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RESEARCH ARTICLES

A GALAPAGOS CENTIPEDE *SCOLOPENDRA GALAPAGOENSIS* PREYS ON A FLOREANA RACER *PSEUDALSOPHIS BISERIALIS*

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SUMMARY

Predation by centipedes on vertebrates has been reported in the wild and in captivity but reports of centipede predation on snakes are rare. Here we report the first known case of a scolopendrid centipede preying on a young terrestrial snake in the Galapagos Islands.

RESUMEN

Un Ciempiés de Galápagos *Scolopendra galapagoensis* depreda una Culebra de Floreana *Pseudalsophis biserialis*. La depredación de vertebrados por ciempiés ha sido reportada en campo y en cautiverio, pero los reportes de depredación de culebras por ciempiés son raros. Aquí reportamos el primer caso conocido de un ciempiés escolopendrino depredando una culebra joven en las islas Galápagos.

The genus *Scolopendra* (Chilopoda: Scolopendridae) is represented in the Galapagos Islands by a single species, the Galapagos Centipede *Scolopendra galapagoensis*, one of the largest centipede species in the world, reaching 30 cm in length (Köster & Köster 1983, Shear & Peck 1992). This species occurs also on Cocos Island (Costa Rica) and in mainland Ecuador and Peru (Shelley & Kisser 2000). Very little is known about the biology of the Galapagos Centipede, with most of the information about its habitat and distribution coming from preserved specimens (Shear & Peck 1992, Shelley & Kisser, 2000). Little information is available about their behaviour in the wild. Galapagos Centipedes inhabit barren lava flows as well as arid and montane scrub (Clark 1981, Köster & Köster 1983, Peck 1996), and are prey to the Galapagos Hawk *Buteo galapagensis*, Short-eared Owl *Asio flammeus*, Yellow-crowned Night-Heron *Nyctanassa violacea*, Galapagos Mockingbird *Mimus parvulus*, Floreana Mockingbird *M. trifasciatus* (Curry 1986, Ortiz-Catedral 2014, Jaramillo *et al.* 2016), the introduced and widespread Black Rat *Rattus rattus* (Clark 1981) and perhaps feral cats *Felis catus* (Konecny 1987). Galapagos Centipedes have been observed preying on crickets (Orthoptera: Gryllidae) (Curry 1986) and the endemic Santa Fe Rice Rat *Aegialomys galapagoensis* (Clark 1979), but their diet in the wild has not been documented in detail.

Here we report an instance of a Galapagos Centipede preying on a small Floreana Racer *Pseudalsophis biserialis* on Gardner-by-Floreana (1°19'52"S, 90°17'20"W), a small (80 ha) islet 8 km off the coast of Floreana Island in the south of the Galapagos archipelago. The observation took place on 25 Nov 2015 at 10h16. While conducting a survey for Floreana Racers we noticed a large centipede c. 20–25 cm long carrying a live small Floreana Racer (Fig. 1). The snake was carried along the ventral region of the centipede with the forcipules, maxillary telopodites, and the first three pairs of locomotory legs. The centipede maintained its head slightly raised as it carried its prey. We observed the centipede for 7 min. and the wriggling body of the snake was clearly visible between its legs. A Floreana Mockingbird, attracted to the scene by our presence, approached the centipede and pecked at its head, whereupon the centipede dropped the snake and rushed into a rock crevice. We recovered the snake, which was still breathing but immobile, and noticed damage caused by the forcipules 5 cm behind the head; it died shortly afterwards. The snake was 25 cm long and



Figure 1. Galapagos Centipede *Scolopendra galapagoensis* carrying a young Floreana Racer *Pseudalsophis biserialis* on Gardner-by-Floreana Islet (photo: LOC).

weighed 18 g, which indicates that it was probably a young of the year, since Floreana Racers can grow up to 103 cm in length and weigh up to 230 g (Christian 2017). The snake was deposited in the Vertebrate Collection of the Charles Darwin Research Station, Puerto Ayora.

Centipedes are known to prey on a variety of live vertebrates including frogs, bats, mice and geckos (McCormick & Polis 1982, Molinari *et al.* 2005, Charles & Smith 2009, Srbek-Araujo *et al.* 2012, Noronha *et al.* 2015, Lindley *et al.* 2017) but reports of predation on snakes in the wild are rare. This has been reported for *Scolopendra dawydoffi* in Thailand (Chiacchio *et al.* 2017), *S. heros* in the U.S.A. (Easterla 1975), *S. hardwickei* and an unidentified *Scolopendra* sp. in India (Mirza & Ahmed 2009, Smart *et al.* 2010). In captivity, *S. heros*, *S. viridicornis*, *Otostigmus tibialis* and *Cryptops iheringi* are reported as consuming live snakes (Smart *et al.* 2010, Guizee *et al.* 2016). To the best of our knowledge this is the first record of a Galapagos Centipede preying on a snake and the first published record of a scolopendrid preying on a snake in South

America. We do not know whether predation on small snakes is an opportunistic or a common behaviour of Galapagos Centipedes, but they co-exist on numerous islands in the archipelago. Its occurrence warrants further investigation.

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FIRST BREEDING RECORD OF THE GALAPAGOS FLYCATCHER *MYIARCHUS* *MAGNIROSTRIS* ON DAPHNE MAJOR ISLET

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SUMMARY

Two juvenile Galapagos Flycatchers *Myiarchus magnirostris* were seen being fed by their parents in the upper part of Daphne Major islet, Galapagos, on 1 March 2019. This appears to be the first breeding record for this passerine on the islet.

RESUMEN

Primer registro de reproducción del Papamoscas de Galápagos *Myiarchus magnirostris* en el islote Daphne Mayor. Dos ejemplares jóvenes de Papamoscas de Galápagos *Myiarchus magnirostris* fueron observados siendo alimentados por sus padres en la parte alta del islote Daphne Mayor, Galápagos, el 1 de marzo de 2019. Esta observación constituiría la primera detección de la reproducción de esta especie de paseriforme en el islote.

It has been proposed that a *Myiarchus* flycatcher colonised the Galapagos Islands from Central America c. 850,000 years ago (Sari & Parker 2012). The resulting Galapagos Flycatcher *M. magnirostris*, endemic to the archipelago, is distributed across all its main islands and many of the islets (Wiedenfied 2006, Sari *et al.* 2013), where it normally nests during the warm and wet period (December–May) (D. Anchundia & R. Heleno pers. comm.). However, no records of breeding have been cited for some islets, such as Daphne Major (see Darwin 1875, Rothschild & Hartert 1899, Harris 1972).

During research into the effects of global change on trophic meta-networks on small islets, we discovered a pair of Galapagos Flycatchers feeding unidentified green caterpillars to two short-tailed young birds on Daphne Major, on 1 March 2019. This observation took place in the upper southeastern area of the *Bursera graveolens* woodland. During

two previous visits, on 23 April 2017 and 16–20 November 2018, we had not seen any birds of this species, although the expedition from the California Academy of Sciences (1905–6) recorded one individual (Van Denburgh 1907). According to the literature, as far as we know, no breeding of this species has previously been recorded on Daphne Islet. Furthermore, during the last 40 years, in which period intensive ornithological work was carried out on the islet, this bird was considered as only an occasional vagrant (Grant & Grant 2014). We hypothesize that this breeding couple originated from the north of Santa Cruz Island, where the nearest populations are located. This constitutes the first confirmation of its reproduction on Daphne Major.

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THE ROLE OF LIGHT IN HILL BLACKBERRY *RUBUS NIVEUS* INVASION OF A GALAPAGOS *SCALESIA* FOREST

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SUMMARY

The invasion success of a species depends on its life history attributes, site conditions and stochastic events. Understanding this process is important for developing effective management. Using a series of field plots and nursery experiments, we examined the association of the *Scalesia* forest canopy cover and light availability with the presence, patterns of germination, growth and reproductive success of *Rubus niveus*, one of the most invasive plants in Galapagos. Increased cover of *R. niveus* was significantly correlated with low canopy cover; however, individual plants were also found to persist under very closed canopies. *Rubus niveus* seeds were able to germinate under four light treatments, however, significantly higher percentages of germination were obtained under medium (50 % and 75 %) light treatments. Plants growing under full light exhibited significantly greater growth rates and biomass production than plants growing under medium (70 %) or low (10 %) light conditions; only plants growing under full light conditions were able to reproduce sexually. These results suggest that light availability might be a key factor for the germination, growth, establishment and subsequent invasion of *R. niveus* in the *Scalesia* forest.

RESUMEN

El papel de la luz en el proceso de invasión de la mora *Rubus niveus* en un bosque de *Scalesia* en Galápagos. El éxito en el proceso de invasión de una especie depende de los atributos de su historia de vida, las condiciones del sitio que invade y los eventos estocásticos. El entendimiento de este proceso es importante para desarrollar un manejo eficiente. Usando una serie de parcelas en el campo y experimentos en vivero, examinamos la asociación de la cobertura del dosel del bosque de *Scalesia* y la disponibilidad de luz en la presencia, patrones de germinación, crecimiento y éxito reproductivo de *Rubus niveus*, una de las plantas más invasoras en las Islas Galápagos. Mayor cobertura de *R. niveus* se correlacionó significativamente con la disminución de la cobertura del dosel; sin embargo, también se encontró que plantas individuales sobrevivían bajo copas muy cerradas. Las semillas de *R. niveus* pudieron germinar bajo los cuatro tratamientos de luz; sin embargo, porcentajes de germinación significativamente más altos se obtuvieron bajo tratamientos de luz media (50 % y 75 %). Plantas creciendo a plena luz mostraron tasas de crecimiento y producción de biomasa significativamente mayores que las de plantas creciendo en condiciones de medio (70 %) o poca luz (10 %); solo las plantas que crecieron en condiciones de luz total pudieron reproducirse sexualmente. Estos resultados sugieren que la disponibilidad de luz podría ser un factor clave para la germinación, crecimiento, establecimiento y posterior invasión de *R. niveus* en el bosque de *Scalesia*.

INTRODUCTION

Explaining plant invasion mechanisms is complicated by the numerous environmental factors and species traits that interact to determine species invasiveness and community invasibility (Crawley *et al.* 1986, Lonsdale 1999, Richardson & Pyšek 2006). However, one generalization is that resource competition is a critical factor determining the likelihood of plant invasions. Resource competition often determines plant community composition, while changes in resource availability due to natural or anthropogenic disturbance can upset the balance of competition within communities, creating opportunities for novel species to invade (Davis *et al.* 2000, Fotelli *et al.* 2005). In many plant communities, light availability may be as or more important than nutrient availability in determining the likelihood of invasion (Crawley 1987, Richardson & Pyšek 2006).

In most closed forests, tree-fall represents the main endogenous form of disturbance, with patterns of forest regeneration being closely linked with the resulting gap dynamics (Hubbell *et al.* 1999). Many aspects of the physical environment, such as light, humidity and temperature, are different in openings and beneath the canopy, providing a range of niches for species with differing life history strategies. (Lieberman *et al.* 1989, Baret *et al.* 2008) Invasive introduced species are rarely found in undisturbed continental tropical forests, probably because the majority lack the necessary traits, especially shade tolerance, to invade these ecosystems (Baret *et al.* 2008). However, there is extensive evidence that disturbance enhances the invasibility of native communities (Hobbs & Huenneke 1992, Huston 2004, Huebner & Tobin 2006, DeGasperis & Motzkin 2007, Eschtruth & Battles 2009), and invasive species can come to dominate and irreparably change these ecosystems (Fine 2002). Such invasions tend to be particularly severe on oceanic islands, where they sometimes cause a significant loss of biodiversity (Tershy *et al.* 2015).

Vegetation succession in the Galapagos is influenced by natural events such as volcanic eruptions, natural fires and the highly variable rainfall associated with the El Niño Southern Oscillation (Hamann 1984, Lawesson 1988, 1990). During an El Niño event, ocean temperatures dramatically increase, leading to high precipitation and low air temperatures; years following an El Niño event are often marked by drought (Hamann 1985, Itow & Mueller Dombois 1988, Tye & Aldaz 1999, Runkle & Runkle 2005). These climatic events can sometimes lead to openings in the forest canopy facilitating the germination and regeneration of native species (Hamann 1985, Itow & Mueller Dombois 1988). However, the same events may also provide ideal conditions for the invasion of introduced plants (Itow 1988, Shimizu 1997). In addition, it appears that forest invasion proceeds gradually through canopy gaps that open due to continuous tree mortality (Shimizu 1997, Jäger *et al.* 2017).

Historically, parts of the humid zone of the Galapagos islands were covered by a forest type dominated by the endemic tree *Scalesia pedunculata* (Asteraceae) on the islands of Santa Cruz, Floreana, San Cristóbal and Santiago (Wiggins & Porter 1971, Hamann 1981). On San Cristóbal and Santiago, this forest has almost disappeared, while on Santa Cruz and Floreana, it has been severely reduced in area, and the remaining patches are heavily degraded (Hamann 1981, Itow & Mueller Dombois 1988). Loss of this forest type was driven initially by the expansion of agriculture before the 1959 establishment of the Galapagos National Park, and more recently by intense herbivory (donkeys and goats) and invasive plant species such as *Rubus niveus* (Snell *et al.* 2002, Renteria & Buddenhagen 2006, Mauchamp & Atkinson 2011).

The *Scalesia* forest at 600 m a.s.l. on the twin volcanic craters of the tourist visitor site Los Gemelos, Santa Cruz Island, is one of the last remnants of this native vegetation type in the humid zone of the inhabited islands of Galapagos (Itow 1995). It is estimated that the *Scalesia* forest now covers c. 100 ha. As indicated by its name, the forest once was dominated by the endemic tree *S. pedunculata* (hereafter termed simply *Scalesia*) and includes many other endemic and native plant species (Hamann 2001, Mauchamp & Atkinson 2011). The *Scalesia* forest has been invaded by several introduced plant species including *Cedrela odorata*, *Cestrum auriculatum*, *Passiflora edulis*, *Tradescantia zebrina*, *Pennisetum purpureum* and *Rubus niveus* among others (Renteria & Buddenhagen 2006, Jäger *et al.* 2017).

Rubus niveus may be the most aggressive invasive plant species in the Galapagos Islands. It is a large, thicket-forming, thorny shrub that invades various habitats, including the *Scalesia* forest at Los Gemelos. Dense stands of *R. niveus* are often found in areas of open *Scalesia* forest canopy resulting from natural or anthropogenic disturbances (Itow 1988, Shimizu 1997). The species often forms a monospecific shrub layer that may compete with tree seedlings and other smaller native species for space, light, soil moisture and nutrients (Renteria *et al.* 2012, Jäger *et al.* 2017).

Forest invasion by other *Rubus* spp. following large-scale disturbances is well documented in other countries and has been related to increases in nutrients and light availability (Tilman 1987, Baret *et al.* 2004, 2008, Gorchoy *et al.* 2011). Understanding the relationship between canopy openings, light availability and the abundance and growth of *R. niveus* might provide important information for management practices to reduce the invasion of this species in this unique forest ecosystem. This study, carried out between 2009 and 2010, investigated the relationships between the presence of *R. niveus* and canopy cover, and the patterns of germination, growth and reproduction under different light conditions.

METHODS

Relationship between *R. niveus* abundance and forest canopy cover

Two hundred random points were generated within the *Scalesia* forest boundaries at Los Gemelos, using GIS. Points where *R. niveus* was completely absent or difficult to reach were omitted, leaving 124 usable points. In total, 124 plots, each of 2 x 2 m, were established at these points, representing a variety of cover densities of *R. niveus* throughout the *Scalesia* forest. From March 2009 to August 2010, the *R. niveus* abundance was assessed in each plot using the point-intercept sampling method. A metal rod was placed at 20 cm intervals along three equally spaced and parallel monitoring transects located at 0.5, 1 and 1.5 m across the plot, resulting in a total of 30 points per plot. Percentage cover of *R. niveus* was calculated based on the frequency of occurrence at these points in each plot; percentage of forest

canopy cover (above 3 m height) within each plot was estimated using a spherical densiometer (Spherical Crown Densiometer, Convex Model A), two readings were taken per plot at breast height and averaged. A Linear Model was used to assess the relationship between the presence of *R. niveus* and the forest canopy cover.

Effects of light availability on the germination of *R. niveus*

The germination experiment was carried out in March–April 2010 at the nursery of the Charles Darwin Foundation in the village of Bellavista (220 m a.s.l.), 7 km from Puerto Ayora on Santa Cruz Island. Soil containing *R. niveus* seeds was collected from highly invaded sites from the *Scalesia* forest at Los Gemelos. Soil was mixed together to standardise the distribution of seeds and subsamples of 200 g were put in plastic trays (15 cm diameter) for germination under four sunlight conditions (approximately: 100, 75, 50 and 10 % of available sunlight).

