterfly fauna.

Butterfly species recorded from Mona

J.A. Ramos (1946) provided the most recent published list of the butterflies of Mona, together with an interesting resumé of entomological collecting on the island. The first butterfly recorded (*Hemiargus ammon noeli*) dates back to 1914 when a party of scientists spent five days on Mona as a contribution to the Scientific Survey of Puerto Rico and the Virgin Islands. No further butterflies appear to have been recorded until Wolcott added eight species from brief visits in 1939 to 1940 and the total of nine is listed by Comstock (1944) in his Table of Distribution. Further collecting was carried out in 1944 by J.A. Ramos, Wolcott and others, and in the report by J.A. Ramos (1946) of the insects of Mona, 21 butterfly species were included. (The total recorded in 1946 is probably 20, since Wolcott (1948) reports that specimens of the skipper initially included as *Urbanus proteus* proved to be *U. dorantes* [see p. 14].)

One of the present authors (S. J. Ramos) visited Mona several times in 1973 and 1975, and raised the species total to 29. These additional observations remained unpublished, and are included below as new records for the island. Two of the authors (DSS, FM) worked on Mona between July 17-23 and December 11-16 1986, 8-14 September 1987 and 5-11 April 1988, adding a further 16 species to the list. An additional recent record (p. 6) raises the current total to 46 species.

Field sites visited are shown in Fig. 1.

1. Sheltered NW plateau forest between Playa Sardinera and Cabo Barrionuevo.
2. Disturbed area around the buildings at Sardinera.
3. Plateau shrub adjoining the cliff edge above Playa de Pajaros (Fig. 7).
4. Transect ca. due N-S from the jeep road across the central plateau through Bajura de los Cerezos to approximately 1km from the north coast. (This region of the plateau was visited only in July 1986.) (Figs. 5, 6).
5. Cliff forest, ESE of Sardinera, adjoining the airstrip and extending towards Uvero (Figs. 8, 9).
6. Beach shrub area and adjacent disturbed plantations (*Casuarina*, *Lantana*, etc.). (Fig. 10).
7. Eastern plateau: disturbed area around the lighthouse (El Faro) and adjacent areas of plateau shrub and tall cactus (Fig. 3).
8. Cliff-edge low cactus area, north of El Faro, towards Cabo Norte (Fig. 2).
9. NW plateau and *bajuras* south of Cabo Noroeste (Fig. 4).
10. Isolated beach areas on S. coast (Playa El Caigo).

These sites are mentioned throughout the descriptive text.

LIST OF SPECIES

** : Species newly recorded from Mona Island

() : Unconfirmed species records

DANAIDAE

Danaus plexippus (Linnaeus 1758). Absent from Comstock's (1944) list, the Monarch butterfly was first recorded from the island by J. A. Ramos (1946) who collected one male on the plateau above Sardinera Beach, July 1944. This specimen was identified as the migratory nominate subspecies, though S. J. Ramos collected two specimens of the Puerto Rican subspecies (*D. p. portoricensis* Clark 1941) a form resembling (and perhaps overlapping with) the non-migratory subspecies *megalippe* (Huebner 1819), occurring through the Greater Antilles, the Bahamas, Jamaica, the Cayman Islands and the Lesser Antilles. In July 1986, *plexippus* was seen around the Sardinera buildings (Loc. 2, Fig. 1) and one in December 1986. Specimens were collected in September 1987, when *plexippus* was recorded from several areas on the coastal plain. Woodbury *et al.* (1977) list five species of Asclepiadaceae from Mona (four *Cynanchum* spp. and a species of *Matelea* which, though apparently not recorded larval foodplants for *Danaus plexippus*, might well support a resident population.

*****Danaus gilippus cleothera*** (Godart 1819). This subspecies is widespread and often common in Haiti (Schwartz, 1983) and the Dominican Republic. It is present, though much more rarely, on Puerto Rico (Comstock, 1944). It is newly recorded from Mona by two males and a female collected by Dr. Hector Quintéro (Interamerican University, San Germán, Puerto Rico) on 29 November 1986. At that time, Dr. Quintéro found *D. gilippus* 'fairly abundant' on the coastal plain between Sardinera and Uvero, and on the plateau above Playa de Pajaros. It is noteworthy that this danaid was not noted in either of these localities, two weeks later (DSS, FM), stressing the conclusion that even conspicuous butterflies may be overlooked by sporadic field study. *Danaus gilippus* has not been noted on subsequent visits but, as noted above for *D. plexippus*, has potential foodplants available.

HELICONIIDAE

Heliconius charitonius charitonius (Linnaeus 1767). Listed by Comstock (1944) (as *H. c. charithonius*), this widespread butterfly is well-established on the island. It was noted by S. J. Ramos (October 1973; June 1976) and found during our survey in several areas, especially in shady regions around the cliff base and disturbed land near Sardinera and elsewhere on the coastal plain. Of the 76 specimens collected by S. J. Ramos and during our work in 1986, 1987 and 1988, 27 (35.5%) exhibit the extra yellow spot on vein 3 described for *H. charitonius punctatus* Hall 1936. According to Riley (1975), *punctatus* is the usual morph on St. Kitts and Antigua but it occurs in diminishing proportions of the populations through the Leeward Islands to Puerto Rico and Mona. Comstock (1944) cites an incidence of 40 per cent in individuals from the Virgin Islands, with 25 per cent in Puerto Rico. The status of *punctatus vis-a-vis* the nominate subspecies is of interest, and it is possible that this taxon represents a clinal variant. Populations in Hispaniola represent, almost uniformly, the subspecies *H. c. churchi* Comstock and Brown (Riley, 1975; Schwartz, 1983); *punctatus* was not represented in 20 specimens taken of *H. charitonius* in eastern Dominican Republic (DSS) in July 1987. The presence on Mona of '*punctatus*' at an incidence similar to or greater than that on Puerto Rico suggests an easterly affinity of present island populations. Woodbury *et al.* (1977) encountered a single *Passiflora* during their survey, *P. suberosa*, found on the coastal plain, at Sardinera and near Uvero.

Agraulis vanillae (Linnaeus 1758). The subspecies *insularis* (Maynard 1889), occupying much of the Antillean area, was recorded by Comstock (1944), and later by J. A. Ramos (1946) as common at Sardinera and Uvero beaches and on the plateau (April, June, July 1944). We found *D. vanillae* to be most common in the disturbed area near Sardinera and along the beach shrub of Playa de Mujeres and near El Faro (2, 6, 7 Fig. 1) (July and December 1986). In September 1987 it was locally common at Playa las Mujeres near

Sardinera, but, in common with most species, was absent from the plateau near El. Faro. J. A. Ramos recorded larvae on Mona feeding on *Corchorus hirsutus* (Tiliaceae), found commonly at Sardinera and elsewhere by Woodbury *et al.* (1977). Riley (1975) lists this species as preferring *Passiflora* spp. as larval food-plant: at least one is present on Mona (see *Heliconius charitonius*).

*****Dryas iulia iulia*** (Fabricius 1775). This insect is newly recorded from Mona from four specimens seen and one (male) collected (9 April 1988) in plantation forest along the road between Sardinera and the airstrip (Fig. 1). This heliconiid is almost universally present through the Antillean islands, in a remarkable range of subspecies (Riley, 1975), and was unsuccessfully sought on our first three visits to the island. Where present, *D. iulia* is often common, and its apparent scarcity on Mona is surprising. Riley (1975) regarded the nominate subspecies as that present in the Virgin Islands and Puerto Rico [with TL 'America' designated as Virgin Isles, St. Croix], and regarded Comstock's (1944) *D. iulia juncta* from this region [TL Adjuntas, P.R.] as a synonym. We provisionally follow Riley's course, while noting that the Mona specimen conforms in detail with Comstock's figure (1944: Pl. 6, Fig. 1) of a male paratype of *iulia juncta*. Puerto Rican and Virgin Island populations are generally distinct from *D. iulia hispaniola* (Hall 1925) from Haiti (Schwartz, 1983) and the Dominican Republic (Riley, 1985, and our records). The addition of this record to the Mona list, though as yet based on a single capture, augments the island's alignment with the butterfly populations of its easterly neighbors and thereby its faunal separation from Hispaniola. *Dryas iulia*, in common with the last two species, uses *Passiflora* as the larval food plant.

NYMPHALIDAE

Junonia evarete (Cramer 1779). No 'buckeyes' were included in Comstock's list, but both *Junonia evarete zonalis* (C & R Felder 1876) and *J. evarete genoveva* (Stoll 1782) were recorded by J. A. Ramos (1946) for Mona. Recorded again after 40 years, we collected three specimens of *J. evarete* in the dune area near Sardinera (Loc. 6) in December 1986, flying with *J. genoveva*, and it was more frequent there in September 1987 and April 1988, and also occurred at Uvero. The taxonomy of these nymphalids has recently been clarified (especially *vis-à-vis* the Jamaican fauna) by Turner and Parnell (1985). This insect, formerly regarded by some authors as a subspecies, is reinstated by Turner and Parnell as *Junonia evarete*. Duller beneath than the next species, it has the Black Mangrove (*Avicenna germinans*) as its larval food-plant in Jamaica, and *Lippia* in Cuba (Howe 1975). Neither is present on Mona, but other genera of Verbenaceae are well represented, including *Stachytarpheta* (= *Valerianoides*) recorded as a food plant (Riley, 1975) and *Lantana*.

Junonia genoveva (Cramer 1780). Not recorded by Comstock (1944) but mentioned by J. A. Ramos (1946) from 'several specimens taken on the plateau, July 20, 1944'. This species was recorded by Ramos as *J. evarete genoveva* but, following the recent revision of Turner and Parnell (1985), is here regarded as *Junonia genoveva*. This more brightly coloured buckeye is widespread in the Antillean region, and is quite distinct from the previous species. In July and December 1986, *genoveva* was common only along the coastal dunes east of Sardinera (Loc. 6) and near the airstrip (Loc. 2), and in December 1986 was noted occasionally in the NW plateau forest (Loc. 1). In September 1987 and April 1988 it was noted in the same localities, except for the N.W. plateau (Locs. 1, 9). Riley (1975) lists *Stachytarpheta* (= *Valerianoides*) and *Lippia* as larval food-plants while Turner and Parnell (1985) cite the first, plus *Ruellia* spp. and *Blechum* spp. Woodbury *et al.* (1977) recorded three *Stachytarpheta* species, and two species of *Blechum* on the island.

