

Biodiversity and biogeography of birds in Pacific Mexico along an isolation gradient from mainland Chamela via coastal Marias to oceanic Revillagigedo Islands

INGO J. HAHN^{1,2}, STEFFEN HOGEBACK^{1,2}, UWE RÖMER³
& PABLO M. VERGARA⁴

¹ Institute of Landscape Ecology, Biogeography Research Group, University of Münster,
Robert-Koch-Str. 28, 48149 Münster, Germany.
ingo.hahn(at)uni-muenster.de (corresponding author).

² Estacion de Biologia en Chamela, National Autonomic University of Mexico (UNAM), Jalisco, Mexico.

³ Institute of Biogeography, University of Trier, 54296 Trier, Germany.

⁴ Dep. of Ecology, Pontifical Catholic University of Chile, P.O. Box 114–D, Alameda 340, Santiago, Chile.

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> Abstract

Following an isolation gradient in West-Mexico the avifauna of three study areas is investigated, on mainland reserve and two island groups. The avifaunas are described and analysed regarding species richness, environmental attributes, endemism, broader ecological niches, and brood status. The taxonomical composition is determined on different hierarchy levels. Most species records come from mainland Chamela (262), followed by the coastal Marias (191) and the oceanic Revillagigedos (148). Thereof 139 bird species breed in Chamela, 61 on Marias and only 29 on the Revillagigedos. In total, in the three study areas 364 species were recorded, which belong to 22 orders. On island groups generally less taxa per hierarchy level are present than on the mainland, especially on the remote Revillagigedos. Here, on average 1.7 species are found per genus, 2.2 genera per family, and 2.5 families per order. In the analysis of the taxonomical hierarchy relations to each other an isolation gradient is identified: from mainland Chamela via the coastal Marias to the oceanic Revillagigedos the degree of relatedness decreases on average. The results support the theoretical hypothesis that on islands closely related taxa tend to exclude each other and that one generalist tends to replace several specialists. Small ecological niches are often not occupied by specialist species on islands, but are used by generalists.

> Kurzfassung

Entlang eines Isolationsgradienten in Westmexiko wird die Avifauna von drei Gebieten untersucht, einem Festlandreservat und zwei Inselgruppen. Die Avifaunen werden hinsichtlich Artenreichtum, Lebensräumen, Endemismus, grober ökologischer Nischen und Brutstatus beschrieben und analysiert. Die taxonomische Komposition wird auf unterschiedlichen Hierarchieebenen bestimmt. Die meisten Artennachweise kommen von festländischen Chamela (262), gefolgt von den Küsteninseln Marias (191) und den ozeanischen Revillagigedos (148). Davon brüten 139 Vogelarten in Chamela, 61 auf den Marias und nur 29 auf den Revillagigedos. Insgesamt wurden in den drei Gebieten zusammen 364 Vogelarten nachgewiesen, die zu 22 Ordnungen gehören. Auf den Inselgruppen sind durchweg weniger Taxa jeder Hierarchieebene vertreten als am Festland, besonders auf den abgelegenen Revillagigedos. Hier kommen im arithmetischen Mittel 1,7 Arten je Gattung, 2,2 Gattungen je Familie und 2,5 Familien je Ordnung vor. In der Analyse der taxonomischen Hierarchieverhältnisse zueinander zeigt sich ein deutlicher Isolationsgradient: vom festländischen Chamela über die Küsteninseln Marias zu den ozeanischen Revillagigedos nimmt der Verwandtschaftsgrad durchschnittlich ab. Die Ergebnisse stützen die theoretische Annahme, dass nah verwandte Taxa dazu tendieren sich auf Inseln gegenseitig auszuschließen und dass ein Generalist dazu tendiert mehrere Spezialisten zu ersetzen. Schmale ökologische Nischen werden auf Inseln häufig nicht durch spezialisierte Arten besetzt, sondern durch Generalisten erschlossen.

> Key words

Species richness, biodiversity, island biogeography, island theory, endemics, endangered species, conservation, Isla Isabel, Marias, Revillagigedo, Socorro, Mexican Pacific.

Introduction

A great proportion of the global biodiversity is hosted by islands, although these cover only about 2 % of the terrestrial surface of the earth. For example, 14 % of all terrestrial mammal species are found on them (ALCOVER *et al.*, 1998), and 17 % of all bird species occur only on islands (WHITTAKER & FERNÁNDEZ-PALACIOS, 2007; comp. CLEMENTS, 2000; DICKINSON, 2003). Because of their ability to fly, birds were able to reach nearly any island, to colonise it and evolve there. Therefore birds are highly suitable as study objects, especially to analyse the species richness on islands.

The geographical isolation of islands, mainly characterised by size and distance to other land masses, is considered as a main factor for species richness (MACARTHUR & WILSON, 1967; CARLQUIST, 1974; WALTER, 1998; WHITTAKER & FERNÁNDEZ-PALACIOS, 2007; *etc.*). In course of time, in isolation great numbers of endemic bird species evolved on islands (e.g. MOORS, 1985; JOHNSON & STATTERSFIELD, 1990; GRANT, 1998), and through adaptive radiation often increased the total species richness. As a result of their small distribution area and their specific life conditions, endemic island birds are highly sensitive against environmental changes (STATTERSFIELD & CAPPER, 2000). These changes are often caused directly or indirectly by man. Thus, in this sense many of these endemic species are indicators for the degree of nativity and/or change of an island ecosystem (comp. WEGE & LONG, 1995; STATTERSFIELD *et al.*, 1998).

In the Mexican Pacific birds take a key position in the ecosystem of the oceanic Revillagigedo Islands (JEHL & PARKES, 1982). The latter belong to the few islands and places in general, which remained entirely untouched by mankind until the discovery of Spanish sailors in the 16th century. The Polynesians in the West did not reach further than Easter Island and Hawaii. The American natives in the East stayed on the continent and some coastal islands. The late discovery is one reason for only limited anthropogenic shaping of the environment. In several regions of these islands native habitat lasted out (CASTELLANOS & RODRIGUEZ-ESTRELLA, 1993; MARTÍNEZ-GÓMEZ & CURRY, 1998; MARTÍNEZ-GÓMEZ *et al.*, 2001; BARBER *et al.*, 2004) and few endemics yet have become extinct, contrasting the situation in central Polynesia (e.g. STEADMAN, 1989; 1995). Thus, on these archipelagos it can be investigated how island bird populations develop, under natural-near as well as under man-made habitat conditions.

The avifauna of the Revillagigedo Islands is poorly known in general. A number of species accounts have been published (ANTHONY, 1898; BRATTSTROM & HOWELL, 1956; JEHL & PARKES, 1982; SANTAELLA & SADA, 1991; WEHTJE *et al.*, 1993; HOWELL & WEBB,

1995; RODRIGUEZ-ESTRELLA *et al.*, 1996); they are valuable but deal only with a limited part of the total spectrum of species. Then FOX QUESADA *et al.* (2004) gave a first overview based on more comprehensive field surveys. The coastal Marias island group is avifaunistically even less known (EDWARDS, 1998; HOWELL & WEBB, 1995; SANTOS DEL PRADO GASCA *et al.*, 2006; CALDERÓN HINOJOSA *et al.*, 2008); it is highly suitable for a biogeographical comparison with Revillagigedo because of its intermediate position just between the mainland and the high sea. Beginning in 2009 and continuing to 2010, own investigations have yielded a wealth of new avifaunal data from own field surveys and rarely known Mexican reports.

Based on the distribution pattern and selected study areas, it will be possible to investigate the effects upon island landbirds, specifically on their biogeographical characteristics, environments, and ecological characteristics in different degrees of isolation. Suitable as study areas are the oceanic Revillagigedo, the coastal Marias Islands, and the mainland nature reserve Chamela in the Mexican Pacific. This gradient of increasing isolation (longer distance to other land-masses/populations) represents a unique geographical constellation, and in the following is named “isolation gradient”.

This survey aims to accomplish three principal goals. Firstly, it wants analyse the environmental attributes of all three study areas, and to make a comparison of all recorded species, breeders only, and endemics according to their spatial relations. Secondly, it wants to present an ecological approach to the avifauna of all three study areas. Species richness shall be given according to the three ecological groups of landbirds, freshwater birds and seabirds as well as according to their breeding status, basing on own field observations as well as data sources from references. Thirdly, the taxonomic composition of the avifauna shall be analysed in order to know which bird species, genera, families, and orders are present in the insular and mainland study areas, and in which proportion. Thus, generally we aim to identify the effect of isolation on bird species richness by investigating these three topics along a natural gradient including several endemic bird areas.

Study area and biogeographical background

For this work three different study areas are part of one terrestrial region and two marine regions. The terrestrial Chamela is located in a sub-humid, tropic area with a highly seasonal annual precipitation of 731 mm and an average temperature of 22.1 °C. The range of altitudes is from 10 m to 580 m including numerous

plateaus and hills with steep hillsides. Most of the area has an altitude of not more than 150 m and is covered by over 1,100 different plant species (Estacion Chamela).

The group of costal Marias Islands has an average distance of about 100 km to the mainland and consists of four islands located in-line. The archipelago provides a surface area of more than 24,000 ha of which Isla Maria Madre covers more than the half. Not only this is the largest of the four islands but it also holds the highest elevation of this archipelago (640 m above sea level). Second largest is Maria Magdalena, followed by Maria Cleofas, and San Juanito. Climate conditions are similar to the mainland but there is less precipitation (564.2 mm) and a higher average temperature (24.9 °C) (CALDERON HINOJOSA *et al.*, 2008). The islands are covered by various types of vegetation composed by 387 plant species. On the different islands these plants are forming tropical deciduous and (tropical) sub-deciduous forests, with trees up to a height of 25 m. Furthermore shrubs, mangroves and cacti form other parts of the island vegetation.

Revillagigedo is an archipelago which closest part to the mainland is located about 550 km off the west coast of Mexico. This archipelago consists, in decreasing order of size, of Isla Socorro, Isla Clarion, San Benedicto, and Roca Partida. 21 °C is the average annual temperature joined by a precipitation of 313.8 mm at sea-level, which creates a dry climate in this study area. The type of vegetation on these islands ranges from open grassland areas to small trees and shrubs with a maximum height of 3 meters (WEHTJE *et al.*, 1993). Recent volcanic activity influenced San Benedicto in the year 1953, and erased the population of the endemic Rock wren *Salpinctes obsoletus exsul* RIDGWAY, 1903 (BRATTSTROM, 1990).

The single and small Isla Isabel (0.82 km²) is located 30 km off the Mexican coast, about one third on the way to Marias Islands (SANTOS DEL PRADO GASCA *et al.*, 2005). We have surveyed this island and its avifauna for ten days in 2010 (Appendix IV). However, because of the small area and the lack of other islands, it is not suitable for a direct comparison to the avifaunas of Marias and Revillagigedo archipelagos.

On the one hand the mainland study area, Chamela Reserve, covers a much smaller area than both island groups. This means that also the number of bird habitats is likely to be smaller. The lower maximum elevation of mainland Chamela of only 580 m a.s.l. represents another factor for a reduced bird (habitat) diversity compared to both archipelagos. On the other hand mainland Chamela shows a much better connectivity to other bird regions, being not isolated by water, and hosting a much higher number of plant species than both island groups. Mainland Chamela hosts more than 20 times more plant species per area than the is-

lands, respectively (e.g. MIRANDA, 1960; VILLAREAL, 1972).

Data collection and evaluation

For being able to compare the study sites' avifaunal composition, occurring bird taxa are pooled in four lists representing mainland Chamela, Isabel Island, Marias Islands, and Revillagigedo Islands. Species lists are generated from a detailed, local literature survey (partly unpublished references; App. I-IV), and own additional fieldwork (App. I & IV). Own field data were collected in February and March of the years 2009 and 2010 in Chamela and Isabel Island. The reference sources, especially the grey Spanish reports, are indeed an important basis of the result chapter. Taxonomical classification in the attached species lists of recorded birds (appendices I-IV) is based on HOWELL & WEBB (1995), and DICKINSON (2003). Species in the lists were classified as breeders or non-breeders, and are additionally assigned to the single islands of the Marias and Revillagigedo groups. Endemic and extinct species were separately indicated. For comparison between the study areas, total numbers were summarised in order to calculate the ratios between recorded bird species, genera and family. Thus, ratios for hierarchical taxa relations were calculated by building average values from the total sums: $R = \sum S_{a+b+c} / \sum G_{A+B}$, where R is the ratio, S is the species ($_{a+b+c}$ total number), and G the genera ($_{A+B}$ total number) of a certain study area (comp. Table 3).

