ASSESSMENT OF INVENTORY EFFORT FOR LEPIDOPTERA (INSECTA) AND THE STATUS OF ENDEMIC SPECIES ON SANTA BARBARA ISLAND, CALIFORNIA

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Abstract—The small size of Santa Barbara Island (2.6 km^2), its remote location 38 km from the nearest other island, and extreme reduction of its native vegetation, create a model for study of dispersal, endemism, survival, and biogeography. Endemic taxa include plants, a bird, and evidently at least three species of moths, whose persistence in spite of human disturbance, feral browsers, and fires, should interest conservation biologists. Considering its size and relatively uniform topography, considerable effort has been devoted to survey of the island's Lepidoptera. These insects have been collected on about 100 dates from 1939 to 2003. I attempted to confirm the identity of all Lepidoptera species reported from the island by study of museum specimens, and I made additional collections on 13 dates in May 2001 and September 2003. Eight species of butterflies and about 145 species of moths have been recorded, yet their accumulation has not reached an asymptote, and 31% are recorded by a single specimen, indicating much additional effort will be required to complete an inventory. In spite of a generally accepted belief that Santa Barbara Island was submerged in late Pleistocene times, its Lepidoptera fauna includes not only endemic moth species but higher species richness relative to its size and floral diversity, than any other Channel Island.

Keywords: endemic, insects, inventory, Lepidoptera, Santa Barbara Island

INTRODUCTION

Lepidoptera (moths and butterflies) make up the most species-rich group of plant feeding insects in North America. There are an estimated 4,000 named species in California, and many other species have not been named or described. More than 800 species are known on the Channel Islands (Powell 1994 unpubl. data). Caterpillars of most are specialists on one or several closely related plants, but many species are generalists, often including weedy plants, and some of the Lepidoptera are exotic species themselves, having been introduced by human activities. Larvae of many species feed only in flowers or seeds, in growing stems, roots, or as miners within a single leaf. A minority of species are scavengers, living in decaying plant matter, or feed in fungi or on animal products including fur, feathers, guano and other detritus associated with nests and burrows.

These insects, particularly the caterpillars, provide an important part of the diet of vertebrates, especially birds, small mammals, bats, and lizards (Ehrlich and Ehrlich 1982, Cowie and Hinsley 1988, Fellers and Drost 1991, Scoble 1992, Brown et al. 1994). Through flower-visiting activities of the nocturnal adult moths, Lepidoptera perform a function in pollination of native plants, which in turn are used by seed-feeding birds, ants, and other insects. By these activities Lepidoptera play important roles in the balanced functioning of the biological community.

Management of rare or endangered vertebrates and plant species should involve comprehensive care of their habitats and associated biota, including insects. A necessary basic phase of such management is the acquisition of a comprehensive inventory of the organisms that make up the community. Insect species outnumber those of all other animals and higher plants combined, with Lepidoptera comprising the most speciose plant-feeding guild (Strong et al. 1984, Scoble 1992, Powell et al. 1999). Hence, it is important to the overall success of habitat recovery projects to know the extent and diversity of the insect community. Historically, inventory on the Channel Islands insects lagged far behind that of vertebrates and flowering plants. My colleagues and I have made considerable progress in surveying the Lepidoptera during recent decades, and this report provides a summary of our efforts for Santa Barbara Island (SBI).

About 25 Lepidoptera considered to be valid species are endemic to the Channel Islands (ca. 3% of the recorded species; Powell 1994, Powell and Povolny 2001, Povolny 2004). In addition, intraspecific variation is recognized in numerous moths and butterflies, and subspecies names have been proposed for some. Several endemic species are restricted to Santa Catalina or another of the large islands, while others display complex geographical patterns (Powell 1994 unpubl. data). Among the smaller islands, Lepidoptera species restricted to one island occur only on SBI.

This is the first attempt to analyze the Lepidoptera fauna of one of the California Channel Islands in detail. I selected SBI because it is the smallest island and had been sampled for insects more comprehensively than some of the larger islands (Appendix 1). Geologists and paleontologists have inferred SBI to have been submerged during interglacial periods of raised sea level in late Pleistocene (Valentine and Lipps 1967, Vedder and Howell 1980). Therefore, I reasoned this island should have the fewest species and one of the best documented inventories, with few problems identifying potential endemic species and retrieving museum specimens to confirm past records; however my assumptions were overly optimistic.

Topography, Climate, and Geological History

Santa Barbara Island is the smallest of the eight Channel Islands of southern California, only about 2.6 km^2 (1.0 mi^2) in area. It is located 61 km (38 mi) from the nearest point on the mainland and 38 km (24 mi) west of Santa Catalina Island. However, SBI is geologically and floristically more closely related to San Clemente Island, 58 km (36 mi) to the southeast. The topography of SBI is dominated by a ridge connecting rounded hills of 170 m (555 ft.) and 193 m (635 ft.; Fig. 1). Most of the island consists of gradual slopes descending from the ridge to the east and west. There are precipitous escarpments that drop 150–180 m (500–600 ft.) at the southwest and northwest ends of the ridge, and 60–100-m cliffs along the margins of the terraces. SBI has no above tidal beach dunes or salt marshes, and no surface water other than temporary seeps following rains.

The climate is Mediterranean, with winter rain brought by northern storms, and a long dry season, from April to October or later. Rainfall averages about 11.25 cm (4.5 inches), although it has been recorded consistently only since 1981 (www.wrcc.dri.edu/channel_isl/index.html), and there are large fluctuations from year to year. Temperatures rarely rise above 29°C (85°F) or drop below 4.5°C (40°F), and the average is remarkably equitable throughout the year. Conditions are strongly influenced by prevailing northwest winds and persistent fog, especially during spring and summer.

The geological history of the California Channel Islands is highly complex and not fully understood. A period of igneous activity that dominated the early development of present day features culminated 16 to 12 million years ago (mya) (mid- Miocene) and diminished 10 to 7 mya (late Miocene; Vedder and Howell 1980). This activity coincided with complex tectonic activity

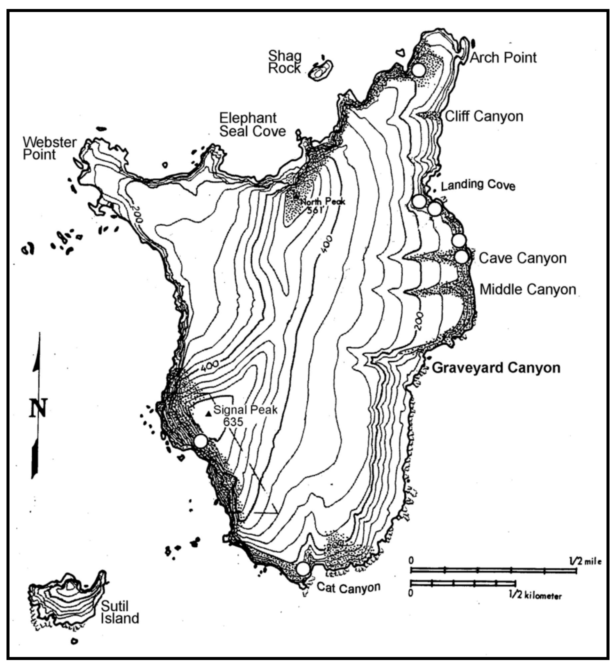

Figure 1. Map of Santa Barbara Island (modified from Menke 1985). Stippled areas delineate portions of the island that retain predominantly native vegetation. Open circles indicate blacklight sampling sites in 2001 and 2003.

that brought the San Clemente block, with San Clemente Island and possibly SBI, far northward to its modern position (Luyendyck 1991). The southern islands project from a series of submarine ridges that are more or less parallel with the mainland coastline and separated by basins, which have been accumulating sedimentation from insular sources since late Miocene times (Fig. 2). SBI is subtended by a San Clemente to Santa Cruz Ridge and probably appeared during volcanic activity sometime between late Miocene (10 mya) to as recently as late Pliocene (2 mya; Vedder and Howell 1980). It has never been connected to the mainland and probably not to any other extant island (Teng and Gorsline 1989). Emery (1960) suggested that SBI probably is the remnant of the north slope of a Miocene volcano.