*****Anaea troglodyta borinquenalis*** Johnson & Comstock 1941. This 'leafwing' was first noted on Mona by S. J. Ramos (1 specimen) and was locally not uncommon in July 1986, over a wide area from the NW plateau coastal scrub forest above Sardinera (Loc. 1), along the road between Sardinera and Uvero (Loc. 2) and a worn specimen was recorded on

the plateau near Bajura de los Cerezos (Loc. 4). In December 1986, however, it was seen only once on the plateau, and a worn female was collected at the airstrip. In September 1987, this species was seen only in one area: a few fresh specimens recorded near the N.W. bajuras (Loc. 9). In April 1988, two specimens of *A. troglodyta*, were collected on the coastal plains, at Uvero and bordering the airstrip: as Riley (1975) notes, these 'dry season' examples display a more falcate FW tip than those collected at other times. The 13 specimens collected in 1986 and the few specimens collected in 1987 and 1988 correspond to the Puerto Rican subspecies (e.g. with material from the Guánica xeric forest of southwestern P.R.) rather than to the Hispaniolan nominate subspecies. The larval food-plant in Puerto Rico is *Croton humilis* (Wolcott, 1948) and *C. discolor* and *C. humilis* (S. J. Ramos, 1984); Woodbury *et al.* list three species of *Croton* (*betulinus*, *discolor*, *lucidus*) as common and widespread on Mona, with a fourth rare species (*rigidus*); any (or all) of which may serve as the larval food-plant for Mona populations.

*****Euptoieta hegesia watsoni*** Comstock 1944. This subspecies was described by Comstock from Puerto Rican material (TL San Juan). It is newly recorded for Mona from a single specimen collected in the NW plateau forest (Loc. 1) in July 1986. A second specimen was collected in the same area in December (DSS) and another seen on the Sardinera dunes (Loc. 6). All other Antillean populations (including those on Hispaniola) are regarded as nominate *E. h. hegesia* (Cramer 1779). The first Mona specimens appear to correspond to the Puerto Rican subspecies though longer series would be desirable. Comstock reared the type material of *watsoni* from larvae feeding on *Turnera ulmifolia* (Turneraceae); Woodbury *et al.* record *T. diffusa* as common at Sardinera and on the plateau.

[NOTE: The alignment of the first Mona specimens of *E. hegesia* with the Puerto Rican subspecies requires qualification. In describing *E. hegesia watsoni* [TL San Juan], Comstock (1944) mentions that Hispaniolan specimens "while determined as *watsoni* show some slight modification in the direction of the Jamaican subspecies *hegesia*." The Mona specimens and material from western Puerto Rico (DSS, SJR) conform in detail to the holotype description and figure (Pl. 6, Fig. 12) (notably in the markings in the fore wing cell). Riley (1975) mentions *watsoni* as the Puerto Rican subspecies; Schwartz (1983) found this species, sometimes in abundance, in several localities in Haiti (Western portion of Hispaniola) and determined all as *E. h. hegesia*. The precise status of Mona material will be established, beyond the present tentative attribution, when substantial series are available from this island, and from the adjacent eastern Dominican Republic.]

*****Marpesia petreus petreus*** (Cramer 1776). The 'daggerwing' was first found on Mona by S. J. Ramos (June 1975) and 4 specimens were collected (DSS) in July 1986, all in the 'hammock' forest area (Loc. 5) bordering the cliff adjoining the cleared airstrip area: similar to the habitat in which this butterfly is often abundant in southern Florida. It was absent from this area in December 1986 and was sighted once in September 1987 and two were collected in the cliff forest in April 1988. Riley (1975) mis-cites this insect as described by Cramer in 1779: Comstock (1944) proposed to resurrect the taxon *thetys* (Fabricius 1777) 'for that phase of *petreus* which appears north of Panama and extends into Mexico' and used this name for the 'few specimens from Porto Rico' available to him. Riley (1975) refers to 'The Central American subspecies *thetys* Fabricius' and records *petreus* in the Antillean area only from 'the Windward and Leeward Islands.... and very rarely on Porto Rico'. Miller and Brown (1981) point out that *thetys* is preoccupied (by *Papilio thetys* Drury 1773) and, pending further study, specimens from Puerto Rico (and Mona) are probably best referred to as the nominate subspecies. Comstock cites *Ficus brevifolia* as the larval food-plant (presumably in Puerto Rico); Woodbury *et al.* (1977) record *F. citrifolia* and *F. stahlii*, both precisely from the restricted area where *Marpesia petreus* occurred in July 1986.

*****Biblis hyperia*** (Cramer 1782). This unmistakable butterfly is newly recorded from Mona from a clear sight record (FM) in the plantation forest area near Sardinera (Loc.

2) in December 1986. Elsewhere in the Caribbean, its distribution includes Hispaniola, Puerto Rico and through the Lesser Antilles; locally common throughout its range. Riley (1975) mentions Pine nettle (*Tragia volubilis*) as larval foodplant; this plant occurs in Vieques and Culebra (off eastern Puerto Rico) but is not included by Woodbury *et al.* (1977) among the rich euphorbiaceous flora of Mona.

Hamadryas amphichloe diasia (Fruhstorfer 1916). Four specimens of *Hamadryas* were collected at Sardinera Beach by J. A. Ramos, in August 1944, and determined by Comstock as *H. ferox diasia* (J. A. Ramos, 1946). Two specimens were collected (DSS) in July 1986, in the 'hammock' forest below the cliff, east of Sardinera one in December 1986 and it was present in September 1987. In April 1988 *H. amphichloe* was common in the same area, most specimens being worn. The species *H. ferox* Staudinger 1888 is South American (see Miller and Brown, 1981) and Antillean specimens have been referred to as *H. februa diasia* (Riley, 1975). Jenkins (1983) revised the genus, and determined representatives of the subspecies occurring in the Greater Antilles (including Mona specimens forwarded by SJR) as *H. amphichloe diasia*. Riley cites this butterfly as 'fairly common' in Hispaniola but "rare in Cuba, Jamaica and Porto Rico where it would seem to occur as a wandering vagrant". In Puerto Rico, *H. a. diasia* is undoubtedly resident, and locally not uncommon in the Guánica forest in the southwest of the island, and it is widespread and common in the Dominican Republic (Hispaniola. Comstock notes information on the larval food-plant of continental *Hamadryas* spp., but provides no records for Antillean populations, while Riley (1975) gives *Dalechampia* as larval food-plant. This genus is not included by Woodbury *et al.* (1977) but other genera of Euphorbiaceae (*Euphorbia*, *Croton*, *Chamaesyce*, *Phyllanthus* etc.) are richly represented.

Colobura dirce (Linnaeus 1758). This distinctive nymphalid is tentatively included here on the basis of Wolcott's (1948) statement that it occurs "in Hispaniola, in Jamaica and Cuba and possibly on Mona Island, although not collected there". This vague reference may relate to a sight record. It occurs quite commonly in Hispaniola and in western Puerto Rico: Woodbury *et al.* (1977) do not list its usual larval foodplant (*Cecropia*) for Mona, but its presence on the Island, at least as a vagrant from East or West, would not be surprising. Any specimens found on Mona are likely to represent the subspecies *C. d. wolcottii* (Comstock 1942) [TL Puerto Rico and Hispaniola].

Eunica monima (Cramer 1782). J. A. Ramos (1946) and Wolcott (1948) recorded the first Mona specimen, collected by L. F. Martorrel in March 1940. It was not encountered by S. J. Ramos on subsequent visits, or by us in July 1986. However, *E. monima* was widespread in December 1986, in the NW plateau forest (Loc. 1), in the scrub bordering the dunes (Loc. 6) and in the 'hammock' forest (Loc. 5) where two newly emerged adults were collected. It was recorded frequently in September 1987, except on the plateau. In April 1988, a single fresh specimen was noted in Loc. 5. A well known (albeit irregular) migrant, *monima* was reported by Wolcott (1948) in 'swarms' at Santa Rita, Guánica, in 1915. *E. monima* appears to be regularly present in Cuba and Hispaniola and through Central and South America to Venezuela, without any regional variation. The larval food-plant (Dyar, cited by Comstock, 1944) is *Xanthoxylum pentomon* (Rutaceae): Woodbury *et al.* (1977) record *X. punctatum* as 'rare' on the coastal plain and on the plateau but three other genera of Rutaceae (*Amyris*, *Citrus* and *Triphasia*) are included in their list.

*****Eunica tatila tatilista*** Kaye 1925. First collected by S. J. Ramos in June and October 1975, we did not note this species in July or December 1986, though it was particularly sought for in the 'hammock' forest (Loc. 5) below the cliff along the SW edge of the island, east of Sardinera. However, it was seen here in September 1987. In South Florida, *E. tatila* adults are sometimes abundant in the hardwood 'hammock' forest on the Keys and North Key Largo, and at other times absent, not on a predictable annual basis. All Antillean populations represent the subspecies *tatilista*. The immature stages are undescribed, and the larval food-plant in the Antillean region is unknown.

Hypolimnys misippus (Linnaeus 1764). Wolcott collected this species on Mona in September 1944 (see J. A. Ramos 1946), but it was not recorded on subsequent visits until December 1986, when males (only) were seen near El Faro (Loc. 7), the Sardinera and Playa las Mujeres dunes (Loc. 6) and in the NW plateau forest (Loc. 1). It was not recorded in September 1987 or in April 1988. A widespread and often common insect in the Old World tropics and subtropics, *H. misippus* is established in northern South America, occurs more or less regularly in the Lesser Antilles (Riley, 1975), but is rare or sporadic further north, with a few mainland U.S. (Florida) records. Wolcott (1948) cites several records from Puerto Rico and S. J. Ramos has subsequently collected it on several occasions. The larval food plants are generally listed as Malvaceae (*Ipomoea*, *Portulaca* etc.) (Comstock, 1944; Riley, 1975): both genera are well represented on Mona, though listed by Woodbury *et al.* (1977) respectively as members of the Convolvulaceae and Portulacaceae.

*****Vanessa cardui*** (Linnaeus 1758). This cosmopolitan species, noted for wandering far from its breeding areas, is added to the Mona list by two specimens seen (and one collected) in coastal scrub/grass adjoining the buildings at Sardinera, on 10 April 1988. The insect collected was in relatively fresh condition, with no wing damage: the following day, no specimens were seen. Comstock (1944) noted that he had not seen *V. cardui* from Puerto Rico but Wolcott (1948) cited a specimen from Cayey and noted that early authors (Dewitz and others) knew it as a rare visitor. Of the occasional Antillean records, Riley (1975) suggests that *V. cardui* "... is not known for certain to breed anywhere in the islands."

LYCAENIDAE

*****Tmolus azia*** (Hewitson 1873). The interest provided by this 'hairstreak' is quite incommensurate with its size! Not mentioned by Riley (1975) from any 'West Indian' locality, it was cited by Howe (1975) as ranging from South America into southern Arizona and Texas [TL 'Mexico']. In the last decade, it has been noted frequently in S. Florida and, more recently, in the Dominican Republic (e.g. Boca de Yuma and Rio Chavón, July 1986 (DSS)) and in western Puerto Rico (SJR), while the first Antillean record is that of Vyhmeister (1980), in Jamaica. *T. azia* is newly recorded for Mona from specimens collected along the mimosa (*Leucaena leucocephala*) stands, bordering the airstrip in September 1987. In April 1988, this species was common in the area, nectaring on newly opened Mimosa blossoms, from early morning through late afternoon. Its small size, rapid flight, inconspicuous coloration and evidently (from Hispaniolan data) short adult flight period render this butterfly very readily overlooked. We suggest that its remarkably extending range is more likely to reflect awareness of its possible presence among collectors, rather than a dramatic colonizing event. On Mona, no adults were seen in July and December 1986, in precisely the same area where it was first noted in September 1987 and commonly in April 1988. The early stages and larval food plant are unknown, though its association with the Mona mimosa stands may be suggestive.