Results

In regard to bird numbers, the same tendency and a similar relation between mainland and island study areas is detected (Table 1). Bird species are more than eight times more abundant on the mainland, taking only breeding species into account even more than 16 times. Analysing the numbers of endemic bird taxa (on species and subspecies level), the situation appears to be different. In mainland Chamela no endemic taxon exists, as all breeding species also occur in other regions of Jalisco and/or Mexico. Contrarily, coastal Marias and oceanic Revillagigedo islands host 15 and 13 endemics, respectively. During the past centuries two endemics became extinct on Revillagigedo: the Socorro Elf Owl *Micrathene whitneyi graysoni* RIDGWAY, 1886 by human impact and the San Benedicto Rock Wren *Salpinctes obsoletus exsul* RIDGWAY, 1903 by a natural eruption of a volcano. Taking the size of study areas into account, an endemism gradient is found

Table 1. Island attributes and bird species abundance in the Mexican Pacific study areas. Data originate from the sources of appendices I–III.

attributes and area relation	mainland Chamela Reserve	costal Marias Islands	oceanic Revillagigedo Islands
total area (ha)	3319	24544	15783
min. distance to mainland (km)	0	87.33	547.22
max. elevation of terrain (m)	580	640	1040
plant species number	1149	387	202
plant species per area (km ²)	34.62	1.58	1.28
bird species per area (km ²)	7.89	0.77	0.94
breeding bird species per area (km ²)	4.19	0.25	0.18
endemics (ssp. & sp.) per area (km ²)	0	0.06	0.08 (0.1)

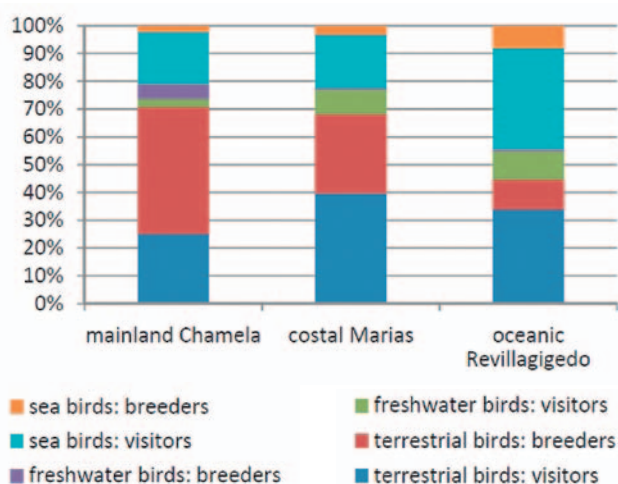


Fig. 1. Relative numbers of bird species recorded as breeders and non-breeding visitors in three study areas of the Mexican Pacific: mainland Chamela reserve, coastal Marias Islands, and oceanic Revillagigedo Islands.

from mainland Chamela via coastal Marias to oceanic Revillagigedo ($0 < 0.06 < 0.08$). Before the two extinctions, the relation was as high as one endemic taxon per 10 square kilometres.

A total of 364 bird species belonging to 22 orders have been recorded in the three study areas of Chamela, Marias, and Revillagigedo, of which 224 are considered to be regular breeders. Thus many of the recorded species are non-breeding visitors. The proportion of breeders on the overall avifauna decreases from mainland Chamela (53%) via coastal Marias (32%) to oceanic Revillagigedo (20%) islands (Fig. 1). Thus, relatively few birds manage to breed and establish a reproductive population on the islands, whereas about half of the recorded species do breed in the mainland reserve. Analyzing the total number of bird species separately for each of the three study areas, a decrease is detected regarding all recorded as well as the breeding species from mainland Chamela

via coastal Marias to oceanic Revillagigedo islands following the isolation gradient (Table 2).

Amongst all recorded species, landbirds are very numerous in all three study areas (Fig. 1). However, their proportion on the entire avifauna decreases from mainland Chamela (71 %) via coastal Marias (68%) to oceanic Revillagigedo (45%). Species richness gradient is contrary in seabirds, as their proportion increases from mainland Chamela (21%) via coastal Marias (23%) to oceanic Revillagigedo (45%). Thus, in the Mexican Pacific only about half of the avifauna of oceanic islands is presented by landbirds, as sea-bird species become more numerous. The last group, freshwater bird species, are similarly rare in all three study areas: mainland Chamela (8%), Marias (9%), and Revillagigedo (10%).

The two contrary gradients for landbirds and sea-birds are also present if taking only the breeding species into account. According to landbirds, 119 species regularly breed in mainland Chamela (representing 86% of this study area's total breeding avifauna), 54 on the coastal Marias (89%), and 16 on the oceanic Revillagigedo (55%). Thus, landbirds take an overwhelming part in the avifaunas of mainland and coastal islands, both in regard to breeders as well as non breeders. However, freshwater birds seem to be non-breeding guests on the islands (except for one species, respectively) and mainly breed on the mainland.

The mean number of all recorded bird species per genus is not highly different between the three study areas (ranging from 1.53 to 1.72; comp. Table 3). However, analysing the higher taxonomic hierarchies, this gradient is found for four constellations: more species per family ($5.6 < 4.7 < 3.7$), more genera per family ($3.6 < 2.8 < 2.2$), more species per order ($13.1 < 10.6 < 9.3$), and more genera per order ($8.6 < 6.4 < 5.4$) are present towards the mainland. Only the relation of families per order is not clearly gradual, ranging from 2.28 to 2.5 (Table 3). Thus, in the taxonomical hierarchy relations a clear isolation

Table 2. Principal ecological types of bird species in the Mexican Pacific study areas. Data originate from the sources of appendices I–III.

bird numbers	mainland Chamela Reserve	costal Marias Islands	oceanic Revillagigedo Islands
terrestrial birds (all records)	185	130	66
terrestrial birds (only breeders)	119	54	16
freshwater birds (all records)	22	18	16
freshwater birds (only breeders)	14	1	1
sea birds (all records)	55	43	66
sea birds (only breeders)	6	6	12
Σ of bird species (all records)	262	191	148
Σ of breeding species (only breeders)	139	61	29
Σ of endemics (subsp. & species)	0	15	13 (+2 extinct)

Table 3. Hierarchical taxa relations of bird species in the Mexican Pacific study areas. Data originate from the sources of appendices I–III.

relation of hierarchical taxa	mainland Chamela Reserve	costal Marias Islands	oceanic Revillagigedo Islands
bird species (all records)	262	191	148
bird genera (all records)	171	115	86
bird families (all records)	47	41	40
bird orders (all records)	20	18	16
bird species per genus (ratio)	1.53	1.66	1.72
bird species per family (ratio)	5.57	4.66	3.7
bird genera per family (ratio)	3.63	2.8	2.15
bird species per order (ratio)	13.1	10.61	9.25
bird genera per order (ratio)	8.55	6.39	5.38
bird families per order (ratio)	2.35	2.28	2.5

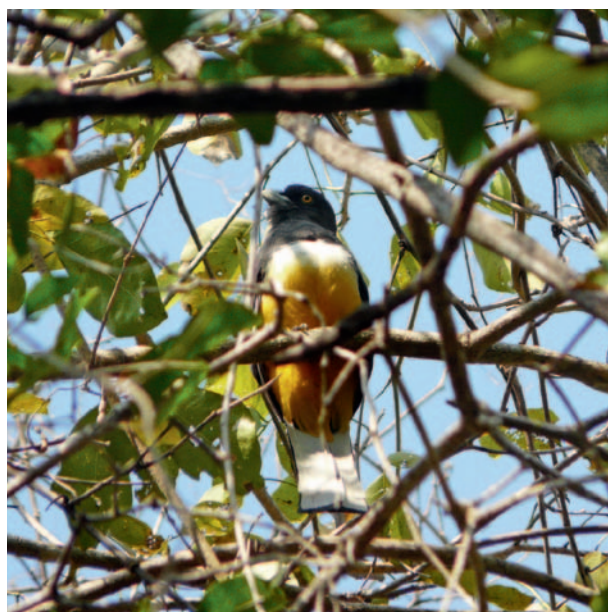
**Fig. 2–3.** The Citreoline Trogon *Trogon citreolus sumichrasti* and the West-Mexican Chachalaca *Ortalis poliocephala poliocephala* are endemic to West-Mexico mainly restricted to the Pacific slope. Both are rather difficult to observe in the tropical deciduous forests of mainland Chamela reserve but are unmistakably identified and localised by their intensive calls.



Fig. 4–5. The Cinnamon Hummingbird *Amazilia rutila rutila* and the Streak-backed Oriole *Icterus pustulatus microstictus* were caught in the mainland Chamela reserve during the dry seasons in March 2009 and 2010. They also are distributed along the Pacific side of Mexico, their ranges reach further south to the evergreen tropical rainforests in Central America.

gradient is found: from mainland Chamela via the coastal Marias to the oceanic Revillagigedos the degree of relatedness of bird taxa overall decreases.

Discussion

The avifauna of the West-Mexican Pacific study areas is represented by a high number of bird species on the mainland, and relatively lower numbers on the oceanic islands, especially taking into account the breeders only (comp. also JEHL & PARKES, 1982; RODRIGUEZ-ESTRELLA *et al.*, 1996). However, the results show that on the islands, especially on the remote Revillagigedos, isolation and difficulty of dispersal may not represent the prime reason for bird species scarcity. One may conclude that the critical point is the establishment of a permanent colonisation by immigrants, maybe in relation to limited habitat suitability.

Interestingly the majority of breeding species does only inhabit one of the two island groups, although dispersing to the other archipelago does not appear to be a critical factor: several specimens were seen on the other major island group but have not established a permanent population there. Thus the number of breeders is not limited by geographical isolation and low immigration rates, but also by ecological factors such as presence of suitable habitat, competition with resident species, and successful antagonistic strategies (HAHN *et al.*, 2009).

Seabirds are as frequent as landbirds on oceanic Revillagigedo, but by no means in mainland Chamela. This is probably because most seabirds have large foraging, wandering and dispersal areas, and the

Revillagigedo waters are rich in fish and other marine food sources (related overview in BRATTSTROM, 1990), and offer protected resting and breeding grounds.

Among the breeding avifauna, however, landbird species are more numerous than seabirds in all study areas. The relatively high number of landbird visitors on Marias and Revillagigedo Islands can be explained by the geographical position. Both archipelagos are placed far away from the mainland; however, they kind of are positioned in the western Pacific migration routes, especially for those birds following the Baja California Peninsula in autumn. Thus, the islands can be considered as important stop-over locations for migrant species (comp. BRATTSTROM & HOWELL, 1956; WEHTJE *et al.*, 1993). The heavy and abundant hurricanes hitting this region (average of three per season) represent another factor increasing the number of accidental guests and irregular vagrants on both island groups. Therefore further species records are to be expected in the future (comp. JEHL & PARKES, 1983).

Freshwater birds were recorded as visitors on the islands in remarkable numbers (although less than landbirds and seabirds), but nearly all species lack any breeding records. This may be due to the absence of lakes or lagoons, poor food sources in creeks, and high predation risk by raptors. Many of the island species have been recorded only few times, probably due to the low frequency and intensity of observation in these remote places. Contrarily, mainland Chamela reserve is much better known and monitored, as two professional ornithologists work here all year round (e.g. ARIZMENDI *et al.*, 1990).

The relatively low ratio of Revillagigedo taxa belonging to the next higher taxonomic category (species per genus, genera per family, families per order) is suggested to be the result of isolation by distance, small area and limited habitats, as well as increased

competition for limited resources. It corresponds to the theoretical suggestions that closely related taxa tend to reduce each other and that one generalist of a taxonomic or ecological group tends to replace two or more specialists on islands; small niches are not occupied by a specialist species but covered by a generalist (LACK, 1969; DIAMOND, 1974; ABBOTT, 1980). However, all taxonomical ratio values are still higher than those of the South-eastern Pacific Juan Fernandez Islands off Chile (HAHN *et al.*, 2009). The latter are less numerous, smaller in area size, and further away from any migration route. The resident landbird species pattern provides excellent support for these hypotheses. Most endemic landbird taxa originate from generalist species which are widely distributed on the (Mexican) mainland, not from specialists or continental restricted endemics.