The major glacial and interglacial stages of the Quaternary caused periodic sea level shifts that alternately exposed larger insular land masses and reduced their size by submergence. Resultant marine fossil deposits occur on San Nicolas Island to the present highest elevation (253 m) and on San Clemente Island to 450 m (Vedder and Norris 1963, Valentine and Lipps 1967). Disregarding possible episodes of local uplift and subsidence along the ridges, Vedder and Howell (1980) infer that the smaller present day islands were inundated during maximum extent of the sea in mid Pleistocene (less than 0.5 mya) and probably again during Wisconsin post-glacial sea rises, as recently as 14–17,000 years ago. This scenario has been accepted by biologists, who assume the fauna and flora of SBI originated entirely by oversea migration since the late Pleistocene (e.g., Philbrick 1972, Bezy et al. 1980, Powell 1994, Rubinoff and Powell 2004). A deposit of "probable Pleistocene age" at ca. 160 m on Signal Peak was reported by Dunkle (1942). It consists of volcanic detritus and contains terrestrial gastropods, according to Lipps et al. (1968), who consider the deposit to be of non-marine origin, probably having its provenance a

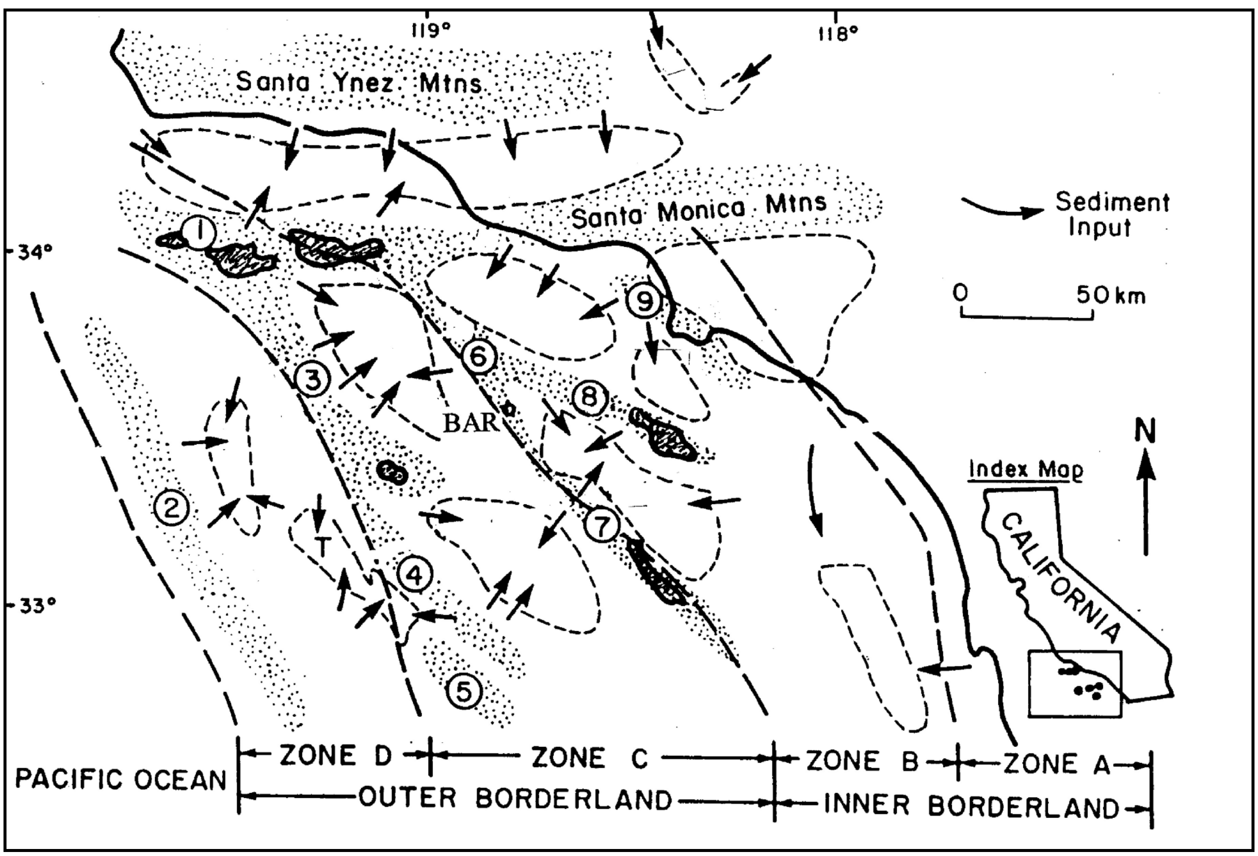

Figure 2. Geologic structure of the California Continental Borderland (modified from Teng and Gorsline 1989). Stippled, numbered areas are topographic ridges; curvilinear areas outlined by dashed lines are basins that have been accumulating sediment since the Miocene (directional arrows); heavy-dashed lines depict major faults. Islands are darkly shaded, and approximate position of Santa Barbara Island (BAR) is indicated on the Santa Cruz-San Clemente ridge.

former higher area to the west of the present edge of the island that has been destroyed by marine erosion. Thus there is no direct evidence of submergence of the upper part of SBI.

Human Impact on the Flora

The earliest mention of presumed damage to the natural flora of SBI is by Farnham (1849, p. 107), who stated that SBI, San Nicolas, and San Clemente islands were “partially covered with trees... and densely populated with goats.” However, Farnham’s text indicates that he never saw the southern islands, and he did not give the source of his statement. Presumably there was no permanent surface water then, as is true now, and persistence of feral ruminants on SBI is doubtful. Skulls of sheep were observed on SBI in the 1890s and in 1908 (Britton 1897, Howell 1917 [both cited by Philbrick 1972]), but the extent of 19th century managed grazing is unknown.

Human impact during the 20th century is well documented by Philbrick (1972, based on a 1970 interview with D.O. Hyder), Weinman (1978), and Bailey (1993, from taped interviews with Hyder in 1986–1991). Post WWII events were chronicled by Sumner in an unpublished 1958 report that was quoted extensively by Philbrick (1972) and by Sumner (1959). The island was leased by the Office of Lighthouse Engineers to Alvin Hyder, who began ranching and farming on SBI in 1914. Up to 17 people occupied the island along with 200–300 sheep, horses, and other domestic animals. They brought water from the mainland, constructed reservoirs, cleared land by periodic burning, and planted barley hay and potatoes. Hyder introduced “Belgian hares” (a domestic variety of *Oryctolagus cuniculus*) as an income source from sales to mainland restaurants. The Hyders left by 1924, taking their domestic animals and equipment, but they left the rabbits. They conducted additional stints of sheep grazing without contract in 1926–1930.