Light conditions were manipulated using wooden frames covered with different thicknesses and multiple layers of shade cloth. The four light levels were established on a sunny day at the start of the experiment: to determine the amount shade cloth necessary to get the required % sunlight for each treatment, a digital light meter (GrowBright) was used to measure the visible light in lumens. Fourteen trays (replicates) were used for each light treatment (56 trays in total) and soil was watered regularly. The number of *R. niveus* seedlings that emerged from the soil samples was recorded daily for a period of four weeks after which seed germination was not observed further. A Generalized Linear Model (quasibinomial family) was fitted to assess the relationship between sunlight availability and the emergence of *R. niveus* seedlings; model significance was tested using an ANOVA. Tukey *post-hoc* comparisons were performed to assess the difference between treatments, using the multcomp package in R (Hothorn *et al.* 2008).

Effect of light availability on growth and reproduction of *R. niveus*

Rubus niveus seedlings were planted under three different light treatments in an experimental setting at the Charles Darwin Foundation nursery. A two-year-old *Scalesia* plantation (*c.* 3–4 m tall, plantation density of 1 tree/m² in an area of 20 x 30 m) was used as the low-light treatment (*c.* 10 % of natural sunlight), a 5 x 10 m area covered by a wooden structure covered with shade cloth was used as a medium-light treatment (*c.* 70 % of natural sunlight) and an open 5 x 10 m area was used as full-light treatment (100 % of natural sunlight): the GrowBright digital light meter was used to measure the visible light in lumens at the beginning of the experiment as an estimate of the light availability (%) within each treatment. In March 2009, 24 seedlings of *R. niveus* per treatment were planted directly into the ground at 1 m spacing. After 12 months, plants were cut to ground level and plant height, maximum stem length, foliar area, above ground biomass, and sexual or vegetative reproduction were recorded. Total foliar area per plant was estimated from a subsample of 50 leaves per plant: leaf area was calculated using a 0.5 x 0.5 cm paper grid, then the average leaf area was multiplied by the total number of leaves per plant. Plant material was dried at 45°C for five days and weighed to obtain above-ground biomass. As an indicator of sexual or vegetative reproduction, the numbers of canes that had produced flowers and rooted stolons were also recorded.

Generalized Linear Models (Gaussian family) were used to assess the relationship between light availability and growth and biomass production of *R. niveus*; model significance was tested using an Anova. Tukey *post-hoc* comparisons were performed to assess the difference between light treatments. All statistical analyses were performed using R (R Core Team 2018).

RESULTS

Rubus niveus was present along a light gradient in the *Scalesia* forest from open to nearly closed canopies (0–98% canopy cover as measured by the densiometer); however, the density of *R. niveus* correlated negatively with canopy cover (Generalized Linear Model $r^2=0.7$, $P<0.001$, Fig. 1).

Rubus niveus seed germination occurred across all light treatments; however there was significant variation in the number of seedlings that germinated (Fig. 2). *Rubus niveus* germination rates were significantly higher under both of the medium light treatments (75 and 50 %) than under low and full light ($\chi^2_3 = 38$, $P < 0.001$). Seed germination under medium light conditions (50% and 75% combined) was 30 % and 50 % higher than under low light and full light conditions respectively. There was also significantly higher emergence of seedlings under the full light treatment than the low light treatment.

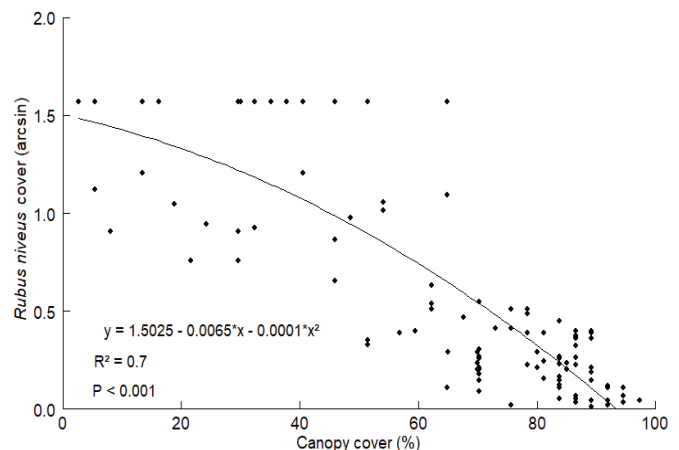


Figure 1. Relationship between *R. niveus* density and canopy cover in the *Scalesia* forest (y axis shows arcsine values of canopy cover).

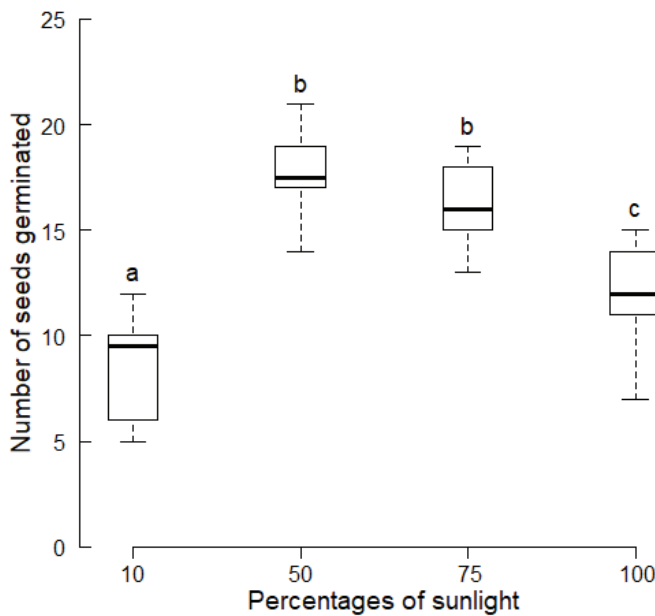


Figure 2. Number of *R. niveus* seedlings emerged after four weeks under different light treatments. Light levels are expressed as percentages of full sunlight. Lines within the box represent the median values of the number of seedlings emerged; a, b, c denote statistical significance between light treatments (Tukey test).

After 12 months, growth of *R. niveus* seedlings expressed as change in plant height, stem length, foliar area and above ground biomass, differed significantly between light treatments (plant height: $F_2 = 18.7, P < 0.001$; maximum stem length: $F_2 = 144, P < 0.001$; foliar area: $F_2 = 266.2, P < 0.001$, biomass: $F_2 = 274.4, P < 0.001$) (Fig. 3). Mean values of these variables for *R. niveus* growing under full light conditions were greater than for plants growing under 70 % light and 10 % light (respectively 2.3 and 4.7 times greater for height, 1.7 and 6.7 times greater for maximum stem length, 2.6 and 49.5 times greater for foliar area, and 7.7 and 160.3 times greater for above ground biomass). Overall, *R. niveus* showed best performance when growing under full sunlight. There were also significant growth differences between the plants under medium and low light treatments. As light availability decreased, the mean values of height, stem length, foliar area and above ground biomass of *R. niveus* decreased significantly.

Sexual and vegetative reproduction of *R. niveus* were also influenced by the different light treatments. Plants growing under the low sunlight treatment did not produce any flowers or spread by rooted stolons, 26 % of individuals growing under medium light produced rooted stolons but no flowers, whereas 33 % of plants under full light condition produced rooted stolons and 75 % produced flowers.

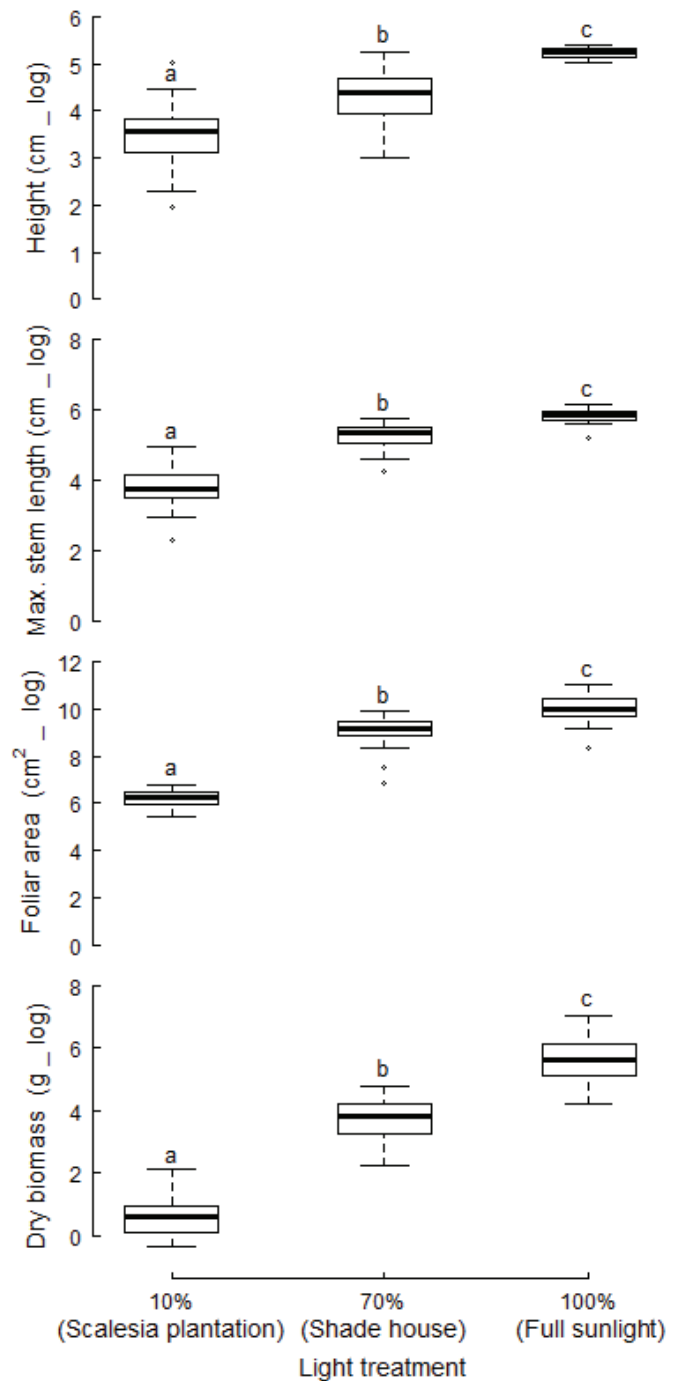


Figure 3. Height, maximum stem length, foliar area and above-ground biomass of *R. niveus* plants grown under three different light conditions. Light levels are expressed as percentage of full sunlight and y axes show the natural logarithm values of growth variables. Lines within the box represent the median values of each variable; a, b, c denote statistical significance between light treatments (Tukey test).

DISCUSSION

The results show that while *R. niveus* can establish and persist under shady conditions, its growth and reproduction are slowed. If light levels increase, such as after a tree-fall, juvenile stems of *R. niveus* can then grow rapidly and reach

maturity. Although the soil seed bank of native species may not be seed limited (Jäger & Kowarik 2010, Renteria 2011, Rivas-Torres *et al.* 2018) and may also depend on light availability for germination, the enormous seed bank (Landázuri 2002, Renteria 2011) and faster growth of *R. niveus* provide a major competitive advantage over native species (Cordell *et al.* 2009).

Dense stands of *R. niveus* were often observed beneath canopy gaps; this may be explained by the fact that the species is better adapted to high, rather than low, light conditions. This is consistent with findings that cover of other invasive *Rubus* species is negatively correlated with higher levels of canopy cover (Gray 2005, Caplan & Yeakley 2006, Baret *et al.* 2008), with some invasive *Rubus* species that are confined to open disturbed areas exhibiting better performance under higher light levels (Caplan & Yeakley 2006). Although *R. niveus* occurred more frequently and at higher density under open canopies, low density stands and individual plants were also found where canopy cover was as high as 98 %, showing that individuals can survive and persist under closed canopy conditions.

These field observations of establishment and survival under low light conditions are backed up by controlled experiments, in which seed germination occurred from low to full light treatments although germination was higher at intermediate levels. Nevertheless, the almost complete absence of light (*c.* 10 %) did not prevent seeds from germinating. Seeds of some *Rubus* spp. can actually germinate in darkness (Suzuki 1993, Díaz Diez *et al.* 2013) but we did not test this. The lower rates of seedling germination found under the full light treatments probably resulted from direct exposure to solar radiation, which often caused drying of the soil and hence, continued dormancy.

The potential for seeds to germinate with little or no light may allow *R. niveus* to colonize areas even within the closed forest (Baret *et al.* 2008) and, together with effective seed dispersal by native and introduced fauna (Buddenhagen & Kelly 2006, Guerrero & Tye 2009) may enable *R. niveus* to colonize remote and undisturbed sites.

While *R. niveus* was able to establish and grow under different light treatments, the species showed significantly higher growth rates when grown in full sunlight than in medium or low sunlight. Hence, while canopy gaps could promote the spread of *R. niveus*, its shade tolerance might allow it to persist even without any gaps being formed. Eventually, when a disturbance event occurs *R. niveus* can then rapidly take over a particular area. This is in line with other invasive *Rubus* species that have been shown to have greater biomass and increased reproduction in forest canopy gaps (Hughes & Fahey 1991, Ricard & Messier 1996, Tabacchi *et al.* 1996, McDowell & Turner 2002).

Growth, and vegetative and sexual reproduction of *R. niveus* were affected by sunlight treatments, so the expansion of *R. niveus* may be slower under a closed canopy. Luminosity can limit reproduction in other *Rubus* species (Baret *et al.* 2004, Innis 2005, Gorchov *et al.* 2011), and light availability could be critical for the expansion of *R. niveus*.

Management to control any invasive plant species should be considered in the ecosystem context, based upon an understanding of how forest dynamics and structure affect its spread (Svejcar 2003, D'Antonio & Jackson 2004). Additionally, efforts to control species such as *R. niveus* in the *Scalesia* forest should consider other impacts of such control (Jäger & Kowarik 2010). Using herbicides may be effective to kill *R. niveus* adults but creates new open spaces that will stimulate the reestablishment and reinvasion of the species from its seed bank (Landázuri 2002). Complementary activities should therefore be considered for management and restoration of the *Scalesia* forest such as enrichment planting of native canopy species (Cordell *et al.* 2009). Although *R. niveus* can establish and grow under a light canopy, shade from a fast-growing species such as *Scalesia pedunculata*, when planted at high densities, may help suppress its growth and delay reproduction.

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FIRST RECORD OF BLACK-CROWNED NIGHT-HERON *NYCTICORAX NYCTICORAX* BREEDING IN GALAPAGOS

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SUMMARY

In early 2020 two pairs of Black-crowned Night-Herons *Nycticorax nycticorax* were observed breeding on a mangrove islet in Academy Bay, Santa Cruz Island, one with a nestling and the other with two dependent fledglings. An independent immature bird was also seen there. Another immature (or the same one) and a non-breeding (moulting) adult were also seen at Black Turtle Cove on the other side of the island, giving a total of nine or ten birds. This is the first time the species, previously regarded as a rare vagrant to Galapagos, has been recorded other than singly and nesting in the archipelago. The breeding night-herons were found within a colony of nesting Cattle Egrets *Bubulcus ibis*, a situation which may have afforded the night-herons (which typically nest colonially and often in mixed-species heronries) protection from predators and a reliable and steady food resource (egret eggs and chicks) for their offspring. As mangrove habitat is extensive in Galapagos and the Black-crowned Night-Heron has a varied diet, it seems likely that this new immigrant could become permanently established in the archipelago.

RESUMEN

Primer registro de la Garza nocturna coroninegra *Nycticorax nycticorax* anidando en Galápagos. A inicios de 2020 se observaron dos parejas de Garza nocturna coroninegra *Nycticorax nycticorax* anidando en un islote de manglar en la Bahía Academia, isla Santa Cruz, una con un polluelo y la otra con dos volantones dependientes. Allí se observó además un inmaduro independiente. Otro inmaduro (o el mismo) y un adulto no reproductivo (en muda) también fueron avistados en la Caleta Tortuga Negra al otro lado de la isla, totalizando nueve o diez individuos. Hasta ahora esta especie había sido considerada una errante ocasional en Galápagos; es la primera vez que se ha registrado simultáneamente más de un individuo, y reproduciéndose, en el archipiélago. Las garzas nocturnas (que típicamente anidan en colonias, a menudo entre otras especies de garza) fueron encontradas anidando en medio de una colonia reproductora de Garza boyera *Bubulcus ibis*, una situación que podría proporcionar a las garzas nocturnas protección contra los predadores y una fuente alimenticia (huevos y polluelos de Garza boyera) confiable y continua para sus crías. Ya que el hábitat de manglar es extenso en Galápagos y la Garza nocturna coroninegra tiene una dieta amplia, es posible que este nuevo inmigrante pudiera establecerse permanentemente en el archipiélago.

