# FLOWERING PLANTS OF THE SAN BENITO ISLANDS, BAJA CALIFORNIA, MEXICO

**Steven A. Junak[1] and Ralph Philbrick[2]**

[1]Santa Barbara Botanic Garden, 1212 Mission Canyon Road, Santa Barbara, CA 93105
(805) 682-4726 ext. 105, FAX (805) 563-0352, E-mail: sjunak@sbbg.org
[2]29 San Marcos Trout Club, Santa Barbara, CA 93105, (805) 967-0875

## ABSTRACT

The San Benito Islands, comprising three islets with a combined area of just over 5 km$^2$, are located about 480 km south of the border between the United States and Mexico. They lie at the edge of the continental shelf, about 27 km west of Cedros Island and 66 km from the Baja California peninsula. A total of 51 native and naturalized plant taxa, representing 24 families and 42 genera, have been documented for the three islets. At least three of them are endemic to the San Benito Islands (*Dudleya linearis*, *Hemizonia streetsii*, and *Mammillaria neopalmeri*), while six others are restricted to two or more of the California Islands. Maritime desert scrub vegetation covers most of the landscape and annual wildflowers (like the endemic *Hemizonia*) can be extremely abundant in years with adequate rainfall. Of the nine nonnative plant taxa that have been found on the San Benitos, only two annual iceplants (*Mesembryanthemum crystallinum* and *M. nodiflorum*) are abundant. The terrestrial ecosystem has been degraded by nonnative herbivores for at least 50 years, but recent conservation actions have nearly put an end to destructive browsing. Introduced rabbits are still decimating native plant populations on the eastern islet, but have now been removed from the western and middle islets.

**Keywords:** San Benito Island, San Benito Islands, Isla San Benito, California Islands, Baja California, Mexico, endemic plants, flora, vegetation, botanical exploration, feral animals.

## INTRODUCTION

The San Benito Islands are natural areas known for their rugged coastline, dramatic landscapes, nesting seabird populations, endemic plants and animals, and rocky beaches teeming with elephant seals and sea lions. Insects thought to be endemic to the San Benitos include a scorpion (*Vaejovis baueri*) (Williams 1980) and at least two tenebrionid beetles (*Helops benitensis* and *Stibia williamsi*) (Blaisdell 1943). An endemic land snail (*Xerarionta pandorae*) is known only from the San Benito Islands (Smith et al. 1990). Endemic subspecies of Leach's storm-petrel (*Oceanodroma leucorrhoa chapmani*), rock wren (*Salpinctes obsoletus tenuirostratus*), savannah sparrow (*Passerculus sandwichensis sanctorum*), and house finch (*Carpodacus mexicanus mcgregori*) have been described from the islands, although the McGregor house finch is now presumed to be extinct (Jehl 1971; Boswall 1978). An endemic subspecies of side-blotched lizard (*Uta stansburiana*) has also been reported from the San Benitos (Bostic 1975). At least three vascular plant taxa are endemic to the San Benitos (*Dudleya linearis*, *Hemizonia streetsii*, and *Mammillaria neopalmeri*) and six others are restricted to two or more of the California Islands.

For at least 50 years, the biota on these islands has been subjected to damage caused by feral animals, including burros, cats, and goats. Rabbits have been introduced during the last decade, threatening several endemic plant taxa. Human visitation has also increased during the last two decades, raising both the demand for information about the island's flora and the potential for nonnative plant introductions. We hope to promote further scientific investigations on this picturesque group of islands by providing here 1) an introduction to their geography and vegetation, 2) a short history of botanical exploration, 3) a description of historical changes in the vegetation and flora, and 4) an annotated checklist of the flowering plants.

## PHYSICAL ENVIRONMENT

Eight islands lie off the west coast of Baja California between the United States/Mexico border and Punta Eugenia, located about 575 km (357 mi) south of the international border. Ranging in size from 0.4 to 348 km$^2$ (0.2 to 134 mi$^2$), seven of the islands are on the continental shelf, and six of them lie within 23 km (14 mi) of the coastline. Situated near the edge of the continental shelf, the San Benito Islands are 66 km (41 mi) from the nearest point on the mainland but only 27 km (17 mi) from neighboring Cedros Island. Guadalupe is an oceanic island 252 km (157 mi) off the Baja California coast.

The San Benito Islands, centered near latitude 28$^o$ 18' 30" N and longitude 115$^o$ 34' 00" W, are situated about 480 km (300 mi) south of the border between the United States and Mexico. The San Benitos are three islets, named West San Benito (also known as San Benito Occidental or Benito del Oeste), Middle San Benito (San Benito Central or Benito del Centro), and East San Benito (San Benito Oriental or

Benito del Este). According to a recent survey (Carrasco 1978), the three islets have a combined area of 5.03 km$^2$ (1.94 mi$^2$). It should be noted that this figure differs from earlier measurements of 6.4 km$^2$ (Philbrick 1967). Their coastline is rocky, but with several cobble beaches (see Figure 1). There are no permanent sources of fresh water on any of the islets.

West San Benito, the largest islet, has an area of about 3.46 km$^2$ (1.34 mi$^2$) and is about 2.85 km (1.77 mi) long and 2.40 km (1.49 mi) wide at its widest point (Carrasco 1978). It has the most topographic diversity of the island group and is about 216 m (708 ft) high. The central part is elevated and relatively flat in several areas, with the high point just west of the middle. The central highlands are surrounded by elevated marine terraces. Several canyons on the north and south sides of the highlands provide moister habitats than the open slopes for plant life and provide some protection from strong winds.

A community of fishermen lives in a village at the southeastern end of the west islet, where there is a small cove and cobble beach protected from north and west swells. Up to 70 people live there for a part of the year (Donlan et al. 1999, this volume). These fishermen, who belong to a cooperative based at the cannery village on neighboring Cedros Island, harvest abalone and lobster seasonally. Fresh water, groceries, and supplies are delivered by boat. A trail system gives access to the north side of the islet and connects the village and two navigation lights on the northwestern and southern sides of the islet.

Middle San Benito lies just northeast of West San Benito, separated by a channel only 1.5 to 4.5 fathoms (9 to 27 ft) deep. Between Middle and East San Benito is Canal de Peck, 12 to 25 fathoms (72 to 150 ft) deep. Middle San Benito, the smallest islet, has an area of 0.53 km$^2$ (0.20 mi$^2$) and is about 1.40 km (0.87 mi) long, and 0.80 km (0.50 mi) wide at its widest point (Carrasco 1978). This islet is mostly flat and has the least topographic diversity, gradually rising to a high point of about 25 m (82 ft) near the eastern end. Middle San Benito has no human inhabitants.