Although brief, the Hyder occupancy severely impacted all of the tillable land of the island, altering forever what probably had been the least perturbed flora of the California Channel Islands. The feral rabbits continued to browse, their numbers likely held in check by intermittent drought years and feral cats (Philbrick 1972). In 1938 the island became part of the Channel Islands National Monument, control of the rabbits began, and by 1941 cats and rabbits were rarely seen (Philbrick 1972). The U.S. Navy took control of the island in 1942–1950, built additional facilities and roads, introduced vehicles, and released "New Zealand red" rabbits (another variety of *Oryctolagus*). After 1950 the rabbits became conspicuously abundant, causing severe reduction of the *Coreopsis* forests. Sumner (1959) described the eradication program and reported an estimated peak population of 6,000 rabbits in 1952–53, and by 1954 the vegetation, even on nearly inaccessible cliffs, was spectacularly reduced. The NPS and U.S. Fish and Wildlife Service began a vigorous rabbit control program, including strychnine poisoning. The last known cats were eliminated by 1957, yet several hundred rabbits continued to ravage the vegetation. An accidental fire in 1959 is said to have destroyed nearly all the vegetation from the east shore to the crest of the ridge, and poison control was ceased to reduce risk to native vertebrates. Rabbit damage to native vegetation, particularly the *Coreopsis* groves, was again severe by 1970, when the Sierra Club organized a visit by biologists to the island (R. Holland pers. comm. 2003). Rabbit removal was completed in 1981 after SBI became a part of the Channel Islands National Park.

The lasting result of such disturbance is replacement of native flora by weediness. Exotics make up 33% of the SBI plant species (Junak et al. 1993) and in areas with fertile soil comprise nearly all of the groundcover. About 90% of the non-native species are annual herbs, including 17 species of grasses (Junak et al. 1993), and in soils that favor them, Mediterranean and other exotic grasses in California typically persist indefinitely. The South African iceplant, *Mesembryanthemum crystallinum* (Aizoaceae), is particularly insidious; it absorbs aerosol salt from onshore winds and greatly increases salinity levels in the surrounding soil, excluding most native plants (Vivrette and Muller 1977). This plant was abundant and widespread by 1939 (Meadows unpubl. field notes, Dunkle 1942), encompassing the same areas as it does today. Native shrubs including *Coreopsis gigantea*, *Baccharis pilularis* (both Asteraceae), and *Suaeda taxifolia* (Chenopodiaceae), are colonizing some weedy areas, but in general only the rocky slopes and ridges have resisted consummate weediness and maintain primarily native vegetation (Fig. 1). Caterpillars of native Lepidoptera, except for the most polyphagous species, feed on native plants and typically do not accept exotic weeds, particularly annual herbs and grasses (Strong et al. 1984, Powell unpubl. data). Thus survival of native Lepidoptera is dependent upon persistence of native plants.

The Flora

There are 132 plant species in 94 genera recorded on Santa Barbara Island, of which 44 are non-native (33%), mostly shared with San Clemente Island (Junak et al. 1993, 1995). However, five native species were recorded only once between 1905 and 1983 and may be no longer present; 15 exotic weeds are known from single collections (1931–1970) or were found during 1968–1993 and purposefully removed (Philbrick 1972, Junak et al. 1993). Thus the surviving flora consists of about 85 native and 29 non-native species (25%). There are 14 insular endemic plants on SBI, most of which are shared with the one or more of the other three southern islands (Santa Catalina, San Nicolas, and San Clemente). Endemics include five of the 15 shrubs. Four taxa are restricted to SBI, *Dudleya traskiae* (Crassulaceae), which is considered to be a distinct species, and three infraspecific forms. At least 20 native plant species are found on all the Channel Islands except SBI (Junak et al. 1993), notably those of coastal sand dunes, salt marshes and, freshwater habitats. The families best represented in the native plant flora are Asteraceae (17 species), Poaceae (8), and Chenopodiaceae (6). There is one fern, no trees, no conifers, and only 15 native shrub species. Nearly 60% of SBI's native plants are annuals (Junak et al. 1993). Therefore neither the diversity nor plant architecture of the SBI flora are suitable for supporting a diverse community of butterflies and moths because Lepidoptera richness is primarily dependent upon plants of high architectural complexity (Strong et al. 1984).

MATERIALS AND METHODS

During the 1970s and at subsequent intervals, Scott Miller and I attempted to identify and capture collection data from all lepidopteran specimens that had been collected on Santa Barbara Island. We searched the collections of the Los Angeles County Museum of Natural History, U.S. National Museum of Natural History, and other institutions, and recruited assistance from several taxonomic specialists (see Acknowledgments). After compiling the data I attempted to locate and reexamine specimens to confirm all unique records and those that seemed doubtful and/or could not be reconciled with confidence (e.g., uncertain if specimens in two or more institutions or identified by two or more persons were the same species, or species identified only to genus). I made dissections to examine genitalia characters needed for identification of numerous moth species. Other IDs were made by comparison to museum specimens or by specialists (see Acknowledgments). A history and seasonal distribution of Lepidoptera collections was reconstructed from specimen label data, published references, and responses from recent collectors (Appendix 1).

Field Surveys

I visited SBI in May 2001 and September 2003 and made diurnal searches over most of the island for adult moths and butterflies and their caterpillars. Ultraviolet lights ("Black lights" = BL) were used to attract moths, usually one 15-watt light hung against a sheet at the NPS Station and two traps deployed at other sites each night. The traps (8-watt BL), powered by small, rechargeable batteries, were used to sample moths in predominantly native plant communities (Fig. 1). Larval collections were held in 25.4- x 45.7-mm polyethylene plastic bags lined with paper toweling or pint and half-pint plastic dishes at the ranger station until transport to Berkeley in camp coolers. Females of the island endemic, *Argyrotaenia isolatissima* (Tortricidae), were held in 15-dram plastic vials for oviposition, and the ensuing larvae were reared on synthetic diet in 30-ml cups. Methods of DNA analysis are reported elsewhere (Landry et al. 1998, Rubinoff and Powell 2004).

Estimating Species Richness

I used three methods to estimate the number of Lepidoptera species potentially present on SBI. First, I compared taxonomic components in the recorded fauna to the relative richness of taxonomic groups that occur locally or regionally on the mainland and used that measure to extrapolate a potential species total for SBI. Well inventoried communities consist of about 40% microlepidoptera, 15% pyraloid moths, 40% macro moths, and 5% butterflies, and extrapolating from the number of species recorded on the island in one or more of these categories thought to be the best surveyed yields a projected total. Second, I compared the Lepidoptera species number to flowering plant richness. I have found the number of Lepidoptera in several local inventories on the mainland to vary from about 1.5 times (coastal and dune communities of low plant architecture) to 3.0 times (diverse, forested-chaparral communities) the number of plant species. A projection based on the flora assumes SBI Lepidoptera are as rich as in a mainland, low architecture community. Third, I estimated species richness using Chao 1, a non-parametric statistical model (Chao 1984) based on proportional rarity among the recorded species, which is a measure of sampling comprehensiveness (e.g., Colwell and Coddington 1994). Chao 1 is represented by the equation: $S_1 = S_{ob} + a^2/2b$, where S_1 is the estimated species richness, S_{ob} is the observed species richness (n = 153), 'a' the number of species represented by one specimen (n = 47) and 'b' species represented by two specimens (n = 13).

