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Author(s): Jon P. Rebman, Thomas A. Oberbauer and José Luis León de la Luz

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THE FLORA OF TORO ISLET AND NOTES ON GUADALUPE ISLAND,
BAJA CALIFORNIA, MEXICO

JON P. REBMAN

San Diego Natural History Museum, P.O. Box 121390,
San Diego, CA 92112-1390, USA
jrebman@sdnhm.org

THOMAS A. OBERBAUER

County of San Diego, Department of Planning and Land Use,
5201 Ruffin Rd. Suite B5, San Diego, CA 92123, USA

JOSÉ LUIS LEÓN DE LA LUZ

Centro de Investigaciones Biológicas del Noroeste, Apdo. Postal 128,
La Paz, 23000, Baja California Sur, México

ABSTRACT

During a natural history expedition to Guadalupe Island and its adjacent islets in June of 2000, the previously unexplored islet, Toro, was botanically surveyed. The flora of this islet was found to have 32 species and one putative interspecific hybrid. This diversity represents 30 dicots and 2 monocots, in 22 plant families. Eighteen of the plant taxa are endemic to the Guadalupe Island group, resulting in a 56.3% endemism in the islet's flora. A few native plant communities were observed on the islet, within which only three plant taxa are obviously exotic, rare in occurrence, and presumably introduced by seabirds. The botanical data obtained from this undisturbed islet helps us to fill in the missing pieces about the overall flora of Guadalupe Island and its adjacent islets especially in relation to the ecological devastation caused by feral goats on the main island. Brief notes on other floristic components of Guadalupe Island and its islets, and new plant records collected during the expedition are also presented.

RESUMEN

Durante una expedición para estudiar la historia natural de la Isla Guadalupe e islotes adyacentes, en junio de 2000, inventariamos la flora del islote Toro, que nunca había sido explorado. En este islote encontramos 32 especies de plantas y un aparente híbrido interespecífico, incluyendo 30 dicotiledonas y 2 monocotiledonas, de 22 familias. Dieciocho de los taxa son endémicos a la Isla Guadalupe e islotes adyacentes, por lo tanto Toro tiene una tasa de endemismo de 56.3%. Se encontraron algunas comunidades de plantas nativas, en las que solamente 3 taxa eran exóticas, poco abundantes, probablemente introducidas por aves marinas. La información botánica de este islote sin disturbio puede ayudarnos a llenar las piezas faltantes de la flora de Guadalupe, especialmente en relación con la devastación ecológica causada por cabras en la isla principal. Además, en este artículo presentamos notas breves sobre otros componentes florísticos de la Isla Guadalupe y sus islotes, y nuevos registros de plantas colectadas durante la expedición.

Key words: Guadalupe Island, Baja California, Mexican flora, expedition, endemism

The Guadalupe Island Expedition in June of 2000 involved 16 scientists from the U.S.A. and Mexico representing arachnology, botany, conservation biology, entomology, marine ecology, ornithology, and phycology. This expedition was organized by the San Diego Natural History Museum and funded by the Biotic Surveys and Inventories section of the National Science Foundation (Grant No. 0074462). The primary emphases of this binational, multidisciplinary endeavor were to observe, record, and collect natural history information on the biodiversity of Guadalupe Island and the previously unexplored Toro Islet. The botanists of the expedition were Dr. José Luis León de la Luz of the Centro de Investigaciones Biológicas del Noroeste, Tom Oberbauer of the Department of Planning and Land Use for the County of San Di-

ego, and Dr. Exequiel Ezcurra, and the senior author from the San Diego Natural History Museum.

The biological data obtained on this trip provides us with additional biodiversity information on all of the terrestrial areas of Guadalupe Island and its islets and will be used for making conservation decisions for the island and evaluating the impacts of introduced species such as feral goats and cats. The floristic information from the expedition can be used to supplement our current knowledge on the entire Guadalupe Island flora as presented by Moran (1996).