While the long axes of West and Middle San Benito run east and west, East San Benito has a north-south orientation. East San Benito, with an area of 1.04 km$^2$ (0.40 mi$^2$), is about 2.40 km (1.49 mi) long and 1.50 km (0.93 mi) wide at its widest point (Carrasco 1978). Four conspicuous buttes, the tallest reaching an elevation of about 138 m (453 ft), dominate the topography, with a few smaller hills scattered around them. Coastal terraces surround the buttes and hills and form most of the perimeter of the island. East Benito has no human residents.

The geology of the San Benito Islands was studied by Van West (1958) and by Cohen et al. (1963). These islands are of considerable interest to geologists because they are near the interface between the oceanic and continental crusts. The islands consist of a folded and sheared synclinal sequence of graywacke, chert, basalt, altered basalt and carbonate, serpentinite, and glaucophane rocks of Jurassic age. Cohen et al. (1963) reported that the association of rocks found on the San Benitos is closely related to the Franciscan rocks of California.

**Figure 1. View of Middle and East San Benito from the highlands of West San Benito Island (photo taken by S. Junak on 27 February 1997).**

No weather records are available for the San Benito Islands, but the climate can be estimated from a station on neighboring Cedros Island and two on the adjacent mainland. Limited precipitation and temperature records, for 4 to 6 year spans, are available for a site near the village on Isla Cedros (latitude 28$^o$ 04' N, longitude 115$^o$ 14' W, elevation 500 m), Vizcaino (27$^o$ 58' N, 114$^o$ 07' W, elevation n.a.), and Bahia Tortugas (27$^o$ 43' N, 114$^o$ 56' W, elevation 5 m) (Hastings 1964). All these stations have an arid climate, with mean annual precipitation ranging from 65.1 to 121.3 mm (2.6 to 4.8 in). About 95 to 96% of the precipitation falls in the fall and winter, between September and March. December, January, and February are usually the wettest months.

Rainfall on the San Benitos and on neighboring Cedros Island is generally very sporadic with long periods of drought. Between 1 January 1945 and 31 December 1947, personnel at the weather station on Cedros Island recorded rain on only 20 days (5 days in 1945, 6 in 1946, and 9 in 1947) (Osorio Tafall 1948). Although the winter months are usually the wettest, no rain at all fell on Cedros Island between 6 June 1945 and 12 August 1946! Heavy rainstorms associated with tropical cyclones can drop significant amounts of moisture in the late summer or early fall. Such a storm dropped 36.5 mm (1.4 in) of rain on Cedros Island on 28 September 1946 (Osorio Tafall 1948). A water spout destroyed most of the village on West San Benito in early 1992 (S. Vogel, pers. comm. 1993).

Mean annual temperatures at these three weather stations range from 19.0 to 20.6$^o$C (66.2-69.1$^o$F). Typically, the coolest months are January and February, with mean monthly temperatures ranging from 15.3 to 17.6$^o$C (59.5 to 63.7$^o$F) for January and from 16.4 to 17.3$^o$C (61.5 to 63.1$^o$F) for February. August and September are typically the warmest months, with mean monthly temperatures ranging from 23.2 to 25.1$^o$C (73.8 to 77.2$^o$F) for August and from 22.8 to 25.5$^o$C (73.0 to 77.9$^o$F) for September.

## HISTORY OF BOTANICAL EXPLORATION

Thomas H. Streets, on the U.S. Navy surveying expedition of the North Pacific between 1873 and 1875, collected the first known botanical specimens from the San Benito Islands in December 1875. San Benito Island tarweed (*Hemizonia streetsii*) and San Benito Island bush mallow (*Lavatera venosa,* now known as *Malva pacifica*) were described from his collections. Streets apparently collected specimens of other plants as well, including island poppy (*Eschscholzia ramosa*).

Charles F. Pond, a U.S. Navy Lieutenant serving on the U.S.S. *Ranger* during a survey of Baja California's coastline and islands, made the next botanical collections on the San Benitos. His discoveries on the island were reported by Edward L. Greene of the University of California at Berkeley (Greene 1889). According to Greene, Pond visited West San Benito several times between December 1888 and February 1889 and also landed on East San Benito. Pond collected additional plant specimens on Los Coronados, San Martin, Cedros, and Asuncion islands between December 1888 and June 1889 (Nelson 1921, Notre Dame-Greene Herbarium 1987).

Edward F. Palmer visited West San Benito on 25 March 1889, while collecting plants for the U.S. Department of Agriculture (McVaugh 1956). He also visited Los Coronados, Guadalupe, and Cedros islands in 1888 and 1889. Palmer's observations and collections from the Mexican islands were published by George Vasey and Joseph N. Rose (1890) of the U.S. Department of Agriculture. The only nonnative plant observed by the early collectors on the San Benitos (Pond and Palmer) was crystalline iceplant (*Mesembryanthemum crystallinum*).

In 1896, field biologist and ornithologist Alfred W. Anthony chartered a schooner and explored the west coast of Baja California (Nelson 1921). During this voyage, he collected plants on the San Benito Islands sometime between July and October 1896.

In the spring of 1897, A. W. Anthony and a number of other scientists visited most of the islands off the west coast of Baja California on Anthony's schooner *Wahlberg* (Brandegee 1900; Moran 1952). Anthony and Townshend S. Brandegee of the University of California at Berkeley both collected plants on the San Benito Islands during the last week of March. Brandegee (1900) reported 14 plant taxa that had not previously been documented for the island, including the nonnative slender sow thistle (*Sonchus tenerrimus*).

During the first quarter of the twentieth century, two expeditions sponsored by the California Academy of Sciences stopped at the San Benitos, but only a few botanical specimens have been preserved. The first of these trips was in the spring of 1903, when the Academy organized a journey aboard the schooner *Mary Sachs*. F. E. Barkelew reportedly collected botanical specimens from the San Benito Islands, but they were apparently destroyed by the San Francisco fire in April 1906 (Nelson 1921).