RESULTS

A history of Lepidoptera collections made on Santa Barbara Island is summarized in Appendix 1. Moths or butterflies have been recorded on about 102 dates between May 1939 and September 2003, but most dates yielded only one or a few species. Charles Drost made collections in all months except February (Table 1), but comprehensive survey efforts have not been attempted in January–February, July–August, and October–December, and minimal attention has been paid to larval rearing.

The Lepidoptera Fauna

About 153 species of Lepidoptera have been recorded from Santa Barbara Island, including 145 moths and eight butterflies (Appendix 2). There are a few other specimens of uncertain taxonomic status. At least 30 species (20%) are not native to California or are widespread, "weedy" species (often multiple-brooded, polyphagous, and/or dependent upon non native plants) and probably not native to the Channel Islands. A few species were recorded once long ago but may have been vagrants or may not have survived severe restriction of their larval host plants during high populations of rabbits in the 1950s and an extensive fire in 1959. Included are *Galgula partita*, *Scotogramma defessa*, *Spodoptera ornithogalli* (Noctuidae), and *Colias eurytheme* (Pieridae) collected in March 1940; *Clepsis peritana* (Tortricidae) in July 1940; and *Orgyia vetusta* (Lymantriidae) in June 1974. None of these is likely to have been misidentified, but they have not been recorded during the past two decades (78% of the sampling dates).

Not all of the 153 species are known or suspected to be resident. At least 12 species of moths and butterflies likely were vagrants, either because the adult was recorded only once and/or the species is a known long-distance migrant (e.g., Powell and Brown 1990, Ferguson 1991), or the larval host plant does not occur on SBI, e.g., *Pyrausta volupialis* (Crambidae) (Powell et al. 2004) and *Galgula partita* (Noctuidae) (Godfrey 1981). The butterflies, *Pyrgus albescens* (Hesperiidae), *Colias eurytheme*, *Pontia protodice* (Pieridae), and *Vanessa cardui* (Nymphalidae), comprising half the species recorded on SBI, are well known as migrants or vagrants, often dispersing late in the season when offshore winds typically occur in southern California. Probably

Table 1. Numbers of dates per month on which collections of Lepidoptera have been made on Santa Barbara Island, California, by Charles Drost in 1981–1989 and by all other persons.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Drost	3	-	5	9	17	8	4	5	6	1	2	8
Others	-	-	8	2	12	2	-	1	8	1	-	-
Total	3	-	13	11	29	10	4	6	14	2	2	8

they immigrate to the Channel Islands repeatedly and colonize temporarily but do not persist through drought eras or unusually cold winters (e.g., Powell 1981). Thus the resident lepidopteran fauna may not be more than 135–140 species, but the high incidence of species taken only once (31%) and of additions to the list in recent visits (Fig. 3) indicate there are many more species to be found on SBI.

I estimated total species richness in the Lepidoptera using three methods. Based on expected representative taxonomic composition (with 31 species of Pyraloidea as a baseline = 15% of the fauna), the total number of species projects to be 206. Comparing Lepidoptera numbers to the floral richness (using 1.5x as a low plant architecture baseline) indicates a total of 186 species. Finally, computation according to the Chao 1 formula provides an estimate of 237 species. Consequently, if a projection of 186–237 species is realistic, the inventory is 65–82% completed.

Composition of the fauna

Irrespective of residency or vagrant status, SBI has no representatives of primitive taxa, but has 33% microlepidoptera (basal taxa of the major derived clade, Ditrysia), 20% pyraloid moths, 41% macro moths, and 5% butterflies (Table 2). Compared to mainland localities and larger islands that have been inventoried comprehensively for Lepidoptera (Table 2), relatively few micro-lepidoptera and a higher proportion of pyraloids and macro moths have been recorded on SBI. By contrast, Santa Cruz Island, although not thoroughly surveyed for Lepidoptera, has about 640 species recorded, of which 46% are primitive and other microlepidoptera (Table 2).

Among the species recorded from SBI, the two most diverse families in North America, Noctuidae (cutworms) are best represented, with at least 40 species, and there are 15 Geometridae (inchworms). Pyraloidea also are well represented, with 31 species. Gelechioidea with 28 species are best represented among the microlepidoptera, including 16 Gelechiidae. Conversely, Tortricidae, which typically comprise 10% or more of a local fauna in California, are depauperate on SBI, with only 8 species (5%), 2 of which are non native.

Endemism

Three species of small moths appear to be endemic on Santa Barbara Island:

1) Gelechiidae, Gnorimoschemini: *Insuloschema barbarae* (Povolny 2004)—I reared specimens from larvae feeding on *Lycium californicum* (Solanaceae) in May 2001. The species is not known from any other locality and has been accorded generic status by D. Povolny.

2) Tortricidae, Archipini: *Argyrotaenia isolatissima* (Tortricidae)—I distinguished this species on subjective bases (Powell 1964), and it appears to be justifiably accorded species status based on recent DNA analysis, relative to other insular and mainland populations of its well studied species complex (Landry et al. 1998, Rubinoff and Powell 2004). The larvae feed on *Coreopsis gigantea* in early spring and

Table 2. Taxonomic guild composition of Lepidoptera recorded on Santa Barbara Island (SBI) and in faunas of two northern and two southern localities[a].

	SBI	CRU[b]	BigCr[b]	CLE[c]	Miramar[c]
Primitive taxa	0	6	5.2	1.6	2.2
other microlep	33	40	39.5	41.5	32.5
Pyraloidea	20	12	8	11	13
macro moths	41	36	40.5	41	44
butterflies	5.2	5.5	6.5	5	8
n total	(153)	(640)	(935)	(243)	(650)
area (km2)	2.6	249	16	145	105
sampling dates	100	144 ± 10	180	78 ± 6	400

[a] Expressed as percent of total species *n* (in parentheses).
[b] northern: CRU = Santa Cruz Island; BigCr = Big Creek Reserve, Monterey County.
[c] southern: CLE = San Clemente Island; Miramar = Miramar Marine Corps Air Station, San Diego County (Brown and Bash 2000).

on *Deinandra* (=*Hemizonia*) *clementina* (both Asteraceae) in late spring to fall (Powell unpubl. data) and may be general feeders.

3) Crambidae, Glaphyriinae: *Dicymolomia* n. sp. or race (Powell pers. observ.)—Adults are numerous, often flushed into flight during the daytime and are attracted to lights, in May–July and September. The color pattern differs distinctly from *D. metalliferalis* (Packard), which is widespread on the mainland and occurs on all the other Channel Islands, and from *D. opuntialis* Dyar, which co-occurs in Cave Canyon. There appears to be slight differentiation in male structures.

Several additional species are known only from SBI and San Clemente Island and are believed to be insular endemics: (1) *Agonopterix toega* (Depressariinae); its food plant on San Clemente, *Sanicula* (Apiaceae; Hodges 1974, Powell unpubl. data), does not occur on SBI, where other umbells, *Apiastrum angustifolium* and *Daucus pusillus* are possible hosts; (2) *Scrobipalpulopsis lycii* (Gelechiidae) (Powell and Povolny 2001); (3 & 4) Two gelechiid species related to *Aristotelia*; and (5) *Saphenista* species near or race of *latipunctana* (Tortricidae, Cochylini), larvae of which feed on *Eriophyllum*.