THE ISLAND ENVIRONMENT

Guadalupe is an oceanic island located approximately 260 km off the Pacific coast of the Baja

California peninsula, in northwestern Mexico. The island's general geographic position is 29°03'N latitude and 118°17'W longitude. Guadalupe Island is about 36 km long on its N-S axis and 12 km wide on the E-W axis, with an approximate surface area of 250 km². The island is the peak of a seamount, which may have originated from several eruptive episodes, with the oldest exposed rocks being dated around 7 million years old (Moran 1996). There are three islets off of the southern end of the main island: Negro (30 m in elevation), Toro (220 m), and Zapato (190 m). Each islet has approximately 1 km² of surface area.

The climate of the island is maritime and heavily influenced by the cold California Current, with its characteristic features of wind, fog, and winter rainfall. A meteorological station on the southern end of Guadalupe (the driest area of the island) indicates almost 120 mm of rainfall annually and a mean monthly temperature of 17–19°C that is relatively stable throughout the year. It should be noted that the annual precipitation value given above does not include the contribution of moisture from fog condensation, which is a common event on Guadalupe Island.

Floristically, the island is considered an “outlier” of the California Floristic Province (Moran 1996) since it is composed of many native plant species either disjunct from this vegetation type on the mainland or on other islands, or endemic species with northern affinities. Although the island is home to Mexico's only populations of many plant species from the California Floristic Province, its most striking attribute is its endemism, which occurs in many biological groups. According to Moran (1996) in respect to plants, almost 22% of the native species are endemic, including two monospecific genera. Although there have been 220 different plant taxa documented over time on Guadalupe Island and its islets, the activities of feral goats released in the early 19th century by whalers have devastated most of the main island's flora. This impact on the flora is not only from the direct browse of goats, but also from the damage to the insular substrates as a result of soil erosion. At present, the main island's original flora and natural plant communities have practically vanished. It is estimated (Moran 1996) that at least 26 native plant species could now be extinct, including one endemic, monospecific genus and many other plant species seem to be on the threshold. To add to the problem, the vegetation is now dominated mainly by weedy species; 62 exotic plant taxa have been recorded on the island, of which many are quite aggressive and capable of competing for niches and displacing native species.

Toro (also known as Islote de Adentro or Inner Islet) is a small islet that lies directly off of the southern end of Guadalupe Island, situated between the main island and another southern islet, Zapato. Toro Islet is a dome-shaped rock that reaches ap-

proximately 500–700 feet (165–220 m) in elevation. The islet has very steep, vertical walls that arise out of the water at an angle of almost 90 degrees and that have, heretofore, prohibited its exploration. However, during this expedition the scientists used a helicopter to facilitate landing and exploration on the islet. On its top, Toro has a small basin in its center with a high western ridge. A narrow ridge extends to the north and drops into a steep slope facing the main island. There are two types of rocky substrates that exist on this volcanic islet. One type of substrate is a rocky, fractured basaltic material with darker coloration and the other is a tan, hard solid rock with characteristics of andesite. Plant species occur on both substrates but most seem to prefer the broken basaltic materials.

THE FLORA OF TORO

The known flora (see Table 1) of Toro Islet that was documented during the expedition consists of 32 species and 1 putative hybrid. This diversity represents 30 dicots and 2 monocots, in 22 plant families. Eighteen of the taxa are endemic to Guadalupe Island, resulting in a 56.3% rate of endemism in the islet's flora. The Asteraceae are the best represented on the islet with 5 genera, 6 species and one putative interspecific hybrid in the genus *Hemizonia*. Other families such as Malvaceae, Scrophulariaceae, and Fabaceae are represented with two genera. Only *Cryptantha*, *Hemizonia*, and *Mesembryanthemum* are represented with two species in the same genus.

Only three plant taxa (*Hordeum murinum* ssp. *glaucum*, *Mesembryanthemum crystallinum*, and *M. nodiflorum*) are obviously exotic. As of yet, their populations on the islet are small and their occurrences quite rare. It is likely that they are rather recent introductions, which presumably arrived by seabirds. In fact, *Hordeum* seems to be currently confined to the steep northern slope of the islet in an area near Western Gull (*Larus occidentalis*) nests.

Of the 32 plant species found on the islet, eleven are succulent in nature with fleshy leaves, stems, or both, and are represented by species in eight different plant families (Rebman 2001). Six of these succulent taxa are endemic to the Guadalupe Island and its adjacent islets. One of the leaf succulent species, *Baeriopsis guadalupensis* belongs to an endemic, monotypic genus in the Sunflower family (Asteraceae).