The schooner *Academy* stopped at the San Benito Islands in mid-July 1905, while en route to the Galapagos Islands on another expedition sponsored by the California Academy of Sciences (Slevin 1931). The scientific party visited West San Benito on 14 July and landed on both Middle and East San Benito on 15 July. Additional trips were made to both West and East San Benito on 17 July. The botanist on this voyage, Alban Stewart, collected a few specimens from the San Benitos, including San Benito Island tarweed (*Hemizonia streetsii*).

Joseph N. Rose, of the U.S. National Museum and Carnegie Institution of Washington, collected on the San Benito Islands on 9 March 1911. He was aboard the *Albatross* expedition to Baja California, which was sponsored by the American Museum of Natural History.

P. J. Rempel of the University of Southern California collected terrestrial plants on West San Benito Island in mid-July 1937. He was on an expedition aboard the *Velero III* sponsored by the Allan Hancock Foundation (Fraser 1943; Gentry 1949). Rempel collected small-flowered iceplant (*Mesembryanthemum nodiflorum*), apparently the third nonnative plant species to establish populations on the San Benitos. Rempel also collected plants on Cedros Island during the same voyage.

During the 1940s, '50s, and '60s, Reid Moran and George Lindsay were the primary collectors on the San Benitos. Their first trip to West San Benito was on 18-20 April 1948 (Moran and Lindsay 1949). Moran later became curator of botany at the San Diego Museum of Natural History. Lindsay collected plants on the San Benitos on 5-6 February 1950; he subsequently became director of the San Diego Museum of Natural History and then the California Academy of Sciences (Mitich 1989). Moran returned to West San Benito on 24 May 1952 during an expedition to the Gulf of California aboard the *Orca* (Lindsay 1952) and collected plants from all three San Benito Islands on 18-19 April 1963, while on an expedition aboard the yacht *Gringa*. Darley F. Howe and entomologist C. F. Harbison of the San Diego Natural History Museum visited West San Benito on 8-9 November 1966. While she was a graduate student at San Jose State College, Joyce MacFall Roderick collected a few specimens on West Benito in December 1966 (Roderick and Roderick 1967).

During the 1970s, Reid Moran was the most frequent botanical visitor to the San Benitos. He visited West and East San Benito on 19-20 April 1970, on a return trip from Guadalupe Island. Moran made additional trips to the San Benitos on 25 May 1971 (middle islet), 24 January 1972 (west islet), 26 March 1973 (west islet), 25 March 1974 (west islet), and 12 May 1979 (west islet). Other collectors on West San Benito during this decade included R. Mitchel Beauchamp of San Diego (on 8 February and 4 April 1971, and on 28 February 1972), Gilbert A. Voss of the Quail Botanical Gardens (on 13 February 1972), Edward F. Anderson of Whitman College (on 8 January 1973), Mark Hoefs of the Wrigley Botanical Garden (on 19 January 1975), and James Henrickson of California State University at Los

Angeles (on 19 January 1975). Beauchamp also collected on East San Benito on 28 February 1972. Ralph Philbrick collected plants from West Benito on 20 January 1975 and Michael Benedict visited the same islet on February 23rd of the same year; both were collecting specimens for the Santa Barbara Botanic Garden. Christopher Davidson of the Los Angeles County Museum of Natural History collected plants on West San Benito on 19 February 1977; Elizabeth McClintock of the California Academy of Sciences and Wilda Ross collected there on 19 February 1978.

During the 1980s, botanists from Rancho Santa Ana and Santa Barbara botanic gardens made several trips to the San Benitos. Ralph Philbrick and Peter Schuyler of the Santa Barbara Botanic Garden landed on the east islet on 4-5 July 1983, while Marla Daily and Steve Junak collected plants on West San Benito. Robert F. Thorne, of Rancho Santa Ana Botanic Garden, visited the west islet on 31 January 1985 and on 16 February 1986. Steve Junak collected on the east islet on 28-29 March 1987 and returned to West San Benito on March 29th, along with Marla Daily. Other collectors on West San Benito during the 1980s included Thomas Oberbauer of San Diego (on 17 February 1981 and 11 January 1983).

In the 1990s, Steve Junak made several additional trips to West San Benito, on 12 March 1991, 15 March 1993, 3 March 1996, 27 February 1997, and 27 February 1998. He also visited East San Benito on 2 March 1996, along with several other botanists from southern California. Patricia West of Flagstaff, Arizona collected a number of voucher specimens on West and East San Benito on 3-14 December 1997.

In summary, at least 30 botanists have collected specimens during more than 40 trips to the San Benito Islands. Undoubtedly additional botanists, especially from Mexico, have also visited the islands, but we have not seen their collections.

## HISTORICAL CHANGES IN THE VEGETATION AND FLORA

The island's vegetation has been disturbed by decades of human activities and by introduced herbivores, including burros, goats, and, most recently, rabbits. No herbivores were noted by early visitors to the islands (e.g., Brandegee 1900; Thayer and Bangs 1907; Hanna 1925). By 1918, there was a lobster camp on West San Benito, and a Japanese abalone camp was there in 1922 (Hanna 1925). Cats had apparently been introduced by early residents or visitors and were having a significant effect on nesting sea birds by 1922 (Hanna 1925).

Several shrubs (*Mirabilis californica*, *Trixis angustifolia*, and *Viguiera lanata*) reported by Greene (1889) have not been seen by subsequent visitors. *Dudleya albiflora* was apparently collected by Alban Stewart in 1905, but has not been seen since. These native plants may have been extirpated on the San Benitos by introduced herbivores.

By the time that Moran and Lindsay visited the islands in 1948, burros and goats had been introduced to West San Benito and were eating some of the plants, including the endemic San Benito Island bush mallow (*Lavatera venosa* or *Malva pacifica*) and San Benito Island live-forever (*Dudleya linearis*). Moran (1948) reported that *Lavatera* was then "uncommon on the island because of burros and goats." Lindsay (1950) stated that "… *Lavatera* is found on all three of the San Benito Islands, but is most common on Middle Benito, where it has not been destroyed by goats." Moran and Lindsay (1951:78-80) reported "wild goats and two or three burros" and stated that "at the time of our visit, it [*Lavatera*] was scarcely to be found on the main island; like its cousin of the California islands, it seems to be a favorite of browsing animals and hence is now nearly confined to the rocks offshore." They found only a few living plants of *Dudleya linearis* on the western islet and observed that "… many dead caudices showed that it had been quite common until recently. Apparently the burros … and goats are rapidly exterminating the *Dudleya*." Moran (1951:191) reported that "In 1948, there were few living plants of *Dudleya linearis* on the west island of the San Benito group, and only three were found in flower. Many dead caudices showed that this plant had recently been more common. Apparently burros like to exterminate it. However, on the east island, where burros are absent, I found no plants at all of *Dudleya*."

