

The need for pre-release health screening in animal translocations: a case study of the Cuban iguana (*Cyclura nubila*)

Allison C. Alberts¹, Marcie L. Oliva², Michael B. Worley¹, Sam R. Telford, Jr³, Patrick J. Morris⁴ and Donald L. Janssen⁴

¹Center for Reproduction of Endangered Species, Zoological Society of San Diego, P.O. Box 551, San Diego, CA 92112, USA

²Department of Pathology, Zoological Society of San Diego, P.O. Box 551, San Diego, CA 92112, USA

³Florida Museum of Natural History, University of Florida, Gainesville, FL 32611, USA

⁴Department of Veterinary Services, San Diego Zoo, P.O. Box 551, San Diego, CA 92112, USA

(Received 21 October 1997; accepted 23 February 1998)

Abstract

A serious concern with the increasing use of translocation and reintroduction in animal conservation programs is the potential for disease transmission between captive and free-ranging populations. As part of an experimental headstarting program, 45 juvenile Cuban iguanas, *Cyclura nubila*, were artificially incubated, maintained in captivity for six to 18 months, and subsequently released into natural areas on the US Naval Base at Guantánamo Bay, Cuba. Prior to release, all animals underwent physical examinations, hematological analyses, plasma biochemical determinations, and blood and fecal parasite screening. Comparable data were collected from free-ranging juveniles to establish normal baseline values. Although all hematological parameters were within expected ranges for healthy reptiles, captive juveniles exhibited higher total leukocyte counts and percent lymphocytes, but lower percent heterophils, than free-ranging juveniles. All biochemical values other than lactate dehydrogenase and creatine phosphokinase were within normal ranges. Although higher than reported in other species, these enzymes did not differ in captive and free-ranging juveniles. Free-ranging juveniles significantly exceeded captive juveniles in levels of potassium, alkaline phosphatase, lactate dehydrogenase, total protein, cholesterol and triglycerides, whereas the reverse was true for carbon dioxide and glucose. Although free-ranging juveniles exhibited oxyurids and coccidian oocysts in their feces, captive juveniles were negative for the presence of these parasites. Electron microscopy confirmed that a high percentage of both captive and free-ranging juveniles possessed erythrocytes infected with the piroplasm *Sauroplasma*. Implications of these results for successful repatriation of captive-reared iguanas are discussed.

INTRODUCTION

As the number of endangered taxa continues to grow, the release of animals bred or raised in captivity to augment depleted wild populations is becoming an increasingly important conservation tool (Griffith *et al.*, 1989; Burke, 1991; Gipps, 1991; Bloxam & Tonge, 1995). One major concern with such efforts is the potential for transmission of pathogenic microorganisms from released to free-ranging individuals (Dodd & Seigel, 1991; Griffith *et al.*, 1993). The risk is particularly high for captives that have been exposed to species with which they would not ordinarily have contact (Jacobson, 1994). Rigorous health screening prior to release can substantially reduce the probability of disease transmission between captive

and free-ranging populations (Beck, Cooper & Griffith, 1993). When coupled with comparable data from the wild, physical examinations, measurement of hematological and blood chemistry values, and screening of blood and fecal samples for potentially pathogenic organisms can be useful in determining whether captives are suitable candidates for release (Woodford & Kock, 1991; Jacobson, 1993).

The West Indian rock iguanas (genus *Cyclura*) are among the most endangered lizards in the world, with the majority of taxa numbering less than 2500 individuals (Alberts, in press). Most rock iguana populations are depressed as a result of heavy predation on hatchlings by introduced mammalian predators rather than by increased adult mortality or lack of suitable habitat (Iverson, 1978; Vogel, Nelson & Kerr, 1996). For this reason, repatriation of headstarted hatchlings once they have reached a less vulnerable size, while not appropriate for all reptilian

species (Frazer, 1992; Congdon, Dunham & Van Lobensels, 1993), appears to be a viable conservation strategy for rock iguanas. Headstarting programs, which are planned or in progress for several taxa (Alberts, in press), have the potential to directly address the problem of reduced juvenile recruitment (Reinert, 1991), and can probably be accomplished without exceeding the natural carrying capacity of the habitat.

