Adult female Jamaican Iguana (*Cyclura collei*) covered with red dirt acquired while digging a nesting burrow. *Photograph by John Binns.*

Status of the Jamaican Iguana (*Cyclura collei*): Assessing 15 Years of Conservation Effort

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Abstract.—Following its rediscovery in 1990 in the remote Hellshire Hills, the Jamaican Iguana (*Cyclura collei*) has been the focus of a sustained conservation effort aimed at securing the species' short- and long-term survival. Major threats to the iguana's persistence include habitat destruction by humans and predation by introduced mammals such as dogs, cats, and the Indian Mongoose.

Beginning in 1990 with field surveys of the remnant *C. collei* population and the formation of the Jamaican Iguana Research and Conservation Group (JIRCG), a variety of conservation measures have been implemented. Protection and monitoring of known nesting areas have facilitated the collection of founder stock for captive breeding and "headstart" programs, and have resulted in the collection, mark, and release of hundreds of *C. collei* hatchlings. As hedges against extinction in the wild, breeding nuclei of *C. collei* have been established at the Hope Zoo in Kingston and also at six U. S. zoos (Central Florida, Fort Worth, Gladys Porter in Brownsville, Texas, Indianapolis, San Diego, and Sedgwick County in Wichita, Kansas). The first captive-bred hatchlings were produced in September 2004 at the Hope Zoo. Adult-sized, headstarted *C. collei* reared at the Hope Zoo have been successfully repatriated into the Hellshire Hills, and we have now verified post-release survival of up to eight years. Egg-laying has been observed in repatriated females, suggesting that this zoo-based augmentation effort is having a positive effect on the remaining wild population.

Ongoing exotic predator removal efforts seek to maintain a conservation zone that is largely devoid of non-native mammalian predators such as cats and mongooses. To date, hundreds of these invasive predators have been trapped and removed from the core *C. collei* area, and preliminary data suggest that the iguana may be benefiting from this predator control program. More recently (2003–2004), efforts to control feral dog and pig populations have been intensified.

Overall, the biological interventions directed at *C. collei* appear to have been highly successful. Unfortunately, *C. collei*'s dry forest habitat is at risk of ecological destruction. The remaining primary forest in Hellshire is under constant assault from the activities of illegal tree cutters, primarily charcoal burners. The JIRCG has protected a small portion of the forest in the vicinity of the known nesting areas and major iguana concentration, and attempts to discourage charcoal burners from penetrating farther into the undisturbed forest. If implemented, tabled government plans from the 1960s for large-scale commercial and residential development would likely cause the extinction of *C. collei*. Encouragingly, increased national and international appreciation of Hellshire's stature as one of the finest remaining examples of Caribbean dry forest, together with considerable interest in the iguana's plight, give hope that this unique ecosystem and its endangered occupants will receive adequate protection. Indeed, the Jamaican government's declaration of the Portland Bight Protected Area (PBPA) in 1999 (including the Hellshire Hills and the Goat Islands) and the recent (2004) delegation of management authority to the Urban Development Corporation (UDC) is a positive step in that direction.

Key Words: *Cyclura collei*, Dry Forest Herpetofauna, Endangered Species, Headstarting, Jamaica, Predator Control, Conservation

Introduction

Thought extinct for much of the last century, the Jamaican Iguana (*Cyclura collei*) was rediscovered by a pig hunter in the remote interior of the Hellshire Hills in 1990 (Vogel et al. 1996). Field surveys in the latter half of 1990 revealed a remnant iguana population persisting in the central portion of the Hellshire range, and also resulted in the identification of two active nesting sites (Vogel 1994). The adult population was estimated at 50–200 individuals, and low recruitment potential was inferred from the virtual absence of observations of young iguanas and the rarity of new females appearing at the known nesting sites (Vogel 1992, 2000). Considered at the time to be the

Nesting female Jamaican Iguana at one of the two known communal nesting areas in the central Hellshire Hills. *Photograph by Glenn Gerber.*

One of the two known communal nesting sites of the Jamaican Iguana. *Photograph by Peter Vogel.*

Byron Wilson processing a mongoose captured in the core iguana conservation area. *Photograph by Peter Vogel.*

"most endangered lizard in the world," *C. collei* appeared to be at the brink of extinction (Alberts 1993).

The 1990 rediscovery of *C. collei* led to a sustained recovery effort that began with the formation of the Jamaican Iguana Research and Conservation Group (JIRCG), a local organization comprising members from the University of the West Indies, the Hope Zoo, the National Environment and Planning Agency, and the Institute of Jamaica. Working with a variety of international conservation and funding agencies over the last 15 years, the JIRCG has endeavored to protect the remnant *C. collei* population and continues to lobby on behalf of both the iguana and its threatened dry forest habitat.