For conservational concern, especially the endemic breeding birds of the islands are important. Distribution areas and number of habitats are generally very limited on these small archipelagos. The destruction of native habitat is particularly detrimental to the endemic taxa, since their habitat preferences are more selective than those of non-endemics (comp. RODRIGUEZ-ESTRELLA *et al.*, 1996; HAHN *et al.*, 2005, 2011a, b). Most of the endemic species seem to be threatened today (restricted area and low abundance) and should be classified for conservation importance in the future (e.g. like done by WALTER 2004). Presently a third endemic taxon, the Socorro Dove *Zenaida graysoni* LAWRENCE, 1871 is close to extinction (only captive population maintained), and may speed up the recently high extinction rate on Revillagigedo. A reliable conservation ranking, including factors as habitat loss may prepare the basis for a more successful species management. Further threats seem to be the new invasive mammals on the islands (e.g. RODRIGUEZ-ESTRELLA *et al.*, 1991; comp. also HAHN & RÖMER, 2002).

Habitat destruction, mainly through man-made fires and introduced herbivores, is valued as the most serious concern for this critical situation. By destroying higher vegetation, herbivores are likely to have a negative effect on most scrubland and forest birds. Conservation management for the endemics must include the total eradication of introduced mammals. In spite of the present species inventories, very little is known about the endemic species. More detailed studies of the ecology of most endemics of Marias and Revillagigedo Islands are necessary. Such knowledge is urgently needed in order to develop conservation policies and regulations for the preservation of these unique bird assemblages.

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References

- ABBOTT, I. (1980): Theories dealing with the ecology of land-birds on islands. – *Advances in Ecological Research*, **11**: 329–371.
- ALCOVER, J.A., SANS, A. & PALMER, M. (1998): The extent of extinction of mammals on islands. – *J. Biogeography* **25**: 913–918.
- ANTHONY, A.W. (1898): Avifauna of the Revillagigedo Islands. *The Auk*, **15**, 311–318.
- ARIZMENDI, M.C., BERLANGA, H., ARQUEZ-VALDELAMAR, L., NAVARRO, L. & ORNELAS, F. (1990): Avifauna de la región de Chamela, Jalisco. Cuadernos del Instituto de Biología 4, UNAM, Mexico – (<http://www.ibiologia.unam.mx/ebchamela/www/aves.htm> accessed on 10 June 2010).
- BRATTSTROM, B.H. & HOWELL, T.R. (1956): The birds of the Revilla Gigedo Islands, Mexico. – *The Condor*, **58**: 107–120.
- BRATTSTROM, B.H. (1990): Biogeography of the Islas Revillagigedo, Mexico. – *Journal of Biogeography*, **17**: 177–183.
- CALDERÓN HINOJOSA, J.R., ELVIRA QUESADA, G., GARCIA LUNA, E., ENKERLIN HOEFELICH, D., GUTIÉRREZ CARBONELL, A., ELTON BENHUMEA, E., HERRERA CHI & J. A. CASTREJON PINEDA (EDS.) (2008): Programa de conservacion y manejo, Reserva de la Biosfera Islas Marias, Mexico. – CONANP Jaras Impresores S.A., Mexico City: 217p.
- CARLQUIST, S. (1974): *Island Biology*. – Columbia University Press, New York & London: 660p.

- CASTELLANOS, A. & RODRIGUEZ-ESTRELLA, R. (1993): Current status of the Socorro Mockingbird. – *Wilson Bulletin*, **105**: 167–171.
- CHIPLEY, R. & PISANTY, I. (1999): North American Important Bird areas. – Commission for Environmental Cooperation, Montreal: 359p.
- CLEMENTS, J.F. (2000): Birds of the world: a checklist. – Cornell University Press, Vista: 880p.
- DIAMOND, J.M. (1974): Continental and insular speciation in Pacific land birds. – *Systematic Zoology*, **26**: 263–268.
- DICKINSON, E.C. (2003): The Howard & Moore complete checklist of the birds of the world. – Princeton University Press, Princeton: 1040p.
- EDWARDS, E.P. (1998): A field guide to the birds of Mexico and adjacent Areas. – University of Texas Press, Austin: 209p.
- FOX QUESADA, V., A. CÁRDENAS JIMÉNEZ, A. ECHEVARRÍA DOMÍNGUEZ, E. ENKERLIN HOEFELICH, D. GUTIÉRREZ CARBONELL & C. GARCÍA CHABELAS (Eds.) (2005): Programa de conservación y manejo del Parque nacional Isla Isabel, Mexico. – CONANP Jaras Impresores S.A., Mexico City: 164 p.
- FOX QUESADA, V., A. CÁRDENAS JIMÉNEZ, E. ENKERLIN HOEFELICH & D. GUTIÉRREZ CARBONELL (Eds.) (2004): Programa de conservación y manejo Reserva de la Biosfera Archipelago Revillagigedo. – CONANP Jaras Impresores S.A., Mexico City: 222 p.
- GRANT, P.R. (1998): Evolution on Islands. – Oxford University Press, Oxford: 334p.
- GRANT, P.R. & COWAN, I. (1964): A review of the avifauna of the Tres Marias Islands, Nayarit, Mexico. – *Condor*, **66**: 221–228.
- HAHN, I. & RÖMER, U. (2002): Threatened avifauna of the Juan Fernandez Archipelago, Chile: the impact of introduced mammals and conservation priorities. – *Cotinga*, **17**: 56–62.
- HAHN, I., VERGARA, P. & RÖMER, U. (2011a): Importance of environmental nest attributes in the conservation of Juan Fernandez endemic landbirds. – *Bird Conservation International*. DOI: 10.1017/S0959270911000050
- HAHN, I., VERGARA, P. & RÖMER, U. (2011b): Habitat selection and population trends in terrestrial bird species of Robinson Crusoe Island: habitat generalists vs. forest specialists. – *Biodiversity and Conservation*. DOI 10.1007/s10531-011-0109-x
- HAHN, I., RÖMER, U. & SCHLATTER, R. (2005): Distribution, habitat use, and abundance patterns of land bird communities on the Juan Fernández Islands, Chile. – *Ornitología Neotropical*, **16**: 371–385.
- HAHN, I., RÖMER, U., VERGARA, P. & WALTER, H. (2009): Diversity, biogeography and, conservation of the birds of the Juan Fernández Islands, Chile. – *Vertebrate Zoology*, **59**: 103–114.
- HOWELL, S.N.G. & WEBB, S. (1995): A guide to the birds of Mexico and northern central America. – Oxford University Press, New York: 851p.
- JEHL, J.R. JR. & PARKES, K.C. (1982): The status of the avifauna of the Revillagigedo Islands, Mexico. – *The Wilson Bulletin*, **94**: 1–19.
- JEHL, J.R. JR. & PARKES, K.C. (1983): “Replacement” of landbird species on Socorro Island, Mexico. – *The Auk*, **100**: 551–559.
- JOHNSON, T.H. & STATTERSFIELD, A.J. (1990): A global review of island endemic birds. – *The Ibis*, **132**: 167–180.
- LACK, D. (1969): The number of bird species on islands. – *Bird Study*, **4**: 193–209.
- MACARTHUR, R.H. & WILSON, E.O. (1967): The theory of island biogeography. – Princeton University Press, Princeton: 244p.
- MARTÍNEZ-GÓMEZ, J.E. & CURRY, R.L. (1998): Distinguishing sex of Socorro Mockingbirds by body measurements. – *Ornitología Neotropical*, **9**: 103–110.
- MARTÍNEZ-GÓMEZ, J.E., FLORES-PALACIOS, A. CURRY, R.L. (2001): Habitat requirements of the Socorro Mockingbird *Mimodes graysoni*. – *The Ibis*, **143**: 456–467.
- MIRANDA, F. (1960): Vegetación. In: ADEM, J., COBO, E., BLÁSQUEZ, L., MIRANDA, F., VILLALOBOS, A., HERRERA, T., VILLA, B. & VÁSQUEZ, L. (Eds.): La Isla Socorro, Archipiélago de Revillagigedo. – Monografías de del Instituto de Geofísica de la UNAM, Mexico City: 126–152.
- MOORS, P.J. (1985): Conservation of island birds: case studies for the management of threatened island birds. – ICBP Page Bros, Cambridge: 276p.
- RODRIGUEZ-ESTRELLA, R., ARNAUD, G., ALVAREZ CARDENAS, S. & RODRIGUEZ, A. (1991): Predation by feral cats on birds at Isla Socorro, Mexico. – *Western Birds*, **22**: 141–143.
- RODRIGUEZ-ESTRELLA, R., LUZ, J.L.L. DE LA, BRECEDA, A., CASTELLANOS, A., CANCINO, J. & LLINAS, J. (1996): Status, density and habitat relationships of the endemic terrestrial birds of Revillagigedo Islands, Mexico. – *Biological Conservation*, **76**: 195–202.
- SANTAELLA, L. & SADA, A.M. (1991): The avifauna of the Revillagigedo Islands, Mexico: additional data and observations. – *Wilson Bulletin*, **103**: 668–675.
- SANTOS DEL PRADO GASCA, K., NEGRETE FERNÁNDEZ, G.J., CABBALLERO NIETO, J., GONZÁLEZ MEDRANO, F. & MEDELLÍN LEGRRETA, R. (Eds.) (2006): Investigación para la conservación el manejo sustentable del Archipiélago Islas Marías. – CONANP Jaras Impresores S.A., Mexico City: 188p.
- STATTERSFIELD, A.J. & CAPPER, D.R. (2000): Threatened Birds of the World. – BirdLife International & Lynx Edicions, Barcelona & Cambridge: 852p.
- STATTERSFIELD, A.J., CROSBY, M.J., LONG, A.J. & WEGE, D.C. (1998): Endemic bird areas of the world: Priorities for Biodiversity Conservation. – BirdLife International (Conservation Series No. 7), Cambridge: 815p.
- STEADMAN, D.W. (1989). Extinction of birds in eastern Polynesia: a review of the record, and comparisons with other Pacific island groups. – *Journal of Archaeological Science*, **16**: 177–205.
- STEADMAN, D.W. (1995). Prehistoric extinctions of Pacific island birds: biodiversity meets zooarchaeology. – *Science*, **267**: 1123–1131.
- VILLAREAL, P.L. (1972): Vegetación de las Islas Socorro y San Benedicto. – Sociedad de Ciencias Naturales de Jalisco (Mexico), **6**: 1–36.

- WALTER, H.S. (1998): Driving forces of island biodiversity: an appraisal of two theories. – *Physical Geography*, **19**: 351–377.
- WALTER, H.S. (2004): The mismeasure of islands: implications for biogeographical theory and the conservation of nature. – *Journal of Biogeography*, **31**: 177–197.
- WEGE, D.C. & LONG, A.J. (1995): Key Areas for Threatened Birds in the Neotropics. – BirdLife International (Conservation Series No. 5), Cambridge: 312p.
- WEHTJE, W.H., WALTER, S., RODRIGUEZ-ESTRELLA, R., LLINAS, J. & CASTELLANOS, A. (1993): An annotated checklist of the birds of Isla Socorro, Mexico. – *Western Birds*, **24**: 1–16.
- WHITTAKER, R.J. & FERNÁNDEZ-PALACIOS, J.M. (2007): Island biogeography: ecology, evolution, and conservation. – Oxford University Press, Oxford: 401p.

Appendix I.

Bird species of the West-Mexican study area: mainland Chamela Reserve.