INTRODUCTION

Prior to 2020 there were only three reported sightings of Black-crowned Night-Herons *Nycticorax nycticorax* in the Galapagos. The first was a sub-adult observed at Tortuga Bay (Bahía Tortuga), Santa Cruz, on 1 Apr 1971 by H. van der Werff (Harris 1973, 1974, Castro & Phillips 1996) but as no photographs were taken nor descriptive details provided, and because young *N. nycticorax* can be confused with young Yellow-crowned Night-Herons *Nyctanassa violacea*, this record was regarded by Wiedenfeld (2006) as “hypothetical”. Almost 40 years later, an adult was photographed in Black Turtle Cove (Caleta Tortuga Negra), Santa Cruz, on 12 May 2010 by T. Sigler (reported by W. Stephens at <<https://ebird.org/checklist/S52166958>>, consulted 1 Apr 2020) and an adult (presumably a different individual) was photographed in the same place on 5 Oct 2019 by M. Plaza (confirmed by L.D. Dejean pers. comm.).

In early 2020 several sightings, representing more than one individual *N. nycticorax*, were reported, all on Santa Cruz (Fig. 1): C. Sievers (CS) photographed an adult on a tidal islet in Academy Bay on 18 Jan; G. Estes (GE), several tourists and I photographed a different adult (apparently in second pre-basic moult) in Black Turtle Cove on 30 Jan; P. Freire (pers. comm.) photographed an independent immature there on 19 and 27 Feb; GE photographed an immature (possibly the same as the previous individual) in the same place on 28 Feb (Fig. 2). These sightings represent two adults and at least one immature. Between 25 Feb and 17 Mar 2020 I observed a group of *N. nycticorax* in Academy Bay: these observations, made with binoculars during morning hours (6h00–9h00) and detailed below, provide the first evidence of this species breeding in Galapagos.

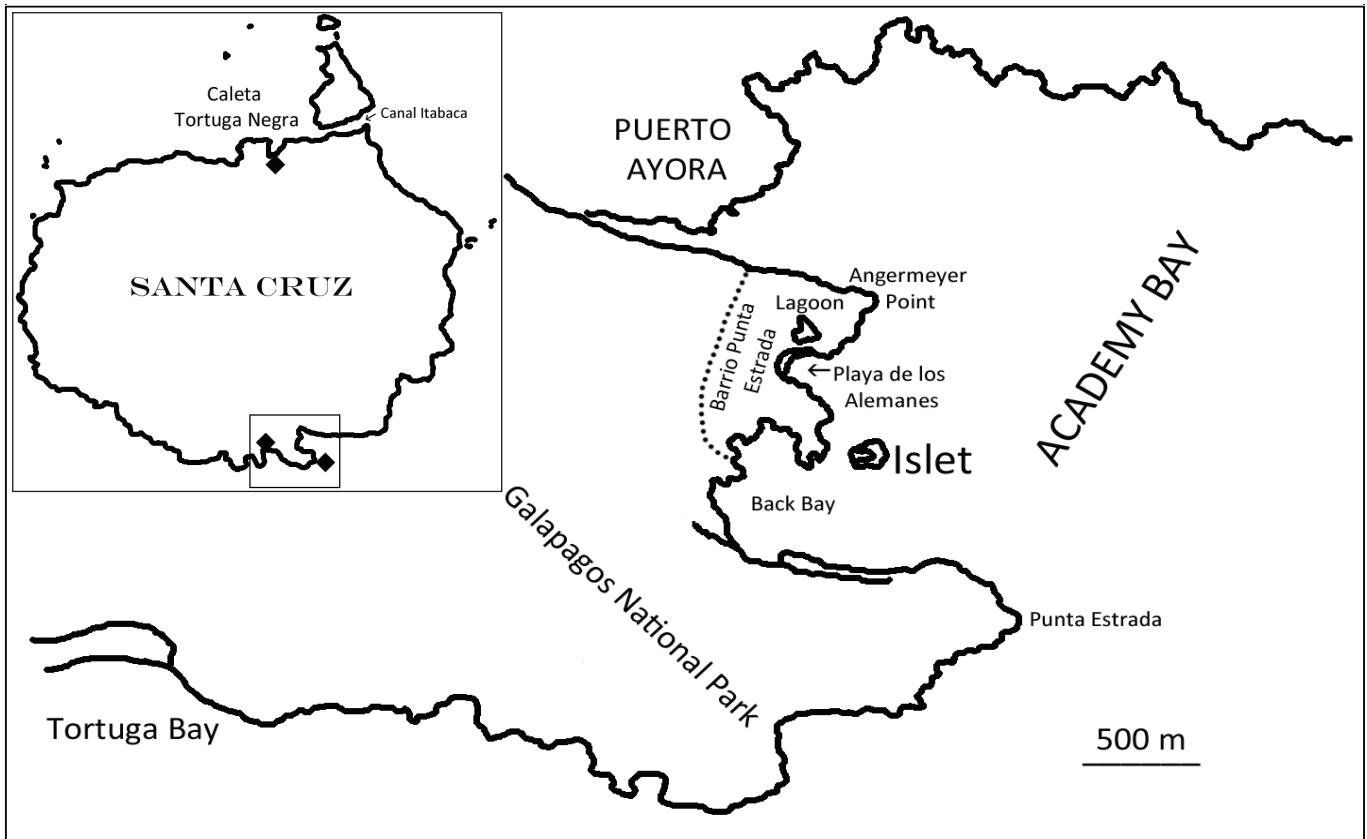


Figure 1. Inset: Santa Cruz Island showing Galapagos locations of *N. nycticorax* sightings (black diamonds). The area within the rectangle is expanded in the larger map, which shows the location of the breeding islet off Barrio Punta Estrada, Academy Bay, and other localities mentioned in the text. The dotted line indicates the approximate boundary between the Galapagos National Park and the Urban Zone of Barrio Punta Estrada.

OBSERVATIONS

The group of *N. nycticorax* was found on the same tidal islet in Academy Bay where CS photographed the adult in January (Fig. 1). This small (c. 5000 m²) unnamed islet (0.755983°S, 90.308550°W), situated between Playa de los Alemanes and Back Bay (also known as Divine's Bay), administratively within the local authority "Urban Zone" of



Figure 2. Black-crowned Night-Herons *Nycticorax nycticorax* in Galapagos: left, an adult, Academy Bay, 18 Jan 2020 (photo: CS); centre, adult, Black Turtle Cove, 30 Jan 2020 (photo: KTG); right, immature, Black Turtle Cove, 28 Feb 2020 (photo: GE).

Barrio Punta Estrada, connects briefly to the main island of Santa Cruz at lowest tides (Fig. 3). It is characterised by two large thickets of White Mangrove *Laguncularia racemosa* which partially encircle a beach of shelly sand and sea urchin spines. Red Mangrove *Rhizophora mangle*, Button Mangrove *Conocarpus erectus*, Common Carpetweed *Sesuvium portulacastrum*, Galapagos Opuntia *Opuntia echios*, Leatherleaf *Maytenus octogona*, Desert Thorn *Lycium minimum* and Saltbush *Cryptocarpus pyriformis* also grow on the islet. Marine Iguanas *Amblyrhynchus cristatus* nest in the sand. The White Mangroves provide roosts and nesting sites for large flocks of Cattle Egret *Bubulcus ibis*, and the Red Mangroves on the southeast side of the islet provide the same for smaller numbers of Brown Pelicans *Pelecanus occidentalis*. Various shore birds, including Great Blue Heron *Ardea herodias*, Striated Heron *Butorides striatus* and Yellow-crowned Night-Heron *Nyctanassa violacea*, also feed on the islet.

On 25 Feb I observed two adult and one immature *N. nycticorax* on the northeast side of the islet. They were perched on top of a White Mangrove tree, surrounded by several adult and immature Cattle Egrets. On 26 Feb I found one adult and one immature *N. nycticorax* on the same mangrove tree; the immature flew a short distance into a dip in the canopy and out of sight, while the adult watched me intently without moving. Peering under the mangrove I saw c. 30 Cattle Egret nests among the branches, many containing eggs and nestlings. In a nest superficially identical to the Cattle Egret nests and relatively high up at c. 2 m was a heron nestling (Fig. 4a), whose brown dorsal feathers, dark grey down and greenish yellow legs (not visible in the photo) clearly identified it as a night-heron chick, and specifically of the Black-crowned and not the Yellow-crowned Night-Heron (whose nestling has longer, whiter and more scraggly down filaments giving the bird a greyer and more streaked appearance: Hothem *et al.* 2020, Watts 2020). No adult Yellow-crowned Night-Herons were seen on the islet that day nor any day over the next two weeks.

On 27 Feb 2020, four adult, one independent immature and two dependent fledgling (hereafter “juvenile”) *N. nycticorax* were present in the canopy of the same mangrove, surrounded by Cattle Egrets (Fig. 5). One of the juveniles, which appeared somewhat smaller and younger than the other, begged from an adult (Fig. 6). Upon detecting me, two adults and the immature quickly disappeared into the dip in the canopy. The juveniles remained in sight with the other two adults for several minutes before following.



Figure 3. The tidal islet in Academy Bay, Santa Cruz Island, at high tide (left) and low tide (centre and right), March 2020. The yellow arrow points downwards to the approximate location of the *N. nycticorax* nest (Photos: left and centre, KTG; right, GE)



Figure 4. Nestling *N. nycticorax* in its nest on the Academy Bay islet, 26 Feb 2020 (photo: KTG).



Figure 5. Adult *N. nycticorax* surrounded by Cattle Egrets *Bubulcus ibis* on the Academy Bay islet, 27 Feb 2020. (Photo: KTG).



Figure 6. Juvenile *N. nycticorax* begging from an adult on the Academy Bay islet, 27 Feb 2020. (Photo: KTG).



Figure 7. Adult *N. nycticorax* flying over Playa del los Alemanes, 2 Mar 2020 (photo: KTG).

It is possible that the immatures seen on the islet and at Black Turtle Cove were the same individual, as the two sites are only 28 km apart and short-distance (10–100 km) dispersal flights after fledging are common in *N. nycticorax* (Hancock & Kushlan 2005). In any case, the presence of an immature suggests that successful breeding occurred in Galapagos in 2019 as well as 2020, although the possible arrival of immatures with adults from elsewhere cannot be ruled out.

Nycticorax nycticorax nests on all continents except Antarctica and Australia. The relatively pale ventral plumage of the individuals in Galapagos indicates that they belong to the subspecies *N. n. hoactli*, which is widespread in North, Central and northern South America, and is also found in the Hawaiian Islands; *N. n. obscurus*, found in southern Peru, Chile and Argentina, and *N. n. falklandicus* from the Falkland Islands, typically have darker plumage. The northernmost breeding populations of *N. n. hoactli* migrate to Central America or the Caribbean for the non-breeding season. Populations in the tropics typically breed at the beginning of the rainy season, and undertake short post-breeding dispersal (Hancock & Kushlan 2005, Hothem *et al.* 2020). The Galapagos individuals could have arrived from North America, after deviating off course during a migration, as was most likely the case with the founders of the Hawaiian population (Pyle & Pyle 2017), but a South American origin is more likely, given that the prevailing winds entering Galapagos come from the southeast. The fact that the Galapagos individuals bred Dec–Jan is also consistent with a tropical population. The closest point of possible origin is the west coast of mainland Ecuador, where mangrove

During trips to the islet on 28 Feb and 1 Mar, an adult, an immature and one juvenile were observed, in the same mangrove tree. On 2 Mar the nest was empty, with the chick perched on a branch c. 3 m away. An immature was also observed in the tree.

On 13 Mar I observed, from the sea, an adult fly to the east side of the islet where a juvenile emerged from the canopy and started begging. It was unclear whether it was the nestling of 11 days earlier, or one of the older juveniles. On 14 and 17 Mar there were two juveniles, one appearing larger and older than the other, and an adult, again on the east side of the islet.

Between 29 Feb and 10 Mar, I also observed adult *N. nycticorax* elsewhere in Barrio Punta Estrada. On 29 Feb I watched an adult catch a mullet *Mugil* sp., from a mangrove perch at the edge of the Punta Estrada lagoon, c. 500 m from the islet (Fig. 1). On 2 Mar I saw an adult flying from this lagoon towards the islet. On 3 Mar I photographed an adult flying low over the Finch Bay Hotel (behind Playa de los Alemanes) and then out towards the islet (Fig. 7), and on 5, 8 and 10 Mar I saw an adult flying high from the direction of Tortuga Bay towards Angermeyer Point (Fig. 1).

DISCUSSION

The *N. nycticorax* observed on the islet and elsewhere in Barrio Punta Estrada between 25 Feb and 17 Mar 2020 represent at least eight individuals (four adults in two breeding pairs, one immature, two juveniles and one nestling). Based on plumage, the nestling, whose pin feathers on the head indicated a minimum age of 12 days, was c. 2–3 weeks old when first observed on 26 Feb, and the juveniles the next day were c. 5–7 weeks old (McVaugh 1972, Hothem *et al.* 2020). The immature, with its grey and streaked plumage, was at least six months and probably closer to a year old. The incubation period of *N. nycticorax* is generally 21–26 days (Hancock & Kushlan 2005, Hothem *et al.* 2020), indicating that egg-laying occurred about the third week of Jan 2020 (nestling), in mid or late Dec 2019 (juveniles) and between Jan and Jun 2019 (immature).

forests in Manabí and Guayas provinces support populations of *N. nycticorax* that breed in mixed-species heronries (Ridgley & Greenfield 2001, Freile & Restall 2018).

There is no obvious reason why the species could not establish a resident breeding population in Galapagos. *N. nycticorax* has a varied diet of mainly fish, but also rodents, arthropods, reptiles, amphibians, bird chicks and crustaceans, all of which are found in the islands. There are relatively few mammalian and avian predators in Galapagos and few avian diseases, such as West Nile disease, to which *N. nycticorax* is particularly susceptible (Wheeler *et al.* 2009, Torres & Mena 2018). All sightings of *N. nycticorax* in Galapagos have been in mangroves, and there are over 3657 ha of mangrove forest in the archipelago, with c. 339 ha on Santa Cruz (Moity *et al.* 2019).

Furthermore, *N. nycticorax* frequently breeds in mixed-species heronries (Hothem *et al.* 2020), so the presence of many Cattle Egrets on Santa Cruz could also favour its establishment on this island. The Cattle Egret was first reported in Galapagos in the early 1960s (Lévêque *et al.* 1966), with nesting confirmed in 1986 (Harris 1973, Fitter *et al.* 2016). Numbers have grown dramatically since then, most noticeably this century, and almost certainly as a result of habitat modification by people and increased agriculture (Torres & Mena 2018). Recently, during the warm season months (which is also the breeding season), 3000–5000 Cattle Egrets have been counted flying from feeding grounds in the highlands of Santa Cruz to nocturnal roosts in the mangroves of Back Bay (M. Dvorak pers. comm., KTG and GE pers. obs.), and the species has other roosting sites elsewhere on the island (*e.g.* at Black Turtle Cove and at the western entrance to Canal Itabaca) so the total island population may be much larger. However, *N. nycticorax* does not always nest with other herons, so it need not be dependent on Cattle Egrets for its Galapagos breeding success.

In general, herons that nest together (whether in single species or multi-species colonies) often benefit from reduced nest predation (*e.g.* Burger & Hahn 1977). There is some evidence that dark-plumaged herons benefit from associating with white-plumaged herons because white is more conspicuous to predators (Caldwell 1986). There is also evidence that herons which feed on similar prey and nest together close to a high quality food source benefit from increased foraging success (*e.g.* Gibbs 1991). In Galapagos, *N. nycticorax* and *B. ibis* share potential nest predators (*e.g.* frigatebirds *Fregata* spp. and Great Blue Herons) but they have very different foraging strategies, diets and feeding habitat, with *B. ibis* feeding diurnally, mainly on arthropods in the highlands and *N. nycticorax* feeding nocturnally, presumably mainly on fish in the lowlands. Nonetheless, because *N. nycticorax* also eats bird eggs and nestlings, including those of *B. ibis* (Hothem *et al.* 2020), foraging could still be considered a potential benefit of *N. nycticorax* nesting with *B. ibis*. For a new arrival with limited local knowledge, the advantages of nesting in an existing heron colony are potentially strong.

