Chapter 15
Conservation of a New Flagship Species: The Galápagos Pink Land Iguana (*Conolophus marthae* Gentile and Snell, 2009)

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A New Species of Land Iguana in Galápagos

The Galápagos Pink Land Iguana (*Conolophus marthae*, Fig. 15.1) was first seen on Volcán Wolf (Isabela island) in 1986, when a group formed by Galápagos National Park rangers and technical personnel of the Charles Darwin Foundation accidentally encountered it during a field trip to the remote northwestern slope of Volcán Wolf (Márquez et al. 2010). After this, pink iguanas were only spotted on a few occasions. However, it is only recently that *C. marthae* has been brought to the attention of science as a new species (Tzika et al. 2008; Gentile et al. 2009).

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Fig. 15.1 A large adult male of *Conolophus marthae* (Photo G. Gentile)

Threats and Actions

A number of threats endanger *C. marthae*. To preserve the species, some of these threats have been tackled with planned actions, discussed in this section. Some of these threats and actions have been the subject of the 2014 meeting of the Iguana Specialist Group of the IUCN, held in Puerto Ayora, Santa Cruz (Galápagos).

Taxonomic Definition and Risk Assessment

Although it is not considered as a threat per se, lack of formal taxonomic status can hinder conservation planning and funding for undescribed species, even though they show unique morphological, ecological, behavioral, and evolutionary traits (Robertson et al. 2011).

The Galápagos Pink Land Iguana was arguably first recognized by the common name of "rosada," meaning "pink" in Spanish (Tzika et al. 2008; Gentile et al. 2009). However, the species was not formally described and internationally recognized as *Conolophus marthae* until 2009 (Gentile and Snell 2009). Despite Gentile and Snell (2009) agreeing with the importance of establishing preserved holotypes when describing a new species, they considered the combination of several threats impacting the only known population of *C. marthae* as incompatible with the sacrifice of an individual to be fixed as the holotype and preserved as a museum specimen. The decision not to sacrifice an individual for the purpose of a holotype fueled further

debate on the protocol for describing and recognizing new species that are clearly critically endangered (Donegan 2009; Dubois 2009; Minelli 2009; Nemésio 2009).

The description of *C. marthae* was based on morphological, genetic, and behavioral diagnostic traits. The holotype was branded a free-living adult male and tagged with a passive integrated transponder (PIT) tag, a subcutaneous electronic marker. Genetic data were also deposited in Genbank (http://www.ncbi.nlm.nih.gov/genbank), and exhaustive photo-video documentation was deposited in MorphoBank (Project n. 241; http://www.morphobank.org). To maximize the chances of the holotype being eventually placed as a fixed specimen in a museum collection, the Galápagos National Park Directorate—the legal authority governing Galápagos Protected Areas and its biological diversity—will collect the holotype, or another individual, from the population. They will then move it to an existing captive facility at the Galápagos National Park Center. Here, it will be maintained until its natural death. Subsequently, it will be preserved and deposited in the Governmental Galápagos collection, maintained by the Charles Darwin Foundation in Puerto Ayora, Galápagos. This action will be enforced if continued monitoring of pink iguanas indicates that their population is increasing. A naturally, freshly dead or dying individual can also be considered. However, since 2005 when formal empirical study of the species initiated, no pink iguana cadavers or dying individuals have been encountered in the field.

A delay in taking actions for the conservation of a threatened species may also arise from the lack of proper evaluation of that species' risk of extinction. Increasingly, the IUCN Red List of Threatened Species has been used for conservation policy and planning purposes (Mace et al. 2008), even if it has been suggested that conservation prioritization should take into account the risk of extinction and other aspects, such as measures of the evolutionary relevance of a species (Redding and Mooers 2006; Drummond et al. 2010).

For the purpose of its inclusion in the IUCN Red List, the first evaluation of the risk status of *C. marthae* was completed in 2012. Currently, the species is listed in the IUCN Red List as "Critically Endangered" primarily for its distribution, geographically restricted and limited to a single location, and for the small number of mature individuals (http://www.iucnredlist.org/details/174472/0). It has to be noted that having described and named *C. marthae* was beneficial for the purposes of the inclusion of the species in the IUCN Red List. In fact, despite the inclusion of undescribed species in the IUCN Red List is exceptionally allowed, although discouraged, the permanence of undescribed species in the IUCN Red List is conditional on the publication of the description of the new species. The description must be completed within the subsequent four years or the assessment will be removed (IUCN Standards and Petitions Subcommittee 2014).

Currently, all species of iguanas belonging to the genus *Conolophus* are included under Appendix II of "Convention on International Trade in Endangered Species of Wild Fauna and Flora" (CITES). Upon its discovery, *C. marthae* was included in the "Conservation and Restoration of Ecosystems" program. This was part of the Galápagos Protected Areas management plan.