Information sources are: 1 = ARIZMENDI *et al.* (1990), 2 = HOWELL & WEBB (1995) (breeding status), 3 = personal records by the authors. **Symbols**: × = marks a record a in the category.

scientific name	common name	breeder	non breeder	source
<i>Crypturellus cinnamomeus</i>	Thicket Tinamou	×		1, 2
<i>Gavia immer</i>	Common Loon		×	1, 2
<i>Podilymbus podiceps</i>	Pied-Billed Grebe	×		1, 2
<i>Puffinus griseus</i>	Sooty Shearwater		×	1, 2
<i>Puffinus opistomelas</i>	Black-Vented Shearwater		×	1, 2
<i>Oceanodroma microsoma</i>	Least Storm-Petrel		×	1, 2
<i>Paethon aethereus mesonauta</i>	Red-billed Tropicbird		×	1, 2
<i>Sula leucogaster</i>	Brown Booby		×	1, 2
<i>Pelecanus erythrorhynchos</i>	American white Pelican		×	1, 2
<i>Pelecanus occidentalis</i>	Brown Pelican		×	1, 2
<i>Phalacrocorax brasilianus</i>	Neotropic Cormorant		×	1, 2
<i>Fregata magnificens</i>	Magnificent Frigatebird		×	1, 2, 3
<i>Ixobrychus exilis</i>	Least Bittern	×		1, 2
<i>Ardea herodias</i>	Great blue Heron		×	1, 2
<i>Egretta alba egretta</i>	Great Egret	×		1, 2
<i>Egretta thula</i>	Snowy Egret	×		1, 2
<i>Egretta caerulea</i>	Little blue Heron	×		1, 2
<i>Egretta tricolor</i>	Tricolored Heron	×		1, 2
<i>Egretta rufescens</i>	Reddish Egret		×	1, 2
<i>Bubuculus ibis ibis</i>	Cattle Egret	×		1, 2
<i>Butorides virescens</i>	Green Heron	×		1, 2
<i>Cochlearius cochlearius</i>	Boat-billed Heron	×		1, 2
<i>Dendrocygna autumnalis</i>	Black-Bellied Whistling-Duck	×		1, 2
<i>Cairina moschata</i>	Muscovy Duck	×		1, 2
<i>Anas discors</i>	Blue-winged teal		×	1, 2
<i>Anas cyanoptera</i>	Cinnamon teal		×	1, 2
<i>Anas clypeata</i>	Northern shoveler		×	1, 2
<i>Aythya americana</i>	Redhead		×	1, 2
<i>Aythya affinis</i>	Lesser Scaup		×	1, 2
<i>Oxyura dominica</i>	Masked Duck	×		1, 2
<i>Coragyps atratus</i>	Black Vulture	×		1, 2
<i>Cathartes aura</i>	Turkey Vulture	×		1, 2
<i>Pandion haliaetus</i>	Osprey		×	1, 2
<i>Chondrohierax uncinatus</i>	Hook-Billed Kite	×		1, 2

<i>Elanus leucurus majusculus</i>	White-tailed Kite	×		1, 2
<i>Accipiter striatus</i>	Sharp-Shinned Hawk	×		1, 2
<i>Accipiter cooperii</i>	Cooper's Hawk		×	1, 2
<i>Geranospiza caerulescens</i>	Crane Hawk	×		1, 2
<i>Buteogallus anthracinus</i>	Common Black Hawk	×		1, 2
<i>Buteogallus urubitinga ridgwayi</i>	Great Black Hawk	×		1, 2
<i>Parabuteo unicinctus</i>	Harris' Hawk	×		1, 2
<i>Buteo nitidus</i>	Grey Hawk	×		1, 2
<i>Buteo magnirostris</i>	Roadside Hawk	×		1, 2
<i>Buteo brachyurus fuliginosus</i>	Short-tailed Hawk	×		1, 2
<i>Buteo albonotatus albonotatus</i>	Zone-tailed Hawk		×	1, 2
<i>Buteo jamaicensis</i>	Red-tailed Hawk		×	1, 2
<i>Caracara planus</i>	Crested Caracara	×		1, 2
<i>Herpetotheres cachinnans</i>	Laughing Falcon	×		1, 2
<i>Micrastur semitorquatus naso</i>	Collared Forest-Falcon	×		1, 2
<i>Falco sparverius</i>	American Kestrel		×	1, 2
<i>Falco rufigularis</i>	Bat Falcon	×		1, 2
<i>Falco peregrines</i>	Peregrine Falcon		×	1, 2
<i>Ortalis poliocephala</i>	West-Mexican Chachalaca	×		1, 2, 3
<i>Philortyx fasiatus</i>	Banded Quail		×	1, 2
<i>Callipepla douglasii</i>	Elegant Quail		×	1, 2
<i>Aramides axillaris</i>	Rufous-Necked Wood-rail		×	1, 2
<i>Porphyryla martinica</i>	Purple Gallinule	×		1, 2
<i>Gallinula chloropus cacinmans</i>	Common Moorhen	×		1, 2
<i>Fulica americana americana</i>	American Coot	×		1, 2
<i>Pluvialis squatarola</i>	Black-bellied Plover		×	1, 2
<i>Charadrius collaris</i>	Collared Plover	×		1, 2
<i>Charadrius alexandrinus</i>	Snowy Plover		×	1, 2
<i>Charadrius wilsonia</i>	Wilson's Plover		×	1, 2
<i>Charadrius semipalmatus</i>	Semipalmated Plover		×	1, 2
<i>Charadrius vociferous vociferous</i>	Killdeer	×		1, 2
<i>Haematopus palliatus</i>	American Oystercatcher		×	1, 2
<i>Himantopus mexicanus</i>	Black-necked Stilt	×		1, 2
<i>Recurvirostra americana</i>	American Avocet		×	1, 2
<i>Jacana spinosa</i>	Northern Jacana	×		1, 2
<i>Tringa melanoleuca</i>	Greater Yellowlegs		×	1, 2
<i>Tringa flavipes</i>	Lesser Yellowlegs		×	1, 2
<i>Catoptrophorus semipalmatus</i>	Willet		×	1, 2
<i>Heteroscelus incanus</i>	Wandering Tattler		×	1, 2
<i>Actitis macularia</i>	Spotted Sandpiper		×	1, 2
<i>Numenius phaeopus hudsonicus</i>	Whimbrel		×	1, 2
<i>Numenius americanus</i>	Long-billed Curlew		×	1, 2
<i>Limosa fedoa</i>	Marbled Godwit		×	1, 2
<i>Calidris alba</i>	Sanderling		×	1, 2
<i>Calidris pusilla</i>	Semipalmated Sandpiper		×	1, 2
<i>Calidris mauri</i>	Western Sandpiper		×	1, 2
<i>Calidris minutilla</i>	Least Sandpiper		×	1, 2
<i>Calidris himantopus</i>	Stilt Sandpiper		×	1, 2
<i>Limnodromus griseus</i>	Short-billed Dowitcher		×	1, 2
<i>Limnodromus scolopaceus</i>	Long-billed Dowitcher		×	1, 2
<i>Gallinago gallinago delicata</i>	Common Snipe		×	1, 2
<i>Phalaropus tricolor</i>	Wilson's Phalarope		×	1, 2
<i>Phalaropus lobatus</i>	Red-Necked Phalarope		×	1, 2
<i>Phalaropus fulicaria</i>	Red Phalarope		×	1, 2
<i>Larus atricilla</i>	Laughing Gull		×	1, 2
<i>Larus pipixcan</i>	Franklin's Gull		×	1, 2

<i>Larus philadelphia</i>	Bonaparte's Gull		×	1, 2
<i>Larus heermanni</i>	Hermann's Gull		×	1, 2
<i>Larus delawarensis</i>	Ring-billed Gull		×	1, 2
<i>Larus argentatus smithsonianus</i>	Herring Gull		×	1, 2
<i>Sterna caspia</i>	Caspian Tern		×	1, 2
<i>Sterna maxima maxima</i>	Royal Tern		×	1, 2
<i>Sterna elegans</i>	Elegant Tern		×	1, 2
<i>Sterna hirundo hirundo</i>	Common Tern		×	1, 2
<i>Sterna forsteri</i>	Forster's Tern		×	1, 2
<i>Chlidonias niger surinamensis</i>	Black Tern		×	1, 2
<i>Anous stolidus</i>	Brown Noddy		×	1, 2
<i>Rynchops niger niger</i>	Black Skimmer		×	1, 2
<i>Columba livia</i>	Feral Pidgeon	×		1, 2
<i>Columba flavivestris</i>	Red-billed Pigeon	×		1, 2
<i>Zenaida asiatica</i>	White-winged Dove	×		1, 2
<i>Zenaida macroura</i>	Mourning Dove	×		1, 2
<i>Columbina inca</i>	Inca Dove	×		1, 2
<i>Columbina passerina</i>	Common Ground-Dove	×		1, 2, 3
<i>Columbina talpacoti</i>	Ruddy Ground-Dove	×		1, 2
<i>Leptotila verreauxi</i>	White-tipped Dove	×		1, 2
<i>Aratinga holochlora</i>	Green Parakeet		×	1, 2
<i>Aratinga canicularis</i>	Orange-fronted Parakeet	×		1, 2
<i>Ara militaris</i>	Military Macaw	×		1, 2
<i>Forpus cyanopygius</i>	Mexican Parrotlet	×		1, 2
<i>Amazona finschi</i>	Lilac-crowned Parrot	×		1, 2
<i>Amazona oratrix</i>	Yellow-headed Parrot	×		1, 2
<i>Coccyzus minor</i>	Mangrove Cuckoo	×		1, 2
<i>Piaya cayana</i>	Squirrel Cuckoo	×		1, 2
<i>Morococcyx erythropygus</i>	Lesser Ground-Cuckoo	×		1, 2
<i>Geococcyx velox</i>	Lesser Roadrunner	×		1, 2
<i>Crotophaga sulcirostris</i>	Groove-billed Ani	×		1, 2
<i>Tyto alba</i>	Barn Owl	×		1, 2
<i>Otus seductus</i>	Balsas Screech-Owl		×	1, 2
<i>Glaucidium griseiceps</i>	Central American Pygmy-Owl		×	1, 2
<i>Glaucidium brasilianum</i>	Ferruginous Pygmy-Owl	×		1, 2
<i>Athene cunicularia</i>	Burrowing Owl		×	1, 2
<i>Strix virgata</i>	Mottled Owl	×		1, 2
<i>Chordeiles acutipennis</i>	Lesser Nighthawk	×		1, 2
<i>Nyctidromus albicollis</i>	Pauraque	×		1, 2
<i>Caprimulgus ridgwayi</i>	Buff-Collared Nightjar	×		1, 2
<i>Nyctibius jamaicensis</i>	Northern Potoo	×		1, 2
<i>Chaetura vauxi</i>	Vaux's Swift	×		1, 2
<i>Phaethornis superciliosus</i>	Long-tailed Hermit		×	1, 2
<i>Chlorostilbon canivetii</i>	Canvet's Emerald		×	1, 2
<i>Cynanthus latirostris</i>	Broad-billed Hummingbird	×		1, 2
<i>Amazilia rutila</i>	Cinnamon Hummingbird	×		1, 2, 3
<i>Amazilia violiceps</i>	Violet-crowned Hummingbird	×		1, 2
<i>Helimaster constantii</i>	Plain-capped Starthroat	×		1, 2
<i>Philodice dupontii</i>	Sparkling-tailed Woodstar	×		1, 2
<i>Archilochus colubris</i>	Ruby-throated Hummingbird		×	1, 2
<i>Archilochus alexandri</i>	Black-chinned Hummingbird		×	1, 2
<i>Trogon citreolus</i>	Citreoline Trogon	×		1, 2, 3
<i>Momotus mexicanus</i>	Russet-crowned Motmot	×		1, 2
<i>Ceryle torquata torquata</i>	Ringed Kingfisher	×		1, 2
<i>Ceryle alcyon</i>	Belted Kingfisher		×	1, 2
<i>Chloroceryle amazona mexicana</i>	Amazon Kingfisher	×		1, 2