*****Strymon acis mars*** (Fabricius 1777). Until December 1986 (see below) this distinctive insect was the sole hairstreak recorded from Mona. Absent from the lists of Comstock (1944) and J. A. Ramos (1946), a single specimen was collected by S. J. Ramos in June 1975. In July 1986, we found it, never commonly but over a substantial area, with records from the coastal plateau forest NE of Sardinera (Loc. 1), a single specimen on the plateau near Bajura de los Cerezos (Loc. 4) in coastal shrub above Playa de Pajaros (Loc. 3) and bordering the cactus scrub near El Faro, at the SE of the island (Loc. 7): in December 1986, however, it was common in localities 1 and 7, and recorded in all areas collected, including the zone dominated by low cactus (Loc. 8) north of El Faro where few butterflies were noted. Adults were conspicuously absent in all localities visited, in September 1987, but two fresh specimens were collected on the N.W. plateau (Loc. 1) in April 1988. It occurs locally in Puerto Rico and was found in some numbers (SJR, DSS) in December 1986, in the xeric area of Cabo Rojo, SW Puerto Rico. Several subspecies of *S. acis* have

been described, from Florida, through the Bahamas, Cuba, Jamaica and the Cayman Islands, Hispaniola (*S. acis petioni*), to the nominate subspecies in Antigua and Dominica, *S. acis mars* is reported to occur from Puerto Rico, through the Virgin Islands to St. Kitts. Mona specimens are identical to those collected in Puerto Rico. The larval food-plant is *Croton* (Euphorbiaceae), well represented on Mona (Woodbury *et al.*, 1977) by four species.

*****Strymon toussainti*** (Comstock & Huntington 1943). Newly added to the Mona list in December 1986 from 4 specimens collected in the NW plateau forest near Cabo Barrionuevo (Loc. 1) (Fig. 15) and one near El Faro (Loc. 7). It is an inconspicuous hairstreak, flying with *Strymon acis*. We did not find it in the same localities in July 1986 or September 1986, and most seen in December were recently emerged. In April 1988, ten specimens were collected (Loc. 1): some were worn, and these are tentatively ascribed to this species. This species has not been recorded from the main island of Puerto Rico; Riley (1975) mentions two localities in Haiti and one in the Dominican Republic; Schwartz (1983) recorded two Haitian specimens at ca. 500-600m, and *S. toussainti* represents the sole 'Hispaniolan' butterfly in the Mona list, to date. Immature stages and larval foodplant are unknown.

*****Strymon bubastus ponce*** (Comstock & Huntington 1943). This hairstreak was first recorded from Mona in April 1988, when several fresh specimens were collected at flowers of *Lantana* and *Bidens* in coastal/beach scrub near Sardinera (Loc. 2). Locally common in Puerto Rico, and present through the Lesser Antilles, *S. bubastus ponce* is not known from Hispaniola, and thus Mona Island represents the most westerly recorded extension of its range. Immature stages and larval food plant(s) are not known.

*****Electrostrymon angelia boyeri*** (Comstock & Huntington 1943). This subspecies [TL Hispaniola] was first recorded from Mona in April 1988, from a male and a female collected (FM) at mimosa blossoms bordering the air strip near Sardinera (Fig. 1). Several specimens were seen, nectaring in company with *Tmolus azia* (see note 3). Late in the afternoon, this hairstreak was noted, apparently preparing to roost, among the upper branches of a nearby isolated mahogany tree: similar behaviour has been noted in a population of *E. angelia* in Puerto Rico (DSS). Of four subspecies of *E. angelia* in the Caribbean, *boyeri* occurs on Hispaniola, Puerto Rico and the Virgin Islands (Riley, 1975). The larval food plant is unrecorded.

Hemiargus thomasi noeli (Comstock & Huntington 1942). This lycaenid was first recorded on Mona (Comstock 1944) from a single male collected in February 1914 by F. E. Lutz: the first butterfly record for the island. Subsequently *H. thomasi noeli* was collected by J. A. Ramos at Uvero Beach and on the plateau in 1944 and was found to be abundant in all localities by S.J. Ramos in June 1973. In July 1986, we found this insect commonly at Sardinera and in the coastal scrub forest on the NW edge of the plateau (Locs. 1, 2) and in small numbers elsewhere, with only a single record from the central plateau (Loc. 4). Many of the specimens collected in 1986 were small, with FW length ca. 8-9 mm (cf. 10-12 mm commonly reported for *Hemiargus thomasi*). Commoner in December 1986, *H. t. noeli* was generally larger (FW length 10-13 mm): it accompanied *Strymon acis* as one of the few species noted in the exposed low cactus area north of El Faro. [Note: J. A. Ramos (1946) suggested, we are sure correctly, that specimens taken at Sardinera in April 1940 and cited by Wolcott (1941) as '*Hemiargus* sp. near *zachaeina*' were *H. t. noeli*: *zachaeina* is a Central American subspecies of *H. ammon* [TL Costa Rica]. *H. thomasi* was rare in all localities in September 1987, and was the only 'blue' recorded during that visit. In April 1988, *H. thomasi* was noted in most localities, but the sparse adult populations generally represented worn specimens. Klots (1960) states that the larval food-plants of the subspecies of *thomasi* occurring in Florida are *Pithecellobium* and *Guilandina*: on Mona, Woodbury *et al.* (1977) list *Pithecellobium unguis-cati* and several species of *Caesalpinia* (= *Guilandina*) among the Leguminosae of the island.]

*****Hemiargus ceraunus watsoni*** (Comstock & Huntington 1943). This lycaenid is newly recorded from Mona from three specimens collected on the plateau edge above Playa de Pajaros (Loc. 3) in July 1986 and two specimens on *Cassia* along the airstrip road in December. It was not recorded in September 1987 and only a single specimen, at the airstrip in 1988. This subspecies also occurs on Puerto Rico and thence through the Lesser Antilles. This insect, and the last, are indistinguishable on the wing, and further collecting is required to establish the distribution of *H. ceraunus* on Mona. Among larval food plants recorded elsewhere, Klots (1960) cites *Chamaecrista* (= *Cassia*) spp., well represented on Mona.

*****Leptotes cassius*** (Cramer 1775). A single male of this widespread lycaenid was collected in July 1986, above Playa de Pajaros (Loc. 3), representing a new record for the Island. Further material was collected in December 1986: 5 specimens in the NW plateau forest (Loc. 1) and 5 at flowers of *Lantana* in the coastal shrub area near Sardinera (Loc. 6). In the former locality, the first 60 'blue males' netted included three *L. cassius* and 57 *H. thomasi*. These probably represent *L. cassius theonus* (Lucas 1857), occurring widely in the Greater Antilles (Comstock, 1944). *L. cassius* was not found in September 1987, but in April 1988, a few fresh specimens were noted on the coastal plain (Loc. 6). As mentioned for the preceding two species, *L. cassius* joins *H. thomasi* and *H. ceraunus* as a small lycaenid, difficult to identify in flight, and the distribution of these butterflies on Mona will be clarified by further observations in the major habitats.

PIERIDAE

*****Anteos maerula*** (Fabricius 1775). This conspicuous pierid extends through tropical America and is noted by Riley (1975) as extending, in the Antilles, from Cuba to Puerto Rico, and Jamaica and it has been occasionally recorded in S. Florida (Klots, 1960) and in the Bahamas. Added to the Mona list in September 1987, it was collected near the airstrip and recorded frequently in the coastal plain to Uvero, but was not seen on the plateau. Riley (1975) records *Cassia* sp. as the larval foodplant in Cuba: this genus is well represented on Mona (Woodbury et al., 1977).

Phoebis sennae sennae (Linnaeus 1758). First recorded from Mona by J.A. Ramos (1946) (few adults seen flying near the cliff at Sardinera Beach, April 4-7 1944), this widely ranging and often common 'sulfur' was later noted by S. J. Ramos (June 1975) and in July 1986, when it was most frequent near Sardinera (Locs. 2,6) but seen occasionally in all localities except the central plateau (Loc. 4): in December 1986, September 1987 and April 1988 it was less common. In Puerto Rico (Comstock, 1944) the main food-plant is said to be *Cassia occidentalis*: this, and other *Cassia* spp. are present on Mona (Woodbury et al. 1977).

*****Phoebis agarithe antillia*** Brown 1929. Previously found only by S. J. Ramos (three specimens, in October 1973), it was recorded near the airstrip and the beach area of Playa las Mujeres, in September 1987 and April 1988. Larvae have been noted on '*Pithecolobium*' spp. (Wolcott, 1944): *Pithecolobium unguis-cati* (and other leguminous potential food-plants) are reported by Woodbury et al. (1977).

*****Eurema nicippe*** (Cramer 1782). Added to the Mona list by two specimens on the plateau near El Faro, December 1986 (DSS). This widespread and invariant species is locally common on Hispaniola and Puerto Rico, extending through Cuba and the Bahamas into the southeastern United States. Riley (1975) cites *Cassia* as larval foodplant, well represented on Mona.

(*Eurema daira palmira* (Poey 1853).) Listing of *E. daira* on Mona rests on a single female specimen (recorded as *E. palmira palmira*) mentioned by J. A. Ramos (1946) and determined by Comstock. While males of *E. elathea* (see below) are readily distinguishable from males of *E. daira*, individual females cannot reliably be separated (see Riley, 1975). Both species

are present on Puerto Rico (Comstock, 1944) and *E. daira* is tentatively retained on the present list, in particular to encourage careful examination of *Eurema* series collected on Mona. Comstock (1944) cites Gundlach's account of immature stages, with *Desmodium* cited as the larval food plant in Cuba; four species of this leguminous genus are present on Mona (Woodbury *et al.*, 1977.)

*****Eurema elathea*** (Cramer 1775). This species was first collected on Mona by S. J. Ramos (five males, June 1975) and we found it to be common in July 1986, notably around the Sardinera buildings and in the disturbed area around the airstrip (Loc. 2), and, in very small numbers, on the plateau edge above Playa de Pajaros (Loc. 3). In September 1987, a few adults were noted, all near the airstrip. All specimens collected in July and September correspond to the 'wet season' form (typical *elathea*) while in December a small proportion of both sexes represented the 'dry season' form (*elathides* Staudinger). In April 1988, *E. elathea* was sparsely present bordering the airstrip, the majority representing f. *elathides*, thus determining the dry season morph, at least for 1987-1988. Jordan (1973) mentions the rainfall pattern of Mona (average 32" annually) as distributed with January through March as usually dry (less than 2" per month) and with a relatively rainy season in August through November, with a secondary higher probability of rain in May. Further work is obviously needed to determine the pattern of seasonal variation in *E. elathea*. The larval food plant on Mona is unknown: the genera cited by Riley for this species in Brazil (*Zornia*) and Jamaica (*Stylosanthes*) are not listed by Woodbury *et al.* (1977) but a wide variety of legumes are available on the island to maintain the populations present (and see *E. daira*, above).