N. nycticorax should be monitored to determine how it is adapting to life in the archipelago, whether it is dispersing to other islands, and how it is affecting the native fauna. This presents challenges since the species is nocturnal and elusive, hiding in trees during the day, and it can be very sensitive to human disturbance when breeding (Tremblay & Ellison 1979, Burger & Gochfeld 2016). Furthermore, potential habitat (mangrove forests, estuaries, lagoons and freshwater highland pools) is widespread in the archipelago. However, given *N. nycticorax*'s known association with Cattle Egrets, searches could initially be focussed on mangroves known to be used by the latter. Ecological studies of both species would be useful.

The Academy Bay islet is worth monitoring regularly, not only for *N. nycticorax* but also for other vagrant species. It is relatively undamaged, even though it lies outside the boundaries of the Galapagos National Park; it is separated from the mainland by a 100 m stretch of water during high and mid tides, and by very slippery intertidal rocks and pools at low tide, so it is relatively protected from cats and dogs (but not rats) and it is rarely visited by humans. Barrio Punta Estrada itself is sparsely developed with few residents, although tourist activities, including snorkelling and kayaking near the islet, have been increasing. I have occasionally seen other vagrant herons (Tricoloured Heron *Egretta tricolor*, Snowy Egret *E. thula* and Little Blue Heron *E. caerulea*) near the islet in past years, and on 23 Feb 2020 saw one Little Blue Heron fly to the islet with nesting material. I was unable to find a nest and suspect it was alone, but its behaviour demonstrates the attraction of the islet for colonially nesting herons.

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THE PARK MONUMENTS OF GALAPAGOS: A HISTORY AND TRIBUTE

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SUMMARY

The National Park monuments of Galapagos are stone plinths bearing notices advising visitors of the protected status of Galapagos and its wildlife, which were constructed by members of the Charles Darwin Foundation and the Ecuadorian Navy over half a century ago, when the Park was in its infancy. They represent the earliest efforts of the first conservation managers of the Park, before the Galapagos National Park Service was established, to control human activities in the uninhabited areas of Galapagos and ensure that tourism developed in a manner compatible with conservation. There were purportedly 18 monuments scattered throughout the archipelago, on 14 different islands. We identify their locations and provide a history of their origins, an assessment of their current condition, and a photographic record of most of them. Simply called “park notices” when they were first erected, 12 remain standing, on ten islands. They are now icons of that era of Galapagos conservation and we propose that they warrant the designation of historical monuments with corresponding protection.

RESUMEN

Los monumentos del parque Galápagos: historia y homenaje. Los monumentos del Parque Nacional Galápagos, plintos de piedra con avisos que informan a los visitantes sobre el estado de protección de Galápagos y de su vida silvestre, fueron construidos por el personal de la Fundación Charles Darwin y la Armada del Ecuador hace más de medio siglo, cuando el Parque estaba en su infancia. Estos avisos representan las medidas iniciales tomadas por las primeras autoridades administradoras del Parque (previo al establecimiento del Servicio Parque Nacional Galápagos) para regular la actividad humana en las áreas deshabitadas de Galápagos y procurar el desarrollo del turismo de manera compatible con la conservación. Se presumía que había 18 monumentos dispersos a lo largo del archipiélago, en 14 islas diferentes. Identificamos sus ubicaciones y brindamos una historia de sus orígenes, una evaluación de su estado actual y un registro fotográfico de la mayoría de ellos. Conocidos simplemente como “avisos del parque” cuando fueron erigidos, 12 permanecen todavía, distribuidos en diez islas. Son ahora íconos de la etapa inicial de la conservación de Galapagos, por lo que proponemos que merecen la designación de monumentos históricos con el correspondiente estado de protección.

INTRODUCTION

The Park monuments of Galapagos are familiar to almost everyone who has completed a boat tour of any length in Galapagos. They stand at a number of sites throughout the archipelago; flat-topped, trapezoidal pyramids of cemented lava rocks, most 1.5–2 m. in height, inset on one side with a rectangular 50 x 60 cm white marble plaque, engraved and painted with black letters (Fig. 1). The plaques, originally known as “National Park notices” (Perry 1968, 1970b, T. De Vries pers. comm.) and sometimes as “National Plaques” (Perry 1969) or “Wildlife Reserve notices” (Mountfort 1970), advise visitors, in Spanish above and English below, of the status of the Galapagos Islands as a National Park and of the legal protection of its indigenous wildlife (Fig. 2).

Most of the monuments are situated at what are now designated tourist “visitor sites”, *i.e.* sites where regulated tourism is currently permitted by the Galapagos National Park Directorate (GNPD). All are found at historical “visiting sites”, *i.e.* sites with a history of frequent or regular visitation before access restrictions were imposed. The monuments cut imposing figures wherever they stand, typically on or near the shoreline, but they blend aesthetically with their surroundings because they are made from locally-sourced lava blocks. They are often adorned with one or more of the native species they were designed to protect: depending on the island, Marine Iguanas *Amblyrhynchus cristatus*, lava lizards *Microlophus* spp., Galapagos Hawks *Buteo galapagoensis*, Nazca Boobies *Sula granti*, Blue-footed Boobies *S. neboxii*, Swallow-tailed Gulls *Creagrurus furcatus*, Brown Pelicans *Pelecanus occidentalis urinator*, Galapagos mockingbirds *Mimus* spp., Galapagos Doves *Zenaida galapagoensis* and Darwin’s finches *Geospiza* spp., regularly use them as perches (Fig. 3).



Figure 1. The Park monument at Santa Fé, 26 Nov 2019. (Photo: KTG)

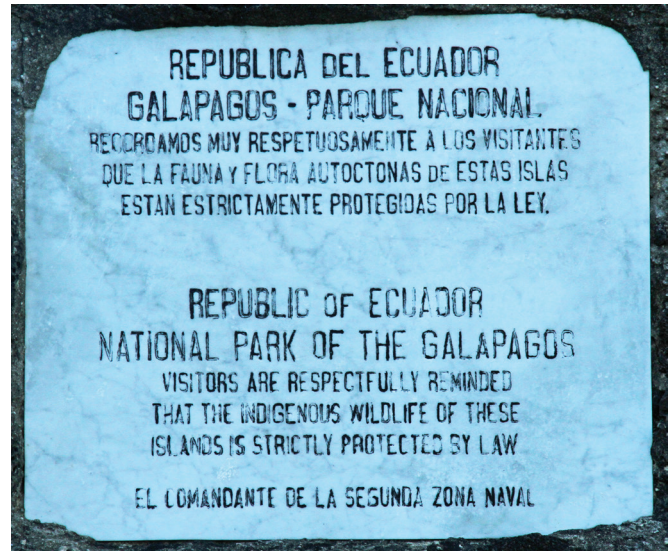


Figure 2. The plaque of the Park monument at Playa Espumilla, Santiago, 30 Jan 2020. (Photo: KTG)



Figure 3. The Park monument at Punta Suárez, Española, topped with Marine Iguanas (left), a Blue-footed Booby and Brown Pelican (centre), and a Galapagos Hawk (right). (Photos on left, GBE 1983; photo of hawk, KTG 20 Jul 2014)

Over the past few decades we have come across many of these monuments and read their plaques countless times. However, we never thought to document them until our curiosity was piqued by a 45-year old Galapagos postcard, advertised for sale, bearing a photograph of one of the Park monuments (minus its plaque) standing next to the famous Post Office Barrel of Floreana Island, where the postcard was mailed on 18 Jun 1974 by a tourist on the *Golden Cachelot* (Fig. 4). The photograph was taken in 1973 or 1974, as indicated by the dates painted on the planks plastering the barrel and the post on the right, and by the mailing date of the postcard. No such stone structure exists at Post Office Bay today, nor did it when we first visited this site in the 1980s, and the image struck



Figure 4. Picture postcard showing the Park monument at Post Office Bay, Floreana, photographed in 1973 or 1974. (Authors' collection)

us as so bizarre that we fleetingly wondered if the picture was a hoax. We looked for corroborating evidence that a Park monument really had existed next to the barrel, and found it in two published photographs (Bridge 1970, Laycock 1970), in the memories of a couple of local people and, most recently, in a collection of photographic slides shared by an acquaintance whose late father had visited Galapagos on the tour ship *Lina A* in early 1970 (Fig. 5). We searched the area for remains of the monument on our next visit to Post Office Bay and found several pieces of it scattered in the undergrowth of a sprawling Palo Verde tree *Parkinsonia aculeata*, not 10 m from where it had originally stood (Fig. 5 inset). When the monument was destroyed was less easy to determine, for the local people we questioned had widely differing memories and opinions on this matter, and most of the photographs of the Post Office Barrel we came across were inconclusive, as it was clearly possible to photograph the barrel without the monument in the frame. We did, however, find a panoramic image of the area, photographed in February 1978, showing that the monument had already been dismantled by then.

This foray into recent history and archaeological sleuthing sparked other questions. How many Park monuments were there? When and where were they erected and by whom? Who destroyed the monument at Post Office Bay and why? Had other Park monuments suffered the same fate? How many monuments remain, where are they and what condition are they in? It soon became apparent that the story of the Park monuments was an untold part of the otherwise well-repeated narrative of the earliest days of Galapagos conservation and tourism (Corley-Smith 1990, Epler 2007, Oxford & Watkins 2009), of potential interest to anyone engaged in these industries. An informative tribute to the monuments also seemed timely because 2019 marked the 60th anniversary of the creation of the Galapagos National Park (GNP) and the Charles Darwin Foundation (CDF) and the 50th anniversaries of the Galapagos National Park Service (GNPS, now known as the Galapagos National Park Directorate GNPD) and of regulated tourism in Galapagos.

METHODS

We began by listing all the monuments we remembered seeing since we first arrived in Galapagos, in 1973 (KTG) and 1982 (GBE). We then set out to find as many as we could, record their geographical location with GPS, and measure and photograph them. We perused the literature for mention of them and the internet for old photographs. We questioned long term residents of Galapagos about the monuments and particularly sought out people who had worked for or



Figure 5. The Park monument at Post Office Bay, Floreana, with the shattered remains of its plaque clearly visible at its base, in 1970 (Photo by Marcel F. Sandoz, courtesy of Shirley Sandoz) and (inset) the top right corner of the demolished monument, 29 Dec 2016. (Photo: GBE)

with the Charles Darwin Research Station (CDRS) and GNPS in the early days of their establishment. Conversations with Tjitte De Vries, an early UNESCO appointee at the CDRS, who arrived in the islands in 1964 and “played an important role in shaping the station’s activities” (Perry 2004), José (Pepe) Villa, one of the first two officials of the GNPS, who arrived in September 1968, and Oswaldo Chappy, a native of Galapagos whose career as a field warden of the CDRS started in the mid-1960s, were particularly revealing. As well as providing personal recollections, De Vries pointed us to the CDRS’s *Scientific and Conservation Reports*, a series of 21 documents compiled by Roger Perry, CDRS Director 1964–70, detailing the activities of the station during his tenure. In Report 15, a short note about the “notices” answered many of our questions (Perry 1968).

RESULTS

How many Park monuments were there?

Perry (1968) states that 18 monuments were erected in total, with the first 16 built between 12 Jun 1967, when funds for their manufacture were secured, and December 1968, the date of Perry’s report. The specified locations were: San Cristóbal (Puerto Baquerizo Moreno); Española (Gardner Bay and Punta Suárez); Floreana (Post Office Bay and Black Beach); Pinzón; Baltra (“marine terminal”); Plaza Sur; Santa Fé; Genovesa (Darwin Bay); Pinta (“anchorage on S coast”); Fernandina (Punta Espinosa); Isabela (Tagus Cove); Santiago (James Bay, Playa Espumilla and “Sullivan Bay”, though the “Sullivan Bay” monument was actually built on neighbouring Bartolomé Islet: Fig. 6).



Figure 6. The Park monument at “Sullivan Bay”, located on Bartolomé, with a close-up view of its plaque, 12 Dec 2019. (Photos: KTG)

Perry (1968) also reveals that at the end of 1968 there were plans to install two more notices, one at Puerto Villamil, Isabela, and the other at Puerto Ayora, Santa Cruz. O. Chappy (pers. comm.) has a distant recollection that the Villamil monument was built at the land end of the old dock (“muelle viejo”) near the offices of the Port Captain (“Capitania”) and was taken down at an unknown date. The Puerto Ayora structure was erected by early 1970 (Fig. 7 left). It stood near the end of the road leading from Puerto Ayora to the CDRS; its site became a small traffic island, beside which the current CDRS administration building was later erected. This monument was unique in that it was inset with only half a marble plaque, the Spanish portion, above which was a larger bronze plaque, also in Spanish, commemorating the inauguration of the CDRS on “el 21 enero 1964” (21 Jan 1964). The accuracy of this date has since been questioned, because even though contemporary newspaper articles (e.g. Oakland Tribune 23 Jan 1964) and some early publications (e.g. Dorst & Laruelle 1967) record the event as having taken place on 21 Jan, several other publications (e.g. Smith 1965, Corley-Smith 1990, Monsalve 2014) record the date as 20 Jan. However, a private letter from one of the participants (D. Balfour) to his parents, written shortly after the event and shown to us by M.-E. Balfour, states that “the ceremony was in fact held on the 21st”. The Puerto Ayora monument must have been rebuilt with different lava rocks, but more or less on the same spot and with the original plaques inserted into the new plinth, sometime prior to April 1983, as evident in Fig. 7 centre. This second monument was then removed sometime between May and November 2007 (A. Izurieta pers. comm., A. Tye pers. comm.) and replaced with the wooden welcome sign that stands there today, straddling the still-visible rectangular foundations of the old stone monument (Fig. 7 right).



Figure 7. Left to right: the Park monument at the CDRS on Santa Cruz, Feb 1970 (photo: S. Ito, courtesy University of Nagasaki), GBE standing next to the rebuilt monument, Apr 1983 (Photo: GBE), and the entrance sign to the CDRS, where the monument used to stand, 24 Jan 2020. (Photo: KTG).

Who built the Park monuments?

Construction of the monuments and plaques was financed by the Securities Commission of the National Finance Corporation of Ecuador (“Comision de Valores de la Financiera Nacional de Ecuador”) which in 1967 provided 200,000 sucres to the CDRS for “urgent” conservation matters, *i.e.* for the salaries, equipment and transportation of the “wardens and officials connected with conservation work”, and for the fabrication and installation of the plaques (Perry 1967, 1968). This amount was the equivalent then of about US\$ 11,000 (Steinberg 1966), or of US\$ 85,000 in 2020. Perry prepared the text for the notices (T. De Vries pers. comm.), and the stone plinths were built and the plaques installed by naval personnel and members of the CDRS (including Chappy, Lautaro Andrade and De Vries), working under the direction of Miguel Castro, the first Conservation Officer of the CDRS (O. Chappy, T. De Vries and J. Villa pers. comm.). The naval personnel were also acting under the orders of the commander of the “segunda zona naval” (the Ecuadorian naval zone that encompasses Galapagos), who was based on San Cristóbal; this was Mario Jaramillo del Castillo in 1967 and Édison Ruiz Rivas in 1968 (Monteverde Granados 2003). De Vries, who helped build several of the monuments, remembers that they started with the one on Santa Fé (Fig. 1). Chappy, who was also involved in the Santa Fé construction and at least one of the Santiago monuments, recalls that the Plaza Sur monument was one of the first to be built (Fig. 8).

According to Chappy (pers. comm.), several boat trips were made to erect all the monuments. The CDRS did not own a vessel at this time; the *Beagle II*, which the CDRS acquired in May 1964, was decommissioned in August 1967 and the *Beagle III* did not arrive until December 1971 (Barlow 1967, 1969, Kramer 1972). Thus various vessels, mainly fishing boats, had to be chartered for the purpose. A military vessel may also have been used (J. Villa pers. comm.); if so, it may have been the naval patrol vessel LP-82, whose identification number is painted in large white letters on the portion of the cliff that supports the monument in Darwin Bay (Fig. 9). The accompanying date (13 Nov 1968) falls within the period of time in which the first 16 notices were erected (Perry 1968). At the time, LP meant “Lancha Patrullera” (patrol boat); this naval category was later changed to LAE (Lancha de la Armada del Ecuador), at which point the LP-82 was renamed *LAE 10 de Agosto* and later *LAE Isla Santa Cruz* (Armada del Ecuador 2014). Today LP refers to “Lancha de Pesca” (fishing boat).