<i>Chloroceryle americana</i>	Green Kingfisher	×		1, 2
<i>Centurus chrysogenys</i>	Golden-cheeked Woodpecker		×	1, 2, 3
<i>Picoides scalaris</i>	Ladder-backed Woodpecker	×		1, 2
<i>Dryocopus lineatus</i>	Lineated Woodpecker	×		1, 2, 3
<i>Campephilus guatemalensis</i>	Pale-billed Woodpecker	×		1, 2
<i>Xiphorhynchus flavigaster</i>	Ivory-billed Woodcreeper	×		1, 2
<i>Lepidocolaptes leucogaster</i>	White-striped Woodcreeper	×		1, 2
<i>Camptostoma imberbe</i>	Northern beardless Tyrannulet	×		1, 2
<i>Myiopagis viridicata</i>	Greenish Elania	×		1, 2
<i>Empidonax trailii</i>	Willow Flycatcher		×	1, 2
<i>Empidonax minimus</i>	Least Flycatcher		×	1, 2
<i>Empidonax difficilis</i>	Pacific Slope Flycatcher		×	1, 2
<i>Sayornis nigricans</i>	Black Phoebe		×	1, 2
<i>Pyrocephalus rubinus</i>	Vermilion Flycatcher	×		1, 2
<i>Attila spadiceus</i>	Bright-rumped Attila	×		1, 2
<i>Myiarchus tuberculifer</i>	Dusky-capped Flycatcher	×		1, 2
<i>Myiarchus cinerascens</i>	Ash-throated Flycatcher		×	1, 2
<i>Myiarchus nuttingi</i>	Nutting's Flycatcher	×		1, 2
<i>Myiarchus tyrannulus</i>	Brown-crested Flycatcher	×		1, 2
<i>Deltarhynchus flammulatus</i>	Flammulated Flycatcher	×		1, 2
<i>Pitangus sulphuratus</i>	Great Kiskadee	×		1, 2
<i>Megarynchus pitangua</i>	Boat-billed Flycatcher	×		1, 2
<i>Myiozetetes similis</i>	Social Flycatcher	×		1, 2
<i>Myiodynastes luetiventris</i>	Sulphur-billed Flycatcher	×		1, 2
<i>Tyrannus melancholicus</i>	Tropical Kingbird	×		1, 2
<i>Tyrannus vociferans</i>	Cassin's Kingbird	×		1, 2
<i>Tyrannus crassirostris</i>	Thick-billed Kingbird	×		1, 2
<i>Pachyrhamphus major</i>	Grey-collared Becard	×		1, 2
<i>Pachyrhamphus aglaiae</i>	Rose-throated Becard	×		1, 2
<i>Progne chalybea</i>	Grey-brested Martin	×		1, 2
<i>Tachycineta albilinea albilinea</i>	Mangrove Swallow		×	1, 2
<i>Stelgidopteryx serripennis</i>	Northern Rough-winged Swallow	×		1, 2
<i>Hirundo rustica erythrogaster</i>	Barn Swallow	×		1, 2
<i>Calocitta formosa</i>	White-throated Magpie-Jay	×		1, 2, 3
<i>Cyanocorax yncas</i>	Green Jay	×		1, 2
<i>Cyanocorax sanblasianus</i>	San Blas Jay	×		1, 2, 3
<i>Thryothorus felix</i>	Happy Wren	×		1, 2, 3
<i>Thryothorus sinaloa</i>	Sinaloa Wren	×		1, 2
<i>Urospila leucogaster</i>	White-bellied Wren	×		1, 2
<i>Troglodytes aedon</i>	Northern House Wren		×	1, 2
<i>Poliophtila caerulea</i>	Blue-grey Gnatcatcher		×	1, 2, 3
<i>Poliophtila nigriceps</i>	Black-capped Gnatcatcher	×		1, 2, 3
<i>Catharus aurantiirostris</i>	Orange-billed Nightingale-Thrush	×		1, 2
<i>Catharus ustulatus</i>	Swaizon's Thrush		×	1, 2
<i>Turdus assimilis</i>	White-throated Thrush	×		1, 2
<i>Turdus rufopallatus</i>	Rufous-backed Thrush	×		1, 2
<i>Melanotis caerulescens</i>	Blue Mockingbird	×		1, 2
<i>Mimus polyglottos leucopterus</i>	Northern Mockingbird		×	1, 2
<i>Vireo belli</i>	Bell's Vireo		×	1, 2
<i>Vireo atricapillus</i>	Black-capped Vireo		×	1, 2
<i>Vireo vicinior</i>	Grey Vireo		×	1, 2
<i>Vireo solitarius solitarius</i>	Blue-headed Vireo		×	1, 2
<i>Vireo hypochryseus</i>	Golden Vireo	×		1, 2
<i>Vireo gilvus</i>	Warbling Vireo		×	1, 2
<i>Vireo olivaceus</i>	Red-eyed Vireo		×	1, 2
<i>Vermivora celata</i>	Orange-crowned Warbler		×	1, 2

<i>Vermivora ruficapilla</i>	Nashville Warbler		×	1, 2
<i>Vermivora luciae</i>	Lucy's Warbler		×	1, 2
<i>Parula pitiayumi</i>	Tropical Parula	×		1, 2, 3
<i>Dendroica petechia</i>	Yellow Warbler		×	1, 2
<i>Dendroica coronata</i>	Yellow-rumped Warbler		×	1, 2
<i>Dendroica nigrescens</i>	Black-throated Grey Warbler		×	1, 2
<i>Mniotilta varia</i>	Black-and-white Warbler		×	1, 2, 3
<i>Setophaga ruticilla</i>	American Redstart		×	1, 2
<i>Seiurus aurocapillus</i>	Ovenbird		×	1, 2
<i>Seiurus noveboracensis</i>	Northern Waterthrush		×	1, 2
<i>Seiurus motacilla</i>	Louisiana Waterthrush		×	1, 2
<i>Oporornis formosus</i>	Kentucky Warbler		×	1, 2
<i>Oporornis tolmiei</i>	MacGillivray's Warbler		×	1, 2
<i>Geothlypis trichas</i>	Common Yellowthroat	×		1, 2
<i>Geothlypis poliocephala</i>	Grey-crowned Yellowthroat	×		1, 2
<i>Wilsonia pusilla</i>	Wilson's Warbler		×	1, 2
<i>Basileuterus lachrymose</i>	Fan-tailed Warbler	×		1, 2
<i>Icteria virens</i>	Yellow-breasted Chat		×	1, 2
<i>Granatellus venustus</i>	Red-breasted Chat	×		1, 2
<i>Euphonia affinis</i>	Scrub Euphonia	×		1, 2
<i>Habia rubica</i>	Red-crowned Ant-Tanager	×		1, 2
<i>Piranga rubra</i>	Summer Tanager		×	1, 2
<i>Piranga ludoviciana</i>	Western Tanager		×	1, 2
<i>Spermangara erythrocephala</i>	Red-headed Tanager	×		1, 2
<i>Rhodinocichla rosea schistacea</i>	Rosy Thrush-Tanager	×		1, 2
<i>Saltador coerulescens</i>	Greyish Saltador	×		1, 2
<i>Cardinalis cardinalis</i>	Northern Cardinal		×	1, 2
<i>Pheucticus chrysopheplus</i>	Yellow Grosbeak	×		1, 2
<i>Pheucticus ludovicianus</i>	Rose-breasted Grosbeak		×	1, 2
<i>Pheucticus melanocephalus</i>	Black-headed Grosbeak		×	1, 2
<i>Cyanocompsa paellina</i>	Blue Bunting	×		1, 2
<i>Passerina caerulea</i>	Blue Grosbeak		×	1, 2
<i>Passerina cyanea</i>	Indigo Bunting		×	1, 2
<i>Passerina versicolor</i>	Varied Bunting	×		1, 2
<i>Passerina leclancherii</i>	Orange-breasted Bunting	×		1, 2
<i>Passerina ciris</i>	Painted Bunting		×	1, 2
<i>Arremonops rufivirgatus</i>	Olive Sparrow	×		1, 2
<i>Volatinia jacarina spendens</i>	Blue-black Grassquit	×		1, 2
<i>Sporophila torqueola</i>	White-collared Seedeater	×		1, 2
<i>Sporophila minuta parva</i>	Ruddy-breasted Seedeater	×		1, 2
<i>Aimophila humeralis</i>	Black-crested Sparrow		×	1, 2
<i>Aimophila ruficauda</i>	Stripe-headed Sparrow	×		1, 2
<i>Aimophila botterii</i>	Botteri's Sparrow	×		1, 2
<i>Chondestes grammacus</i>	Lark Sparrow		×	1, 2
<i>Ammodramus savannarum</i>	Grasshopper Sparrow		×	1, 2
<i>Melospiza lincolni</i>	Lincoln's Sparrow		×	1, 2
<i>Zonotrichia leucophrys</i>	White-crowned Sparrow		×	1, 2
<i>Agelaius phoeniceus</i>	Red-winged Blackbird	×		1, 2
<i>Sturnella magna</i>	Eastern Meadowlark	×		1, 2
<i>Quiscalus mexicanus</i>	Great-tailed Grackle	×		1, 2, 3
<i>Molothrus aeneus</i>	Bronzed Cowbird	×		1, 2
<i>Molothrus ater</i>	Brown-headed Cowbird	×		1, 2
<i>Icterus spurius</i>	Orchard Oriole		×	1, 2
<i>Icterus cucullatus</i>	Hooded Oriole		×	1, 2
<i>Icterus graduacauda</i>	Audubon's Oriole	×		1, 2
<i>Icterus pustulatus</i>	Streak-backed Oriole	×		1, 2

<i>Icterus galbula</i>	Baltimore Oriole		×	1, 2
<i>Cacicus melanicterus</i>	Yellow-winged Caique		×	1, 2, 3
<i>Carduelis psaltria</i>	Lesser Goldfinch	×		1, 2
<i>Passer domesticus domesticus</i>	House Sparrow	×		1, 2

Appendix II.

Bird species list of the West-Mexican study area: Marias Islands.

Island records: Mg = Maria Magdalena, Ma = Maria Madre, C = Maria Cleofas, J = San Juanito, IM = all Tres Marias Islands (information source with no details to islands). **Information sources:** 1 = CALDERÓN HINOJOSA *et al.* (2008), 2 = GRANT & COWAN (1964), 3 = HOWELL & WEBB (1995), 4 = SANTOS DEL PRADO *et al.* (2006). **Symbols:** E = endemic.

scientific name	common name	breeder	non breeder	Source
<i>Podiceps nigricollis californicus</i>	Eared Grebe		IM	1,3
<i>Phaethon aethereus mesonauta</i>	Red-billed Tropicbird	J,Ma,Mg,C	J,Ma,Mg,C	1,2,3,4
<i>Sula nebowxii nebowxii</i>	Blue-footed Booby	J,C	J,C	1,2,3,4
<i>Sula leucogaster</i>	Brown Booby	J,C	J,C	1,2,3,4
<i>Sula sula</i>	Red-footed Booby			4
<i>Pelecanus occidentalis</i>	Brown Pelican	J,C	J,Ma,Mg,C	1,2,3,4
<i>Phalacrocorax auritus</i>	Double-crested Cormorant		IM	3
<i>Fregata magnificens</i>	Magnificent Frigatebird	J,C	J,Mg,C	1,2,3,4
<i>Ardea herodias</i>	Great Blue Heron		J,Ma,Mg,C	1,2,3,4
<i>Egretta alba</i>	Great White Egret		J,Ma,Mg,C	1,2,3
<i>Egretta thula</i>	Snowy Egret		Ma	1,2,3,4
<i>Egretta caerulea</i>	Little Blue Heron		Mg	2,3
<i>Egretta tricolor</i>	Tricolored Heron		Ma	1,2,3
<i>Bubulcus ibis</i>	Cattle Egret		IM	1,3,4
<i>Butorides virescens</i>	Green Heron		IM	1,3
<i>Nycticorax violaceus</i>	Yellow-crowned Night-Heron	Mg	Ma,Mg,C	1,2,3,4
<i>Plegadis falcinellus</i>	Glossy Ibis		Ma	1,2
<i>Plegadis chihi</i>	White-faced Ibis		IM	3,4
<i>Anas crecca carolinensis</i>	Green-winged Teal			4
<i>Anas discors</i>	Blue-winged Teal			4
<i>Anas clypeata</i>	Northern Shoveler		IM	1
<i>Aythya americana</i>	Redhead		IM	3
<i>Mergus merganser americanus</i>	Common Merganser		IM	1
<i>Mergus serrator</i>	Red-breasted Merganser		IM	1,3
<i>Gallus gallus domesticus</i>	Chicken			4
<i>Coragyps atratus</i>	Black Vulture		IM	1,3
<i>Cathartes aura</i>	Turkey Vulture	IM	J,Ma,Mg,C	1,2,3,4
<i>Pandion haliaetus</i>	Osprey	IM, Ma	J,Ma,Mg,C	2,3,4
<i>Chondrohierax uncinatus</i>	Hook-billed Kite	IM	Mg	1,2,3
<i>Circus cyaneus hudsonius</i>	Northern Harrier		Ma	1,2,3
<i>Accipiter cooperi</i>	Cooper's Hawk			4
<i>Buteogallus anthracinus</i>	Common Black Hawk		Mg	1,2,3
<i>E Buteo jamaicensis fumosus</i>	Tres-Marias Red-tailed Hawk	IM	Ma,Mg,C	1,2,3,4
<i>Caracara plancus</i>	Crested Caracara	IM,Mg	J,Ma,Mg,C	1,2,3,4
<i>Falco sparverius</i>	American Kestrel		Ma,Mg,C	1,2,3,4
<i>Falco columbarius</i>	Merlin		Ma,C	1,2,3,4
<i>Falco rufigularis</i>	Bat Falcon		Ma	1,2,3