Eurema lisa euterpe (Ménétriés 1832). First recorded by J. A. Ramos (1946) from "two males, one white and one yellow female on the plateau, July 20, 1944". In July 1986, *lisa* was present in the same localities as *E. elathea* (see above) but less commonly: in December 1986 it was rarely seen, and in September 1987, it was one of the few species recorded on the N.W. plateau (Locs. 1,9), and was not noted in April 1988. No preferred legumes are noted as larval food plants for *E. lisa* elsewhere, and a wide range is available on Mona.

Ascia monuste eubotea (Latreille 1819). Riley (1975) cites *A. monuste evonima* (Latreille 1836) as representing this species in the Greater Antilles, but Comstock's (1944) reference to *monuste eubotea* for "the phase of *monuste* which occurs generally in the Antilles" is probably to be preferred pending further evaluation of West Indian, and notably Puerto Rican material (S. J. Ramos, in preparation). *A. monuste* was first recorded on Mona from two males and one female at Sardinera Beach in June 1944 (J. A. Ramos 1946). It was found in 1975 (S. J. Ramos), and on our July and December 1986 visits was abundant, especially in the vicinity of Sardinera and in the disturbed plantation/road area east of Sardinera; elsewhere occasional, and not seen on the plateau (Loc. 4). In September 1987, this pierid was present, generally in large numbers in most localities, and was occasionally seen on the N.W. plateau (Locs. 1,9) where few butterflies were recorded. On isolated beaches along the south coast (Playa el Caigo) it was extremely abundant around sea grape and other maritime plants, where other butterflies were absent. In September 1987, 'puddling' clusters of up to 100 male *A. monuste* were seen before midday at mud patches on the track near Uvero: a small group is shown in Fig. 11. No other species was noted among the numerous aggregates observed. In April 1988, *A. monuste* was markedly scarce. [J. A. Ramos cites Comstock's comment on his female specimen as "dark ... like many from Hispaniola" — presumably this refers to the form *phileta* (Fabricius 1775) which occurs sporadically in Southern U.S. populations and elsewhere, and has no preferential association with any part of the West Indies]. A variety of Cruciferae and Capparidaceae (Capparaceae) have been noted as larval food plants of *A. monuste* (Comstock, 1944; Klots, 1960; Riley, 1975); both families are well represented on Mona (Woodbury *et al.*, 1977). This pierid appears to be remarkably opportunistic in its larval diet, perhaps contributing to its local abundance and irregular migratory behaviour. Klots (1960) cites Saltwort (*Batis*)

as an unusual food plant for a pierid, and suggests a connection between this and the 'migratory phase' — a plausible (but apparently unsubstantiated) hypothesis!

Appias drusilla boydi (Comstock 1943). Comstock (1944) records this pierid from Mona, in February, together with several Puerto Rican records, but without further information. J. A. Ramos collected four specimens on three visits to Mona in 1944, and S. J. Ramos added a further five specimens in June 1975. Seven specimens were collected (DSS) in July 1986 in the 'hammock' forest beneath the cliff between Sardinera and the airstrip, and it also occurred there in December 1986, September 1987 and April 1988, when it visited *Guaiacum* flowers. Three females collected in April 1988 showed very reduced black markings FW above, approaching the 'dry season' f. *peregrina* Röber described from Cuban populations of *A. d. poeyi* (Butler 1872). This very restricted forest area much resembles residual hardwood 'hammock' forests of South Florida, where *A. drusilla* is still locally common. In this area (Loc. 5) *A. drusilla* is not readily distinguished on the wing from *Ascia josephina* (see below). The larval food plant on the island is unknown: Klots cited *Capparis* spp. (in Brazil), and two species of this genus (*C. cynophallophora* and *C. flexuosa*) are reported for Mona by Woodbury *et al.* (1977), the distribution of which includes the very limited area where *A. drusilla* was found during the recent surveys.

*****Ascia josephina krugii*** (Dewitz 1877). This pierid is newly recorded from Mona by three female specimens collected in July 1986 in the 'hammock' forest beneath the cliff, east of Sardinera (Loc. 5). *A. josephina* was not uncommon in this locality (extending west to the cliff above Sardinera) but was generally flying high towards the canopy and difficult to capture. It was present in December 1986, but in smaller numbers and again more frequently in September 1987 when one male and one female were collected. In April 1988, this pierid was similarly frequent in the cliff forest canopy, but a short series was collected, nectaring at a low lignumvitae tree (*Guaiacum officinale*). These specimens were fresh, and revealed that the ground color in both sexes is pale blue-green, rather than white. Until this report, *A. j. krugii* was known only from the type locality [S. W. Puerto Rico], and differs (Figs. 12c, d) from the larger and more heavily marked nominate subspecies on Hispaniola (Figs. 12a, b), and from the Jamaican form (*A. j. amaryllis*) in which the female is 'yellowish and devoid of discal markings' (Riley, 1975). The subspecies occurring on Mona is undoubtedly in common with that described from Puerto Rico. No information is available on immature stages of this relatively little-known Greater Antillean endemic species.

*****Kricogonia lyside*** (Godart 1824). Unrecorded by Comstock (1944) and J. A. Ramos (1946), this widespread pierid was first noted on Mona by S. J. Ramos in October 1973 and June 1975, and a single specimen was collected in the coastal shrub area (Loc. 6) in December 1986. In September 1987 *K. lyside* was frequent in coastal shrub at Playa las Mujeres, and specimens collected included the yellow form *unicolor* Godman & Salvin. In April 1988, a single worn specimen was noted at Uvero. This species, widely ranging in the West Indies, is somewhat sporadic in its occurrence (e.g. in South Florida), but generally abundant in the Antilles, south to Venezuela. The usual larval food plant is Lignumvitae (*Guaiacum*). Woodbury *et al.* (1977) note the presence of Lignumvitae in the Uvero area (S. W. Mona) and cite Little's statement that "quantities of the valuable wood were removed in the past".

PAPILIONIDAE

*****Heraclides aristodemus aristodemus*** (Esper 1794). Sightings of a swallowtail were made at Sardinera in July 1986, and again in the coastal scrub/plantation bordering the beach east of Sardinera (Loc. 6) in December 1986. In September 1987, the expectation that these insects are *P. aristodemus* was confirmed by a specimen collected at Uvero and determined as the nominate subspecies. Other adults were seen near Uvero and Sardinera. Riley (1975) cites the nominate subspecies as occurring in Hispaniola: it is

also resident (SJR) in western Puerto Rico (Guánica xeric forest and other localities). Thus the Mona population appears to conform to those of its two close neighbors. Cuba and the Cayman Islands support the subspecies *temenes* Godart 1819, while another subspecies *bjordnali* Clench 1980 has recently been described from Great Inagua Island, Bahamas (Clench and Bjørndal, 1980) and yet another, *majasi* L. Miller 1987 flies on Crooked Island in the Bahamas. The subspecies *ponceanus* occurs in South Florida (Schaus' swallowtail): subspecific radiation over relatively small distances in the Antilles suggests that this swallowtail, though strongly flying over short distances, has a low dispersal potential. *P. aristodemus* (and related species) use various Rutaceae as larval foodplants, and representatives of the genera *Amyris*, *Citrus*, *Triphasia* and *Zanthoxylum* are cited by Woodbury *et al.* (1977), potentially supporting a resident population of this swallowtail.

HESPERIIDAE

*****Polygonus leo savignyi*** (Latreille 1824). The 'Hammock skipper' is newly recorded from Mona: in July 1986, three specimens were collected (DSS) in the 'hammock' forest (Loc. 5) beneath the cliff, adjoining the cleared airstrip area. On first entry into this narrow belt of hardwood forest, this species (and *Appias drusilla*, *Marpesia petreus* and *Eunica tatila*) were particularly sought, since the habitat so clearly resembled the South Florida localities where these butterflies are to be expected, and it was gratifying to find all but the last, (with the unexpected record of *Ascia josephina* making up for this deficiency!) The specimens collected are clearly of the above subspecies [cited by Riley (1975) as occurring in the Bahamas, Cuba, the Virgin Islands and Montserrat] (Fig. 14a) and conspicuously differing from the Hispaniolan *P. leo ishmael* Evans 1951 (Fig. 14b), in which the ground colour of the hindwing underside is grey-green, rather than purple. Riley (1975) does not mention *Polygonus leo* from Puerto Rico in the text, but includes this island in his check-list of distribution. *P. leo savignyi* has been collected in Puerto Rico (SJR, DSS) in a few locations and in very limited numbers. A series of *P. l. ishmael* was collected (DSS) near Bavaro, at the eastern tip of Dominican Republic (Hispaniola) in January 1986, representing a striking demarcation between two subspecies, separated by only ca. 40 miles of the western Mona Passage. In December 1986, no adults of *P. leo* were seen; presumably only immature stages were then present but a few adults were seen in the same locality in April 1988. Among the variety of larval food plants noted for *Polygonus leo*, at least one, *Lonchocarpus* (Leguminosae) is represented on Mona (*L. domingensis*); possibly as an introduction (see Woodbury *et al.*, 1977).

*****Urbanus proteus domingo*** (Scudder 1872). This appears to be an uncommon skipper on Mona. It was first reported (Wolcott, 1941) as "abundant on flowers of *Moringa moringa* and *Pisonia albida* at Sardinera Beach, April 1, 1940" (see J. A. Ramos, 1946), but Wolcott (1948) deleted it from the Mona list, noting that specimens collected there by Martorel proved to be *Urbanus dorantes*. Thus the first confirmed record is that of S. J. Ramos (June, 1975). In July 1986, we collected a single specimen on the NW plateau (Loc. 1), and two in the same area in December 1986. It was not recorded on our September 1987 visit, but *U. dorantes* was quite common on the NW plateau in April 1988, and a fresh specimen was noted on the coastal plain.

Urbanus dorantes cramptoni (Comstock 1944). In describing this subspecies, Comstock (1944) designated the holotype as a male from Mayagüez (Puerto Rico) and included three specimens from Mona in the paratype series. *A. d. cramptoni* represents the form of this skipper occurring in Hispaniola, Puerto Rico and the Virgin Is. We found *U. d. cramptoni* (July 1986) to be widespread, in all localities except the interior of the plateau, but nowhere common. In December 1986 it was scarcer, and found mainly in the NW plateau forest; in September 1987, it was once again more common, but was not seen on the plateau though it was common on the NW plateau in April 1988. In describing this subspecies, Comstock (1944) noted that, of over 100 specimens examined, "sixty per cent showed the spots reduced to less than half the size of those in typical *dorantes*" [TL Surinam].

Further, "in some specimens, some of the spots are obsolete or absent, and in two specimens, the spot in cell M_3 is the only one remaining, and that in the form of a thread-like bar." Figure 13a illustrates a Mona example with conspicuous hyaline spots, while in Figs. 13b and c, spot reduction approaches the level mentioned by Comstock, above. The larvae of this, and the next species, feed on legumes. (We are grateful to S. Steinhäuser for confirming the identity of Mona specimens by genitalic dissection.)