Threats to Iguanas

Because the small iguana population was persisting in a relatively large tract of undisturbed primary forest, predation by nonnative mammalian predators was considered to be the primary cause for the species' apparent low recruitment potential and low population density (Alberts 1993, Vogel et al. 1996). Subsequent research and field observations have validated this early assessment. We now have definitive evidence that dogs, cats, and mongooses prey on *C. collei*. Dogs pose an obvious threat even to adult iguanas (Woodley 1980, Vogel 1992, Vogel et al. 1996), and feral cats have recently been identified as a serious threat to young *C. collei* (Wilson et al. 2004). Predation on young iguanas by the Indian Mongoose (*Herpestes auropunctatus*) is regarded as the single most important source of mortality (Vogel 1992, 2000; Alberts 1993, 2000; Wilson et al. 2004).

Other important threats to the *C. collei* population are social rather than biological, and present the most formidable challenges to the species' existence. At present, degradation of the forest by charcoal burners is reducing the remaining primary forest habitat to the point where the Hellshire Hills could be incapable of supporting a viable iguana population within the next several decades. In addition, previously tabled government plans for large-scale development in undisturbed sections of the peninsula have not been officially abandoned.

In response to these various threats, the JIRCG instituted an emergency conservation strategy to preserve the species. An immediate objective sought to divert traditional forest users away from the core iguana area and to protect the known nesting sites during the reproductive season. By 1992, the JIRCG formulated a management plan outlining a strategy both for reducing the risk of short-term extinction and for securing the iguana's long-term persistence in a protected conservation zone (Vogel 1992).

The original recovery plan outlined three general management priorities: (1) establishment of captive breeding and satellite populations as safeguards against extinction, (2) research and conservation efforts aimed at protecting the remnant wild pop-

ulation, and (3) long-term preservation of the iguana's habitat. Significant progress has been made; for example, we now possess a comprehensive set of biological management tools that have proven successful in the field. Unfortunately, social and political issues have so far prevented the implementation of a management system for the conservation of the dry forest habitat, despite the inclusion of the Hellshire Hills in the recently (1999) declared Portland Bight Protected Area (PBPA). As a consequence, in spite of some notable successes in recovering and protecting the species, the status of the wild *C. collei* population remains precarious. Below we summarize the progress of the *C. collei* recovery effort and comment on prospects for the species' long-term survival.

Captive Populations

As hedges against catastrophic loss in the wild and potential reservoirs of genetic diversity, the maintenance of captive populations can be a valuable tool in efforts to prevent extinctions. For *C. collei*, genetically managed captive-breeding programs have now been established at the Hope Zoo in Kingston and at six U. S. zoos. Mating or egg-laying has been observed at several institutions, and, in 2004, the first successful captive breeding of *C. collei* was confirmed at the Hope Zoo. Specifically, three healthy hatchlings were retrieved from one of the headstart enclosures. We anticipate accelerated production from these breeding nuclei as the captive cohorts mature into full reproductive stature and as improvements to breeding facilities are completed.

View of the Hellshire Hills, one of the last remaining stands of pristine dry tropical forest in the insular Caribbean. *Photograph by Peter Vogel.*

Satellite Populations: The Goat Islands Iguana Reserve

Small offshore islands either lack invasive species or can be rendered completely pest-free (Tolson 2000), and human encroachment is constrained by access. Moreover, the biological interventions necessary to rehabilitate small islets are comparatively simple and correspondingly cost effective. Not surprisingly, such satellite islands have become valuable centers for biodiversity conservation in the Caribbean and elsewhere.

An important component of the original (1992) recovery strategy for *C. collei* was the establishment of a satellite *C. collei* population on Great Goat Island, off the western edge of the Hellshire Peninsula. Great Goat Island contained an iguana population at least until the 1940s, and has long been recognized as an ideal site for the creation of a biodiversity reserve featuring a repatriated *C. collei* population. Both Great and Little Goat Island form part of the Portland Bight Protected Area, and Great Goat Island is posted as a no (bird) shooting reserve. However, semi-feral goat populations overrun both islands. The goats are owned by private individuals based on the nearby mainland, who bring water to and occasionally harvest the animals. Other exotic species include rats, mice, and mongooses. The mongoose was apparently introduced to the Goat Islands by fishermen in the 1920s, in a misguided effort to reduce the Jamaican Boa (*Epicrates subflavus*) population (Lewis 1944).

A wild female Jamaican Iguana constructing a nesting chamber. *Photograph by Glenn Gerber.*

Mongoose trapped in the core iguana conservation zone. *Photograph by Byron Wilson.*

Due to proximity to a major city and area of coastal commerce (Old Harbor and Old Harbor Bay), the Goat Islands are readily accessible by boat, so security risks to equipment and field personnel are significant concerns. In addition, the removal of the goats will require the presence of a permanent and locally well-recognized management entity. Therefore, initiation of a conservation program for the Goat Islands will not be feasible until permanent security and enforcement capacities are operational. Importantly, the eradication of invasive species from the Goat Islands is a high priority objective of the Jamaican government's "National Strategy and Action Plan on Biological Diversity in Jamaica" (NEPA 2003).