Although vulnerable to a variety of threats, the Cuban iguana, *Cyclura nubila*, is still fairly numerous in the wild (Perera, 1985). Because they are similar to other rock iguanas in their life history, ecology and habitat requirements (Schwartz & Henderson, 1991), Cuban iguanas provide a valuable model for more critically endangered members of the genus. As part of an experimental test of the potential utility of headstarting as a conservation tool, 45 juvenile Cuban iguanas were reared at the San Diego Zoo. This study reports results of a comprehensive health screening protocol conducted prior to releasing juveniles into their native habitat.

METHODS

Study animals and husbandry protocol

Eggs of free-ranging females captured on the US Naval Base at Guantánamo Bay, Cuba were collected and artificially incubated (Alberts *et al.*, 1997). An initial group of 30 was hatched in 1993 and a second group of 15 in 1994. Neonates were housed indoors at Guantánamo Bay in 1.5 m² enclosures equipped with infrared heat lamps and hiding areas. At one month of age, hatchlings were transported to the Center for Reproduction of Endangered Species at the San Diego Zoo as part of an experimental headstarting program.

Juvenile iguanas were segregated into two groups by age and maintained indoors for six to 18 months at a density of one individual/m² under ultraviolet-transmitting plastic roofing. Enclosures were equipped with rocks and wood structures to simulate natural terrain. Ceramic infrared heating elements provided several localized basking sites with surface temperatures up to 45 °C. Juveniles were fed mixed greens supplemented with *Hibiscus* leaves and flowers, fresh fruit, and a commercial cereal product (Hill's Product #6920). Each juvenile was implanted in the inguinal region with a passive integrated transponder tag for permanent identification.

Although two other iguanid species (seven *Brachylophus fasciatus* and two *Iguana delicatissima*) were housed at the facility, all enclosures were physically separated by corridors, and a footbath containing orthophenylphenol (1 Stroke Environ, Sanofi Inc., Overland Park, KS, USA) was utilized for entry to and exit from the Cuban iguana enclosures at all times. Daily cleaning was accomplished with designated equipment that was not shared among enclosures. Animal care was in accordance with the Zoological Society's Institutional Animal Care and Use Committee and standard guidelines set by the National Institutes of Health.

Sample collection

Three months prior to release, all juveniles were given physical examinations, including macroscopic evaluation for the presence of ectoparasites. For juveniles weighing > 300 g ($n = 19$), 2.7 ml blood samples were collected into heparin-flushed syringes by caudal venipuncture (Esra, Benirschke & Griner, 1975; Gorzula, Arocha-Piñango & Salazar, 1976) and transferred into heparinized tubes for blood chemistry and hematological analyses. Also, 1.0 ml blood samples were collected from seven additional juveniles weighing > 100 g for hematology only. Thin blood smears were subsequently made for hemoparasite evaluation of 25 randomly selected individuals representing both juvenile groups. Plasma samples for blood chemistry determinations were obtained by centrifugation at 4000 rpm for 15 min. For all individuals from which blood was obtained, 0.5 ml plasma was banked for retrospective studies.

Two pooled fecal samples representing 25% of the individuals in each of the two juvenile captive groups were preserved in 10% neutral-buffered formalin for protozoologic evaluation. In addition, pooled fecal samples for bacteriological evaluation were obtained by homogeneously coating dry sterile swabs with fresh fecal material from each of the two juvenile groups. Pooled fecal samples were deemed sufficient for detecting the presence of enteric pathogens given that captive juveniles were housed in stable groups with close social contact for six to 18 months, as well as the impracticality of collecting fecal samples from known individuals under these housing conditions.

In April 1995 blood samples and smears were collected at Guantánamo Bay to determine blood chemistry parameters and parasite prevalence in 16 free-ranging juvenile Cuban iguanas weighing > 300 g. Blood was centrifuged at 4000 rpm for 15 min and plasma was immediately frozen in a liquid nitrogen vapor shipper. Fecal samples from five free-ranging individuals were collected and fixed in 10% neutral-buffered formalin. In January 1997, additional blood samples for hematological evaluation were obtained from 13 free-ranging juveniles weighing > 100 g. All free-ranging juveniles were macroscopically evaluated at the time of capture for the presence of ectoparasites.