The vegetation of Toro Islet is best described as a maritime, succulent scrub and is similar to that found on the other southern islets, Zapato and Negro. This type of vegetation probably dominated most of the southern portions of the main island as well, but is mostly extirpated now by the impacts of feral goats. This vegetation is dominated by *Atriplex barclayana*, *Cistanthe guadalupensis*, *Euphorbia misera*, *Spergularia macrotheca* var. *talinum*,

TABLE 1. FLORISTIC LIST OF TORO ISLET, BAJA CALIFORNIA, MEXICO. Note that Coll. # refers to the collection numbers of plant specimens made by Rebman et al.

Plant taxon (family)	Coll. #
<i>Atriplex barclayana</i> (Benth.) D. Dietr. (Chenopodiaceae)	6753, 6763
<i>Baeriopsis guadalupensis</i> J. T. Howell (Asteraceae)	6758, 6882
<i>Castilleja fruticosa</i> Moran (Scrophulariaceae)	6774
<i>Cistanthe guadalupensis</i> (Dudley) Carolin in Hershkovitz (Portulacaceae)	6765
<i>Coreopsis gigantea</i> (Kellogg) H. M. Hall (Asteraceae)	6759
<i>Cryptantha foliosa</i> (Greene) Greene (Boraginaceae)	6781a
<i>Cryptantha maritima</i> (Greene) Greene var. <i>maritima</i> (Boraginaceae)	6781b
<i>Dichelostemma capitatum</i> Alph. Wood ssp. <i>capitatum</i> (Themidaceae)	6773
<i>Dudleya guadalupensis</i> Moran (Crassulaceae)	6757
<i>Erysimum moranii</i> Rollins (Brassicaceae)	6772
<i>Eschscholzia palmeri</i> Rose (Papaveraceae)	6755
<i>Euphorbia misera</i> Benth. (Euphorbiaceae)	6779
<i>Galvezia speciosa</i> (Nutt.) A. Gray (Scrophulariaceae)	6761
<i>Hemizonia greeneana</i> Rose ssp. <i>greeneana</i> (Asteraceae)	6756, 6766
<i>Hemizonia</i> hybrid (Asteraceae)	6775
<i>Hemizonia palmeri</i> Rose (Asteraceae)	6760
<i>Hordeum murinum</i> L. ssp. <i>glaucum</i> (Steud.) Tzvelev. (Poaceae)	6770
<i>Lavatera lindsayi</i> Moran (Malvaceae)	6754, 6764
<i>Lomatium insulare</i> (Eastw.) Munz (Apiaceae)	6780
<i>Lotus argophyllus</i> (A. Gray) Greene ssp. <i>ornithopus</i> (Greene) Raven (Fabaceae)	6769
<i>Lupinus niveus</i> S. Watson (Fabaceae)	6778
<i>Lycium californicum</i> Nutt. (Solanaceae)	6884
<i>Mammillaria blossfeldiana</i> Boed. var. <i>shurliana</i> (Gates) Wiggins (Cactaceae)	6784
<i>Mesembryanthemum crystallinum</i> L. (Aizoaceae)	6767
<i>Mesembryanthemum nodiflorum</i> L. (Aizoaceae)	n/a
<i>Mirabilis laevis</i> (Benth.) Curran var. <i>crassifolia</i> (Choisy) Spellennb. (Nyctaginaceae)	6777
<i>Perityle incana</i> A. Gray (Asteraceae)	6776
<i>Phacelia floribunda</i> Greene (Hydrophyllaceae)	6782
<i>Plantago ovata</i> Forssk. (Plantaginaceae)	6783
<i>Rhus integrifolia</i> (Nutt.) Brewer & S. Watson (Anacardiaceae)	6771
<i>Spergularia macrotheca</i> (Hornem.) Heynh. var. <i>talinum</i> (Greene) Jepson	6762
<i>Sphaeralcea palmeri</i> Rose (Malvaceae)	6768
<i>Stephanomeria guadalupensis</i> Brandegeee (Asteraceae)	6883