DISCUSSION

Status of Inventory

Any attempt to discuss relationships of Lepidoptera on the Channel Islands in general and on Santa Barbara Island specifically must be considered preliminary because we have only tentative estimates of how complete the inventory may be and no comparable quantitative measure of past survey effort. In marked contrast to inventories of flowering plants, herpetofauna, mammals, and even some insects, such as ground beetles and butterflies, discovery of the moths present at a given locality and confirmation of residency is problematic for several reasons. First, most species in California are present in larval or adult stages that are likely to be detected for only brief seasonal periods each year. Secondly, there are enormous fluctuations in many insect population numbers from year to year. Finally, many moths disperse to places where they are not resident and do not normally complete their life cycle. Thus rare records of a given species may be the result of sampling in marginal habitats or too early or too late in the season, sampling in a low numbers year for that species, or encountering vagrant individuals.

The success of biogeographical studies of insects depends in large part on the expertise of specialists who are experienced with the taxa surveyed (e.g., Fig. 3). In two visits, sampling 13 days, I doubled the number of species recorded on SBI. Accordingly, there have been marked differences in survey effort between islands and at any given island from one time to another. Many of the records originate from persons conducting general arthropod surveys or from incidental collections by ecologists or specialists of other insects. Moreover, intensive and more comprehensive approaches, using techniques that have greatly improved during the 65 years since Lepidoptera survey began on SBI, have dramatically increased the effectiveness of inventory efforts.

Standardized sampling methods for Lepidoptera usually involve light trapping (e.g., Thomas and Thomas 1994), which is less effective for microlepidoptera (40% of the fauna) than for macro moths and is dependent upon favorable conditions (i.e., ideally, warm temperature, minimal wind, low moonlight intensity). However, there has been little

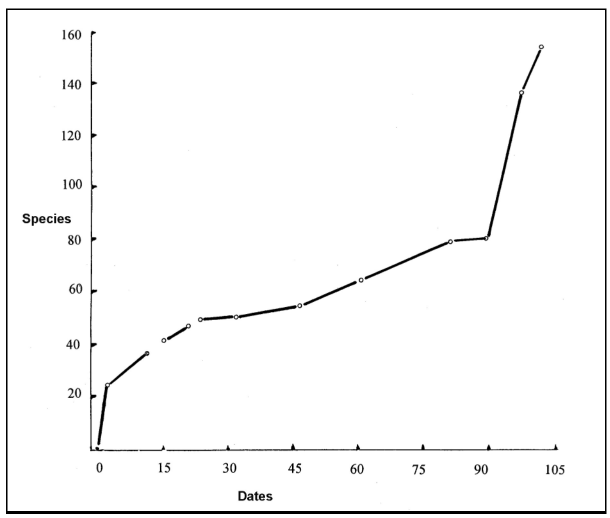

Figure 3. Graph of Lepidoptera species accumulation during the history of collecting on Santa Barbara Island, 1939–2003. Vertical axis: cumulative number of species recorded; horizontal axis: cumulative number of sampling dates as documented by specimen labels.

attempt to standardize sampling during surveys on the Channel Islands by method, numbers of dates, seasonal coverage, weather conditions, or other variables. Therefore we have no index of sampling effort, such as number of hours of larval search or blacklight trap nights, that will be needed to reach some kind of asymptote in species accumulation on an island the size of SBI versus one that is more than 10 times its size (San Miguel Island) or one nearly 100 times larger (Santa Cruz Island).

More than half of the recorded Lepidoptera species on SBI have been added in the most recent 13 sampling dates (Fig. 3), so a statistical projection of the total fauna based on accumulation rate during the survey would be inappropriate because we have no comparable measure of past effort other than number of dates. Already the number of species on SBI exceeds those of Anacapa and San Nicolas islands and is nearly equal to that of San Miguel Island. The latter two are 22 and 14 times larger than SBI.

Faunal Relationships

Comparing total numbers of Lepidoptera shared between island pairs is not meaningful because most are widespread species, and Santa Cruz Island has so many species (1.4 to 6 times the number recorded on the other large islands). As a result, each of the other islands has a subset, to a greater or lesser degree, and shares more of its species with Santa Cruz Island than with any other island. Thus 63% of the SBI Lepidoptera occur on Santa Cruz Island and 50% or more on each of the other large islands, but only 42% or fewer on the other small islands. This subset effect between a large and small island can be minimized by comparing the number shared with the total species occurring on both islands. By that calculation, SBI shares more of the pooled fauna with San Nicolas Island (29%), San Clemente Island (26.5%), and San Miguel Island (25%) than with the other islands (18% or fewer).

Such comparisons, however, are dominated by widespread species, those that occur on the mainland and most of the islands and therefore mask inter-island relationships. A more informative approach, when all the islands have been surveyed more completely for microlepidoptera, will be to compare native species that do not occur on both the northern and southern island groups. Based on present, incomplete data, and excluding vagrants and exotic species, SBI shares seven species exclusively with San Clemente Island, three with Santa Catalina Island, and not more than two with any other island. The San Clemente Island links include the five insular endemics listed above and two species with mainland desert affinities, *Chionodes kincaindella* and *C. sistrella* (Gelechiidae). Several other Lepidoptera on SBI show desert affinities on the mainland, yet are not known on San Clemente Island, namely an undescribed "*Scythris*" of the *anthracina* lineage (Scythrididae), two species of *Ypsolopha* (Plutellidae), *Oidaematophorus* new species near *gratiosus* (Pterophoridae), *Pyrausta pseudonythesalis* (Crambidae), and *Eupithecia adequata* (Geometridae).

The lower than expected proportion of microlepidoptera species on SBI may be an effect of sampling error. Macro moths and pyraloids are more reliably sampled by light traps than are micros, especially in cooler temperatures. However, larger moths may be more numerous because they are better dispersers and colonizers, in part because larvae of many are general feeders, whereas nearly all microlepidoptera are specialists. Much more effort needs to be devoted to larval collections on SBI in order to answer such questions. For example, there are larval records for more than half the microlepidoptera at Big Creek, Monterey Co., CA and for 45% of the Santa Cruz Island micros, but for only 24% on SBI. The low architecture of the flora on SBI, with no trees and only 10 native shrub species, plants that typically harbor the majority of caterpillars, is a limiting factor. There are no members of the true leaf mining superfamilies (Nepticuloidea, Tischerioidea, Gracillarioidea) recorded from SBI, species of which nearly all depend upon woody perennials. By contrast, leaf miners make up 30% of the Santa Cruz Island micro moths and nearly 10% of all Lepidoptera. Even so, probably many species of microlepidoptera await discovery on SBI. Many are tiny, easily overlooked even if attracted to lights, and specimens are difficult to prepare so are often ignored by non-specialists.

Floral Relationships

A regression analysis of the correlation between plant species and Lepidoptera species (Fig. 4) suggests that inventories of Lepidoptera on

Table 3. Island area, numbers and proportions of native and non-native species of vascular plants and Lepidoptera of the eight California Channel Islands[a] (plant data from Junak et al. 1995).