Ephyriades arcas philemon (Fabricius 1775). J. A. Ramos (1946) reported a single specimen from the plateau in July 1944. In July 1986, we found it locally frequent in the grassy verges of the air strip and along the road to Sardinera but rarely elsewhere (Playa de Pajaros, El Faro: Locs. 3, 7). It was generally common in December 1986. A series of 12 females was collected in July 1986 and, in these specimens, the character cited by Riley (1975) to distinguish between the female of *E. arcas* and *E. zephodes* (lack of alignment of the forewing hyaline spots in space 2 and in the cell) was not uniformly satisfactory. However, genitalic dissection (DSS) of the three male specimens collected in July 1986 showed them to be *P. arcas* (see Evans, 1953) and it is almost certain that all the above females are of this species. *E. arcas* was scarce in September 1987 and restricted to the S.W. coastal plain.

There has been considerable confusion on the status and distribution of these closely related skippers. Comstock (1944) regarded *zephodes* as a synonym of female *arcas*, but Evans (1953) showed the two species to be clearly separable by male genitalic characters and points out that the figure of Williams (1931) labelled as '*arcas*' (from Cuba), is in fact of *zephodes*. Riley (1975) cites *E. zephodes* as "apparently widespread in Cuba and Hispaniola, less common in Puerto Rico, the Virgin Isles, St. Thomas and St. Bartholomew" and the range of *E. arcas philemon* as Jamaica, St. Thomas and Cuba. He then mentions that "... both appear to occur in Puerto Rico (although this is by no means certain)." Other than a pair with Puerto Rican data cited by Evans as in the British Museum (Natural History) collection, we know of no evidence of the occurrence of *zephodes* on that island. Males from several localities in Puerto Rico examined by DSS (Cambalache, Sabana Seca, Culebra Is. etc.) all proved to be *E. arcas* (*sensu* Evans).

Riley (1975) gives the larval food plants as *Stigmaphyllon ligulatum*, *Malpighia fulcata* and *Ceiba pentandra*, though pointing out that it is uncertain to which of the above two species the description of larval stages refers. Representatives of the first two of these genera of Malpighiaceae occur on Mona (Woodbury *et al.* 1977).

Pyrgus oileus oileus (Linnaeus 1767). Wolcott (1944) collected this species (identified as *Pyrgus syrichtus*) at Sardinera in August 1939 and March 1940, and J. A. Ramos found it on the plateau in August 1944. We found it quite commonly in July 1986 around Sardinera, and occasionally in other localities, except on the plateau, while in December 1986 it was widespread, except in the NW plateau forest and in September 1987 and April 1988, commonly around Sardinera, and rarely elsewhere. Recorded food plants include a range of Malvaceae, a family well represented on Mona (Woodbury *et al.*, 1977).

Cymaenes tripunctus tripunctus (Herrich-Schaeffer 1865). Recorded (as *Lerodea tripuncta*) by Wolcott (1941) from specimens collected at Sardinera in August 1939, and by J. A. Ramos (1946) from the same locality in August 1944. In July and December 1986, we found this skipper to be extremely local, but common in deep shade at the edge of the 'hammock' forest beneath the SW cliff (Loc. 5) and east of Uvero along the shady hill linking the coastal plain with the plateau see Fig. 1). In September 1987 and April 1988, it was rare, and recorded only from the cliff forest (Loc. 5). Comstock (1944) reports Guinea Grass (*Panicum maximum*) as a larval food plant in Puerto Rico: this, and other species of *Panicum* occur on Mona (Woodbury *et al.*, 1977).

*****Perichares philetes philetes*** (Gmelin 1790). Newly recorded from Mona by a single

specimen collected (DSS) July 1986, in deep shade on the edge of the 'hammock' forest beneath the cliff opposite the cleared airstrip area (Loc. 5). Riley (1975) mentions that this species, widely ranging from Cuba, Hispaniola, Jamaica to Puerto Rico, is 'rather crepuscular ... resting by day in shady forest paths': as was this specimen. Reportedly (Howe, 1975) a minor pest of sugar cane in the West Indies, alternative larval food plants reported include Guinea Grass (*Panicum*), of which the flora of Mona offers four species (Woodbury *et al.*, 1977).

Wallengrenia otho druryi (Latreille 1824). Described as *W. otho mutchleri* Watson, this skipper was first collected on Mona by Wolcott at Sardinera Beach in August 1939 and March 1940 (Comstock 1944; J. A. Ramos 1946). In July 1986, we found it the commonest hesperiid; in the NW plateau forest, around the Sardinera buildings, along the track to Carabineiros Beach, and in the *Casuarina* area between. In December 1986 it was considerably less common and rare in September 1987 though again common and widespread in April 1988. A wide range of grasses are available as larval food-plant(s).

Nyctelius nyctelius nyctelius (Latreille 1824). This skipper, readily distinguished by its underside pattern, was presumably first recorded from Mona by Wolcott (1941) (as *Panoquina nyctelia*) collected at Sardinera Beach and later thus cited by J. A. Ramos (1946). Two further specimens were collected in July 1986, at the edge of the 'hammock' forest beneath the cliff (Loc. 5) three in December 1986 on the dunes near Mujeres beach. It was noted in the same locality in September 1987 and in April 1988. The larval food-plants reported include a variety of grasses.

*****Panoquina panoquinoides panoquinoides*** (Skinner 1891). Other than the subspecies *P.p. eugeon* described by Godman and Salvin 1896 from Grenada and the Grenadines, this skipper displays a wide and invariant range from Florida and Texas, generally through the Antilles and Central America into South America. It was newly recorded from Mona in July and December 1986 and September 1987 in the grassy scrub bordering the air strip, east of Sardinera and in the adjoining coastal shrub. Riley (1975) cites sugar cane and Bahama grass (*Cynodon dactylon*) as larval food plants: the latter is present at Sardinera (Woodbury *et al.*, 1977).

*****Panoquina sylvicola*** (Herrich-Schaeffer 1865). This skipper is present throughout the West Indies south of the Bahamas, but was first recorded from Mona during our visit in July 1986, when specimens were collected in the dune area bordering the beach near Sardinera (Loc. 6), where further specimens were noted in December 1986 and September 1987. Larval food plants reported include several grasses.

DISCUSSION

At first sight, with its small size and largely xeric ground cover, Mona Island might be thought an unpromising candidate as a source of useful data on butterfly community distribution. Four centuries ago, and for some time thereafter, Mona had fresh water, but now the only standing water is brackish and restricted to a small pond and a one acre stand of mangrove. Jordan (1973) was unable to account for the transition other than suggesting 'climatic changes and changes in land use' and, speaking as a hydrologist, summarized the island as a 'barren scrub-covered waste'. Thompson (1987), considering the land snails, considered Mona as a 'desert island'. Yet Mona has been uniquely preserved through historical chance, and today supports a considerably more extensive and varied butterfly fauna than might be predicted from its area and terrain.

In any approach to specific and intraspecific diversity in an island group such as the Antilles, the biogeographical concepts of MacArthur and Wilson (1967) are of obvious importance. However, as Gilbert (1984) noted, the perception of an island's fauna as an

'equilibrium' between input by vagrancy or migration, the evolution of new species or races, and extinctions, was first developed by Munroe (1948) with special reference to the butterflies of the West Indies, in an unpublished doctoral thesis. In a subsequent abstract, Munroe (1953) proposed a formal relationship between the number of species in the fauna at equilibrium, the number of potential and actual migrants from neighboring land areas, the probability of extinction of a population and the area of the island considered.

Munroe demonstrated a reasonably close linear relationship between species numbers and the logarithm of island area, throughout the Antilles, from the largest island (Cuba) to the smallest island group considered (Virgin Islands). Most islands deviated only minimally from this plot: only Hispaniola and the Virgin Islands clearly exceeded the expected species number, while Barbados fell well below the predicted count. Munroe accounted for the Hispaniolan cusp largely as a result of the remarkable radiation of the Antillean satyrid genus *Calisto* on the island, now known to be considerably greater (Schwartz 1983, 1985; Schwartz and Gali, 1984; Gali, 1985; Gonzales, 1987) than at the time of Munroe's work. The situation of the Virgin Islands was accounted for by the proximity of the relatively large island of Puerto Rico as a potential immigrant source (possibly reflecting a degree of 'pooling' in the absence of records from individual islands). Conversely, the paucity of butterfly species on Barbados was accounted for by its situation to the windward of the closest immigration sources (the southern Lesser Antilles) which are also small islands; furthermore, Barbados is ecologically monotonous as a consequence of virtual destruction of its native habitats for building or cultivation.

Against the above background, the butterfly fauna of Mona, respectively only ca. 37 and 42 miles from Hispaniola (area: 29,400 mi²) and Puerto Rico (3435 mi²) is of particular interest. An estimate of the richness of Mona's present fauna is provided by closer comparison with Munroe's (1948) data (cf. the species: area plot reproduced as Fig. 3.1 in Gilbert, 1984). Munroe's upward cusp for the 'Virgin Islands' was derived from records from the British Virgin Islands (67 mi²) in area, St. Croix (U.S. Virgin Islands) being afforded a separate point. Twenty eight species were recorded by Munroe from the former, 61% of the present Mona total on an island group almost three times the area of Mona. Riley (1975) lists 41 species from the Virgin Islands *in toto*, substantially less than the present Mona list, but distributed over ca. 200 mi², almost nine times the area of Mona.

Data further underlining the richness of Mona's butterfly fauna has been provided by Clench and Björndal (1980) (updated by Simon and Miller 1986) in their survey of Great and Little Inagua Islands, the southernmost components of the Bahamas chain, lying approximately equidistant (ca. 56 mi/90 Km) to the NE and N of Cuba and Hispaniola. These islands are arid, though retaining some fresh water, and are apparently relatively undamaged by human activity, though continuously populated for a long period. These islands, respectively ca. 580 mi² (1500 Km²) and 49 mi² (127 Km²) in area yielded 34 and 19 butterfly species³. Little Inagua, over twice the area of Mona, is presently known to support less than half of the confirmed Mona species count. Yet these islands are little further from Cuba and Hispaniola than is Mona from the latter and Puerto Rico. A comparison from the Lesser Antillean island of Montserrat is provided by Schwartz and Jiménez (1982): from this mountainous island (200 km²), over three times the area of Mona, extensive recent work has documented 38 species.

Scott (1972, 1986) has provided an interesting statistically based overview of the affinities of Antillean butterflies with respect to islands and island groups and the continental land masses of North, Central and South America, resulting in a number of proposals concerning patterns and routes of origin and dispersal of endemic and non-endemic species and genera within the area. Scott made extensive use of an 'index of

³. Clench and Björndal (1980) comment on these figures that Great Inagua has only 34 known species "instead of the roughly 48 that would be expected of an island of its size in the Bahamas [and that] similarly, Little Inagua has only 19 species, instead of an expected 25." Reference to the basis of these extrapolations is not given, but they would fall reasonably close to Munroe's original species/log. area plot (see Munroe, 1953; Gilbert, 1984).

faunal resemblance' between an island pair (or an island and a continental land mass) defined as "the percentage of species found on the island with the smaller fauna which are the same as those on the island [or continental land mass] with the larger fauna": for affinity analysis, as Scott points out, this index has the advantage of not being directly linked with island area and absolute species numbers. Use of this index was discussed by Munroe (1957) as one means by which closely related faunas may be compared.