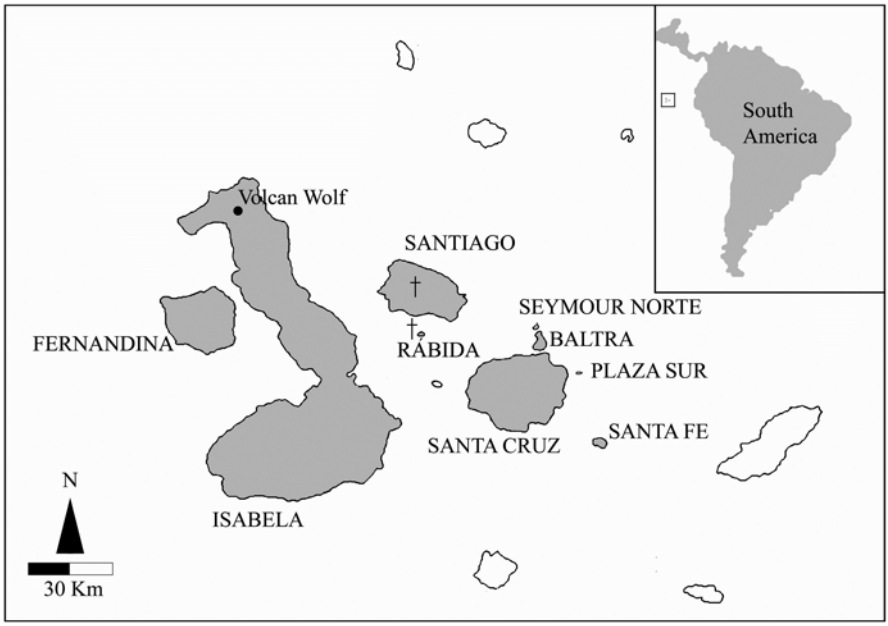

Fig. 15.2 Galápagos archipelago. *Grey* indicates islands where land iguana species occur or have occurred in historic times. *Crosses* indicate extinction in whole island. A *dot* indicates Volcán Wolf (redrawn after Gentile and Snell 2009)

Distribution

C. marthae is endemic to Volcán Wolf on Isabela island (Galápagos, Ecuador). Despite the species first being encountered along the northwestern slopes of the volcano it is most common along the northern slopes of the volcano up to its rim, at altitudes ranging from 600 to 1700 m a.s.l. (Fig. 15.2). The geographic area within which the species can be found is not larger than 25 km^2. However, the largest polygon, obtained by unifying the geographic capture points, measures only 10.9 km^2. Additionally, more than 95 % of observations cluster in a much smaller area (Gentile 2012). Pink iguanas have never been seen inside the caldera, where, in turn, *C. subcristatus* iguanas were nesting in June 2012 and June 2014 (Gentile, personal observation).

Population Size and Recruitment

The single existing population of *C. marthae* approximates a closed population. In stark contrast to *C. subcristatus*, *C. marthae* iguanas were never observed on Volcán Darwin or Volcán Ecuador—the two volcanos on Isabela closest to Volcán Wolf.

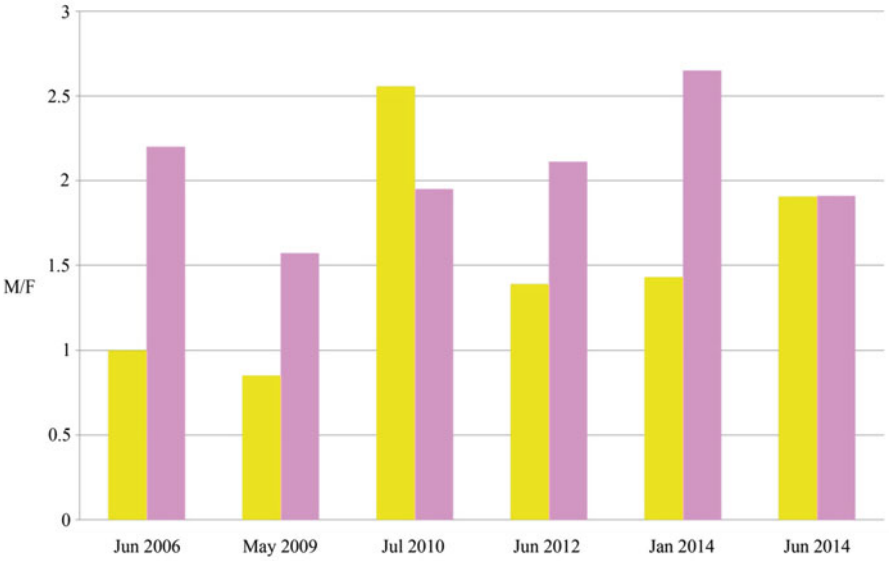

Fig. 15.3 Sex ratio in *C. marthae* (*pink*) and *C. subcristatus* (*yellow*) in Volcán Wolf, Isabela Island

Early mark–recapture data indicated 192 individuals (95 % CL = 155–260). This was calculated by applying the Lincoln–Petersen method from two contiguous temporal samples in 2009 and 2010 (Gentile 2012). Figure 15.3 plots the sex ratio of the two populations. Here, the ratio is indicated as the simple proportion of males and females (M/F) captured and marked on each sampling year (2006, 2009, 2010, 2012, 2014). In 2014, M/F was estimated in January and June. Notably, *C. marthae* consistently shows higher M/F values than *C. subcristatus*.

As *Conolophus* species are iteroparous with overlapping generations we pooled temporal samples of adults of mixed cohorts captured from 2005 to 2009 to estimate N_e, taking advantage of single sample methods based on linkage disequilibrium (Hill 1981; Palstra et al. 2009). The effective population size (N_e) of *C. marthae* was estimated to be as large as 90.7 (95 % CL = 62.9–148.7). This was calculated by using LDNe (Waples and Do 2008) and 20 microsatellite loci data from a sample of 61 individuals. The analogous estimate, obtained from a sample of 64 *C. subcristatus*, returned $N_e = 357.7$ (95 % CL = 200.2–1342.1). Thus, the effective population size of *C. marthae* is four times smaller than the effective size of *C. subcristatus* population in Volcán Wolf alone. Under the assumption that the population size remained constant over the sampling years, the N_e/N ratio for *C. marthae* would be equal to 0.47. It should be noted that, in our estimations, N_e reflects the size of an ideal population experiencing the same rate of random genetic change over time as the real population while N reflects the total census population size including adults, subadults, and juveniles.