Hematological and blood chemistry evaluations

Hematocrit values were determined in microcapillary tubes centrifuged at room temperature for 5 min at 12 000 rpm. An indirect total leukocyte count was obtained by the eosinophil unopette method. The percentages of lymphocytes, heterophils, basophils, azurophils, eosinophils and monocytes were determined by differential counting of 300 cells on smears stained on an automated slide stainer with modified Wright's stain.

Chemistry values for plasma samples were determined using chemistry analyzers for the following parameters: sodium, potassium, chloride, carbon dioxide, phosphorus, lactate dehydrogenase, creatine phosphokinase and

albumin (Kodak Ektachem System); calcium, alkaline phosphatase, glutamic oxaloacetate transaminase (AST/SGOT), glutamic pyruvic transaminase (ALT/SGPT), γ -glutamyltransferase, glucose, blood urea nitrogen, uric acid, total protein, total bilirubin, cholesterol and triglycerides (DuPont Analyst System). Carbon dioxide was not analyzed for seven individuals due to insufficient plasma volume. Statistical comparisons of hematological and plasma chemistry values in free-ranging and captive individuals were made using *t* tests with a significance level of $P = 0.05$.

Fecal screening and bacteriological evaluations

Immediately after collection, swabs from pooled fecal samples from the two captive groups were immersed in sterile transport media and subsequently streaked onto blood agar and MacConkey agar plates. In addition, tubes of selenite broth were inoculated with fecal material from the swabs. Plates and tubes were incubated at 37 °C and examined at 24 and 48 hours for bacterial growth. Gram stains of bacterial samples were made for microscopic evaluation and bacteria isolated from culture were typed using the BBL crystal identification system (Benton Dickinson, Franklin Lakes, NJ, USA).

Screening of pooled fecal samples for ova and parasites was carried out by direct microscopic examination and fecal flotation in sodium nitrate. Ziehl–Nielsen acid-fast staining of fecal smears was used to screen primarily for cryptosporidia and secondarily for acid-fast bacteria (Pratt, 1985). Formalin-fixed fecal samples from free-ranging individuals were examined microscopically after sample concentration by sedimentation (Ritchie, 1948).

Hemoparasite screening

At the time of sampling, thin blood smears from both captive and wild juveniles were air-dried and fixed in absolute methanol for 15 min. Smears were then stained with a modified Wright's stain and examined by light microscopy at 100 \times magnification. In addition, blood samples from three captive and three free-ranging juveniles were collected and fixed for electron microscopy in 2.5% glutaraldehyde in phosphate-buffered saline (PBS). Cells from captive individuals were fixed within 1 hour of collection, while those from free-ranging individuals were fixed within 72 hours of collection, following transport to San Diego. Cells were post-fixed in 1% osmium tetroxide (OsO₄), dehydrated through graded ethanol, cleared in propylene oxide, and embedded in plastic. Thin sections were mounted on 300-mesh copper grids, stained with uranyl acetate and lead citrate, and viewed using a Phillips electron microscope.

RESULTS

Hematological values for captive and free-ranging juvenile *C. nubila* are presented in Table 1. No differences between the sexes were observed. Hematocrits and total

Table 1. Hematological values for captive ($n = 26$) and free-ranging ($n = 13$) juvenile Cuban iguanas

	Captive	Wild
Hematocrit (g %)	30.62 \pm 0.51 (25–35)	29.12 \pm 0.74 (25–34)
Total leukocytes ($\times 10^3$)*	12.52 \pm 0.72 (7.0–19.1)	7.83 \pm 1.53 (3.6–20.9)
Lymphocytes (%)*	79.65 \pm 1.59 (64–93)	35.15 \pm 7.67 (2–87)
Heterophils (%)*	9.65 \pm 1.20 (2–28)	49.46 \pm 6.81 (3–82)
Basophils (%)	5.39 \pm 0.50 (2–12)	5.23 \pm 0.80 (0–9)
Azurophils (%)*	3.73 \pm 0.59 (0–12)	9.62 \pm 1.37 (5–21)
Eosinophils (%)	1.35 \pm 0.34 (0–6)	0.46 \pm 0.18 (0–2)
Monocytes (%)*	0.27 \pm 0.09 (0–1)	0.00 \pm 0.00