How many remain and what condition are they in?

Of the 18 original monuments listed by Perry (1968), a dozen remained standing as of 2019 (Fig. 10, Table 1). Eleven are located on nine uninhabited islands and one (Tagus Cove) on the uninhabited part of inhabited Isabela.



Figure 8. The Park monument on Plaza Sur, 26 Nov 2019 (photo: KTG), and close-up views of the plaque in 1970 (middle photo: M.F. Sandoz courtesy of S. Sandoz) and on 26 Nov 2019 (photo: KTG).

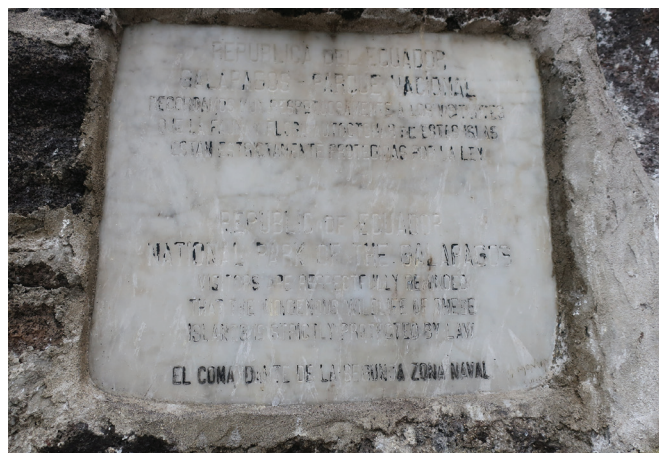


Figure 9. The Park monument in Darwin Bay, Genovesa, with close-up view of the plaque after being wiped clean of bird guano, 8 Jan 2020. (Photos: GBE)

plaques are almost scratch-free (Figs. 9 and 11). All the surviving plaques bear the signature “A. Moncayo, Quito”, cut into the bottom right-hand corner (Fig. 16), probably the name and location of the manufacturer (O. Chappy pers. comm.). On the Santa Fé plaque, this inscription and all the graffiti have at some point been scratched out (Fig. 17).

Three plaques show significant damage. Only two small fragments remain of the plaque belonging to the monument on Pinzón Island (Fig. 18). Only half a plaque exists at Tagus Cove: the lower portion with the English words

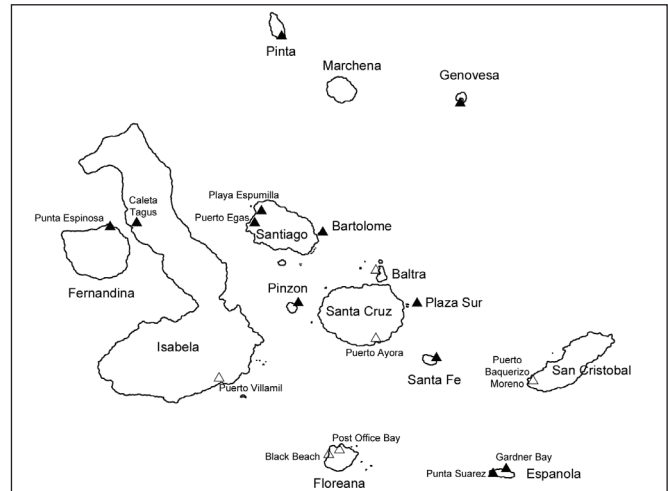


Figure 10. Distribution of the 18 Galapagos Park monuments. Black triangles denote monuments that are still standing, open triangles those that no longer exist.

The six that have disappeared, from Baltra, Puerto Villamil (Isabela), Post Office Bay and Black Beach (Floreana), Puerto Ayora (Santa Cruz) and Puerto Baquerizo Moreno (San Cristóbal) were all on inhabited islands and, with the exception of the Post Office Bay monument, in populated areas. Perhaps one of these six was never built at all: Lenín and Walter Cruz (pers. comm.), long-term residents of Floreana Island, claim there was never a monument at Black Beach, despite Perry’s (1968) report to the contrary.

All the surviving plinth structures are in excellent condition, with little sign of erosion. However, the monument at Gardner Bay, Española, is at present almost entirely covered in scrub, mainly *Cordia lutea* and *Vallesia glabra* (Fig. 11), while on Santiago *C. lutea* is also encroaching on the James Bay monument (Fig. 12), as is Button Mangrove *Conocarpus erectus* on that at Playa Espumilla (Fig. 13).

Most of the plaques are also remarkably well preserved, despite the black paint that filled the engraved letters having weathered away to a greater or lesser extent on all. The plaque at Gardner Bay, Española, is almost completely devoid of paint (Fig. 11), as is the Pinta plaque, which is also so worn as to be effectively illegible (Fig. 14). The plaque at Playa Espumilla is one of the least weathered (Fig. 2).

The uniquely-veined marble of each plaque bears faint scratch marks made by past visitors; some scratches look like random skate tracks on an ice rink, while others form the initials and names of people and places (mainly Manta and Quito), and dates from the late 1960s to early 1980s. The Plaza Sur (Fig. 8) and Punta Espinosa (Fernandina) (Fig. 15) plaques bear the most scratch marks, whereas the Darwin Bay (Genovesa) and Gardner Bay (Española),

Table 1. Location, dimensions and condition of the Park monuments in Galapagos. Coordinate datum WGS 84. Dimensions (cm) in order: height, width (base), width (top), breadth (base), breadth (top). NM = not measured, NA = not applicable.

Island	Site	Specific Location	Coordinates	Dimensions	Condition
Existing monuments:					
Bartolomé	NW side	Above E end of landing beach (Playa Dorada).	0°17'3.8"S 90°33'18.7"W	177, 118, 86, 68, 37	Intact. Letters missing some paint. Many scratch marks. Fig. 6.
Española	Gardner Bay	Behind centre of beach.	1°21'13.7"S 89°39'37.6"W	205, 128, 78, NM, NM	Intact. Obscured by vegetation. Letters almost paint-free. Few scratches. Fig. 11.
Española	Punta Suárez	Near landing dock and beginning of trail.	1°22'8.8"S 89°44'42.3"W	180, 116, 71, 88, 30	Intact. Bullet holes in plaque. Letters missing much paint. Few scratches. Figs 3, 20.
Fernandina	Punta Espinoza	C. 75 m NW of landing dock.	0°15'55.7"S 91°26'47.0"W	186, 121, 75, 88, 36	Intact. Letters mostly black, the last line entirely white. Many scratches. Fig. 15.
Genovesa	Darwin Bay	Cliff side behind landing beach.	0°19'6.3"N 89°56'55.0"W	60, 87, 87, 63, 63	Intact. Letters missing much paint. Few scratches. Built onto cliff; c. 2m above ground. Fig. 9.
Isabela	Tagus Cove	Against N side of gully, between dock and steps.	0°15'35.9"S 91°22'9.6"W	73, 127, 120, 102, 73	Spanish plaque missing. Letters of rest missing much paint. Many scratches. Fig. 19.
Pinta	S side of island	On rocks W of landing beach.	c. 0°32'41"N 90°44'17"W	NM	Intact. Letters entirely paint-free and difficult to read. Many scratches. Fig. 14.
Pinzón	NE side	Close to shore near snorkelling site.	0°35'56.8"S 90°39'16.2"W	NM	Plaque missing since 1970. Fig. 18.
Plaza Sur	Plaza Sur	Near landing dock and beginning of trail.	0°34'57.4"S 90°9'53.4"W	177, 117, 85, 87, 31	Intact. Letters missing much paint. Many scratch marks. Fig. 8.
Santa Fé	NE side	Between the two landing beaches.	0°48'13.0"S 90°2'26.4"W	182, 120, 81, 73, 30	Intact. Letters missing some paint. A few graffiti, scratched out. Figs 1, 16.
Santiago	James Bay (Puerto Egas)	Inland from landing beach, next to tourist trail.	0°14'28.1"S 90°51'42.8"W	176, 118, 70, 83, 37	Intact. Letters mostly black. Moderately scratched. Fig. 12.
Santiago	Playa Espumilla	Just beyond N end of beach, in mangroves.	0°11'56.6"S 90° 49'44.9"W	168, 116, 78, 86, 44	Intact. Partly hidden by mangroves. Letters mostly black. Few scratches. Figs 2, 13.
Missing monuments:					
Baltra	Marine terminal	Unknown.	?c. 0°26'10"S 90°17'7"W	NA	No longer exists.
Floreana	Black Beach	Unknown.	?c. 1°16'28"S 90°29'20"W	NA	May never have existed.
Floreana	Post Office Bay	Next to Post Office Barrel.	1°14'11.9"S 90°26'55.4"W	NA	Plaque destroyed in 1969. Demolished between 1973 and 1978. Figs 4, 5.
Isabela	Puerto Villamil	?At the end of the old dock near Port Captain office.	?c. 0°57'29"S 90°57'57"W	NA	No longer exists.
San Cristóbal	Puerto Baquerizo Moreno	On naval base, near Darwin	?c. 0°54'8"S 89°36'50"W	NA	No longer exists.
Santa Cruz	Puerto Ayora	Entrance to CDRS.	0°44'31.9"S 90°18'15.2"W	NA	Removed in 2007. Fig. 7.



Figure 11. The Park monument at Gardner Bay, Española, with a close-up view of its plaque, 8 Dec 2019. (Photos: GBE.)

(Fig. 19); a layer of cement covers what, if anything, is left of the Spanish half. The plaque at Punta Suárez has two bullet-sized holes in the centre and may well have been shot at (Figs 3, 20). According to Perry (1969, 1970a) these three plaques and that at Post Office Bay were vandalized within two years of their emplacement; the notices at Punta Suárez and Post Office Bay were “destroyed” in late May or June 1969 (Perry 1969; see also Fig. 5) and those at Pinzón and Tagus Cove, by February 1970 (Perry 1970b). Presumably in the case of the Punta Suárez and Tagus Cove plaques, which still exist, Perry (1969) meant “damaged” rather than destroyed, for we have found no evidence that either was replaced.



Figure 12. The Park monument at James Bay, Santiago, with a close-up view of the plaque, 3 Aug 2017. (Photos: KTG)



Figure 13. The Park monument at Playa Espumilla, Santiago in 2004 (Photo: J. Gibbs) and on 30 Jan 2020 (photo: KTG).



Figure 14. The Park monument on Pinta Island, with a close-up view of the plaque, in 2011. (Photo: D. Lara, courtesy of E. Hunter).

DISCUSSION

History

Seemingly artefacts of the GNPS/GNPD and the tourism industry, the Park monuments were conceived (in 1967), created and most of them erected (in 1967–8), before either entity was formed. The GNPS began in August 1968 as an offshoot of the Forestry Service of the

Ministry of Agriculture, with the first two Park wardens (José Villa and Juan Black) sent to Galapagos the following month. Regulated tourism began in July 1969, with Lindblad Tours operating two-week tours on the ten-passenger



Figure 15. The Park monument at Punta Espinosa, Fernandina with a close-up view of the plaque, 28 Jan 2020. (Photos: KTG)



Figure 16. A close-up of the plaque on Santa Fé, 10 Dec 2019. (Photos: GBE)



Figure 17. The signature found on all the surviving plaques: Tagus Cove, 2 Aug 2017 (left), Plaza Sur, 11 Jul 2017 (middle), Genova, 15 Jan 2020 (right). (Photos: KTG and GBE)



Figure 18. The Park monument on Pinzón, 13 Jan 2018. (Photo: GBE)

the destruction of feral animals, while the Ecuadorian Navy had a law-enforcement role (Grimwood & Snow 1966).

During the first decade of the existence of the GNP, as the CDRS was being built, key conservation issues identified, tortoise recovery programmes initiated, and recommendations for the administration of the GNP drafted, the CDF recognised that for the success of its conservation aims, namely “the protection of endangered species and the control

Golden Cachelot (Lindblad & Fuller 1983, D. Balfour pers. comm.). Rather, the monuments were the brainchild of the CDF and constructed in partnership with the Ecuadorian Navy. These two institutions were the original conservation managers of the GNP, from 1959 when Ecuador first declared all unoccupied lands in Galapagos “parques nacionales de reserva”, with this designation endowing the islands with laws that made it “illegal to colonize or modify unsettled areas” and to capture or remove certain animals, like “tortoises and their eggs”. Additional protection laws came into effect in the 1970s (Grimwood & Snow 1966, MacFarland *et al.* 1974). The CDF administered in the capacity of “scientific adviser to the Ecuadorian Government” but also had authority to implement practical conservation measures including



Figure 19. The Park monument at Tagus Cove, Isabela, 12 April 2017, and close-up view of the plaque, 2 Aug 2017. (Photos: GBE, KTG)

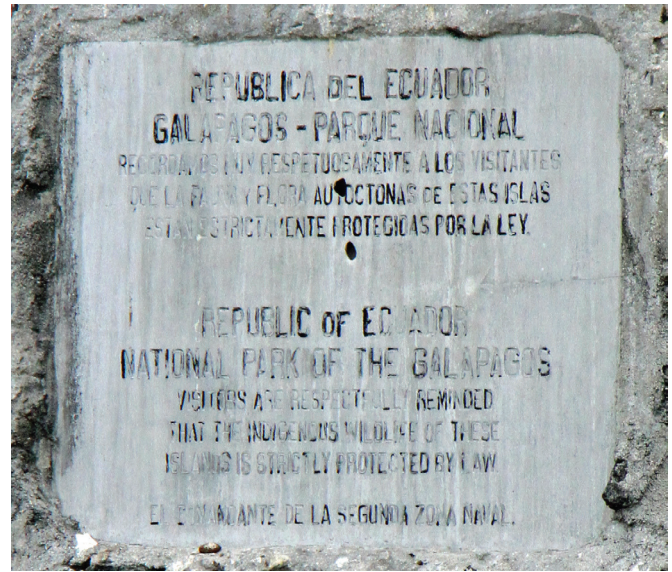


Figure 20. A close-up view of the plaque at Punta Suárez, Española with its two bullet holes, 24 Nov 2019. (Photo: KTG)

or elimination of introduced species of mammals, plants and invertebrates”, urgent steps were needed to control human activities in the islands (Corley-Smith 1975). For roughly 300 years, a succession of pirates, whalers, sealers, fishermen, colonists, museum collectors and scientists had hunted and collected the native wildlife and introduced alien species, and the devastation was continuing as new generations of residents and visitors killed wildlife for food and sale, cleared and occupied new lands, and brought in more non-native plants and animals (Grimwood & Snow 1966, Corley-Smith 1990). The National Park designation itself was attracting more tourists, in unregulated groups who arrived on supply ships (notably the *Cristóbal Carrier*) (Perry 2004, Basset 2009), on the occasional cruise ship (e.g. the *Navarino* which made visits from Peru in 1967 and 1968) (Lindblad & Fuller 1983) and on private yachts, at least two dozen of which were arriving each year in the mid-1960s (D. Balfour pers. comm.). All these people “were capable of doing serious harm and there was nobody to prevent them” (Eibl-Eibesfeldt 1976). Tourism, regulated so as to be compatible with conservation, appeared to be the answer, as it would raise international awareness of

the importance of protecting the islands and generate the funds to do so (Perry 2004). The Ecuadorian government, run by a military junta between 1963 and 1966, was supportive of the idea, especially after Prince Philip entertained officials on the royal yacht *Britannia* during a visit in 1964, and convinced them of the economic value of Galapagos protection and nature tourism (Perry 2004). Ian Grimwood (national parks expert) and David Snow (CDRS Director 1963–4), drew up a list of recommendations for the Park's administration, including for curtailing harmful activities and developing tourism in the islands (Grimwood & Snow 1966).

The fabrication of the Park notices, bearing a text composed by the director of the CDRS and “signed” by the commander of the Second Naval Zone, was one of the first measures taken consequent to this seminal report, to address “the human-interference” problem (Corley-Smith 1990) and pave the way for nature tourism.