Since our estimates of population size come from a single generation, future population trends are impossible to assess. However, genetic data from both microsatellite (Tzika et al. 2008) and mitochondrial DNA (Gentile 2012) suggest that *C. marthae* may have suffered severe demographic reductions in the past.

Indeed, Volcán Wolf is an active volcano, with several eruptions recorded over the last century. The last recorded eruption was in 1982. Most recently, lava has been found on the eastern and southern slopes of the volcano and in the caldera (Geist et al. 2005). It can be argued that eruptions have caused the extinction of local populations of *C. subcristatus* in the past (e.g., Volcán Chico, eastern Volcán Sierra Negra, in 1979, Snell et al. 1984).

Since 2005, no hatchlings, only one juvenile, and a few subadults were observed. This strongly suggests that population recruitment may be noneffective. For these reasons, the Galápagos National Park Directorate is considering a head-start or a captive breeding program.

Given its small population size, *C. marthae* appears prone to demographic, genetic, and environmental stochasticity (Boyce 1992).

Possible Competition with C. subcristatus

As *C. marthae* is syntopic (sensu Rivas 1964) with a population of *C. subcristatus* on Volcán Wolf, there could be competition between the two populations. Competition between iguana species may have negative effects: the introductions of *Iguana iguana* in the area of *I. delicatissima* (Lesser Antilles) resulted in population declines for *I. delicatissima* throughout much of its range (Knapp et al. 2014).

Given the difficult logistics of the site, which limits the duration of field studies, current knowledge of the reproductive biology of the two species in Volcán Wolf is based on circumstantial evidence. In mid-July 2010, the reproductive status of 19 *C. marthae* females was investigated. As ultrasonography proves a reliable, non-destructive method to obtain life history data such as egg and clutch size in wild populations of reptiles (Gilmar and Wolf 2007), we used a Nanomax portable ultrasound system with a 5–8 MHz bandwidth and 10 cm scan depth transducer (FUJIFILM SonoSite, Inc.). The depth settings and screen contrast on the instrument were varied to optimize visualization of the internal anatomy. We applied 0.25–0.5 cm of gel to reduce interference in the signal transmission. We performed transverse, sagittal, and coronal scans of each individual. Continuous video and still images were recorded for future analysis. Five out of the 19 females (26.3 %) showed large shelled eggs (Fig. 15.4), carrying on average 4.4 (±1.5 SD) eggs. No eggs were observed in any of the eight *C. subcristatus* females tested in the same period. In June 2012, out of the 29 *C. subcristatus* females tested, 26 (92.9 %) carried on average 8.4 (±3 SD) shelled eggs. At the same time, one of the 23 (4.3 %) *C. marthae* females carried one egg. In June 2014, nine of 20 (45 %) tested *C. subcristatus* females showed on average 8.5 (±3.3 SD) shelled eggs. Furthermore, a few more females showed follicular eggs (smaller and more spherical than shelled eggs),

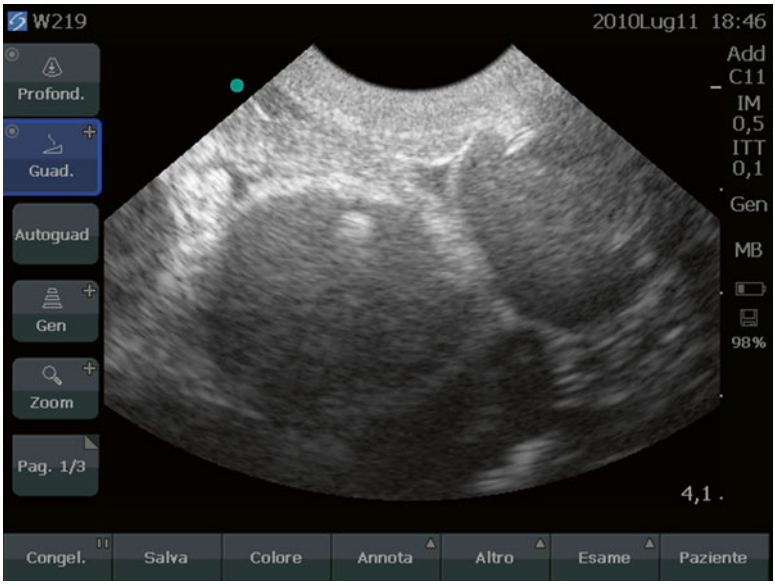

Fig. 15.4 Shelled eggs in a *C. marthae* female. The shell is located around the circumference of the eggs and is more or less echogenic depending on the degree of calcification

while three of 18 (16.6 %) *C. marthae* females carried eggs. Of these, one *C. marthae* female carried three shelled eggs and two carried four to five follicular eggs. While no difference was observed between the average number of shelled eggs carried by *C. subcristatus* in the same sampling periods (June) of 2012 and 2014, the number of *C. subcristatus* females carrying shelled eggs in 2012 and 2014 was significantly different (Z-score = 3.678; two-tailed $p \ll 0.01$). The lower percentage was observed in 2014.