	ANA	CRU	ROS	MIG	SBI	CAT	NIC	CLE
Area (km^2)	2.9	249	217	37	2.6	194	58	145
Plants, *n*	265	650	485	267	132	604	270	382
n native	190	480	387	198	88	421	139	272
% exotic	28	26	20	26	33	30	48	28
Lepid, *n*	135	640	373	163	153	372	91	243
% exotic and vagrant	19	9	6	12	20	16	31	19
n Lepid/native plant sp.	0.71	1.33	0.96	0.82	1.72	0.88	0.65	0.89

[a] Abbreviations for island names: MIG = San Miguel, ROS = Santa Rosa, CRU = Santa Cruz, ANA = Anacapa, SBI = Santa Barbara, CAT = Santa Catalina, NIC = San Nicolas, CLE = San Clemente.

Santa Cruz Island and SBI are more complete than for the other islands. Compared to the other three small islands (Anacapa, San Miguel, and San Nicolas) the numbers of recorded Lepidoptera on SBI are greater or nearly equal, even though the other three have 3.2 times greater species richness of flowering plants (Table 3). Anacapa Island, comprised of three islets, is the only other of the Channel Islands that is similar to SBI in area. It has greater topographic complexity than does SBI, and the flora is much richer, with more than 190 species, including three native trees and 33 shrubs (Junak et al. 1993). Anacapa Island is closer to the mainland and to Santa Cruz Island, with which it was connected during glacial episodes as recently as the Wisconsin era. It therefore would be expected to support a much richer flora and fauna of plant feeding insects.

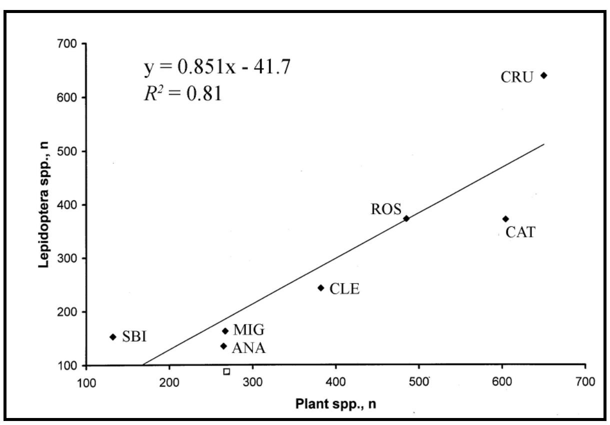

Figure 4. Correlation between numbers of vascular plants (Junak et al. 1995) and Lepidoptera species (Powell 1994, unpubl. data) recorded from seven California Channel Islands. San Nicolas Island, with fewer than 100 lepidopteran species, is omitted from the regression because sampling has been insufficient for comparison. Abbreviations are the same as in Table 3.

Ratios of numbers of Lepidoptera species compared to native vascular plants on the Channel Islands range 0.65 to 1.72 (Table 3), lower than on the mainland (2.4 to 3.2; Powell unpubl. data), and this discrepancy is due to incomplete inventory of the island moths and real deficiencies in the fauna (Powell and Wagner 1993). Even where larval host plants are present on the islands, often they persist only as small patches, unlikely to be colonized successfully. Although microlepidoptera are under represented on SBI compared to its pyaloid and macro moths, its fauna is richer in Lepidoptera than any other Channel island, relative to its native flora. Considering Pleistocene submergence theories, the incidence of endemism and the surprisingly high richness of species relative to numbers of native plants pose intriguing questions concerning the origin and relationships of the fauna.

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Appendix 1. History of Lepidoptera inventory on Santa Barbara Island (SBI).

Coleoptera (beetles) were recorded from several visits to SBI during the late 19^{th} and early 20^{th} centuries (Miller and Miller 1985), but no Lepidoptera are known to have been collected before 1939 when the Los Angeles County Museum of Natural History (LACM) Biological Survey was undertaken.

1939—May 27–30. LACM survey group included two lepidopterists, Don Meadows and Lloyd Martin, Comstock (1939). They made diurnal collections and sampled by gasoline lanterns at Landing Cove for two hours each of three evenings in cool, foggy weather [Meadows field notes]. They collected at least 25 species of moths and three of butterflies. Some of the pyraloid and macro moths were deposited in the U.S. National Museum with the Meadows collection, and probably not all the data have been retrieved.

1940—March 16–23. Second LACM survey visit to SBI included Meadows, Martin, a third lepidopterist, Chris Henne, and George Kanakoff. They established a camp at a shack "to the north of Primero Canyon" (Comstock 1946) [=Cave Canyon according to Menke (1985), i.e., area of the present day NPS station]. Cloudy weather with periods of rain limited collections, but at least 24 species of Lepidoptera were collected, which with those of the 1939 visit, comprised a total of about 40 species.

1940—July 1. G. Kanakoff, who was an invertebrate zoologist of broad interests, made a one-day stop at SBI independent of the LACM expeditions. He collected Coleoptera (Miller and Miller 1985) and at least three species of moths.

1968—August 1. Charles Remington and L. Metlovsky collected one moth, *Heliothis phloxiphagus* (Noctuidae), which often visits flowers during the daytime.

1970—March 22–23. Richard Holland visited SBI and collected a butterfly, *Pontia protodice*, and he recalled in 1980 (*in litt*. to S. Miller) about 40–50 moths at blacklight, which he donated to LACM or the American Museum of Natural History, but these have not been located.

1974—June 5–6. A group from the California Department of Agriculture surveyed SBI for a wide variety of insects and other terrestrial arthropods, records of which were entered into the CDFA files at Sacramento. Included were at least seven species of moths, some identified only to family or by questionable generic identifications, but evidently no vouchers of Lepidoptera were retained.

1978–79—June 11–12, Sept. 19–21, and Oct. 2, 1978, and April 3–4, 1979. Scott Miller, who is primarily a lepidopterist, and J. C. Trager, an ant taxonomist, made general insect surveys during a NPS contract with Santa Barbara Natural History Museum. They collected about 19 species of butterflies and moths. They worked out of a camp site and tried blacklight collecting, but winds were too high at night, so all specimens were net collected by day or in Malaise traps (Miller *in litt*. 2003). At that time the NPS had only a small shelter and no electricity.

1981–1989—Between March 1981 and January 1989, Charles Drost, a NPS vertebrate biologist working on a M.S. degree from UC Davis, made numerous collections of invertebrates, sometimes with the assistance of Gary Fellers. Drost's efforts yielded Lepidoptera on at least 68 dates, in each month of the year except February and October (Table 1). Drost (pers. comm. 2003) recalled that he sampled invertebrates on a more or less regular basis during 1985–88, including blacklight traps deployed at various parts of the island, in relation to vertebrate diet studies. Specimens were trapped alive, and voucher specimens were selected with emphasis towards supplementing existing collections. There were 1–8 species and an average of 2.25 per date in material examined for this summary. In total Drost collected about 50 species of Lepidoptera, about 30 of which had not been recorded on SBI prior to 1981 (Fig. 2).

2001—May 22–29. I visited SBI and had good weather conditions, mostly overcast and relatively warm (15–18° C) and calm some nights. Blacklight traps were deployed widely, and large numbers of moths were attracted. I made 20 larval collections from eight species of plants and reared adults of 12 species. I recorded about 120 species of Lepidoptera, of which 53 were new to the island inventory.

2003—Sept. 16–21. Daytime weather was good on my second visit, but moderate to strong winds and fog hampered nocturnal sampling. I attempted blacklight trapping, but several catches were badly damaged by invading mice or lost when traps were blown over. Eight larval collections were made from three species of native plants, owl (*Tyto*) pellets, and a dry gull (*Larus*) carcass and five species of Lepidoptera were reared. In total about 65 species of Lepidoptera were recorded, of which 19 were new to the inventory.