No goats were seen on the San Benitos Islands by Philbrick or Junak during any of their visits between 1975 and 1992. Burros, however, were seen many times during the same time period, usually in small bands of three to six animals. Boswall (1978) saw four dogs, nine burros, and one goat during a three-week stay on West San Benito in 1975. In the early 1990s, rabbits were introduced and goats were re-introduced to West San Benito. According to residents on West San Benito, there were a few rabbits there in 1993, about 20 goats that had been there for about six months, and 8 to 10 burros (Pers. comm. to S. Junak, March 1993). By 1995, the rabbits and goats were having a marked effect on some plants of West San Benito, especially the endemic live-forever (*Dudleya linearis*) (S. Vogel, pers. comm. 1995). By March 1996, live dudleyas were extremely rare on the islet; numerous dead caudices were seen in several canyons on the north side (S. Junak, pers. obs.).

Rabbits were also introduced to East San Benito sometime before the spring of 1996. They were common there in March 1996; it was an extremely dry year on the island and the rabbits were eating the bark of cliff spurge (*Euphorbia misera*) which has a caustic milky juice (S. Junak, pers. obs.).

Thanks to the cooperative efforts of the Island Conservation and Ecology Group and the Mexican Office of National Protected Areas, rabbit and goat removal began on West San Benito in early 1998 (Donlan et al.1999, this volume). Over a seven-month period, over 400 rabbits were removed from West San Benito by hunting and/or trapping. About 15 rabbits were also removed from Middle San Benito during the same time period (Donlan et al. 1999, this

volume). West and Middle San Benito are now reportedly free of rabbits and goats; rabbits remain on East San Benito however. Burros remain on West Benito, where they are used to transport supplies to the lighthouses on the island, but they have been corralled and imported food is now provided for them (Donlan et al. 1999, this volume).

At least nine nonnative plant taxa have been introduced onto the San Benitos, most of them since the 1970s (see Table 1). Annual iceplants (*Mesembryanthemum crystallinum* and *M. nodiflorum*) are currently the most abundant of the introduced plants. At present, the other plant taxa that have been introduced to the islands grow in scattered populations and do not dominate large areas.

In summary, a continued presence of herbivores on all three islets would undoubtedly have had deleterious effects on the unique plant life of the San Benitos. Goats have decimated the flora of Guadalupe Island (Moran 1996), while sheep and rabbits nearly drove the endemic *Dudleya* on Santa Barbara Island to extinction (Philbrick 1972; Moran 1978). The recent conservation actions on West and Middle Benito may have saved several unique plants from extinction. At times, the abundance and distribution of some endemic plant species, notably the San Benito Island bush mallow (*Malva pacifica*) and San Benito Island live-forever (*Dudleya linearis*), have been drastically affected by introduced herbivores. Several native shrubs that were reported in the late 1890s have not been seen in recent years and may have disappeared from the San Benitos because of herbivores.

## VEGETATION

The terrestrial vegetation on the San Benito Islands is characterized by low-growing, widely spaced, drought-resistant shrubs and stem succulents with large open spaces between them. In years with adequate rainfall, annual plants occupy many of these open spaces for a month or more.

The dominant plant community is maritime desert scrub. This vegetation type consists almost entirely of low perennials, with no trees and few shrubs taller than one meter. The tallest plants on the islands are coastal agave (*Agave sebastiana*), which is abundant and conspicuous on slopes, and old man cactus (*Lophocereus schottii*), which grows only in an isolated colony on East San Benito. Dominant perennial species in the maritime cactus scrub include the shrubs and suffrutescent perennials *Agave sebastiana, Euphorbia misera, Frankenia palmeri, Lycium brevipes, L. californicum, Malva pacifica, Suaeda moquinii,* and the cacti *Mammillaria neopalmeri* and *Opuntia* sp. nova. The cover of the perennial species is not continuous, and short-lived or ephemeral taxa dominate some areas. Large numbers of winter annuals, including *Calandrinia maritima, Cryptantha* spp., *Eschscholzia ramosa, Hemizonia streetsii,* and *Perityle emoryi,* grow in open sites between the larger plants after rainstorms. A perennial herb with a subterranean corm (*Dichelostemma capitatum*) is locally common but is active only while soil moisture is high.

**Table 1. Dates of first known records of nonnative plants on the San Benito Islands.**

| Plant | Date of first known record* |
|---|---|
| *Mesembryanthemum crystallinum* | 1889 |
| *Sonchus tenerrimus* | 1897 |
| *Mesembryanthemum nodiflorum* | 1937 |
| *Malva parviflora* | 1970 |
| *Chenapodium murale* | 1972 |
| *Melilotus indicus* | 1979 |
| *Cakile maritima* | 1993 |
| *Datura discolor* | 1997 |
| *Erodium moschatum* | 1998 |

*See text and appendix for additional information.

Canyons on the north side of West San Benito support a rich mixture of native plants, some of which are found only on north-facing slopes. In years with adequate rainfall, *Malva pacifica* is extremely abundant and is a conspicuous dominant. Rocky canyon walls support populations of *Agave sebastiana, Dudleya linearis, Encelia asperifolia, Euphorbia misera, Phacelia ixodes, Petalonyx linearis,* and *Senecio cedrosensis.* Native annuals like *Aphanisma blitoides, Cryptantha maritima, Cryptantha patula, Eschscholzia ramosa*, and *Perityle emoryi* can be abundant in canyon bottoms in wet years.

Sandy and gravelly areas near the shore, especially on the north side of West San Benito, support small patches of depauperate coastal strand vegetation. Dominant species here include *Atriplex barclayana, Cakile maritima, Frankenia palmeri,* and *Suaeda moquinii*. *Frankenia* and *Suaeda* dominate large areas of alkaline flats around the perimeter of the islands, along with *Mesembryanthemum crystallinum* and *M. nodiflorum*. In rocky intertidal and subtidal habitats around the margin of the island, *Phyllospadix scouleri* and *P. torreyi* grow in a surf-grass community.

