Survival, dispersal and reproduction of headstarted Mona Island iguanas, *Cyclura cornuta stejnegeri*

Miguel A. García[1,2,5], Néstor Pérez-Buitrago[2,3], Alberto O. Álvarez[1], Peter J. Tolson[4]

[1] Division of Wildlife, Department of Natural and Environmental Resources, P.O. Box 366147, San Juan, Puerto Rico, 00936
[2] Center for Applied Tropical Ecology and Conservation (CATEC), University of Puerto Rico-Río Piedras, Puerto Rico, 00931
[3] Department of Biology, University of Puerto Rico-Río Piedras, Puerto Rico, 00931
[4] Department of Conservation and Research, The Toledo Zoo, Toledo, Ohio 43609, USA
[5] Corresponding author; e-mail: magarcia@drna.gobierno.pr

Abstract. The endemic Mona Island Iguana, *Cyclura cornuta stejnegeri*, is considered endangered, and exhibits relatively low population numbers and reduced recruitment of juveniles to adults. A headstarting program was initiated in 1999 to increase the effective population number. Two groups of headstarted iguanas were released in April and August 2002, after reaching a target size. Most of the released iguanas have since been observed to be active and in good health. Two females bred in 2004, the first certain record of reproduction by headstarted *Cyclura* iguanas in the wild. Eight radiotracked individuals had large dispersal ranges, with mean Minimum Convex Polygon (MCP) of 10.7 ha (range 2.6-22.2 ha) and mean distances covered of 288 m (range 471-6396 m). We discuss the future development of the headstarting program for Mona Island iguanas.

Key words: *Cyclura*; dispersal; headstarting; iguana; Mona Island; radiotracking.

Introduction

The Mona Island iguana (*Cyclura cornuta stejnegeri*) is classified as endangered by the IUCN (2006) and as threatened on the U.S. Endangered Species List, due to a relatively low population density and a low recruitment of juveniles into the adult population (Díaz, 1984; DNER, 2004; Moreno, 1995; Wiewandt, 1977; Wiewandt and García, 2000). The main threats to this iguana are habitat modification and predation by exotic mammals (Wiewandt, 1977; Wiewandt and García, 2000). The major habitat changes have been at nesting sites, where the native vegetation has been replaced by plantations of Australian pine, *Casuarina equisetifolia* (Wiewandt,

© Koninklijke Brill NV, Leiden, 2007

Also available online - www.brill.nl/ah

1977; García, 2004). *Casuarina* leaf litter accumulates as a thick layer of organic matter that female *Cyclura* cannot penetrate to nest (Wiewandt, 1977). In addition, there is predation from feral cats and pigs on juveniles and eggs, respectively (Wiewandt, 1977; Wiewandt and García, 2000; García et al., 2001). These impacts on the iguana population might well explain the poor recruitment and scarcity of immature iguanas observed in the wild (Wiewandt, 1977; Wiewandt and García, 2000). In fact, the survival rate of Mona Island iguana hatchlings during their first five months was estimated at less than 25% in one radiotracking study (Pérez-Buitrago, 2000). That finding catalyzed the implementation of a headstarting program on Mona Island in 1999. Headstarting is a conservation strategy consisting of keeping hatchlings in captivity until they reach a size that is less vulnerable to early age-class predators such as feral cats. Herein, we report survival and dispersal of headstarted Mona Island iguanas as determined by radiotracking and direct observation.

Methods

Mona Island (5,301 ha) is located 68 km west of Puerto Rico in the Mona Passage (18°05′ N, 67°54′ W). Mona Island was designated a Natural Reserve in 1973 and is now managed by the Department of Natural and Environmental Resources (DNER). Annual mean precipitation is 810 mm with distinct dry (January-April) and wet (August-November) seasons. The mean annual temperature is approximately 25°C and the habitat on the island is classified as subtropical dry forest (Ewel and Whitmore, 1973).