<i>Falco peregrines</i>	Peregrine Falcon		Ma,Mg,C	1,2,3
<i>Callipepla douglasii</i>	Elegant Quail	IM	Ma	1,2,3,4
<i>Rallus limicola</i>	Virginia Rail			4
<i>Fulica americana americana</i>	American Coot		Ma	1,2,3,4
<i>Pluvialis squatarola</i>	Black-billed Plover		Mg,C	1,2,3,4
<i>Pluvialis dominica</i>	American Golden Plover		Mg	1,2,3,4
<i>Charadrius alexandrinus</i>	Snowy Plover		Mg,C	1,2,3
<i>Charadrius semipalmatus</i>	Semipalmated Plover		Ma,Mg,C	1,2,3,4
<i>Charadrius vociferous vociferous</i>	Killdeer		Mg	1,2,3,4
<i>Haematopus palliatus</i>	American Oystercatcher	IM	J,Ma,Mg,C	1,2,3,4
<i>Himantopus mexicanus</i>	Black-necked Stilt		Ma	1,2,3,4
<i>Tringa flavipes</i>	Lesser Yellowlegs		Ma	1,2,3,4
<i>Tringa solitaria</i>	Solitary Sandpiper		Mg	1,2,3,4
<i>Catoptrophorus semipalmatus</i>	Willet		J,Mg,C	1,2,3,4
<i>Heteroscelus incanus</i>	Wandering Tattler		J,Ma,Mg,C	1,2,3
<i>Actitis macularia</i>	Spotted Sandpiper		J,Ma,Mg,C	1,2,3
<i>Numenius phaeopus hudsonicus</i>	Whimbrel		J,Mg	1,2,3,4
<i>Numenius americanus</i>	Long-billed Curlew		Ma	1,2,3
<i>Limosa fedoa</i>	Marbled Godwit		IM	1,3
<i>Arenaria interpres</i>	Ruddy Turnstone		IM	1,3
<i>Arenaria melanocephola</i>	Black Turnstone		IM	3
<i>Aphriza virgata</i>	Surfbird		IM	1,3
<i>Calidris alba</i>	Sanderling		J	1,2,3
<i>Calidris mauri</i>	Western Sandpiper		IM	1,3
<i>Calidris minutilla</i>	Least Sandpiper		Mg	1,2,3
<i>Calidris bairdii</i>	Baird's Sandpiper		Ma	1,2,3
<i>Calidris melanotos</i>	Pectoral Sandpiper		J,Ma,Mg	1,2,3
<i>Calidris alpina</i>	Dunlin		IM	1,3
<i>Limnodromus griseus</i>	Short-billed Dowitcher		IM	1,3
<i>Limnodromus scolopaceus</i>	Long-billed Dowitcher		IM	3,4
<i>Gallinago gallinago delicata</i>	Common Snipe		IM	1,3
<i>Phalaropus tricolor</i>	Wilson's Phalarope		Ma	1,2,3,4
<i>Larus atricilla</i>	Laughing Gull		Ma	1,2,3
<i>Larus philadelphia</i>	Bonaparte's Gull		IM	1,3
<i>Larus heermanni</i>	Hermann's Gull		Ma,Mg,C	1,2,3,4
<i>Larus delawarensis</i>	Ring-billed Gull		Ma,Mg,C	1,3
<i>Larus argentatus smithsonianus</i>	Herring Gull		J	1,2,3,4
<i>Sterna maxima maxima</i>	Royal Tern		Ma,C	1,2,3,4
<i>Sterna elegans</i>	Elegant Tern		Ma	1,2,3
<i>Columba livia</i>	Feral Pidgeon	IM	IM	1,3,4
<i>Columba flavirostris</i>	Red-billed Pigeon	IM	IM	1,3,4
<i>E Columba flavirostris madrensis</i>	Tres Marias Pigeon	IM,Mg	Ma,Mg,C	2
<i>Zenaida asiatica</i>	White-winged Dove		IM	1,3,4
<i>Zenaida asiatica mearnsi</i>	Western White-winged Dove	IM,Mg	J,Ma,Mg,C	2
<i>Zenaida macroura</i>	Mourning Dove		IM	1,3,4
<i>Zenaida macroura carolinensis</i>	Eastern Mourning Dove		Ma	2
<i>Columbina inca</i>	Inca-Dove		IM	3
<i>Columbina passerina passerina</i>	Common Ground-Dove	IM	IM	1,3,4
<i>Columbina passerina pallescens</i>	Mexican Ground-Dove	IM	J,Ma,Mg,C	2
<i>E Leptotila verreauxi capitalis</i>	Tres Marias Dove	IM,Mg	Ma,Mg,J	1,2,3,4
<i>Forpus cyanopygius</i>	Mexican Parrotlet	IM	IM	1,3,4
<i>E Forpus cyanopygius insularis</i>	Tres Marias Parrotlet	IM	Ma,Mg,C	2
<i>Amazona oratrix</i>	Yellow-headed Parrot	IM	IM	3,4
<i>E Amazona oratrix tresmariae</i>	Tres Marias Parrot	IM	J,Ma,Mg,C	1,2
<i>Amazona auropalliata</i>	Yellow-naped Parrot		IM	1
<i>Coccyzus minor minor</i>	Mangrove Cuckoo	IM	IM	1,3

<i>Coccyzus minor palloris</i>	Mangrove Cuckoo	IM,Mg	Ma,Mg	2
<i>Crotophaga sulcirostris</i>	Groove-billed Ani	IM	IM	1,3
<i>Tyto alba alba</i>	Barn Owl	IM	IM	1,3,4
<i>Tyto alba pratincola</i>	American Barn Owl		Ma	2
<i>E Micrathene whitneyi graysoni</i>	Socorro Elf Owl		IM	1,3,4
<i>Athene cunicularia</i>	Burrowing Owl		IM	1,3,4
<i>Chordeiles acutipennis</i>	Lesser Nighthawk	IM(?)	IM(?)	1,3
<i>Chordeiles acutipennis texensis</i>	Texas Nighthawk	IM(?)	Ma,C	2
<i>Nyctidromus albigollis albigollis</i>	Pauraque	IM	IM	1,3,4
<i>Nyctidromus albigollis insularis</i>	Tres Marias Pauraque	IM,Ma	Ma,Mg,C	2
<i>E Cynanthus latirostris lawrencei</i>	Lawrence's Hummingbird	IM,Ma,Mg	J,Ma,Mg,C	1,2,3,4
<i>E Amazilia rutila graysoni</i>	Grayson's Hummingbird	IM,Mg	J,Ma,Mg,C	1,2,3,4
<i>Selasphorus rufus</i>	Rufous Hummingbird		IM	3
<i>Trogon elegans elegans</i>	Elegant Trogon	IM	IM	1,3,4
<i>Trogon elegans goldmani</i>	Goldman's Trogon	IM	Ma,Mg,C	2
<i>Ceryle torquata torquata</i>	Ringed Kingfisher		C	1,2,3
<i>Ceryle alcyon alcyon</i>	Belted Kingfisher		IM	1,4
<i>Ceryle alcyon caurina</i>	Northwestern Belted Kingfisher		Ma,Mg,C	2
<i>Chloroceryle americana</i>	Green Kingfisher			1,3,4
<i>Picoides scalaris</i>	Ladder-backed Woodpecker	IM,Ma,Mg	J,Ma,Mg,C	1,2,3,4
<i>Camptostoma imberbe</i>	Northern beardless Tyrannulet	IM,Mg	J,Ma,Mg,C	1,2,3
<i>Myiopagis viridicata viridicata</i>	Greenish Elania	IM	IM	1,3
<i>Myiopagis viridicata minima</i>	Small Greenish Elania	IM	Ma,Mg,C	2
<i>Contopus sordidulus</i>	Western Pewee		Ma	1,2,3,4
<i>Contopus virens</i>	Eastern Pewee		IM	1,3
<i>Empidonax difficilis</i>	Pacific Slope Flycatcher		Ma,Mg,C	1,2,3,4
<i>Pyrocephalus rubinus</i>	Vermilion Flycatcher		Ma	1,2,3,4
<i>Myiarchus tuberculifer</i>	Dusky-capped Flycatcher	IM	IM	1,3
<i>Myiarchus tuberculifer tresmariae</i>	Tres Maria Flycatcher	IM	J,Ma,Mg,C	2
<i>Myiarchus tyrannulus</i>	Brown-crested Flycatcher	IM	Ma,Mg,C	1,2,3,4
<i>Tyrannus melancholicus</i>	Tropical Kingbird	IM	IM	1,3,4
<i>Tyrannus melancholicus occidentalis</i>	West Mexican Kingbird	IM,Mg,C	Ma,Mg,C	2
<i>Pachyrhamphus aglaiae</i>	Rose-throated Becard	IM,Mg	Ma,Mg	1,2,4
<i>Tachycineta albilinea albilinea</i>	Mangrove Swallow	IM	IM	3,4
<i>Hirundo rustica erythrogaster</i>	Barn Swallow			4
<i>Campylorhynchus brunneicapillus</i>	Cactus Wren		IM	1
<i>E Thryothorus felix lawrencei</i>	Lawrence's Happy Wren	IM,Mg	Ma,Mg,C	1,2,3,4
<i>Poliophtila nigriceps</i>	Black-capped Gnatcatcher			4
<i>E Myadestes occidentalis insularis</i>	Tres Marias Solitaire	IM	Ma,Mg,C	1,2,3,4
<i>Catharus ustulatus</i>	Swainson's Thrush		Ma,Mg,C	1,2,3,4
<i>E Turdus rufopallatus graysoni</i>	Grayson's Thrush	IM,Mg	Ma,Mg,C	1,2,3,4
<i>E Melanotis caerulescens longirostris</i>	Blue Mockingbird	IM,Mg	J,Ma,Mg,C	1,2,3,4
<i>Mimus polyglottos leucopterus</i>	Northern Mockingbird	IM	Ma,Mg	1,2,3,4
<i>Anthus rubescens</i>	American Pipit		Mg	1,2,3
<i>Bombicilla cedrorum</i>	Cedar Waxwing			1,3
<i>Lanius ludovicianus</i>	Loggerhead Shrike			3
<i>Vireo solitarius solitarius</i>	Blue-headed Vireo		Ma	1,2,3
<i>Vireo hypochryseus hypochryseus</i>	Golden Vireo			1,3,4
<i>Vireo hypochryseus sordidus</i>	Common Golden Vireo	IM	Ma,Mg,C	2
<i>Vireo gilvus</i>	Warbling Vireo		Mg	1,2,3
<i>Vireo flavoviridis flavoviridis</i>	Yellow-Green Vireo			1,3,4
<i>Vireo flavoviridis forreri</i>	Forrer's Vireo	IM,Mg	Ma,Mg,C	2
<i>Vireo olivaceus</i>	Red-eyed Vireo			1
<i>Vermivora celata celata</i>	Orange-crowned Warbler			1,3,4
<i>Vermivora celata lutescens</i>	Lutescent Warbler		Ma,Mg	2
<i>E Parula pitayumi insularis</i>	Tres Marias Tropical Parula	IM,Mg	J,Ma,Mg,C	1,2,3,4