View of the Hellshire forest and Caribbean Sea from a ridge in the core iguana area. *Photograph by Glenn Gerber.*

Profile of wild Jamaican Iguana (*Cyclura collei*). *Photograph by Peter Vogel.*

Great Goat Island, off the western edge of the Hellshire Hills, site of a planned re-establishment of a satellite iguana population. *Photograph by Glenn Gerber.*

The Portland Ridge Peninsula to the west of the Hellshire Hills represents another option for establishing a satellite iguana population. Narrowly connected to the mainland, the essentially unpopulated peninsula has retained significant stands of natural dry forest, and *C. collei* subfossils are known from several cave systems. Portland Ridge has benefited from the presence of bird shooting clubs that have actively prevented or minimized deforestation in various portions of the peninsula. Furthermore, Portland Ridge forms the western section of the Portland Bight Protected Area, so its remaining natural areas might benefit from future management policies.

Headstarting

The Hope Zoo in Kingston is coordinating an active headstart program, whereby hatchling iguanas collected in Hellshire are raised at the zoo to a size at which they are less vulnerable to introduced predators such as the mongoose. At this point, they are reintroduced into the wild. We have now released 51 headstarted individuals back into Hellshire, and post-release monitoring has demonstrated that captive-reared iguanas easily adjust to wild conditions and post-release survival rates have been unexpectedly high (Hudson 2000, Wilson et al. 2004).

Movement patterns, behavior, and short-term survival have been monitored with the use of radio telemetry, and long-term survival has been assessed through live trapping and observations of individually marked animals. We have documented survival of up to eight years following release back into the wild. Of the original 20 iguanas repatriated between 1996 and 1998, at least eight (40%) are known to have survived for over two years post-release (Wilson et al. 2004). Many of these captures were incidental to our mammal trapping program, so actual survival rates of repatriated *C. collei* are undoubtedly higher than these already encouraging figures.

Perhaps more significantly, we have also observed successful egg-laying among repatriated females. Together with observations of released males engaging in seemingly normal social interactions, these results suggest that repatriated iguanas have been successfully integrated into the reproductive population. Given the existing low levels of natural recruitment, this augmentation effort appears to be having a positive influence on the remnant population (Alberts 2000, Vogel 2000, Wilson et al. 2004).

Control of Non-native Mammalian Predators

Aside from habitat loss, the negative impact of introduced species is now regarded as the most significant threat to the maintenance of global biodiversity. On islands in the Caribbean, the impact of introduced mammalian predators has been devastating to indigenous faunas (Schwartz and Henderson 1991; Case et al. 1992). For *C. collei*, non-native mammalian predators are clearly the single most important factor preventing recruitment of new iguanas into the breeding population (Vogel et al. 1996, Vogel 2000, Wilson et al. 2004).

We have been conducting an extensive trap and removal program aimed at these pest species. To date, we have removed

Repatriated, "head-started" Jamaican Iguana perched on a bench at the field camp in the central Hellshire Hills. *Photograph by Byron Wilson.*

over 500 mongooses, several hundred introduced rodents, approximately 40 feral cats, and a growing number of feral dogs (three in 2004) and wild pigs (26 and counting in 2004). Encouragingly, field observations of juvenile iguanas have increased since initiation of this removal trapping effort, suggesting that exotic predator control enhances survival of young iguanas. Future monitoring efforts should confirm that predator control has enhanced survival and recruitment into the breeding population. Additional research in progress seeks to elucidate the long-term demographic responses of several other rare reptilian species to the removal of non-native mammalian predators such as the mongoose. These efforts use a combination of pitfall traps and mark-recapture studies to investigate long-term trends in ground reptile abundance on predator-infested versus predator-controlled plots.

Free-ranging, repatriated Jamaican Iguana wearing a radio-transmitter vest produced and donated by Nike. *Photograph by Joe Wasilewski.*

Threats to Iguana Habitat

The biological components of the recovery effort appear to have been demonstrably effective. The rediscovery and rapid assessment of the iguana population in 1990 have led to the subsequent implementation of successful captive and field-based conservation measures (Vogel 2000, Wilson et al. 2004). Unfortunately, the most serious threats to the iguana's persistence are social and socioeconomic, and are considerably less tractable than the biological issues. The remnant *C. collei* population and its remaining dry forest habitat are both at high risk of extinction due to anthropogenic influences (Vogel et al. 1996, Wilson and Vogel 2000).