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Appendix 2 . Lepidoptera recorded on Santa Barbara Island, CA.

Taxa	Record date	
	First	Last
TINEOIDEA		
Tineidae:		
Monopis crocicapitella (Clemens)	V.1939	IX.2003
Tinea occidentella (Chambers)	V.1939	IX.2003
Tinea sp. *pallescentella*? (Stainton)	VI.1985	IX.2003
Tineinae unplaced female 1	IV.1979 *	
Tineinae unplaced female 2	VI.1985 *	
GELECHIOIDEA		
Oecophoridae:		
Agonopterix toega (Hodges)	V.2001	
Cosmopterigidae:		
Walshia miscecolorella (Chambers)	V.2001	V.2001
Blastobasidae:		
Holcocera (iceryaeella type)	V.2001 *	
Hypatopa sp. 1 (uniform gray)	V.1939	V.2001
Hypatopa sp. 2 (pale with black marks)	V.2001 *	
unplaced sp.	IV.1987 *	

Appendix 2 (Continued). Lepidoptera recorded on Santa Barbara Island, CA.

Taxa	Record date	
	First	Last
Scythrididae:		
Arotrura longissima (Landry)	V.1939	V.2001
Drost, JAP 01E14 r.f. *Lycium californicum*		
Arotrura sp. divaricata complex	VI.1985	IX.2003
JAP 01E29, r. f. *Eriogonum giganteum*		
n. sp. *Scyhthris antracina* lineage (Landry)	IX.2003	IX.2003
Coleophoridae:		
Coleophora accordella (Walsingham)	V.2001	V.2001
Coleophora n. sp. (*Baccharis*?)	IX.2003 *	
Coleophora sp. near *sparsipuncta*	V.1939	V.2001 (2)
Coleophora (tiny gray, *Artemisia*?)	V.2001 *	
Gelechiidae:		
Aristotelia (rust FW)	IX.2003 *	
"Aristotelia" n. sp. (S. Clemente I.)	IX.2003	IX.2003
Chionodes bardus (Hodges)	IV.1987	IX.2003
JAP 01E13, E29, r.f. *Eriogonum giganteum*		
Chionodes kincaidella (Busck)	V.1939	IX.2003
Chionodes nanodella (Busck)	V.1939	IX.2003
[ID uncertain, phenotype more variable than mainland *nanodella*]		
Chionodes sistrella (Busck)	V.2001	IX.2003
Chionodes (small, brown)	V.2001 *	
Filatima? (dark brown, white venter)	IX.2003	IX.2003 (2)
Gelechia sp. (charcoal gray-black)	IX.2003 *	
Gnorimoschema baccharisella (Busck)	IX.2003 *	
Insuloschema barbarae Povolny	V.2001	
JAP 01E14, r.f *Lycium californicum*		
Platyedra subcinerea (Haworth)	V.2001 *	
Scrobipalpula psilella complex	V.1986	XII.1987
Scrobipalpulopsis lycii (Povolny)	V.2001	
Syncopacma sp.	V.2001 *	
Tuta chiquitella (Busck)	V.2001	IX.2003
JAP 01E12, r.f. *Atriplex semibaccata*		
YPONOMEUTOIDEA		
Lyonetiidae:		
Bedellia somnulentella (Zeller)	VI.1974	V.2001
JAP 01E23, r.f. *Calystegia macrostegia*		

Appendix 2 (Continued). Lepidoptera recorded on Santa Barbara Island, CA.

Taxa	Record date	
	First	Last
Plutellidae:		
Plutella xylostella (L.)	IV.1979	IX.2003
Ypsolopha barberella (Busck)	V.2001	V.2001
Y. arizonella/schwartziella group	V.2001	
SESIOIDEA		
Sesiidae:		
Melittia gloriosa (H. Edwards)	VIII.1986 *	
TORTRICOIDEA		
Tortricidae:		
Crocidosema plebiana (Zeller)	VI.1987	V.2001 (2)
Eucosma passerana (Walsingham)	VII.1986	V.2001
Phaneta pallidarcis (Heinrich)	V.2001 *	
Cnephasia longana (Haworth)	V.2001	V.2001
Argyrotaenia isolatissima Powell	V.1939	IX.2003
Henne r.f. *Coreopsis gigantea*;		
JAP 01E10, 03J1.5 r.f. *Deinandra* (*Hemizonia*) *clementina*		
Clepsis peritana (Clemens)	VII.1940 *	
Platphalonidia n. sp. Powell ms	V.1939	IX.2003
JAP 01E10, 03J2, J7 r.f. *Deinandra clementina*		
Saphenista nr. *latipunctana* (Wlsm.)	V.2001	IX.2003
JAP 01E27, r.f. *Eriophyllum nevinii*		
PTEROPHOROIDEA		
Pterophoridae:		
Anstenoptilia marmarodactyla (Dyar)	V.1939	V.2001 (2)
Emmelina monodactyla (L.)	V.1939	VI.1974
Hellinsia catalinae (McD.)	VI. 1987 *	
Hellinsia n. sp. nr *gratiosus*	VI.1987	IX.2003
JAP 01E28, r.f. *Perityle emoryi*		
Platyptilia sp. *williamsi*? (Grinnell)	V.2001	V.2001 (2)
PYRALOIDEA		
Crambidae:		
Achyra occidentalis (Packard)	V.2001 (2)	
Agriphila attenuata (Grote)	X.1981	XI.1987
Crambus sp. *rickseckerellus*? (Klots)	IX.2003	IX.2003 (2)
Diastictis fracturalis (Zeller)	V.2001 *	

Appendix 2 (Continued). Lepidoptera recorded on Santa Barbara Island, CA.

Taxa	Record date	
	First	Last
Dicymolomia n sp. or race *metalliferalis*	V.1939	IX.2003
Dicymolomia opuntialis (Dyar)	IX.2003	IX.2003
Euchromius ocelleus (Haworth)	V.1939	IX.2003
Eudonia rectilinea (Zeller)	V.1939	V.2001
Eudonia sp. *palloralis*? (Dyar)	V.2001 *	
Hellula rogatalis (Hulst)	IX.2003	IX.2003
Loxostegopsis sp. *xanthocrypta*? (Dyar)	IV.1986	V.1986
Mecyna mustelinalis (Packard)	V.2001	V.2003
Nomophila nearctica (Munroe)	IX.1978	IX.2003
Pyrausta sp. *napaealis*? (Hulst)	V.2001 *	
Pyrausta pseudonythesalis (Munroe)	V.2001 *	
Pyrausta volupialis (Grote)	V.2001 *	
Pyralidae:		
Acrobasis tricolorella (Grote)	V.2001	V.2001
Ephestiodes gilvescentella (Ragonot)	V.1939	IX.2003
Etiella sp. *zinckenella*? (Treitschke)	V.2001	V.2001
Heterographis morrisonella Ragonot	[VIII.1939?]	V.2001 (2)
Homoeosoma electellum (Hulst)	IX.2003	IX.2003
Hulstia undulatella (Clemens)	IX.1987 *	
Lipographis fenestrella (Packard)	V.2001	IX.2003
Ozamia fuscomaculella (W. S. Wright)	VII.1987	IX.2003
Patagonia peregrina (Heinrich)	IX.2003 *	
Phobus funerellus (Dyar)	V.2001 *	
Phycitodes mucidellum (Ragonot)	V.2001	IX.2003
Pima albiplagiatella occidentalis (Heinr.)	V.2001 *	
Pima albocostalialis (Hulst)	V.2001 *	
Pyralis cacamica Dyar	V.1986	IX.2003?
Unadilla erronella (Zeller)	VI.1987 *	
GEOMETROIDEA		
Geometridae:		
Archirhoe neomexicana (Hulst)	IV.1987	V.2001
Cyclophora nanaria (Walker)	IX.1978	V.2001
JAP 01E10, E26, r.f. *Deinandra clementina*		
Elpiste marcescaria (Guenee)	V.2001	V.2001
Eupithecia adequata (Pearsall)	XII.1986	XII.1987
Eupithecia maestosa (Hulst)	I.1989?	IX.2003
Eupithecia misturata (Hulst)	V.2001	IX.2003

Appendix 2 (Continued). Lepidoptera recorded on Santa Barbara Island, CA.