Introduced annuals are common along trails used by burros and humans and in areas disturbed by seabird activity. *Mesembryanthemum crystallinum* and *M. nodiflorum* cover large areas around the island's perimeter, while *Chenopodium murale* and *Malva parviflora* grow in scattered patches.

## FLORA

The documented flora of the San Benito Islands includes 51 vascular plant taxa representing 24 families and 42 genera (see Appendix). Four additional plant taxa (*Errazurizia benthamii, Mirabilis californica*, *Trixis angustifolia*, and *Viguiera lanata*) have been reported in the literature but no voucher specimens have been found to date, so they are not included in the statistics given here. The

largest families are the Asteraceae (seven taxa), Chenopodiaceae (five taxa), and Cactaceae (four taxa). Genera represented by two taxa include *Atriplex*, *Cryptantha, Lepidium, Lycium, Mesembryanthemum,* and *Phyllospadix.*

**Native and Endemic Plant Taxa**

A total of 42 plant taxa presumed to be native have been documented for the San Benito Islands to date. Plant families with the highest number of native taxa are Asteraceae (six taxa), Cactaceae (four taxa), and Chenopodiaceae (four taxa). The genera *Atriplex, Cryptantha*, *Lepidium*, *Lycium,* and *Phyllospadix* are each represented by two native taxa.

Many of the native plant taxa found on the San Benitos are endemic to Baja California. At least nine of them are restricted to the California Islands or offshore rocks and are not found on the adjacent mainland. Three plant taxa are known only from the San Benito Islands (*Dudleya linearis, Hemizonia streetsii*, and *Mammillaria neopalmeri*). Four taxa (*Ferocactus chrysacanthus, Mentzelia hirsutissima* var. *nesiotes*, *Opuntia* sp. nova, and *Senecio cedrosensis*) are found only on the San Benitos and neighboring islands. Two other insular endemics (*Eschscholzia ramosa* and *Malva pacifica*) are more widespread but are not found on the mainland. One additional taxon (*Cryptantha patula*) may also be endemic to the San Benito Islands, but its relationship with other species on the Baja California mainland needs further study.

**Nonnative Plant Taxa**

At least nine plant taxa in eight families and eight genera have been introduced to the San Benitos, primarily since the 1970s (see Table 1). These introductions represent about 17% of the island's total flora. By comparison, known percentages of nonnative plants on the other islands off the west coast of Baja California range from about 18% (Natividad Island) to about 50% (San Geronimo Island). Six of the island's nonnative plants originated in Europe and two taxa are native to South Africa. The only plant family represented on the San Benitos solely by nonnative taxa is the Aizoaceae. The Aizoaceae is also the only family with more than one introduced taxon, namely two species of *Mesembryanthemum*. On the San Benitos, all of the introduced plant taxa are annual plants. Conspicuously absent from these desert islands are the invasive European grasses found on many of the other islands off the west coast of Baja California.

One additional plant may have been introduced to the San Benitos. *Plantago ovata*, presumed at this point to be native to the San Benitos, is also known from all of the California Channel Islands and from Guadalupe, Cedros, and Natividad islands. Although it was among the first plants reported for the San Benitos, this *Plantago* may be a very early introduction from the Mediterranean area of Europe (Dempster 1993).

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## APPENDIX

## ANNOTATED CATALOG OF THE FLOWERING PLANTS OF THE SAN BENITO ISLANDS

Plants listed in this table are arranged alphabetically by family within two major plant groups (dicotyledonous and monocotyledonous flowering plants). Taxa presumed to be introduced to Baja California and/or the San Benito Islands by human activities are preceded by an asterisk (*). The list does not include plant taxa that have been planted at the village unless they are surviving without cultivation in other parts of the islands. Unsubstantiated reports (reports for which no voucher specimen has been found) are enclosed in braces (i.e., { }).

For most taxa, nomenclature follows Wiggins (1980) or Hickman (1993). Abbreviations of author names have been mostly standardized according to Brummitt and Powell (1992). Selected synonyms are shown in brackets (i.e., [ ]). Common names are mostly according to Abrams (1923-1960) and Hickman (1993), with a few additions from Beauchamp (1986), Coyle and Roberts (1975), and Martinez (1979).

Abundance ratings (rare, scarce, occasional, common, and abundant) and distribution descriptions are based on observations of the authors. Dates of first known collection or report from the San Benitos are included for nonnative taxa.

Up to five voucher specimens are cited for each taxon. These are arranged first by islet (i.e., WSBe for West San Benito Island, MSBe for Middle Island, and ESBe for East Island) and then chronologically by date of collection. Labels on some early voucher specimens did not include precise locality information; these are cited as SBe (for San Benito Island). Specimens without date of collection are cited as "n.d."; those collections without collector's number are listed as "s.n.". Abbreviations for herbaria are those used in Holmgren et al. (1990). Herbarium accession numbers are cited only if there is no collector number.

### Dicotyledonous Flowering Plants

#### Aizoaceae (Iceplant Family)

**Mesembryanthemum crystallinum* L. CRYSTALLINE ICEPLANT Common; disturbed flats and slopes on west and east islets. First reported by Greene (1889). Palmer reported that this taxon was "very plentiful" on the west islet (Vasey and Rose 1890).

WSBe, 19 Jan 1975, *Henrickson 14514a* (RSA-POM); WSBe, 31 Jan 1985, *Thorne 58467* (RSA-POM).

**Mesembryanthemum nodiflorum* L. SLENDER-LEAVED ICEPLANT, SMALL-FLOWERED ICEPLANT Common; disturbed flats on all islets. First collected on the west islet in 1937.

WSBe, 14-15 Jul 1937, *Rempel 369* (RSA-POM); WSBe, 14-15 Jul 1937, *Rempel 371* (RSA-POM); WSBe, 18 Apr 1948, *Moran 2949* (UC); WSBe, 19 Jan 1975, *Henrickson 14514b* (RSA-POM).

#### Asteraceae (Sunflower Family)

*Amblyopappus pusillus* Hook. & Arn. PINEAPPLE WEED Occasional; slope and flats, especially around perimeters, on all islets.

SBe, 9 Mar 1911, *Rose 16052* (GH, NY); WSBe, 7 Feb 1972, *Beauchamp 3178* (SD); ESBe, 6 Feb 1950, *Lindsay 1832* (UC).

*Encelia asperifolia* (S.F.Blake) Clark & Kyhos [*E. californica* var. *asperifolia* S.F.Blake] BUSH SUNFLOWER Scarce; slopes and canyon walls on west islet.