The most immediate threat to the iguana's remaining habitat is illegal tree cutting, primarily for charcoal production (Wilson and Vogel 2000). Whereas traditional charcoal burners used machetes to fell trees, today's charcoal burners often use chainsaws, thereby accelerating the rate of forest destruction. Since the iguana's rediscovery in 1990, members of the JIRCG have attempted to divert tree harvesting away from the core iguana area, and these efforts have met with some significant successes (Vogel et al. 1996, Vogel 2000). In particular, the JIRCG's efforts undoubtedly have resulted in protecting the core *C. collei* nesting areas from otherwise likely destruction by charcoal burners. That said, diversion of tree-cutting activities away from the known nesting areas in no way signifies that the rate of iguana habitat loss has lessened in the species' remaining primary forest habitat.

Several factors render charcoal burning an unsustainable and damaging enterprise. Limited soil deposits and scanty rainfall severely limit the ability of dry forests to regenerate, and

Byron Wilson contemplating the problem of invasive species [introduced predators]; note the palm-shaded mongoose trap in the lower right-hand corner. *Photograph by Glenn Gerber.*

An introduced mongoose, shortly after a crash course on invasive predator control. *Photograph by Joe Wasilewski.*

increased solar penetration in clear-cut areas may also inhibit seedling germination and survival by reducing soil moisture (McLaren 2001). As a result, severely degraded areas may never recover to their original condition. With virtually no potential for a sustained yield harvest, charcoal burners necessarily focus their efforts on the remaining uncut, primary forest.

In addition to the charcoal industry, other ominous threats to the iguana's habitat exist. For example, government plans dating from the 1960s to develop a large residential complex across the eastern half of the peninsula, if pursued, would surely doom the iguana to extinction (Vogel et al. 1996). Although now unlikely to be implemented due to the iguana's rediscovery and the considerable local and international interest the species' plight has generated, these development plans have not yet been officially abandoned. The declaration of the PBPA and the recent delegation of management authority (see below) are positive signs that the area may ultimately receive the protection it so desperately needs.

Lessons from a Conservation Effort: The Fate of *Cyclura collei*

After a 15-year commitment to save the iguana, can we say that the species has been rescued from the brink of extinction? The answer to this question is maybe. A successful captive program has been established, and the wild population is showing some tentative signs of recovery. However, the iguana's imperiled habitat still does not enjoy any effective protection, and is very much at risk of ecological annihilation within the next half century.

Portions of the remaining pristine forest are disappearing daily. Nevertheless, we must remain optimistic that the enforcement necessary to halt this destruction will come before it is too late. Clearly, the charcoal burning industry threatens the iguana's persistence in a very immediate and pressing fashion. Predator control efforts and other biological interventions will be superfluous if the Hellshire forest ceases to exist. However, efforts to address critical conservation issues cannot await the initiation of optimal habitat management practices. Indeed, such efforts can provide the necessary foundation for the growth of more comprehensive and enduring conservation programs aimed at securing the persistence of both the iguana and its relictual habitat.

Active management and enforcement of tree-harvesting laws are urgently needed. One promising development was the declaration of the Portland Bight Protected Area (PBPA) on Earth Day 1999. This government-declared conservation zone includes all of the Hellshire Hills and therefore appears to provide a potential mechanism for protecting the iguana's remaining habitat. Unfortunately, the government lacks the resources to manage the PBPA. Now, fully five years after the celebrated and much publicized declaration of this new protected area, no tangible progress has been made toward habitat protection. However, the government has recently (2004) delegated the management authority for the area to the Urban Development Corporation (UDC) — the organization that owns most of the Hellshire Hills and all of the Goat Islands. One can only hope that the UDC acts quickly and decisively to stem the current wave of deforestation; otherwise, the PBPA will remain little more than a paper park, and the Hellshire Hills will soon become little more than a biological wasteland harboring a highly degraded forest containing greatly diminished biological diversity. Encouragingly, the UDC appears keen to preserve the remaining natural habitat and to rehabilitate the Goat Islands for the establishment of a repatriated iguana population.

Beyond Doom and Gloom: Does Hope Exist for the Hellshire Hills?

In large part due to the connection between environmental quality and basic living standards, conservation issues are attracting increased attention in Jamaica. Because Jamaica has long been recognized as a globally important biodiversity hotspot, the impetus for environmental action is now clear at both the national and international levels. The next two decades will be critical. The requisite political will, coupled with the cooperation of relevant conservation and funding agencies, might yet rescue this outstanding example of West Indian dry forest and its unique endemic fauna. The future roles of the UDC and relevant government agencies will ultimately determine whether this outstanding wild area retains its intrinsic biological value for future generations to appreciate.

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View of the dry tropical forest in the central Hellshire Hills. One of the two known nesting areas is located in the bottom of the depression; the other major nesting area is located on the western rim of the depression (to the right). *Photograph by Peter Vogel.*

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