Values are mean \pm SE; range is shown in parentheses. Asterisks indicate a significant difference at $P = 0.05$.

leukocyte counts were within the range reported for other squamate reptiles (Zarafonetis & Kalas, 1960; Hadley & Burns, 1968; Dessauer, 1970; Acuña, 1974; Hattings & Willemsse, 1976). Although basophils, azurophils and monocytes were present in similar proportions to those reported for other lizards (Kelly *et al.*, 1961; Duguay, 1970), eosinophils were less common (Acuña, 1975; Wright & Skeba, 1992). Free-ranging juveniles exhibited lower total leukocyte counts ($t = 3.17$, d.f. = 37, $P = 0.003$) and percent lymphocytes ($t = 7.67$, d.f. = 37, $P = 0.0001$), but higher percent heterophils ($t = 7.89$, d.f. = 37, $P = 0.0001$), than captive juveniles.

Plasma chemistry results for captive and free-ranging juveniles are compared in Table 2. The majority of these values fell within reported ranges for other squamates (Cohen, 1954; Miller & Wurster, 1956; Zarafonetis & Kalas, 1960; Moore, 1967; Dessauer, 1970; Otis, 1973). However, lactate dehydrogenase and creatine phosphokinase levels were elevated compared with other reptile species (Chiodini & Sundberg, 1982; Rosskopf, Woerpel & Yanoff, 1982; Taylor & Jacobson, 1982; Marks & Citino, 1990; Al-Badry, El-Deib & Nuzhy, 1992; Wright & Skeba, 1992; Raphael *et al.*, 1994). Although no differences between the sexes were evident, significant differences between free-ranging and captive juveniles were found. Free-ranging individuals exceeded captive individuals in potassium ($t = 4.30$, d.f. = 33, $P = 0.0001$), alkaline phosphatase ($t = 2.36$, d.f. = 33, $P = 0.02$), lactate dehydrogenase ($t = 2.42$, d.f. = 33, $P = 0.02$), total protein ($t = 2.95$, d.f. = 33, $P = 0.006$), cholesterol ($t = 3.26$, d.f. = 33, $P = 0.003$), and triglyceride ($t = 2.65$, d.f. = 33, $P = 0.01$) levels. Conversely, captive individuals exceeded free-ranging individuals in carbon dioxide ($t = 5.62$, d.f. = 26, $P = 0.0001$) and glucose concentration ($t = 2.48$, d.f. = 33, $P = 0.02$). No differences between the sexes were observed.

No ectoparasites were found on captive juveniles, including ticks (*Ixodes pacificus*) and two mites, *Neotrombicula californica* and *Geckobiella texana*, commonly found on lizards inhabiting southern California (Goldberg & Bursey, 1991, 1993). In contrast, ixodid ticks (*Amblyomma* sp.; Viguera, 1934) were usually found in the gular and inguinal folds of free-ranging juvenile Cuban iguanas at the time of capture

Table 2. Plasma chemistry values for captive ($n = 19$) and free-ranging ($n = 16$) juvenile Cuban iguanas