SBe, 27 Mar 1897, *Brandegee s.n.* (UC 135059); WSBe, 9 Nov 1966, *Howe s.n.* (SD 67083); WSBe, 31 Jan 1985, *Thorne 58475* (RSA-POM, UC).

*Hemizonia streetsii* A.Gray SAN BENITO ISLAND TARWEED Common; slopes and flats of all islets. Can be very abundant in years with sufficient rainfall. Endemic to the San Benito Islands.
SBe, 25 Mar 1889, *Palmer 720* (CAS, NY); WSBe, 24 May 1952, *Moran 4189* (DS); MSBe, 19 Apr 1963, *Moran 10754* (SD, UC); ESBe, 20 Apr 1970, *Moran 17443* (SD).

*Perityle californica* Benth. Scarce; flats and arroyos on north side of west islet.
WSBe, 25 Mar 1974, *Moran 21169* (SD); WSBe, 13 Feb 1972, *Voss 1211* (SD); WSBe, 29 Mar 1987, *Junak 3235* (SBBG).

*Perityle emoryi* Torr. [*P.grayi* Rose] EMORY'S ROCK DAISY Common; flats and arroyos on all islets.
SBe, Feb 1889, *Pond s.n.* (ND-G 061166); WSBe, 8 Jan 1973, *Anderson 3218* (RSA-POM); MSBe, 5 Feb 1950, *Lindsay 1825* (SD, UC).

*Senecio cedrosensis* Greene CEDROS ISLAND RAGWORT Occasional; rocky canyon walls on north side of west islet. Endemic to West San Benito and Cedros islands. Foliage on plants from West San Benito is strongly scented while plants on Cedros are unscented; the San Benito population needs further study and may represent an undescribed taxon.
WSBe, 24 Jan 1972, *Moran 19060* (SD); WSBe, 26 Mar 1973, *Moran 20314* (SD); WSBe, 23 Feb 1975, *Benedict s.n.* (SBBG 53386).

**Sonchus tenerrimus* L. SLENDER SOW-THISTLE Occasional; slopes, flats, and arroyos on west islet. First reported for the island by Brandegee (1900).
WSBe, 7 Feb 1972, *Beauchamp 3174* (SD); WSBe, 25 Mar 1974, *Moran 21170* (SD); WSBe, 16 Feb 1986, *Thorne 61507* (RSA-POM).

{*Trixis californica* Kellogg Reported (as *T. angustifolia* A.Gray) for west islet by Greene (1889); no specimen has been found.}

{*Viguiera lanata* (Kellogg) A.Gray Reported for west islet by Greene (1889); no specimen has been found.}

**Boraginaceae (Borage Family)**

*Cryptantha maritima* (Greene) Greene var. *maritima* [*Krynitzkia m.* Greene] GUADALUPE ISLAND CRYPTANTHA Common; flats and arroyos on north side of west islet.
SBe, 28 Apr 1897, *Brandegee s.n.* (NY, UC 78552); WSBe, 26 Mar 1973, *Moran 20312* (RSA-POM, SD); WSBe, 15 Mar 1993, *Junak 5305* (SBBG).

*Cryptantha patula* Greene SAN BENITO ISLAND CRYPTANTHA Scarce; flats and arroyos on north side of west islet. Only seen in wet years. May be endemic to the San Benito Islands; the relationship of this taxon with *C. pondii* needs further study.
SBe, 1889, *Pond s.n.* (ND-G 001388); SBe, 27 Mar 1897, *Brandegee s.n.* (UC 78590); WSBe, 15 Mar 1993, *Junak 5308* (NY,RSA,SBBG,UC); WSBe, 15 Mar 1993, *Junak 5321* (RSA,SBBG,SD,US).

**Brassicaceae (Mustard Family)**

**Cakile maritima* Scop. SEA ROCKET Scarce; beaches at northeastern side of west islet. First collected on the island in 1993.
WSBe, 15 Mar 1993, *Junak 5312* (SBBG); WSBe, 27 Feb 1998, *Junak 6272* (SBBG).

*Lepidium lasiocarpum* var. *latifolium* C.L.Hitchc. Occasional; flats and arroyos on west islet.
SBe, n.d., *Brandegee s.n.* (UC 117600).

*Lepidium oblongum* var. *insulare* C.L.Hitchc. LENTEJILLA Occasional; flats and arroyos on all islets.
SBe, 27 Mar 1897, *Brandegee s.n.* (UC 117594); SBe, Mar-Jun 1897, *Anthony 275* (DS, SD); ESBe, 20 Apr 1970, *Moran 17446* (SD).

**Cactaceae (Cactus Family)**

*Ferocactus chrysacanthus* (Orcutt) Britton &.Rose CEDROS ISLAND BARREL CACTUS Rare; rocky slopes at upper elevations on west islet. Endemic to West San Benito and Cedros islands (Lindsay 1996).
WSBe, 9 Feb 1986, *Thorne 61505* (RSA-POM).

*Lophocereus schottii* (Engelm.) Britton & Rose var. *schottii* OLD MAN CACTUS or GARAMBULLO Rare; localized colony on flats of east islet.
ESBe, 19 Apr 1963, *Moran 10755* (SD).

*Mammillaria neopalmeri* Craig SAN BENITO ISLAND MAMMILLARIA Occasional; rocky flats on all islets. Can be locally abundant. Endemic to the San Benito Islands.
SBe, Mar-Jun 1897, *Anthony 278* (DS); WSBe, 20 Jan 1975, *Philbrick B75-26* (SBBG).

*Opuntia* sp. nova CEDROS ISLAND CHOLLA Common; rocky slopes and flats on all islets. An undescribed taxon which is apparently endemic to San Benito, Cedros, and Natividad islands (J. Rebman, personal communication, 1997). Sterile specimens of this taxon were collected as early as 1911 (Britton and Rose 1919; Moran and Lindsay 1951)

but no flowers have been collected to date. Some plants on East Benito may represent yet another undescribed taxon (Moran and Lindsay 1951).
WSBe, 9 Mar 1911, *Rose 16043* (US); WSBe, 20 Jan 1975, *Philbrick B75-34* (SBBG).