<i>Dendroica petechia petechia</i>	Yellow Warbler			1,3,4
<i>Dendroica petechia rubiginosa</i>	Alaska Yellow Warbler		Ma	2
<i>Dendroica petechia morocomi</i>	Marocom's Warbler		Ma,Mg	2
<i>Dendroica coronata</i>	Yellow-rumped Warbler			1,3,4
<i>Dendroica auduboni</i>	Audubon's Warbler		Ma,Mg,C	1,2
<i>Dendroica nigrescens</i>	Black-throated Grey Warbler		Mg	1,2,3
<i>Dendroica townsendi</i>	Townsend's Warbler		Ma,Mg	1,2,3
<i>Mniotilta varia</i>	Black-and-white Warbler		Mg	1,2,3,4
<i>Setophaga ruticilla</i>	American Redstart		Mg	1,2,3
<i>Seiurus aurocapillus</i>	Ovenbird		Ma,Mg,C	1,2,3,4
<i>Seiurus noveboracensis</i>	Northern Waterthrush		Mg	1,2,3
<i>Seiurus motacilla</i>	Louisiana Waterthrush		Mg	1,2,3
<i>Oporornis tolmiei</i>	MacGilvray's Warbler		Mg	1,2,3
<i>Wilsonia pusilla</i>	Wilson's Warbler		Ma,C	1,2,3,4
<i>E. Granatellus venustus francescae</i>	Tres Marias Chat	IM,Mg	Ma,Mg,C	1,2,3,4
<i>Granatellus sallaei</i>	Grey-throated Chat			1
<i>Piranga ludoviciana</i>	Western Tanager	Ma,Mg		1,2,3
<i>Piranga bidentata bidentata</i>	Flame-colored Tanager			1,3,4
<i>Piranga bidentata flammea</i>		IM	Ma,Mg,C	2
<i>E. Cardinalis cardinalis mariae</i>	Las Marias Cardinal	IM,Mg	J,Ma,Mg,C	1,2,3,4
<i>Pheucticus melanocephalus</i>	Black-headed Grosbeak		Ma,Mg	1,2,3
<i>Passerina cyanea</i>	Indigo Bunting		Ma	1,2,3
<i>Passerina versicolor</i>	Varied Bunting		Mg	1,2,3
<i>Passerina ciris ciris</i>	Painted Bunting			1,3
<i>Passerina ciris pallidior</i>	Western Painted Bunting		Mg	2
<i>Spiza americana</i>	Dickcissel			1,3
<i>Sporophila torqueola</i>	White-collared Seedeater		Ma	1,2,3
<i>Spizella breweri breweri</i>	Brewer's Sparrow			3
<i>Poocetes gramineus</i>	Vesper Sparrow			1,3
<i>Chondestes grammacus</i>	Lark Sparrow			1,3,4
<i>Melospiza lincolni</i>	Lincoln's Sparrow			1,3
<i>Zonotrichia leucophrys leucophrys</i>	White-crowned Sparrow			1,3,4
<i>Zonotrichia leucophrys gambelii</i>	Gambel's Sparrow			1
<i>Quiscalus mexicanus</i>	Great-tailed Grackle		Ma	1,2,3
<i>Molothrus ater ater</i>	Brown-headed Cowbird			1,3
<i>Molothrus ater obscures</i>	Small Cowbird		J,Mg	2
<i>Icterus cucullatus</i>	Hooded Oriole			1,3
<i>Icterus pustulatus graysoni</i>	Streak-backed Oriole	IM,Ma,Mg	J,Ma,Mg,C	1,2,3,4
<i>Icterus gularis</i>	Altamira Oriole			1
<i>Carpodacus cassinii</i>	Cassin's Finch		Ma	1,2,3
<i>Carduelis psaltria</i>	Lesser Goldfinch	IM	Ma,Mg,C	1,2,3,4
<i>Passer d. domesticus</i>	House Sparrow		J	1,3,4

Appendix III.

Bird species of the West-Mexican study area: Revillagigedo Islands.

Information sources: 1 = FOX QUESADA *et al.* (2004), 2 = HOWELL & WEBB (1995), 3 = WEHTJE *et al.* (1993); 4 = BRATTSTROM & HOWELL (1956); 5 = SANTAELLA & SADA (1991); 6 = JEHL & PARKS (1982). **Island records:** S = Socorro, C = Clarion, SB = San Benedicto, RP = Roca Partida, RG = whole Archipelago (source without details to island). **Symbols:** † = extinct, E = endemic.

scientific name	common name	breeder	non breeder	source
<i>Podilymbus podiceps</i>	Pied-billed Grebe		S	1,2,3,6
<i>Diomedea albatrus</i>	Short-tailed Albatross		SB	1,2,5
<i>Diomedea nigripes</i>	Black-footed Albatross		C, SB	1,2,6
<i>Diomedea immutabilis</i>	Laysan Albatross	C, SB	S,C,SB	1,2,3,5
<i>Pterodroma externa</i>	Juan Fernandez Petrel		C	1,2,5
<i>Pterodroma phaeopygia phaeopygia</i>	Dark-rumped Petrel		RG	2
<i>Pterodroma neglecta juana</i>	Kermadec Petrel		RG	2
<i>Pterodroma arminjoniana</i>	Herald Petrel		RG	2
<i>Pterodroma rostrata</i>	Tahiti Petrel		C	1,2,5
<i>Pterodroma cooki</i>	Cook's Petrel		SB, C, RP	1,2,5
<i>Pterodroma nigripennis</i>	Black-winged Petrel		C	1,2,5
<i>Puffinus creatopus</i>	Pink-footed Shearwater		SB	1,2,6
<i>Puffinus carneipes</i>	Flesh-footed Shearwater		C, RP	1,2,5
<i>Puffinus pacificus cuneatus</i>	Wedge-tailed Shearwater	SB	C, SB	1,2,3,4,5,6
<i>Puffinus griseus</i>	Sooty Shearwater		RG	2
<i>E Puffinus auricularis auricularis</i>	Townsend's Shearwater	S, C, SB	S, C, SB	1,2,3,4,5,6
<i>Puffinus lherminieri</i>	Audubon's Shearwater		S, SB	1,2,3,5
<i>Oceanodroma leucorhoa</i>	Leach's Storm-Petrel		S,C,SB,RP	2,3,5
<i>Oceanites oceanicus</i>	Wilson's Storm-Petrel		C, SB, RP	1,5
<i>Oceanodroma castro</i>	Harcourt's Storm-Petrel		C, SB	1,2,5
<i>Oceanodroma tethys</i>	Galapagos Storm-Petrel		S, RP	2,3,5,6
<i>Oceanodroma melania</i>	Black Storm-Petrel		SB	2,5
<i>Oceanodroma microsoma</i>	Least Storm-Petrel		RG	2
<i>Phaethon aethereus</i>	Red-billed Tropicbird	S, C	S, C, SB	1,2,3,4,5,6
<i>Phaethon rubricauda</i>	Red-tailed Tropicbird	SB	SB	1,2,5
<i>Sula dactylatra</i>	Masked Booby	C, SB	S,C,SB, RP	1,2,3,4,5,6
<i>Sula nebovii</i>	Blue-footed Booby		SB	1,2,4
<i>Sula leucogaster</i>	Brown Booby	RP	S,C,SB,RP	1,2,3,4,5,6
<i>Sula sula</i>	Red-Footed Booby	C	S,C SB,RP	1,2,3,4,5,6
<i>Pelecanus occidentalis</i>	Brown Pelican		SB	1,2,4
<i>Fregata magnificens</i>	Magnificent Frigatebird	SB	S, SB	1,2,3,5,6
<i>Fregata minor</i>	Great Frigatebird	SB	S,C,SB,RP	1,2,3,4,5,6
<i>Ardea herodias</i>	Great Blue Heron		S, C	1,2,3,5
<i>Egretta alba</i>	Great White Egret		S,C	1,2,3
<i>Egretta thula</i>	Snowy Egret		S, C	1,2,3,4,6
<i>Egretta tricolor</i>	Tricolored Heron		RG	2
<i>Bubulcus ibis</i>	Cattle Egret		S, C	1,2,3,5,6
<i>Butorides virescens</i>	Green Heron		S	1,2
<i>E Nycticorax violaceus gravirostris</i>	Socorro Yellow-crowned Night-heron	S	S	1,2,3,4,6
<i>Plegadis falcinellus</i>	Glossy Ibis		C	1,2,4
<i>Plegadis chihi</i>	White-faced Ibis		RG	2
<i>Anas spec.</i>	Duck		C	6
<i>Anas discors</i>	Blue-winged Teal		C	1,2
<i>Pandion haliaetus</i>	Osprey		S, C, SB	1,2,3,4,6
<i>Elanus leucurus majusculus</i>	White-tailed Kite		S	1
<i>Circus cyaneus hudsonius</i>	Northern Harrier	S	S	1,3

<i>Acciper striatus</i>	Sharp-shinned Hawk		S, SB	1,2,3
<i>Accipiter cooperi</i>	Cooper's Hawk		S	1,3
<i>E Buteo jamaicensis socorroensis</i>	Red-tailed Hawk	S	S, SB	1,2,3,4,5,6
<i>Falco sparverius</i>	American Kestrel		S, C, SB	1,2,3
<i>Falco columbarius</i>	Merlin		S	1,2
<i>Falco peregrinus</i>	Peregrine Falcon		S, C, SB	1,2,3,4,6
<i>Porphyryla martinica</i>	Purple Gallinule		S	1
<i>Fulica americana americana</i>	American Coot		C	1,2
<i>Pluvialis squatarola</i>	Black-billed Plover		S	1,2,3,6
<i>Pluvialis fulva</i>	American Golden Plover		C, SB	1,5
<i>Charadrius semipalmatus</i>	Semipalmated Plover		S	1,2,3,6
<i>Charadrius vociferous vociferous</i>	Killdeer		S, C	1,2,3,6
<i>Himantopus mexicanus mexicanus</i>	Black-necked Stilt		S, C	1,2,4
<i>Tringa flavipes</i>	Lesser Yellowlegs		C	1,2
<i>Catoptrophorus semipalmatus</i>	Willet		S	1,2,3,4
<i>Heteroscelus incanus</i>	Wandering Tattler		S, C, SB	1,2,3,5
<i>Actitis macularia</i>	Spotted Sandpiper		S, C	1,2,3,4,5
<i>Numenius phaeopus hudsonicus</i>	Whimbrel		S, C, SB	1,2,3,4,5,6
<i>Arenaria interpres</i>	Ruddy Turnstone		C	1,2
<i>Aphriza virgata</i>	Surfbird		S	1,3
<i>Calidris canutus rufa</i>	Red Knot		S	1
<i>Calidris alba</i>	Sanderling		S, C	1,2,3
<i>Calidris mauri</i>	Western Sandpiper		S, C	1,2,3,4
<i>Calidris minutilla</i>	Least Sandpiper		S, C	1,4
<i>Limnodromus scolopaceus</i>	Long-billed Dowitcher		C	1,2,6
<i>Phalaropus lobatus</i>	Red-Necked Phalarope		C	1,2,6
<i>Phalaropus fulicaria</i>	Red Phalarope		S, C, SB, RP	1,2,3
<i>Stercorarius pomarinus</i>	Pomarine Jaeger		S	1,2,3,6
<i>Stercorarius parasiticus</i>	Parasitic Jaeger		C, RP	1,2
<i>Stercorarius longicaudus</i>	Long-tailed Jaeger		RG	2
<i>Catharacta maccormicki</i>	South Polar Skua		RG	2
<i>Larus atricilla</i>	Laughing Gull		S, C	1,2,3
<i>Larus pipixcan</i>	Franklin's Gull		S	1,2,3,6
<i>Larus philadelphia</i>	Bonaparte's Gull		RG	2
<i>Larus heermanni</i>	Hermann's Gull		S	1,2,3
<i>Larus delawarensis</i>	Ring-billed Gull		S	1,3
<i>Larus californicus</i>	California Gull		S, SB	1,2,3,5,6
<i>Larus argentatus smithsonianus</i>	Herring Gull		S, C	1,2,3
<i>Larus occidentalis wymani</i>	Western Gull		S, C	1,2,3
<i>Larus glaucescens</i>	Glaucous-winged Gull		S	1,2,3,6
<i>Larus sabini</i>	Sabine's Gull		SB	1,6
<i>Sterna paradisaea</i>	Arctic Tern		SB	1,2,5
<i>Sterna fuscata</i>	Sooty Tern	RP	S, RP	1,2,3,5
<i>Anous stolidus</i>	Brown Noddy	S, RP	S, RP	1,2,3,5,6
<i>Gygis alba canadida</i>	White Tern		S	1,2,3
<i>Columba livia</i>	Feral Pidgeon	S	S	1,2,3
<i>E Columbina passerina socorroensis</i>	Socorro Common Ground Dove	S	S	1,2,4,5,6
<i>Zenaida macroura</i>	Mourning Dove	S	S	2,3,5,6
<i>E Zenaida macroura clarionensis</i>	Murning Dove	C	C	1,4
<i>E Zenaida graysoni</i> †	Socorro Dove	S	S	1,2,4,6
<i>E Aratinga brevipes</i>	Socorro Parakeet	S	S	1,2,3,4,5,6
<i>Crotophaga sulcirostris</i>	Groove-billed Ani		S	1,2,3
<i>Tyto alba</i>	Barn Owl		RG, S	1,2,3,6
<i>E Micrathene whitneyi graysoni</i> †	Socorro Elf Owl	S	S	1,2,3,6
<i>E Athene cunicularia rostrata</i>	Burrowing Owl	C	C	1,2,4,5
<i>Asio flammeus flammeus</i>	Short-eared Owl		S	1,2