We collected iguanas for headstarting as hatchlings in November 1999 and marked them individually with AVID® passive integrated transponders (PIT tags). Table 1 shows sex, release details, and size on release and recapture. Individuals grew at different rates, but in 2002 a group of five iguanas was selected for the first release after reaching a target snout-vent length (SVL $>$ 25 cm) and mass ($>$950 g). Internal transmitters were surgically implanted by a veterinary team from the Toledo Zoo. We used AVM® model G3 radiotransmitters powered by K-7 batteries with a 12-month life expectancy. Transmitter mass was 12 g and measured $44 \times 6 \times 8$ mm. Transmitters were thus $<$1.3% of the body mass of the iguanas. The first group was released in the Corral Wiewandt (CW) site, near Punta Arenas, where they had been taken originally from nests. A second group of five iguanas was similarly processed, but they were released at a different site Carabinero (CAR). The first and second groups were released on 25 April and 10 August 2002 (table 1). For visual identification, we marked each individual externally with a unique combination of color-coded beads on wire sewn through the dorsal crest.

We calculated the minimum convex polygon (MCP) for each individual (Jenrich and Turner, 1969). The MCP reported here does not represent a home range sensu stricto, but the area covered by a headstarted iguana while seeking a place to settle down; i.e. a dispersal range. In addition, we estimated the total distance traveled by

Table 1. Morphometrics, sex, release data, number of recapture locations (n), dispersal range MCP estimates and distances traveled for headstarted Mona Island iguanas, *Cyclura cornuta stejnegeri.*

ID #	Sex	Release date	Release site	Release BM (kg)	Release SVL (cm)	n	Monitoring length (d)	MCP (ha)	Distance traveled (m)	Recapture BM (kg)	Recapture SVL (cm)
3784	F	Apr-02	CW	1.32	28.1	69	148	15.45	3421	3.00	40.0
6094	M	Apr-02	CW	1.05	27.3	102	260	16.97	5419	–	–
2796	M	Apr-02	CW	1.04	27.0	43	95	7.54	3148	2.05	39.7
9030	M	Apr-02	CW	1.06	27.4	96	227	11.78	6396	3.60	42.1
0051	F	Apr-02	CW	0.95	26.5	4	5	–	471	2.85	36.5
1277	M	Aug-02	CAR	1.12	29.6	33	66	5.13	1684	–	–
7787	F	Aug-02	CAR	1.05	26.6	17	28	2.55	735	–	–
4096	F	Aug-02	CAR	1.13	28.3	–	–	–	–	–	–
4890	M	Aug-02	CAR	1.04	28.0	13	20	3.79	747	–	–
0582	M	Aug-02	CAR	1.01	25.1	41	88	22.21	3576	–	–

iguanas from the beginning to the end of the monitoring period. We used the animal movement analysis extension for ArcView v3.2 software (Hooge et al., 1999). Animals were tracked on alternate days for as long as the transmitters functioned. Only animals with more than 10 detections were used for the MCP calculations. Values in the text are shown as mean ± SD.

Results

We rapidly lost the signal from three iguanas, one from the first group (five days) and two from the second group (20 and 28 days). Nevertheless, two animals from the first group were tracked for 7-8 months, providing 96 and 102 telemetry fixes (table 1). By November we were unable to detect any signals from the second group, released in August. For animals monitored more than 20 days, the time between consecutive locations ranged from 1.5-2.5 days (mean = 2.1 ± 0.3 d).

We continued searching actively for all iguanas after losing their signals and found four of them, all from the first group. All of these had lost their bead tagging, which was replaced. However, all the animals observed or recaptured were healthy, growing and active. Thus, searching for iguanas with inactive transmitters provided additional survivorship data. Specifically, one individual was recaptured 14 months later (June 2003) and three others were recaptured 27 months afterwards (July 2004). Depending on the time of recapture, these animals gained between two and three times their biomass at release (table 1). A conservative estimate is that at least 40% of the radio-marked headstarted iguanas survived for more than one year and 30% survived more than two years in the wild. This survivorship is similar to the values (30-40%) documented for the Jamaican iguana headstarting project (Wilson et al., 2004). A major achievement of our initiative was that during the 2004 nesting season, two breeding females turned out to be headstarted iguanas released in August 2002, but without radio-transmitters. Reproduction by headstarted iguanas was inferred to occur in the Jamaican iguana (Wilson et al., 2004). However, this is the first certain record of headstarted *Cyclura* breeding in the wild.