Homo-specific pairs of the two species were observed in mid-May 2009 (Fig. 15.5), as well as in sampling trips executed in 2010, 2012, and June 2014. In those periods, both species were sexually active, as indicated sperm at the cloaca of several females and males.

Available data suggest that in the years 2010, 2012, and June 2014 (no ultrasound data are available prior to 2010), only a few *C. marthae* females reproduced, with *C. marthae* showing a smaller clutch size than *C. subcristatus*. This is consistent with the size of *C. marthae*, smaller than the average size of *C. subcristatus* individuals from Volcán Wolf (Gentile 2012). Given that observations were conducted a month later in 2010 (in respect to 2012 and 2014), we can speculate that by mid-July 2010, most *C. subcristatus* females that had mated had already laid their eggs.

Droughts can impact vegetation at the highest altitudes where pink iguanas forage. Adults obtain water from their largely herbivorous diet and are expected to cope sufficiently well with drought as a result. However, scarcity of food caused by droughts has the potential to lower fecundity for the year. This is due to a higher

Fig. 15.5 Male (*left*) and female (*right*) of *C. marthae*, on the rim of Volcán Wolf (Isabela Island) on May 2009 (Photo G. Gentile)

number of infertile eggs being laid, or a failure of females to nest. Further, droughts increase juvenile mortality, exacerbating the reduction in potential recruitment. Indeed, our data would suggest that on Volcán Wolf, as in other island populations (Werner 1983), nesting season for land iguanas appears to occur at the end of the rainy season. In Galápagos, this occurs between the end of December and end of April. Precipitation increases the abundance of trophic resources for herbivorous land iguanas, allowing allocation of fats to be used for yolk formation. Figure 15.6 shows rainfall during the rainy season in 2010, 2012, and 2014. Precipitation was recorded at sea level in Puerto Ayora, Isla Santa Cruz. Although precipitation can quantitatively vary across the islands it is likely that the broadscale pattern across the years may be similar for all islands. Precipitation was more abundant in the 2010 and 2012 rainy seasons (446.2 mm and 435.1 mm, respectively) than in 2014 (176.9 mm). In particular, in 2010 and 2012 precipitation was abundant in the months anteceding the nesting season, while in 2014 a prolonged absence of precipitation was observed up to May. This is reflected in the lower number of *C. subcristatus* females carrying eggs in 2014.

Conolophus females are less likely than males to select and remain in a defined area. In fact, most females enter several male territories during the pre-mating season, establishing temporary relationships. After mating, females leave male territories to reach nesting sites. Given our sampling scheme, these behaviors can be reflected in the sex ratio pattern of the two populations. In fact, in *C. subcristatus*, when sampling was performed from January to June, our sex ratio estimates were

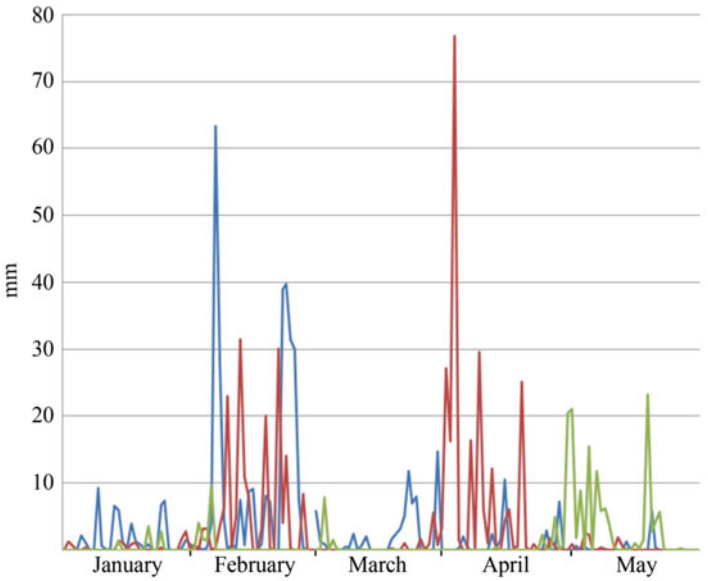

Fig. 15.6 Precipitation in the first semester of years 2010 (*blue*), 2012 (*red*), and 2014 (*green*). Data are from the meteorological station in Puerto Ayora, Santa Cruz Island (Charles Darwin Foundation Meteorological Database: http://www.darwinfoundation.org/datazone/climate/)

closer to 1:1 than when sampling occurred in July 2010, when most females supposedly had already laid eggs. Alarmingly, the sex ratio in *C. marthae* appears to be steadily much higher than 1:1, as would be expected in the case of a small number of females entering male territories for mating.

We need to confirm whether *C. marthae* and the syntopic population of *C. subcristatus* have complete overlapping reproductive seasons as well as whether the two species compete for nesting sites, the location of which is still unknown for *C. marthae*. Competition could also exist for trophic resources. The habitat of *C. marthae* and *C. subcristatus* on Volcán Wolf includes Tropical Dry Shrubland at the top of the volcano and Tropical Dry Forest along the slopes. *C. subcristatus* inhabits areas both surrounding and inside the habitat of *C. marthae*. Preliminary observations (Gentile, unpublished data) suggest that areas surrounding the habitat of *C. marthae* are ecologically distinct from the core area inhabited by *C. marthae*. This suggests that the ecological requirements of *C. marthae* may not be met outside its area. It is clear that uncovering the relationship between area of distribution, habitat characteristics, and its usage will allow us to characterize the ecological niche and formulate a refined habitat suitability model. This could prove crucial in guiding species and implementing habitat conservation actions. This is critical for species that are susceptible and vulnerable to drivers of environmental change. Defining habitat usage for the two species will aid us in identifying the timing and location of competition for resources, should it occur. It will also aid in locating the