	Captive	Wild
Sodium (mEq/l)	164.9 ± 1.3 (158–179)	165.4 ± 2.2 (150–181)
Potassium (mEq/l) *	2.7 ± 0.3 (1.0–5.1)	4.1 ± 0.1 (3.0–5.0)
Chloride (mEq/l)	125.5 ± 0.9 (118–134)	125.3 ± 2.1 (112–140)
Carbon dioxide (mEq/l) *	20.9 ± 1.4 (13–28)	11.7 ± 1.0 (6–23)
Calcium (mg/dl)	11.7 ± 0.2 (9.8–13.3)	13.7 ± 1.2 (9.4–30.0)
Phosphate (mg/dl)	5.4 ± 0.2 (4.1–6.8)	5.8 ± 0.3 (3.9–8.0)
Alkaline phosphatase (IU/l) *	66.1 ± 5.8 (41–154)	96.3 ± 12.2 (40–251)
Glutamic oxaloacetate transaminase (IU/l)	45.5 ± 3.7 (26–79)	43.5 ± 2.3 (30–60)
Glutamic pyruvic transaminase (IU/l)	8.6 ± 0.5 (5–12)	17.4 ± 6.1 (5–107)
Lactate dehydrogenase (IU/l) *	3203.4 ± 451.1 (816–7000)	4787.3 ± 472.8 (1700–7000)
Creatine phosphokinase (IU/l)	2900.2 ± 486.8 (387–6400)	3738.5 ± 504.3 (444–6400)
γ-Glutamyltransferase (IU/l)	5.0 ± 0.0 (5–5)	5.0 ± 0.0 (5–5)
Glucose (mg/dl) *	253.6 ± 5.6 (222–307)	229.9 ± 8.0 (190–314)
Blood urea nitrogen (mg/dl)	2.2 ± 0.2 (2.0–5.0)	2.1 ± 0.1 (2.0–2.9)
Creatinine (mg/dl)	0.2 ± 0.0 (0.2–0.2)	0.2 ± 0.0 (0.2–0.2)
Uric acid (mg/dl)	4.0 ± 0.3 (2.0–7.3)	4.8 ± 0.5 (1.1–8.9)
Total protein (g/dl) *	5.7 ± 0.1 (4.7–6.9)	6.7 ± 0.4 (3.2–8.7)
Albumin (g/dl)	2.4 ± 0.1 (2.2–2.8)	2.6 ± 0.1 (1.4–3.1)
Total bilirubin (mg/dl)	0.1 ± 0.0 (0.1–0.2)	0.1 ± 0.0 (0.1–0.3)
Cholesterol (mg/dl) *	52.6 ± 2.0 (50–86)	82.1 ± 9.6 (50–161)
Triglycerides (mg/dl) *	63.8 ± 11.7 (10–184)	159.8 ± 40.5 (29–484)

Values are mean ± SE; range is shown in parentheses. Asterisks indicate a significant difference at $P = 0.05$.

(97% of individuals affected; mean of 5.8 ± 1.5 ticks per individual). No differences in ectoparasite loads between the sexes were observed.

Pooled fecal samples from captive juveniles were negative for cryptosporidia and acid-fast bacteria. No pathogens were identified from aerobic bacterial culture, including *Salmonella*, the major bacterial pathogen of concern for captive reptiles (Duncan *et al.*, 1994; Ramsay *et al.*, 1996). A lack of large gram-positive spore-forming rods indicated that no significant anaerobic pathogens were present. Fecal samples from free-ranging individuals showed light (\leq one per five fields at 20 \times) to moderate (one to two per field at 20 \times) oxyurids, as well as coccidian oocysts.

Light microscopic examination of blood smears from captive individuals indicated light (20–30% of cells infected) to moderate (30–60% of cells infected) infections with the piroplasm *Sauroplasma* in the erythrocytes of 71% of the juveniles hatched in 1993. None of the captive juveniles hatched in 1994 showed evidence of infection with *Sauroplasma*. Blood smears from free-ranging individuals indicated *Sauroplasma* sp. in 79% of the individuals examined. Electron microscopic examination of erythrocytes confirmed these results, and permitted ultrastructural assessment of these parasites. Because the ultrastructural characteristics of *Sauroplasma* have not been previously described, electron micrographs are included here to facilitate future interspecific comparisons. Low-power magnification revealed parasites adjacent to the cell nucleus in both captive (Fig. 1) and free-ranging individuals (Fig. 2). Higher magnification showed that the parasites were relatively electron-lucent and variable in shape. No other hemoparasites were evident in the two captive groups. In contrast, light to heavy ($>60\%$ of cells infected) intra-cytoplasmic infections with the hemogregarine *Hepatozoon* and the hemococcidian *Schellackia* were observed by light microscopy in 26% of the free-ranging individuals.

DISCUSSION

Physical examinations, together with hematological and fecal analyses, indicated that the juvenile Cuban iguanas in this study were healthy. All values for both captive and free-ranging juveniles fell within the expected range for squamate reptiles. That eosinophils were relatively less common than in some other groups of reptiles potentially reflects the climatic conditions under which samples were collected. In snakes, warm temperatures and active periods are associated with a relative decrease in eosinophils (Wojtaszek, 1992). The higher percentage of heterophils in free-ranging relative to captive juveniles could result from their higher parasite loads, both in terms of the number of different parasites and the percentage of individuals affected (Frye, 1991). The lower percentage of lymphocytes in free-ranging juveniles is more difficult to interpret because this value can be influenced by a wide variety of factors, including age, sex, nutritional condition, health and stage of ecdysis (Frye, 1991).