Taxa	Record date	
	First	Last
Eupithecia rotundopuncta Packard	I.1987	XII.1987 (2)
Eupithecia subvirens (Dietze)	V.2001 *	
Perizoma custodiata (Guenee)	V.1939	IX.2003
Perizoma epictata (Barnes & McDunnough)	VI.1978	IX.2003
Pero sp. *catalina*? (Poole)	V.2001	IX.2003
Prorella leucata (Hulst)	V.2001	V.2001
Semiothisa californiaria (Packard)	V.2001	V.2001 (2)
Stamnodes albiapicata (Grossbeck)	XI.1987	XII.1987
Stamnodes cassinoi (Swett)	XII.1987 *	
Triphosa californiata (Packard)	IX.2003 *	
SPHINGOIDEA		
Sphingidae:		
Hyles lineata F.	III.1940	V.2001
NOCTUOIDEA		
Lymantriidae:		
Orgyia "vetusta"	VI.1974 *	
[CDFA, Somerby ID, no voucher]		
Arctiidae:		
Apantesis proxima (Guerin-Meneville)	V.1939	V.2001
Cisthene faustinula (Boisduval)	V.1986	V.2001
Crambidia suffusa (Barnes & McD.)	V.2001 *	
Noctuidae:		
Abagrotis sp. *reedi*? Buckett	V.2001	V.2001
Agrotis ipsilon (Rottenburg)	V.1986	IX.2003
Aseptis (*paviae* or *ethnica*?)	V.2003 (2)	
Autographa californica (Speyer)	III.1940	V.2001
Bulia deducta (Morrison)	V.2001 *	
Cobalos sp. *angelicus*? (Smith)	V.1939	V.2001
Conochares arizonae (H. Edwards)	V.2001	V.2001
Cucullia serraticornis (Lintner)	XII.1985	I.1988 (2)
Dargida procincta (Grote)	V.1986	V.2001
Euxoa sp. *auxiliaris*? (Grote)	V.2001 *	
Euxoa sp. *henrietta*? (Smith)	IX.2003 *	
Euxoa sp. *olivia*? (Morrison)	V.2001	V.2001
Euxoa sp. *satis*? (Harvey)	V.2001 *	
Euxoa not *septentrionella*?	V.2001	

Appendix 2 (Continued). Lepidoptera recorded on Santa Barbara Island, CA.

Taxa	Record date	
	First	Last
Forsebia perlaeta (H. Edwards)	IX.2003 *	
Galgula partita (Guenee)	III.1940 *	
Heliothis phloxiphagus (Grote & Robinson)	(?V.1939)	V.2001
Heliothis zea (Boddie)	IX.1978	IX.2003
Hemeroplanis finitima (Smith)	III.1940	V.2001
Hemieuxoa rudens (Harvey)	V.1985	V.2001
Lacinipolia quadrilineata (Grote)	V.2001 *	
Lacinipolia sp. *strigicollis*? (Wallengren)	V.1939	IX.2003
Lacinipolia vicina acutipennis (Grote)	VIII.1987	IX.2003
Leucania sp. *oaxacana*? (Schaus) (=“*oregona*”)	V.2001	V.2001
Megalographa biloba (Stephens)	III.1940	V.2001
Melipotis indomita (Walker)	VI.1987	V.2001
Melipotis jucunda (Huebner)	V.2001 *	
Micrathetis triplex (Walker)	VIII.1987	V.2001
Orthosia praeses (Grote)	XII.1986 *	
Parabagrotis insularis (Grote)	III.1940	IX.2003
Peridroma saucia (Huebner)	III.1940	IX.2003
Protorthodes alfkeni (Grote)	V.1939	IX.2003
Pseudaletia unipuncta (Haworth)	III.1940	IX.2003
Scotogramma deffessa (Grote)	III.1940	III.1940
Spodoptera exigua (Huebner)	III.1940	IX.2003
Spodoptera ornithogalli (Guenee)	III.1940 *	
Spodoptera praefica (Grote)	V.2001 *	
Synedoida tejonica (Behr)	V.2001	IX.2003
Trichoclea antica (Smith)	III.1940	V.2001
Trichoplusia ni (Huebner)	III.1940	IX.2003
Tridepia nova (Smith)	V.2001 *	
unplaced noctuid	IX.2003 *	
HESPERIOIDEA		
Hesperiidae:		
Pyrgus albescens (Ploetz)	VI.1978 (2)	
PAPILIONOIDEA		
Pieridae:		
Pontia protodice (Boisduval & LeConte)	III.1970	V.2001
Colias eurytheme (Boisduval)	III.1940 *	

Appendix 2 (Continued). Lepidoptera recorded on Santa Barbara Island, CA.

Taxa	Record date	
	First	Last
Lycaenidae:		
Brephidium exilis (Boisduval)	V.1939	IX.2003
Plebeius acmon (Westwood & Hewitson)	IX.2003 *	
Strymon melinus (Huebner)	III.1940	IX.2003
Nymphalidae:		
Vanessa annabella (Field)	V.1939	V.2001
JAP 01E11, r.f. *Malva parviflora*		
Vanessa cardui (L.)	V. 1939	IX.2003
JAP 01E11, r.f. *Malva parviflora*		

* = unique specimen; (2) = 2 specimens; r.f. = reared from larvae to adults; I-XII = months, January to December

Total 153 spp.

micros	51 (+ 4?)	33%
pyral	31	20%
macros	63 (+ 1?)	41%
butterfly	8	5%

The following additional species have been listed for Santa Barbara Island, but the records are suspected to be based on mislabeled specimens, errors in recording data, or misidentifications:

Tineidae:

Tineola bisselliella (Hummel):

One specimen labeled “S. Barbara I. emgd. 9 July 1940" (no food substrate given), evidently was reared in Los Angeles four months following the LACM visit in March. Contamination by this ubiquitous household species on the mainland is likely.

Tortricidae:

Eucosma ridingsana (Robinson) VIII.1939 *

Label error? — no LACM visit to SBI in Aug. 1939; they collected on Santa Rosa Island on the same date.

Crambidae:

Parargyractis sp. VI.1974*

CDFA, det. Somerby, no voucher; no surface water on SBI, possibly misid. of *Dicymolomia*

Nymphalidae:

Danaus plexippus (L.) Recorded by Miller (1985) based on a sight record on SBI, but it certainly does not reside there, with no larval host plant and no trees offering an overwintering roost.