nesting sites of *C. marthae*, which is instrumental for the purpose of a possible head-start program. Furthermore, it will clarify whether *C. marthae* and *C. subcristatus* compete for the same nesting sites and lead to a better characterization of the area of distribution for *C. marthae*. Additionally, it will help us to understand times and patterns of the usage of the area and develop habitat suitability models, which will be important to predict habitat changes under different climatic scenarios. Such information may also help us evaluate the feasibility of potential conservation actions. For example, translocations aimed at decreasing the risk of extinction by increasing the range of *C. marthae*, or by establishing new populations in other suitable areas. Understanding the intimate relationship between *C. marthae* and its environment will also allow us to identify and remove the barriers to dispersal, if they exist. Additionally, it will help us to optimize strategies for habitat conservation actions such as the design and implementation of focused and effective campaigns aimed at pest control (see later). Crucial information on the possible inherent competition for trophic resources can be achieved by the assessment of the diets of *C. marthae* and *C. subcristatus* on Volcán Wolf. An in-depth analysis of the diet of *C. marthae* is also important for the purposes of captive breeding or head-start programs. As the logistics of the site are difficult, prolonged study on the volcano is prohibitive. Thus, long-lasting direct observations cannot be carried out. For the purposes of diet assessment, the analysis of stomach-content remains can be obtained through stomach flushing. However, this technique is invasive, logistically difficult and, ultimately, not recommendable as it may affect the survival of lizards (Luiselli et al. 2011). Indirect and completely noninvasive methods, by both traditional scat inspection and more recent PCR-based methods, prove very useful when animals are predominantly herbivores (Soininen et al. 2009). These latter methods are particularly well suited to the iguanas on Volcán Wolf. As the scats are morphologically identical in the two species, the correct species assignment of each scat is impossible without the use of molecular tools. An additional advantage of using molecular tools is that they supply indirect information about the geographic occurrence of the species, providing further data with respect to direct capture or sighting. Recently, Di Giambattista et al. (submitted) optimized a protocol for the molecular species assignment of *Conolophus* scats. Currently, a program aimed at the analysis of the feeding behaviors of *C. marthae* and *C. subcristatus* from Volcán Wolf has started as a collaboration between the University Tor Vergata, the Galápagos National Park Directorate and the Charles Darwin Foundation (Jaramillo et al. 2014). Here, a collection of stool samples is processed. The seeds contained in the feces are identified, classified, and then germinated. Germination confirms their identification and tests whether feces contribute to seed dispersal throughout the area of distribution of iguana's species. This approach, although very important, only provides information on the frugivory component of the iguanas' diet. The folivory component is also important and deserves attention by using a different and complementary approach that includes the use of molecular tools.

Possible Hybridization Between C. marthae *and* C. subcristatus

In recent years, it has been documented that introgressive hybridization is a powerful evolutionary factor through which new trajectories may be established (Schwenk et al. 2008), even via lineage fusion, as shown in some Galápagos vertebrates (Garrick et al. 2014; Kleindorfer et al. 2014). In Galápagos, iguanas hybridization is known to occur between the marine iguana *Amblyrhynchus cristatus*—the sister taxon of *Conolophus* (Wiens and Hollingsworth 2000)—and *C. subcristatus* at Plaza Sur island, with introgression being limited to the F1 generation (Rassmann et al. 1997). More recently, Mac Leod et al. (2015) suggested that introgressive hybridization could mask speciation in the marine iguana. However, hybridization may also cause genetic introgression and contamination of pure populations. For example, hybridization between *I. iguana* and *I. delicatissima* throughout the Guadeloupe Archipelago and French West Indies represents a serious threat for *I. delicatissima* (Knapp et al. 2014).

Due to their overlapping ranges and possible overlapping breeding seasons, hybridization could occur, mediating introgression between *C. marthae* and *C. subcristatus* on Volcán Wolf. The head nodding behavior of *C. marthae* is very distinctive and completely different from *C. subcristatus* (Gentile and Snell 2009). This may act as a barrier to hybridization, with other possible unknown mechanisms of mate choice also existing. Gentile et al. (2009) found no evidence of living F1 hybrids. Instead, they discussed the possibility that one *C. subcristatus* individual exhibited a genotype consistent with it being a second generation backcross. Ultimately, introgressive hybridization appeared to be rare and insufficiently strong to prevent genetic differentiation between the two species. However, it must be considered that the *C. marthae* sample used in Gentile et al. (2009) comprised only 15 individuals and nine microsatellite loci. Clarifying the frequency of hybridization and level of genetic introgression between *C. marthae* and *C. subcristatus* is crucial for the purpose of a possible captive breeding program. This hypothesis has been further investigated by Di Giambattista and Gentile (2014) by genotyping 108 *C. marthae* and 162 *C. subcristatus* from Volcán Wolf at 20 microsatellite loci. Their results provide little evidence of successful hybridization with most individuals revealing a proportion of admixture lower than 1 %, and 2–3 % for a small number of iguanas.

Introduced Species

Introduced species such as cattle, donkeys, pigs, goats, dogs, cats, and rats may have a very strong impact on Galápagos wildlife, including iguanas. Nonnative herbivorous species such as donkeys and goats may generate strong competition for food with iguanas and cause habitat destruction. Pigs can destroy nesting habitat while searching for iguana eggs and possibly hatchlings. Feral dogs and cats are predators

of hatchlings, juveniles, and adult females, while black rats (*Rattus rattus*) are predators of hatchlings and juveniles.