Headstarted iguanas dispersed from the release sites (fig. 1). Total distances (table 1) traveled by iguanas until the end of the monitoring period ranged from 471-6396 m (mean = 2844 ± 2122 m) and were highly correlated with the number of fixes per animal ($n = 9$, $r = 0.958$, $p < 0.0005$). No differences in the total distance traveled were detected between the iguanas released at the two sites (U-test = 0.97, $p = 0.327$, $n = 8$).

Distances traveled between consecutive monitoring days ranged from 56-157 m (mean = 76 ± 33 m). The mean MCP was 10.7 ± 2.5 ha and no differences were detected between release site groups (U-test = 1.15, $p = 0.248$, $n = 8$). Unfortunately, we lost important information due to the small number of fixes (<20) from iguanas with malfunctioning transmitters (table 1). However, the home ranges of these headstarted iguanas (fig. 1) were larger than those previously recorded for wild Mona Island iguanas (mean 0.5 ha; Pérez-Buitrago et al., 2007).

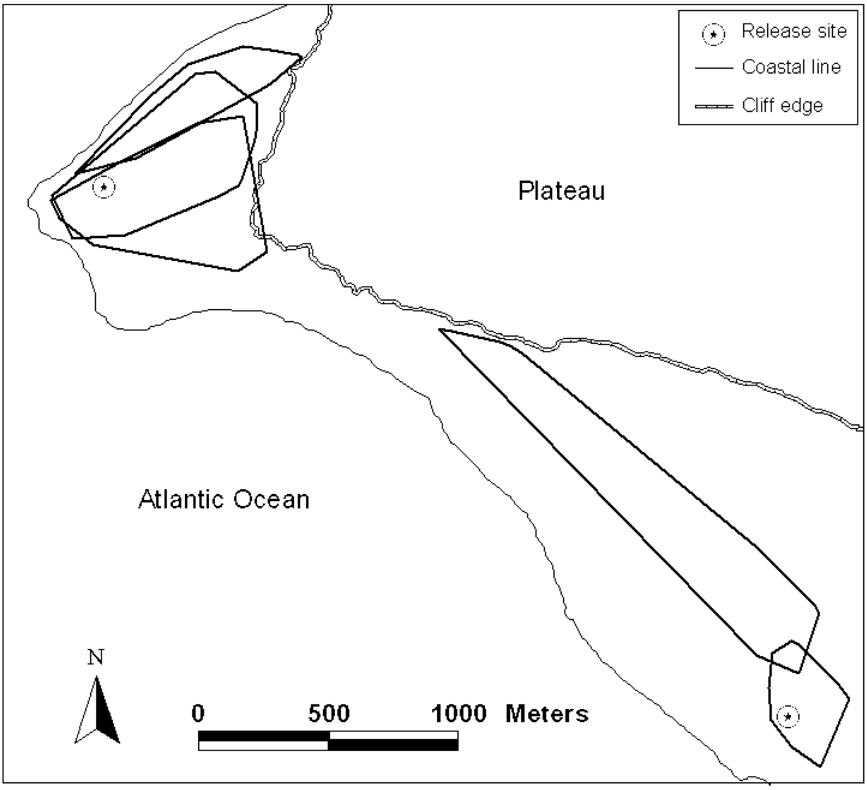

Figure 1. Minimum convex polygon (MCP) for the dispersal range estimates of five headstarted iguanas, *Cyclura cornuta stejnegeri,* monitored for 66-260 days.