Results of plasma chemistry determinations, with the exception of lactate dehydrogenase and creatine phosphokinase, also fell within expected ranges for reptiles. Although values for these two enzymes were markedly higher in juvenile Cuban iguanas than reported for other species, the same pattern was observed in both captive and free-ranging individuals, suggesting that variation of this magnitude is normal for this species. All individuals were sampled at midday, when body temperatures were at their highest. Increased locomotion and associated vigorous muscular activity may partially explain the elevated enzyme levels, particularly for those individuals that ran significant distances prior to capture (Al-Badry *et al.*, 1992; O'Connor *et al.*, 1994). Alternatively, as has been suggested for skinks (Wright & Skeba, 1992), the highly territorial and aggressive nature of rock iguanas, even as juveniles, may result in undetected

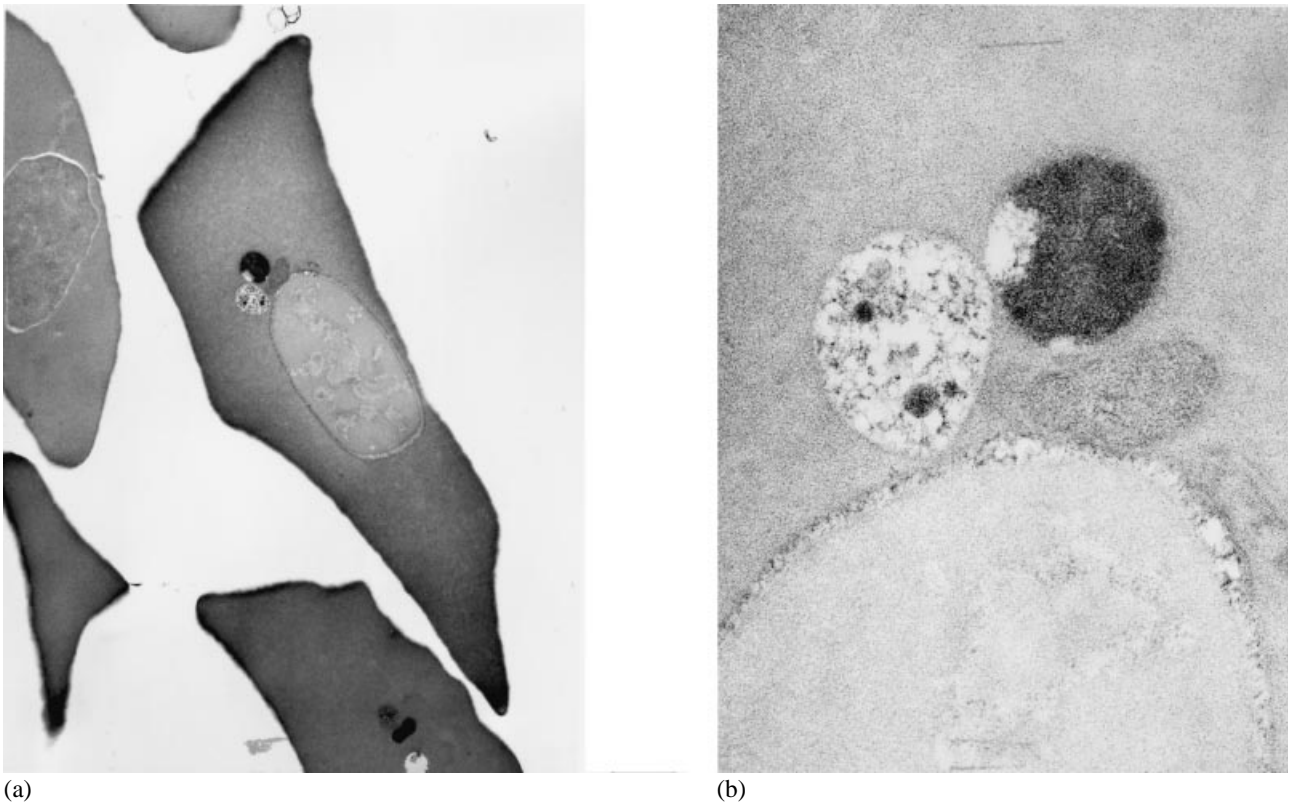


Fig. 1. Electron micrographs of *Sauroplasma* sp. in the erythrocytes of a captive juvenile Cuban iguana at magnifications of $4800\times$ (a) and $30000\times$ (b). The parasite is oblong in shape, approximately $0.87\ \mu\text{m}$ in its greatest length and $0.67\ \mu\text{m}$ in its greatest width. It contains three spherical electron-dense bodies varying in size from $0.15\times 0.13\ \mu\text{m}$ to $0.06\times 0.06\ \mu\text{m}$.



Fig. 2. Electron micrographs of *Sauroplasma* sp. in the erythrocytes of a free-ranging juvenile Cuban iguana at magnifications of $7000\times$ (a) and $24000\times$ (b). The parasite is irregularly shaped, approximately $0.79\ \mu\text{m}$ in its greatest length and $0.44\ \mu\text{m}$ in its greatest width. It contains one prominent electron-dense body approximately $0.27\ \mu\text{m}$ long \times $0.20\ \mu\text{m}$ wide.

injuries that could account for elevated creatine phosphokinase levels. However, no external evidence of trauma was found in any of the juveniles examined.

While within the normal ranges for squamate reptiles, several biochemical parameters differed significantly between free-ranging and captive juveniles. Elevated potassium levels in free-ranging juveniles were most likely the result of dietary differences. Rock iguanas are herbivorous, and like other reptiles that inhabit arid ecosystems, may be exposed to high potassium loads in their spring forage (Nagy & Medica, 1986; O'Connor *et al.