This approach, while valuable in assessing affinities within a large geographical area, including many land masses varying greatly in size, is limited, as Scott noted, by the reliability of 'zone definition' with respect to continental areas⁴ and by varying completeness of island faunal documentation.

Scott estimated the Hispaniola: Puerto Rico index as 0.89 (i.e. 89% of species on Puerto Rico also occur on Hispaniola). We concur almost exactly with this figure, with 88 Puerto Rican species (including vagrants and recent records), 79 of which are 'shared' with Hispaniola, providing an index of 0.90. It should be noted that recent additions to the faunal list of Hispaniola (notably of *Calisto* species now approaching 30; see Riley (1975) and Schwartz (1983a, b: 1985) and Schwartz and Gali (1984) and *Strymon monopeteinus* (Schwartz and J. Miller 1985) do not affect the index, though augmenting the total species divergence between the two islands.

The 'index of faunal resemblance' however, when employed at the specific level, provides only a general indication of inter-island faunal 'overlap'. The incidence of evolution of island races/subspecies is a notable feature of the Antillean faunas, displayed both between island populations and between these and continental populations. With respect to the Hispaniolan and Puerto Rican butterflies, of the species common to both islands, 15 are represented on Puerto Rico (and in some instances also on the Virgin Is. and elsewhere) by subspecies *not* occurring on Hispaniola. When these are considered, the incidence of congruence falls substantially to 0.73, leaving the difference (an 'index of subspecific disparity') of 0.17 (or 17% of the Puerto Rican and associated taxa).

Scott (1972) rejected the selection of 'a few examples' in his wide treatment of the Antilles, but we do not accept his suggestion that selection necessarily implies a 'favorite view' and propose, rather, that detailed comparison between island pairs or groups may yield valuable information, affording 'high resolution' insight into the origin and dispersal pattern of certain West Indian butterflies (see also Munroe, 1957). The proliferation of subspecies of butterflies such as *Battus polydamus* and *Dryas iulia* provides well known examples of divergence in populations separated often by short distances. In the Hispaniola: Puerto Rico context, a number of species and subspecies are common to (and restricted to) these two islands: e.g. *Lycorea ceres cleobaea*, *Libytheana terena*, *Dismorphia spio*, *Panoquina nero* and *Achlyodes thraso sagra*, etc.). Of particular interest here are species common to both islands, but which have evolved distinct subspecies in populations separated by as little as the ca. 80 miles of the Mona Passage, in which Mona Island is situated.

Of Mona's presently documented 46 species, 44 are common to Hispaniola, and 45 common to Puerto Rico: *Marpesia petreus* and *Strymon bubastus* occur on Mona (and Puerto Rico) but not on Hispaniola, where *M. eleuchea* is present, while available records suggest that the converse is true of *Strymon toussainti*.

The affinity and probable derivation of Mona's butterflies is substantially clarified when comparison with its neighbours is extended to the subspecific level. While island area

⁴ For example, in considering the affinities of the butterflies of southern Florida and the Florida Keys *vis-à-vis* Antillean faunas, we suggest that Scott's original figures of 119 and 80 species to be, respectively 20% and 30% too high: the former discrepancy resulting from differing definitions of the limits of 'southern Florida' and the latter from acceptance of an inaccurate statement that certain species are found 'throughout the State'.

alone might suggest a migratory input biased toward Hispaniola rather than Puerto Rico as the primary potential 'donor' source of immigrants, (the ratio of areas being ca. 9:1), the observed Mona fauna is contrary to this expectation.

Where subspeciation has occurred between Hispaniola and Puerto Rico, the sub-set of butterflies recorded from Mona clearly represents an extension of the smaller easterly, rather than the larger westerly island. Comparisons are summarized as follows:

| MONA (and Puerto Rico) | HISPANIOLA |
|---|---------------------------------------|
| <i>Danaus plexippus portoricensis</i> | <i>Danaus plexippus plexippus</i> |
| <i>Heliconius charitonius charitonius</i> (with 'punctatus') | <i>Heliconius charitonius churchi</i> |
| <i>Dryas iulia iulia</i> | <i>Dryas iulia hispaniola</i> |
| <i>Anaea troglodyta borinquenalis</i> | <i>Anaea troglodyta troglodyta</i> |
| <i>Euptoieta hegesia watsoni</i> | <i>Euptoieta hegesia hegesia</i> |
| <i>Strymon acis mars</i> | <i>Strymon acis petioni</i> |
| <i>Hemiargus ceraunus watsoni</i> | <i>Hemiargus ceraunus ceraunus</i> |
| <i>Ascia josephina krugii</i> | <i>Ascia josephina josephina</i> |
| <i>Polygonus leo savigny</i> | <i>Polygonus leo ishrael</i> |

These nine butterfly subspecies provide a direct 19.6% linkage between the Mona/Puerto Rico fauna rising to 24% when the 'Puerto Rican' *Marpesia petreus* and *Strymon bubastus* are included, with only *Strymon toussainti* documenting a small (2.2%) 'Hispaniolan' input. The bias towards Puerto Rico becomes even more striking when the Mona fauna is viewed in the context only of species that are represented by distinct subspecies on Hispaniola and Puerto Rico. Including the recently described Puerto Rican subspecies *Pseudochrysops bornoi escobedoi* separated by Schwartz (1986) from the nominate subspecies on Hispaniola, this group numbers 16. Of these, nine (56 per cent) are found on Mona in the Puerto Rican form and no Hispaniolan subspecies have been recorded. In one instance (*Anartia jatrophae*) insufficient material from Mona is available to sustain a reliable determination of one subspecies or another, while five potential 'indicator' species (*Pseudochrysops bornoi*, *Strymon columella*, *Adelpha gelania*, *Proteides mercurius*, and *Phoebis argante*) are not at present known to occur on Mona. Beyond this morphological analysis, further information on the origins of Mona populations may in future be obtained at the genetic/biochemical level, where populations on the sister islands do not differ in wing pattern from those on Mona.

As with other Antillean islands, the majority of Mona butterflies are widely ranging species, known or presumed migrants or vagrants, or species that have evolved no subspecies within the Antilles (*Vanessa cardui*, *Hypolimnys misippus*, *Eunica monima*, *Kricogonia lyside*, *Junonia evarete*, *Junonia genoveva*, *Cymaenes tripunctus* etc.) or where broadly ranging subspeciation has separated Antillean populations in general from those of continental areas (e.g. *Agraulis vanillae insularis*).

Interestingly, the status of Mona's vascular plant flora appears to show parallels with its butterfly fauna. Woodbury et al. (1977) state that the flora of the island is "for the most part similar to that of the Guánica Forest of southwest Puerto Rico, plus a touch of southeastern Dominican Republic. The distribution pattern shows that 40 species are unique. Five are found only in Mona, 27 have migrated west to Mona but not beyond and eight species have migrated east to Mona but not beyond".

It is believed that Mona has never been physically joined to its neighbouring islands (Kaye, 1959; Anon, 1973) and its butterfly fauna has presumably been established by active migration and/or passive wind-borne vagrancy, 'rafting' on flotsam being an extremely unlikely means of butterfly dispersal (Fox, 1963) though from plausible to likely

for some plant and animal species⁵. Wadsworth (1973) records that damaging hurricanes passed over the island in 1511 and 1514 while Calvesbert (1973), extrapolating with due caution from Puerto Rican records, estimates that Mona may be statistically subjected to gusts of over 100 mph every 32 years, with sustained hurricane winds of the same speed every 70 years and extreme storms with devastating winds of 150 mph to be expected three or four times per millennium.

Possible effects of the last on the fauna and flora of Mona are entirely unknown, no such event having occurred in the few decades of biologists' awareness of the island. The most extensive hurricanes, with a diameter filling the Mona Passage, would presumably expose Mona to airstreams from both East and West, but the far more frequent storms of lesser intensity would favor arrival of wind-borne insects from the easterly direction. Whatever the pattern of colonization and extinction on Mona may have been, this easterly bias, in the absence of land bridges with Hispaniola or Puerto Rico, have presumably found expression in the biology of the island throughout its history⁶.

A further feature of interest on Mona's butterflies concerns their species distribution over the island's 23 square miles. Thus far, only two species (*Eurema nicippe* and *Strymon toussainti*) have been noted only from the plateau (90 per cent of the total area): the former is a widely ranging butterfly and special association with the plateau is unlikely. Excluding the unconfirmed records (*Eurema daira* and *Colobura dirce*), just under half the known Mona species (21) are generally distributed on the plateau, the coastal plain, the dune area etc.) while 23 species have so far been found only on the coastal plain and cliff-edge forest, together occupying less than 10 per cent of the island's area. Of these, 5 species (*Eunica tatilia*, *Appias drusilla*, *Ascia josephina*, *Polygonus leo* and *Perichares philetus*) appear to be virtually or entirely restricted to the narrow fringe of primary cliff forest, estimated by Woodbury et al. (1977) as now comprising only 50 acres, or less than 0.4 per cent of the area of Mona. As mentioned above, degradation and clearing of this forest may have started over five centuries ago, was undoubtedly accelerated during the 'Guano period' around the turn of the last century and probably was continued by limited clearing and planting within the last fifty years. Conservation of this tiny but ecologically critical area is a matter of obvious concern.

Although recent work has extended our knowledge of Mona's butterfly fauna, it would be very surprising if further study fails to add to the species list. Although present records place Mona as the most marked upward cusp on Munroe's original species: area plot for the Antilles, it must be stressed that the 24 days (about 300 'man hours') field work in 1986, 1987 and 1988 more than doubled previous time specifically devoted to the island's butterfly fauna. While a substantial number of species are now known from the sheltered NW plateau area, very few have been recorded from the xeric forest of the central plateau or from the scattered *bajuras*: sampling of these regions has been extremely limited and, to our knowledge, no records have been made from the north coast of Mona. Other than recognition of substantial differences between adult populations flying in July and December 1986, September 1987 and April 1988 (documented above), virtually nothing is known of life cycle patterns and seasonality of Mona populations. A few species (notably *Battus polydamas*) almost universally distributed in the Caribbean and conspicuous for their subspecific radiation, seem to be absent from Mona at the present time. Faunal 'prediction' is generally unhelpful, but in the unusual context of Mona it may be noted, for example, that several small and inconspicuous lycaenids (*Pseudochrysops bornoi*,

⁵ Clench (1950) (cited by Kaye, 1959) recorded 14 species of land snail from Mona, and noted that this fauna appears to be more closely allied to those of islands lying to the East, rather than to Hispaniola. While this list was very preliminary, it concerns a group of animals for which 'rafting' is a probable means of dispersal.