Sphaeralcea palmeri, and *Stephanomeria guadalupensis*. The succulent, perennial *Cistanthe guadalupensis* appears to be the most common of all of the species on the islet. It was in full flower during our visit in the early part of June, but other conspicuously flowering species included *Baeriopsis guadalupensis*, *Eschscholzia palmeri*, *Perityle incana*, and two species of *Hemizonia*. The plant community of the central basin on the islet is dominated by *Atriplex barclayana*, *Cistanthe guadalupensis*, and *Sphaeralcea palmeri* with a strong presence of *Dudleya guadalupensis*, *Euphorbia misera*, *Lavatera lindsayi*, *Lycium californicum*, *Mammillaria blossfeldiana* var. *shurliana*, *Spergularia macrotheca*, and *Stephanomeria guadalupensis*. On the upper slopes of the basin *Baeriopsis guadalupensis*, *Coreopsis gigantea*, *Eschscholzia palmeri*, *Hemizonia greeneana* ssp. *greeneana*, and *H. palmeri* are prominent. The endemic *Stephanomeria guadalupensis* is most common on the lower slopes and bottom of the basin. The steep northern slope was the only location where *Erysimum moranii*, *Phacelia floribunda* and *Rhus integrifolia* were found. One individual plant of a putative interspecific hybrid between *Hemizonia greeneana* ssp.

greeneana and *H. palmeri* was found on the northern ridge.

The flora of Toro Islet is very similar to that of Zapato Islet (also known as Islote de Afuera or Outer Islet) with a few exceptions. It is noteworthy that *Eriogonum zapatoense* was not found on Toro, though an effort was made to look for it. This endemic buckwheat species apparently only occurs on Zapato, where it is found on the upper ridge and basin rim and is relatively common there. Similar habitats were examined on Toro Islet, but it was not seen. Zapato Islet has a large basin that drops down to near sea level where plants such as *Aphanisma blitoides* occur. In general, Zapato appears to have a greater diversity of habitat types than Toro. Other species that occur on Zapato and not on Toro are *Atriplex californica*, *Calystegia macrostegia* ssp. *macrostegia*, *Crassula connata*, *Crossosoma californica* (which may no longer occur on Zapato), *Descurainaea pinnata* ssp. *menziesii*, *Hutchinsia procumbens*, *Lavatera occidentalis*, *Oligomeris linifolia*, *Parietaria hespera* var. *hespera*, *Perityle emoryi*, and *Pholistoma racemosum*. Plant taxa found on Toro Islet and not on Zapato include: *Cryptantha maritima*, *Hemizonia palmeri*, a puta-

tive *Hemizonia* hybrid, *Hordeum murinum*, *Lupinus niveus*, *Mesembryanthemum nodiflorum*, and *Plantago ovata*. All of these plants are found on the adjacent main island, which lies in closer proximity to Toro.

While Toro Islet was explored quite fully, there are still possibilities for plants that were missed, particularly annual species. A botanical survey of Toro in early spring of a rainy year would probably identify additional annuals in the islet's flora in genera such as *Descurainaea*, *Hutchinsia*, *Oligomeris*, *Parietaria*, and *Pholistoma*, all of which have been recorded on Zapato Islet.

MISCELLANEOUS BOTANICAL NOTES AND OBSERVATIONS FROM THE EXPEDITION

In total, 149 plant collections were made during the entire expedition of which, four specimens document new distributional records for both native and exotic species not previously known to occur on the island. The new records of naturalized, exotic species include: *Atriplex rosea* L. (*Rebman et al.* 6817) and *A. semibaccata* R. Br. (*Rebman* 6750), both found near the airstrip in the center of the main island; and *Schismus barbatus* (L.) Thell. (*Rebman* 6752) found in the vicinity of the Northeast Anchorage along the trail in Barracks Canyon.

Of particular note was the discovery of a new native species for the island, *Lonicera hispidula* Douglas var. *vacillans* A. Gray. This pink-flowered honeysuckle is also found on Santa Cruz, Santa Catalina, and San Clemente islands of California, but is the first record (*Rebman et al.* 6800) of its occurrence in Mexico. Only one individual plant was found on the upper parts of a 5-meter-high rocky cliff cascade.