**Chenopodiaceae (Goosefoot Family)**

*Aphanisma blitoides* Moq. APHANISMA Occasional; flats and arroyos on west and east islets.
SBe, Jul-Oct 1896, *Anthony s.n.* (UC 116501); WSBe, 18 Apr 1963, *Moran 10745* (SD); ESBe, 20 Apr 1970, *Moran 17450* (SD).

*Atriplex barclayana* (Benth.) D.Dietr. [*A. b.* subsp. *dilatata* (Greene) H.M.Hall & Clem.] SALADILLO Occasional; coastal flats on all islets; locally common on north side of west islet.
SBe, Mar-Jun 1897, *Anthony 269* (UC); WSBe, 8 Feb 1971, *Beauchamp 1532* (RSA-POM).

{*Atriplex coulteri* (Moq.) D.Dietr. Reported for the island by Brandegee (1900); all specimens seen appear to be *A*. aff. *davidsonii*.}

*Atriplex* aff. *davidsonii* Standl. DAVIDSON'S SALTSCALE Scarce; flats on west islet.
SBe, Mar-Jun 1897, *Anthony 277* (CAS, RSA-POM); WSBe, 24 May 1952, *Moran 4194* (DS).

**Chenopodium murale* L. NETTLE-LEAF GOOSEFOOT Common; disturbed flats near village on west islet and on east islet. First collected on the island in 1972.
WSBe, 24 Jan 1972, *Moran 19062* (SD); WSBe, 31 Jan 1985, *Thorne 58476* (RSA-POM).

*Suaeda moquinii* (Torr.) Greene BUSH SEEPWEED Common; coastal flats on all islets.
SBe, 1889, *Pond s.n.* (ND-G 015455); WSBe, 18 Apr 1963, *Moran 10739* (SD); ESBe, 20 Apr 1970, *Moran 17452* (SD).

**Crassulaceae (Stonecrop Family)**

*Crassula connata* (Ruiz & Pavon) A. Berger [*C. erecta* (Hook. & Arn.) A. Berger] PYGMY WEED Rare; coastal flats near village on west islet.
WSBe, 15 Mar 1993*, Junak 5306* (SBBG).

*Dudleya albiflora* ROSE LIVE-FOREVER or SIEMPREVIVA Rare; apparently known only from a collection made in 1905. The specimen cited below may have been mislabelled as to location. This dudleya has not been seen on the San Benitos by other collectors, but it is common on Cedros and Natividad, the next islands visited by Stewart.
SBe, 14 Jul 1905, *Stewart s.n.* (CAS 136281).

*Dudleya linearis* (Greene) Britton & Rose SAN BENITO ISLAND LIVE-FOREVER Scarce; canyon walls and slopes on north side of west islet. Endemic to West San Benito Island.
SBe, 1889, *Pond s.n.* (ND-G 020620); WSBe, 18 Apr 1963, *Moran 10744* (SD).

**Cuscutaceae (Dodder Family)**

*Cuscuta californica* Hook. & Arn. DODDER or WITCH'S HAIR Occasional; north shore of west islet. Parasitic on *Frankenia palmeri* and several annual species on San Benito.
WSBe, 26 Mar 1973, *Moran 20315* (RSA-POM, SD); WSBe, 19 Feb 1977, *Davidson 5455* (RSA-POM, SD).

**Euphorbiaceae (Spurge Family)**

*Euphorbia misera* Benth. CLIFF SPURGE Common; rocky slopes and flats on west and east islets. E. L. Greene applied the name *Euphorbia benedicta* to plants from the San Benito islands; they may indeed represent a distinct taxon and need further study.
SBe, Jul-Oct 1896, *Anthony 20* (NY); SBe, 9 Mar 1911, *Rose 16050* (NY); WSBe, 9 Mar 1971, *Benedict s.n.* (SBBG 48227); ESBe, 6 Feb 1950, *Lindsay 1827* (UC).

**Fabaceae (Pea Family)**

{*Errazurizia benthamii* (Brandegee) I.M.Johnst. Reported for San Benito Island by Wiggins (1940); no specimen has been found.}

*Lotus salsuginosus* subsp. *brevivexillus* Ottley [*Hosackia maritima* Nutt.] COASTAL LOTUS Occasional; flats on west islet.
SBe, 28 Mar 1897, *Brandegee s.n.* (UC 80939); WSBe, 26 Mar 1973, *Moran 20318* (SD).

**Melilotus indicus* (L.) All. YELLOW SWEET CLOVER Rare; known from a single collection made in 1979 near village on west islet.
WSBe, 12 May 1979, *Moran 27230* (SD).

*Phaseolus filiformis* Benth. Scarce; north side of west islet.
SBe, 28 Mar 1897, *Brandegee s.n.* (UC 82395); WSBe, 31 Jan 1985, *Thorne 58474* (RSA-POM).

**Frankeniaceae (Frankenia Family)**

*Frankenia palmeri* (Molina) I.M.Johnst. [*F. grandifolia* Cham. & Schltdl.] PALMER'S FRANKENIA or YERBA REUMA Common; lower slopes and flats around perimeters of all islets.
WSBe, 9 Mar 1971, *Benedict s.n.* (SBBG 48233); WSBe, 20 Jan 1975, *Philbrick B75-25* (SBBG).

**Geraniaceae (Geranium Family)**

**Erodium moschatum* (L.) L'Her. WHITESTEM FILAREE Rare; disturbed flats near village on west islet. First collected in 1998.
WSBe, 27 Feb 1998, *Junak 6283* (SBBG).

**Hydrophyllaceae (Waterleaf Family)**

*Phacelia ixodes* Kellogg COSTA BAJA PHACELIA or ISLAND MISERY Occasional; rocky n-facing slopes, primarily in canyons, on north side of west islet. This plant should be avoided as it can cause severe contact dermatitis in humans.
SBe, Jul-Oct 1896, *Anthony s.n.* (UC 107389); WSBe, 6 Feb 1950, *Lindsay 1833* (UC); WSBe, 12 May 1979, *Moran 27237* (SD).

**Loasaceae (Stick-leaf Family)**

*Mentzelia hirsutissima* var. *nesiotes* I.M.Johnst. NATIVIDAD ISLAND BLAZING STAR Rare; rocky slopes and flats of west islet. Endemic to San Benito, Cedros, and Natividad islands.
SBe, 28 Mar 1897, *Brandegee s.n.* (UC 138558).