<i>Chaetura pelagica</i>	Chimney Swift		RG	2
<i>Chaetura sp.</i>	Swift sp.		C	1,5
<i>Ceryle alcyon</i>	Belted Kingfisher		S, C	1,2,3,4
<i>Sphyrapicus varius</i>	Yellow-bellied Sapsucker		S	1
<i>Sphyrapicus nuchalis</i>	Red-breasted Sapsucker		S	1,3
<i>Tachycineta bicolor</i>	Tree Swallow		S	1
<i>Stelgidopteryx serripennis</i>	Northern Rough-winged Swallow		S	1,2,3
<i>Stelgidopteryx ruficollis</i>	Southern Rough-winged Swallow		S	6
<i>Hirundo rustica erythrogaster</i>	Barn Swallow		S, C, SB	1,2,3,4,5
<i>E Corvus corax clarionensis</i>	Northern Raven	C	C, SB	1,2,4,5,6
<i>Sitta canadensis</i>	Red-breasted Nuthatch		RG	2
<i>Salpinctes obsoletus</i>	Rock Wren		RG	2
<i>E Salpinctes obsoletus exsul †</i>	San Benedicto Rock Wren	SB	SB	1,4,6
<i>E Troglodytes tanneri</i>	Clarion Wren	C	C	1,2,4,5
<i>E Troglodytes sissonii</i>	Socorro Wren	S	S	1,2,3,4,5,6
<i>Catharus ustulatus</i>	Swaizon's Thrush		S	1,3
<i>Mimus polyglottos leucopterus</i>	Northern Mockingbird	S	S	1,2,3,5,6
<i>E Mimodes graysoni</i>	Socorro Mockingbird	S	S	1,2,3,4,5,6
<i>Anthus rubescens</i>	American Pipit		C,S	1,2,3
<i>Bombcilla cedrorum</i>	Cedar Waxwing		S	1,3
<i>Sturnus vulgaris vulgaris</i>	European Starling		S	1
<i>Vireo griseus</i>	White-eyed Vireo		S	1,2
<i>Vermivora peregrina</i>	Tennessee Warbler		S	1,2,3,6
<i>E Parula pitiayumi graysoni</i>	Tropical Parula	S	S	1,2,3,4,5,6
<i>Dendroica petechia</i>	Yellow Warbler		S	1,2,3,6
<i>Dendroica tigrina</i>	Cape May Warbler		S	1,2
<i>Dendroica coronata</i>	Yellow-rumped Warbler		S, SB	1,2,3,6
<i>Dendroica townsendi</i>	Townsend's Warbler		S	1,2,3,6
<i>Dendroica virens</i>	Black-throated Green Warbler		S	1,2,3,6
<i>Dendroica palmarum</i>	Palm Warbler		S, C	1,2
<i>Dendroica castanea</i>	Bay-breasted Warbler		SB	1,2,4,6
<i>Dendroica striata</i>	Blackpoll Warbler		S	1
<i>Setophaga ruticilla</i>	American Redstart		S, SB	1,2,3,6
<i>Seiurus aurocapillus</i>	Ovenbird		S	1
<i>Seiurus noveboracensis</i>	Northern Waterthrush		RG	2
<i>Geothlypis trichas</i>	Common Yellowthroat		S, C	1,2
<i>Wilsonia pusilla</i>	Wilson's Warbler		S	1,3
<i>Piranga rubra</i>	Summer Tanager		S	1,3
<i>Pheucticus ludovicianus</i>	Rose-breasted Grosbeak		S	1,2,3
<i>Passerina cyanea</i>	Indigo Bunting		S	1,2,3
<i>Pipilo erythrophthalmus socorrensis</i>	Socorro Towhee	S	S	1,2,3,4,5,6
<i>Chondestes grammacus</i>	Lark Sparrow		S, C	1,2,3
<i>Xanthocephalus xanthocephalus</i>	Yellow-headed Blackbird		S	1,3
<i>Molothrus ater</i>	Brown-headed Cowbird		S	1,2,3
<i>Icterus cucullatus</i>	Hooded Oriole		S	1,2
<i>Passer domesticus domesticus</i>	House Sparrow		S	1,3

Appendix IV.

Bird species list of the West-Mexican study area: Isla Isabel.

Information sources: 1 = FOX QUESADA *et al.* (2005), 2 = personal data by authors.

scientific name	common name	breeder	non breeder	Source
<i>Oceanodroma melania</i>	Black Storm-Petrel		×	1
<i>Oceanodroma microsoma</i>	Least Storm-Petrel		×	1
<i>Phaethon aethereus mesonauta</i>	Red-billed Tropicbird	×		1,2
<i>Sula dactylatra</i>	Masked Booby	×		1
<i>Sula neboxii neboxii</i>	Blue-footed Booby	×		1,2
<i>Sula leucogaster</i>	Brown Booby	×		1,2
<i>Sula sula</i>	Red-footed Booby	×		1
<i>Pelecanus occidentalis</i>	Brown Pelican	×		1,2
<i>Phalacrocorax penicillatus</i>	Brandt's Cormorant		×	1
<i>Fregata magnificens</i>	Magnificent Frigatebird	×		1,2
<i>Botaurus spec.</i>	Bittern		×	1
<i>Ardea herodias</i>	Great Blue Heron		×	1,2
<i>Egretta alba</i>	Great White Egret		×	1
<i>Egretta thula</i>	Snowy Egret		×	1
<i>Egretta rufescens</i>	Reddish Egret		×	1
<i>Bubulcus ibis ibis</i>	Cattle Egret		×	1
<i>Nycticorax nycticorax hoactli</i>	Black-crowned Night-Heron		×	1
<i>Nycticorax violaceus</i>	Yellow-crowned Night-Heron		×	1
<i>Anas discors</i>	Blue-winged Teal		×	1
<i>Accipiter striatus</i>	Sharp-shinned Hawk	×		1,2
<i>Caracara plancus</i>	Crested Caracara		×	1
<i>Falco sparverius</i>	American Kestrel		×	1
<i>Falco columbarius</i>	Merlin		×	1
<i>Falco peregrinus</i>	Peregrine Falcon		×	1
<i>Rallus spec.</i>	Rail		×	1
<i>Fulica americana americana</i>	American Coot		×	1
<i>Charadrius vociferous vociferous</i>	Killdeer		×	1
<i>Haematopus palliatus</i>	American Oystercatcher	×	×	1,2
<i>Himantopus mexicanus mexicanus</i>	Black-necked Stilt		×	1
<i>Tringa solitaria</i>	Solitary Sandpiper		×	1
<i>Catoptrophorus semipalmatus</i>	Willet		×	1
<i>Heteroscelus incanus</i>	Wandering Tattler	×		1,2
<i>Actitis macularia</i>	Spotted Sandpiper		×	1
<i>Numenius phaeopus hudsonicus</i>	Whimbrel		×	1
<i>Calidris mauri</i>	Western Sandpiper		×	1
<i>Calidris minutilla</i>	Least Sandpiper		×	1
<i>Phalaropus tricolor</i>	Wilson's Phalarope		×	1
<i>Larus atricilla</i>	Laughing Gull		×	1
<i>Larus heermanni</i>	Heermann's Gull	×	×	1,2
<i>Larus californicus</i>	California Gull		×	1
<i>Larus argentatus smithsonianus</i>	Herring Gull		×	1
<i>Larus occidentalis wymani</i>	Western Gull		×	1
<i>Larus tridactylus pollicaris</i>	Black-legged Kittiwake		×	1
<i>Sterna elegans</i>	Elegant Tern		×	1
<i>Sterna fuscata</i>	Sooty Tern	×		1
<i>Anous stolidus</i>	Brown Noddy	×		1
<i>Columba livia</i>	Feral Pidgeon		×	1
<i>Zenaida asiatica mearnsi</i>	Western White-winged Dove		×	1

<i>Columbina passerina pallescens</i>	Mexican Ground-Dove	×		1,2
<i>Leptotila verreauxi</i>	White-tipped Dove		×	1
<i>Crotophaga sulcirostris</i>	Groove-billed Ani	×		1,2
<i>Otus asio mcgillii</i>	Eastern Screech Owl		×	1
<i>Athene cunicularia</i>	Burrowing Owl		×	1
<i>Nyctidromus albicollis insularis</i>	Tres Marias Pauraque		×	1
<i>Amazilia yucatanensis</i>	Buff-bellied Hummingbird		×	1
<i>Myiopagis viridicata minima</i>	Small Greenish Elania		×	1
<i>Contopus sordidulus</i>	Western Pewee		×	1
<i>Empidonax traillii</i>	Willow Flycatcher		×	1
<i>Empidonax difficilis</i>	Pacific slope Flycatcher		×	1
<i>Pyrocephalus rubinus</i>	Vermilion Flycatcher		×	1
<i>E. Myiarchus tuberculifer tresmariae</i>	Tres Maria Flycatcher		×	1
<i>Myiarchus cinerascens</i>	Ash-throated Flycatcher		×	1
<i>Myiarchus tyrannulus</i>	Brown-crested Flycatcher		×	1
<i>Tyrannus melancholicus</i>	Tropical Kingbird		×	1
<i>Tyrannus verticalis</i>	Western Kingbird		×	1
<i>Tyrannus forficatus</i>	Scissor-tailed Flycatcher		×	1
<i>Tachycineta albilinea albilinea</i>	Mangrove Swallow		×	1
<i>Stelgidopteryx serripennis</i>	Northern Rough-winged Swallow		×	1
<i>Regulus calendula</i>	Ruby-crowned Kinglet		×	1
<i>Poliophtila caerulea</i>	Blue-grey Gnatcatcher	×		2
<i>Myadestes occidentalis</i>	Brown-backed Solitaire		×	1
<i>Catharus ustulatus</i>	Swaision's Thrush		×	1
<i>Catharus guttatus</i>	Hermit Thrush		×	1
<i>Turdus rufopalliatus</i>	Rufous-backed Thrush		×	1
<i>Turdus migratorius</i>	American Robin		×	1
<i>Mimus polyglottos leucopterus</i>	Northern Mockingbird		×	1
<i>Vermivora celata</i>	Orange-crowned Warbler		×	1
<i>E. Parula pitiayumi insularis</i>	Tres Marias Tropical Parula	×		1,2
<i>Dendroica petechia rubiginosa</i>	Alaska Yellow Warbler		×	1
<i>Dendroica coronata auduboni</i>	Audubon's Warbler		×	1
<i>Dendroica townsendi</i>	Townsend's Warbler		×	1
<i>Dendroica dominica</i>	Yellow-throated Warbler		×	1
<i>Seiurus aurocapillus</i>	Ovenbird		×	1
<i>Geothlypis trichas</i>	Common Yellowthroat		×	1
<i>Basileuterus lachrymosa</i>	Fan-tailed Warbler		×	1
<i>Piranga rubra</i>	Summer Tanager		×	1
<i>Cardinalis sinuatus</i>	Pyrrhuloxia		×	1
<i>Passerina caerulea</i>	Blue Grosbeak		×	1
<i>Volantinia jacarina spendens</i>	Blue-grey Grassquit		×	1
<i>Aimophila carpalis</i>	Rufous-winged Sparrow	×		2
<i>Chondestes grammacus</i>	Lark Sparrow		×	1
<i>Icterus bullockii</i>	Bullock's Oriole		×	1
<i>Passer d. domesticus</i>	House Sparrow		×	1