⁶ This wind pattern seems likely to contribute to the very occasional capture of 'Puerto Rican' and/or more eastern forms in the Dominican Republic (*Danaus plexippus portoricensis*, *Euptoieta hegesia watsoni*, *Heliconus c. charitonius* 'punctatus') mentioned by Cucurullo (1959).

Chlorostrymon simaethis, *C. maesites*) present on Hispaniola and/or Puerto Rico, are all noted for their localized distribution and brevity of adult flight period. *Strymon toussainti* was first recorded from Mona in December 1986 in precisely the same area in which intensive work failed to reveal it in July, or in September 1987: the tiny *Tmolus azia* was first seen in September 1987, during three days only, yet was common in April 1988. Sporadic field observation leaves recognition of such species to a matter of chance.

When J. A. Ramos (1946) published the most recent list of the insects of Mona, the butterflies accounted for 21 of a total of 526 species. The count of butterfly species has now been more than doubled, to 46, and it is probable that further intensive field work would substantially extend species records of all or most Orders. Ramos recorded 24 insect species endemic to the island, 27 elsewhere known only from the main island of Puerto Rico, 53 occurring elsewhere in the Caribbean but not recorded from Puerto Rico with the balance (80%) representing species ranging widely through the area. Ramos noted that these figures "could be interpreted in the sense that the island's insect fauna had less affinity with that of Puerto Rico itself than with that of the other Greater Antilles" but points out that "the lack of a better knowledge of these islands, especially of Hispaniola, does not permit a more definite statement in this respect". This last reservation is clearly apposite: in a discussion of spread potential between islands, Leston (1957) further stressed the importance of adequacy of knowledge of the available species pool on each land area. Even from presently available records, the 2:1 ratio between 'Greater Antilles' and 'Puerto Rican' species cited from the cumulative data may alternatively be interpreted as reflecting some degree of easterly bias in the structure of the island's insect fauna as a whole, since the land area of Hispaniola alone is nine times that of Puerto Rico, while that of the Greater Antilles represents a potential species pool source distributed over islands totalling over twenty times the land area of Mona's easterly neighbors.

To varying degrees, the islands of the Antilles have all been ecologically degraded by human presence. We have little direct information on the effects of habitat change over the centuries, but this must have resulted in many extinctions, as well as opportunistic colonization of newly created disturbed habitats. Among the few documented instances of extinction are Riley's (1975) note that *Battus p. polydamas* may formerly have been present on Barbados, while *Battus p. antiguus* is known only from a figure in Drury (1770). Some indication of the extent of faunal change may be inferred from comparison between the species diversity of relict (and often very restricted) regions and the damaged areas that surround them; for example, the Guánica xeric forest of western Puerto Rico and the hardwood 'hammock' forest of Cambalache (Puerto Rico) and near Bavaro in eastern Hispaniola. To this list may now be added all areas of Mona and the SW cliff forest in particular, already a 'relict' habitat in an unusually preserved island.

Continuing work on the butterflies of Mona is planned, to extend the present account. In a wider context, we know of no small island in the Caribbean, or indeed, anywhere in the world — of comparable promise in high resolution, small-scale analysis of colonization patterns of insects with varying dispersal potential and of the level of species diversity maintainable on a small land area, proximate to large species pools.

ACKNOWLEDGEMENTS

This work was supported by an Overseas Field Research Travel grant (1986) from the Royal Society (DSS) and, throughout, by the Medical Sciences Campus of the University of Puerto Rico. We are grateful for the help and encouragement offered by the Chancellor, Dr. José Manuel Saldaña. We are grateful to Dr. Eduardo Cardona for granting us permission to work on Mona Island; to Lcda Zenaída Acosta Ronda, Sr Alexis Molinares, Sra Myrna L. Robles and Sra Barbara Cintrón who generously helped us in many ways, and to Secretary Justo Méndez, who arranged our boat transport for the first visit. We thank Srs Raul Quiñones, Israel Cordero, Miguel Antonio Nieves, Juan José Vasquez,

Heriberto Soto, Ivan Negron, José Francisco Bravo, Milton Perez and Ivan Vicente, members of the staff of the Departamento de Recursos Naturales who provided excellent help on Mona at all times. We thank Srs Carlos Torres and José Figueroa (UPR, Mayagüez) for their help with the first survey in July 1986, Sr Jimmy Rodriguez (Instituto de Neurobiología, UPR, San Juan) for his excellent planning and support work on each visit, and Sra Betsy Payne McGinnis (Instituto de Neurobiología, UPR, San Juan) who accompanied us on field work during our last visit. We also thank the two Directors of the Instituto de Neurobiología, first Dr. José del Castillo and then Dr. Richard Orkand, who have approved these studies, which, while stressing the importance of the local fauna, are not strictly 'neurobiological'! We record our special gratitude to Sr. Gerardo Garcia de la Noceda (Instituto de Neurobiología, UPR, San Juan) who flew us and our supplies and equipment from San Juan to Mona and back, on each of our last three visits. In addition, Sr Garcia flew us around the island, enabling us to observe details of the eastern and northern coast, areas difficult to reach, on foot. His generous and tireless help afforded us several extra days' field work, which directly resulted in our adding several new species records to the Mona list. Finally, we thank Mrs. Dierdre Kincaid for her patient help in preparation of the typescript.

REFERENCES

- Aaron, J.M. 1973. Geology and mineral resources of Isla de Mona, P.R. *In* Mona and Monito Islands—an assessment of their Natural and Historical Resources. Estado Libre Asociado de P.R. Office of the Governor, Vol. 2, appendix B:1-7.
- Anon. 1973. Mona and Monito. *In* Mona and Monito Islands—an assessment of their Natural and Historical Resources. Estado Libre Asociado de P.R. Office of the Governor, Vol. 1:26.
- Calvesbert, R.J. 1973. The climate of Mona Island. *In* Mona and Monito Islands—an assessment of their Natural and Historical Resources. Estado Libre Asociado de P.R. Office of the Governor, Vol. 2, appendix A:1-11.
- Clench, H.K. and Björndal, K.A. 1980. Butterflies of Great and Little Inagua, Bahamas. *Ann. Carnegie Mus.* 49:1-30.
- Clench, W.J. 1950. Land shells of Mona Island, Puerto Rico. *J. Conchologie* 90:269-276.
- Comstock, W.P. 1944. Insects of Porto Rico and the Virgin Islands, Lepidoptera (Suborder) Rhopalocera. Scientific Survey of Porto Rico and the Virgin Islands, *Ann. N.Y. Acad. Sci.* 12 Pt.4:421-622.
- Cucurullo, O. 1959. Lista de Mariposas (Rhopalocera) de Santo Domingo, pp. 1-13 (privately published, Santo Domingo).
- Drury, D. 1770. Illustrations of Exotic Insects, London.
- Evans, W.H. 1952. A Catalogue of the American Hesperiidæ . . . in the British Museum (Natural History). Part II. Pyrginae, Section 1. *Urbanus*, 85-101. BM(NH).
- Evans, W.H. 1953. A Catalogue of the American Hesperiidæ . . . in the British Museum (Natural History). Part III. Pyrginae, Section 2. *Ephyriades*, 203-205.
- Fox, R.M. 1963. Affinities and distribution of Antillean Ithomiidae. *J. Res. Lepidopt.* 2:173-184.
- Gali, F. 1985. Five new species of *Calisto* (Lepidoptera: Satyridae) from Hispaniola. *Milwaukee Public Mus. Contr. Biol. & Geol.* 63:1-16.
- Gilbert, L. E. 1984. The biology of butterfly communities. *In* The Biology of Butterflies. Sympos. R. Ent. Soc. Lond. 11. (R.I. Vane-Wright and P.R. Ackery, eds.), Academic Press, N.Y. and London.
- Gonzalez, F.L. 1987. Three new species and one new subspecies in the *grannus* complex of Hispaniolan *Calisto* (Lepidoptera: Satyridae). *Bull. Allyn Mus.*: No. 108:1-17.
- Howe, W.H. 1975. The Butterflies of North America. Doubleday & Co., Garden City, N.Y.
- Jenkins, D. 1983. Neotropical Nymphalidae I Revision of *Hamadryas*. *Bull. Allyn Mus.* No. 81, 1-146.
- Jordan, D.G. 1973. A summary of actual and potential water resources Isla de Mona, P.R. *In* Mona and Monito Islands—an Assessment of their Natural and Historical

- Resources. Estado Libre Asociado de P.R. Office of the Governor, Vol. 2, appendix D-1-8.
- Kaye, C.A. 1959. Geology of Isla Mona Puerto Rico, and note on age of Mona Passage. With a section of the Petrography of the Phospholites (by) Altschuler, Z.S. Coastal Geology of Puerto Rico: Geological Survey Professional Paper 317-C. United States Government Printing Office, Washington, 145.
- Klots, A.B. 1960. A Field Guide to the Butterflies of North America, East of the Great Plains. Houghton Mifflin Co., Boston.
- Leston, D. 1957. Spread potential and the colonization of islands. Supt. Zool. Washington 6:41-46.
- MacArthur, R.H. and Wilson, E.O. 1967. The Theory of Island Biogeography. Princeton University Press, 1967.
- Miller, L.D. and Brown, F.M. 1981. A Catalogue/Checklist of the Butterflies of America North of Mexico. Lep. Soc. Memoir 2:1-280.
- Munroe, E. 1948. The geographical distribution of butterflies in the West Indies. Ph.D. dissertation, Cornell University, Ithaca, N.Y., U.S.A.
- Munroe, E. 1953. The size of island faunas. VII Pacific Science Congr. 4:52-53 (Abstract).
- Munroe, E. 1957. Comparison of closely related faunas. Science, Wash. 126:437-439.
- Ramos, J.A. 1946. The insects of Mona Island (West Indies). J. Agr. Univ. P.R. 30:1-74.
- Ramos, S.J. 1984. Notes on the life cycle and biology of *Anaea troglodyta borinquenalis* (Lepidoptera: Apaturidae). Carib. J. Sci. 20: 19-24.
- Riley, N.D. 1975. A Field Guide to the Butterflies of the West Indies. Collins, London.
- Schwartz, A. 1983a. Haitian butterflies. 1-69, Editora Taller, Santo Domingo, Dominican Republic.
- Schwartz, A. 1983b. A new Hispaniolan *Calisto* (Satyridae). Bull. Allyn Mus. No. 80:1-10.
- Schwartz, A. 1985. A new subspecies of *Calisto* (Satyridae). From Hispaniola. Bull. Allyn Mus. No. 93:1-5.
- Schwartz, A. and Gali, F. 1984. Five new species of *Calisto* (Satyridae) from Hispaniola. Bull. Allyn Mus., No. 85:1-18.
- Schwartz, A. and Jiménez, C.J. 1982. The butterflies of Montserrat, West Indies. Bull. Allyn Mus. No. 66:1-18.
- Schwartz, A. and Miller, J.Y. 1985. A new species of hairstreak (Lycaenidae) from Hispaniola. Bull. Allyn Mus. No. 99:1-6.
- Scott, J.C. 1972. Biogeography of antillean butterflies. Biotropica 4:32-45.
- Scott, J.C. 1972. Distribution of Caribbean butterflies. Papilio N.S. No. 3:1-26 (privately issued).
- Simon, M. and Miller, L. D. 1986. Observations on the butterflies of Great Inagua Island, Bahamas, with records of three species new to the island. Bull. Allyn Mus., No. 105:1-14.
- Steinhauser, S. A revision of the *proteus* group of the genus *Urbanus* Hübner Lepidoptera: Hesperidae. Bull. Allyn Mus. No. 62:1-41.
- Thomson, F.G. 1987. A review of the land snails of Mona Island, West Indies. *Bull. Fl. State Mus. Biol. Sci.*, 31. 69-106.
- Turner, T.W. and Parnell, J.R. 1985. The identification of two species of *Junonia* Hübner (Lepidoptera: Nymphalidae): *J. evarete* and *J. genoveva* in Jamaica. J. Res. Lepidopt. 24:142-153.
- Vyhmeister, G. 1980. *Tmolus azia* in Jamaica: a new record for the West Indies. J. Lep. Soc. 34:60.
- Wadsworth, F.H. 1954. Nuestra Isla de Tesoro. San Juan, Dept. of Public Instruction Press, 3rd ser., No. 24:1-59.
- Wadsworth, F.H. 1973. The historical resources of Mona Island. In Mona and Monito Islands-an Assessment of their Natural and Historical Resources. Estado Libre Asociado de P.R. Office of the Governor, Vol. 2, appendix N:1-37.
- Wolcott, G.N. 1941. Supplement to "Insectae Borinquensis". J. Agr. Univ. P.R. 25:33-158.
- Wolcott, G.N. 1948. The Insects of Puerto Rico. Lepidoptera Rhopalocera. J. Agr. Univ. P.R. 32:537-573.
- Woodbury, R.C., Martorel, L.F. and Garcia-Tuduri, J.G. 1977. The flora of Mona and Monito Islands, Puerto Rico, West Indies.