In mid-1970s, dogs almost caused the extinction of two populations of *C. subcristatus* in Santa Cruz island and in Bahia Cartago (southern Isabela) where *C. subcristatus* has been successfully repatriated after dogs' eradication (Fabiani et al. 2011). Feral dogs can also attack marine iguanas (Burnett and Rudd 1983). In February 2005 a few dogs attacked and bit hundreds of marine iguanas along the coast flanking the town San Cristóbal in San Cristóbal island. Gentile and collaborators counted 147 cadavers of marine iguanas along a 1-km long transect. Land iguanas had disappeared from Baltra by 1954 after the construction and operation of an American airbase during the Second World War. A combination of habitat destruction, human predation, and feral cats proved fatal to the iguana population (Woram 1991).

Such negative effects are observed also in other areas of the world. For example, introduced ungulates put at risk some populations of the rock iguana *Cyclura pinguis* on Anegada in the British Virgin Islands (Mitchell et al. 2000) while pigs have strongly impacted on nests of *Cyclura stejnegeri* (Wiewandt 1977), endemic to Mona Island (Puerto Rico). In the 1970s, a large population of *Cyclura carinata* in Pine Cay (Turks and Caicos Islands) was almost completely destroyed within five years by a few dogs and cats introduced by hotel workers (Iverson 1978). The Jamaican Iguana *Cyclura collei* is currently severely affected by feral cats which occur throughout the area and are known predators of juvenile iguanas (Wilson 2008). Despite some evidence showing coexistence of invasive rats and mice with apparently healthy iguana populations (Mitchell et al. 2000), invasive rodents, particularly rats, may have a great impact on endangered insular populations of iguanas. Recently, Hayes et al. (2012) investigated tail damage (including tail-break and tail-furcation) in 3537 individuals of three species of West Indian rock iguanas (genus *Cyclura*) in the Bahamian Archipelago, including the Turks and Caicos Islands. They found that such damages are significantly higher in populations coexisting with invasive rodents, supporting that they result from failed attempts of predation. Besides the potential effect on the fitness that such damages may cause in injured individuals, it is clear that successful predation has a detrimental effect on the population.

The Galápagos National Park Directorate runs major campaigns to control and eradicate exotic species in Galápagos, including Volcán Wolf. So far, such campaigns have successfully prevented habitat disturbance by non-autochthonous goats in northern Isabela, as well as promoted habitat restoration in southern Isabela.

The Galápagos Hawk (*Buteo galapagoensis*) is the only native predator of *C. marthae* on Volcán Wolf. However, feral cats and black rats also occur in Isabela, including Volcán Wolf. Consequently, given the small population size of *C. marthae*, such pests may pose a threat to the *C. marthae* population's recruitment. On this island, the control of feral cats is particularly challenging. Its large area (4588 km^2) impedes the complete elimination of feral cats (Nogales et al. 2004) and control actions can only aim at mitigating the impact.

In the early 2000s, a 3-year program to eradicate feral cats from the Baltra island (where *C. subcristatus* was repatriated from 1991 onwards) was initially effective. It involved poisoning the cats with sodium monofluoroacetate (compound 1080) and then trapping or shooting them (Phillips et al. 2005). However, the applicability of such a protocol at the Volcán Wolf site is still to be evaluated. Further evaluation of the feral cat population on Volcán Wolf is needed for the purpose of implementing a program for their control.

A strategic plan was implemented by the Galápagos National Park Directorate, aimed at the eradication or mitigation of the introduced population of rodents, such as black rats and house mice (*Mus musculus*), from a medium-small area of the Galápagos islands. North Seymour (1.84 km^2) was used as a pilot to test the plan and train personnel. In the case of North Seymour, the campaign to eradicate black rat was conducted using the anticoagulant rodenticide Brodifacoum (Sevilla-Paredes and Rueda Cordova 2014).

Since the early 1980s, the house mouse has been found on South Plaza Island (0.12 km^2). Since then, a decline in the arborescent prickly pear (*Opuntia echios echios*) has occurred. This cactus is a major food item and source of water for the South Plaza land iguana (*C. subcritatus*) population. Mice undermine the root system of the cactus, ultimately resulting in the death of the cactus. The anticoagulant rodenticide Brodifacoum was also used on this island. This was based on prior research of green iguanas (*Iguana iguana*) that indicated a low risk of toxicity in this species and, presumably, in other iguana species. During a rodent eradication campaign, a plan to safeguard the population of iguanas on South Plaza was developed (Tapia et al. 2014). The applicability of these or similar protocols on Volcán Wolf has not yet been evaluated.

Although it is very unlikely that rats and cats may be completely eliminated from Isabela, mitigation actions and monitoring are in order. Additionally, as in Isabela feral cats and rats coexist, integrated actions should be carried out, aimed at the contemporary mitigation of both cat and rat populations (Rayner et al. 2007; Nogales et al. 2013).