Discussion

This is the first report of survival and reproduction for headstarted rock iguanas. Although some herpetological headstarting programs have failed, such projects were conducted for sea turtles (Frazer, 1992; Bowen et al., 1994). The Mona Island iguana headstarting program has been successful at rearing rapidly growing and healthy iguanas that were capable of survival and reproduction in the wild. Sound husbandry practices such as complementary feeding with natural food and acclimation to natural weather conditions (Hudson and Alberts, 2004; Knapp and Owens, 2005) seem to be a key element to achieve that goal (Alberts et al., 2004).

We ascribed the lost signals to transmitter failure rather than predation. The large size of the released iguanas (>950 g body mass) would make them a difficult prey item for both Mona boas and feral cats. In fact, we have analyzed ca. 50 feral cat stomachs and found only small reptiles (García et al., 2001) such as *Anolis monensis*, *Sphaerodactylus monensis*, and hatchling *Cyclura cornuta* (mean SVL = 11.2 cm; Wiewandt, 1977). Because all of the antennas used for the second release were internal (i.e. coiled around the transmitter pack) the signal range was reduced compared to the first release. Therefore, half of the headstarted iguanas used in this study may have quickly moved out of detection range, (ca. 400-500 m) which was small for the size of transmitter they carried.

In contrast to adult Mona Island iguanas that moved within areas not exceeding 0.5 ha (Pérez-Buitrago et al., 2007), released headstarted iguanas traveled larger distances before settling down at a specific site. These long-distance movements have been also exhibited by *C. cychlura cychlura* in Andros (Knapp and Owens, 2005) and for *C. lewisi* (Goodman et al., 2005). Interestingly, the natural nesting and headstarting release sites in this study harbor few mature iguanas outside the nesting season, suggesting that this habitat might not be suitable for them (Pérez-Buitrago and Sabat, 2000). In fact, most of the headstarted iguanas released in 2004 and 2005 in a known iguana locality remained near the release area. Nevertheless, it is important to point out that our release areas in 2002 were typical nesting sites.

In future work, we plan to obtain movement data from juvenile wild iguanas to determine if the large movement ranges found in this study are natural or caused by releasing headstarted iguanas in unsuitable habitat. We have decided not to conduct future release of iguanas in habitat not commonly used by wild adult iguanas. Suitable areas with relatively high iguana densities have already been identified (Pérez-Buitrago and Sabat, 2000). Another priority will be the headstarting of hatchlings from other nesting sites (e.g. Playa de Pájaros) to increase the genetic diversity of the managed population.

Radiotracking and surveys will continue to increase the sample size and detection probability of released iguanas, therefore gathering more survivorship and life history information. At this point, we have the capability to increase the number of headstarted iguanas for release. Nevertheless, we understand that it is important to determine scientifically the effective population size required for a positive and sustained growth of Mona Island iguanas. This estimate will be used as a target for the headstarting program and, coupled with the ongoing cat eradication program, will serve to recuperate the population of this species.

Acknowledgements. We would like to thank the staff from the Toledo Zoo (TZ) and the Puerto Rico Department of Natural Resources and Environment (DNER). In particular, Dr. Wynonna Shellaberger, Sally Noss, Debbie Paperd (TZ), and Dr. Irma Gracia, Alberto Puente, Gaspar Pons, José Jiménez, and Antonio Matos (DNER) provided special support to make this project a success. We also appreciate the help offered by the volunteers who participated in the radiotracking and husbandry activities. Funding came principally from the USA Fish and Wildlife Service Project E-1 Study 16-Conservation Initiatives for the Mona Island Iguana.

References

Alberts, A.C., Lemm, J.L., Grant, T.D., Jackintell, L.A. (2004): Testing the utility of headstarting conservation strategy for West Indian Iguanas. In: Iguanas: Biology and Conservation, p. 210-219. Alberts, A.C., Carter, R.L., Hayes, W.K., Martins, E.P., Eds, University of California Press, Berkeley.

Bowen, B.W., Conant, T.A., Hopkings-Murphy, S.R. (1994): Where are they now? The Kemp's ridley headstart project. Conserv. Biol. **8**: 853-856.

Diaz, C.D. (1984): Mona Iguana Recovery Plan. U.S. Fish and Wildlife Service, Atlanta, Georgia.