Choice of Sites

The Park monuments were distributed widely throughout the archipelago (Fig. 10) to ensure that visitors would encounter at least one and be reminded of the protected status of Galapagos. They were placed at ports of entry and

at sites on uninhabited islands which were being harmed by frequent and unregulated visits by locals, fishermen, private yachtsmen, scientists and military personnel (J. Villa pers. comm.). Darwin Bay, Tagus Cove, Plaza Sur, Bartolomé and Post Office Bay, for example, were popular stopping places for private yachts, where graffiti painting, souvenir hunting, collecting native animals for “pets”, and other damaging activities were often conducted. Plaza Sur and Santa Fé islands were regularly visited by residents of neighbouring Santa Cruz, who went there to hunt land iguanas and goats. Española and Genovesa were used as target practice by the navy, who, despite lending a vital and effective enforcement hand to the CDF’s conservation efforts, still tended to consider the Galapagos as their privileged preserve (Perry 1965a, 1969, 2004). Tagus Cove, Santiago, Pinzón and Pinta were frequently visited by local and foreign fishermen, who camped on these and other shores to hunt tortoises and other animals for food, poach young tortoises to sell “for the international pet trade” (MacFarland *et al.* 1974) and kill sea-lions and fur-seals for their teeth and fur, which they then sold to tourists (Perry 1965b, 1969, 1970a). On Pinta they also introduced goats, which multiplied and devastated the native vegetation (Weber 1971).

Most of the sites chosen for Park monuments later became official tourist visitor sites, after David Balfour, Carl Angermeyer and Bernhard Schreyer, who all knew the archipelago well from ferrying scientists around the islands from 1963 to 1967, recommended several for their safe anchorages and landings, seabird colonies, congregations of iguanas, picturesque landscapes and other tourist attractions (Barlow 1967, D. Balfour pers. comm.). These sites included the CDRS, where tour groups stopped for coffee with the director. A Park monument was not a pre-requisite, however. Daphne Major, a first stop for *Golden Cachelot* passengers after they arrived by plane to Baltra, and Conway Bay (Santa Cruz), which was on the itinerary of the *Lina A* in 1970, are two visitor sites without monuments. Conversely, Pinta and Pinzón had monuments but never became terrestrial visitor sites, although both are now dive sites. Pinzón is also regularly visited for snorkelling, as it occasionally was in the 1970s (G. Shreyer and S. Divine pers. comm.).

Reception

The Park monuments were not well received by everyone. One of the early challenges of the CDRS was to change local attitudes from exploitation to conservation, and to persuade residents to accept the implications, there being “of course, settlers who dislike the restrictions imposed upon them by nature conservation” (Eibl-Eibesfeldt 1976). Progress was made in “reconciling local opinion with the idea of conservation” thanks in large part to education programmes initiated by Roger Perry and expanded by subsequent CDRS directors (Corley-Smith 1990). Initially, however, “there was considerable local opposition” to the CDRS and its conservation programs (Corley-Smith 1990) and it is generally believed that the damage to the Park plaques at Punta Suárez (Española) and Pinzón in 1969 and 1970 was caused by fishermen acting on the animosity they felt towards the CDRS. These two islands were the focus of the CDRS’s earliest tortoise conservation programs, and it may be no coincidence that the Pinzón plaque was destroyed the same year (1970) that the first CDRS-reared Pinzón tortoises were released onto the island (MacFarland 1976, Corley-Smith 1990).

One of the main points of contention between the CDF and the residents was territory. The CDF was tasked with “determining the areas to be included in the park” (Grimwood & Snow 1966) and, until the boundaries were delimited, there was great confusion about how much land on the inhabited islands would constitute National Park. On Isabela, San Cristóbal and especially on Santa Cruz there was a general “increase in movement to occupy [new] land” before the boundaries between the GNP and colonised zones could be officially marked, a task that was carried out between 1969 and 1975 (Perry 1966, 1967, 1968, 2004, MacFarland 1976, Corley-Smith 1990). There were even attempts to claim land on uninhabited Santiago (Perry 1966, 1968, 1969, 2004). On Floreana the settlers feared that the whole island “had been proposed as a reserve and that [they] ... would be required to vacate their land” (Perry 1967). Some suspect that the vandalism of the Post Office plaque (before the monument itself was removed) was exacted by certain Floreana settlers in response to this misperceived threat.

Boundary issues may also explain why some of the monuments erected on the inhabited islands have since disappeared. The Park notices imply, if not declare, that the site they stand on is National Park land, but for four of the six monuments that have disappeared (Baltra, Puerto Villamil, Puerto Baquerizo Moreno and Black Beach) this was simply not true. With the possible exception of the Black Beach monument, which may not have been erected at all, these monuments were probably taken down shortly after the GNP boundaries were established, once it was clear that the land they stood on was not GNP land, and perhaps also to make way for municipal development. The Post Office Bay monument may also have been dismantled for a similar reason, for although Post Office Bay lies within the GNP, in 1975 it was declared a “Special Use Zone”, an area “traditionally ... used by settlers” (Corley-Smith 1975), which could have been interpreted as licence for the monument’s removal, either by locals in defiance, or officials in concession.

Epilogue

This story is incomplete, in part because we could not speak with everyone involved in the planning and construction of the monuments. Many of the early Station and Park personnel have passed away, including Miguel Castro, Roger

Perry, Juan Black, Jacinto Gordillo (who represented the CDRS on Isabela in the 1960s) and Rolf Wittmer (hired by Perry to monitor the flamingos on Floreana), and the memories of those that remain are naturally limited. Our initial list of monuments, compiled solely from our own memories, included structures on Marchena, Rábida and North Seymour Islands. We are now confident there were never monuments on Rábida or North Seymour, but though we have found no evidence for one on Marchena either, including among photographs we took during field trips there in the 1980s and early 1990s, Lenín Cruz and Tjitte De Vries (pers. comm.) also “remember” one there. We hope this article will prompt others to come forward with photographs of the missing monuments listed in Table 1, and substance for a sequel.

We have referred to the structures and their plaques as “monuments” because, with the passage of time, the notices and their plinths have become true monuments in the sense of “something that by its survival commemorates and distinguishes a person, action, period, event ... or that serves as a reminder of, or witness or tribute to, a way of life, attitude, achievement, etc.” (<www.oed.com> consulted 15 Dec 2019). The Park monuments stand testament to the monumental dedication and perseverance of the instigators of the conservation movement, a diversity of Ecuadorian and international groups and individuals working together to protect the islands and their wildlife. The remaining monuments commemorate conservation successes with dignity, while the damaged plaques and echoes of the fallen plinths remind us that the battle was hard fought.

We hope this article will inspire new appreciation of the venerable Park monuments which, despite provoking visitors’ curiosity, are often dismissed as uninteresting relics of the past with a redundant message: it is now common knowledge that Galapagos is a National Park and its wildlife protected by law. However, it is for this very message that these dignified obelisks should be protected and their plaques re-inked. All too often old edifices get torn down when their initial purpose is thought to have expired and before their deeper significance is realised. We echo the sentiment of T. De Vries (pers. comm.), a key player in the construction of the monuments and the development of other conservation measures in Galapagos: “I hope they do not take all the monuments of the 1960s away even though they are somewhat deteriorated”. The monuments are still being used by the wildlife they were put up to protect, and often it is the hawks, boobies, iguanas and other animals perched on them that draw our attention to them and invite us to reread the message they hold. Over 50 years ago, by declaring Galapagos a National Park, forming the CDF, CDRS and GNPS, and funding and supporting these institutions with nature tourism, humans made a pledge to protect the Galapagos. The monuments should not be torn down; in the midst of the current global devastation, we need their reminder of this like never before.

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FIRST EVIDENCE OF CHILEAN FLAMINGO *PHOENICOPTERUS CHILENSIS* BREEDING IN GALAPAGOS

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SUMMARY

Evidence of Chilean Flamingo *Phoenicopterus chilensis* breeding in Galapagos was obtained in 2017, when an adult was photographed feeding a dependent juvenile in the Punta Cormorant lagoon on Floreana Island on 9 April and an independent immature, possibly the same individual, was photographed at the same site on 21 May. These observations constitute the first record of *P. chilensis* breeding anywhere in Ecuador. This mainland South American species was recorded in Galapagos for the first time in 2008. Since 2015 there have been many sightings, but always of 1–3 birds and only on Floreana. Because flamingos nest colonially and engage in group displays as a precursor to breeding, we posit that the breeding pair, whose nest was not found, may have been either part of a larger group of *P. chilensis* adults existing undetected in the archipelago, or stimulated to breed by joining the group courtship displays of the resident American Flamingo *P. ruber*, either on Floreana or another island. Given these possibilities, the likelihood that *P. chilensis* will breed again in the islands appears to be high, perhaps leading to the establishment of a permanent breeding population.

RESUMEN

Primera evidencia de Flamingo chileno *Phoenicopterus chilensis* reproduciéndose en Galápagos. Evidencia de reproducción del Flamingo chileno *Phoenicopterus chilensis* en Galápagos se obtuvo en 2017, cuando un adulto fue fotografiado alimentando a un juvenil dependiente en la laguna de Punta Cormorán en la isla Floreana el 9 de abril. También en el mismo lugar un inmaduro independiente, posiblemente el mismo individuo, fue fotografiado el 21 de mayo. Estas observaciones constituyen el primer registro de *P. chilensis* criando en Ecuador. Esta especie de Sudamérica continental fue observada en Galápagos por primera vez en 2008. Desde 2015 ha habido muchos avistamientos, pero siempre solo de 1–3 individuos y únicamente en Floreana. Ya que los flamings anidan en colonias y participan en despliegues grupales como preámbulo a la reproducción, proponemos que la pareja reproductora cuyo nido no fue encontrado, pudo haber sido, o parte de un grupo más numeroso de *P. chilensis* adultos viviendo indetectados en el archipiélago, o estimulada a anidar al sumarse a los despliegues nupciales del residente Flamingo americano *P. ruber*, en Floreana u otra isla. Dadas estas posibilidades, parece probable que *P. chilensis* vuelva a reproducirse en las islas, y tal vez hasta establecer una población reproductiva permanente.

INTRODUCTION

The Chilean Flamingo *Phoenicopterus chilensis* is the most common and widespread flamingo species in South America. Found south of the Equator, it breeds in saline lakes, often at high altitude, in Peru, Chile, Argentina, Bolivia and Paraguay (Hoyo *et al.* 2020). It is a non-breeding migrant to southern Ecuador, where flocks feed in the Lagunas de Ecuasal of Salinas on the Santa Elena peninsula (Freile & Restall 2018). The species was recorded in Galapagos for the first time on 25 Jul 2008, when a single adult was photographed in the Punta Cormorant lagoon (PCL: 1°13'40"S, 90°25'42"W), Floreana Island, by A. Jaramillo (Table 1). For much of the year this salt water lagoon supports small numbers (<50) of the genetically and morphologically distinct population of the American Flamingo *P. ruber* which resides in Galapagos as an isolated, panmictic population of c. 500 individuals (Weidenfeld & Jiménez-Uzcátegui 2008, Frias-Soler *et al.* 2014, Tindle *et al.* 2014), separated by some as *P. r. glyphorynchus* (Jiménez-Uzcátegui *et al.* 2017, Hoyo *et al.* 2020). The *P. chilensis* individual was, at the time, mistaken for this native species and was only identified correctly when the photograph was re-examined in 2020 (A. Jaramillo, pers. comm.). Another (or the same) individual was photographed by one of us (KTG) in the same location on 2 Aug 2015 (Fig. 1). It, too, was initially presumed to be a *P. ruber*, even though *P. chilensis* is distinguished from *P. ruber* by its yellow and grey legs, relatively thick neck, and more extensive black pigmentation of the lower mandible; the head and neck feathers of *P. chilensis* are also typically paler than those of adult *P. ruber* (Fig. 2) although progressive loss of pigmentation in *P. ruber* during breeding can

Table 1. Sightings confirmed by photographs of Chilean Flamingo *Phoenicopterus chilensis* adults in Galapagos. Photos deposited on <eBird.org> are identified by the corresponding checklist number. N = number of adults photographed.

Date	Location	N	Photographer	Source
25 Jul 2008	PCL	1	A. Jaramillo	https://ebird.org/checklist/S11093600 , originally misidentified as <i>P. ruber</i>
2 Aug 2015	PCL	1	KTG	Fig. 1, originally misidentified as <i>P. ruber</i>
17 Oct 2015	PCL	2	TDR	Jiménez-Uzcátegui 2017
29 Oct 2015	PCL	2	TDR	Jiménez-Uzcátegui 2017
14 Jul 2016	PCL	2	LDD	https://ebird.org/checklist/S32825231 Jiménez-Uzcátegui 2017
19 Jan 2017	PCL	1	J. Stone	https://ebird.org/checklist/S33813829 , misidentified as <i>P. ruber</i>
29 Jan 2017	PCL	1	GBE	
9 Feb 2017	PCL	1	M. Cowlard	https://ebird.org/checklist/S44615545 , misidentified as <i>P. ruber</i>
9 March 2017	PCL	1	LDD	https://ebird.org/checklist/S39241940
9 April 2017	PCL	2	GBE	Fig. 4
21 May 2017	PCL	1	GBE	Figs 5, 6
10 Mar 2018	PCL	1	GBE	
15 Apr 2018	PCL	1	LDD	https://ebird.org/checklist/S44657562
25 Apr 2018	PCL	1	D. Degel Andrade	https://ebird.org/checklist/S44950073
20 Sep 2018	LOB	1	LDD	https://ebird.org/checklist/S48742882
2 Oct 2018	PCL	1	M. Homan	https://ebird.org/checklist/S48889361
12 Jan 2019	PCL	1	GBE	
12 Aug 2019	PCL*	1 (2 recorded)	D. Plambeck	https://ebird.org/checklist/S59900447
18 Aug 2019	PCL	1	C. Brown	https://ebird.org/checklist/S59155054
24 Nov 2019	PCL	1	LDD	https://ebird.org/checklist/S61933816
11 Dec 2019	LOB	1	P. Freire	Fig. 2
26 Jan 2020	PCL	1	KTG	

*And “Post Office Bay”, probably referring to LOB.

also result in almost-white plumage (R. Tindle, pers. comm.). Subsequently, *P. chilensis* was photographed in October 2015, by T. de Roy (TDR), who had also recorded two individuals in May of that year (TDR, pers. com), and in July 2016 by L.D. Dejean (LDD) (Jiménez-Uzcátegui 2017: Table 1). Since then, intermittent sightings of 1–2 *P. chilensis* adults have been reported by naturalist guides and tourist visitors at PCL and at the beaches of La Olla Bay (LOB: 1°13'48"S, 90°26'28"W), near the “Baroness’s Lookout” visitor site, which lies c. 1 km from PCL (Fig. 3). Records supported by clear identifying photographs are included in Table 1.

Until now, *P. chilensis* has been considered a vagrant to Galapagos, meaning a naturally-arriving species that is recorded rarely or occasionally and does not breed in the archipelago (Jiménez-Uzcátegui 2017). However, the number and continuity of recent sightings suggest that birds recorded since 2015, and including perhaps the bird seen in 2008, may be residing permanently in Galapagos. Furthermore, the following observations made at PCL indicate that the species recently bred in the archipelago and could potentially establish itself as a breeding population.



Figure 1. An adult Chilean Flamingo *Phoenicopterus chilensis* (on right), feeding next to two adult American Flamingos *P. ruber* in the Punta Cormorant lagoon, Floreana Island, 2 Aug 2015. (Photo: KTG)

OBSERVATIONS

At c. 8h00 on 9 Apr 2017, GBE photographed an adult *P. chilensis* feeding a dependent juvenile flamingo (Fig. 4) in the northern corner of PCL (Fig. 3, point 1). They were surrounded by five adult *P. ruber* and another adult *P. chilensis*. Seven more *P. ruber* adults were present elsewhere in the lagoon. Six weeks later, on 21 May 2017, GBE photographed a solitary independent juvenile that may have been the same bird (Fig. 5). It was first spotted at c. 7h00, standing on its own on the northwestern edge of the lagoon (Fig. 3, point 2). Twenty minutes later it had moved into deeper water on the western side (Fig. 3, point 3) where a group of 16 *P. ruber* adults was feeding. By 8h00 the juvenile and adults had moved to the northeastern edge of the lagoon (Fig. 3, point 4) where they were joined by another ten adult *P. ruber* and one adult *P. chilensis*. No



Figure 2. Left: an adult *P. chilensis* (front) stands with an adult *P. ruber*, Punta Cormorant lagoon, 9 Apr 2017 (Photo: GBE). Right: a *P. chilensis* standing behind a *P. ruber* at La Olla Bay, 11 Dec 2019. (Photo: P. Freire)

interactions between the juvenile and the adults were observed; rather, the adults appeared to ignore it. An additional ten *P. ruber* adults were observed sitting (presumed incubating) in a known *P. ruber* nesting area on the eastern side of the lagoon (Fig. 3, point 5; Fig. 6); the total lagoon count was 38 flamingos.