Moran (1996) lists the weedy exotic *Chamomilla suaveolens* (Pursh) Rydb. (= *Matricaria matricarioides* (Less.) Porter) as part of the Guadalupe flora, but it should be noted that the specimen (*Wiggins & Ernst* 113) upon which this is based was misidentified and is actually the native species *C. occidentalis* (E. Greene) Rydb. Another plant species, *Dichelostemma capitatum*, was listed in Moran (1996) as possibly introduced to Guadalupe Island. However, its presence on Toro and Zapato as well as on major portions of the main island does not support the concept that it was introduced.

In preparation for the expedition, all of the data from specimens previously collected on Guadalupe Island and its adjacent islets that are housed in the SD Herbarium were compiled into a database. Digitized images, mostly scanned herbarium specimens, of the endemic plant taxa for the island archipelago were also captured.

Botanical specimens collected on the expedition were done so in replicate, whenever possible, so that specimens would be available for study in several herbaria. The first collections will be deposited at the SD Herbarium of the San Diego Natural His-

tory Museum, and duplicates will be in Mexican herbaria at HCIB in La Paz and BCMEX in Ensenada. Plant materials including seeds and/or specimen samples for genetic analyses were collected and sent to several institutions. Samples of species in the Asteraceae including *Baeriopsis*, *Perityle incana*, *Stephanomeria*, and the putative *Hemizonia* hybrid material were sent to the Jepson Herbarium (UC/JEPS) at the University of California Berkeley. Leaf material of *Castilleja fruticosa* was sent to the University of Washington (WTU) and samples of *Lavatera lindsayi*, *Lupinus niveus*, and *Phacelia floribunda* were sent to the University of South Dakota. *Triteleia guadalupensis* material was sent to the University of Wisconsin for research on the Themidaceae.

While conducting botanical explorations on Zapato Islet during the expedition, some observations were made on the reproductive biology of two plant species endemic to the Guadalupe Island group. These observations are based only on morphology and their functionality still needs to be investigated further. It appears that *Mammillaria blossfeldiana* var. *shurliana* is a gynodioecious species with two sexual conditions. Although many of the cacti were not in flower at the time of our visit, a few flowering individuals showed evidence for two flower types occurring on different plants. Most flowering individuals appeared to have only bisexual flowers, with both functional stamens and pistils. However, a few plants were obviously different and seemed to be functionally female. These pistillate individuals had flowers with smaller tepals, abortive anthers not producing pollen, and pistils with a larger size and increased number of stigmatic lobes. Plants showing these different floral characteristics grew in the same immediate vicinity on the islet. Gynodioecy is not uncommon in the *Mammillaria* species of Baja California since it has been documented in *M. dioica* and some of its relatives in the region (Lindsay and Dawson 1952). However, this is the first report of this sexual condition in this cactus species.

The other notable flower forms occurred in *Cistanthe guadalupensis*. Some individuals had flowers with "normal-sized" petals (corolla diameter approximately 3–4 cm.) and yellow anthers, while other plants had "normal-sized" flowers but had pink-purple anthers. Furthermore, a fewer number of individual plants had significantly smaller flowers (corolla diameter approximately 2 cm.) and much shorter inflorescences. These plants with smaller flowers and inflorescences exhibited only yellow anthers and no fruit formation was seen. All of these three different flower forms were observed on individuals growing in close proximity to one another on Zapato. The comparable stages of flowering and similar moisture conditions of the local habitat seem to rule out any environmental cause for these floral variations. Therefore, it is hypothesized that *Cistanthe guadalupensis* is an andro-

dioecious species. It appears that the individuals that have smaller flowers, shorter inflorescences, and no fruit formation are functionally staminate, while the plants with "normal-sized" flowers and viable pistils that develop into fruits are hermaphrodites. The variability in anther color on different hermaphroditic plants is not yet understood and may not affect the reproductive system of this species.

CONCLUSION

The botanical data obtained from Toro Islet during this expedition not only helps to fill in the missing pieces about the overall flora of Guadalupe Island and its adjacent islets, but it also yields important information for conservation efforts. Due to the extinction of various plant species as a result of the ecological devastation caused by feral goats on the main island, the undisturbed Toro Islet is a very important resource for plant taxa that can be used for restoration of the main island if and when the goats are removed. The diversity of native and endemic plants in this region is a rich heritage and serious conservation strategies need to be implemented in order to lessen the threats for their survival into the future.

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