DNER (2004): Regulation to Govern the Endangered and Threatened Species in the Commonwealth of Puerto Rico. Department of Natural and Environmental Resources, San Juan, Puerto Rico.

Ewel, J.J., Whitmore, J.L. (1973): The Ecological Life Zones of Puerto Rico and the Virgin Islands. USDA Forest Service Research Paper ITF-18.

Frazer, N.B. (1992): Sea turtle conservation and halfway technology. Conserv. Biol. **6**: 179-184.

García, M.A. (2004): The effect of exotic tree plantations on the biodiversity of leaflitter arthropod in tropical islands. Unpublished dissertation thesis, University of Michigan, Ann Arbor.

García, M.A., Diez, C.E., Álvarez, A.O. (2001): The impact of feral cats on Mona Island wildlife and recommendations for their control. Carib. J. Sci. **37**: 107-108.

Goodman, R.M., Echternacht, A.C., Burton, F.J. (2005): Spatial ecology of the endangered iguana, *Cyclura lewisi*, in a disturbed etting on Grand Cayman. J. Herpetol. **39**: 402-408.

Hooge, P.N., Eichenlaub, B., Solomon, E. (1999): The Animal Movement Program. USGS, Alaska Biological Science Center, Anchorage.

Hudson, R.D., Alberts, A.C. (2004): The role of zoo in the conservation of West Indian Iguanas. In: Iguanas: Biology and Conservation, p. 274-289. Alberts, A.C., Carter, R.L., Hayes, W.K., Martins, E.P., Eds, University of California Press, Berkeley.

IUCN (2006): 2006 IUCN Red List of Threatened Species. Gland, Switzerland. Accessed on line at http://www.iucnredlist.org/.

Jennrich, R.I., Turner, F.B. (1969): Measurement of non-circular home range. J. Theor. Biol. **22**: 227-237.

Knapp, C.R., Owens, A.K. (2005): Home range and habitat associations of a Bahamian iguana: implications for conservation. Animal Conserv. **8**: 269-278.

Moreno, J.A. (1995): Interim Report — Mona Island Iguana Survey. U.S. Fish and Wildlife Service, Caribbean Field Office, Puerto Rico.

Pérez-Buitrago, N. (2000): The Mona iguana (*Cyclura cornuta stejnegeri*): Its status and hatchling biology. Masters thesis, University of Puerto Rico, Rio Piedras Campus. San Juan, Puerto Rico.

Pérez-Buitrago, N., Sabat, A. (2000): Population status of the Rock Iguana (*Cyclura cornuta stejnegeri*) in Mona Island, Puerto Rico. Acta Científica **14**: 67-76.

Pérez-Buitrago, N., Sabat, A., Funk, S.M., García, M.A., Álvarez, A.O., McMillan, W.O. (2007): Spatial ecology of the Mona Island iguana *Cyclura cornuta stejnegeri* in an undisturbed environment. Appl. Herpetol. **4**: in press.

Wiewandt, T.A. (1977): Ecology, behavior, and management of the Mona Island Ground Iguana, *Cyclura stejnegeri*. Ph.D. dissertation, Cornell University, Ithaca, New York.

Wiewandt, T.A., García, M.A. (2000): Mona Island iguana *Cyclura cornuta stejnegeri*. In: West Indian Iguanas: Status Survey and Conservation Action Plan, p. 27-31. Alberts, A.C., Ed., IUCN/SSC West Indian Iguana Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

Wilson, B.S., Alberts, A.C., Graham, K.S., Hudson, R.D., Bjorkland, R.K., Lewis, D.S., Lung, N.P., Nelson, R., Thompson, N., Kunna, J.L., Vogel, P. (2004): Survival and reproduction of repatriated Jamaican Iguanas. In: Iguanas: Biology and Conservation, p. 220-231. Alberts, A.C., Carter, R.L., Hayes, W.K., Martins, E. P., Eds, University of California Press, Berkeley.

Accepted: July 16, 2007 (AH).