We did not find *P. chilensis* on any subsequent trips to the lagoon in 2017: on 4 Jun (when 31 *P. ruber* adults were counted, 13 of them in the nesting area), 30 Jul (when 6 *P. ruber* chicks with grey down were in the nesting area) and 27 Aug (when a single juvenile *P. ruber* was observed being fed by a *P. ruber* adult). The next sighting of *P. chilensis* was at PCL on 9 Mar 2018 (Table 1), when one adult was with a flock of 25 adult *P. ruber*.

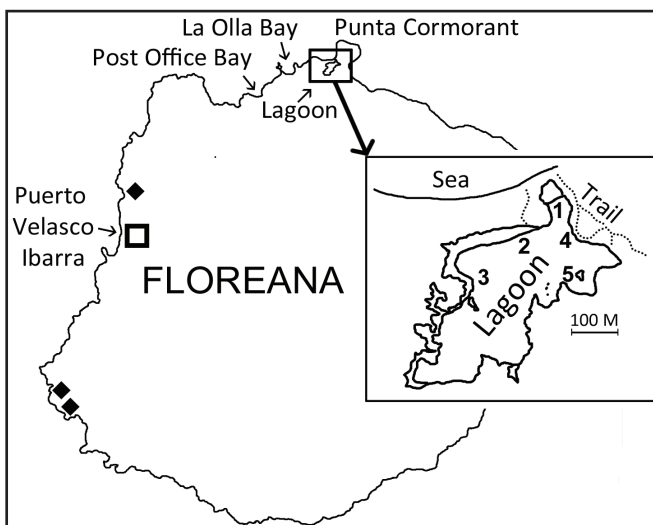


Figure 3. Floreana Island showing localities mentioned, with an enlargement of the Punta Cormorant lagoon. Black diamonds indicate smaller flamingo lagoons.



Figure 4. *P. chilensis* adult feeding a juvenile, with two adult *P. ruber* (facing forward) and another *P. chilensis* adult (tail forward) nearby, PCL, 9 Apr 2017. (Photo: GBE)



Figure 5. Juvenile *P. chilensis* surrounded by adult *P. ruber* in PCL, 21 May 2017. (Photo: GBE)



Figure 6. Juvenile *P. chilensis* (centre, side arrow) preening, with one *P. chilensis* adult (at back, downwards arrow) and 22 *P. ruber* adults in the PCL, 21 May 2017. A small cluster of nesting *P. ruber* can be seen on the far shoreline. (Photo: GBE)

DISCUSSION

The juvenile flamingo being fed by an adult *P. chilensis* in April 2017 (Fig. 4), and the juvenile seen on its own the following month (Figs 5 and 6), appear to be conclusive evidence of *P. chilensis* breeding in Galapagos. The juvenile in Fig. 4 is almost certainly the offspring of the *P. chilensis* adult feeding it, though not necessarily of the other adult *P. chilensis* in the photograph: the attending adult's very pallid plumage indicates that it had been feeding the offspring regularly and over a long period, losing pigmentation in the process, whereas the other adult's pinker feathers on its lower back and face suggest otherwise (R. Tindle, pers. comm.). The off-duty parent may have been feeding elsewhere, perhaps at another lagoon, as is typical for flamingo parents which take turns attending their juvenile rather than remaining together (Tindle *et al.* 2014). Because no nesting was observed, two alternative possibilities regarding the identity of the juvenile must be considered: that it was a *P. ruber* juvenile, which the *P. chilensis* had adopted or fostered, or that it was the result of a hybrid pairing between a *P. chilensis* and a *P. ruber*. The first of these can almost certainly be ruled out because adoption is virtually unknown in flamingos, including *P. chilensis* and *P. r. glyphorhynchus*; parents care only for their own progeny and rebuff other begging chicks (Rooth 1965, Brown & King 2005, R. Tindle pers. comm.). Fostering, in which a flamingo pair takes over the nest of another pair, hatches the egg and rears the chick as their own, has rarely been recorded and only among captive Greater Flamingos *P. roseus* (Anderson 2017).

The second alternative is more plausible because hybrid pairing between *P. chilensis* and *P. ruber* is known to occur readily in zoos (Anderson 2017) and in the wild in Europe, where escaped captive *P. ruber* and *P. chilensis* coexist with natural populations of *P. roseus* (Cezilly & Johnson 1992, Anderson 2017). It is thought that hybridisation occurs when these normally allopatric species come together, because all three species are colonial nesters, have similar courtship displays, and do not differ greatly in body size. *Phoenicopterus chilensis*, at roughly 105–110 cm tall (Anderson 2017, Freile & Restall 2018, Hoyó *et al.* 2020) is close in size to *P. r. glyphorhynchus* (Frias-Soler *et al.* 2014), which measures c. 105 cm in height (Castro & Phillips 1996) but has a slighter body (Figs 1, 2, 5). There is, in fact, circumstantial evidence that hybridisation between these two species may have been attempted in Galapagos in 2018, for on 2 Oct of that year a *P. chilensis* was photographed (<https://ebird.org/checklist/S48889361>) at the PCL, standing within a group of incubating flamingos, all of which appear to be *P. ruber*; one of them may have been the Chilean Flamingo's mate.

Despite the potential for hybridisation, there is no obvious physical evidence that the juvenile at PCL in 2017 was a hybrid. Although *P. chilensis* and *P. ruber* juveniles are similar in appearance, the thick (densely-plumaged) neck, white abdomen and brownish dorsal plumage of the PCL juvenile in Figs 5 and 6 are characteristic of a pure *P. chilensis*; *P. ruber* juveniles have a thinner neck and darker dorsal and ventral plumage, and a hybrid would presumably exhibit some of these traits (Hoyó *et al.* 2020, R. Tindle pers. comm.).

Assuming that the juvenile was a pure-bred *P. chilensis*, based on known patterns of plumage development in flamingos it was probably 2.5–4.5 months old in early April 2017. Vaned feathers start to emerge at 35 days (Allen 1956, Brown & King 2005, Anderson 2017, Hoyó *et al.* 2020), juvenile plumage in *P. chilensis* develops over a variable period of at least 56 days and often twice that (Chiale *et al.* 2018) and flight is generally achieved at 84–120 days (Allen 1956, Wackernagel 1959, Brown & King 2005). The juvenile in Figs 5 and 6 was probably ≥ 6 months old, because at this age *P. chilensis* offspring stop being fed by their parents, even intermittently, and are typically ignored (Wackernagel 1959, Rooth 1965).

As the incubation period of *P. chilensis* is 27–31 days (Anderson 2017, Hoyo *et al.* 2020), the egg that gave rise to the juvenile in Fig. 4 must have been laid sometime between November 2016 and January 2017. This date range falls within the egg-laying periods both of *P. chilensis* in South America, which is October in Lago Junín, Peru, Nov–Dec in Argentina, and Jan–Mar in the lakes of the Altiplano (Hoyo *et al.* 2020) and of *P. r. glyphorhynchus* in Galapagos, which can occur anytime between August and May but in the 1970s when this subspecies was studied in greatest detail, it was mostly Oct–Dec (Tindle *et al.* 2014).

No flamingo nesting was recorded at PCL during this putative breeding period (Nov 2016 to Jan 2017). Although unobserved or unrecorded nesting may have occurred there, the juvenile in Fig. 4 appears capable of flight, so its parents might have nested at another lagoon, on Floreana (Fig. 3) or another island (R. Tindle pers. comm.). Arrival of the juvenile from outside Galapagos is unlikely, not only because of the distance (>1000 km) from the mainland but also considering the juvenile's young age and its dependency on the adult. Long-distance dispersal of juvenile flamingos is only known for independent individuals no longer being fed by their parents (Winkler *et al.* 2020). Given that flamingos are colonial nesters it seems likely that the *P. chilensis* family nested with *P. ruber*, rather than on its own, though solitary nesting cannot be ruled out. Nesting by *P. ruber* has been recorded at nine sites: Quinta Playa, Cuarta Playa, and Cementerio on Isabela Island; Espumilla, Mina de Sal, El Sartén on Santiago; the lagoon on Rábida island; the lagoon on Bainbridge 3; PCL on Floreana (Vargas *et al.* 2008). Three of these (Espumilla, Mina de Sal and Rábida) have not hosted flamingo nesting for many years (Vargas *et al.* 2008), and most recent nesting has been recorded on Isabela (the closest nesting island to Floreana) and Bainbridge 3. Adult and immature *P. ruber* readily fly around the archipelago (Tindle *et al.* 2014) but whether the juvenile would have been capable of flying the >80 km required to reach Floreana from one of these islands is unknown.

Breeding by *P. chilensis* in Galapagos is surprising, because like most flamingos, the species typically breeds in large colonies, sometimes of thousands of birds, with group courtship involving large numbers of birds being a precursor to nesting (Anderson 2017, Hoyo 2020). Even in captivity flocks of ≥ 40 individuals are generally needed to stimulate regular breeding (Brown & King 2005). In contrast and unusually among flamingos, *P. r. glyphorhynchus* regularly breeds in small groups, sometimes of only three pairs, with courtship displays involving just 4–22 individuals (Tindle *et al.* 2014). Given the difficulty of long-distance oceanic flight, the founder population of *P. r. glyphorhynchus* is presumed to have been small, and a capacity to breed in small numbers may have allowed its establishment in the archipelago, >70,000 years ago (Frias-Soler *et al.* 2014, Tindle *et al.* 2014). *P. chilensis* is clearly also capable of breeding in small numbers, because once a flock of just four individuals successfully bred in captivity (Brown & King 2005). However, no more than two adult *P. chilensis* (three according to unsubstantiated reports) have been recorded at any one time in Galapagos, and a single pair would normally be insufficient to expect breeding.

Two factors could explain *P. chilensis* breeding in Galapagos. First, there may be more *P. chilensis* in Galapagos than we know about. To date, all confirmed sightings of *P. chilensis* in Galapagos have been on Floreana Island; reports of this species at Las Bachas on Santa Cruz Island and at Puerto Villamil on Isabela Island are not supported by the photographs we have seen. However, many of the archipelago's c. 40 flamingo lagoons are rarely visited (Tindle *et al.* 2014), so more birds could be "hiding" elsewhere. The other explanation is that the parents of the juvenile in Fig. 4 were stimulated to breed by joining the group displays of a flock of *P. r. glyphorhynchus*. Courtship involving more than one flamingo species occurs in captivity and among escaped captives (Cezilly & Johnson 1992, Anderson 2017). It also occurs in Galapagos, for on 24 Nov 2019 a *P. chilensis* was photographed engaging in courtship display with a group of *P. ruber* in the PCL (<https://ebird.org/checklist/S61933816>). Courtship uncoupled from nesting can occur any time of year and does not always lead to breeding, so the *P. chilensis* did not necessarily nest in the same location or at the same time as the *P. ruber*, but it might have stimulated in them a physiological response allowing them to breed.

The juvenile *P. chilensis* has not been seen since the records listed above. There have been several confirmed sightings of a single adult (Table 1), and other reports of 2–3 adult *P. chilensis* on Floreana but, as flamingos do not attain adult plumage for 3–6 years, these sightings almost certainly represent repeated sightings of the parents or of other immigrants, rather than the grown juvenile. *Phoenicopterus chilensis* does not occupy PCL year round, and presumably, like *P. ruber*, travels to other lagoons in the archipelago as food supplies fluctuate, (Vargas *et al.* 2008, Tindle *et al.* 2014). The alternative explanation, that it returns to mainland South America, seems unlikely as it would require a non-stop flight of ≥ 1000 km over the open ocean against the prevailing east winds. Generally, flamingos that undertake long (>900 km) migratory flights rest at wetland stopovers along the way (Amat *et al.* 2005). As it is, *P. chilensis* now shares with *P. r. glyphorhynchus* the long distance record for oceanic travel among all flamingos (Frias-Soler *et al.* 2014).

The arrival and breeding of *P. chilensis* in Galapagos could lead to a rare colonisation event involving a bird group that last successfully colonised the islands tens of thousands of years ago. Whether *P. chilensis* establishes a breeding population in the archipelago remains to be seen, but its continued presence suggests that further nesting can be expected. This presents a unique research opportunity, as *P. chilensis* and *P. ruber* do not normally overlap in the wild. An investigation of the breeding, feeding and dispersal of the *P. chilensis*, with a focus on their interactions with the

resident *P. ruber* would inform greatly on the biology of both species. Although the Galapagos population of *P. ruber* has been studied (Tindle *et al.* 2014) and monitored (Gordillo 1967–2007) in detail, significant ecological changes have occurred in several flamingo lagoons since the 1960s and 1970s when these projects began, owing to major El Niño episodes, vegetational succession, feral animal eradication and control, and improved management of human activities; as a result some lagoons (*e.g.* Espumilla) no longer host flocks of flamingos, whereas others (*e.g.* PCL, which supported flamingo nesting just once in 13 years in the 1960s–70s), have since seen a significant increase in flamingo activity (Vargas *et al.* 2008, Tindle *et al.* 2014). Flamingo surveys and censuses conducted since 1995 have tracked population fluctuations in *P. r. glyphorhynchus*, but more detailed monitoring is needed to understand breeding occurrence and success in the various parts of the archipelago. Such monitoring would also help to reveal where *P. chilensis* might be nesting. Studying *P. chilensis* feeding would help our understanding of how it might impact the *P. r. glyphorhynchus* population, which is already considered vulnerable to fluctuations in food supply and climate change (Vargas *et al.* 2008). Food partitioning occurs where *P. chilensis* overlaps with the Andean Flamingo *Phoenicoparrus andinus* and James’s Flamingo *Phoenicoparrus jamesi*, with *P. chilensis* feeding in deeper water than these other species (Mascitti & Castañera 2006), so perhaps a similar form of resource partitioning might develop between *P. chilensis* and *P. r. glyphorhynchus*. The research recommendations suggested by Vargas *et al.* (2008), for monitoring *P. r. glyphorhynchus* in the context of climate change, would provide information on many of these points. We recommend marking birds to monitor their survival, radio-tracking to reveal movement between lagoons and islands, and making detailed observations on feeding, courtship and other social behaviour. Searches for *P. chilensis* at lagoons favoured by *P. ruber* but which are rarely visited by humans are highly recommended, especially during peak nesting months. Continued reporting of *P. chilensis* by visitors to Floreana should also be encouraged but caution needs to be used in interpreting reports unaccompanied by photographs, as *P. chilensis* is easily confused with pale subadult and adult *P. ruber* (which can become almost white during breeding: R. Tindle pers. comm.), as the several mislabelled photographs on eBird (<<https://ebird.org/species/chifla1>>, <<https://ebird.org/species/grefla2>>) demonstrate. Reports of several *P. chilensis* seen separately in place and time, for example at PCL and LOB in different hours of the day, must also be treated cautiously, as flamingos fly readily between sites during the day.

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FIRST RECORD OF THE NEMATODE *STEPHANURUS DENTATUS* IN FERAL ARTIODACTYLS ON THE GALAPAGOS ISLANDS

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SUMMARY

Stephanurus dentatus is a nematode endoparasite of swine *Sus scrofa* and cattle *Bos taurus*, both of which are feral introduced species in the Galapagos islands. In 2018 in the National Park area of Isabela Island, we collected *S. dentatus* in different stages of its life cycle in the muscle along the spine and legs and in the kidneys of these feral artiodactyls. The swine and cattle co-occur with other possible hosts, such as goats *Capra hircus* and giant tortoises *Chelonoidis* spp. and the possible impact of the parasite on the health of these species is of concern.

RESUMEN

Primer registro del nemátodo *Stephanurus dentatus* en artiodáctilos ferales en las Islas Galápagos. *Stephanurus dentatus* es un nemátodo endoparásito de cerdos *Sus scrofa* y bovinos *Bos taurus*, las cuales son especies introducidas y ferales en las Islas Galápagos. En 2018 en el área del Parque Nacional Galápagos de la isla Isabela se colectó *Stephanurus dentatus* en diferentes etapas de su ciclo de vida en el músculo a lo largo de la columna vertebral y de las piernas y en los riñones de estos artiodáctilos ferales. Los cerdos y bovinos comparten áreas con otros huéspedes potenciales, como la cabra *Capra hircus* y las tortugas terrestres gigantes *Chelonoidis* spp. y el posible impacto del parásito en la salud de estas especies es de preocupación.

INTRODUCTION

Stephanurus dentatus is a nematode that affects the kidney, liver, renal and perirenal tissues, axial musculature and occasionally the spinal canal in swine *Sus scrofa* and cattle *Bos taurus*, which may be infected by ingesting eggs and larvae directly, or by the ingestion of the paratenic hosts such as earthworms (Bowman 1995, Merck & Co. 2000, Ballweber

2001). Clinical signs range from cystitis to posterior paralysis depending on the number of parasites (intensity), the location of the parasites in the body, and the stage of the parasite (Bowman 1995, Ballweber 2001).