Parasites

Ectoparasite load is high on both *C. marthae* and *C. subcristatus* on Volcán Wolf. In fact, the location is characterized by a massive occurrence of ticks (*Amblyomma usingeri* and *A. macfarlandi*). Ticks are much more abundant on Volcán Wolf than elsewhere in the Galápagos archipelago. Cost of infestation by ticks has been estimated for *A. cristatus* and species' behavioral adaptations to reduce the impact of infestation have been discussed (Wikelski 1999). Ticks infesting reptiles can transmit viruses, bacteria, and hemoparasites (Labuda and Nuttall 2004; Kho et al. 2015; Telford 2009). The hemogregarin *Hepatozoon* (Apicomplexa) appears as the only hemoparasite occurring in Galápagos land iguanas (Fulvo 2010). Both the Volcán Wolf populations of *C. marthae* and *C. subcristatus* show a high prevalence of

Hepatozoon infection, as well as a different leukocyte count (WBC), compared to other populations of land iguanas from the whole archipelago. In particular, the heterophils/lymphocytes (H/L) ratio is higher in infected than in noninfected individuals (Onorati and Gentile 2014). It is interesting to note that in iguanas, the H/L ratio is considered to be an effective indicator of stress (Davis et al. 2008). Whether ectoparasite and hemoparasite load affect the fitness of the two populations is currently under investigation.

Illegal Trade

According to TRAFFIC, the wildlife trade monitoring network (www.traffic.org), the wildlife trade involves hundreds of millions of individual plants and animals from tens of thousands of species. Such illicit trade is now estimated to be worth between US$8 and $10 billion per year globally (Haken 2011).

Illegal wildlife trade in Galápagos is a serious issue. Between 2010 and 2012, the authorities of the Galápagos National Park Directorate recorded four cases of illegal collection of Galápagos reptiles. In July 2012, a German tourist was arrested in Galápagos for trying to illegally transport four land iguanas out of the province. The use of appropriate molecular tools, in combination with a previous genetic characterization of a large number of Galápagos iguanas, proved crucial for the purposes of taxonomic identification and rapid repatriation of confiscated iguanas (Gentile et al. 2013). The work was also used in the case of forensics, following the arrest of the tourist, who was then sentenced to 4 years in prison, the maximum penalty. In fact, according to Ecuadorian law, any attempt to remove wildlife from the Galápagos Islands is a serious environmental crime, punishable under Articles of the Ecuadorian Criminal Code. Cases as the one described above are not accidental. In 2011, the same German tourist was arrested in Fiji for attempting to smuggle local reptiles out of that country. Recently, the Galápagos National Park Directorate uncovered a complex network of people involved in illicit trafficking of Galápagos iguanas (Angermeyer 2014). To clarify, there is no legal trade allowed for Galápagos iguanas protected under CITES. Consequently, any specimen from private captive breeding is illicitly reared as resulting from contraband. Authorities of the Galápagos National Park Directorate are strongly committed to the continuous effort required to prevent the illegal trade of Galápaganian wildlife.

The Galápagos Pink Land Iguana as a New Flagship Species

Over the last 20 years, several definitions of the flagship species concept have been proposed and used. For example, the World Wildlife Fund (WWF) currently highlights priority species as those ecologically or socially important (http://wwf.panda.org/what_we_do/endangered_species/). Among these, flagship species are defined

as "iconic animals that provide a focus for raising awareness and stimulating action and funding for broader conservation efforts." In this view, focusing efforts on these species will also help conserve other species that share their habitats and/or are vulnerable to the same threats. While general agreement is still lacking, the socio-economic and strategic significance of the concept has been increasingly emphasized in recent years. In a recent review, a flagship species was defined as "the focus of a broader conservation marketing campaign based on its possession of one or more traits that appeal to the target audience" (Veríssimo et al. 2011). Based on this concept, which no longer has any biological or ecological implications, a methodology was proposed to evaluate existing conservation flagships. Such methodology evaluates the success of a particular flagship by assessing its visibility and recognition (Veríssimo et al. 2014).

It is not the purpose of this chapter to further contribute to the general debate on the flagship species concept. Nevertheless, we will provide some additional considerations of the evolution of *C. marthae*, as well as the social impact the species has had since its discovery. These considerations may help to identify the potential role of *C. marthae* as a flagship species.

Evolutionary Importance

The discovery of a new species of megafauna in one of the most remote, yet greatly investigated, areas of the world was surprising. Indeed, *C. marthae* was found in the Galápagos Islands, one of the most important locations in the world for the development of evolutionary thinking. Charles Darwin visited the Galápagos in 1835 and his 5-week stay in the archipelago proved crucial for the development of his theory of evolution by natural selection. Darwin visited Isabela island but he did not explore Volcán Wolf. Thus, although he noted and commented on both the marine and land iguanas (Darwin 1839), he did not encounter the Galápagos Pink Land Iguana. In a sense, he missed it.

Gentile et al. (2009) performed genetic analyses indicating that the most recent common ancestor between *C. marthae* and the other two congeneric species (*C. subcristatus* and *C. pallidus*, also endemic to Galápagos) existed long ago. They suggested that such an ancestor could have existed between five and six million years (Myr) ago, when the Galápagos did not have their current appearance and none of the existing islands had yet emerged (Geist et al. 2005). Currently, the age of the original split between *C. marthae* and other congeneric species is being revisited, with a more recent proposed origin between one and two million years (Mac Leod et al. (2015)). It is clear that *C. marthae* is a real biogeographic conundrum. It only occurs on Volcán Wolf, which is considered younger than Volcán Sierra Negra, at 0.53 million years Sierra Negra is the oldest volcano of Isabela (Nordlie 1973). Volcán Wolf is almost as old as Volcán Cerro Azul, which is 0.35 million years (Naumann and Geist 2000). The species carries substantial evolutionary information. In fact, it is the only representative of a separate ancient lineage that testifies to

the divergence events occurring within *Conolophus* since its original splitting from the marine iguana lineage (Rassmann 1997).