*, 1994). As in other vertebrates, elevated levels of alkaline phosphatase in free-ranging juveniles may reflect higher rates of growth and bone deposition at the time samples were collected (Kaneko, 1980). Because they were exposed to relatively constant temperatures and a non-seasonally varying diet, captive juveniles in this study may have grown at a more continuous rate than those in the wild. In contrast, growth rates in free-ranging juveniles are probably closely tied to the availability of suitable plant material and may have been maximized at the time of sample collection with the advent of spring foliage.

As has been suggested for some snakes, higher protein, cholesterol and triglyceride levels in free-ranging juvenile Cuban iguanas may be indicative of greater metabolic activity (Chiodini & Sundberg, 1982; Al-Badry *et al.*, 1992). On average, body temperatures of free-ranging juveniles (37.4 ± 0.4 °C) were higher than those of captive juveniles (35.2 ± 0.2 °C) (Alberts & Grant, 1997). Although elevated cholesterol in reptiles is often associated with estrogen production and vitellogenesis (Jackson, Holcomb & Jackson, 1974; Taylor & Jacobson, 1982; Raphael *et al.*, 1994), none of the females in the present study were reproductively mature, and no differences in cholesterol levels between the sexes were observed.

Higher levels of blood glucose in captive juveniles may reflect daily feeding of a consistently high quality diet. In the wild, juveniles may not feed every day, and the nutritional content of their food plants varies seasonally (Wiewandt, 1977; Iverson, 1979; Perera, 1985). In other reptiles, high blood glucose levels have been associated with both the regularity of feeding (Miller & Wurster, 1956; Moore, 1967) and the amount of food consumed prior to sampling (Zarafonitis & Kalas, 1960; Wright & Skeba, 1992). The higher levels of carbon dioxide observed in captive animals are more difficult to interpret. Because higher body temperatures result in an increase in the partial pressure of carbon dioxide in plasma (Robin, 1962; Haning & Thompson, 1965), carbon dioxide levels in free-ranging juveniles might have been expected to exceed those in captive juveniles. Decreased plasma carbon dioxide in free-ranging individuals could have resulted from increased respiratory rates brought on by the stress of capture, but this possibility remains speculative without experimental study.