Swine and cattle are introduced species in the Galapagos Islands (Hoeck 1984), first introduced in 1832 and now present, as both domestic and feral animals, on the four main islands inhabited by humans (Florea, San Cristóbal, Isabela and Santa Cruz) (Jiménez-Uzcátegui *et al.* 2007). Swine damage natural habitats and compete with and prey on indigenous species of reptiles and birds (Cruz *et al.* 2005, Tindle *et al.* 2016), therefore this species is controlled in the National Park Area of the four inhabited islands and was eradicated on the uninhabited Santiago Island in 2004. Feral cattle have also been controlled on populated islands because they destroy native vegetation and compete for resources with herbivorous endemic animals (Hoeck 1984, Cruz *et al.* 2005, Jiménez-Uzcátegui *et al.* 2007).

OBSERVATIONS

As part of the GNPD control programme, seven pigs were hunted in an area of 1 km² (centroid 0°58'54"S, 91°25'11"W) on Cerro Azul Volcano, Isabela Island between 7 and 26 Jan 2018 and on necropsy dozens of helminths were found in their muscles along the spine and legs and in their kidneys. Another pig (not shot) was seen running away with uncoordinated movements. On 26 Jun 2018 at Caleta Iguana (0°58'36"S, 91°26'42"W) on Isabela Island, five cattle were hunted, necropsies performed, and a cyst was discovered in a liver. Also at Caleta Iguana, three cattle and one pig were hunted on 21 Jul 2018, necropsies performed, and parasites were found in their kidneys. The parasites were collected and preserved in 75 % alcohol and then frozen.

From all helminths collected, six specimens from swine and five from cattle, chosen at random, were fixed with glycerin and lactophenol. They were identified morphologically as *Stephanurus dentatus*, following the key of Quiroz (1996). The specimens included adults and sub-adults of both sexes (Table 1). The oral and caudal structure enabled the species to be identified according to Soulsby (1988) and Urquhart *et al.* (2001), confirming that they were *S. dentatus*.

DISCUSSION

Swine and cattle are widespread on the inhabited islands of Galapagos, where they share habitat with other introduced feral artiodactyl species, such as goats *Capra hircus*, and endemic herbivores such as the giant tortoises *Chelonoidis* spp. (Hoeck 1984, Jiménez-Uzcátegui *et al.* 2007, 2016). These species could be infected with this endoparasite by eating plants or drinking water contaminated with eggs, but in the case of the tortoises there is no information on infestation with *S. dentatus*, although they suffer parasitism from other nematodes (Burse & Flanagan 2002, Deem *et al.* 2014, Fournie *et al.* 2015). Humans hunt the swine, cattle and goats for consumption, but *S. dentatus* is not described as a human parasitic disease (Merck & Co 1994).

In Galapagos there are 11,600 domestic cows (MAGAP 2016) and 3,651 pigs (CGREG 2014) in the agricultural area, and the number of feral animals in the National Park is unknown. *S. dentatus* is an economic problem for farmers, because infected individuals may show symptoms of decreased weight, emaciation and ascites, and their productivity (meat or milk) is reduced (Ballweber 2001). Since clinical signs are not pathognomonic, an ante-mortem diagnosis is often difficult (Bowman 1995, Merck & Co. 2000, Ballweber 2001). Control of this disease is also difficult because the prepatent period of the parasite is 9–16 months after infection and the worms may live three or more years undetected (Bowman 1995, Ballweber 2001). To control *S. dentatus* efficiently on farms, anthelmintic use is necessary, as well as a thorough knowledge of the parasite cycle and epidemiology to avoid the development of resistance in this endoparasite and other nematodes. It is important to monitor this parasitism in the artiodactyls and in possible hosts such as the

giant tortoises. This monitoring should be done primarily in areas they share on farms and in the National Park, in order to understand prevalence and incidence (Ballweber 2001). Monitoring in slaughterhouses can also help to record *S. dentatus* and other parasites.

Table 1. *Stephanurus dentatus* collected from feral swine and cattle in the Galapagos Archipelago.

Individual	Life stage	Sex	Found in
1	sub-adult	male	Swine
2	adult	female	Swine
3	adult	female	Swine
4	adult	male	Swine
5	sub-adult	male	Swine
6	sub-adult	female	Swine
7	sub-adult	male	Cattle
8	sub-adult	male	Cattle
9	sub-adult	female	Cattle
10	adult	male	Cattle
11	sub-adult	male	Cattle

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FIRST REPORT OF CO-OCCURRENCE OF TWO SPECIES OF MOCKINGBIRD IN THE GALAPAGOS ISLANDS: A SAN CRISTÓBAL MOCKINGBIRD *MIMUS MELANOTIS* IN A POPULATION OF FLOREANA MOCKINGBIRD *M. TRIFASCIATUS*

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SUMMARY

The four *Mimus* species (mockingbirds) inhabiting the Galapagos archipelago have non-overlapping distributions. Here we report the co-occurrence of two *Mimus* species on one islet in the archipelago, Gardner-by-Floreana, where the native species is *M. trifasciatus*. In February 2012, an unusual mockingbird was heard and observed constructing a nest on Gardner-by-Floreana. This bird was subsequently captured, measured and ringed and its alarm calls were recorded. Its measurements and colour pattern were within the ranges reported for *M. melanotis* from San Cristobal Island and an analysis of alarm calls also suggests it was of this species. Despite searches we have not found more individuals of *M. melanotis* on Gardner-by-Floreana. The ringed bird was last seen in October 2012.

RESUMEN

Primer reporte de co-ocurrencia de dos especies de cucuve en las Islas Galápagos: un Cucuve de San Cristóbal *Mimus melanotis* en una población del Cucuve de Floreana *M. trifasciatus*. Las distribuciones de las cuatro especies de *Mimus* (cucuves) en el archipiélago de Galápagos no se sobreponen. Aquí presentamos el primer registro de co-ocurrencia de dos especies de *Mimus* en un islote del archipiélago, Gardner-por-Floreana, en donde la especie nativa es *M. trifasciatus*. Un cucuve inusual fue escuchado y observado construyendo un nido en Gardner-por-Floreana en febrero 2012. Este individuo fue eventualmente capturado, medido y anillado, y sus vocalizaciones fueron grabadas. Sus medidas y coloración cayeron dentro del rango reportado para *M. melanotis* de la isla San Cristóbal y el análisis de vocalizaciones de alarma también sugiere que se trata de esta especie. A pesar de posteriores búsquedas no hemos encontrado más individuos de *M. melanotis* en Gardner-por-Floreana. El individuo anillado fue visto por última vez en octubre 2012.

INTRODUCTION

The genus *Mimus* (mockingbirds) is represented in the Galapagos Islands, Ecuador, by four endemic species, with non-overlapping distributions. The Floreana mockingbird *M. trifasciatus* is currently restricted to Champion and Gardner-by-Floreana Islets (Curry 1986, Grant *et al.* 2000, Cody 2005), the Española (Hood) Mockingbird *M. macdonaldi* is only found on Española Island and Gardner-by-Española Islet (Cody 2005), and the San Cristóbal Mockingbird *M. melanotis* is found on San Cristóbal Island and adjacent islets (Cody 2005). A fourth species, the Galapagos Mockingbird *M. parvulus* is found on Santa Fe, Santa Cruz, Isabela, Santiago, Fernandina and most islands and islets to the northwest, except Pinzón (Cody 2005). The four species are thus allopatric (Abbott & Abbott 1978, Bowman 1983).

The Floreana Mockingbird currently has the most restricted distribution of all 14 species in the genus *Mimus* (Cody 2005), found only on Champion and Gardner-by-Floreana islets off the coast of Floreana Island, with a combined area of <100 ha. Historically, the Floreana Mockingbird occurred on Floreana Island but became extinct there in the early 1900s (Curry 1986). The species is classified as Endangered (EN) (<<https://www.iucnredlist.org/species/22711063/132093428>>), with a global population size of approximately 500–750 individuals (L. Ortiz-Catedral

unpubl.). Recent molecular analyses have revealed that the population of Galapagos Mockingbirds on Genovesa Island, *M. parvulus bauri*, represents a hybrid lineage with alleles from *M. melanotis* (Nietlisbach *et al.* 2013); this is the only previous evidence of the past co-occurrence of two *Mimus* lineages in the Galapagos Islands.

Here, we report the first field observation of two Galapagos *Mimus* species on the same islet.

METHODS

From November 2010 to October 2012, Champion and Gardner-by-Floreana were visited monthly by groups of 2–4 people to conduct population surveys of the Floreana Mockingbird, as part of the conservation plan for the species (Charles Darwin Foundation 2008). Floreana Mockingbirds were captured regularly to maintain a ringed population. On 22 Feb 2012, an unusual mockingbird alarm call was heard by LO, but the bird making the call was not observed. On 23 Feb, LO and AL heard the same call and found an unusual-looking mockingbird that did not match the phenotype of Floreana Mockingbirds but resembled the San Cristóbal species. The calls of the unusual bird were recorded using a hand-held Canon EOS 1100D camera with audio-video function. We then attempted to capture the bird, using our standard capture method for Floreana Mockingbirds, consisting of, a wire treadle Potter trap with a hanging decoy placed within *c.* 20–50 m of the target bird and containing a plastic insect, a dead caterpillar or piece of metallic paper. The mockingbirds of Galapagos are curious and usually approach the traps within a few minutes. Once the bird steps on the treadle to peck the bait the trap door closes. In this case a trap baited with a dead caterpillar was placed next to the partially constructed nest and the recorded calls were played to lure the bird into the trap. Within minutes we successfully captured it, weighed and measured it and ringed it and a unique combination of numbered and colour metal bands, following methods approved by the Galapagos National Park Directorate.

RESULTS

The unusual mockingbird was observed for 2 h while it collected nesting material and called continuously but no evidence of other individuals of the same species was found. Floreana Mockingbirds in the vicinity responded with their own distinctive alarm calls and repeatedly attacked the bird while it was carrying sticks and twigs to the nest under construction. No Floreana Mockingbirds were observed picking up or carrying twigs or branches, and no other interactions between the two species were observed.

The mostly grey plumage of the unusual bird, with a dark mask extending from the back of the eye towards the neck and a mostly white ventral region (Fig. 1), greatly differs from the lighter brown plumage, dirty or mottled ventral region, dark pectoral marks and white mask of normal Floreana Mockingbirds (Fig. 2) and was consistent with that of San Cristóbal Mockingbird (Fig. 3). The measurements of the unusual bird also matched the range for San Cristóbal Mockingbird, while Floreana Mockingbird is larger, the second largest of the four mockingbirds of Galapagos, and differs markedly in mass, wing length, tail length and bill width (Table 1). The alarm calls of the unusual bird were short and loud, quite different from those of Floreana Mockingbird. Spectrograms of the field recordings show a greater similarity to alarm calls of San Cristóbal Mockingbird (Fig. 4).

The unusual bird was last seen on 14 Oct 2012. No similar birds were detected during subsequent semi-annual visits to Gardner-by-Floreana, from 2013 to 2019. To date no unusual mockingbirds have been detected on Champion Islet, where the only other population of Floreana Mockingbird occurs, despite similar survey effort as on Gardner-by-Floreana.



Figure 1. Unusual mockingbird on Gardner-by-Floreana Islet, 23 Feb 2012 (photos: LO).



Figure 2. Floreana Mockingbirds *M. trifasciatus*, Gardner-by-Floreana Islet, 23 Feb 2012 (top) and 12 Oct 2012 (photos: LO).

Table 1. Morphometrics of the unusual bird found on Gardner-by-Floreana, San Cristóbal Mockingbirds *M. melanotis* captured on San Cristóbal, and Floreana Mockingbirds *M. trifasciatus* on Gardner-by-Floreana. Field measurements (mean \pm SD) of *M. melanotis* provided by S. Espinoza and of *M. trifasciatus* by E. Rodríguez-Reyes.

	Unusual bird (n=1)	<i>M. melanotis</i> n=19	<i>M. trifasciatus</i> n=52
Mass (g)	42	48.94 \pm 3.73	60.44 \pm 6.87
Exposed culmen (mm)	20.2	20.02 \pm 1.11	23.05 \pm 1.09
Bill width (mm)	5.2	5.24 \pm 0.31	6.21 \pm 0.27
Bill depth (mm)	5.5	5.63 \pm 0.41	6.15 \pm 0.30
Wing length (mm)	103	106.54 \pm 4.67	117.33 \pm 4.92
Tail length (mm)	97	98.54 \pm 5.62	118.92 \pm 7.38
Tarsus (mm)	36.5	37.32 \pm 0.84	39.31 \pm 1.35



Figure 3: San Cristóbal Mockingbird *M. melanotis*, Playa Ochoa, San Cristóbal Island, 14 Aug 2012 (photo: LO).

DISCUSSION

Based on plumage, measurements and voice, we identify the unusual individual as a San Cristóbal Mockingbird. To our knowledge, this is the only documented record of two species of *Mimus* occurring together on one island in the Galapagos archipelago. San Cristóbal lies 87.5 km NE of Gardner-by-Floreana. Although mockingbirds of the Galapagos Islands are considered poor fliers, the presence throughout the archipelago of this monophyletic group shows that the distance is not impossible for them. Further, the hybrid ancestry (*M. parvulus* \times *M. melanotis*) of the population *M. p. bauri* on Genovesa Island, 145 km NW of San Cristóbal (Nietlisbach *et al.* 2013) suggests that such long-distance dispersal of San Cristóbal Mockingbirds is possible. Although there are a few reports of mockingbirds flying onto

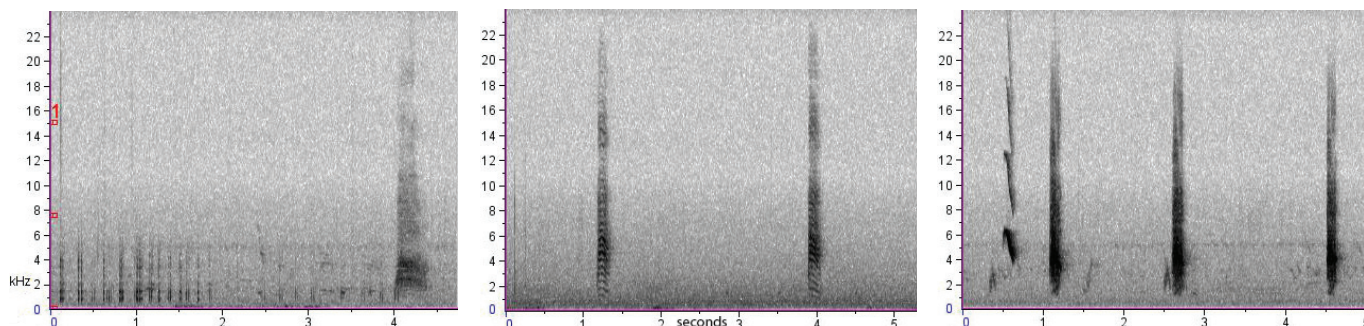


Figure 4. Spectrograms of alarm calls of: Floreana Mockingbird *Mimus trifasciatus* (left); San Cristóbal Mockingbird *M. melanotis* on San Cristóbal Island (middle); the unusual bird on Gardner-by-Floreana Islet (right).

tourist vessels in Galapagos, and such birds might hitchhike on boats to other islands, there are no confirmed cases of mockingbirds reaching other islands in this way (L. Cruz and K.T. Grant pers. comm.).

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Format of tabular material, numbers, metric units, references, *etc.* should match recent issues. Note particularly: dates should be in the form 2 Feb 1990 but months standing alone in text may be written in full; times of day are written 6h45, 17h32 and coordinates in the form 0°46'N, 1°4'W (no leading zeros); numbers up to ten are written in full, except when followed by abbreviated units (*e.g.* 6 m), numbers from 11 upwards are written in figures except at the beginning of a sentence. All references mentioned in the article, and only such, must be entered in the bibliography.

Locality names should be widely recognised and in current use where possible. Articles citing older names, or localities that are not widely known, should contain a map or gazetteer, including all such localities mentioned.

Scientific names should follow a recognised authority, which should be cited in papers dealing with taxonomic issues or lengthy species lists. Scientific names of **plants** should follow P.M. Jørgensen & S. León-Yáñez (1999) Catalogue of the Vascular Plants of Ecuador. *Monographs in Systematic Botany from the Missouri Botanical Garden* 75 (see <http://www.tropicos.org/> for database), unless sound reasons for following a different scheme are presented.

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