*Petalonyx linearis* Greene Occasional; rocky canyon walls, arroyos, and slopes on west islet.
SBe, Jul-Oct 1896, *Anthony 31* (SBBG); WSBe, 8 Feb 1971, *Beauchamp 1535* (SD); WSBe, 4 Apr 1971, *Beauchamp 2093* (SD).

**Malvaceae (Mallow Family)**

*Eremalche exilis* (A.Gray) Greene [*Malvastrum e*. A.Gray] Rare; not seen recently.
SBe, Mar 1897, *Brandegee s.n.* (UC 174088).

*Malva pacifica* M.F.Ray [*Lavatera venosa* S.Watson] SAN BENITO ISLAND BUSH MALLOW Common; arroyos, slopes,and flats throughout west islet; scattered on flats of middle and east islets. Native populations are endemic to San Geronimo Island, the San Benito Islands, and an islet at the mouth of Bahia Tortugas; probably introduced on Cedros, Natividad, and Asuncion islands.
SBe, 27 Mar 1897, *Brandegee s.n.* (UC 109034, 109040); WSBe, 25 Mar 1974, *Moran 21173* (SD, UC); MSBe, 5 Feb 1950, *Lindsay 1823* (UC); MSBe, 25 May 1971, *Moran 18399* (SD); ESBe, 20 Apr 1970, *Moran 17442* (SD).

**Malva parviflora* L. CHEESEWEED Occasional; disturbed flats near lighthouse and village on west islet. First collected on the island in 1970.
WSBe, 19 Apr 1970, *Moran 17435* (SD); WSBe, 20 Jan 1975, *Philbrick B75-30* (SBBG); WSBe, 9 Feb 1986, *Thorne 61517* (RSA-POM).

**Nyctaginaceae (Four-O'Clock Family)**

{*Mirabilis californica* A.Gray Reported for west islet by Greene (1889); no specimen has been found.}

**Papaveraceae (Poppy Family)**

*Eschscholzia ramosa* Greene [*E. crassula* Greene] ISLAND POPPY Common; arroyos and flats on west and east islets. Endemic to Santa Rosa, Santa Cruz, Santa Barbara, San Nicolas, Santa Catalina, San Clemente, Los Coronados, Todos Santos, San Martin, Guadalupe, San Benito, Cedros, and Natividad islands.
SBe, Dec 1875, *Streets s.n.* (GH); SBe, 25 Mar 1889, *Palmer 909* (CAS); WSBe, 20 Apr 1948, *Moran 2953* (GH); ESBe, 6 Feb 1950, *Lindsay 1829* (UC).

**Plantaginaceae (Plantain Family)**

*Plantago ovata* Forssk. [*P. insularis* Eastw.] Occasional; flats on west and east islets. May be introduced.
SBe, Feb 1889, *Pond s.n.* (ND-G 050700); SBe, 27 Mar 1897, *Brandegee s.n.* (UC 102793).

**Portulacaceae (Purslane Family)**

*Calandrinia maritima* Nutt. SEA KISSES or SEASIDE CALANDRINIA Common in arroyos and on flats of west islet; scarce on flats of east islet.
WSBe, 7 Feb 1972, *Beauchamp 3179* (SD); ESBe, 20 Apr 1970, *Moran 17448* (SD).

**Resedaceae (Mignonette Family)**

*Oligomeris linifolia* Vahl OLIGOMERIS Common; coastal slopes and flats on west and east islets.
SBe, Mar-Jun 1897, *Anthony 272* (SD); WSBe, 7 Feb 1972, *Beauchamp 3169* (SD); ESBe, 20 Apr 1970, *Moran 17447* (SD).

**Scrophulariaceae (Figwort Family)**

*Antirrhinum watsonii* Vasey & Rose [*A. kingii* var. *w.* (Vasey & Rose) Munz, *Sairocarpus w.* Vasey & Rose) D.A. Sutton] WATSON'S SNAPDRAGON Scarce; arroyos and flats of west and east islets.
WSBe, 26 Mar 1973, *Moran 20317* (SD); WSBe, 12 May 1979, *Moran 27235* (SD).

**Solanaceae (Nightshade Family)**

**Datura discolor* Bernh. JIMSON WEED Rare; disturbed flats near village on west islet. Probably introduced; first collected at village garbage dump in 1997.
WSBe, 5 Dec 1997, *West 13* (SBBG); WSBe, 27 Feb 1998, *Junak 6282* (SBBG).

*Lycium brevipes* Benth. var. *brevipes* FRUTILLA Common; flats on all islets.
WSBe, 12 May 1979, *Moran 27239* (SD).

*Lycium californicum* Nutt. CALIFORNIA BOXTHORN Occasional on flats of west islet; common on flats of east islet.
SBe, 28 Mar 1897, *Brandegee s.n.* (UC 103835); WSBe, 12 May 1979, *Moran 27238* (SD); ESBe, 20 Apr 1970, *Moran 17445* (SD).

**Monocotyledonous Flowering Plants**

**Agavaceae (Agave Family)**

*Agave sebastiana* Greene [*A. shawii* var. *sebastiana* (Greene) Gentry] COASTAL AGAVE or MESCAL Abundant; slopes of west and east islets.
SBe, Mar-Jun 1897, *Anthony 264* (DS, US); WSBe, 8 Nov 1966, *Howe & Harbison s.n.* (SBBG 55151); WSBe, 9 Mar 1971, *Benedict s.n.* (SBBG 43885); WSBe, 20 Jan 1975, *Philbrick B75-31* (SBBG).

**Alliaceae (Onion Family)**

*Dichelostemma capitatum* (Benth.) A.W.Wood [*D. pulchellum* (Salisb.) A.A. Heller] BLUE DICKS Locally common near lighthouse and along north shore of west islet; occasional elsewhere on west and east islets.
WSBe, 11 Jan 1889, *Pond s.n.* (ND-G 000246).

**Zosteraceae (Eel-Grass Family)**

*Phyllospadix scouleri* Hook. SURF-GRASS Common; rocky intertidal and subtidal habitats along north shores of west and middle islets.
WSBe, 18 Apr 1963, *Moran 10742* (SD); WSBe, 19 Apr 1970, *Moran 17440* (RSA-POM, SD); MSBe, 25 May 1971, *Moran 18400* (RSA-POM).

*Phyllospadix torreyi* S.Watson SURF-GRASS Occasional; rocky intertidal and subtidal habitats along west shore of west islet.
WSBe, 31 Jan 1985, *Thorne 58485* (RSA-POM).