While no endoparasites were identified in captive juveniles, infection with both oxyurid nematodes and coccidian protozoans was observed in free-ranging juve-

niles. Both of these parasites are acquired by exposure to fecal matter, are common in reptiles, and appear to cause little overt disease in free-ranging animals (Klingenberg, 1993; Jacobson, 1994). Consumption of feces is well documented among young iguanid lizards, and may be related to the need for juveniles to acquire bacterial microflora for hindgut fermentation of food plants (Troyer, 1984).

Evidence of hemogregarine infection, a common intra-erythrocytic parasite of reptiles, was also found among free-ranging juveniles. While heavy hemogregarine infections may result in anemia (Barnard & Upton, 1994), light to moderate infections such as those observed in the present study are usually not pathogenic in their natural hosts (Wozniak, Telford & McLaughlin, 1994). Arthropod vectors, particularly ticks and mosquitoes, are the most likely means of transmission (Booden, Chao & Ball, 1970; Oda, Chao & Ball, 1971; Wozniak *et al.*, 1994). Future monitoring of released captives will be important in determining if parasitic infections with oxyurids, coccidia and hemogregarines eventually occur (Woodford & Kock, 1991; Spalding & Forrester, 1993). Based on the rapidity with which free-ranging hatchling lizards acquire both intestinal protozoan infections in the wild (Telford, 1970) and hemoparasites (Telford, 1996), captive juveniles are expected to exhibit endoparasites fairly soon after release.

The piroplasm *Sauroplasma* infects diverse lizard families worldwide (Svahn, 1976). Although no evidence suggests that *Sauroplasma* is pathogenic, its occurrence in one of the captive juvenile groups necessitated that its presence in the wild population be confirmed before proceeding with the release. Not only was *Sauroplasma* detected in a high percentage of free-ranging juvenile Cuban iguanas, but it was also found in two healthy captive reared groups of juveniles on Grand Cayman (*C. nubila lewisi*) and Jamaica (*C. collei*), indicating that it may be widespread in the Greater Antilles, and perhaps throughout the Caribbean. Ticks are probably the major invertebrate vector responsible for transmission of *Sauroplasma* (Barnard & Upton, 1994; Telford, 1997). The captive juveniles in this study were artificially incubated and raised indoors without contact with potential arthropod vectors. Controlled studies would be useful in assessing the possibility that these juveniles were infected through vertical transmission from their mothers. That none of the 1994 captive juveniles were infected is not surprising. In contrast to its prevalence in older juveniles and subadults, *Sauroplasma* infections are often extremely light in hatchling and adult lizards (Telford, 1997). Follow-up blood sampling of the two released juvenile groups should clarify the developmental stages at which *Sauroplasma* is most prevalent.

Health screening results indicated that the captive Cuban iguanas in this study were in good health. No deleterious pathogens were identified in the captive groups that could pose a threat to the wild population. The only significant parasitic organism found in captive

juveniles, the piroplasm *Sauroplasma*, was also present in a similar proportion of free-ranging juveniles. In addition, although oxyurid nematodes, coccidian protozoans and hemogregarines were identified in the wild population, none of these organisms are considered clinically significant in reptiles. Although the captive juveniles will likely acquire these parasites subsequent to their release, the associated health risks are minimal and unlikely to have a strong influence on the success of the repatriation. Based on these considerations, the captive juveniles were released in June 1995 at two sites at Guantánamo Bay. The release sites will be monitored over the next several years in order to compare growth and survival rates in the two juvenile groups. Collection of additional blood and fecal samples will be essential in assessing the health status of the released individuals and determining how quickly their parasite and biochemical profiles approach those of free-ranging juveniles.

Acknowledgements

We are grateful to the US military and civilian personnel at the Guantánamo Bay Naval Base for logistical support, particularly Captain Len Murray and Captain Cristiano Colon, to Lori Jackintell, Tandora Grant and Lisa Morici for help with sample collection and analysis in the field, to Ken Kelly for photographic assistance, and to Ching-Ming Chang of the Scripps Research Institute for preparing blood samples for electron microscopy. Juvenile iguanas and blood samples were imported under US Fish and Wildlife Permit PRT-783930. This research was supported by National Science Foundation Conservation and Restoration Biology Grant DEB-9424471.

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