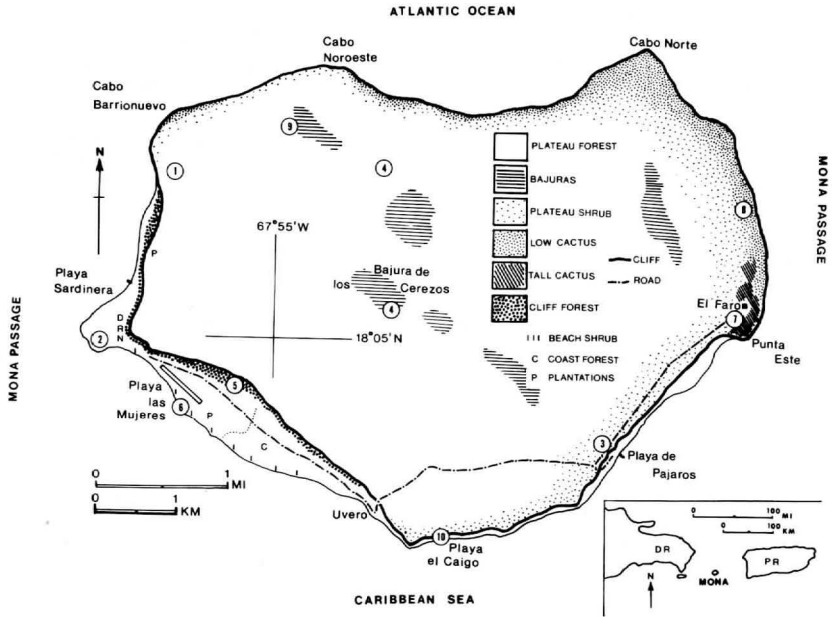


Fig. 1. Map of Mona Island (based on Woodbury et al., 1977). Numerals (1-10) indicate sites visited in 1986, 1987 and 1988: see p. 4, text and Figs. 2-10.



Fig. 2. Approaching Mona from the East: note the sheer cliff, and the bare cactus zone fringing the cliff edge merging with the xeric forest of the plateau. Punta Este is off the print to the right, and Cabo Norte is seen in the distance.



Fig. 3. View from the lighthouse (El Faro) (Loc.7) to the NNW: tall cactus in the foreground merges with the general plateau forest. A *bajura* area, rising above the central plateau forest, is seen in the distance (arrow).



Fig. 4. The edge of a *bajura* on the NW plateau (Loc. 9) south of Cabo Noroeste. The taller, more varied and more mesic trees of the depression in the plateau surface are sharply demarcated from the general xeric plateau forest.



Fig. 5. Illustrating typical vegetation and substrate on the plateau (Loc. 4): note the eroded limestone, often 'stepped' as here, and the xeric forest, occasional trees reaching a height of ca. 7m (Woodbury et al., 1977) including *Tabebuia*, *Bursera* and *Metopium*.



Fig. 6. *Bajura* forest: in the major depressions on the plateau, the forest is taller, more varied and more mesic, with (as illustrated here) large *Ficus* and a variety of other trees, extending from the moist sink-holes in the surface limestone.



Fig. 7. Vegetation (coastal scrub) at the cliff edge, above Playa de Pajaros (Loc. 3). This area includes ground cactus, larger cactus species, *Plumeria*, *Agave*, *Croton*, *Eupatorium*, *Cuscuta*, etc. FM provides a 'scale'.



Fig. 8. The cliff and associated cliff forest, above Sardinera. The forest (Loc. 5) extends upwards beyond the cliff base, and in a narrow strip adjoining the cliff base. This restricted forest includes *Mastichodendron*, *Bursera*, *Lonchocarpus*, etc. with the largest trees present on Mona.



Fig. 9. Within the cliff forest (Loc. 5), the varied canopy permits the growth of a substantial understorey of saplings and ground plants. These very limited areas resemble 'open' hammock forest of S. Florida or relict lowland forest in Puerto Rico.



Fig. 10. Coastal vegetation in the 'disturbed' area near Sardinera. This region is dominated by *Casuarina* and mixed grass and *Lantana* scrub, with a variety of leguminous shrubs (*Pithecellobium*, *Canavalia*, etc.) Playa de Sardinera is obscured in this photograph, but the distant cliff towards Cabo Barrionueva is seen at left.



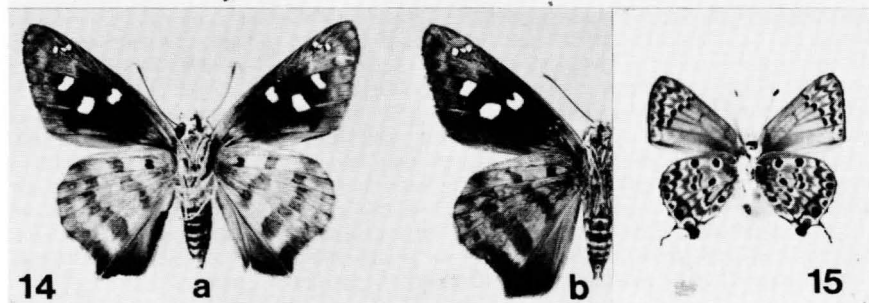
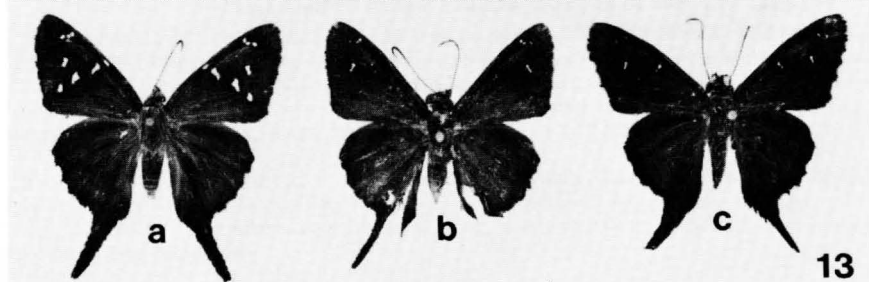
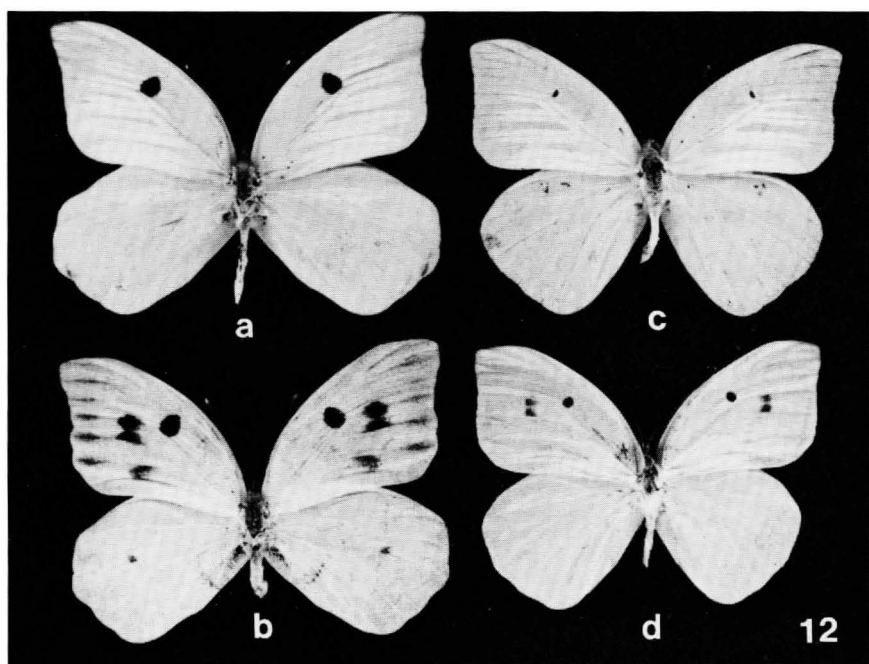
Fig. 11. A group of 'puddling' *Ascia monuste* (September 1987) at Uvero: this behavior was noted on one of three visits, and only this pierid was observed at rainwater pools and mud patches.

Fig. 12. **a, b.** *Ascia josephina josephina* (m, f), Boca de Yuma, Dominican Republic (July 1986): **c, d.** *Ascia josephina krugii* (m, f), Mona Island (July 1986).

Fig. 13. **a** *Urbanus dorantes cramptoni* (Mona Island): typical example of this subspecies (December 1986). **b, c** individuals of this subspecies in which the hyaline markings are greatly reduced (see text) (Mona Island, December 1986).

Fig. 14. **a** *Polygonus leo savigny*. Mona Island (July 1986). **b** *Polygonus leo ishmael*. Bavaro, Dominican Republic (December 1986). Underside. The undersides of these two subspecies are very distinct to the eye: *savigny* is russet-brown with a purple sheen, while *ishmael* is grey-green in ground color. Use here of a light orange filter does not over-emphasize the distinction between them.

Fig. 15. *Strymon toussainti* (f. underside) Mona Island (December 1986).



This public document was promulgated at a cost of \$1,756.00 or \$2.509 per copy. It makes available to libraries, scholars and all interested persons the results of researches in Entomology.