For these reasons, *C. marthae* was featured as the closing scene of the recent series of documentary movies "GALÁPAGOS," written and presented by Sir David Attenborough and produced by Colossus Productions. While advertising the series, Attenborough publicly commented on the species:

> I used to collect stamps and this [pink iguana] was a Penny Black of the natural world in a very big way.

It is interesting to note that the UK's 1840 issued Penny Black was the first adhesive postage stamp ever to be produced. In the series, evolutionary questions regarding *C. marthae* were posed, including the origin and possible selective significance of its color.

The evolutionary importance of the species was also recognized at academic level. In fact, in 2010, the International Institute for Species Exploration at Arizona State University nominated *C. marthae* to be among the most important species newly discovered for the year. In 2012, the same institute included *C. marthae* among the most important new species of the century.

The Galápagos Pink Land Iguana and Society

After the vast mass-media coverage upon its discovery, *C. marthae* became the focus of several educational publications. The species entered the Guinness Book of World Records as the "newest species of iguana" (http://www.guinnessworldrecords.com/world-records/newest-species-of-iguana), although it was reported with a wrong scientific name. The name "Pink Iguana" and logos referring to the species have also started being used for commercial purposes in the Galápagos (Fig. 15.7). Unexpectedly, *C. marthae* was also inspirational to several different initiatives. The link between the animal and evolution was adopted in different ways and contexts to express unicity and capability to evolve in a changing environment. For example, in an economic context, newly founded private business companies were named after the Galápagos Pink Land Iguana to express excellence and ability to perform in a changing market.

The concept was also developed in an artistic context. In 2011, *C. marthae* became the subject of the INPUT Journal, an aesthetic journal on contemporary currents and cultural conditions published by an international ensemble of editors. The species served as a metaphor, considering that the form of the book is near extinction and the art book is distributed via a threatened environment—the art and architecture book store. INPUT asked a community of 12 emerging artists to contemplate *C. marthae* as they considered the art book as an evolving and adapting medium of artistic engagement. The work "INPUT #3—The Pink Iguana" was presented on August 4, 2011 in New York City, http://vimeo.com/26775603.

Fig. 15.7 A signboard portraying the Pink Iguana name and logo in Villamil (Isabela Island) (Photo: L. Di Giambattista)

Remarkably, for its delicate color, *C. marthae* also became the subject of storybooks for children to convey concepts of love and friendship (Fig. 15.8).

The Galápagos Pink Land Iguana and Conservation

In 2009, the WWF-Italy identified a project that led to the discovery of *C. marthae* as among the most relevant Italian projects contributing to the safeguard of biodiversity. It also received attention in 2013, when the Species Survival Commission of the IUCN featured the species in the "Amazing Species"; an initiative to promote popular understanding of threatened species (http://jr.iucnredlist.org/documents/amazingspecies/conolophus-marthae.pdf). Currently, such an initiative has over 21,000 followers on Twitter and over 33,000 on Facebook. These two examples show how *C. marthae* has a role in focusing the attention of the general public on themes of biodiversity and conservation.

Furthermore, *C. marthae* also plays a role as a strategic element in the conservation of the Galápagos Islands. An excellent example of this is provided by Lonesome

Fig. 15.8 Illustration from "The Blue Footed Booby Brothers and The Pink Iguanas," written and illustrated by Gabrielle Shamsey, Pennington, NJ (gabrielleshamsey@verizon.net). The image is courtesy of the Author

George, the last documented member of *Chelonoidis abingdoni* and one of the endemic species of giant tortoises inhabiting the Galápagos. Lonesome George was the most effective icon of Galápagos conservation and a global conservation symbol. Even after passing away in 2012, Lonesome George keeps its significance. Efforts are currently being made to ensure the proper preservation of the specimen and its exposure in a museum, allowing a large number of people to experience the species (http://www.amnh.org/explore/preserving-lonesome-george).

In the Galápagos National Park Directorate's vision, environmental education is crucial as it encourages a change in attitude and behavior in Galápagos citizens. Moreover, it promotes the harmonious relationship between man and nature. *C. marthae* provides an important opportunity for environmental education and the promotion of Galápagos identity in the local population. Through the subjects of natural sciences, locals can learn about the exclusivity of the different species of the archipelago, their interrelationships in the ecosystem, and their lifestyle. In particular, the peculiarity and uniqueness of the Galápagos species increases the pride of Galápagos citizens. They are proud to be a part of the Galápagos delicate ecosystem, internalizing the need to care and magnifying their sense of belonging (De la Rosa 2014).

The "Management Plan for the Protected Areas of Galápagos for the Good Living" establishes principles and criteria for the selection of focal species for the conservation Galápagos biodiversity. Several types of species are identified, which justify a selective administration of biodiversity. Such species are used as

management tools on which available resources and actions are focused (http://www.galapagospark.org/noph.php?page=institucion_plan_de_manejo). Among those species, flagships are considered strategic species which, for popular acceptance, are used as flags of programs contributing to global conservation funding. Certainly *C. marthae* is one of them. The idea of taking advantage of more than one unique and evocative species for conservation campaigns is in line with recent evidence (Veríssimo et al. 2014) that shows it is advantageous for organizations to create flagship fleets. Such fleets can broaden the appeal of conservation campaigns, rather than simply preferring the use of a few long-standing flagships.

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